

~~A REVIEW AND AN ANNOTATED BIBLIOGRAPHY ON SUBPERIODIC
BANCROFTIAN FILARIASIS WITH SPECIAL REFERENCE TO ITS
VECTORS IN POLYNESIA, SOUTH PACIFIC~~

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INTRODUCTION

It was gratifying that the South Pacific Commission (SPC) endorsed the recommendations of the Conference of Experts on Filariasis held in Tahiti in 1951 for issuing a series of bibliographies on human filariasis in the South Pacific area which Dr M O.T. Iyengar competently prepared during 1954-1960 (see Abstract Nos. 44, 59, 66, 75, 87, etc.). These constituted a wealth of information abstracted from published and unpublished reports since the 18th century.

The present review and bibliography cover essentially the period 1960-1978. However, it was found necessary to abstract certain selected papers prior to 1960, particularly those dealing with vector biology and control, which have relevance to the later papers reviewed. Some of the abstracts before 1960 were either copied from the bibliography of Iyengar, as original paper could not be obtained or Iyengar's abstracts were found sufficient. The original papers which have not been available to us are marked with (*). With regard to the period after 1960 which is essentially dealt with in the present bibliography, as mentioned above, we were selective but more liberal in abstracting papers dealing with clinical aspect, pathology, immunology and drug trials so long as these were relevant to the programme of filariasis control in Polynesia.

Experience shows that many field workers particularly in remote areas have difficulty in obtaining copies of the original papers, and, if available, these may take a long time to reach them. Many unpublished documents may not have a wide circulation. Therefore, the present bibliography has been prepared principally to provide field workers engaged in filariasis survey and control with abstracts of papers which focus attention on vector biology and control, vector parasite relationship and the entomological procedures related particularly to these aspects. However, in the course of preparation of the bibliography, it was thought useful to abstract papers dealing with other components of the epidemiology of filariasis. Thus, in order to place the entomological component in its epidemiological perspective, some papers dealing with clinical aspects, parasitology and chemotherapy have also been abstracted even though these components would need further elaboration by epidemiologists and parasitologists.

In order to fulfill the aim of practical usefulness of the bibliography, it was decided not to follow the conventional style of abstracting. The abstracts have been made in a comprehensive way so that users will feel self-sufficient with this document. Even data and graphical presentations have been incorporated whenever appropriate, and extracts from the authors' own text have often been included for clarity. Data provided in original papers have sometimes been re-analyzed, discrepancies pointed in the findings of different authors, and comments provided. The latter have been put between parenthesis (N.B.).

The system adopted herein follows that of Iyengar's bibliography, i.e. the abstracted references are presented chronologically, which enables following up the progress made in different fields year by year, and an alphabetical list of the authors is also provided. The number between parenthesis indicates the serial number of the bibliography list.

To increase the scope of the bibliography, it was found useful to include selective references cited by the authors in their original papers. Also, cross references to papers already abstracted in the bibliography have been made in order to assist the user in comparing the views of different workers involved.

It was through the kind cooperation of Dr R.I. Muller of the WHO Reference Centre for Filarioidea, London School of Hygiene and Tropical Medicine, that a computer print-out of the global bibliography on filarial infections has been made available which helped in cross-checking whether some important references have been missed.

The present review paper aims first at assisting the users in identifying abstracts on certain topics in the bibliography and secondly to provide an inventory of the available knowledge which would assist in identifying the gaps in knowledge which need further investigation.

The bibliography has not been restricted to specific topics or to the findings of certain countries and island groups in Polynesia, but publications and unpublished papers dealing with filariasis in broad general terms in the South Pacific area have been cited. First of all, there are the series of bibliographies by Iyengar with a notion of their contents as follows: Iyengar, 1954 a (44), dealing with clinical manifestations of filariasis, epidemiology and chemotherapeutic aspects; 1954 b (45), dealing with the distribution of filariasis and its vectors in the South Pacific area; 1956 (59), dealing with vector aspects throughout the Region and extending this to vectors of Brugia malayi; 1957 (65), dealing with clinical, pathological and diagnostic aspects of filariasis due to Wuchereria bancrofti and B. malayi; this document was supplemented by a further issue in 1959 a (74); 1959 (73), reviewing the prevalence of filariasis and bionomics of its vectors in the South Pacific Region; 1959 b (75), dealing with drug treatment of filariasis due to W. bancrofti and B. malayi; 1960 (86), dealing with drug treatment and/or vector control; and 1960 a (87), up-dating the knowledge on vectors of filariasis, distribution and bionomics; 1960 b (231), summarizing data on filariasis in the South Pacific; and also two papers on the problem of human filariasis in general by Iyengar have been abstracted, viz. 1961 (94) and 1965 (108) giving a comprehensive review of the knowledge of bancroftian filariasis and its vectors by country and island groups, and finally collating all the available information on problems related to the epidemiology of periodic and subperiodic bancroftian filariasis and its control throughout the South Pacific.

Of the general papers dealing with the bionomics and control of vectors of filariasis in the Pacific Region are those of Chow, 1965 (107); 1968 (120); 1971 (134); 1973 (156); 1974 (165) and 1977 (211).

Several other papers dealing with problems of human filariasis, its vectors and control on a global basis are those such as Kessel, 1961 (95); Brown, 1962 (98); Kessel & Massal, 1962 (99), which reviews the answers to a questionnaire on filariasis circulated to countries in the South Pacific Region; Edeson & Wilson, 1964 (102); Galliard, 1964 (103); Nelson, 1959 (81), which deals with identification of the infective stage larvae of different species of filarial parasites; and 1964 (104), which reviews the factors related to the parasite in its arthropod host; Maung, 1974 (168), which describes in detail the clinical manifestation of bancroftian

filariasis. A few papers reviewing the aspects of chemotherapy have been cited, viz. Ricosse & Picq, 1973 (162) and Moreau & Picq, 1976 (200). Among the important general papers is the publication of Hawking & Denham, 1976 (195) which reviews the distribution of human filariasis in the Pacific Region as one of their series of world-wide surveys.

A useful guide to the procedures and techniques which have been utilized in filariasis and vector investigations is that of Ramachandran, 1970 (133). Important textbooks dealing with filariasis and its vectors are also cited, viz. Belkin, 1962 (97), which reviews comprehensively the systematics of all mosquitos in the Region, including their distribution and synoptic notes on their bionomics and relation to disease; and Sasa, 1976 (206), which is a leading reference for all workers engaged in filariasis epidemiology and control. A recent SPC document on sanitary engineering and mosquito control has been cited, Richard, 1977 (223).

A number of WHO unpublished documents and published reports of general interest have been abstracted, viz. the WHO report of the Inter-Regional Seminar on Filariasis, Manila, 1966 (114); and the Technical Report Series of the WHO Expert Committee on Filariasis, 1962 (100); 1967 a (119); and 1974 (178). Also included are the reports of the WHO/SPC joint seminars on filariasis, Apia, Samoa in 1968 (235) and in 1974 (179); the report on the Working Group on Subperiodic Bancroftian Filariasis in Apia in 1978 (225); and the report on the Informal Consultations on Research on Filarial Infections, 1975 (191). It should be noted that as far as possible more elaborate abstracts were made from certain documents prepared by WHO consultants or staff members. Because these remained unpublished, they may not have been accessible to workers at field level.

In all the above-mentioned references of general interest, it would have been too extensive to make specific abstracts of the contents because of the wide coverage of the topics; therefore, the abstract was basically constructed from the title of the topics discussed in each paper.

PART I

REVIEW OF THE AVAILABLE KNOWLEDGE ON SUBPERIODIC WUCHERERIA BANCROFTI
WITH SPECIAL REFERENCE TO ITS VECTORS, PARTICULARLY FOR THE PERIOD
1960 - 1978

This review consists of four Sections:

SECTION I - COUNTRY INFORMATION

1. Literature by country, 1959 to 1978

A reference list for the literature cited in the bibliography for each country/island group in Polynesia from 1959 to 1978 is given in Table 1, and the population figures for 1978 in Table 2. This list should help the reader select specific abstracts concerning the country of particular interest to him. As shown in column 2 of the table, the author's name with the year of publication are given and in parenthesis the serial number of the abstract in the bibliography. In addition, codes indicate whether a specific component has been included in the paper. (Code symbols are shown beneath the table). Since the main attention is focussed on vector studies and control, references dealing exclusively with this aspect have been shown separately in column 3.

For ready reference, a map of the South Pacific area is attached.

2. Brief review of recent situation of filariasis

The following review is based mainly on the report of the WHO/SPC Joint Seminar on Filariasis and Vector Control held in Apia, Samoa in 1974 (179) and the report on the WHO Working Group on subperiodic Wuchereria bancrofti held also in Apia in 1978 (225), and partly on the assignment reports of WHO staff.

2.1 American Samoa

The report of WHO/SPC Seminar (179) reviewed the data of 1962 before the mass drug administration (MDA) and the results of surveys during the post-treatment period of 1972.

In 1962, of 1000 persons examined in five pilot villages in Tutuila Island, the average microfilaria (mf) rate was 21%. MDA with diethylcarbamazine (DEC) at 6 mg/kg was started in 1963. A total dosage of 72 mg/kg was administered over a period of one year. Post-treatment survey in 1965 in the same five villages revealed an mf rate of 3.1% out of 1135 persons examined. After the second round of MDA started in 1965, the mf rate was 0.27% out of 1053 persons examined in 12 villages in 1968, who had completed 144 mg/kg. No infective mosquitos were found. The surveys conducted in 1970-1972, involving 79.7% of the total population, indicated an overall mf rate of 0.97%, a mean mf density in positive blood films of 10.7 per 20 mm³, an elephantiasis rate of 0.9%, and a hydrocele rate of 2.1%.

MAP OF
SOUTH PACIFIC AREA

Equatorial Scale

MILES

Marshall Islands

KIRIBATI

Oceania

Line Islands

Equator

Southern

Line Islands

Northern

Cook Islands

Southern

Dates Islands

Southern

Phoenix Islands

Southern

Samoa Islands

Northern

Samoa

Southern

Tonga Islands

Southern

Fiji Islands

Southern

New Caledonia

Southern

New Zealand

Southern

Fiji Islands

Southern

New Zealand

NOTE

Map 1

Map 2

TABLE 1
LIST OF LITERATURE BY COUNTRY/ISLAND GROUPS
FROM 1959 TO 1978

COUNTRY/ ISLAND GROUPS	EPIDEMIOLOGY AND CONTROL ¹	VECTOR STUDIES AND/ OR VECTOR CONTROL
AMERICAN SAMOA	Byrd & St Amant, 1959 (72)c,v Iyengar, 1959 c (76)v Iyengar, 1965 (108)v Ciferri <i>et al.</i> , 1966 (112 unpublished) Ciferri & Kessel, 1967 (115)c Hairston & Jachowski, 1968 (121)v Ramalingam, 1968 (125)v Ciferri, 1969 (127)c Kessel <i>et al.</i> , 1970 (131)c Kessel <i>et al.</i> , 1970 a (132)c,v Mahoney & Kessel, 1971 (141) Buck, 1978 (224 unpublished)c,v	Annual Report of the Gov. 1961 (91) Ramalingam & Belkin, 1964 (105) Ramalingam, 1976 (204, 205) Suzuki, 1976 (207 unpublished)
COOK ISLANDS	McCarthy, 1959 (80)v Iyengar, 1965 (108)v	Tamashiro, 1964 (106) Laird, 1967 (117)
Fiji	Burnett, 1960 (84)v, 1960 a (85) Symes, 1960 (90)v Burnett & Mataika, 1964 (101)c Iyengar, 1965 (108)v Mataika <i>et al.</i> , 1971 (142)v Mataika <i>et al.</i> , 1971 a (143)c South & Desowitz, 1971 (144 unpublished)P Desowitz, 1973 (157)P Desowitz & Southgate, 1973 (158)c Desowitz, Southgate & Mataika, 1973 (159)P Southgate, 1973 (164)P Southgate, 1974 (176)P	Burnett, 1959 (71) Burnett, 1960 (84) Burnett & Ash, 1961 (93) Rakai, <i>et al.</i> , 1974 (175) Suzuki, 1977 (219)
FRENCH POLYNESIA	Kessel, 1959 (78 unpublished)c,v Laigret, 1959 (79 unpublished)c,v March <i>et al.</i> , 1960 (89)c Iyengar, 1965 (108)c,v Laigret <i>et al.</i> , 1965 (110)c,v Laigret <i>et al.</i> , 1966 (113)c,v Kessel, 1967 (116)c,v Saugrain & Outin-Fabre, 1969 (128)c,v Galliard, 1971 (136)c Kessel <i>et al.</i> , 1971 (139)c,v Lagraulet & Thooris, 1971 (140)ch,c Lagraulet <i>et al.</i> , 1972 (147)c Lagraulet <i>et al.</i> , 1972 (148)c Moreau & Outin-Fabre, 1972 (149)ch Moreau <i>et al.</i> , 1972 (150)im Outin-Fabre <i>et al.</i> , 1972 (152)c,v Outin-Fabre <i>et al.</i> , 1972 a (238)c,v Lagraulet, J., 1973 (239)c Lagraulet, J. <i>et al.</i> , 1973 (240)c,v Fain, 1975 (184)c,v Merlin <i>et al.</i> , 1976 (199)ch Merlin <i>et al.</i> , 1976 a (245)c,v Pichon <i>et al.</i> , 1976 (201 unpublished) Pichon <i>et al.</i> , 1976 b (203 unpublished)P	Pichon, 1974 (172) Pichon, 1974 a (173) Pichon <i>et al.</i> , 1974 (174) Pichon <i>et al.</i> , 1975 (187) Pichon <i>et al.</i> , 1975 a (188 unpublished) Pichon <i>et al.</i> , 1975 b (189 unpublished) Pichon <i>et al.</i> , 1976 a (202 unpublished)

¹ = Epidemiology includes clinical/parasitological assessment of the filariasis situation.
The entomological and control components as indicated below.

c = Paper includes filariasis control mainly chemotherapy

cl = Paper mainly deals with clinical aspects

ch = Paper mainly deals with drug testing

P = Paper mainly deals with testing of parasitological techniques

v = Paper has a component on vector studies and/or vector control

im = Paper mainly deals with immunology

Table 1 (cont'd)

COUNTRY/ ISLAND GROUPS	EPIDEMIOLOGY AND CONTROL ¹	VECTOR STUDIES AND/ OR VECTOR CONTROL
NIUK	Iyengar, 1965 (108) ^v Maung, 1974 a (169 unpublished)	
SAMOA	Iyengar, 1965 (108) ^v Southgate & Desowitz, 1971 (144 unpublished) ^P Sasa, 1972 (153 unpublished) Thieme & Penaias, 1972 (155) ^{c v} Desowitz & Southgate, 1973 (158) ^c Hairston, 1973 (160 unpublished) ^{c v} Fain, 1975 (184 unpublished) Buck & Zahar, 1975 (180 unpublished) ^{c v} Buck, 1975 (181 unpublished) Bryan & Southgate, 1976 (192) ^{c v} Maung & Penaias, 1976 (198 unpublished) ^c Shibuya, 1977 (218 unpublished) ^{c p} Buck, 1978 (224 unpublished)	Ramalingam & Belkin, 1964 (105) Ramalingam 1976 (204) Suzuki & Maung, 1968 (126 unpublished) Suzuki & Sone, 1974 (177) Suzuki & Sone, 1975 (190) Suzuki, 1976 (207 unpublished) Suzuki & Sone, 1976 (208 unpublished) Suzuki & Sone 1976 a (209 unpublished)
TONGA	Iyengar, 1965 (108) ^v Desowitz, 1973 (157) ^P Desowitz, 1974 (166) ^P Desowitz & Hitchcock, 1974 (167) ^P Buck & Zahar, 1975 (180 unpublished) ^v Desowitz & Una, 1976 (193) ^{im} Desowitz, Berman & Puloka, 1976 (194) ^{im} Self, 1977 (217 unpublished)	Ramalingam & Belkin, 1964 (105) Hitchcock, 1968 (123) Hitchcock, 1970 (130) Hitchcock, 1971 (137) Hitchcock, 1976 (196 unpublished) Ramalingam, 1976 (204)
TUVALU (ELLIICE)	Iyengar, 1965 (108) ^v Maung, 1974 a (169 unpublished)	Suzuki, 1976 (207 unpublished)
WALLIS	Byrd & St Amant, 1959 (72) ^{c v} Rageau & Estienne, 1959 (82 unpublished) ^{c v} Iyengar, 1965 (108) ^v	

After the second MDA, there has been no further mass treatment, except the positives being treated with DEC at 6 mg/kg once a day for 12 days. Follow-up surveys showed an increase of mf rates as follows:

<u>Year</u>	<u>No of persons examined</u>	<u>mf rates, %</u>
1971	14 396	0.8
1973	16 461	1.0
1975	4 530	2.9
1977	7 351	3.7

It was stated that increased migration from other endemic areas in the South Pacific and the decreased public cooperation are the important contributing factors.

From Buck's report (224), the information provided indicated that examination of children born after the MDA has revealed that active transmission of filariasis in the population has been continuing. There was also some indication of DEC drug failures since the 67 cases found positive in 1976 were treated with a total dose of DEC, and 15-22% were found to have persistent microfilaraemia after one year. Buck also indicated that health authorities were anxious to know how to improve the filariasis control programme, what diagnostic technique could be recommended for routine use, and what facilities can be provided for training their health workers. They also wish to see improvement in coordination of surveillance activities in countries of the South Pacific.

2.2 Cook Islands

The report of WHO/SPC Seminar (179) presents the available data on mf rates recorded after MDA in 1968 on Aitutaki Island. In 1969 and 1971, the rates were 0.8% (of 2492 persons examined) and 0.2% (of 2600 persons examined) respectively, a considerable reduction from the original level of more than 30%

A mosquito control programme by environmental sanitation was started in 1946. and mosquito control legislation came into effect in 1949. Only Aedes polynesiensis is the vector.

In 1977, survey on Mitiaro Island of 273 persons revealed an mf rate of 18.3% with an average mf density of 79/60 mm³.

2.3 Fiji

Due to the geography of the country and the population distribution, simultaneous MDA for the entire country has not been feasible. Thus, mass treatment programme was divided into five stages, each of which was implemented in different geographical areas of the country in the following sequence.

Stage I - 1969-1971, Stage II - 1970-1972, Stage III - 1971-1973,
Stage IV - 1972-1974 and Stage V - 1973-1975.

The programme was continued for two years in each of the five geographical areas. DEC dosage was 5 mg/kg weekly for six weeks, then monthly for 22 months, giving a total dose of 140 mg/kg. Post-treatment surveys were confined to the 16-60 age group as they showed the highest mf rate before treatment. There was a dramatic reduction in hospital admissions due to filariasis since the programme started. Post-treatment surveys also showed a decrease in mf rate to about 1% as follows:

- In Stage I, from 17.8% to 1%
- In Stage II, from 10.2% to 0.7%,
- In Stage III, from 15.2% to 1.5%, and
- In Stage IV, from 6.7% to 1%.

These figures were given during the working group meeting in Apia in 1978 (225).

Ae. polynesiensis is important particularly in the smaller islands, and the coastal belt of Viti Levu and Vanua Levu. *Ae. pseudoscutellaris* plays an important role in urban and sub-urban areas and in and around villages and settlements in inland areas. *Ae. fijiensis* is responsible in areas around the Navua River up to Namosi. *Culex quinquefasciatus* is only of minor importance.

2.4 French Polynesia

The report of WHO/SPC Seminar (179) summarized the results of MDA from 1950 to 1972.

It was mentioned during the working group meeting in Apia in 1978 (225) that on the island of Maupiti, nine doses of DEC at 6 mg/kg were distributed to more than 90% of the total population of about 600 persons in 1974-1977 (3 doses/year). The mf rate dropped from 5% to 0.3%, and the mf density from 30 to 6/20 mm³. During the same period, an average of 2-1/2 doses of DEC was distributed on the island of Tahiti. In 1977, the mf rate dropped from 4.4% to 2.1% and mf density from 21.4 to 13.4/20 mm³ (of 19 789 rural community residents examined before this treatment and 34 393 residents after this treatment). The island of Moorea has approximately 6000 inhabitants, and had heavy drug treatment schedules for many years. In 1974, there remained an mf rate of 1.6% with an average mf density of 8/20 mm³. Seven doses were distributed (one dose about every 5 months) until 1977 when it revealed an mf rate of 0.5% with an average mf density of 11.6/20 mm³.

Buck, 1978 (224) collected information during his visit to Papeete which indicated that in 1977 the crude mf rate on the islands was 1.5% using 2 x 40 mm³ of blood from finger prick. He indicated that the decrease from 4% in 1974 to the above rate recorded recently was achieved by annual mass treatment of the entire population with a single dose of DEC. In contrast, the prevalence of microfilaraemia is still higher in the population of Marquesas island group where corresponding residual mf rates were 13-15% in 1974 and 5% in 1977. Population coverage by mass treatment was, on an average, 75%. He remarked that the newly adopted strategy of one week single dose treatment of the entire population of the islands as compared with the previous practice of treating only the known carriers, has yielded satisfactory results. In addition to the stated decrease in prevalence of infection, new cases of elephantiasis have disappeared and there has been a decrease in prevalence of filarial fever, lymphangitis and hydrocele.

2.5 Niue

MDA was started in mid-1972. DEC was given at 6 mg/kg once a week for 12 weeks followed by once a month for 12 months. Pre-treatment surveys of 4408 persons revealed an mf rate of 16.3% with an average mf density per carrier of 30.6/20 mm³. Overall elephantiasis rate was 0.4%. The vector is Ae. cooki. The above information is based on the report of WHO/SPC Seminar (179) and of Maung (169).

2.6 Samoa (formerly called Western Samoa)

A WHO/UNICEF supported pilot project was carried out from 1965. The first round of MDA with DEC at 5 mg/kg, once a week for six weeks followed by once a month for 12 months (a total of 18 doses) was undertaken in 1965 - 1966. The second round was completed in the year of 1971, with DEC at 6 mg/kg, once a month for 12 months. The mf rate dropped from 19.1% to less than 1%. No vector control was applied.

Detailed results of parasitological evaluation are given by Maung & Penaia, 1976 (198), and entomological evaluation by Suzuki 1976 (207). The mf rates recorded in 1974, 1975 and 1976 were 0.33%, 2.12% and 1.43% respectively, with a mean mf density of 41.79 per positive and 0.88 per person examined in 1975, and 30.95 per positive and 0.46 per person examined in 1976. During 1972-1975, of 2513 Ae. polynesiensis dissected, the infective rate was 0.12%.

However, since the mf rate has increased considerably after the completion of each round of MDA, it is not possible to undertake further rounds of mass treatment. The WHO/Samoa filariasis research project was therefore started in the latter part of 1977 to determine the true rate of infection, the dynamics of transmission at present low level of microfilaraemia, and alternative feasible control measures. Details of the priorities for the research project are given in Buck's report (181).

The Japanese Overseas Cooperative Volunteers provided the Government of Samoa with equipment and supplies and assigned field staff to assist the project. Technical cooperation was also given by the United States Peace Corps.

Preliminary results obtained so far by the research project are briefly given below:

There was evidence of active transmission taking place in certain areas at a high rate as shown by the mf rate of 5.7% detected by Nuclepore technique, and as indicated by children of the five-year-old age group (born after the second MDA) found positive (one showed an mf count of 2272 per ml of blood), Shibuya (218). It may be mentioned that the rate found by the finger-prick method was only slightly lower than that by the Nuclepore methods.

Shibuya (218) recommended that a total population blood survey in a systematically random sample of villages, stratified according to the geographical location, population density and previously determined mf rates, is necessary to determine the real prevalence of the filaria infection in Samoa using the Nuclepore and blood film methods. It was also recommended that studies should be undertaken on the role of the low density microfilaraemia, both epidemiologically and entomologically. The importance of recording the drug taking was stressed in order to ascertain drug failures. Statistical analysis of the available data should provide the basis for developing a control strategy. Blood surveillance should cover all the villages of Samoa within a period of three years.

Studies have been carried out with laboratory-bred Ae. polynesiensis by artificial infection with mf carriers at different levels of mf density. A very low carrier with 8-14 mf per ml of blood infected 5.2% of the mosquites. All the infected mosquitos harboured only a single infective larva.

2.7 Tonga

The nationwide control programme consisted of MDA and vector control by environmental sanitation and health education.

During the working group in Apia in 1978 (225), it was mentioned that the drug distribution commenced in May 1977 at a dosage of 6 mg/kg. The first 12 doses were given at weekly intervals followed by 12 consecutive monthly doses.

The mf rate revealed that the pre-treatment surveys of 10% of the population by the conventional method (60 mm^3 of blood) was 17.1%. The rate was reduced to 1.8% after 12 weekly doses as shown in the four indicated villages. After his visit, Self, 1977 (217) reported that just prior to the MDA the mf rate recorded was 20.4% in males and 14.2% in females. The prevalence of hydrocele and elephantiasis was 2.4% and 0.39% respectively. Two months before the MDA, the infection rate of Ae. tabu (129 mosquitos dissected) was 2.3% and the infective rate was 0.78%. Three months after the MDA the mf rate was 1.6% and 0.84% for the males and females respectively. During the period of six months after MDA started, only one out of 899 Ae. tabu dissected was found with an infective larva (in June 1977).

2.8 Tuvalu (formerly called Ellice)

On the eight islands of Tuvalu, filariasis constitutes a major public health problem as mentioned in the report of the WHO/SPC seminar (179). The MDA started in 1972 seemed to have reduced the mf rate considerably as indicated from a preliminary post-treatment survey showing an 8% positive as compared with pre-treatment mf rate of 14.7%. Maung, 1974 (169) gave detailed results of pre-treatment surveys during the period 1972-1973, as well as results of post-treatment surveys. Entomological data are given by Suzuki, 1976 (207), indicating that no infected Ae. polynesiensis was found in 444 mosquitos dissected in February 1974.

(Remark: Based on the book "World Population 1977" (ISP-WP-77) by U.S. Department of Commerce, 1978, Tuvalu belongs to Micronesia. It has been included in the present review because of the occurrence of the same form of filariasis - subperiodic W. bancrofti, and the same vector species Ae. polynesiensis. Iyengar, 1965 (108) divided the South Pacific into four epidemiological zones, one of which is Polynesia including Tuvalu.)

2.9 Wallis and Futuna

There is a paucity of information from Wallis and Futuna Islands since no report can be traced after those shown in Table 1.

Conclusions:

From the above review of country information of the filariasis situation it is clear that reporting is not adequate from certain island groups, such as Cook, Tuvalu, Niue and Wallis. As for the other countries and island groups, it seems that after an active period of technical publications during the 1960's and 1970's, there has been a decline in the flow of published information from certain island groups. The most recent information has been collected through the assignment report of staff members or consultants of WHO. This situation creates a gap in knowledge on how the progress of filariasis control campaigns is proceeding. A system of reporting and dissemination of information needs to be established in order to ensure coordination of efforts for which WHO can play an important role. The great need of the exchange of information was emphasized during the filariasis meetings in Apia in 1974 (179) and in 1978 (225).

TABLE 2

ESTIMATED POPULATION FOR THE COUNTRY/ISLAND GROUPS UNDER REVIEW FOR 1978

(Following estimates are based on best available figures)

Country/Area	Population in Thousands
American Samoa	30
Cook Islands	19
Fiji	603
French Polynesia	142
Niue	4
Samoa	156
Tokelau	2
Tonga	93
Tuvalu	8
Wallis and Futuna	10

SECTION II - EPIDEMIOLOGY

1. Vector studies

1.1 Taxonomy and genetics

In the bibliography several important papers on taxonomy and identification of vectors of subperiodic filariasis in the South Pacific with special reference to Polynesia are cited, giving the highlights of their contents. This will only serve as a guide since it is obvious that for taxonomic and identification problems the original publication should be consulted. The most important early references are those of Marks, 1951 (27) naming Ae. (Stegomyia) polynesiensis and separating it from Ae. (S.) pseudoscutellaris and 1954 (47) making a complete review of the Aedes scutellaris group. Difficulties in reliable identification of the two species were expressed by Symes, 1960 (90) and subsequently by Burnett, 1960 (85) who had to treat them as a single problem when considering their infection rates or response to control measures.

As mentioned earlier, the book of Belkin, 1962 (97) remains the most important reference for the systematics of mosquitos of the South Pacific. There have been records of new species and revision of the description of certain species in the area of Polynesia. Thus Ae. (S.) tabu occurring in Tonga and Ae. (Finlaya) tutuilae in American and Western Samoa were described as new species, Ramalingam & Belkin, 1965 (111); Ae. (S.) tongae which was initially recorded from Ha'api group of islands in Tonga in 1925 was redescribed by Huang, 1972 (46); and Ae. pseudoscutellaris, the highly variable species occurring only in Fiji, was redescribed by Huang, 1975 (185) who gave the diagnostic morphological characters to differentiate it from Ae. polynesiensis.

Systematic specialists, however, became more concerned about the taxonomic problems related to the identification of several members of the Aedes scutellaris group in Tonga-Samoa area. Thus Huang & Rozeboom, 1971 (138) drafted a plan for a research project in the South Pacific. A WHO project was implemented during 1971-75 in the Kingdom of Tonga for collecting material of members of the Ae. scutellaris group for taxonomic studies with observations on their bionomics on the basis of recommendations made by a specialist group that met in Geneva in 1971, WHO, 1972 (145). While the results of these studies undertaken by the Smithsonian Institution, Washington, USA, are awaited, Hitchcock, 1976 (196) prepared an interim report giving the highlights of the preliminary new taxonomic findings and species distribution records from the Tonga areas and some other islands. Of his tentative findings, is the collection of two unnamed species: Ae. (S.) sp. "Tafahi" from Niuatopatapu and Tafahi islands in Tonga and Ae. (S.) sp. "Wallis form" from Uvea, Wallis Islands, the clarification of the taxonomic status of which is awaited.

Of the recent keys for identification is that of Ramalingam, 1976 (204) which covers the adults, pupae and larvae of mosquitos of Samoas and Tonga. In this publication, the author gave notes on the bionomics of species of Stegomyia and Finlaya and of other genera. Of the Ae. (Finlaya) kochi group the same author gave a description of the immature stages of Ae. samoanus, Ramalingam, 1976 (205). In this publication he also reviewed the status of Toxorhynchites.

As field workers were experiencing difficulties in the identification of culicine mosquitos including vectors of filariasis and dengue fever in Polynesia, at the request of the WHO Regional Office for the Western Pacific, the Smithsonian Institution prepared a pictorial key which would be helpful in improving the identification of these mosquitos, Huang, 1977 (213).

The problem of correct identification of members of the Ae. scutellaris group based on morphological characters, however, remained prominent. Thus, resort was made to more advanced techniques. Although cytogenetic techniques have been a useful tool in identifying certain members of anopheline sibling species such as the Anopheles gambiae complex, attempts to apply these techniques on culicines have been hampered by the difficulty in getting good spreading of the polytene chromosomes. As some recent attempts have been successful with certain culicine species as reviewed by White, Coluzzi & Zahar, 1975¹, an investigation was started in the Liverpool School of Tropical Medicine to determine the possibility of using Giemsa (C-banding technique) on members of the Ae. scutellaris group. The early findings have been reported by Rooney, 1977 (216). Further attempts have been started to utilize the electron microscopy for comparative scanning of eggs of members of the Ae. scutellaris groups, Tompkins & Williams, 1977 (220). At the same time, WHO supported investigations on the application of gene-enzyme studies on members of the Ae. scutellaris group simultaneously at Liverpool School and the John Hopkins University, School of Public Health. The early findings have been reported from Liverpool School by Townson, Meredith & Thomas, 1977 (221) which showed promising results with main esterase enzyme system for differentiating several members of the Ae. scutellaris group including Ae. polynesiensis and Ae. pseudoscutellaris from Fiji.

On the genetic aspect, the John Hopkins School of Public Health has for a long time been conducting crossing experiments with members of the Ae. scutellaris group for investigating their compatibility and the mode of inheritance of autogeny, Hitchcock & Rozeboom, 1973 (161); Hoyer & Rozeboom, 1976 (197).

In the Liverpool School, crossing experiments have also been conducted for compatibility studies in members of the Ae. scutellaris group, Wade & Macdonald, 1977 (222), as well as on the mode of inheritance in refractory species to filarial infection, namely Ae. malayensis and susceptible Ae. polynesiensis and other species, together with an investigation on the microfilaria migration pattern in both the susceptible and refractory members of the group, Owen, 1977 (214). The main aim of these genetic studies is to define the genetic factors in mosquitos which control the susceptibility of filarial infections and the long term hope that these refractory factors can be transferred into a susceptible vector species. If successful, it may be possible to attempt to replace a vector by a refractory species which would have similar characteristics except for its lack of susceptibility to filarial infections. This investigation was hampered by the presence of rickettsia-like microorganisms in members of the

¹White, G.B., Colluzzi, M. & Zahar, A.R. (1975) Review of cytogenetic studies on anopheline vectors of malaria. Unpublished document WHO/VBC/75.538; WHO/MAL/75.849

Ae. scutellaris group apparently causing incompatibility barriers. Thus attempts have been made to remove these organisms by the use of antibiotics so that successful backcrosses can be made to the susceptible species. The presence of these organisms have been detected by the electron microscopes, Beckett, Boothroyd & Macdonald, 1977 (210).

Conclusions:

It is clear the genetic studies are of long term nature, but the taxonomic studies are of immediate concern to field workers. It is hoped that with the forthcoming publication on the Ae. scutellaris group in Tonga and other islands, and with the available keys to this and other species groups that the morphological identification will be improved and consequently make vector studies more precise and meaningful. Identification based on cytogenetic or by gene-enzyme systems, if eventually successful, would add more precision and may even reveal the presence of subpopulations within species which may have a more important role in disease transmission.

1.2 Mosquito dissection methods and identification of filarial parasites

Several authors described the method of dissecting mosquitos for either experimental infection studies or for determination of natural infection rates in wild caught specimens. All the methods are more or less similar. The only points that may be worth emphasizing are those related to the processing of the specimens and identification of filarial parasites.

Rosen, 1955 (56) stated that mosquitos were dissected within 48 hours from capture and referred to his paper, 1954 (49) for the criteria of differentiating between the larvae of W. bancrofti and Dirofilaria immitis. Bonnet *et al.*, 1956 (58) indicated that mosquitos collected in the morning were dissected in the afternoon and if the number of mosquitos from a capture station was 10 or less all specimens were dissected. If more than 10, a random selection of 10 mosquitos was made. The limitation of the numbers aimed at completing the dissections within a reasonable period of time and to avoid that large numbers from a few capture stations would not unduly "weight" the results. The separation of the developing larvae of D. immitis was based on their presence in the malpighian tubes and the third stage larvae on the basis of a single caudal papilla rather than 3 as in W. bancrofti. Ramalingam, 1968 (125) working in Samoa and Tonga similarly limited the number of mosquitos dissected to 10 and gave similar criteria for differentiating the larvae of the two parasites but added the length for the infective stage larvae. Byrd & St Amant, 1959 (72) dissected the body of the mosquito in Locke solution on a glass slide. Positive mosquitos were fixed in Schaudinn's solution, stained and mounted. Nelson, 1959 (81) working in East Africa used a fixative for freshly dissected infective stage larvae and examined them in a hanging drop-like device. As he found that dissection of mosquitos in the field was often difficult he utilized a method for preservation and staining of mosquitos which enabled dissections to be made at ease in the laboratory and also clearly showed all the characters of the larvae at their exact position in the mosquito. He also gave the important criteria as being the length of the larva giving the factors that could produce its variability, the shape of caudal extremity and the "anal ratio" and developed a key for differentiating the infective larvae of W. bancrofti from the larvae of animal parasites.

Symes, 1960 (90) made a survey of filarial parasites in mammals and birds and described the position of developing larvae of D. immitis and those of the fruit bat in the mosquito and also gave the criteria for differentiating the infective larvae of these filariae from that of W. bancrofti as being the length, "anal ratio" and caudal papillae.

However, he concluded that neither bird nor cattle filariae are likely to cause confusion in results of mosquito dissection. Burnett, 1960 (85), based on initial results of mass DEC treatment trial, stated that under drug treatment the human parasite disappeared (this is perhaps from early trials) from mosquitos, and it was only D. immitis larvae which remained to be seen, and excluded the possibility of the presence of other animal or bird filariae. Both Symes and Burnett made a distinction between 3rd and mature larvae on the basis of locating the latter in the proboscis, and indicated that if 3rd stage and mature larvae were found in the same mosquito, infection was considered mature, otherwise separate records were given to the two stages. This is in contrast to Nelson, cited above, who quoted observations of previous workers indicating that 3rd stage larvae move rapidly from the abdomen and the proboscis when the mosquito starts feeding. Thus he pointed out that 3rd stage larvae should be considered mature whether they are found in the proboscis or elsewhere in the mosquito. Rakai *et al.*, 1974 (175) working in Fiji followed the same definition as that of Nelson. Suzuki, 1977 (219), similar to Nelson, fixed wild caught and experimentally infected Ae. polynesiensis with alcohol/glycerine mixture but used Azur II for staining instead of Meyer's acid haemalum.

Nothing has been reported on the assessment of the technique of mass separation of 3rd stage larvae from mosquitos under field conditions in Polynesia, Muller & Denham, 1974 (171). As yet no reports are available in the recently planned investigations to take place in Western Samoa and Tonga, Self, 1977 (217).

Conclusions:

With the availability of fixation and staining technique, field workers should be encouraged to adopt this procedure so that the large number of vectors captured can be preserved for dissection when time is available instead of limiting the dissection to a small sample to be selected at "random" which may entail unintended bias.

Although authoritative criteria have been laid down for differentiating W. bancrofti from animal filariae D. immitis, it would be necessary to encourage new workers to avail themselves of the facilities rendered by the WHO Reference Centre in the London School of Hygiene and Tropical Medicine, when identifications are doubted, vide Suzuki, 1976 (207). Such doubtful results can cause great confusion in assessing the impact of control measures on vector infections, let alone the consequence in quantitative approaches.

The mass separation of 3rd stage larvae deserves rigorous assessment versus the conventional technique of dissection in the field as it would save a great deal of time and effort particularly in advanced stages of a control programme. Indeed, its result cannot then be compared with the level of infective rates which have been previously recorded by the conventional technique nor could it lead to a calculation of an index for the infective bites per year. However, some approach should be developed for the epidemiological interpretation of an index to be derived from the results.

1.3 Laboratory rearing

A lot of information has been provided on raising colonies either for bionomics studies or for experimental infection investigations or for genetic and taxonomic studies involving vectors and suspected vectors of subperiodic *W. bancrofti* in South Pacific, viz: for bionomics, Jachowski, 1954 (46); Ingram, 1954 (42); for taxonomy, Marks, 1954 (47); Belkin, 1962 (97); for genetics, Hitchcock & Rozeboom, 1973 (161); Hoyer & Rozeboom, 1976 (197); and for experimental infection, Rosen, 1955 (56); Ramalingam, 1968 (125); Hitchcock, 1971 (137); Pichon *et al.*, 1975 (188); Bryan & Southgate, 1976 (192).

Conclusions:

Workers interested in raising laboratory colonies can find in the above references sufficient material according to the objectives of the work desired. A few points, however, may be of interest to those who are in charge or initiating laboratory colonization. First, Burnett, 1960 (85) remarked that a colony of *Ae. pseudoscutellaris* was much more readily colonized in the laboratory than *Ae. polynesiensis* for which the addition of sea water did not enhance its oviposition unlike the findings of Bonnet & Chapman, 1958 (70). In this connection, Ingram (*loc. cit.*) found that 4th instar larvae and pupae could develop normally in 1.5% saline solution.

Secondly, a warning was made by Bonnet & Mukaida (63) on a predacious cyclops on mosquitos and *Toxorhynchites* cultures.

Thirdly, the difficulties encountered in raising vigorous females of the *Aedes kochi* group in laboratory colonies as experienced by Ramalingam (*loc. cit.*) may be subjected to investigation.

1.4 Studies on life cycle, gonotrophic cycle and longevity of vectors

1.4.1 Life cycle

Information on the effect of environmental conditions and the duration of immature stages is only available from experimental observations in the laboratory. The pioneer work of Buxton & Hopkins, 1927 (6) involved extensive observations on *Ae. polynesiensis* in comparison with *Ae. aegypti* regarding egg resistance to desiccation, larval ecology and factors influencing oviposition. Since then, it does not seem that there had been further studies until Jachowski's publication, 1954 (46) on his field observations of 1948 - 1950 supplemented by some laboratory studies on *Ae. polynesiensis* on feeding and oviposition habits, duration of the immature stages and adult gonotrophic cycle and longevity under controlled temperature and humidity conditions. From these studies, a mean of 6.9 days was given for the life span and the mean of 9.4 days was given for the period from eclosion until the female mosquitos emerged. The work of Jachowski on *Ae. polynesiensis* was pursued by Ingram, 1954 (42) who intensified observations on factors affecting egg hatching, the effect of drying and salinity on larval and pupal development and survival, as well as on the duration of the gonotrophic cycle and longevity. All his experiments were carried out under controlled temperature and humidity conditions. In his observations egg hatching took about 5-8 days but much less when eggs were placed in a medium of low oxygen content. Ingram's

data on duration of larval and pupal stages were close to those of Jachowski, both working under nearly the same laboratory conditions. These may be compared with those of Symes, 1960 (90) working in Fiji at normal room temperature who gave a mean duration of 3.2 days, 11 days and 2 days for egg hatching, larval and pupal stage respectively for Ae. polynesiensis. Symes also gave nearly similar records for Ae. pseudoscutellaris but longer larval developmental period for Culex quinquefasciatus (used to be called Culex pipiens fatigans).

1.4.2 Duration of the gonotrophic cycle

The only source of information on the duration of the gonotrophic cycle covering the period from one blood meal to the next is the two laboratory observations of Jachowski and Ingram, cited above, and two papers giving the results of field observations on Ae. polynesiensis. Experiments by Suzuki, 1977 (219) who tried mark/release and recapture method and also utilized the distribution of infection in different ages of mosquitos. Both observations of Jachowski and Ingram gave the same period, 7 days, for the duration of feeding cycle of Ae. polynesiensis, but differed in the detail. While Ingram showed that mosquitos took four days for the blood digestion - oviposition phase, he stated that mosquitos did not feed until three days after oviposition. This is despite the fact that he was offering them a blood source every day and the reason for this remains inexplicable, although Suzuki (loc. cit.) thought that the behaviour of mosquitos in captivity may be different form that of the natural populations in the field. On the other hand, Jachowski seemed to have given a period of seven days without any indication of period of rest after oviposition. The only possible explanation for that prolonged duration could be the effect of sugar feeding delaying oviposition, a phenomenon for which evidence was provided by De Meillon, Sebastian & Khan, 1967¹. Byrd & St Amant, 1959 (72) working in American Samoa on infection rates and survival of Ae. polynesiensis noted that a few mosquitos harboured larvae of W. bancrofti in different stages of development. From the examination of the ages of these larvae according to their classification, they inferred that a period of 3-4 days was the most frequent interval between feeding times in Ae. polynesiensis under field conditions as judged by the age of successively acquired filarial parasites. Thus both the finds of Suzuki and of Byrd & St Amant are in agreement.

1.4.3 Vector longevity

Jachowski (46) and Ingram (42) reported their findings on longevity of Ae. polynesiensis but only from laboratory observations, the former showing that the mean survival for the adult females was 21.2 days at a temperature of 26.7°C and high relative humidity and the latter indicating that 50% of the females survived for 50, 32 and 17 days with temperature of 21.1°C, 26.7°C and 32.2°C. Ingram also reported that some adults survived 100 days. However, such laboratory findings may only serve as a guide but they will never represent the happenings in nature with the daily fluctuation in environmental conditions.

¹De Meillon, B., Sebastian, A. & Khan, Z.H. (1967) Cane-sugar feeding in Culex pipiens fatigans. Bull. Wld Hlth Org., 36, 53-65

An intensive investigation was carried out by Byrd & St Amant, 1959 (72) in American Samoa during 1943-1944. These authors carried out a determination of the infection and infective rates in Ae. polynesiensis in wild caught mosquitos and experimentally infected mosquitos in the laboratory. They made inference from the ratio of the infective rate and infection rate to determine the survival rate. The monthly dissection data were presented in detail and the authors discussed the influence of rainfall on the density and infection rates. Using the data of the authors we have calculated the probability of the survival (p) using the method adopted by Lawrence (1963)¹ and Samarawickrema (1967)². The results showed that during the season of little rain when cooler weather prevails the probability of daily survival was around 90%, i.e., 10% mortality on the assumption that the period of development of the parasite to the infective stage (n) was 14 days as indicated by the authors and during the hotter season with high rainfall and relative humidity the probability of survival was around 80%, i.e., 20% mortality. Assuming that (n) is 10 days as the authors postulated, Burnett, 1960 (85) has, as in the case of Byrd & St Amant, cited above, utilized the data of the infection and infective rates for determination of the survival of Ae. polynesiensis and pseudoscutellaris combined, Ae. fijiensis and C. quinquefasciatus. In his estimation he utilized the data shown in Table 1 of Macdonald (1957)³ to derive the probability of daily survival. Two types of estimates were made by the author; the first was by utilizing the data of the proportion of infected mosquitos with all stages including the microfilaria stage to the third stage/mature (infective) larvae and the proportion of mosquitos with the infective stage larvae. The second was by using the data of the proportion of infected mosquitos with the first to the third stage/mature larvae and the proportion of mosquitos with the infective stage larvae. We have checked the calculation of these estimates and found no discrepancy except in the case of the estimate made on the basis of the number of mosquitos harbouring infection from the first to the infective stage. Thus, the author estimated for Ae. polynesiensis and pseudoscutellaris combined 21% daily mortality while our estimate is of the order of 16%. The other discrepancy was concerning Ae. fijiensis where the author gave daily mortality of 22.5% while our estimate shows about 16%. The reason for discrepancy could not be traced. It is not quite clear whether the author derived his estimates from interpolation of data in Macdonald's book.

Suzuki (personal communication 1977) stated that he estimated the parous rate in Ae. polynesiensis in Western Samoa as 40%. His publication has not so far appeared. The only published report which gave the results of age grouping of the population of a member of the Ae. scutellaris group by applying Polovodova's technique (in Detinova, 1962)⁴ was that of Hitchcock, 1970 (130). In this report he correlated the infection and infective rates in different classes of parous mosquitos. It is interesting to note that in 1-parous mosquitos 3.95% were infected with all larval stages of W. bancrofti, this was also observed in C. quinquefasciatus by Self et al., 1977 (unpublished report to WHO) in

¹Lawrence, B.R. (1963) Bull. Wld Hlth Org., 28, 229-234

²Samarawickrema, W.A. (1967) Bull. Wld Hlth Org., 37, 117-137

³Macdonald, G. (1957) The epidemiology and control of malaria. Oxford University Press, London

⁴Detinova, T.S. (1962) Age-grouping methods in diptera of medical importance. WHO Monograph Series No. 47

Jakarta, Indonesia who found 3 nulliparous mosquitos with all stage larvae. Also Samarawickrema (loc. cit.) in Sri Lanka found the long "sausage" stage larvae in nulliparous and infective stage larvae in a 1-parous mosquito. This author tried to explain the reason for the young mosquitos to become infected with advanced stage larvae as possibly being due to their taking insufficient blood meals or to the pre-gravid state as reported by Gillies (1954)¹ in A. gambiae in Africa.

Conclusions:

From the above review it is quite clear that there is a paucity in knowledge with regard to two important parameters that are of epidemiological significance, namely the duration of the gonotrophic cycle and longevity, in spite of the recommendations made by the WHO Expert Committees on Filariasis. Thus, priority should be given to determination of these two parameters and the local staff should be trained to carry out reliably the age grouping technique, at least the technique of Detinova by the ovarian tracheoles for the determination of the parous rate. In the study of the gonotrophic cycle, it is important to investigate whether nulliparous females of the vectors take repetitive blood meals to lay their first batch of eggs, and to determine the proportion of these females in vector populations in nature.

Also mark/release and recapture methods, as in the preliminary experiments of Suzuki (219), should give the answer to the determination of the duration of the gonotrophic cycle as well as on vector longevity. These investigations should cover not only one vector, but all major vectors of filariasis in different islands of the South Pacific and be carried out in different seasons.

Life cycle studies in the laboratory are useful but, as mentioned earlier, they serve only as a guide and field observations are highly desirable.

1.5 Breeding habitats

Many papers and reports have covered the breeding habitats of vectors of filariasis in the South Pacific, however, reference will only be made here to some of the key publications on this subject.

Buxton & Hopkins (7) as mentioned above, carried out a great deal of experimental work on the immature stages, as well as on the oviposition behaviour of the mosquito adults of different Aedes mosquitos including Ae. polynesiensis in Apia, Samoa; observations were also made in the natural habitat. This work is quite extensive and it was unrealistic to abstract it. The full reference should be consulted whenever an investigator wishes to study the influence of one of the environmental, physical or chemical factors on breeding and oviposition of the vector.

¹Gillies, M.T. (1954) The recognition of age-groups within populations of Anopheles gambiae by the pre-gravid rate and the sporozoite rate. Ann. trop. Med. Parasit., 48, 58-74

Bonnet & Chapman, 1956 (57) made elaborate investigations in Tahiti to determine quantitatively the importance of different types of trees, counting the tree holes and recording those which contained larvae of Ae. polynesiensis. Their survey showed that the most important species of trees from the point of view of breeding of Ae. polynesiensis was the breadfruit (Artocarpus incisa). Methods of control were reported by the authors and this will be shown later under "vector control". Edgar & Bambridge, 1951 (22) made an estimate of the rat damaged coconut as constituting 50% of all breeding sites of Ae. polynesiensis in Tahiti, they also gave an estimate for the reduction in breeding by bandaging the coconut trees. Jachowski (46) in American Samoa, and Rageau & Estienne, 1951 (82) working in Wallis enumerated the breeding places of Ae. polynesiensis as being coconut shells, rat-eaten coconuts, tree holes, tins and other water storing containers. The latter authors indicated that larvae may survive for a long time in water deprived of nutritional material but they cannot tolerate water salinity above 1%. Bonnet & Chapman, 1958 (70) made a very useful review on the types of breeding habitat of Ae. polynesiensis in Tahiti and suggested certain control measures that would be suitable for each type. In addition the authors pointed out that many lists have been compiled showing the types of breeding places but no allowance has been made for the quantitative differences in the productivity of each type such as the comparison of a medium-sized tree hole with the production of several hundred rat-eaten coconuts. In this connexion they stressed the importance of determining the productivity whether continuous throughout the season or only temporary. They considered that the most important sources of Ae. polynesiensis in Tahiti are the permanent natural breeding containers including tree holes, rock holes and crab holes and that all these serve to maintain mosquito populations through the dry season and act as "mother foci" from which temporary containers can be infested.

Byrd & St Amant (72) described the breeding places of Ae. polynesiensis in Wallis and Ellice Islands as well as in the Samoas as being discarded tin cans, coconut shells, tree holes and rainwater containers, viz. barrels, troughs and cisterns. These were located in and around villages in shaded places. They stated that Ae. polynesiensis was rarely observed breeding in open containers in direct sunlight. In Funafuti, Ellice Islands, because of the acute water shortage, the inhabitants kept several thousand steel drums for water storage and hundreds of these were found breeding mosquitos. This type of breeding place was considered in excess of all other for the Aedes mosquito on that island.

In Fiji, Symes, 1960 (90) made larval surveys covering the breeding places of Ae. pseudoscutellaris and Ae. polynesiensis and Ae. fijiensis and C. quinquefasciatus. In addition to the well known breeding places of the first two species, he found that both were breeding in cut bamboo. As for Ae. fijiensis the author gave the type of species of Pandanus plants which is favoured for its breeding, namely P. tectorius and P. joskei, but the small type of pandanus was used less frequently. Other leaf axil plants, such as taros (Alocasia indica) were thought to be favoured by Ae. fijiensis if the large pandanus plants were removed as a control measure. No information was added to the commonly known breeding places of C. quinquefasciatus. Symes made a very interesting description of crab holes and the method he devised for sampling Ae. polynesiensis and Ae. pseudoscutellaris from this type of breeding place. In Fiji too,

Burnett, 1960 (85) who pursued the work of Symes, gave an account of his observation on Ae. polynesiensis and Ae. pseudoscutellaris which are nearly similar to those described by Symes. Ae. fijiensis, he specified that it did not utilise P. thurstonii in coastal areas to any extent but did so abundantly inland. Iyengar, 1965 (108) reviewed the types of breeding places of vectors of filariasis in different islands and island groups in the South Pacific including Polynesia.

In American Samoa, Western Samoa and Tonga, Ramalingam, 1968 (125) described the type of breeding places of Ae. polynesiensis, Ae. upolensis, Ae. samoanus, Ae. tutuilae, Ae. tabu and C. quinquefasciatus. It may be useful only to cite here a few notes on the breeding habits of Ae. upolensis which has a restricted distribution in the Samoan islands. The author indicated that the immature stages of this species were obtained in only two collections, both at the edge of the rain forest. One of the breeding sites was a deep longitudinal depression in a fallen tree trunk and the other in a fern tree stump, in the type locality in Upolu island. With regard to Ae. samoanus it was never found breeding in leaf axils of taro and pandanus and it was found only once in leaf axils in American Samoa. In Western Samoa heavy breeding of this species was found in the leaf axils of Freycinetia sp. as well as in pandanus.

In Western Samoa Hairston, 1973 (160) made a very useful survey to determine the relative importance of different types of breeding places occurring in five villages. Thus, he conducted several transect inspections across villages, each transect was 5 m wide, starting from the sea or from the centre of the village and proceeding in a straight line to a point of 100 m. He showed that tins constituted 60.4% of the breeding places and tree holes 22%. The object of this survey was to estimate the work load and cost of eliminating breeding places within 100 m around the villages. Hairston also made useful observations on the configuration of crab holes breeding Ae. polynesiensis. Also in Western Samoa Suzuki & Sone, 1976 (208) made a comprehensive survey for the breeding habits and distribution of mosquitos of Stegomyia and Finlaya. They provided data for the distribution of larvae of different species in various types of breeding places found positive but they did not give an estimate of how many breeding places were examined of each type in the localities surveyed. Apart from the well known types of breeding of Ae. polynesiensis the authors stressed that the density of this species was extremely high in the coastal areas where crab holes are numerous. Unlike the Stegomyia species, the Ae. upolensis larvae were rarely collected since the main survey was made close to human activities while this mosquito is considered a forest species. The authors reported the type of plants with leaf axils which provide breeding for Ae. samoanus and Ae. tutuilae. With regard to Ae. oceanicus the authors indicated that it breeds in taro, pandanus and pineapple plants, the first being the most important breeding site.

Regarding Tonga, the main source of information comes from the report of Hitchcock, 1976 (196) describing the type of breeding places of members of the Ae. scutellaris group which he recorded from different islands. The most recent information came from the report of Self, 1977 (217) on his visit to Tonga where he gave a brief description of the types of breeding places. He stated that the larvae of Ae. tabu were found in the leaf axils of pandanus and also the leaf axils of two main root crops: taro (Colocasia) and small kape (Alocasia). It is worth noting here that the use of ovitraps may offer a tool for locating the oviposition sites with a

view to the utilization of attractants and insecticides to kill the ovipositing females. From the work of Rozeboom, Rosen & Ikeda, 1973 (163) who conducted observations by ovitraps for Ae. albopictus and Ae. polynesiensis, it was shown that the females seldom laid all their mature eggs in single oviposition and instead they appeared to move from one trap to another, leaving behind each time only a few of the eggs which they were able to oviposit. Self, cited above, stated that observations are being conducted with ovitraps in Tonga. Much earlier Buxton & Hopkins, 1927 (6) suggested the use of ovitraps as a means of control.

Conclusions:

From the above review it seems that there is a wealth of information on the types of natural and artificial breeding places of vectors of filariasis in Polynesia but given in a very descriptive way. Few papers dealt with the quantitative aspects and therefore, from the point of view of planning larval control measures on a sound basis, well planned surveys of breeding places should be conducted aimed at determining their importance by ranking them as suggested by Bonnet & Chapman (70) on the basis of: relative abundance; volume of water; productivity, whether permanent or seasonal and the effect of rainfall; and proximity from human habitation or places where people gather. Another important aspect which has not been clearly shown is the larval sampling methods. Therefore, attempts should be made to develop standardized procedures for larval sampling in order to provide suitable indices from the surveys of breeding places for comparative studies.

1.6 Host preference

Although many authors have remarked on the host preference of Ae. polynesiensis they were mainly descriptive and not supported by data. Thus Ingram (42) and Jachowski (46) stated that, in laboratory observations Ae. polynesiensis was feeding on any type of animal that was provided as a source of food. The latter author tried to collect blood-fed mosquitos from their resting places but did not succeed. However, from casual observations, he indicated that Ae. polynesiensis was found feeding on a horse and on pigs, and also on dogs as evidenced by the findings of all larval stages of D. immitis in this mosquito in nature. He assumed that, if more than one host is available, man is preferred.

McCarthy, 1959 (80) tried to explain that the voraciousness and persistance of Ae. polynesiensis attacks in uninhabited islets were due to its urgency for a blood meal. He postulated that the mere presence of a large number of this species may indicate that a sufficient blood source was available for its existence. He excluded the possibility of autogeny and thought that some type of animals may provide sufficient food and keep the population reproducing. Indirect evidence was also given by the absence of this vector from uninhabited islets and suggested that an investigation of the survival and the reproductive capacity of Ae. polynesiensis in such places would be worthwhile.

Rageau & Estienne (82) stated that Ae. polynesiensis was a most voracious man-biting species and much less attracted to domestic animals and birds but gave no data to support this.

The only piece of information on the host preference as derived from precipitin testing, was provided by Symes (90) & (96) in Fiji. From the batches of blood meal smears he sent to the Lister Institute, London, for precipitin testing: 42% of smears of Ae. polynesiensis, 80% of smears of Ae. fijiensis, and 70% of smears of C. quinquefasciatus gave positive reaction to human blood. However, a large proportion of smears of the first two species was found negative and the author explained that these belonged to mosquitos collected from an unoccupied island. Since there were about 30% smears of various species which gave positive reaction to mammals other than man and domestic animals, the author postulated that they may come from an unknown mammalian host. In his investigation Symes did not mention the exact resting place from which the mosquitos were collected but referred to mosquitos collected from the bush and inside houses which had red blood in their stomachs when dissected.

Conclusions:

It is obvious that information on host prevalence is meagre and determination of the human blood index, which is important parameter of epidemiological significance, should be regarded as top priority. Field workers should be made aware of the facilities provided by WHO for testing blood smears of vectors of diseases in a central laboratory at the Imperial College Field Station, Silwood Park, Ascot, UK. Also, the WHO document of 1967 (118) giving instruction for the collection and forwarding of mosquito blood meal smears for identification of the host by precipitin test should be circulated to all concerned in different countries and island groups in Polynesia.

1.7 Resting habits

It seems that most of the information comes from incidental observations on the resting sites of the vectors of filariasis in Polynesia. All of the available evidence indicates that Ae. polynesiensis in several island groups in Polynesia and Ae. pseudoscutellaris in Fiji do not rest in houses but enter houses to feed. Resting occurs in natural shelters for which the following information is summarized. Davis, 1949 (16) indicated that Ae. polynesiensis showed marked preference for damp places shaded by foliage. Houses were not used for resting but female mosquitos were found resting under eaves of native thatched huts and these were found to harbour developing filarial larvae. Thick hedges were also found to be important resting places from which infected mosquitos were recovered. Jachowski (46) referred to the observations of O'Connor, 1923 (3) who found Ae. polynesiensis resting in dry tree holes and behind partially detached bark and dry coconut husks. However, Jachowski in American Samoa could not locate this vector resting in houses but observed them on leaves and bushes and in crevices of stone walls sheltering pigs. He also tried to find resting places in sweepings but without success.

In Fiji, Burnett, 1960 (84) and Symes, 1960 (90) found that Ae. polynesiensis and Ae. pseudoscutellaris were scarce in catches made in houses by pyrethrum spray (fog catch). Ramalingam, 1968 (125) did not find any adult Ae. polynesiensis in pyrethrum spray catches in houses in Western Samoa. He also quoted O'Connor (3) on the type of outside natural resting

shelters. Ramalingam, from his observations in Tonga, found that Ae. tabu could not be recovered by pyrethrum spray catches from houses but was found on several occasions resting in tree holes and other sheltered places on trees. Some females were obtained from sweeps made in grass and bushes.

Suzuki & Maung, 1968 (126) gave a brief account of the resting habits of Ae. polynesiensis in Western Samoa. Resting was rarely observed in houses both in daytime and at night. However, on three occasions, several Ae. polynesiensis were seen to rest on mats on the floor of the local houses but not more than a minute or so. Outside resting was observed in places sheltered from the wind and sunshine near the breeding places including resting on the ground in the vicinity of crab holes. Burnett (loc. cit.) stated that both sexes of Ae. polynesiensis were observed resting in crab holes.

On the Ae. kochi group, both Symes and Burnett carrying out density estimation by pyrethrum spray catches in the morning, found a considerable number of Ae. fijiensis. This is in contrast with the observations made by Ramalingam (loc. cit.) on the other member of the Ae. kochi group, Ae. samoanus, of which only a few were collected resting indoors in daytime. He indicated that Ae. samoanus rests mainly outdoors. Of the indoor resting mosquitos is C. quinquefasciatus which was reported by Symes and Burnett as being found in large numbers in pyrethrum spray catches together with Ae. fijiensis. When Burnett compared the catches made by pyrethrum spray and the night catches, he concluded that all the species encountered in the houses, except C. quinquefasciatus which leave in numbers after they feed. In his report on a visit to Tonga, Self, 1977 (217) indicated that field entomologists thought that large mango trees, which often have fruit from which droplets of sugar ooze, are good sites for human bait collections. Adults of Ae. tabu and Ae. oceanicus may utilize the thick shady branches for resting.

Conclusions:

In view of the above observations, there is a need for developing sampling devices for exophilic species of Ae. polynesiensis, of Ae. pseudoscutellaris, of Ae. samoanus and of Ae. fijiensis to be collected from outside resting shelters. The determination of the preferential outdoor resting sites still have dual value: first for collecting a sizeable sample of blood meal smears from resting mosquitos for precipitin testing aimed at the determination of a valid human blood index. Secondly, the location of sites of outside resting populations would guide vector control measures by imagocides. In the past there was a general view that clearing bushes and grass around houses would reduce the number of mosquitos, hence this was one of the control measures frequently practised as will be shown under "Vector control". A confirmation of this would come from an intensive search for the preferential outside resting sites and their location in relation to human habitation. Specimens collected either from temporary indoor resting shelters as in the case of Ae. fijiensis or from outside resting sites should be graded according to abdominal appearance of blood digestion stages.

1.8 Biting cycle

Much information has been accumulated on the biting cycle of vectors of filariasis in Polynesia, particularly Ae. polynesiensis. Only the most important work will be cited here. Jachowski (46) studied in detail the diurnal biting activity of Ae. polynesiensis in 1949 in American Samoa. His observations indicated that there is biomodal distribution of the biting mosquitos with a lesser peak occurring in the morning and a greater one in the afternoon. This biomodal distribution was observed in sites located in clearings, in a house and in the bush but the density varied greatly in order of magnitude, being the highest in the bush and lowest in clearings where destruction of suitable mosquito harbourage may have taken place. Jachowski indicated that when the wind velocity was less than 5 knots and under conditions of cloudy skies, biting by Ae. polynesiensis may continue throughout the whole day. Bright sunshine, strong wind and rain act directly upon the mosquitos and this explains the low biting observed in cleared areas. In the bush where heavy vegetation protects the environment from wind conditions, Ae. polynesiensis was found to bite the collectors even during the rains and biting continued with the protection offered by plants with large leaves. Ramalingam (125) confirmed the findings of Jachowski on the diurnal biting cycle with the observed peaks except for higher catches between 1200 to 1400 hours and this he explained as having been due to the presence of clouds when the mosquitos became more active as reported previously by Jachowski. Ramalingam also found some females of this species biting at night both indoors and in the bush. Suzuki & Maung (126) reported that Ae. polynesiensis in Western Samoa has the same biting cycle found by Jachowski in American Samoa. This was also confirmed by Suzuki & Sone, 1974 (177) who indicated that in night time collections carried out specifically for Ae. samoanus, Ae. oceanicus and C. quinquefasciatus, Ae. polynesiensis was recorded biting man at night. These authors mentioned that the number of these species caught biting around midnight in a Samoan type of house was 5 mosquitos/man-hour which was slightly higher than the record of catches around noon, 3/man-hour. They explained that such observations were made during nights with a bright moon. Jachowski stated that collections late at night were omitted because it was believed that the use of flash lights in the earlier survey had activated mosquitos which normally would not have tempted to feed at night.

Information on the biting cycle of Ae. samoanus is available from Ramalingam (125), Suzuki & Maung (126) and Suzuki & Sone (177) who indicated that this vector is a nocturnal biter. The first author found that the peak of biting activity was around 2300 hours while the others indicated that the peak was between midnight and 0330 hours.

In Fiji, Symes (90) studying the biting activity of Ae. polynesiensis and Ae. pseudoscutellaris, stated that both prefer calm or slightly moving air and do not become very active in wind moving at more than 3 to 4 knots. Similarly, they stated that the two species were numerous in the vicinity of clumps of vegetation or large trees in the bush. These findings are similar to those of Jachowski (loc. cit.). Night catches carried out by Symes (loc. cit.) on Ae. fijiensis and C. quinquefasciatus using a canvas hut fitted with window cages and adjustable shutters showed that the peaks of entry were between 2000 and 2300 hours. Symes believed that although C. quinquefasciatus is a poor vector, control of this species and Ae. fijiensis is justified on account of their numbers, their feeding habits and the long period they spend in houses making closer contact with the people than Ae. polynesiensis and Ae. pseudoscutellaris. He indicated that this contact is with all ages of the human population and at all times during the night.

Burnett (84) on the other hand, supporting the control of Ae. fijiensis, suggested that more information should be collected on the time this species spends in houses and the degree of contact that might be offered by residual insecticides. Rakai et al., 1974 (175) noting the paucity of knowledge on the biting time of mosquitos in Fiji, conducted man-biting observations in different ecological locations in 1969. Although they have given the results for all Aedes and Culex species encountered, no information was given on Ae. fijiensis. Perhaps the localities studied were devoid of this species. With regard to Ae. polynesiensis and Ae. pseudoscutellaris, they showed a diurnal pattern of biting. The biting cycle of the former tallies with the observations made by Jachowski (46) and Ramalingam (125) in American Samoa, showing an increased biting after dawn, reaching a peak in the early afternoon and tapering off after sunset, but the authors indicated that biting at a low level persisted throughout the night, rising again before dawn.

Conclusions:

There is sufficient information on the biting cycles of the important vectors. However, two points may deserve attention: (a) verification of the night biting by Ae. polynesiensis which has epidemiological significance in that it increases the opportunity of the population of this species to pick up filarial infection, and (b) the duration of resting Ae. fijiensis in houses at night which may apply also to Ae. samoanus. This will provide some useful background for exploring the possibility of application of space spraying indoors.

1.9 Seasonal and spatial distribution

Some work has been done to determine the spatial distribution of vectors of filariasis but there is limited information on the seasonal pattern of density and infection rates. Jachowski (46) indicated that Ae. polynesiensis was recovered from all inhabited islands of American Samoa whether at sea level or on the mountain ridges so long as the environment is suitable for its breeding and provides the adult population with sheltered resting sites. Symes, 1960 (90), in Fiji stated that Ae. polynesiensis and Ae. pseudoscutellaris are connected with bush conditions, but the former species was found in greater number than the latter in coastal areas although the differentiation between the two species was difficult. Nevertheless, he indicated that Ae. pseudoscutellaris occurred in coastal and inland areas. Suzuki & Sone, 1976 (208) indicated that the density of Ae. polynesiensis is as high as 400-500 bites/man-hour in the coastal areas where crab holes constituted the main breeding places. In contrast with the statement made by Symes, Rakai et al. (175) from their intensive studies indicated the absence of Ae. polynesiensis in inland villages on Viti Levu island. These authors considered that inland villages were those situated at 0.8 km from the coast. Rakai et al. (175) indicated that the absence of Ae. polynesiensis in inland villages was due to the lack of salinity in breeding waters. Further, they elaborated on the effect of rainfall in the coastal area and tried to find an explanation for the lower density recorded in some coastal areas with high rainfall. They postulated that in coastal areas surf-blown spray, which is not diluted by high rainfall, provided Ae. polynesiensis with favourable salinity in its breeding water.

On the seasonal distribution, Jachowski (46) showed that despite some fluctuation in rainfall, there was no recognizable seasonal variation in the density of Ae. polynesiensis in American Samoa. Contradiction of this view comes from earlier observations made by Davis (16) who found a different pattern according to the temperature and rainfall in Cook Islands. Suzuki & Sone (177) showed that Ae. polynesiensis followed a definite pattern according to the rainfall but no effect of relative humidity and temperature was apparent. Regarding Ae. samoanus, Ramalingam (125) considered it as a bush mosquito and Suzuki & Maung (126) stated that it occurred in all interior villages connected with the presence of leaf axil plants. However, Suzuki & Sone (177) showed that the highest density peak of Ae. samoanus occurred during May but there was no relationship between the density, temperature and humidity. The relationship between rainfall was less distinct than in the case of Ae. polynesiensis. The breeding sites of Ae. samoanus in Western Samoa were confined to leaf axils and they could contain water even during the dry season so that breeding continued. Burnett (85) found that in Fiji the density of bush vectors, Ae. polynesiensis and Ae. pseudoscutellaris, remained remarkably high throughout the unusually dry spells and attributed this to the continuous breeding in crab holes. Similarly, Ae. fijiensis was able to survive in a minimum amount of water in leaf axils.

Most of the papers cited above give some information on the seasonal distribution of Culex quinquefasciatus which is considered a vector of minor importance on most of the islands of Polynesia, as will be discussed below. Some of the papers, such as Ramalingam (125) and Suzuki (207) gave information on the distribution of Ae. upolensis.

Conclusions:

The spatial distribution of the different vectors has been quite well outlined for Ae. polynesiensis, Ae. pseudoscutellaris, Ae. samoanus, and Ae. fijiensis. However, there is an obvious need to determine the exact association of these vectors in different ecological niches where foci of transmission are occurring so that vector control measures can be designed according to the different vector behavioural patterns.

On the other hand, it is extremely important that the seasonal prevalence pattern be precisely determined together with the infection rates in the major vectors in order to serve as a guide as to the season when transmission takes place at a high rate.

1.10 Range of flight

There have many statements on the flight range of the important vector Ae. polynesiensis and such statements can be classified as follows:

(a) Statements not supported by evidence or by indirect evidence obtained from reduction in density as a result of removing breeding places from an area of 100 to 150 m around houses. References are:

Buxton, 1928 (7); Phelps, 1930 (8); Paine, 1934 (9); Amos, 1946 (13); Amos, 1947 (14); Davies, 1949 (16); Amos, 1953 (33); Dumbleton, 1953 (35); Lopdell, 1953 (37); Otto & Jachowski, 1953 (40); Rageau & Estienne, 1959 (82).

(b) Statements supported by investigations on infection rates, viz. by Byrd & St Amant, 1959 (72), reporting from American Samoa in 1943/44. These authors studied the infection rates in different locations in an island village and in a coastal village at distances varying from near the huts up to 150 m away from them. While an infection rate for Ae. polynesiensis of 28% was recorded near the huts, the rate dropped to 3.6% at 50 m and only a single mosquito came from each of the sites at 75 and 100 m away. Beyond this point no infected mosquitos were found. The work was repeated in a coastal village and the results confirmed that mosquitos at a distance of 136 m from the village showed very low infection rates or were totally free from infection.

Satchell, 1950 (19) carried out dissections in Cook Islands and showed that the infection rate of mosquitos collected from houses was 9.1% and from outside houses within a radius of about 23 m, the infection rate was 6.9%. From collections taken in plantations, the infection rate was 1.6% and estimates of the density levels at each site were given.

From a limited observation in Cook Islands McCarthy, 1959 (80) also showed that in an isolated area inhabited by a person who had a moderate count of microfilariae, the infection rate in Ae. polynesiensis was 25.9% in the vicinity of his quarters while the infection rate was nil at a distance of 180 m.

(c) Statements supported by experimental evidence. The only study came from Jachowski (46) who conducted mark/release and recapture of Ae. polynesiensis using different stains. Although the numbers obtained from these experiments were too small to be suitable for statistical analysis, the author indicated that the study gave some information on the dispersal of the species. About 27% of all the mosquitos recaptured were taken within five days at the points of release. The dispersal was rather slow and the distance travelled was found to be 91 m (100 yards); this was considered the maximum distance of dispersal. Finally, it was stated that clearings such as the main roads and air strip, which existed in the experimental area, seem to have acted as a barrier to the movement of this mosquito and flight was oriented along the path of prevailing wind.

Conclusions:

Only one experimental trial has dealt with this most important aspect of vector behaviour although the findings of declining infection rates away from the village boundaries can be of value as well.

Therefore, experiments with mark/release and recapture should be attempted in different ecological substrata on different islands. It may be possible that such experiments can be planned so as to study the dispersal as well as the duration of the gonotrophic cycle and longevity of the vectors. It is also suggested that such information is needed for vectors other than Ae. polynesiensis, viz. Ae. pseudoscutellaris and Ae. fijiensis in Fiji, as well as Ae. samoanus in the Samoas, Ae. tabu and Ae. cooki in Tonga, and the latter in Niue islands.

2. Sampling techniques, indices and criteria for assessment

2.1 Parasitological techniques

Most of the assessment of the filariasis situation before the application of control measures depended on examination of blood films made by sampling 20 mm³ of finger prick blood. On the other hand, Lagraulet et al., 1972 (236) emphasized the importance of sampling blood from the ear lobe as this allowed detection of 9.5% of mf carriers who were negative in finger blood. After the commencement of the control measures, it was often the case to increase the volume of blood from 20 to 60 mm³. The need was felt to introduce methods utilizing a larger volume of blood (Knotts' technique). This was tried early in Fiji by Symes (90) and Burnett (85) and was found to be difficult to use on a large scale in the field. With the development of the counting chamber method by Denham et al., 1971 (135) and their deduction on the loss of microfilariae during preparation and staining of thick blood films as well as with the development of filtration techniques, various trials have been conducted in some countries of the South Pacific where subperiodic bancroftian filariasis occurs. Authors who have carried out comparative studies involving thick blood films, counting chamber and/or membrane filtration technique or Nuclepore filter technique are:

Southgate & Desowitz, 1972 (144) in Fiji and Western Samoa
Desowitz, 1973 (157) in Fiji, Tonga and Western Samoa
Desowitz & Southgate, 1973 (158) in Fiji
Desowitz, Southgate & Mataika, 1973 (159) in Fiji
Southgate, 1973 (164) in Fiji
Desowitz, 1974 (166) in Tonga
Desowitz & Hitchcock, 1974 (167) in Tonga
Southgate, 1974 (176)
Kaeuffer et al., 1976 a (244) in French Polynesia

The general conclusions that can be derived from these investigations and the various recommendations made are as follows:

- both the counting and the Millipore membrane filtration technique were more sensitive and more efficient at detecting cases of microfilaria than the conventional 60 mm³ stained thick blood film techniques;
- the Millipore filtration technique was capable of detecting mf densities occurring at a very low level;
- it was recommended that entomological investigations be carried out to determine the infectivity of low level pre- and post-treatment mf carriers to mosquitos as well as an investigation on the low density persisting microfilaria after DEC therapeutic courses. It was also recommended that the clinical significance of persisting microfilaria should be studied after the completion of the main DEC campaign for several years.

Southgate (176) showed that the use of the membrane filtration technique gave a more accurate age and sex specific prevalence profile of the population. In addition to the membrane filtration method, Kaeuffer et al. (244) also demonstrated the superiority of the haemoconcentration method, but both methods were often resented by the inhabitants. More recently Partono & Idris, 1977 (215) in Indonesia, studying the factors influencing the loss of microfilariae from blood films, remarked that they

could not find an explanation to account for the difference in results obtained by them and other workers. In Western Samoa, Shibuya, 1977 (218) made a very careful study comparing the thick blood films of 60 mm^3 from finger prick and from venous blood as well as the Nuclepore filter technique. In addition to the different conclusions and recommendations he made for the programme in Western Samoa, he indicated that the mf rates using 1 ml blood sample and 60 mm^3 were surprisingly similar, indicating that the smaller quantity of blood is quite suitable for detecting most mf carriers especially heavily infected ones, so that they can be given individual treatment. With the Nuclepore filter method the ratio of low density cases to all positive cases was 22.2%. The critical density of approximately 17 microfilariae per 1 ml is equivalent to about one microfilaria per 60 mm^3 of blood.

2.2 Entomological techniques

The method of sampling vector populations varied greatly and reference is made to the paper which gave description of various sampling techniques: Jachowski & Otto, 1952 (31); Bonnet *et al.*, 1956 (58) who devised a method of "intensive mosquito survey", which was followed in the programme of Tahiti and American Samoa; Symes, 1960 (90); Burnett, 1960 (84), both utilized pyrethrum spray catch ("fog catch"); Suzuki & Maung, 1968 (126); Rakai *et al.*, 1974 (175); Suzuki & Sone, 1974 (177).

2.3 Indices of assessment

2.3.1 Parasitological indices

Before 1967 the assessment of the filariasis situation in Polynesia prior to and after application of the mass treatment measures, apart from the determination of the prevalence of the clinical manifestations, largely depended on the crude mf rate and also as grouped by age and sex as well as mf density per person examined or per person infected. From 1967 onwards, in the majority of cases, the assessment of the mf density was based on the method recommended by the Expert Committee on Filariasis (119) adopting Sasa's method, 1967¹ for estimating MfD₅₀. The Expert Committee on Filariasis, 1974 (178) further advised on the use of parameters for calculating the infectivity index of the human population. The index was defined as an expression of the infectivity potential of human population for the vector population on the assumption that people were evenly exposed to the mosquito bites and that all filarial larvae and mosquitos survived until the time of capture and dissection.

2.3.2 Entomological indices

A wide variety of indices was designed by different workers. Otto & Jachowski (31) expressed density index as the average number of mosquitos per 10-minute collections. These authors used an index of transmission which combines the average density of mosquitos and the infection rate. In 1954 Jachowski (46) gave the density index as the mean number of mosquitos in 1/3 of man-hour. It was stated that 10-minutes per catch were spent at each station. When the catch was less than 150 mosquitos, a reliable biting index could be estimated and when the number was greater, the accuracy of the index was doubted as many mosquitos were lost. Bonnet *et al.* (70) gave several indices such as the percent of stations positive for mosquitos, the percent

¹Sasa, M. (1967) Microfilaria survey methods and analysis of survey in filariasis control programmes. *Bull. Wld Hlth Org.*, 37, 629-650

of stations with 10 or more mosquitos, the percent of stations with mosquitos positive for larvae of W. bancrofti and the density index as the mean number of mosquitos caught per minute. From these data, the potential transmission index was developed, Kessel, 1957 (68), which was utilized for assessing the impact of the mass DEC campaign on the infection in mosquitos mainly in Tahiti and American Samoa. From 1967 onwards this index seems to have been abandoned and reliance was based on the rate of infective stage larvae in many programmes. Symes (90) defined the index of "a standard catch" as a series of seven 5-minute collections. Burnett (85) followed the same index but devised other indices for special studies: for example for the diurnal catches the index was the mean number per hour and for the "fog catch" the index was the mean number of mosquitos per house. Rakai *et al.* (175) made the calculations on the basis of biting rate per man-hour for the biting cycle studies from 15-minute collections every hour and in vector distribution studies they used mean number caught per village. Suzuki & Sone (177) expressed the density as the mean number of mosquitos per man-hour from 30-minute collections every hour. It seems that the transmission index of Wharton (1962)¹ which gives the infective bites per year, has never been utilized in Polynesia.

2.3.3 Criteria for progress of control

Some attempts were made to put some critical values indicating the target of the mass treatment campaigns, as was given by Kessel (*loc. cit.*): "It is proposed for a mass treatment campaign that reduction of persons positive for microfilaria to a maximum of 5% with a corresponding maximal mf density of one should be sufficient to reduce transmission to a negligible minimum". In 1970, Kessel *et al.* (132) and Kessel, 1971 (139) have modified the previous criteria for initiation of surveillance and changing the programme from control to eradication as follows: "For further progress, when simultaneously the mf rates fall to 1% or less, the MfD₅₀ falls to one or less and intensive mosquito surveys show an infective stage larva rate of 0.5% or less, often 0, and if these falls are associated with a decline in a clinical disease, that indicates that filariasis is no longer an important public health problem".

It may not be out of place to refer to Mahoney & Kessel, 1971 (141) for the criteria of defining the infections into persistent, recurrent and new infection.

Earlier in 1970, the drug coverage was given as the percentage of the people who have taken the drug out of the total population. Sasa, 1972 (153) estimated the coverage from calculations based on the frequency distribution of the number of people in Western Samoa who have taken different doses of DEC. Maung & Penaia, 1976 (198) followed the same calculations and gave certain indices to assess the population coverage by drug. Buck, 1975 (181) calculated the average total dose of DEC/kg to assess the drug coverage.

¹Wharton, R.H. (1962) The biology of Mansonia mosquitos in relation to the transmission of filariasis in Malaya.

Institute for Medical Research, Federation of Malaya, Bull No. 11, 113 pp.

Conclusions:

A lot of work has been done for assessing the parasitological sampling techniques and it may appear that while the 60 mm³ blood film examination could be recommended for routine examination, the filtration techniques may be reserved for special epidemiological studies. However, this question needs to be examined by the epidemiologists together with the criteris for assessing the progress of control of filariasis as well as for the defining of the type of infection.

While the parasitological techniques have been rigorously assessed in the field of Polynesia, the critical appraisal of the different methods of the entomological sampling techniques and the indices used for assessment have not received similar attention. There has been no attempt made to define the sample size of the mosquitos to be dissected taking into account the reduction in infective rates of the vector as a result of reduction of the infection in the human population under treatment.

Therefore, there is an urgent need for selecting and standardizing the entomological techniques of sampling and for developing a reliable index by which the impact of any control measures can be assessed jointly with parasitological indices.

3. Host/parasite/vector relationship

3.1 Relative importance of vectors

Ample evidence has been accumulated from experimental and natural infections that Ae. polynesiensis is the most important vector of subperiodic W. bancrofti where it occurs in different island groups in Polynesia as reviewed by Iyengar, 1965 (108) and Ramalingam, 1968 (125). It is worth noting that Rosen, 1955 (56) found that Ae. polynesiensis was less efficient when infected with the periodic strain of W. bancrofti (by a mf carrier of this infection who happened to be in Tahiti) than with the subperiodic local Tahitian strain while the reverse was recorded with C. quinquefasciatus. Rosen who reviewed the evidence hitherto available on the role of C. quinquefasciatus concluded from his experimental and natural infection studies that this species cannot propagate the Polynesian strain in the absence of more efficient vectors and remarked that direct evidence of this cannot be obtained unless the major vectors are brought under complete control.

In Fiji, Symes, 1960 (90) demonstrated, by experimental and natural infection, that Ae. polynesiensis and Ae. pseudoscutellaris, which he considered as bush vectors, as well as Ae. fijiensis, were equally efficient vectors while C. quinquefasciatus appeared to have low vector potential. However, the evidence provided from natural infection in Ae. polynesiensis and C. quinquefasciatus showed lower infective rates than those reported in Tahiti by Rosen (56) and Kessel (68). Symes explained that this was due to the possibility of sampling a wider area around human habitation in Fiji than in Tahiti, differences in mosquito sampling techniques and ecological conditions, which make it difficult to compare the infective rate between widely separated areas. As mentioned earlier, Symes believed that control of Ae. fijiensis and C. quinquefasciatus, despite the latter being a weak vector, is worth considering in view of their numbers and having close contact with man. He, 1961 (96) further suggested that a full taxonomic and biological study on C. quinquefasciatus and the determination of its vector potential in islands representative of the whole South Pacific would yield valuable data.

Burnett, 1960 (85) made a special study to determine the relative importance of the four vectors of filariasis in Fiji, classifying villages into groups, according to the predominance of certain vectors. There were group of villages with C. quinquefasciatus predominating, few villages with Ae. fijiensis predominant and other groups with both Ae. polynesiensis and Ae. pseudoscutellaris abundant.

From elaborate calculation for estimating the mf rates in the inhabitants who contracted the infection in their villages under the influence of the prevailing vector, together with estimates of vector density and infection rates, the author concluded that C. quinquefasciatus is of minor importance as a vector and Ae. polynesiensis is possibly the most important, closely followed by Ae. pseudoscutellaris and Ae. fijiensis, the last species is important when it occurs as it has a restricted distribution by virtue of its special breeding requirements. Mataika et al., 1971 (142), investigating the factors influencing the prevalence of microfilaraemia in rural areas in Fiji in 1968-1969, obtained evidence from analysis of mf rates according to the size of household that transmission was not predominantly intrafamilial. Hence, they inferred that this gives support to Burnett's view (*loc. cit.*) that the role of C. quinquefasciatus in filariasis transmission is relatively insignificant.

In American and Western Samoa, Ramalingam (125) indicated that, while Ae. polynesiensis is the major vector, Ae. samoanus is an efficient vector as demonstrated from natural and experimental infection studies, Ramalingam & Belkin, 1964 (105) and it could be more important than Ae. polynesiensis in inland villages surrounded by bush, as noted from his transmission studies. Having reviewed all the available information on the experimental and natural infections of C. quinquefasciatus as well as his studies, he concluded that this species in Samoa and Tonga was not a significant vector. Regarding the role of Ae. tutuilae, only limited information was obtained from natural and experimental infection and additional evidence was needed for its incrimination as a vector. From the natural infection rates recorded on Ae. upolensis, and transmission studies in the Samoas, Ramalingam indicated that this species could play an important role in transmission in inland and coastal villages and plantations surrounded by bush.

In Tonga, Hitchcock, 1976 (196) found Ae. cooki naturally infected in Vav'u island group. In Niue island, where Ae. cooki is the only member of the Ae. scutellaris group, the same author demonstrated its ability to develop W. bancrofti by experimental infection. Although Ramalingam & Belkin, 1964 (105) did not find infection in Ae. oceanicus, Hitchcock (137) found evidence of its being a vector in Tafahai, Tonga by experimental and natural infection.

Conclusions:

There is a fair amount of knowledge on the relative importance of the major vectors from a number of island groups in Polynesia. It would be desirable to investigate the role of vectors of secondary importance, such as Ae. tutuilae as well as C. quinquefasciatus at present, since no investigation seems to have been carried out recently. It is also desirable to investigate the relative importance of Ae. oceanicus, Ae. cooki in Tonga and Ae. upolensis.

3.2 Experimental infection studies

3.2.1 The developmental period of the parasite in the vector

Byrd & St. Amant (72) found that the average time for the development of the subperiodic W. bancrofti in Ae. polynesiensis was about 11-17 days; Rosen (56) showed that development in Ae. polynesiensis in Tahiti was completed in 12-13 days at 24-28°C. Rageau & Estienne (82) reported that the development was completed in Ae. polynesiensis in 13-16 days. Symes (90) in Fiji, found that the development was completed in Ae. pseudoscutellaris on the 13th-14th day, in Ae. fijiensis on 13th-15th day, and in C. quinquefasciatus on 15th-16th day. However, he found seasonal fluctuation of the developmental period; Bryan & Southgate, 1976 (192) in Western Samoa, reported that the development was completed in Ae. polynesiensis in 12 days.

3.2.2 Intake and loss of microfilariae

Rosen (56) observed that Ae. polynesiensis did not expel blood while in the process of taking a blood meal, but rather a clear serum-like fluid. On the other hand, Symes did some experiments by which he demonstrated in Ae. pseudoscutellaris, that the intake of microfilaria was more than would be expected and that the loss in the microfilaria injected was about half in the first 24 hours. He estimated that the number of microfilariae injected was about equal to that which could be found in 5-7 mm³ of blood of the carrier. He observed excretion of serum by the mosquito during feeding and excretion of red blood during the 12 hours following feeding but he did not examine the presence of microfilaria in this material. Bryan & Southgate stated that Ae. polynesiensis did not expel blood during feeding although occasionally drops of clear serum-like fluid were seen.

3.2.3 Threshold density of infective microfilaraemia

Rosen (56) indicated that, in his experiments, a significant proportion of Ae. polynesiensis became infected with a density as low as 0.4 mf per 20 mm³ and he considered that any density of microfilaria that can be detected in 20 mm³ blood from capillaries can be infective to mosquitos. Rosen also reviewed the literature on the question of the concentration of microfilariae by mosquitos and stated that there was little to suggest that such a phenomenon occurs to a significant extent in Ae. polynesiensis. Analysis of his data showed that there was a concentration of microfilariae at different levels of density with the exception of the very high counts. The highest concentration was at mf density levels of 0.1-3.5 per 20 mm³. This was more or less similar to the estimate made by Pichon, 1974 a (173) who mathematically examined the data of Rosen. Symes (90) indicated that Ae. pseudoscutellaris, Ae. fijiensis and C. quinquefasciatus become infective after feeding on blood counts as low as 0.04, 0.03 and 0.05 per 20 mm³ respectively and concluded that these mosquitos may thus become infective after feeding on blood with numbers of microfilariae so low that they might not be seen in a 20 mm³ blood sample. In feeding experiments, the author recorded first stage larva in one out of 29 and 2 out of 100 specimens of Ae. pseudoscutellaris fed upon a man whose mf count in 1 ml of blood had been reduced by DEC from 4050 to nil. Bryan & Southgate (192) carrying out investigations on the infectivity of an ultra-low density mf carrier of

Ae. polynesiensis in Western Samoa found that mosquitos could pick up and sustain the development of microfilariae 12 times the expected number that could be found in the peripheral blood of the carrier. Analysis of the data of these authors showed that mosquitos' actual intake averaged about 17 times the expected number of microfilariae in peripheral blood. In their experiments, the number of microfilariae recorded by 10 blood examinations of 60 mm³ of blood of the donor was 3.

3.2.4 The effect of the parasite on survival of mosquitos

Rosen (56) showed that there was no recognizable effect of heavy infection on the longevity of Ae. polynesiensis in the first week after the infective feed, and there was no extensive mortality to the parasite up to 9-1/2 days. The effect of heavy parasite load on the longevity of the mosquito was observed near the end of the period of development to the mature stage, and Rosen concluded from some special observations that more heavily infected mosquitos died before those with lighter infections. He also raised the question as to the level of the density of microfilariae in the blood that would result in the successful transmission of the largest number of larvae by a given mosquito population. In this connexion Hairston & Jachowski (121) re-examined the data of Rosen and came to the conclusion that the average survival of larvae through the mosquito phase of the life cycle is ten times as great for intermediate densities as for either high or low densities.

Symes (90) provided evidence that heavy loads of microfilaria of an average count of 57 per mm³ could influence the death rate of about 63% in Ae. pseudoscutellaris. From his experiments it appears that the largest death rate occurred in the first 24 hours after ingestion of the microfilariae. Bryan & Southgate (192) stated that mortality in their experiments was independent of infection.

3.2.5 Effect on DEC on the parasite in mosquitos

Laigret et al. (110) analysing the data accumulated during 11 years of chemotherapy by DEC in Tahiti for mass treatment of the superperiodic W. bancrofti assumed that the decrease in the proportion of mosquitos with infective stage larvae and the density of this stage per mosquito dissected could have been due to the effect of DEC reducing the chances for the larvae to develop to the mature stage, and suggested that this point deserves special attention. From the work of Rosen (56), Symes (90) and Bryan & Southgate (192) there was no evidence that DEC treatment of the volunteers used in their experimental infection studies interfered with the development of the parasite in the mosquito.

Conclusions:

Among all of these aspects which have been studied by different workers, the question of the infectivity of ultra-low microfilaraemia to mosquito vectors in Polynesia needs a rigorous re-evaluation involving different vector species. This is of prime importance for determining the possibility of resumption of transmission in areas where the MDA has brought down the mf density to a very low level.

3.3 Quantitative approaches

Beye & Gurian, 1960 (83) reviewed all the factors involved in filariasis transmission and developed a mathematical approach for characterizing the dynamics of transmission. The work of Pichon and his co-workers presents the mathematical approaches for determining the relationships between the microfilariae ingested by the vector and number of mature parasites produced as well as the low distribution of the microfilaria ingested. Pichon, 1974 (172); Pichon, 1974 a (173); Pichon et al., 1974 (174); Pichon et al., 1975 (187) and Pichon et al., 1975 a (188). An important mathematical approach was further developed by Pichon et al., 1975 b (189) which deals with the question of vector mortality due to parasitism and overcrowding of the parasite. In 1976 Pichon et al. (201) studied the distribution of the parasite in both sexes in the human population. Pichon and his co-workers, 1976 a (202) continued to study the distribution of microfilaria ingested under carefully standardized experimental conditions. It is interesting to note that in Pichon et al. (174) the practical implications of the phenomenon of "limitation" (which is thought to occur in *Aedes* mosquitos such as *Ae. polynesiensis*) under DEC mass treatment was explained but histological evidence for the occurrence of this phenomenon still cannot be obtained, Pichon (173).

In the last paper Pichon et al., 1976 b (203) studied the distribution of the density of microfilaria in carriers in the foci of filariasis.

Hairston & Jachowski (121) analysed the data obtained in American Samoa from the same population examined over 4-1/2 years during 1948-1953. The results showed that there was long term variation in the mf density in individuals followed up, which shows that a pattern exists. The mf density takes the form of a wave-like progression of the counts increasing during 3-24 months until a definite peak is reached and then a decrease of shorter duration occurs. There was no evidence indicating that the peaks occurred during a particular season and the pattern appeared in all ages and both sexes. From the data of these peaks the authors derived an estimate for the worm burden in the human population in villages with low and high transmission rate. In their final discussion, the authors proposed that similar analysis would be complete, if it includes quantitative estimates of all factors involved in the life cycle of the parasite particularly vector biting rates and the survival of larvae in the naturally infected mosquitos, and they suggested that such analysis should be extended to other areas where the parasite and vector are the same. There were certain objections to the mathematical model used by these authors such as shown in Sasa's book, 1976 (206) and Mahoney & Kessel, 1972 (141).

A mathematical model, including all vectors and parasite parameters was developed by Dietz, 1975 (182). This model allowed the calculation of the critical man-bite rate below which transmission cannot be maintained and the critical mf density below which the infection would disappear without vector control, i.e. the "break point". Other parameters can also be calculated. Reference should be made to an attempt made by Hairston, 1973 (160) on the data he mathematically quantified from Western Samoa. An estimate was made

of the number of mf carriers in the country, based on the mf rates of 0.19% recorded in 1971; the number of Ae. polynesiensis that can become infected daily was determined. From these parameters, the author could provide an estimate of the number of human infections that can become mature in an average year. A similar estimate was made by Bryan & Southgate (1972), utilising a mathematical approach to estimate the number of mf carriers in Western Samoa and the number of infective larvae produced in Ae. polynesiensis.

Conclusions:

Mathematical approaches have been useful in appreciating the interaction of factors involved in filariasis transmission. At a field level it is hoped that a complete mathematical model can be ready for testing for an eventual prediction to assist filariasis control schemes. It would be highly desirable if workers in charge of this specialized subject would indicate the type and the scale of field sampling methods from which input data can be provided.

3.4 The question of focality of transmission

The determination of the exact focus of transmission in the rural environment, whether it is within the village or in plantation and bush has been a subject of controversy and the views may be classified as follows:

(a) Views in favour of transmission occurring in villages

Reference has already been made to Byrd & St Amant (72) on the evidence they provided for considering the village as being the main focus of transmission. Davis, 1949 (16) from his surveys in the Cook Islands, stated that no infected mosquitos could be found in plantations although they were obtainable from resting sites near dwellings and in villages. In addition, he found that the biting times of Ae. polynesiensis did not coincide with the times when the people were in the plantation which were usually well cleared and in full sun. However, he considered that biting may have occurred when plantation workers rested in the shade of the bush. He also stated that the exposure to bites in plantations was not regular except during the season of intensive replanting. Satchell, 1950 (19) showed that mosquito infection rates were 6 times as great in houses as in plantation and that mosquito density in plantations was 2.4 times as great as in houses. Hence he advocated the destruction of mosquitos in and around houses. Iyengar, 1957 (65) compared the infection rates of Ae. polynesiensis caught in and around houses with those caught at a distance of 100 m from human habitation. He showed that the specimens collected inside houses frequently harboured infective stage larvae in the head and labium and that multiple infections were also recorded within the village. From this and from the findings of microfilarial infection in very young children, he concluded that transmission was primarily within the village and the peri-domestic situation. Southgate, 1974 (176) from his studies in Fiji, pointed out that his data implied that considerably more peri-domestic transmission is occurring than had been previously thought and suggested that careful studies of mosquito biting rates in children infection rates in and around homesteads are urgently needed and should include the vectors, Ae. fijiensis and Ae. samoanus.

(b) Views supporting that transmission occurs principally in plantation/bush

The first objection to the observation made by Byrd *et al.* (72) from their work in American Samoa during 1943-44 came from Jachowski & Otto, 1952 (31) who provided entomological evidence that transmission was principally in the bush and plantation. Further, the latter two authors, 1953 (40) and 1955 (52), gave the results of their parasitological investigation comparing the age and sex distribution of infection in the human population. They pointed out that infection rates in the pre-teen age were comparatively low in the more open villages. In small bush encompassed villages there was a significantly greater increase in the infection rates in the female through adolescence to maturity. They also indicated that the severest infection rates were found in adult males on account of their occupation in plantation and bush. They showed that infection rates rise gradually in males from adolescence to middle life when it reaches its maximum and then levels off or declines. McCarthy & Fitzgerald, 1955 (53) and 1956 (60), analysing the infection rates in the population of inland and coastal villages of different age groups and sexes have supported the views of Jachowski & Otto in that transmission was higher in places surrounded by bush. They also pointed out that there had been a recession in the filariasis situation due to improvement in the village environment and by clearing of the village area through the domestic demands for firewood. *Ae. polynesiensis* was thus confined to the bush leaving the villages relatively free as a focus. In Fiji, Symes (90) did not carry out intensive studies on the focality of transmission, but from limited observation, the infection and infective rates of *Ae. pseudoscutellaris* and *Ae. polynesiensis* were much higher at a distance of 360 m from the village than from those recorded at 23-46 m and from the mf rate and density in people frequently working in the bush and those who stayed in the village, he concluded that transmission was higher in plantation and bush.

Burnett (85) carried out limited studies in Fiji on the focality of transmission. Although he found infection rates in gardens and plantations were lower than those recorded in the village, he indicated that this might be due to irregular visits by the inhabitants but, nevertheless, he considered that the risk of infection in garden or plantation was not negligible, thus supporting the view of Otto & Jachowski. Rakai *et al.* (175) also in Fiji, showed that the biting activities of *Ae. polynesiensis* and risk of infection were highest in the bush away from the village although they indicated that the percentage of mosquitos caught within the village harboured a higher number of filarial larvae than elsewhere. However, they inferred from the infection and infective rates that the survival of mosquitos within the village was lower and tried to explain this by certain hypotheses.

(c) Views indicating that the intensity of transmission depends on ecological conditions

In Cook Islands, McCarthy, 1959 (80) took flexible attitude in analysing infection rates by age and sex. He considered the ecology of the locality in surveys conducted to show whether transmission was possible in villages or outside. Ramalingam (125) made intensive transmission studies involving *Ae. polynesiensis*, *Ae. upolensis* and *Ae. samoanus* in villages surrounded by bush, villages in the open and in plantations in American and Western Samoa. He utilized the potential transmission index of Bonnet *et al.* (58) for each of the above mentioned vectors and for all combined. His conclusions were

drawn from careful analysis of the data obtained: transmission in the two ecological sites varied greatly from village to village and was probably not restricted only to bush, plantation or village. He stressed that transmission occurred in both places the relative proportion depending on the particular ecological situation at the time. For this he pointed to the important socio-economic changes that occurred in American Samoa since the time Jachowski & Otto carried out their investigation. Men no longer spend a good part of the day in plantations as they are occupied in Government or industrial work; they may only work in plantations on the weekends. Similar changes were taking place in Western Samoa but the agricultural economy still prevailed, requiring most men to work in plantations. It is important to note that the author carried out studies on periodicity of the microfilariae in a bush village where Ae. samoanus showed a high potential transmission index and in an open coastal village where the diurnal biter, Ae. polynesiensis, was the only vector. These studies indicated that there was no shift in the mf density to correspond with the maximum biting activity of the predominant vector. As the mf density remained high until about midnight and Ae. samoanus was active after sunset with a biting peak until 2300 h, there was ample opportunity for it to become infected at night and for Ae. polynesiensis to pick up the infection during the day. Mahoney & Kessel, 1971 (141) from their analysis of the reasons of the DEC failure were inclined to support Jachowski & Otto's hypothesis that transmission is principally occurring in bush and plantation. However, they referred to the changes in socio-economic conditions in Samoa where men work outside villages, as was shown by Ramalingam. As their data did not show that the incidence of infection was higher in women and older men who remain in the village, they suggested that transmission may occur in the new sites of work. Mataika et al. (143) in their studies in Fiji as mentioned earlier, found that transmission was not intrafamilial. The clustering of infection within households was not marked. The prevalence of microfilaraemia in people living in outlying settlements was relatively low, indicating a lower risk of infection due to isolation. In Western Samoa, Suzuki & Maung, 1968 (126) indicated that transmission could be intense in and near villages and could also be so in most inland villages which are usually surrounded by bush.

Conclusions:

From the above, it is clear that the controversial views about the principal sites of transmission of filariasis in the rural environment have not been completely settled but more light was brought by the work of Ramalingam, cited above. Since he carried out this work some 15 years ago, and there have been considerable socio-economic developments in the area, it is important that in starting programmes of control and in programmes that are at the advanced stages, it is of high priority that studies should be intensified to delineate with precision the main sites where transmission is occurring. In programmes underway and in advanced programmes this undoubtedly help in deciding on the role and scope of vector control as a supplementary measure to mass chemotherapy for the complete elimination of transmission. Knowledge that can be obtained from observations on the range of flight of the main vectors should form an integral part of this study.

SECTION III - FILARIASIS CONTROL STRATEGY

Up to the early 1950's, the trend for filariasis control in Polynesia, was based on measures against vectors, particularly by elimination of the breeding places within 100 m around the villages, this distance being the commonly accepted range of flight of *Ae. polynesiensis*. There were many supporters of this view starting with Manson-Bahr, 1912 (1), obviously this was because of the lack of suitable insecticides or drugs for treatment of the people. In the early 1950's with the availability of chlorinated hydrocarbon insecticides, the trend changed to the application of these insecticides and some trials were undertaken. With the advancement of knowledge on therapy with DEC and the promising results obtained from trials, the trend was to develop mass DEC drug treatment covering the whole population. Thus, vector control trends which had been prominent in the past, have declined with the application of mass treatment except in a few programmes where sanitation measures continue to be applied. It may be worthwhile to review the subject as follows:-

1. Attempts of vector control alone or combined with chemotherapy

1.1 Sanitation

Elimination of breeding places around houses was reported by O'Connor (2) and (3) in Ellice Islands; Buxton (4) in Samoa; Buxton & Hopkins (6) in Apia town, Western Samoa; Paine (10) on the control of mosquitos in coconut plantations in Fiji; Byrd & St Amant (12) and (72), described in detail the sanitation measures undertaken in American Samoa and Wallis Islands which reduced the density of *Ae. polynesiensis* from an overall level of 96-129 per man-hour to zero in a single effort of clearing the breeding and resting sites of the vector within 100 m, and continued efforts could maintain the density of zero level. They believed that once the breeding and resting places of the mosquitos were removed or destroyed, very little effort was required to maintain the area mosquito free. Amos (14) initiated a vigorous programme of sanitation in Fiji and prepared a training manual for the health inspectors. Davis (16) described in detail the programme of breeding places and cutting out the bushes around houses which provided resting shelters for *Ae. polynesiensis* in Cook Islands and outlined the staff duties and described the health education on the basis of which the programme was carried out with the community participation under the supervision of the staff. His evaluation was not supported by detailed data since it was too early to assess the impact of the measures on the microfilaraemia prevalence but he indicated that naturally infected mosquitos could not be obtained. Hercus & Faine (24), who pursued the evaluation of the campaign launched by Davis, found an increase of the mf rate in school children which they could not explain. Edgar & Bambridge (22) estimated the reduction in the rat damaged coconut crop as 0.3% in the plantations which were protected by bandaging against 28% damage of the crop in unprotected plantations. Amos (34) described the aims of the programme he organized in Fiji, as not attempting to destroy all mosquitos but within 100 m around villages in order to stamp out the filarial disease by eliminating the vector breeding and sheltering through education of the people. Even Jachowski (36) and Otto & Jachowski (55) who at the beginning were opposing the idea of village transmission, agreed that because of larviciding or attack on adult vector population by ground or aerial spraying was impracticable on an island-wide basis and also because the effects of chemotherapy at that time were not certain, clearing

out all the harbourage and breeding sites could offer protection within the village, particularly in younger children and partially to the adult population. Iyengar (43) devised a scheme for the control of filariasis by sanitation 120 m around houses in Western Samoa and made general recommendations for sanitation measures in Polynesia (77). Bonnet & Chapman (57) tried filling in tree holes with cement or with plastic materials for prevention of larval breeding. The method was found to be suitable for urban areas where the number of trees are small but it would be costly in rural areas. They also developed a cheap, simple method placing fern in tree holes after partial filling with sand. As the fern roots grew, water was withdrawn and preliminary results of nine months trial showed that breeding of mosquitos was eliminated. The Annual Report of the Government of American Samoa (91) gives the detail of the effect of sanitation measures as carried out by the people within a radius of 100 m and that the results depended on the enthusiasm and cooperation of the population.

As shown above, the evaluation was mainly based on the reduction of mosquito density. The first attempt to evaluate parasitologically the campaign which was initiated by Amos in Fiji was made by Symes (90) and Burnett (85) who carried out a blood survey in 56 villages. The conclusion was that no measurable decline in filariasis could be detected resulting from this campaign because sampling was inadequate to show any appreciable decline. Both authors carried out sanitation trials in Fiji eliminating the breeding grounds within a radius of 360 - 450 m of villages. After ten months, it was found that the results were disappointing because of the lack of supervision and the non-cooperation of the public to the extent that the breeding places of *Ae. polynesiensis* were replenished. The last author gave a detailed account of the number of natural breeding places eliminated including tree holes as well as the number of artificial containers which involved 24-70 man-days per village. The author concluded that the estimation of cost/effectiveness of sanitation measures cast doubt on their practicability even if new breeding places were not created by the inhabitants as rapidly as the old ones were removed. He believed that because *Ae. polynesiensis* and *Ae. pseudoscutellaris* breed in crab holes, any measures that did not include the control of these sites would fail. The results of felling pandanus plants to control *Ae. fijiensis* did not seem to be consistent.

1.2 Insecticide trials

As early as 1949-50, trials with insecticides were reported from Cook Islands by Satchell (90). The author described a trial involving the spraying of five houses and their surroundings with DDT (water dispersible powder) at a dosage of 2 gm/m². The spraying was applied to inside and outside surfaces of the houses as well as all foliage and tree trunks up to a height of 3.3 m within a radius of 9 m. The results showed that in sprayed houses, the density of the mosquitos was 1/6, the number of infected mosquitos 1/12 and the number of mosquitos carrying the infective larvae 1/16 of that found in the unsprayed houses. However, the author indicated that clearance of bush and breeding places around houses should be the main measure and that DDT spraying should be regarded as a supplementary measure. Wharton & Jachowski (21) gave the results of the DDT application in American Samoa as a residual spray in houses followed by aerial spraying at intervals of 14 days. Considerable reduction in the mosquito density was observed but the density rose to the uncontrolled level after 14 days. No infected

mosquitos were found when spraying was applied. From a trial combining earlier spraying, cleaning up of the breeding places and mass chemotherapy in a village, the authors concluded that by aerial spraying, filariasis transmission by the bush mosquito (Ae. polynesiensis) may be effectively interrupted but it needs a repetition at two week intervals. Therefore, they suggested that mosquito reduction by cleaning up within a satisfactory distance from the village would give the most satisfactory long-term control. At that time they considered DEC as a supplementary measure. Bonnet & Chapman (57) carried out trials for controlling breeding of Ae. polynesiensis in tree holes in Tahiti. They reported that DDT, lindane and dieldrin applied in a few squirts by a hand oiler into the holes, irrespective of their sites, were all effective for a period up to three months. They considered that chemical control of mosquito breeding in tree holes is of limited value because of the necessity of repeating the application. The most intensive trials with insecticides were those of Symes (90) which was followed by Burnett (85) in Fiji. Since the study trials of the second author were more comprehensive and complete, their results can be briefly reviewed here. For controlling breeding in coconut shells, dieldrin spray, applied at 2 gm/m² prevented breeding for five months while a thatched cover of the coconut pile was less successful. Pellets in bamboo pots made from 16.5% dieldrin and 2.5% HCH prevented breeding of Ae. pseudoscutellaris for 43 weeks. Likewise, 16.3% dieldrin pellets suppressed breeding in tree holes for 8-9 months. It was not recommended for regular use but as a rapid measure and filling in or draining should be the main measure. (In this connexion, reference is made to the work of Oldham *et al.*, 1972 (151) who tried several insecticides in tree holes in the USA and found that chlorpyrifos (Dursban) cleared breeding of Ae. sierrensis for 21 months). Although 16% dieldrin pellets in crab holes gave a reduction of adult Ae. polynesiensis for about ten weeks after treatment and the catches remained low for another five months, the author preferred baiting for the control of breeding in crab holes as a trial previously carried out by Burnett (71). With baiting and stopping the crab holes the criterion used was the number of crab holes reopened. In a wet zone, baiting with dieldrin followed by DDT and finally by HCH gave a final kill estimated from the crab holes which did not reopen as 89%. For a reduction of the breeding in other sites, i.e. tree holes, cutting of vegetation was carried out but the catches of adult Ae. pseudoscutellaris gave inconclusive results. The results of house spraying with dieldrin emulsion gave a good control on the daytime catches of resting mosquitos, i.e. Ae. fijiensis for at least 3-9 months according to the dosage applied but the number of Ae. fijiensis entering the houses at night was only reduced for a few weeks. The author concluded that for the control of vectors of filariasis, the permanent measures should be the main weapon and that the use of insecticide should be reserved for special situations such as breeding in coconut husks or in crab holes. He advocated that in crab hole areas, vegetation must be cleared to reveal the holes and the bait continued to be reapplied until the holes are permanently stopped. He gave the estimate of Symes of the number of holes per ten hectares as 50 000 and to treat an area of about 360 m around human habitation would involve 190 000 holes. He cautioned the use of insecticides for larval control as he noted in Ae. pseudoscutellaris signs of resistance to DDT, Burnett & Ash (93).

More recently, Suzuki & Sone, 1976 (209) carried out several laboratory trials with insecticides in Western Samoa during 1969-77. Using 1% Abate sand granules in 200 litre drums, allowing the water to overflow daily and replenishing it every week, the results showed that where the water was added to the drums, more than 90% mortality was obtained until the 4th week, while in the drums which were not subjected to replenishment of water, more than 90% mortality was obtained until the 9th week. In the field trial applying 5% DDT suspension in tree holes by pipettes or with a knapsack sprayer on leaf axil plants, the authors indicated that no advanced larval stage reappeared in tree holes or stumps up to the 76th week with the dosage estimated to be 500 ppm. In the leaf axil plants, the larvae reappeared at the 10th to 18th week, i.e. much earlier than in tree holes or stumps. The species involved were Ae. polynesiensis, Ae. samoanus, Ae. tutuilae and Ae. oceanicus. A trial of spraying DDT in the area of breeding places of Ae. polynesiensis showed an average reduction of 64% in Ae. polynesiensis, but definite conclusions cannot be drawn from such a trial which has no untreated comparison area. Further, the hazards of contamination of the environment with persistent insecticides has to be taken into account. Another trial was carried out in an area where Ae. polynesiensis breeding was occurring extensively in crab holes. Abate emulsion at 0.5 gm/litre was poured into crab holes and 6% malathion solution in kerosene was applied by fogging machines. It is difficult to interpret the data after a period of initial reduction observed in the first week after application since sharp fluctuations in vector densities in the treated and check areas, for which no explanation was offered by the authors.

The possible use of bed nets treated with insecticides was suggested by Suzuki (181). It was noticed that in villages with high Ae. samoanus density, about 95% of the houses use bed nets. Impregnation or spraying of the bed nets may prove to be the only means of controlling this vector which comes to feed at night in the Samoan type of houses.

1.2.1 Vector resistance to insecticides

Burnett & Ash, 1961 (93) seem to have been the first authors to report on tests made in Polynesia for determining the susceptibility of the larvae and adults of members of the Ae. scutellaris and Ae. kochi groups as well as C. quinquefasciatus and Ae. aegypti occurring in Fiji. The most important finding was that Ae. pseudoscutellaris showed resistance to DDT in some field strains and by laboratory selection pressure on larvae, although tests with adults from the 18th generation of the selected population showed only an LC₅₀ of 1.75% indicating the possible presence of low degree of resistance.

Information on the pesticides used in the field for public health was not very elucidating.

More recently Chow & Suzuki, 1974 (165) compiled the results of susceptibility tests carried out in Fiji on vectors of filariasis and Ae. aegypti starting from Burnett & Ash, 1961 to 1974. The tests were made with organochlorine and organophosphorus insecticides. Adult testing with DDT on Ae. polynesiensis in Fiji in 1974 showed 1.5% which is double the value of the LC₅₀ recorded by Burnett & Ash (93), but in Western Samoa normal susceptibility was recorded. Larval testing showed normal susceptibility of all species tested with DDT, dieldrin, HCH and organophosphorus compounds.

1.3 Combined vector control/chemotherapy

It is worth noting the available information on initial trials on vector control alone and combined measures. Beye *et al.*, 1952 (29) carried out a trial involving the use of DEC treatment for mf carrier, treatment of all people of the trial area, sanitation only, treatment of carriers plus sanitation, DDT spraying only, treatment of positives plus DDT spraying, sanitation plus DDT spraying, treatment of positives plus sanitation plus DDT spraying and treatment of positives and equal number of negatives. Sanitation was carried out within a radius up to 70 m around houses. DDT spraying was applied every three months inside and outside the surfaces of houses and all shrubs up to 27 m around houses. The results showed that neither sanitation nor DDT spraying alone had an impact on the biting population of *Ae. polynesiensis* but spraying indoors had an apparent effect on the resting density of *C. quinquefasciatus* but it is possible that this was through the effect of excito-irritability. The data of the infective rates were too limited to allow statistical analysis to be made on the comparative effectiveness of the measures employed.

Further, Beye *et al.* (34) reported more observations made on the effect of combined control measures extending the previous trial to 15 districts: mass drug administration in four districts; measures against *Ae. polynesiensis* which included general sanitation of household; DDT residual house spraying with 5% emulsion; DDT spraying with 1% emulsion 20 m around human habitation, repeated at six monthly intervals; filling in tree holes with cement and draining of swamps by volunteers; and an intensive education programme to the public and health legislation imposing penalties against irregularities.

In their review of the Tahiti programme, Saugrain & Outin-Fabre, 1972 (155) remarked that residual house spraying or anti-larval measures failed to influence transmission. No infective larvae were detected but the number of mosquitos dissected was too small to be of value. Outin-Fabre *et al.*, 1972 a (238) reviewed the impact of the DEC MDA on mf rate and density and on infection of *Ae. polynesiensis*. A concise but complete review of the filariasis control programme in French Polynesia was made by Merlin *et al.*, 1976 a (245). After 25 years of control against the vector mosquitos by sanitation and the parasite by drug the endemicity of filariasis stabilized to an acceptable level. Mass chemotherapy with DEC giving a single dose treatment produced a desirable effect. The treatment of carriers only, although theoretically accepted, is not effective in practice. Efforts should be made to control the vector by sanitation and biological control. Lagraulet, 1973 (239) stated that mass treatment should be made with a monthly dosage of 6 mg/kg for one or two years. He indicated that elimination of breeding sites around houses is feasible and effective. The DEC control results in the Marquesas Islands was reviewed by Lagraulet *et al.*, 1973 (240).

On the other hand, Kessel, 1957 (68) reviewing the initial period of mass treatment programmes in Tahiti remarked that in part of a district after one year of treatment there was a decline of mf rate and density with corresponding reduction in the larval density in mosquitos but the transmission index remained high. He explained that this may have been due to the absence of mosquito control measures. Kessel & Massal, 1962 (99) indicated that the majority of the Directors of the filariasis control programmes in the South Pacific were convinced that the most rapid and efficient control can be achieved by combined measures. Galliard, 1964 (103) doubting the efficacy of sanitation alone, gave support to combined control measures.

1.4 Trials of biological control

There were several attempts in the early 1950's to introduce the predator Toxorhynchites into some islands of Polynesia in the hope of controlling vectors of filariasis, Muspratt, 1951 (28); Hu, 1952 (30); Muspratt, 1952 (32); Engber *et al.*, 1978 (249); and Bonnet & Chapman, 1956 (57) who expressed their doubts about the effectiveness of this method, point out that the predator does not reproduce as fast as the target mosquito. Ramalingam, 1976 (205) reviewed the introduction into American Samoa of T. brevipalpis and T. amboinensis. The latter was shown by circumstantial evidence that it was misidentified as T. splendens. The author reviewed the assessment made on the effectiveness of T. amboinensis and concluded that, despite the fact that it could establish itself in American Samoa, it had little effect on Ae. polynesiensis due to difference in breeding sites, and could not even suppress Ae. oceanicus which breeds in the same leaf axils.

A preliminary field trial was made by Engber & Pillai, 1977 (212) on the effectiveness of T. amboinensis in Western Samoa against Ae. polynesiensis and Ae. aegypti breeding in tyres which indicated that reduction of the larval density was about 50%. The conclusion was that such a method of control, like any other measure, is not expected to give 100% effectiveness, hence combined measures are recommended. For the first time, a field trial was carried out for the control of Ae. polynesiensis in the coral islands of Tokelau by the introduction of Coelomomyces in permanent and semi-permanent breeding places and the use of dieldrin briquettes in natural and man-made breeding places, Laird, 1967 (117). The findings were encouraging and demonstrated the possibility of practical integrated control.

2. Strategy adopted in filariasis control

After the period of trials with drugs and/or vector control, the principal measure adopted by certain countries was the application of DEC mass treatment in campaigns aiming at covering the whole population. Certain programmes combined mass treatment with vector control by sanitation measures around houses as in Tahiti, Kessel, 1957 (68), except in the experiment of Moorea where DEC treatment was the sole measure, Outin-Fabre, 1972 (152). While in Western Samoa only mass DEC treatment was applied, in American Samoa no organized vector control was undertaken besides mass drug treatment, except for regular village clean-up programmes, Kessel, 1970 (131). For DEC dosage regimens and the results of periodic assessment of the mass treatment campaigns, reference shown in Table 1 for each country and island groups should be consulted.

With the progress of the treatment programmes, the mf rates and densities decreased to a very low level. However, recently there has been either stagnation or tendency of the rates to rise and with more careful surveys utilizing filtration techniques in selected areas, higher mf rates and densities were detected than those recorded by normal routine survey as was reported by several authors and shown under Section I,2. The application of further rounds of mass treatment was found to be impracticable. The crucial question has been what needs to be done to keep the filariasis situation under control fearing of the eventual return to endemicity of the disease with mf carriers escaping detection and treatment and vector populations remaining unchecked. The need, therefore, for establishing an efficient system of surveillance for detection and treatment of mf carriers was repeatedly emphasized with some authors recommending vector control

measures to be attempted, Kessel *et al.* (132), Sasa (153), Hairston (160), Buck (181), Shibuya (218) and Buck (224). The surveillance mechanism thus awaits development. High risk groups and areas must be identified. Buck (181) defined that high risk groups are those villages with poor treatment coverage, young adult males and females when arriving at new residences, pregnant women and old persons incapacitated to attend clinics for treatment. As for identifying high risk areas, in addition to what Buck said about villages with poor coverage, it may be of interest to note that Mahoney & Kessel (141) indicated that persons originally positive, experience the majority of infection acquired after treatment, hence, environmental studies and control should be focussed on living and working areas of this group. Also Hairston, 1973 (160) remarking on transmission in Western Samoa, stated that neither positive cases nor mosquitos are randomly distributed but tend to cluster in certain areas, and infected mosquitos have been found since the end of mass treatment campaigns in certain localities. Such areas of higher transmission would be expected to develop into sources of infection for the rest of the country.

Conclusions:

As has been shown above, the time has come to reconsider the authoritative recommendations highlighting the role of vector control as a component in the new strategy to be developed for preventing resurgence of filariasis transmission in programmes at the advanced stages. Consideration may even be given to the possible role that vector control can play in filariasis control programmes at the initial stages.

If accepted in either or both types of programmes the need for developing effective and economic methods of vector control is to be rated as high priority area. Having reviewed the past experience of vector control attempts the following conclusions may be drawn:

- Sanitation in the peridomestic situation showed, according to some evidence from the early experiences, that with full community participation it could remarkably reduce vector density, so long as the control efforts were continuously sustained and supported by efficient health education and well organized supervision. However, its contribution as adjuvant to mass chemotherapy was nullified on the basis of results of some early trials and control programmes even went on without it.
- The use of insecticides as residual spraying of houses and their surroundings and/or as aerial spraying proved to be of transient or even doubted effect against the highly exophilic vectors. Furthermore, its recurrent cost, hazard to the environment particularly with persistent insecticides and the possibility of eventual development of vector resistance under extensive coverage rule out its consideration even for partial effect. In this context information on vector susceptibility to insecticide is limited and on agriculture pesticides is meagre.
- Useful information has been accrued on the possible means and the procedures of application for dealing with a specific type of breeding place such as tree holes, coconut husks and crab holes. Yet the assessment of such methods largely depended on absence or presence of larvae and some cases on reduction of adult densities

- which was hampered by the presence of other types of breeding places remaining untreated or by other factors. Only a single experiment was conducted which dealt with permanent and semi-permanent breeding places simultaneously in a coral island using insecticide briquettes. No information is available on the control of crabs by mechanical means such as trapping as was suggested by Buxton & Hopkins, 1927 (6).
- Information on cost/effectiveness is fragmentary and is either given as general statements or as man/hour expended in the work or the costs of insecticides hitherto used.
- Biological control has a long way to prove its efficacy and permanency suppressing the target vector. Nevertheless, field trials may be encouraged.

SECTION IV - RECAPITULATION AND FINAL CONCLUSIONS

Following on from the last conclusions concerning the development of a new strategy with vector control as a component, it is necessary to recapitulate the important gaps in knowledge in vector bionomics and other related aspects that are relevant to the epidemiological study of the subperiodic filariasis and to the control of its vectors in Polynesia. For this, an attempt is now made to group the specific conclusions that are related to each other, concentrating on those which need immediate decision for high priority action.

- (a) There is a definite paucity in knowledge of the duration of the gonotrophic cycle, longevity and host preference of major vectors under field conditions (vide SECTION II, 1.4.2, 1.4.3 and 1.6). Host preference studies have been hampered by the lack of precise knowledge on outside resting places of major vectors (II, 1.7) hence the precipitin testing service has scarcely been utilized. Needless to repeat the importance of the above-mentioned parameters for determining the role played by each vector and in quantitative epidemiology.
- (b) The available knowledge on vector flight range being 100 m concerns mainly Ae. polynesiensis and comes from indirect evidence and was supported only by one single experiment with its limitations clearly stated by the investigator (II, 1.10). The early strategy of vector control was based on this range. Nevertheless, contradictions arose, indicating that control should be extended to not less than 300-400 m around houses.

Connected with this aspect is the question of the focality of transmission, whether in the village or plantation and bush, which remained controversial until some sound approach was implemented based on a careful study involving ecological conditions and vector association (II, 3.4). About 15 years have elapsed since this study was carried out, and the possible socio-economic changes would warrant a carefully planned reinvestigation. In this context consideration should be given to the related aspect of the seasonal

distribution of major vectors and fluctuation of infective rates in areas with intense transmission (II, 1.9 and 3.1). A point that was revealed from studies on the biting cycle in Western Samoa which is the finding of fair density of Ae. polynesiensis biting at night (II, 1.8) may also be considered. Verification of this can be integrated in studies on focality of transmission.

Investigations on range of flight and focality of transmission will guide the planning of vector control measures, besides its relevance to the epidemiological studies.

- (c) Regarding vectors' breeding habits, despite a wealth of information on preferential types of habitat, there is a paucity of knowledge on their relative importance and productivity (II, 1.5). This has to be studied under different ecological substrata. The need here arises for developing some system of geographical reconnaissance for locating of breeding sites and for establishing standardized larval sampling techniques as appropriate to each type.

Any anti-larval measures would benefit from the findings of such studies in that the attack can be directed to the main and more permanently producing breeding places.

- (d) Of all experimental infection studies, the infectivity of ultra-low microfilaraemia to major vectors is to be rated as a high priority (II, 3.2.3). Most of the available information comes from a period when mass DEC treatment had not been operating and only one single experiment was carried out in 1973 on Ae. polynesiensis only. It is suggested that further experiments should cover other important diurnal as well as nocturnal biting vectors.
- (e) While standardization of the parasitological techniques is fairly easy to be achieved, the standardization of the entomological sampling techniques, procedures and indices (II, 2) is greatly needed. Statistical approach should be adopted for determination of the sample size of vector species to be dissected within an acceptable level of error. This is particularly important when the vector infective rate falls to a very low level under mass drug treatment. For dealing with large samples the technique of mass separation of the third stage filarial larvae (II, 1.2) should be tried and it may also enhance the contribution of entomology in surveillance. In this and other vector studies correct identification needs to be ascertained. Available keys may help in identifying closely related species (II, 1.1). Local keys may need to be developed. At any rate, consultation of specialists needs to be sought for confirmation should the need arise.

Final conclusions:

- (i) Due to the multiplicity of studies proposed as high priority, it is suggested that most of these can be concentrated in areas of high risk to be determined in advanced programmes or in areas of relatively higher transmission in programmes at the initial stages. Well studied protocols should be prepared so as to cover comprehensively vector studies on the duration of gonotrophic cycle, longevity, range of flight, breeding and resting sites and investigations on focality of transmission combined with observations on vector seasonal prevalence and infective rates in selected areas of epidemiological importance as described above.

- (ii) Vector control efforts being envisaged on a long term basis should be primarily based on non-chemical means to be largely carried out with full community participation stimulated by sustained effective health education and supervision. The use of insecticides should be reserved for special situations. Biodegradable insecticides should be the first choice to be tried. It goes without saying that sound planning of vector control trials should await the results of investigations under (i). Individual trials may have to be conducted to deal with a specific target, i.e. dealing with a specific type of breeding place for a reasonable period to determine fairly accurately cost/effectiveness ratio of different methods. The ultimate goal should be the simultaneous control of all important breeding places and/or the use of imagocides and such ultra-low volume (ULV) applications as may be found appropriate. The procedures adopted in the past may be utilized with improvement as may be found necessary when dealing with a specific type of breeding place. Also other methods which have not been widely tried in the past, such as the trapping of crabs, the use of ovitraps with attractants/insecticides should be assessed. Wherever insecticides are going to be employed for vector control, vector susceptibility levels should be established and periodically checked with concurrent collection of information on pesticides used in agriculture and/or public health fields. It is understood that vector control trials can principally be assessed on an entomological basis. It would be of dual value if entomological assessment of control measures would include dengue vectors.
- (iii) Improvement and standardization of recording and reporting of data including those of population drug coverage have been recommended by several consultants. This will facilitate computerizing the data and statistical analysis and possible the eventual utilization of mathematical models (II, 3.3). Further coordination will be ensured by continuous flow and dissemination of information (I, 2)
- (iv) As has been shown the new strategy and control approach involve the utilization of advanced techniques for which training and refresher training of national staff are inevitably the key answer to success of all operations aiming at eliminating transmission of the disease on which a good deal of resources and efforts have been devoted for many years.

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PART II

BIBLIOGRAPHY AND ABSTRACTS

As under Part I, the review was made particularly for the period 1960-1978. Bibliography and abstracts will also cover essentially the same period.

Part II consists of two Sections: in Section I are lists of bibliography and an Addendum for additional references which have been omitted in the original bibliography but provided by several filariasis workers, especially Dr J. Laigret, as mentioned under acknowledgments. Abstracts are given in Section II.

SECTION I - LISTS OF BIBLIOGRAPHY

1. List by chronological order of the year of publication

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(1)	Manson-Bahr, P.H.	1912	Filariasis and elephantiasis in Fiji
(2)	O'Connor, F.W.	1922	Some results of medical research in the Western Pacific
(3)	O'Connor, F.W.	1923	Researches in Western Pacific
(4)	Buxton, P.A.	1925	The control of mosquitos in Apia, Samoa
(5)	Lambert, S.M.	1926	Health survey of the Cook Islands, with special reference to hookworm disease
(6)	Buxton, P.A. & Hopkins, G.H.F.	1927	Researches in Polynesia and Melanesia: Parts I - IV
(7)	Buxton, P.A.	1928	Researches in Polynesia and Melanesia: Parts V - VII
(8)	Phelps, J.R. <u>et al.</u>	1930	Experimental treatment of filariasis with intramuscular injection of oil of chenopodium
(9)	O'Connor, F.W.	1932	The aetiology of the disease syndrome in <u>Wuchereria bancrofti</u> infections

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(10)	Paine, R.W.	1934	Entomological notes. Mosquito control in coconut plantations
(11)	Venner, R.B.	1944	Filarial problem of Nanumea
(12)	Byrd, E.E., St Amant, L.S & Bromberg, L.	1945	Studies on filariasis in Samoan area
(13)	Amos, D.W.	1946	The mosquito position and filariasis in Rarotonga
(14)	Amos, D.W.	1947	Mosquito control, Suva, Fiji
(15)	Murray, W.D.	1948	Filariasis studies in American Samoa
(16)	Davia, T.R.A.	1949	Filariasis control in the Cook Islands
(17)	Galliard, H., Mille, R. & Robinson, W.H.	1949	La filariose à <u>Wuchereria bancrofti</u> var. <u>pacifica</u> à Tahiti et dans l'archipel de la Societe
(18)	Galliard, H. & Mille, R.	1949	Essais de traitement de la filariose à <u>W. bancrofti</u> var. <u>pacifica</u> par le 1-diethylcarbamyl-4-methyl piperazine à Tahiti
(19)	Satchell, G.H.	1950	On the possibility of controlling filariasis in Rarotonga (Cook Islands) by residual spraying with DDT
(20)	Satchell, G.H., Paine, S. & Hercus, C.E.	1950	Report of the New Zealand Medical Research Council Research Expedition to the Cook Islands, 1949-1950
(21)	Wharton, J.D. & Jachowski, L.A.	1950	Development of methods for control of filariasis in American Samoa
(22)	Edgar, S.A. & Bambridge, B.S	1951	Importance du rat dans la fabrication des gîtes à larves de moustiques. Ou efficacité du baguage pour la protection du cocotier contre les rats

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(23)	Faine, S & Hercus, C.E.	1951	Infections in Rarotonga, Cook Islands
(24)	Hercus, C.E. & Faine, S.	1951	The Rarotongan villager's environment
(25)	Jachowski, L.A., Otto, G.F. & Wharton, J.D.	1951	Filariasis in American Samoa I. Loss of microfilaria in the absence of continued reinfection
(26)	Manson-Bahr, P.	1951	Fiji revisited
(27)	Marks, E.N	1951	The vector of filariasis in Polynesia: a change in nomenclature
(28)	Muspratt, J.	1951	The bionomics of an African <u>Megarhinus</u> (Diptera, Culicidae) and its possible use in biological control
(29)	Beye, H.K. <u>et al.</u>	1952	Preliminary observations on prevalence, clinical manifestation and control of filariasis in Society Islands
(30)	Hu, S.M.K.	1952	Mosquito control in the South Pacific
(31)	Jachowski, L.A. & Otto, G.F.	1952	Filariasis in American Samoa II. Evidences of transmission outside of villages
(32)	South Pacific Commission	1953	Filariasis in South Pacific
(33)	Amos, D.W.	1953	The educational programme on filariasis in Fiji
(34)	Beye, H.K. <u>et al.</u>	1953	Nouvelles recherches sur l'importance, les manifestations cliniques et la lutte contre la filariose à Tahiti, Océanie Française
(35)	Dumbleton, L.J.	1953	A review of progress in mosquito control in the South Pacific area
(36)	Jachowski, L.A.	1953	Transmission of nonperiodic filariasis in the South Pacific

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(37)	Lopdell, J.C.	1953	Filariasis in Western Samoa
(38)	Manson-Bahr, P.	1953	The fight against filariasis in the Pacific
(39)	Otto, G.F., Jachowski, L.A. & Wharton, J.D.	1953	Filariasis in American Samoa III. Studies on chemotherapy against the nonperiodic form of <u>W. bancrofti</u>
(40)	Otto, G.F. & Jachowski, L.A.	1953	Factors in the epidemiology of mosquito-borne filariasis
(41)	Wright, W.H.	1953	The chemotherapy of filariasis
(42)	Ingram, R.L.	1954	A study of the bionomics of <u>Aedes (Stegomyia) polynesiensis</u> Marks under laboratory conditions
(43)	Iyengar, M.O.T.	1954	A scheme for filariasis control in Western Samoa
(44)	Iyengar, M.O.T.	1954 a	Annotated bibliography of filariasis and elephantiasis
(45)	Iyengar, M.O.T.	1954 b	Repartition de la filariose dans la Region du Pacifique Sud
(46)	Jachowski, L.A.	1954	Filariasis in American Samoa. V. Bionomics of the principal vector, <u>Aedes polynesiensis</u> Marks
(47)	Marks, E.N.	1954	A review of the <u>Aedes scutellaris</u> subgroup with a study of variation in <u>Aedes pseudoscutellaris</u> (Theobald) (Diptera: Culicidae)
(48)	Rosen, L.	1954	Human filariasis in the Marquesas Islands
(49)	Rosen, L.	1954 a	Observations on <u>Dirofilaria immitis</u> in French Oceania
(50)	Rosen, L. & Rozeboom, L.E.	1954	Morphologic variations of larvae of the <u>scutellaris</u> groups of <u>Aedes</u> (Diptera, Culicidae) in Polynesia

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(51)	Iyengar, M.O.T.	1955	Distribution of mosquitos in the South Pacific Region
(52)	Jachowski, L.A. & Otto, G.F.	1955	Filariasis in American Samoa. IV. Prevalence of microfilaraemia in the human population
(53)	McCarthy, D.D. & Fitzgerald, N.	1955	Researches in Western Samoa
(54)	Nelson, S. & Cruikshank, J.M.	1955	Filariasis in Fiji
(55)	Otto, G.F. & Jachowski, L.A.	1955	Problems in the epidemiology and control of filariasis
(56)	Rosen, L.	1955	Observations on the epidemiology of human filariasis in French Oceania
(57)	Bonnet, D.D. & Chapman, H.	1956	The importance of mosquito breeding in tree holes with special reference to the problem in Tahiti
(58)	Bonnet, D.D. <u>et al.</u>	1956	Mosquito collection and dissection for evaluation transmission of filariasis in Polynesia (Tahiti)
(59)	Iyengar, M.O.T.	1956	Annotated bibliography of filariasis and elephantiasis. Part 2
(60)	McCarthy, D.D. & Fitzgerald, N.	1956	Habit, habitat and hyper-filarilation in the epidemiology of filariasis in Western Samoa
(61)	Peterson, G.D.	1956	The introduction of mosquitos of the genus <u>Toxorhynchites</u> into American Samoa
(62)	Symes, C.B.	1956	Observations on the natural history of human filariasis in Fiji
(63)	Bonnet, D.D. & Mukaida, T.	1957	A copepod predacious on mosquito larvae

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(64)	Edeson, J.F.B., Hawking, F., & Symes, C.B.	1957	The periodicity of micro-filariae. VI. The response of microfilariae of <u>Wuchereria malayi</u> and <u>W. bancrofti pacific</u> type to various stimuli
(65)	Iyengar, M.O.T.	1957	Annotated bibliography on filariasis and elephantiasis. Part 3. Symptomatology, aetiology, pathology and diagnosis of filariasis due to <u>Wuchereria bancrofti</u> and <u>Brugia malayi</u>
(66)	Iyengar, M.O.T.	1957 a	A report on an investigation on filariasis in the Cook Islands
(67)	Kessel, J.F.	1957	Disabling effects and control of filariasis
(68)	Kessel, J.F.	1957 a	An effective programme for the control of filariasis in Tahiti
(69)	Simpson, E.J.B.	1957	Mass therapy in filariasis. A note on the control in Niue Island
(70)	Bonnet, D.D. & Chapman, H.	1958	The larval habitats of <u>Aedes polynesiensis</u> Marks in Tahiti and methods of control
(71)	Burnett, G.F.	1959	Control of land crabs ("Lairo tui") in Fiji
(72)	Byrd, E.E., & St Amant, L.S	1959	Studies on the epidemiology of filariasis in Central and South Pacific
(73)	Iyengar, M.O.T.	1959	A review on the literature on the distribution and epidemiology of filariasis in the South Pacific Region
(74)	Iyengar, M.O.T.	1959 a	Annotated bibliography of filariasis and elephantiasis. Part 3, Suppl. 1
(75)	Iyengar, M.O.T.	1959 b	Annotated bibliography of filariasis and elephantiasis. Part 4. Treatment

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(76)	Iyengar, M.O.T.	1959 c	Filariasis in American Samoa
(77)	Iyengar, M.O.T.	1959 d	Combating filariasis in Polynesia
(78)	Kessel, J.F. <u>et al.</u>	1959	Epidemiology and control of filariasis with special reference to French Polynesia
(79)	Laigret, J.	1959	Rapport annuel, 1958
(80)	McCarthy, D.D.	1959	Filariasis in the Cook Islands
(81)	Nelson, G.S.	1959	The identification of infective larvae in mosquitos: with a note on the species found in "wild" mosquitos in Kenya coast
(82)	Rageau, J. & Estienne, J.	1959	Enquete sur la filariose a Wallis
(83)	Beye, H.K. & Gurian, J.	1960	The epidemiology and dynamics of transmission of <u>Wuchereria bancrofti</u> and <u>Brugia malayi</u>
(84)	Burnett, G.F.	1960	The arrival of <u>Aedes (Ochlerotatus) vigilax</u> (Skuse) in Fiji
(85)	Burnett, G.F.	1960 a	Filariasis research in Fiji, 1957-1959
(86)	Iyengar, M.O.T.	1960	Annotated bibliography of filariasis and elephantiasis. Part 5. Prophylaxis and control of filariasis due to <u>Wuchereria bancrofti</u> and <u>Brugia malayi</u>
(87)	Iyengar, M.O.T.	1960 a	A review of the mosquito fauna of the South Pacific (Diptera: Culicidae)
(88)	Kessel, J.F.	1960	Nonperiodic bancroftian filariasis
(89)	March, H.N. <u>et al.</u>	1960	Reduction in the prevalence of clinical filariasis in Tahiti following adoption of a control programme

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(90)	Symes, C.B.	1960	Observations on the epidemiology of filariasis in Fiji
(91)	Annual Report of the Government of American Samoa to the Secretary of the Interior,	1961	
(92)	Belkin, J.N.	1961	Nonperiodic bancroftian filariasis in the South Pacific: its vectors and a hypothesis as to its origin
(93)	Burnett, G.F. & Ash, L.H.	1961	The susceptibility to insecticides of disease carrying mosquitos in Fiji
(94)	Iyengar, M.O.T.	1961	Some aspects of filariasis in the South Pacific
(95)	Kessel, J.F.	1961	The ecology of filariasis
(96)	Symes, C.B.	1961	A note on vectors of filariasis in the South Pacific
(97)	Belkin, J.N.	1962	Mosquitos of the South Pacific, Vol. I & II
(98)	Brown, A.W.A.	1962	Insecticidal control of filariasis
(99)	Kessel, J.F. & Massal, E.	1962	Control of bancroftian filariasis in the Pacific
(100)	World Health Organization	1962	Expert Committee on Filariasis (<u>Wuchereria</u> and <u>Brugia</u> infections)
(101)	Burnett, G.F. & Mataika, J.U.	1964	Mass administration of diethylcarbamazine citrate in preventing transmission of aperiodic human filariasis. II. Results of a blood survey made four years after drug administration
(102)	Edeson, J.F.B. & Wilson, T.	1964	The epidemiology of filariasis due to <u>Wuchereria bancrofti</u> and <u>Brugia malayi</u>
(103)	Galliard, H.	1964	A propos de la prophylaxie de la filariose lymphatique. Choix d'une methode

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(104)	Nelson, G.S	1964	Factors influencing the development and behaviour of filarial nematodes in their arthropod hosts
(105)	Ramalingam, S. & Belkin, J.N.	1964	Vectors of the superperiodic bancroftian filariasis in the Samoa-Tonga area
(106)	Tamashiro, M.	1964	Observations on the larval ecology of the <u>Aedes</u> (<u>Stegomyia</u>) <u>polynesiensis</u> Marks on Aitutaki, Southern Cook Islands
(107)	Chow, C.Y.	1965	Vectors of filariasis: their response, susceptibility and resistance to insecticides
(108)	Iyengar, M.O.T.	1965	Epidemiology of filariasis in the South Pacific
(109)	Kessel, J.F.	1965	Combined control methods in filariasis
(110)	Laigret, J. <u>et al.</u>	1965	La lutte contre la filariose lymphatique aperiodique en Polynesie française
(111)	Ramalingam, S & Belkin, J.N.	1965	Mosquito studies: III. Two new <u>Aedes</u> for Tonga and Samoa
(112)	Ciferri, F. <u>et al.</u>	1966	A filariasis control programme in American Samoa
(113)	Laigret, J. <u>et al.</u>	1966	Onze ans de chimio-prophylaxie par la diethyl-carbamazine de la filariose lymphatique aperiodique à Tahiti
(114)	World Health Organization	1966	Inter-Regional Seminar on Filariasis, Manila
(115)	Ciferri, F. & Kessel, J.F.	1967	Relation of age and sex, and microfilaria density to treatment of superperiodic filariasis with diethyl-carbamazine
(116)	Kessel, J.F.	1967	Diethylcarbamazine in filariasis control

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(117)	Laird, M.	1967	A coral island experiment. A new approach to mosquito control
(118)	World Health Organization	1967	Instructions for the collection and forwarding of bloodmeal smears of mosquito for identification of the hosts by precipitin test
(119)	World Health Organization	1967 a	Expert Committee on Filariasis (<u>Wuchereria</u> and <u>Brugia</u> infections); second report
(120)	Chow, C.Y.	1968	Vectors of filariasis in the South Pacific
(121)	Hirston, N.G. & Jachowski, L.A.	1968	Analysis of <u>Wuchereria bancrofti</u> population in the people of American Samoa
(122)	Hirston, N.G. & De Meillon, B.	1968	On the inefficiency of transmission <u>Wuchereria bancrofti</u> from mosquito to human host
(123)	Hitchcock, J.C.	1968	UCLA mosquito studies in Tonga
(124)	Laurence, B.R.	1968	Elephantiasis and Polynesian origins
(125)	Ramalingam, S.	1968	The epidemiology of filarial transmission in Samoa and Tonga
(126)	Suzuki, T. & Maung, T.M.	1968	Review of entomological activities in the filariasis control pilot project in Western Samoa
(127)	Ciferri, F. <u>et al.</u>	1969	A filariasis control programme in American Samoa
(128)	Saugrain, J. & Outin-Fabre, D.	1969	Etude comparative des incidents d'administration de la DEC ordinaire et de la diethylcarbamazine sous son conditionnement enduit
(129)	Desowitz, R., Chularerk, P. & Palumbo, N.E.	1970	Evaluation of a simplified membrane filtration technique for the diagnosis of canine filariasis

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(130)	Hitchcock, J.C.	1970	Evaluation of filariasis mosquito surveys based on the physiological age of the vector
(131)	Kessel, J.F., Tompkins, H. & Jones, K.	1970	Recent studies on the control of filariasis in American Samoa
(132)	Kessel, J. F. <u>et al.</u>	1970 a	Periodic mass treatment with diethylcarbamazine for the control of filariasis in American Samoa
(133)	Ramachandran, C.P.	1970	A guide to methods and techniques in filariasis investigations
(134)	Chow, C.Y.	1971	A review of mosquito vectors of subperiodic <u>Wuchereria bancrofti</u>
(135)	Denham, D. A. <u>et al.</u>	1971	Comparison of a counting chamber and thick smear method of counting microfilariae
(136)	Galliard, H.	1971	Effet du diethylcarbamazine dans la filariose lymphatique au debut de la prophylactique a Tahiti
(137)	Hitchcock, J.C.	1971	Transmission of subperiodic filariasis in Tonga by <u>Aedes oceanicus</u>
(138)	Huang, Y.M. & De Meillon, B.	1971	A brief survey of the <u>Aedes (Stegomyia) scutellaris</u> group of species (Diptera: Culicidae)
(139)	Kessel, J.F.	1971	A review of the filariasis control programme in Tahiti
(140)	Laugralet, J. & Thooris, G.	1971	Reaction a la diethyl-carbamazine chez les porteurs de microfilaires de bancroft (Etude preliminaire)
(141)	Mahoney, L.E. & Kessel, J.F.	1971	Treatment failure in filariasis mass treatment programmes

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(142)	Mataika, J.U. <u>et al.</u>	1971	Mosquito-borne infections in Fiji. I. Filariasis in Northern Fiji: epidemiological evidence regarding factors influencing the prevalence of microfilaraemia of <u>W. bancrofti</u> infections
(143)	Mataika, J.U. <u>et al.</u>	1971 a	Mosquito-borne infections in Fiji. III. Filariasis in Northern Fiji: epidemiological evidence regarding the mechanisms of pathogenesis
(144)	Southgate, B.A. & Desowitz, R.S.	1971	Comparative efficacy of the stained blood film, counting chamber and membrane filtration techniques in the determination of microfilaria rates and microfilaria densities
(145)	World Health Organization	1972	A project on the biology, ecology, systematics and naturalistic control of filariasis vectors in the Pacific group. Report of an advisory working group
(146)	Huang, Y.M.	1972	A redescription of the holotype male of <u>Aedes (Stegomyia) tongae</u> with a note on two topotypic females
(147)	Lagraulet, J. <u>et al.</u>	1972	L'elephantiasis aux Iles Marquises
(148)	Lagraulet, J. <u>et al.</u>	1972 a	Enquete epidemiologique sur la filariose lymphatique aux Marquises
(149)	Moreau, J.P.J. & Outin-Fabre, D.	1972	Essais in vitro de la diethylcarbamazine I. Activite sur les microfilaires de <u>Wuchereria bancrofti</u> var. <u>pacifica</u> II. Activite sur les larves infestantes de <u>W. bancrofti</u> var. <u>pacifica</u>

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(150)	Moreau, J.P. <u>et al.</u>	1972	Serum protein in filariasis of the lymphatic system caused by <u>Wuchereria bancrofti</u> var. <u>pacifica</u> . Electrophoretic analysis and quantitative immunochemical determination of A, M, G, and E immunoglobulins
(151)	Oldham, M., Lusk, E.E. & Womeldorf, D.J.	1972	Residual activity of various insecticides in tree holes
(152)	Outin Fabre, D. <u>et al</u>	1972	Une experience pilote de campagne antifilarienne en milieu insulaire (Moorea, Polynesie française)
(153)	Sasa, M.	1972	Assignment report
(154)	Saugrain, J. & Outin-Fabre, D.	1972	Bilan de vingt années de lutte contre la filariose périodique de bancroft en Polynésie française
(155)	Thieme, J.C. & Penaia, L.	1972	Filarial control project in Western Samoa
(156)	Chow, C.Y.	1973	Filarial vectors in Western Pacific Region
(157)	Desowitz, R.S.	1973	Epidemiological investigations on filariasis in Fiji and Tonga including a small additional survey in Western Samoa
(158)	Desowitz, R.S. & Southgate, B.A.	1973	Studies on filariasis in the Pacific: 2. The persistence of microfilaraemia in diethylcarbamazine treated populations
(159)	Desowitz, R.S., Southgate, B.A. & Mataika, J.U.	1973	Studies on filariasis in the Pacific: 3. Comparative efficacy of the stained blood film counting-chamber and membrane-filtration techniques for the diagnosis of <u>Wuchereria bancrofti</u> microfilaraemia in untreated patients in areas of low endemicity

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(160)	Hairston, N.	1973	Assessment report on filariasis in Western Samoa
(161)	Hitchcock, J.C. & Rozeboom, L.E.	1973	Cross-breeding of <u>Aedes</u> (<u>S.</u>) <u>polynesiensis</u> with an autogenous species of the <u>A. scutellaris</u> group
(162)	Ricosse, J.H. & Picq, J.J.	1973	Indications cliniques des filaricides
(163)	Rozeboom, L.E., Rosen, L. & Ikeda, J.	1973	Observations on oviposition of <u>Aedes</u> (<u>S.</u>) <u>albopictus</u> and <u>A. (S.) polynesiensis</u> in nature
(164)	Southgate, B.A.	1973	Studies on filariasis in the Pacific: 1. A field trial of a counting chamber technique for the determination of microfilaria rates and densities
(165)	Chow, C.Y. & Suzuki, T.	1974	Filariasis vectors and their control in the South Pacific
(166)	Desowitz, R.S.	1974	The application of a membrane filter concentration method in filariasis survey in the South Pacific area
(167)	Desowitz, R.S. & Hitchcock, J.C.	1974	Hyperendemic bacroftian filariasis in the Kingdom of Tonga: the application of the membrane filter concentration technique to an age-stratified blood survey
(168)	Maung, T.M.	1974	Clinical aspects of filariasis
(169)	Maung, T.M.	1974 a	Assignment report, Feb. 1972 to Dec 1974
(170)	Maung, T.M.	1974 b	Filariasis control by the application of mass drug administration in Western Samoa, Ellice Islands and Niue

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(171)	Muller, R.L. & Denham, D.A.	1974	A field technique for the recovery and preservation of infective filarial larvae from their vectors
(172)	Pichon, G.	1974	Etude de la reduction parasitaire chez differents vecteurs naturels ou experimentaux de filariose
(173)	Pichon, G.	1974 a	Relations mathematiques entre le nombre des microfilaires ingerees et le nombre des parasites chez differents vecteurs naturels et experimentaux de filariose
(174)	Pichon, G. Perrault, G. & Laigret, J.	1974	Rendement parasitaire chez les vecteurs de filariose
(175)	Rakai, I.M. <u>et al.</u>	1974	Mosquito-borne infection in Fiji. IV. Biting times for village mosquitos and human filaria transmission potential of <u>Aedes polynesiensis</u> and <u>Aedes pseudoscutellaris</u>
(176)	Southgate, B.A.	1974	A quantitative approach to parasitological technique in bancroftian filariasis and its effect on epidemiological understanding
(177)	Suzuki, T. & Sone, F.	1974	The bionomics of filariasis vectors in Western Samoa
(178)	World Health Organization	1974	Expert Committee on Filariasis, third report
(179)	WHO/SPC	1974	Report on the Joint Seminar on Filariasis and Vector Control
(180)	Buck, A.A. & Zahar, A.R.	1975	Report on a visit
(181)	Buck, A.A.	1975	Mission of Dr A.A. Buck
(182)	Dietz, K.	1975	An epidemiological model for filarial infections

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(183)	Desowitz, R.S.	1975	Immunoglobulin levels in an untreated population living in an area of hyperendemic bancroftian filariasis (Tonga) and in a population subject to a filariasis control programme (American Samoa)
(184)	Fain, A.	1975	Resume et analyse des projets de la filariose dans la region du Pacifique
(185)	Huang, Y.M.	1975	A redescription of <u>Aedes (Stegomyia) pseudoscutellaris</u> (Theobald) with a note on the taxonomic status of <u>Aedes (Stegomyia) polynesiensis</u> Marks
(186)	Moreau, J.P. Radanielina, R. & Barbier, P.	1975	Activite du levamisole dans la filariose de bancroft. Evolution de la microfilaremie au cours d'une cure de 12 jours apres un recul de 45 jours
(187)	Pichon, G., Prodhon, J. & Riviere, F	1975	Recherche d'une loi de distribution des microfilaires ingerees par des moustiques piquant un filarien. Premiers resultats
(188)	Pichon, G., Prodhon, J. & Riviere, F.	1975 a	Distribution des microfilaires ingerees par les moustiques
(189)	Pichon, G. Prodhon, J. & Riviere, F.	1975 b	Rendement parasitaire chez les vecteurs de la filariose 3. Influence combinee de la moralite vectorielle du au parasitisme et du suspeuplement parasitaire
(190)	Suzuki, T. & Sone, F.	1975	Filarial infection in vector mosquitos after mass drug administration in Western Samoa
(191)	World Health Organization	1975	Research on filarial infections

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(192)	Bryan, J.H. & Southgate, B.A.	1976	Some observations on filariasis in Western Samoa after mass administration of diethylcarbamazine
(193)	Desowitz, R.S. & Una, S.R.	1976	The detection of antibodies in human and animal filariasis by counter-current immuno-electrophoresis
(194)	Desowitz, R.S., Berman, S.J. & Puloka, T.	1976	Hyperendemic subperiodic bancroftian filariasis: a search for clinical and immunological correlates of microfilaremia
(195)	Hawking, F. & Denham, D.	1976	Distribution of human filariasis. Part I
(196)	Hitchcock, J.C.	1976	Final report on field investigation on filarial infections
(197)	Hoyer, L.C. & Rozeboom, L.E.	1976	Inheritance of autopsy in the <u>Aedes scutellaris</u> subgroup of mosquitos
(198)	Maung, T.M. & Penaia, L.	1976	Filariasis control in Western Samoa by the mass drug administration method
(199)	Merlin, M. <u>et al.</u>	1976	Activite du levamisole (solaski) dans la lymphatique a <u>Wuchereria bancrofti</u> (var. <u>pacifica</u>)
(200)	Moreau, J.P. & Picq, J.J.	1976	Chimiotherapie des filarioses lymphatiques applications pratiques et donnees recentes
(201)	Pichon, G., Prodhon, J. & Riviere, F.	1976	Influence de la "surdispersion" et de l'etat sexue sur la dynamique des populations de parasites
(202)	Pichon, G. <u>et al.</u>	1976 a	Heterogeneite de l'ingestion des parasites sanguicoles par leurs vecteurs: description quantitative, interpretation et consequences

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(203)	Pichon, G. <u>et al.</u>	1976 b	Etude de la distribution des densites microfilarieennes dans les foyers de filariose lymphatique
(204)	Ramalingam, S.	1976	Annotated checklist and keys to mosquitos of Samoa and Tonga
(205)	Ramalingam, S. & Belkin, J.N.	1976	Immature stages of <u>Ae. samoanus</u> and the status of <u>Toxorhynchites</u> in American Samoa
(206)	Sasa, M.	1976	Human filariasis. A global survey of epidemiology and control
(207)	Suzuki, T.	1976	Final report of Intercountry Filariasis Team
(208)	Suzuki, T. & Sone, F.	1976	Breeding habits of vector mosquitos of filariasis and dengue fever in Samoa
(209)	Suzuki, T. & Sone, F.	1976 a	Laboratory and field tests of insecticides against vector mosquitos of subperiodic filariasis in Western Samoa
(210)	Beckett, E.B., Boothroyd, B. & Macdonald, W.W.	1977	Rickettsia-like micro-organisme in members of the <u>Aedes scutellaris</u> complex
(211)	Chow, C.Y.	1977	Filariasis studies in the Western Pacific Region
(212)	Engber, B. & Pillai, J.S.	1977	<u>Toxorhynchites amboinensis</u> as biological control agent of vector mosquitos
(213)	Huang, Y.M.	1977	The mosquitos of Polynesia with a pictorial key to some species associated with filariasis and/or dengue fever
(214)	Owen, R.R.	1977	Differences in the migration patterns of <u>Brugia pahangi</u> microfilaria in susceptible and refractory members of the <u>Aedes scutellaris</u> group

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(215)	Partono, F. & Idris, K.N.	1977	Some factors influencing the loss of microfilaria from stained thick blood film
(216)	Rooney, D.E.	1977	A study of the chromosomes of members of the <u>Aedes scutellaris</u> group with particular reference to the differences revealed by Giemsa C-banding
(217)	Self, L.S.	1977	Report on a field visit to Tonga
(218)	Shibuya, T.	1977	Assignment report on Western Samoa
(219)	Suzuki, T.	1977	Preliminary studies on blood meal interval of <u>Ae. polynesiensis</u> in the field
(220)	Tompkins, N. & Williams, T.R.	1977	A comparative scanning electron microscope study of the eggs of four <u>Aedes scutellaris</u> complex species. Laboratory demonstrations exhibited at the Liverpool School of Tropical Medicine
(221)	Townson, H., Meredith, S.E.O. & Thomas, K.	1977	Studies of enzymes in the <u>Aedes scutellaris</u> group
(222)	Wade, J.O. & Macdonald, W.W.	1977	Compatible and incompatible crosses within the <u>Aedes scutellaris</u> group
(223)	Richard, C.	1977	Sanitary engineering and mosquito control
(224)	Buck, A.A.	1978	Visit to research institutions in the USA, countries and territories in the South Pacific area and to Papua New Guinea
(225)	World Health Organization	1978	Report on the Working Group on Subperiodic Bancroftian Filariasis

2. Addendum to the above list

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(226)	Edgar, S.A. et al.	1952	A preliminary report on a "periodic tendency" of microfilariae of <u>W. bancrofti</u> observed in Tahiti, French Oceania
(227)	McCarthy, D.D.	1953	New Zealand Medical Research in the South Pacific
(228)	Iyengar, M.O.T.	1958	An investigation on filariasis in Niue
(229)	McCarthy, D.D.	1959 a	The endemicity of filariasis in the Pacific Island Dependencies of New Zealand
(230)	South Pacific Commission	1960	Summary of the report of the Study Group on Filariasis
(231)	Iyengar, M.O.T.	1960 b	Summary data on filariasis in the South Pacific
(232)	Norman-Taylor, W.	1963	Bibliographie commentée de la recherche médicalé dans le Pacific sud
(233)	Laigret, J.	1965	Consideration sur les crises de lymphangite récurrente survenant au cours de l'évolution de la filariose lymphatique à <u>Wuchereria bancrofti</u> subpériodique
(234)	McCarthy, D.D. & Carter, D.G.	1967	Report on filariasis in Tokelau Islands
(235)	World Health Organization	1968	Report on the Second WHO/SPC Joint Seminar on Filariasis
(236)	Lagraulet, J., Barsinas, M. & Fagneau, G.	1972	Hétérogénéité de la répartition de microfilaires dans le sang périphérique chez les malades atteints de filariose de Bancroft et aperçu général sur la filariose aux Marquises

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(237)	Moreau, J.P., Cuzon, G., Pichon, G., Outin-Fabre, D. & Lagraulet, J. (avec la collaboration technique de Mme N. Lefbevre et Mlle S. Lee Sang)	1972 a	Les protéines sériques du filarien lymphatique à <u>Wuchereria bancrofti</u> var. <u>pacifica</u> . Etude électrophorétique et dosage immuno-chimique des immunoglobulines A, M, G, et E
(238)	Outin-Fabre D., Moreau, J.P., & Stranghellini, A.	1972 a	Physionomie actuelle de l'endémie filarienne en Polynésie et son contrôle. Recherches en cours.
(239)	Lagraulet, J.	1973	Prophylaxie et traitement de la filariose lymphatique en Polynésie française
(240)	Lagraulet, J., Barsinas, M., Fagneaux, G. & Teahui, M.	1973	Etat actuel de la filariose aux Marquises et différents aspects épidémiologiques
(241)	Carme, B., Kaeuffer, H. & Laigret, J.	1976	Eosinophilie et filariose lymphatique en Polynésie française
(242)	Carme, B., Pichon, G., Kaeuffer, H. & Laigret, J.	1976 a	L'invasion filarienne dans la filariose lymphatique
(243)	Kaeuffer, H., Carme, B. & Laigret, J.	1976	Intérêt de l'hémagglutination passive et perspectives immatérielle de filariose lymphatique
(244)	Kaeuffer, H., Carme, B. & Merlin, M.	1976 a	Etude comparative de trois méthodes de mise en évidence des microfilaries sanguicoles appliquées à la filariose lymphatique
(245)	Merlin, M. Fiviere, F., Kaeuffer, H. & Laigret, J.	1976 a	25 ans de campagnes de masse antifilariales en Polynésie française
(246)	Carme, B., Pichon, G., Merlin, M. & Laigret, J.	1977	Longévité des filaires lymphatiques: A propos d'une filaire <u>Wuchereria bancrofti</u> toujours féconde après 40 ans d'existence

<u>Serial No</u>	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
(247)	Carme, B., Pichon, G., Merlin, M. & Laigret, J.	1977 a	Rôle des intraporteurs de microfilaires dans la transmission de la filariose lymphatique
(248)	Parc, F., Rivière, F., Roux, J. & Laigret, J.	1978	Méthodes simplifiées de récolte des formes larvaires de <u>Wuchereria bancrofti Cobbold</u> (var. <u>pacifica</u>): leur préparation pour immuno-fluorescence
(249)	Engber, B., Sone, P.F. & Pillai, J.C.	1978	The occurrence of <u>Toxorhynchites amboinensis</u> in Western Samoa

3. List by alphabetical order of author(s)

The figures in () after the title denote the serial number in Series 1 & 2 of SECTION I.

	<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
1.	Amos, D. W.	1946	The mosquito position and filariasis in Rarotonga (13)
2.	Amos, D.W.	1947	Mosquito control, Suva, Fiji (14)
3.	Amos, D.W.	1953	The educational programme on filariasis in Fiji (33)
4.	Annual Report of the Government of American Samoa to the Secretary of the Interior, 1961 (91)		
5.	Beckett, E.B., Boothroyd, B. & Macdonald, W.W.	1977	Rickettsia-like microorganisms in members of the <u>Aedes scutellaris</u> complex (210)
6.	Belkin, J.N.	1961	Nonperiodic bancroftian filariasis in the South Pacific: its vectors and a hypothesis as to its origin (92)
7.	Belkin, J.N.	1962	Mosquitos of the South Pacific vol I & II (97)
8.	Beye, H.K. & Gurian, J.	1960	The epidemiology and dynamics of transmission of <u>W. bancroftian</u> and <u>B. malayi</u> (83)

<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
9. Beye, H.K. <u>et al.</u>	1952	Preliminary observations on prevalence, clinical manifestation and control of filariasis in Society Islands (29)
10. Beye, H.K. <u>et al.</u>	1953	Nouvelles recherches sur l'importance, les manifestations cliniques et la lutte contre la filariose à Tahiti, Océanie française (34)
11. Bonnet, D.D. & Chapman, H.	1956	The importance of mosquito breeding in tree holes with special reference to the problem in Tahiti (57)
12. Bonnet, D.D. & Mukaida, T.	1957	A copepod predacious on mosquito larvae (63)
13. Bonnet, D.D. & Chapman, H.	1958	The larval habitats of <u>Ae. polynesiensis</u> in Tahiti and methods of control (70)
14. Bonnet, D.D. <u>et al.</u>	1956	Mosquito collection and dissection for evaluation transmission of filariasis in Polynesia (Tahiti) (58)
15. Brown, A.W.A.	1962	Insecticidal control of filariasis (98)
16. Bryan, J.H. & Southgate, B.A.	1976	Some observations on filariasis in Western Samoa after mass administration of diethylcarbamazine (192)
17. Buck, A.A.	1975	Mission of Dr A.A. Buck (181)
18. Buck, A.A.	1978	Visit to research institutions in the USA, to countries and territories in the South Pacific area, and to Papua New Guinea (224)
19. Buck, A.A. & Zahar, A.R.	1975	Report on a visit (180)
20. Burnett, G.F.	1959	Control of land crabs ("Lairo tui") in Fiji (71)
21. Burnett, G.F.	1960	The arrival of <u>Ae. (Ochlerotatus) vigilax</u> in Fiji (84)

<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
22. Burnett, G.F.	1960 a	Filariasis research in Fiji, 1957-1959 (85)
23. Burnett, G.F. & Ash, L.H.	1961	The susceptibility to insecticides of disease carrying mosquitos in Fiji (93)
24. Burnett, G.F. & Mataika, J.U.	1964	Mass administration of diethylcarbamazine citrate in preventing transmission of aperiodic human filariasis. II. Results of a blood survey made four years after drug administration (101)
25. Buxton, P.A.	1925	The control of mosquitos in Apia, Samoa (4)
26. Buxton, P.A.	1928	Researches in Polynesia and Melanesia: Parts V - VII (7)
27. Buxton, P.A. & Hopkins, G.H.F.	1927	Researches in Polynesia and Melanesia: Parts I - IV (6)
28. Byrd, E.E., St Amant, L.S. & Bromberg, L.	1945	Studies on filariasis in Samoan area (12)
29. Byrd, E.E. & St Amant, L.S.	1959	Studies on the epidemiology of filariasis in Central and South Pacific (72)
30. Carme, B. <u>et al.</u>	1976	Eosinophilie et filariose lymphatique en Polynésie française (241)
31. Carme, B. <u>et al.</u>	1976 a	L'invasion filarienne dans la filariose lymphatique (242)
32. Carme, B. <u>et al.</u>	1977	Longévité des filaires lymphatiques: A propos d'une filaire <u>Wuchereria bancrofti</u> toujours féconde après 40 ans d'existence (246)
33. Carme, B. <u>et al.</u>	1977 a	Rôle de intraporteurs de micro-filiaires dans la transmission de la filariose lymphatique (247)
34. Chew, C.Y.	1965	Vectors of filariasis: their response, susceptibility and resistance to insecticides (107)

<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
35. Chow, C.Y.	1968	Vectors of filariasis in the South Pacific (120)
36. Chow, C.Y.	1971	A review of mosquito vectors of subperiodic <u>W. bancrofti</u> (134)
37. Chow, C.Y.	1973	Filariasis vectors in the Western Pacific Region (156)
38. Chow, C.Y.	1977	Filariasis studies in the Western Pacific Region (211)
39. Chow, C.Y. & Suzuki, T.	1974	Filariasis vectors and their control in the South Pacific (165)
40. Ciferri, F. <u>et al.</u>	1967	Relation of age and sex, and microfilaria density to treatment of subperiodic filariasis with diethylcarbamazine (115)
41. Ciferri, F. <u>et al.</u>	1966	A filariasis control programme in American Samoa (112)
42. Ciferri, F. <u>et al.</u>	1969	A filariasis control programme in American Samoa (127)
43. Davis, T.R.A.	1949	Filariasis control in the Cook Islands (16)
44. Denham, D. A. <u>et al.</u>	1971	Comparison of a counting chamber and thick smear method of counting microfilariae (135)
45. Desowitz, R.S.	1973	Epidemiological investigations on filariasis in Fiji and Tonga including a small additional survey in Western Samoa (157)
46. Desowitz, R.S.	1974	The application of a membrane filter concentration method in filariasis survey in the South Pacific area (166)
47. Desowitz, R.S.	1975	Immunoglobulin levels in an untreated population living in an area of hyperendemic bancroftian filariasis (Tonga) and in a population subject to a filariasis control programme (American Samoa) (183)

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48. Desowitz, R.S., Chularerk, P. & Palumbo, N.E.	1970	Evaluation of a simplified membrane filtration technique for the diagnosis of canine filariasis (129)
49. Desowitz, R.S. & Southgate, B.A.	1973	Studies on filariasis in the Pacific: 2. The persistence of microfilaraemia in diethyl-carbamazine treated populations (158)
50. Desowitz, R.S., Southgate, B.A. & Mataika, J.U.	1973	Studies on filariasis in the Pacific: 3. Comparative efficacy of the stained blood film counting-chamber and membrane-filtration techniques for the diagnosis of <u>W. bancrofti</u> microfilaraemia in untreated patients in areas of low endemicity (159)
51. Desowitz, R.S. & Hitchcock, J.C.	1974	Hyperendemic bancroftian filariasis in the Kingdom of Tonga: the application of the membrane filter concentration technique to an age-stratified blood survey (167)
52. Desowitz, R.S. & Una, S.R.	1976	The detection of antibodies in human and animal filariasis by counter-current immuno-electrophoresis (193)
53. Desowitz, R.S., Berman, S.J. & Puloka, T.	1976	Hyperendemic subperiodic bancroftian filariasis: a search for clinical and immunological correlates of microfilaraemia (194)
54. Dietz, K.	1975	An epidemiological model for filarial infections (182)
55. Dumbleton, L.J.	1953	A review of progress in mosquito control in the South Pacific (35)
56. Edeson, J.F.B., Hawking, F. & Symes, C.B.	1957	The periodicity of microfilariae. VI. The response of microfilariae of <u>W. malayi</u> and <u>W. bancrofti</u> pacific type to various stimuli (64)

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57. Edeson, J.F.B. & Wilson, T.	1964	The epidemiology of filariasis due to <u>W. bancrofti</u> and <u>B. malayi</u> (102)
58. Edgar, S.A. & Bambridge, B.S.	1951	Importance du rat dans la fabrication des gites à larves de moustiques (22)
59. Edgard, S.A. <u>et al.</u>	1952	A preliminary report on a "periodic tendency" of microfilariae of <u>W. bancrofti</u> observed in Tahiti, French Oceania (226)
60. Engber, B. & Pillai, J.S.	1977	<u>Toxorhynchites amboinensis</u> as biological control agent of vector mosquitos (212)
61. Engber, B. <u>et al.</u>	1978	The occurrence of <u>T. amboinensis</u> in Western Samoa (249)
62. Faine, A.	1975	Resumé et analyse des projets de la filariose dans la région du Pacifique (184)
63. Faine, S. & Hercus, C.E.	1951	Infections in Rarotonga, Cook Islands (23)
64. Galliard, H.	1964	A propos de la prophylaxie de la filariose lymphatique. Choix d'une méthode (103)
65. Galliard, H.	1971	Effet du diéthylcarbamazine dans la filariose lymphatique au début de la prophylactique à Tahiti (136)
66. Galliard, H. & Mille, R.	1949	Essais de traitement de la filariose à <u>W. bancrofti</u> var. <u>pacifica</u> par le 1-diéthylcarbamyl-4-methyl piperazine à Tahiti (18)
67. Galliard, H., Mille, R. & Robinson, W.H.	1949	La filariose à <u>W. bancrofti</u> var. <u>pacifica</u> à Tahiti et dans l'archipel de la Société (17)
68. Hairston, N.	1973	Assessment report on filariasis in Western Samoa (160)
69. Hairston, N.G. & De Meillon, B.	1968	On the inefficiency of transmission of <u>W. bancrofti</u> from mosquito to human host (122)

<u>Author(s)</u>	<u>Year of Publication</u>	<u>Title</u>
70. Hairston, N.G. & Jachowski, L.A.	1968	Analysis of <u>W. bancrofti</u> population in the people of American Samoa (121)
71. Hawking, F. & Denham, D.	1976	Distribution of human filariasis. Part I (195)
72. Hercus, C.E. & Faine, S.	1951	The Rarotongan villagers' environment (24)
73. Hitchcock, J.C.	1968	UCLA mosquito studies in Tonga (123)
74. Hitchcock, J.C.	1970	Evaluation of filariasis mosquito surveys based on the physiological age of the vector (130)
75. Hitchcock, J.C.	1971	Transmission of subperiodic filariasis in Tonga by <u>Ae. oceanicus</u> (137)
76. Hitchcock, J.C.	1976	Final report on field investigations on filarial infections (196)
77. Hitchcock, J.C. & Rozeboom, L.E.	1973	Cross-breeding of <u>Ae. polynesiensis</u> with an autogenous species of the <u>Ae. scutellaris</u> group (161)
78. Hoyer, L.C. & Rozeboom, L.e.	1976	Inheritance of autogeny in the <u>Ae. scutellaris</u> subgroup of mosquitos (197)
79. Hu, S.M.K.	1952	Mosquito control in the South Pacific (30)
80. Huang, Y.M.	1972	A redescription of the holotype male of <u>Ae. tongae</u> with a note on two topotypic females (146)
81. Huang, Y.M.	1975	A redescription of <u>Ae. (Stegomyia) pseudoscutellaris</u> with a note on the taxonomic status of <u>Ae. polynesiensis</u> (185)
82. Huang, Y.M.	1977	The mosquitos of Polynesia with a pictorial key to some species associated with filariasis and/or dengue fever (213)

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83. Huang, Y.M. & De Meillon, B.	1971	A brief survey of the <u>Ae. scutellaris</u> group of species (138)
84. Ingram, R.L.	1954	A study of the bionomics of <u>Ae. polynesiensis</u> under laboratory conditions (42)
85. Iyengar, M.O.T.	1954	A scheme for filariasis control in Western Samoa (43)
86. Iyengar, M.O.T.	1954 a	Annotated bibliography of filariasis and elephantiasis (44)
87. Iyengar, M.O.T.	1954 b	Repartition de la filariose dans la Region du Pacifique sud (45)
88. Iyengar, M.O.T.	1955	Distribution of mosquitos in the South Pacific Region (51)
89. Iyengar, M.O.T.	1956	Annotated bibliography of filariasis and elephantiasis. Part 2 (59)
90. Iyengar, M.O.T.	1957	Annotated bibliography on filariasis and elephantiasis. Part 3. Symptomatology, aetiology, pathology and diagnosis of filariasis due to <u>W. bancrofti</u> and <u>B. malayi</u> (65)
91. Iyengar, M.O.T.	1957 a	A report on investigation on filariasis in the Cook Islands (66)
92. Iyengar, M.O.T.	1958	An investigation on filariasis in Niue (228)
93. Iyengar, M.O.T.	1959	A review of the literature on the distribution and epidemiology of filariasis in the South Pacific Region (73)
94. Iyengar, M.O.T.	1959 a	Annotated bibliography of filariasis and elephantiasis. Part 3, Suppl. 1 (74)
95. Iyengar, M.O.T.	1959 b	Annotated bibliography of filariasis and elephantiasis. Part 4. Treatment (75)

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96. Iyengar, M.O.T.	1959 c	Filariasis in American Samoa (76)
97. Iyengar, M.O.T.	1959 d	Combating filariasis in Polynesia (77)
98. Iyengar, M.O.T.	1960	Annotated bibliography of filariasis and elephantiasis. Part 5. Prophylaxis and control of filariasis due to <u>W. bancrofti</u> and <u>B. malayi</u> (86)
99. Iyengar, M.O.T.	1960 a	A review of the mosquito fauna of the South Pacific (87)
100. Iyengar, M.O.T.	1960 b	Summary data on filariasis in the South Pacific (231)
101. Iyengar, M.O.T.	1961	Some aspects of filariasis in the South Pacific (94)
102. Iyengar, M.O.T.	1965	Epidemiology of filariasis in the South Pacific (108)
103. Jachowski, L.A.	1953	Transmission of nonperiodic filariasis in the South Pacific (36)
104. Jachowski, L.A.	1954	Filariasis in American Samoa. V. Bionomics of the principal vector, <u>Ae. polynesiensis</u> (46)
105. Jachowski, L.A. & Otto, G.F.	1952	Filariasis in American Samoa II. Evidences of transmission outside of villages (31)
106. Jachowski, L.A. & Otto, G.F.	1955	Filariasis in American Samoa. IV Prevalence of microfilaraemia in the human population (52)
107. Jachowski, L.A., Otto, G.F. & Wharton, J.D.	1951	Filariasis in American Samoa. I Loss of microfilaria in the absence of continued reinfection (25)
108. Kaeuffer, H. <u>et al.</u>	1976	Intérêt de l'hémagglutination passive et perspectives in matière de filariose lymphatique (243)
109. Kaeuffer, H. <u>et al.</u>	1976 a	Etude comparative de trois méthodes de mise en évidence de microfilaires sanguicoles, appliquées à la filariose lymphatique (244)

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110. Kessel, J.F.	1957	Disabling effects and control of filariasis (67)
111. Kessel, J.F.	1957 a	An effective programme for the control of filariasis in Tahiti (68)
112. Kessel, J.F.	1960	Nonperiodic bancroftian filariasis (88)
113. Kessel, J.F.	1961	The ecology of filariasis (95)
114. Kessel, J.F.	1965	Combined control methods in filariasis (109)
115. Kessel, J.F.	1967	Diethylcarbamazine in filariasis control (116)
116. Kessel, J.F.	1971	A review of the filariasis control programme in Tahiti (139)
117. Kessel, J.F. <u>et al.</u>	1959	Epidemiology and control of filariasis with special reference to French Polynesia (78)
118. Kessel, J.F. & Massal, E.	1962	Control of bancroftian filariasis in the Pacific (97)
119. Kessel, J.F., Tompkins, H. & Jones, K.	1970	Recent studies on the control of filariasis in American Samoa (131)
120. Kessel, J.F. <u>et al</u>	1970 a	Periodic mass treatment with diethylcarbamazine for the control of filariasis in American Samoa (132)
121. Lagraulet, J.	1973	Prophylaxie et traitement de la filariose lymphatique en Polynésie française (239)
122. Lagraulet, J. & Thooris, G.	1971	Réaction à la diethylcarbamazine chez les porteurs de micro-filariae de Bancroft (140)
123. Lagraulet, J. <u>et al.</u>	1972	L'éléphantiasis aux Iles Marquises (147)
124. Lagraulet, J. <u>et al.</u>	1972 a	Enquête épidémiologique sur la filariose lymphatique aux Marquises (148)

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125. Lagraulet, J. <u>et al.</u>	1972 b	Hétérogénéité de la répartition des microfilaires dans le sang périphérique chez les malades atteints de filariose de Bancroft et aperçu général sur la filariose aux Marquises (236)
126. Lagraulet, J. <u>et al.</u>	1973	Etat actuel de la filariose aux Marquises et différents aspects épidémiologiques (240)
127. Laigret, J.	1959	Rapport annuel, 1958 (79)
128. Laigret, J.	1965	Consideration sur les crises de lymphangite récurrente survenant au cours de l'évolution de la filariose lymphatique à <u>Wuchereria bancrofti</u> subpériodique (233)
129. Laigret, J. <u>et al.</u>	1965	La lutte contre la filariose lymphatique apériodique en Polynésie française (110)
130. Laigret, J. <u>et al.</u>	1966	Onze ans de chimioprophylaxie par la diethylcarbamazine de la filariose lymphatique apériodique à Tahiti (113)
131. Laird, M.	1967	A coral island experiment - A new approach to mosquito control (117)
132. Lambert, S.M.	1926	Health survey of the Cook Islands (5)
133. Laurence, B.R.	1968	Elephantiasis and Polynesian origins (124)
134. Lopdell, J.C.	1953	Filariasis in Western Samoa (37)
135. Mahoney, L.E. & Kessel, J.F.	1971	Treatment failure in filariasis mass treatment programmes (141)
136. Manson-Bahr, P.	1912	Filariasis and elephantiasis in Fiji (1)
137. Manson-Bahr, P.	1951	Fiji revisited (26)
138. Manson-Bahr, P.	1953	The fight against filariasis in the Pacific (38)

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139. March, H.N. <u>et al.</u>	1960	Reduction in the prevalence of clinical filariasis in Tahiti following adoption of a control programme (89)
140. Marks, E.N.	1951	The vector of filariasis in Polynesia: a change in nomenclature (27)
141. Marks, E.N.	1954	A review of the <u>Ae. scutellaris</u> subgroup with a study of variation of <u>Ae. pseudoscutellaris</u> (147)
142. Mataika, J.U. <u>et al.</u>	1971	Mosquito-borne infections in Fiji. I. Filariasis in Northern Fiji: epidemiological evidence regarding factors influencing the prevalence of microfilaraemia of <u>W. bancrofti</u> infections (142)
143. Mataika, J.U. <u>et al.</u>	1971 a	Mosquito-borne infections in Fiji. III. Filariasis in Northern Fiji: epidemiological evidence regarding the mechanisms of pathogenesis (143)
144. Maung, T.M.	1974	Clinical aspects of filariasis (168)
145. Maung, T.M.	1974 a	Assignment report Feb. 1972 to Dec. 1974 (169)
146. Maung, T.M.	1974 b	Filariasis control by the application of mass drug administration in Western Samoa, Ellice Islands and Niue (170)
147. Maung, T.M. & Penaia, L.	1976	Filariasis control in Western Samoa by the mass drug administration method (198)
148. McCarthy, D.D.	1953	New Zealand Medical Research in the South Pacific (227)
149. McCarthy, D.D.	1959	Filariasis in the Cook Islands (80)
150. McCarthy, D.D.	1959 a	The endemicity of filariasis in the Pacific Islands (229)

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151. McCarthy, D.D. & Fitzgerald, N.	1955	Researches in Western Samoa (53)
152. McCarthy, D.D. & Fitzgerald, N.	1956	Habit, habitat and hyperfilariation in the epidemiology of filariasis in Western Samoa (60)
153. McCarthy, D.D. & Carter, D.G.	1967	Report on filariasis in Tokelau Islands (234)
154. Merlin, M. <u>et al.</u>	1976	Activité du levamisole (solaskil) dans la lymphatique à <u>W. bancrofti</u> (var. <u>pacifica</u>) (199)
155. Merlin, M. <u>et al.</u>	1976 a	25 ans de campagnes de masse antifilariales en Polynésie française (245)
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166. Nelson, S. & Cruikshank, J.M.	1955	Filariasis in Fiji (54)
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SECTION II - ABSTRACTS

- (1) Manson Bahr, P.
1912
*
Filariasis and elephantiasis in Fiji. A report to the London School of Tropical Medicine J. Lond. Sch. trop. Med., Suppl. 1, 192 pp.
Abstracts taken from Iyengar (1959) South Pacific Commission, Technical Paper Nos. 124 and 126, and (1960) No 129

A large proportion of Fijians harbour microfilariae in their blood. It cannot be definitely stated whether the Fijian filaria is a new species because of its exhibiting no periodicity, or whether it is Wuchereria bancrofti (referred to as Filaria bancrofti).

Aedes polynesiensis (referred to as Stegomyia pseudoscutellaris), the common mosquito in Fiji, is the main vector. Mosquito destruction, carried out on the same lines as for malaria and yellow fever control, is the only means likely to prove of service in controlling or eradicating filariasis. Mosquito nets being of little use in the case of day-biting mosquitos; mosquito-proof homes should be helpful. Environmental sanitation is recommended.

Descriptions with many illustrations of the development of filarial larvae in Ae. polynesiensis and in Culex fatigans are given. The author describes the mode of entry of the infective larvae into the human host as direct entry through the pores of the skin.

- (2) O'Connor, F.W.
1922
*
Some results of medical research in the Western Pacific
Trans roy. Soc. trop. Med. Hyg., 16, 28-56
Abstract taken from Iyengar (1959)
Techn. Paper No 126

The worst of the breeding places of Ae. polynesiensis (referred to as Stegomyia pseudoscutellaris) are those made by man, such as coconut shells and holes in living coconut trees excavated to hold rain water by the natives in the Ellice Islands (now called Tuvalu). Its breeding places are all within the scope of sanitary control. At Funafuti, it was demonstrated that the clearing of bush in the strips of land on the large lagoon atolls was followed by a marked reduction in the number of Stegomyia mosquitos. In Samoa and the dense northern Ellice Islands the clearing of plantations should result in reducing Stegomyia. By a combination of administrative and sanitary methods these mosquitos can be controlled. In these islands human filariasis is a preventable disease.

(3) O'Connor, F.W.
1923

Researches in the Western Pacific
Res. Mem. Lond. Scho. Trop. Med., 4, 57 pp.*

Studies were carried out between March 1920 and August 1921.

In the Tokelau Islands, Ae. polynesiensis (referred to as Stegomyia pseudoscutellaris) is the only known mosquito. Of 330 persons examined, 102 were positive with microfilariae.

On the Ellice Islands, two mosquitos are known - the night-biting C. annulirostris (referred to as C. jepsoni) and the day-biting Ae. polynesiensis. Of 1169 persons examined, 538 were positive, with the highest count of microfilariae (mf) of 1595 per 20 mm³.

In Samoa, of six species known, two are abundant: Ae. polynesiensis and Ae. kochi (probably referring to Ae. oceanicus). Of 4294 persons examined, 1232 were positive.

Experimental infection studies in Ellice and Samoa showed that the microfilariae were capable of completing their growth in Ae. polynesiensis. Of 300 wild caught mosquitos dissected, three were found with developing and infective filarial larvae.

From a consideration of the resting and breeding habits of Ae. polynesiensis, the main control measures would consist of periodic cutting and burning of bush and of coconut husk, and of trimming and draining tree holes.

(4) Buxton, P.A.
1925

*

The control of mosquitos in Apia, Samoa
Mandated Territory of Western Samoa.
Annual Report of the Department of Health
for the year ended 31 March 1925.
Appendix D, 22 - 23.
Abstract taken from Iyengar (1960) Techn.
Paper No 129

Ae. polynesiensis (referred to as Stegomyia pseudoscutellaris) is the carrier of filariasis in Samoa. In order to obtain full cooperation of the public it is necessary to undertake general anti-mosquito measures.

For the control of Culex fatigans, the ventilators of the septic tanks could be screened and the pit privies treated with cresol once a month. The eradication of Ae. samoanus (referred to as Finlaya kochi) can be accomplished by forbidding the growing of "taro" within the municipal area. The Taufusi swamp should be drained as this would be a suitable breeding site for Anopheles if introduced from the New Hebrides or Solomon Islands.

The principal breeding places of Ae. polynesiensis are coconut shells, rat-eaten coconut and cacao pods, tree holes, discarded tins, etc.

A large scale experiment carried out in Apia town for six months showed that the density of Ae. polynesiensis (referred to as Ae. variegatus) could be greatly reduced if well-trained health inspectors carried out environmental sanitation, with special attention to the clearing of scrub in paddocks, etc., around gardens.

- (5) Lambert, S.M.
1926
*
Health survey of the Cook Islands, with
special reference to hookworm disease
Appendix to Report of Cook Islands
Administration, pp. 27-40
Abstract taken from Iyengar (1959) Techn.
Paper No 126

Elephantiasis is spread rather evenly through the Southern Group, as is filariasis. Filarial abscesses are of very common occurrence., both muscular and glandular. Ae. polynesiensis (referred to as Stegomyia pseudoscutellaris) is especially prevalent and probably accounts for the abundance of filariasis and elephantiasis.

On Atiu Island, Lambert recorded 22 cases of elephantiasis out of a population of 900, 23 cases on Mauke Island out of a population of 560, and no cases of elephantiasis on Mitiaro of a population of 180. On five islands, fresh blood samples were examined for microfilariae. The rates were: Rarotonga, 35.3%; Mangaia, 26%; Mauke, 46.2%; Mitiaro, 54.8%; and Aitutaki, 49.1%. In 218 persons examined both during daytime and at night 98 (45%) were positive for microfilariae by day, and 90 (41.2%) by night, showing that the microfilariae did not exhibit nocturnal periodicity. The author did not find a single person positive at night who, when examined during the day, was found to be negative. Some of those positive in the day were negative at night.

Filariasis cannot be treated with present knowledge; prophylaxis - the suppression of the mosquito - is at present probably out of range of the Cook Islands Treasury.

- (6) Buxton, P. A. &
Hopkins, G.H.F.
1927
Researches in Polynesia and Melanesia
Parts I - IV
Res. Mem. Lond. Sch. Trop. Med., No. 1,
260 pp

The memoire covers Samoa, Tonga, Ellice Islands, Tokelau Islands and the New Hebrides. A comprehensive description of the islands, their geography and flora is given. The results of field collections of arthropoda are presented. Detailed description of the mosquito fauna collected with notes on their bionomics is given. Results of experimental studies involving Ae. polynesiensis (referred to as Ae. variegatus) and Ae. aegypti (referred to as Ae. argentus) in respect of the factors which control egg laying and those which cause egg hatching as well as larval ecology are presented and discussed. Briefly Ae. polynesiensis is less hardy and adaptable than Ae. aegypti. The eggs are less resistant to desiccation and probably also to drying in the atmosphere of the laboratory; a smaller proportion of them hatch in organic infusions. The adults of Ae. polynesiensis when about to lay eggs seem to be more sensitive to water vapour of certain optimum concentration, more dependent on the provision of a landing place, and less willing to go to clean water. It is perhaps for these reasons that this species has a more restricted range, and less power of colonization than Ae. aegypti. It is anomalous that the larvae of Ae. polynesiensis appear to be more resistant to a variety of chemicals.

From a limited trial for vector control by environmental measures including the cutting of scrub in part of Apia town, Samoa where the inhabitants were willing to cooperate, it shows that the density of Ae. polynesiensis was certainly greatly reduced.

While it is impossible, at present, to eradicate this insect because of the great forest areas and innumerable rot holes, any method which can reduce the numbers, even a little, is valuable. If a predatory insect could be found, which would breed in tree holes where Ae. polynesiensis is found, an attempt should be made to introduce it. No such insects were found in the New Hebrides, but "Megarhinus" (Toxorhynchites) occurs in the Bismarck Archipelago, and further west, and an attempt at introduction should certainly be made. Much could be done with poisoned traps of hay infusion and copper sulphate. It is not suggested that their use will eradicate the mosquito, but that if its numbers are reduced, the remaining mosquitos should be given an opportunity of laying eggs in traps; if this is not done, they will probably lay them in unexpected, and difficult to locate places.

(7) Buxton, P.A.
1928

Researches in Polynesia and Melanesia
Parts V - VII
Res. Mem. Lond. Sch. Trop. Med., No 2,
139 pp

Part V of this memoire deals with filariasis studies in Samoa, Ellice, Tokelau and New Hebrides. The studies are mainly parasitological, clinical and pathological with brief notes on vector status and distribution of mosquito species in the South Pacific area. In discussing the distribution of filariasis, the author considered that the short flight range of Ae. polynesiensis (referred to as Ae. variegatus var. pseudoscutellaris) is the influencing factor. The evidence was indirect as derived from a source reduction trial carried out in Apia.

The cause of the varying incidence of filariasis in villages is clearly that Ae. polynesiensis has no great range of flight. One knows from one's own experience that the numbers of this insect in a house can be enormously reduced by cutting back undergrowth and by discovering and destroying the few small breeding places in the immediate vicinity.

(8) Phelps, J.R.,
Smith, O.A.,
Carroll, H.H.,
Washburn, W.A &
Beagley, K.E.
1930
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Experimental treatment of filariasis
with intra-muscular injection of oil
of chenopodium
Nav. med. Bull., Wash., 28, 459 - 487
Abstract taken from Iyengar (1960)
Techn. Paper No 129

The problem of prevention and control of filariasis is one of attempting to limit the numbers of inoculations of human hosts by the insect vectors, and to reduce the numbers of mosquitos infected by human hosts. The problem is not hopeless even under existing conditions in American Samoa. Theoretically it should be easier to control filariasis

than malaria. It is not necessary to prevent the breeding of all mosquitos which may act as vectors. A marked reduction in the numbers of mosquitos may serve, practically, to prevent further infections. A 10% reduction in the total numbers of mosquito vectors in a given locality would lead to more than 10% reduction in the new infection or reinfection rate. In American Samoa there are undoubtedly many places, principally in small collections of water in trees on mountain sides, where mosquitos can breed practically beyond reach. An attempt to control breeding in such places would be very expensive. If all villages would undertake and continuously carry out simple procedures in and around the village for a few hundred metres, great reductions in the number of mosquitos in flight would be secured, and in a comparatively short time such efforts would have a decided effect on the incidence of filariasis. Such work would include careful policing to secure proper disposal of empty tin cans, coconut shells and all other articles which may hold water. Adequate ditches should be dug and kept open to dispose of standing water in the comparatively few swampy areas. Grass and weeds should be kept low for a reasonable distance around each village and attention should be paid to trees in these areas. All vessels, tanks, barrels, or other containers used for storing water should be emptied regularly once a week or be adequately protected by metal screening.

Public health education and law enforcement should go hand in hand. If the natives realise that mosquitos are responsible for filariasis, a great reduction in the numbers of mosquitos in the villages can be secured quickly. The Samoan houses do not lend themselves well to screening.

(9) O'Connor, F.W.
1932

The aetiology of the disease syndrome in
Wuchereria bancrofti infections
Trans. roy. Soc. trop. Med. Hyg., 26, 13-33

In the Ellice Islands, studies were made in eight of the nine atolls, all of which are of the same composition, namely, coral rock and sand surrounding coconut groves. The single village of each island is on the lagoon or the ocean front. Everywhere habits and customs are the same: all the islanders go barefoot, and all are liable to coral sores, which may or may not become infected; among the males at least, the body is uncovered above the waist; all persons are equally exposed to septic infections, internal or external. And yet the several islands showed great variation in the incidence of filarial infection.

On some of the newer atolls - Nukulailai, for example - the lagoon is large and the surrounding rim of land is narrow and unprotected from wind and sun. Ae. polynesiensis (referred to as Ae. variegatus) the insect vector of W. bancrofti in this region, is rarely seen in the village, which is well cleared of bush. To reach the plantations where this mosquito is found, it is necessary to cross the lagoon by boat. Storms are so frequent that young children are not taken on these trips. It is interesting to note that on Nukulailai symptoms of filariasis were seldom observed in children under ten years of age, that the incidence of microfilariae was low for the whole population, that no high microfilarial counts were obtained, that these organisms were rarely found in persons with clinical signs of filariasis, that elephantiasis was uncommon, that multiple elephantiasis was almost never encountered, and that the incidence of filarial infection, as shown by blood and clinical study combined, was only 38.9%.

In Nui, one of the older atolls, where the lagoon has been much reduced in size and where there is thick dark bush in the immediate vicinity of the village, Ae. polynesiensis abounded. Here filarial symptoms were commonly noted in young children; a high incidence of microfilariae was found in the population as a whole, with frequent high individual counts; these organisms were discovered fairly often in the blood of persons with clinical filariasis, an additional evidence of the existence of hyperfilarialation; elephantiasis was common; and multiple elephantiasis was often seen. The incidence of filarial infection, as shown by blood and clinical study, was 73%.

(10) Paine, R.W.

1934

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Entomological notes. Mosquito control in coconut plantations
Agric. J., Fiji, 7, 40 - 41
Abstract taken from Iyengar (1960)
Techn. Paper No 129

In Fiji Ae. pseudoscutellaris (N.B. possibly also Ae. polynesiensis included), the vector of filariasis, breeds in piles of cut coconut husks. It also breeds in rat-bored nuts, which are never collected but accumulate on the ground and hold water for many months after they fall from the tree. By removing all coconut husks (including rat-eaten coconuts) for an area of 50 metres (m) around the house, there was a remarkable reduction in the incidence of Aedes mosquitos in the cleared area in comparison with the area outside. For coconut plantations the author recommends the burning of the husks after the copra cutters have finished with them. Rat-bored coconuts cannot be burned.

(11) Venner, R.B.

1944

Filarial problem on Nanumea

Nav. med. Bull., Wash., 43, 955 - 963

Abstract taken from Iyengar (1960)

Techn. Paper No 129

On Nanumea (Ellice Islands) the chief breeding places of Ae. aegypti and Ae. polynesiensis (referred to as Ae. pseudoscutellaris) are cisterns for storing rain water, water barrels and coconut shells. The measures suggested for the control of these mosquitos are: -

- (i) screening of rainwater cisterns;
- (ii) covering all rain water barrels and other containers used for storing water with target cloth on wooden frames fitting securely over the top of the containers;
- (iii) ridding the entire island of trash and all possible receptacles for water. Cleared areas, well policed, were practically free of mosquitos.

(12) Byrd, E.E.,
St. Amant, L.S. &
Bromberg, L.
1945
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Studies on filariasis in the Samoan Area
Nav. med. Bull., Wash., 44, 1-20
Abstract taken from Iyengar (1959)
Techn. Paper No 126

In the Samoan area, 20-50% of the native population were found to harbour microfilariae in the blood. The rate of infection reaches a peak between the 20th and 40th year of life. Rarely will a child under two years of age harbour sufficient number of microfilariae in the blood stream for them to be demonstrated by routine laboratory procedures. Seldom will a person under the age of 20 develop elephantiasis.

Although Ae. polynesiensis (referred to as Ae. pseudoscutellaris) and Culex fatigans were found naturally infected, it is shown that the former species is the only transmitter of importance within the Samoan area. More than 80% of experimentally infected Ae. polynesiensis mosquitos harboured developing filaria larvae; more than 80% of mosquitos which survived for 14 days after the infective blood meal carried infective stage larvae. In the field 9.9% of 6634 mosquitos proved to be naturally infected; many of these carried double and triple infections and more than 15% of those infected were found to harbour infective stage larvae. Culex fatigans, on the other hand, showed only a 7.4% infection rate in the field and never more than a 29% infection rate in laboratory experiments. Only two out of 1063 C. fatigans taken in the field harboured developmental stages older than recently ingested microfilariae and none of these had reached the infective state. In the experimental studies only 25 specimens of C. fatigans survived to the 15th day and of these, only one harboured an infective stage larva.

The stages in the development of the filaria larva within the Aedes mosquito are illustrated by photomicrographs. Notes are furnished on the breeding and feeding habits of Ae. polynesiensis. Usually the adult mosquito remains close to its breeding place. Its flight range is shown which is proved by the progressive reduction in the incidence of naturally infected mosquitos at the periphery of the native village. Within the village the incidence of infection in the mosquito is high, as much as 25-45%. At 23 m from the periphery of the village the infection rate drops to 20% or less, and at 45 m only a 4-5% infection is encountered. At or beyond 90 m from the village, just an occasional infected mosquito is taken.

Wind has considerable influence on the density of adult Aedes, as well as on the infection rate in the vector. Aedes density as well as the infection rate were considerably lower on the windward side of the village than on the leeward side. The highest incidence of infection occurred among mosquitos taken from the leeward edge of the village. The effect of wind was to shift the region of transmission to the leeward side and to extend the area of infectivity beyond its normal limits.

- (13) Amos, D.W.
1946
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The mosquito position and filariasis
in Rarotonga
Report to the Department of Island
Territories, (New Zealand)
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Attempts at mosquito control in Rarotonga consisted of the introduction of Gambusia in all swamps, drains, etc. Although this had reduced the incidence of the Culex mosquito, it has been useless in so far as controlling the insect responsible for the spread of filariasis. Ae. polynesiensis (referred to as Ae. pseudoscutellaris), the carrier of filariasis, is a small container breeder. The high incidence of filariasis in Rarotonga is due to the presence of heavily bushed areas adjoining habitations and the careless disposal of tins, bottles, coconut shells and similar rubbish.

Eradication of the vector in Rarotonga is not practicable, nor is it necessary in order to eradicate filariasis. What is needed is the destruction of breeding places of the mosquito carrier in areas adjoining habitations for a distance of 100 m, and clearing of all scrub, bushes and long grass.

- (14) Amos, D.W.
1947
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Mosquito Control Training Manual,
43 pp. Government Press, Suva, Fiji
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Total eradication of the vector mosquito Ae. pseudoscutellaris from these islands is not practicable, nor is such a course necessary even if it were possible to do so in order to accomplish effective control of filarial disease in Fiji. What must be done is the destruction of the breeding places of this mosquito in the inhabited areas and for a distance of 100 m around habitations. The cooperation of the people in carrying out these measures is essential for the success of the filariasis control scheme.

- (15) Murray, W.D.
1948
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Filariasis studies in American Samoa
Nav. med. Bull., Wash., 48, 327-241
Abstract taken from Iyengar (1959)
Techn. Paper No 126

From 31 villages in American Samoa, the author examined 5144 persons above the age of four, and found that 19.1% harboured microfilariae in the blood. The mf rates in the different villages ranged from 12.5% to 38.7%.

It is stated that the average mf count gives a better index of the filaria situation than does the mf rate. There occurs an increase in the average mf count from 1.0 in the age-group 5-9 to 30.7 in the age-group 50-54, after which there is a steady drop to the upper age limit. Until

the age of puberty there is little difference in the incidence of microfilaraemia between the males and females. But from that period on the rates in the two sexes diverge, males being far more subject to the condition than females. The incidence of elephantiasis increases steadily as the age increases. Elephantiasis was not observed below the age of 30; 4.2% of people over 30 years of age had elephantiasis. Males have a much higher rate of this disease than females, even when scrotal affections are not taken into consideration. Women appear to be more resistant to all stages of filariasis and its complications than are men. Samoans with elephantiasis had a considerably higher rate of microfilaraemia than did Samoans without elephantiasis, when comparable age and sex groups were considered.

(16) Davis, T.R.A.
1949

Filariasis control in the Cook Islands
N.Z. med. J., 48, 362-370

In his introduction the author indicated that due to the apathy for the widespread distribution of filariasis in the Cook Islands, vector control measures were instituted in 1946. The methods used by the armed forces during World War II were considered too expensive to be afforded by the available resources and modification of the techniques had to be introduced. Thus the paper describes the methods of mosquito control adopted as well as the results of a study on vector bionomics as a prerequisite for applying control measures. The following is a summary of the information provided.

(1) Breeding habitats

Ae. polynesiensis (referred to as Ae. pseudoscutellaris) was considered as the principal vector of subperiodic W. bancrofti in the Cook Islands. Its breeding was found to occur in a variety of natural and artificial water collections in fairly well shaded places. Some breeding was found in plant leaf axils but was considered of negligible importance.

(2) Resting sites

Ae. polynesiensis showed marked preference for damp places shaded by foliaged bush. Houses were not used for nesting and mosquitos enter them only to feed. Adult mosquitos were found resting under the eaves of native thatched nuts and these were found to harbour developing larvae and did not fly when disturbed. Thick unkept hedges were found to be important resting places from which infected mosquitos were recovered. The most important sites were in jasmin bushes in gardens.

(3) Flight range

The flight range was given as being a maximum of 136 m but could be shorter when mosquitos were infected with developing larvae, probably 35-45 m depending on the number of filarial larvae.

(4) Seasonal prevalence

During the months of April to November inclusive, the number was appreciably lowered, probably because there was not enough persistent rain to keep the breeding places effectively filled with water.

(5) Feeding habits

Time of biting was directly associated with dull conditions of natural lighting, occurring mainly in the mornings and in the late afternoons. Light rain did not seem to affect biting habits, but heavy rain could force the mosquito to remain in, or return to its resting place. Houses did not appear to be used as sheltering places during heavy rain or strong winds. The mosquito was not found biting in full sunlight.

(6) The problem of filariasis

The prevalence of the clinical manifestations of filariasis ranged between 60% to 90%. The disease caused a serious loss of man-hours of work in the homes and export economy. Thus some kind of control measures were justified. DEC could be used as prophylactive or suppressive measure but under the conditions hitherto prevailing, it was considered that its application was not feasible since proper regimentation and adequate financing would have been required. It was also found that the treatment of only mf carriers would require the services of specialized staff to carry out blood examination of the population at frequent intervals which could not be afforded. Thus resort was made to vector control.

(7) Vector control measures

These were mainly directed to the village environment by proper disposal of garbage, empty tins, etc., filling tree holes, eliminating breeding sites by house owners, burning fallen leaves, cutting shrubs, etc. To extend them to bush adjacent to plantations was considered to be beyond the available resources. However, in surveys made by the author in plantations no infected mosquitos could be found, although these were invariably obtained from resting sites near dwellings and in villages. In addition, the biting times of Ae. polynesiensis did not coincide with the times when the people were in the plantations, which were usually well cleared and in full sunlight. However, it seemed that biting occurred during the worker's rest periods if the place of resting was in full shade of the bush. Apart from the times when intensive replanting had to be carried out, only one or two members of a family would go into the plantations regularly.

In 1947 the Mosquito Control Ordinance was introduced. However, it was necessary to teach the inspectors an unofficious approach and to proceed in their work in a quiet but effective manner. This aspect of the campaign was particularly stressed as no amount of legislation could supplement the natural, when unoffended, public spirit prevailing among local populations.

(8) Conclusions

The measures undertaken resulted in a general improvement of the villages and the irregularities disappeared and the village pride was offended. Of greater importance was the raising of the standards of the village hygiene.

It was considered at that time too early to assess the effectiveness of the control measures by a microfilaria post-control survey, but there was a marked reduction in vector population density. In 1948 an attempt was made to collect naturally infected mosquitos for experimental and demonstration purposes but none could be found.

- (17) Galliard, H., Mille, R. &
Robinson, W.H.
1949
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La Filariose a Wuchereria bancrofti
var. pacifica a Tajit et dans l'archipel
de la Societe
Ann Parasit, hum. comp., 24, 30-48
Abstract taken from Iyengar (1959)
Techn. Paper No 126

In Paea (Tahiti), of 916 inhabitants (over 5 years of age) examined, 30.6% showed microfilariae in the blood. In school children from four other districts of Tahiti, the mf rates ranged from 13% to 21.5%. In the Papeete Barracks, 31.5% of the troops showed microfilariae in the blood.

In the Leeward Islands, - Huahine, Raiatea, Bora-Bora, and Tahaa - mf rates among children ranged from 0% to 28%, and in adults from 19% to 58%.

In Paea, of the 916 persons examined, 179 (20%) showed clinical evidence of filariasis, of whom 81 (9%) had elephantiasis. The incidences of microfilarial infection, lymphangitis and elephantiasis were each slightly higher in males than in females.

The population on the lagoon side is less affected than that on the mountain side. The dwellings are cluttered up and it is not rare to find in the same house several diseased persons and several mf carriers. White persons are as frequently infected as the indigenous population.

Ae. polynesiensis (referred to as Ae. pseudoscutellaris) is the major vector. It is extremely abundant and aggressive, bites during daytime, rests among the vegetation at night, and has a short flight range. It breeds in peridomestic breeding sites. Fifty percent of specimens of this mosquito examined showed natural infection with filaria larvae.

The geographical conditions, the mode of life of the people and the abundance and extreme receptiveness of the vector mosquito explain the hyperendemicity of filariasis in Tahiti and the neighbouring islands.

(18) Galliard, H. & Mille, R.
1949

Essais de traitement de la filariose à
W. bancrofti var. *pacifica* par le
1-diethylcarbamyl-4-methyl piperazine à
Tahiti
Bull. Soc. Path. exot., 4, 304-313
Reabstracted from Iyengar (1959)
Techn. Paper No 124

Various dosages of DEC were tried. Within 6 hours of administration of 2 mg of DEC per kg of body weight to six patients, 70% to 90% of the microfilariae disappeared from the blood. Of 96 patients given 25 mg thrice daily for 4 days and 50 mg thrice daily for 3 days, 87% were free from microfilariae at the end of the treatment; of 65 of these persons followed up for 4 months, 47% showed slight relapses, 14% showed heavy relapses, and 15% remained free from microfilariae. In patients treated with single daily doses, the reactions were too severe and the sterilization less complete.

The reactions noted in the treated cases were fever, aches, epistaxis, nausea, pruritis, bulbous eruptions, painful enlargement of the epitrochlear gland or a lymphangitic crisis.

In five early cases of filariasis with lymphangitis, the pain subsided quickly but the signs of inflammation receded more slowly. The results in older patients with lymphangitis were very variable. One case of lymph scrotum cleared up under treatment. In haematochyluria no permanent effect was produced. Cases of acute lymphangitis of filarial origin responded to benadryl or neo-antergan.

(19) Satchell, G.H.
1950

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On the possibility of controlling
filariasis in Rarotonga (Cook Islands)
by residual spraying with DDT
Appendix to Report of New Zealand Medical
Council Research Expedition to the
Cook Islands 1949-1950 (unpublished)
Abstract taken from Iyengar (1959)
Techn. Paper No 126

The infection rate in the vector population is conditioned by four variables: (1) the rate of emergence of the vector mosquito; (2) the number of people within the flight range of the mosquito; (3) the proportion of these people carrying microfilariae in their blood; and (4) the extent to which these people are about during the period of biting activity of the mosquito. Since mosquito emergence tends to fluctuate, depending on previous showers of rain, it is clear that immediately after a large emergence, the resident mosquito population of an area will be diluted by individuals which have not yet had a chance to become infected. The second variable results in mosquitos away from inhabited areas having low infection rates, since they are unable to pick microfilariae. Variable No. 3 presumably explains the enormous variation in infection rates between one house and the next. Variable No. 4 is also difficult to assess without a detailed knowledge of the way in which the native people spend their day.

There is an almost infinite variety in the way the male members of the family may divide their time between working on the plantations, resting at home or fishing on the reef. As the latter is dependent on the tide, it is constantly varying. Similarly the females may assist on the plantations at certain seasons of the year when the pressure of work is great, whilst remaining at home at other times.

Information was obtained on the proportion of infected mosquitos in houses as compared with plantations. Collections taken in houses in Ngatangia (Rarotonga Island) during six weeks yielded 1258 mosquitos of which 115, or 9.1% carried filaria larvae; the average number of mosquitos per collection was 22.9. Collections taken outside houses within a radius of 23 m yielded 503 mosquitos of which 35 or 6.9% were infected; average catch per collection was 31. Collections taken in the plantations yielded 495 mosquitos in which 8 or 1.6% were infected; average catch per collection was 55. The infection rate is six times as great in houses as in plantations. The overall abundance of mosquitos was 2.4 times as abundant in plantations as in houses. Thus there were actually 2.4 times as many infected mosquitos in the houses as in the plantations. It would thus appear that the greatest number of infected mosquitos can be destroyed most economically by spraying the houses and their immediate surroundings.

- (20) Satchell, G.H., Faine, S. & Herous, C.E. Report of the New Zealand Medical Research Council Research Expedition to the Cook Islands 1949-1950
1950 Mimeo graphed report, 2 pp
* Abstract taken from Iyengar (1959)
Techn. Paper No 126

Lambert (5) from an investigation carried out in five islands of the Cook Islands group during 1925 reported that filariasis is endemic and evenly spread throughout the Cook Islands. In Rarotonga he found that 34% of 149 persons examined during daytime were positive for microfilariae, and 36% of 202 persons examined at night. He thus established the fact that the filaria was of the nonperiodic type and that filarial endemicity was high.

Amos (13) in 1946 found that 47% of the adults and 16% of the children examined from the village of Arorangi (Rarotonga) were positive for microfilariae in the blood.

He further stated that 32% of the entire population showed evidence of clinical manifestations of filariasis, and that 4% had elephantiasis. He reports the local impression that the incidence of the disease had rapidly increased in the last 10-15 years.

During October 1949, the authors carried out a survey of 120 children from Arorangi School and found that 27.5% harboured microfilariae in the blood. Of 305 persons examined (all ages), 12.1% were positive for microfilariae and 16.7% gave a history or some clinical evidence of filariasis. The mf rates in the two sexes were as follows: under 15 years of age, males 4.5%, females 8.8%; 15-60 years, males 21.2% and females 8.0%.

The infection rate in the mosquito in a village is in a state of fluctuation, dropping after emergence of a batch of mosquitos following rain, and steadily rising again as the young mosquitos acquire infections. This was demonstrated by the observations carried out in Ngatangia. During December, following a period of dry weather, the density of mosquitos in the villages was 16.6 (average per collection) and the infection rate was 13.0%. About ten days after heavy rainfall, the average number of mosquitos per collection rose to 38.7 and the infection rate dropped to 1.6%. The increase in the mosquito density was due to emergence of mosquitos as a result of increased facilities for mosquito breeding consequent of heavy rainfall, and the lowering of the infection rate was due to dilution of the infected mosquito by freshly emerged mosquitos which had not had a chance of getting infected. In the following week, the infection rate rose to 3.2%, the average mosquito density being 27.6 per collection. One week later, the infection rate rose to 12.8% (average per collection 54.1). During the last week of study, the infection rate dropped to 9.6% while the average density remained steady at 52.2 per collection.

As an experiment, the author sprayed five houses and their surroundings with DDT (wettable) at a dosage of 2 g/m². The interior of the houses, lavatories and outbuildings, inclusive of the roofs and outside surfaces protected from direct rain wash, as well as all foliage and tree trunks (up to a height of 3.3 m) within a radius of 9 m, were thus treated with DDT. The results are compared with unsprayed houses nearby. In the sprayed houses the average catch of mosquitos per collection was 9, the infection rate in the mosquitos 7.2% and the incidence of mosquitos carrying infective stage filaria larvae 1.3%. For the unsprayed houses these figures were respectively 52.4, 15.0 and 3.6%. In the sprayed houses, the density of mosquitos was one-sixth, the number of infected mosquitos one-twelfth, and the number of mosquitos carrying the infective stage larvae one sixteenth, of that found in the unsprayed houses (taking into account the density level in the sprayed and unsprayed houses).

It is stated that the basic mosquito control measures, namely clearance of bush and destruction of breeding places around habitations, are absolutely fundamental and that DDT spraying is an adjunct rather than a substitute for such measures.

(21) Wharton, J.D., &
Jachowski, L.A.
1950

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Development of methods for control of
filariasis in American Samoa

Nav. med. Res. Inst., Nat. nav. Med.
Center, Bethesda, Maryland, USA, Project
NM 005 048.08, 10 July 1950
Abstract taken from Iyengar (1960)
Techn. Paper No 129

In one village only chemotherapy was used; every person five years of age or over received diethylcarbamazine in doses of 3 mg/kg daily for 14 days. The population was rendered almost microfilaria negative but within 3 months microfilariae reappeared. Nine months after treatment nearly a fourth of the treated population was microfilaria positive but only a few persons had regained the pretreatment number of microfilariae.

There was a significant increase in the mosquito population of this village, a two- or three-fold increase over pretreatment level, whereas no such increase occurred in any of the other villages under observation. It seems possible that filarial infection is fatal to large numbers of mosquitos in such an area and consequently mass treatment of the human population had removed one biological check on the mosquito population.

One large village on Tutuila received only DDT applications. A single application of DDT as a residual in the thatched-roofed houses was followed by aerial spraying at intervals of about 14 days. After the aerial spray, adult catches were 0 to 3 mosquitos on a human bait in 10 minutes, as compared with 50 to 100 before spraying. There was no change in the number of mosquitos caught in adjacent areas. The aerial spraying had no effect on larvae in their breeding sites. The number of mosquitos rose to the uncontrolled level on the day prior to the next spraying (i.e. 14 days later). However, except during the period when spraying was interrupted, no infected mosquitos were found. Although mosquito density had not been reduced, transmission appeared to have been interrupted.

In Aunu'u village, all three measures, namely aerial spraying, clean-up and mass chemotherapy were carried out. Every person above the age of four received the drug in doses of 3 mg/kg daily for 7 days, followed after an interval of two months by a further treatment on the same dosage schedule.

It is stated that transmission of filariasis by a bush mosquito may be effectively interrupted by aerial spraying with DDT. Recurrent spraying of intervals of two weeks should provide control for a considerable period of time.

Mosquito reduction by clean-up offers the most satisfactory long-term programme. If this is done for a satisfactory distance from the village, it would materially reduce the exposure of the villagers to the infection. DEC may offer a supplementary weapon to the attempts at control. The use of the drug by itself as a method of control seems subject to the hazard that increase of the vector population and the presence of any infected persons might actually increase the rate of transmission rather than bring it under control. In a rigidly controlled population group which can be treated without a single omission, DEC might be applied repeatedly in order to achieve control.

(22) Edgar, S.A. &
Bambridge, B.S.
1951
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Importance du rat dans la fabrication
des gites a larvas de moustiques. Ou
efficacite du baguage pour la protection
du cocotier contre les rats
Report, Institut de Recherches Medicales
de l'Oceanie Francaise, Papeete, 18 July
1951 (unpublished)
Abstract taken from Iyengar (1960)
Techn. Paper No 129

In Tahiti, the rat plays an important role in the production of breeding sites of Ae. polynesiensis, the major vector of filariasis. Rat damaged coconuts constitute 50% of all breeding sites of this mosquito.

The narrow opening prevents evaporation of the water and the dark interior is very favourable for the development of the larvae as well as sheltering the adult mosquitos. Bandaging of coconut trees is an effective method of controlling the breeding of Aedes as also of protecting the coconut crop. In plantations where coconuts trees were bandaged, only 0.3% of the coconuts were damaged by rats, as against an average of 28% in plantations in which the coconut trees were not bandaged.

- (23) Faine, S. & Hercus, C.E. Infections in Rarotonga, Cook Islands
1951 Trans. roy. Soc. trop. Med. Hyg., 45,
 341-352
 Abstract taken from Iyengar (1959)
 Techn. Paper No 126

Filariasis is highly endemic throughout the Cook Islands. It is caused by the nonperiodic W. bancrofti. The infection is transmitted by Ae. polynesiensis. Lambert, 1926 (5) found that 35% of 351 persons examined by him from Rarotonga were positive for microfilariae. Amos in 1946 (13) examined adults and school children in Arorangi village and determined the mf rates as 47.7 and 16.3% respectively for the two groups. He stated that 32% of the people showed clinical evidence of filariasis, including 4% with elephantiasis. Amos mentioned the local belief that the incidence of the disease in Rarotonga had increased during the past 10 or 15 years.

Of 305 persons from Arorangi village examined by the authors according to Knott's technique, 37 (12.1%) were positive for microfilaria. Males (15 to 60 years of age) were two and a half times as frequently infected as females of the same age-group (24.2 and 7.5% respectively). Since women are on the whole almost as frequently at work in the plantations as the men, it is doubtful whether this means infection outside the home. Further, Satchell 1950 (19) found, in another village in Rarotonga, 9.1% of the mosquitos near the houses infected, as compared with 1.6% in the plantations.

During October 1949, of 120 school children at Arorangi school examined, 27.5% were positive for microfilaria. This represents a considerable increase in the infection rate over the 16% recorded by Amos in 1946.

- (24) Hercus, C.E. & The Rarotonga villagers' environment
Faine, S. Trans. roy. Soc. trop. Med. Hyg., 45,
1951 353-370

The homes of 63 families were visited soon after the clinical and laboratory examination were completed and the authors tried to correlate these findings with the relevant elements of the domestic environment.

The results are presented on the housing condition, water supply, faecal disposal, mosquito control, health organization, economic status and social aspects. Mosquito control by basic sanitation gave good results. Legal action was taken against persistent offenders.

(25) Jachowski, L.A.,
Otto, G.F. &
Wharton, J.D.
1951

Filariasis in American Samoa. I. Loss of
microfilaria in the absence of continued
reinfection
Proc. helminth. Soc. Wash., 18, 25-28

Information on the period a population retains or loses its microfilariae after reinfection ceases has practical application. This is particularly important in programmes attempting to apply vector control for the control of filariasis. Obviously the period during which transmission is interrupted should be long enough to allow the human population to lose its microfilariae, thus the benefits of vector control will continue after its operations are terminated. Two types of study were undertaken to provide this information. The first was to examine a group of 102 Samoan nurses under training or on duty at the Samoan Hospital in American Samoa. They came from all parts of the country and the nurses under training must spend four years studying at the hospital. Except for brief periodic visits home, the nurses lived and worked in the modern screened buildings within the premises of the US Naval Station where sanitation and mosquito control had been practised for many years.

The second type of study involved a survey of groups of Samoan migrants to Hawaii where there was evidence that filariasis transmission had not occurred. The migrants examined, lived in Hawaii for three or more years. The incidence of infection amongst migrants was compared with that of their home population.

Both data of the Samoan nurses removed from their homes to the protected environment in the hospital with more restricted life either in the hospital or in the village after graduation, and the removal of the migrants of both males and females of all age groups from their endemic areas in Samoa to the filariasis-free area of Hawaii, indicated that the microfilariae disappear from the blood within a period of ten years from leaving the area of exposure and reinfection. Only one in each of the nurses and migrants groups was found positive, both of them were only six years removed from their normal endemic areas. Thus, a mosquito control programme, short of complete vector eradication, would have to be sufficiently effective to prevent transmission for five years or perhaps longer if the gains were to last materially beyond the actual vector control operations.

(26) Manson-Bahr, P.
1951

Fiji revisited
The Lancet, 6 Jan. 1951, 1, 49

In 1910, the author was able to demonstrate the transmission of the filaria of the Pacific, W. bancrofti var. pacifica, by a new species of mosquito. Ae. polynesiensis (referred to as Ae. scutellaris var. pseudoscutellaris) is an insect which has peculiar breeding habits, frequenting mostly small pools of water, discarded tins, crab holes, and coconut shells. By eliminating these reservoirs the numbers of these mosquitos in the vicinity of houses have been much reduced. It has also been found that cutting the grass and clearing the bush around the native houses, or buris, interrupts the parasitic cycle by eliminating resting-places of this mosquito after it has been engorged with human blood.

(27) Marks, E.N.
1951

The vector of filariasis in Polynesia:
a change in nomenclature
Ann. trop. Med. Parasit., 45, 137-140

The author reviewed the previous literature in the South Pacific on the species hitherto named "Ae. pseudoscutellaris". A colony of this species was established in 1948 in the London School of Hygiene and Tropical Medicine, originating from Fiji. From this colony the author kept a subcolony in the Zoology Department of the University of Cambridge since November 1949 and had examined hundreds of specimens in detail for research purposes. The specimens showed constant differences in male genitalia from the form generally identified in the past as Ae. pseudoscutellaris", and as a rule can also be distinguished by differences in scutal scaling. Further, adult specimens raised from eggs sent from a locality near Suva, proved to be the same form as those maintained in the colony.

The author indicated that the previous confusion of the two forms was not surprising, as the differences were small and those of the male genitalia not very obvious unless the genitalia was dissected and the basal lobe of the coxite examined in lateral view. As the laboratory colony breeds true for its distinctive characters and both forms can occur in the same locality, the author believed that the two distinct sibling species (apart from Ae. horrescens) were hitherto included under the name of "Ae. pseudoscutellaris".

Examination of the type specimens of Ae. (S.) pseudoscutellaris (Theobald) showed that it was the laboratory colony which in fact represented the true Ae. pseudoscutellaris, the specimens of which were identified only from localities in Viti Levu and from Vanua Levu, Fiji.

The widespread filaria vector in Polynesia therefore required a new name and the author proposed to call it Ae. (Stegomyia) polynesiensis sp. nov. The author selected as holotype male a specimen in the British Museum (Natural History) collection from Taveuni, Fiji, made in 1933, and the allotype female was from the same locality.

The distinguishing morphological characters between the two species Ae. pseudoscutellaris (Theobald) and Ae. polynesiensis (Marks) were described.

(28) Muspratt, J.
1951

The bionomics of an African Megarhinus (Diptera, Culicidae) and its possible use in biological control
Bull. ent. Res., 42, 355-370

The author reviews the earlier attempts made to introduce certain species of Toxorhynchites (referred to as Megarhinus), such as T. brevipalpis into Hawaii and T. inornatus and T. splendens into Fiji for the control of disease-bearing mosquitos. T. inornatus died out in Hawaii; although T. splendens became established and has spread in Fiji, it is not abundant.

Even in New Guinea and the Philippines where T. splendens occurs naturally it appears to be of little importance in the control of these mosquitos. As T. brevipalpis has a shorter life cycle than T. splendens, it is considered that periodical release of large numbers of adult T. brevipalpis, obtained from intensive laboratory breeding of the species, may be a useful supplement to other control measures, particularly in small islands and circumscribed areas.

The life cycle of T. brevipalpis was normally: egg - 2 days, larva - 15 days, and pupa - 5 days. The larvae killed during their normal life 100-200 Ae. aegypti larvae. Fourth instar larvae did not attack each other readily; they devoured smaller larvae of their own species and small to medium size larvae resorted to cannibalism, particularly in the absence of culicine prey.

- (29) Beye, H.K.,
Edgar, S.A.,
Mille, R.,
Kessel, J.F., &
Bambridge, B. Preliminary observations on prevalence,
 clinical manifestation and control of
 filariasis in Society Islands
 Amer. J. trop. Med. Hyg., 1 637-661

An investigation was undertaken in Tahiti and its vicinity in 1948-1950 on the comparative effectiveness of different control measures by drug treatment with DEC at 2 mg/kg thrice daily for seven days, by eliminating vector breeding places within a radius of 45-68 m around houses, by spraying DDT inside and outside the houses every 3 months including shrubs within 18-27 m around houses, and by combining two or all of the above methods. The results indicated that none of these measures applied had an impact on the mf rate, except where DEC was administered.

It may be mentioned that 56.5% of dogs and 12.5% of cats were found positive with Dirofilaria immitis.

- (30) Hu, S.M.K.
1952 Mosquito control in the South Pacific
 Mosquito News, 12, 164-166

During his trip to the South Pacific, the author observed that environmental sanitation and DDT spraying inside and outside houses were undertaken in Tahiti for the control of Ae. polynesiensis.

Toxorhynchites splendens was introduced into Fiji from Java in 1931.

- (31) Jachowski, L.A. &
Otto, G.F.
1952 Filariasis in American Samoa. II. Evidence
 of transmission outside of villages
 Amer. J. trop. Med. Hyg., 1, 662-670

More vector mosquitos were collected in the houses near or in the bushes rather than in those with extensive cleared areas around them. Mosquito infection rates also do not support the findings of Byrd et al., 1945 (11) that the villages are the hyperendemic focus as the percent of infected mosquitos were on average 6.9 on the open malae (village green), 5.2 in the houses, 2.9 in the nearby bush and 4.9 in the deeper bush.

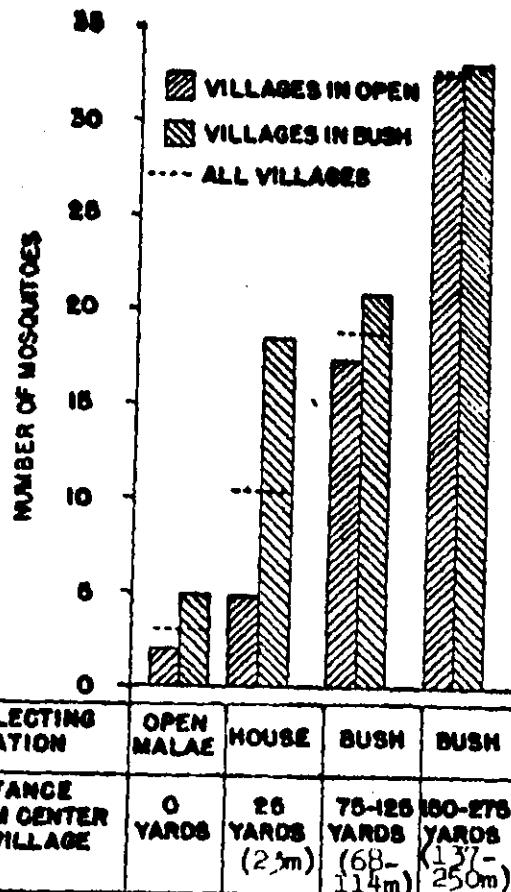


FIG. 1. COMPARISON OF THE DENSITIES OF *AEDES POLYNESIENSIS* PER SURVEY FROM VILLAGES IN THE OPEN WITH THOSE FROM VILLAGES IN THE BUSH.

TABLE I
Summary tabulation of mosquito (*A. polynesiensis*) densities (10 minute collections) and mosquito infections with nonperiodic *W. bancrofti*

Collecting Station	MALAR			HOUSE			sum 50-100 yrs.			sum 150-250 yrs.		
	all	open	bush*	all	open	bush*	all	open	bush*	all	open	bush*
<i>Density</i>												
No. of surveys	27	16	12	27	16	12	59	35	24	8	5	3
No. of mosquitoes collected	83	27	56	202	71	221	1098	600	498	261	182	99
No. of mosquitoes per survey	3.1	1.8	4.8	10.0	4.7	18.4	18.6	17.1	20.7	32.6	32.4	33.0
<i>Infection</i>												
Number dissected	81	27	54	260	71	218	1786†	1098†	648†	247	148	80
Number infected	6	3	3	15	2	13	62	33	19	12	6	6
% infected	6.9	11.1	5.6	5.2	2.8	6.0	2.9	3.0	2.8	4.9	4.1	6.1
<i>Index of transmission</i>												
	0.2	0.2	0.3	0.6	0.1	1.1	0.8	0.8	0.6	1.6	1.5	2.0

* Small villages in which the bush encloses many houses.

† Includes dissection records from special surveys.

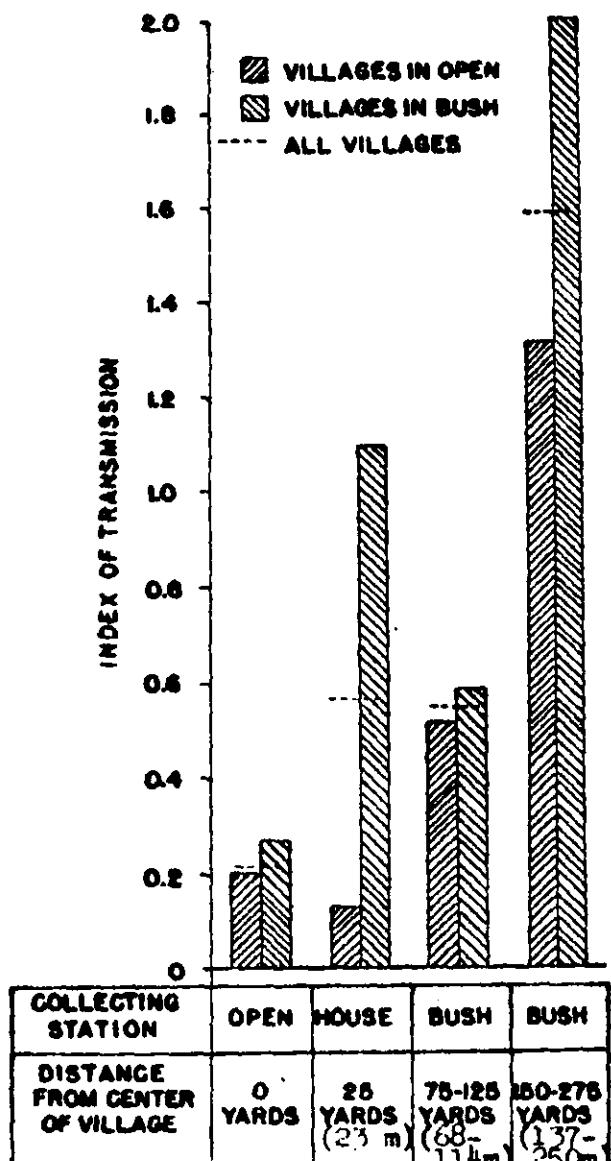


FIG. 2. COMPARISON OF INDICES OF TRANSMISSION FOR VILLAGES IN THE OPEN WITH THOSE FOR VILLAGES IN THE BUSH.

The index of transmission, which is calculated by multiplying the density (the average number of mosquitos per survey) by the proportion of mosquitos infected, is extremely high for the mosquitos collected in the bush 137 to 250 m from the centre of all villages as shown in the table and charts. It is thus concluded that transmission in American Samoa is primarily in the bush, along the trail and in the plantation.

- (32) South Pacific Commission Filariasis in the South Pacific
1953 Proc. of a conference at Papeete, Tahiti
 August - September 1951, 108 pp.

This contains articles on W. bancrofti in Melanesia and Polynesia by T.C. Backhouse, mosquito vectors in Oceania by L. Rosen, epidemiology by E.R. Bryggo, pathological and clinical aspects by P.E.C. Manson-Bahr, chemotherapy by W.H. Wright, control and prophylaxis by H.K. Beye, annotated bibliography by E. Massal & J. Kessel, and recommendations.

In Beye's papers he considered that for a long-term control programme, both drug control and mosquito control must complement each other. A definition of control was suggested which includes basic surveys, measures to be employed and evaluation of these measures. Basic surveys should consist of clinical measurements, filarial infections in man and in mosquitos, mosquito density and breeding, and basic information concerning the human population. These will then serve for evaluation of control results.

The most effective dosage of drugs has yet to be found, but one consisting of one day of treatment per month gives promise of keeping mf free and of being practicable to administer. The question of treating carriers only or the total population is considered.

- (33) Amos, D.W. The educational programme on filariasis
1953 in Fiji
 Proc. 7th Pacific Science Cong., 7, 230-238
 Abstract taken from Iyengar (1960)
 Techn. Paper No 129

Educating the people is the essential step for the control of filariasis, because the only way of controlling the vector mosquitos is by and with the cooperation of the people themselves.

- (34) Beye, H.K., Kessel, J.F., Nouvelles recherches sur l'importance,
Heuls, J., Tooris, G. & les manifestations cliniques et la lutte
Bambridge, G. contre la filariose à Tahiti, Océanie
1953 Francaise
 Bull Soc. Path. exot., 1, 144-163

Summary of the findings is as follows:

1. In Tahiti the proportion of elephantiasis varied between 1.5 and 9.9%.
2. Of 8537 persons examined, 32% were microfilaria positive with a mean mf count of 80 per 20 mm³ of blood.

3. Mf rate among men was 35.5% and among women 30% and the mean mf count was 90 per 20 mm³ blood in men and 54 per 20 mm³ in women.
4. Skin tests with D. immitis antigen gave positive reaction in 70% of Tahitians.
5. With DEC given at a dose of 2 gm/kg thrice daily for 7 days at monthly intervals for 24 months to mf carriers the following results were obtained:
 - 2 days after treatment 6.7% remained positive
 - 1 year after treatment 50% remained positive
 - 2 years after treatment 56% remained positive
6. DEC was administered to mf carriers in five districts in Tahiti at the dose and regimen shown above for 12 months only. All those who showed microfilaraemia one year after the treatment were retreated in the same manner and all were reexamined at the end of the second year.

The results were as follows:

- (a) A group of 233 persons who were all mf carriers received two of the above mentioned treatment regimens. The efficacy of DEC was studied in this group which was perfectly followed up and initially 100% positive. 41% became positive one year after the first treatment and 29% one year after the second treatment. The mf counts per 20 mm³ of blood, during these periods were 79 before treatment, 5 at the end of the first year and 1.5 at the end of the second year.
- (b) The experience obtained from the study of the whole population of six regions provided the actual levels in the campaign where new cases, immigrants and those who escaped the treatment etc. were included. The results were as follows:

38% were positive before treatment
21% were positive after one year
21% were positive after the second treatment

The mean number of mf counts for the corresponding rates was 32.7 and 5 respectively. These figures reflect that in the treated group there was a number of persons who were never treated while in the above mentioned group all actually received the treatment.

7. Health education, environmental sanitation and DDT house spraying are the methods for mosquito control.

Before treatment the infective rate of Ae. polynesiensis was 3.4% (88 mosquitos dissected). No infective larvae were found during the first year (113 mosquitos dissected) and second year (191 mosquitos dissected) after DEC treatment.

(35) Dumbleton, L.J.
1953
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A review of progress in mosquito control in
the South Pacific area
Proc. 7th Pacific Sci. Cong., 7, 354-370
Abstract taken from Iyengar (1960)
Techn. Paper No 129

The fact that Ae. pseudoscutellaris and Ae. polynesiensis, the vectors of filariasis in Polynesia, do not fly from their breeding places is of primary importance in the control of the vector since control measures within such a small radius should, when one considers the type of breeding place utilized (coconut shells, etc.), be possible even in a native community. As this mosquito breeds freely in the jungle, eradication would be very difficult, but the short flight range means that practical control could be achieved in the vicinity of villages. The nature of the main breeding places indicates that control consists more in their elimination than in larvicultural treatment.

(36) Jachowski, L.A.
1953
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Transmission of nonperiodic filariasis in
the South Pacific
Trop. Med. Hyg. Mews, 2, 5-9
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Because of the acceptance of the previous concept of the native village as a hyperendemic focus of transmission, filariasis control programmes in many South Pacific Islands are based solely upon vector elimination in and around native houses. Data collected in American Samoa are not compatible with this interpretation. They indicate that transmission of the nonperiodic filaria occurs in a "wild ecological niche". In view of the concept of diffuse foci of filarial transmission in the bush, it is futile to attempt to control filariasis by attacking the vector mosquito, Ae. polynesiensis, in only this single area. Through careful studies of the bionomics of both the mosquito vector and the human population, in the various islands where the disease is endemic, the foci of transmission can be plotted and a control programme designed which will reduce the mosquito population at all of the important sites. The initial step should be a programme of village sanitation for it is most easily achieved and can do no harm. The problem of sanitation outside of the villages is another matter. A tremendous amount of work is necessary to control Ae. polynesiensis. The final solution seems to lie in a coordinated programme of improved agricultural practices, better land use and continued medical education.

(37) Lopdell, J.C.
1953

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Filariasis in Western Samoa

Proc. 7th Pacific Sci. Con., 7 223-228
Abstract taken from Iyengar (1960)
Techn. Paper No 129

The picture in Samoa is of universal exposure and almost certainly universal infestation. The great difficulty in tackling the problem comes with the habits of both men and mosquito. The carrier rate may be reduced by the use of DEC. The mosquito population may be reduced by clearing away the low shrubs and grass where the mosquitos rest, and cleaning up breeding places in the villages for 100 m around all dwellings. It has been shown that Ae. polynesiensis (referred to as Ae. pseudoscutellaris) is a weak flier and rarely goes more than 150 m from its breeding place. Then only the bush gardens will remain likely common infective areas, apart from the special problem of the cocoa plantations. The rebite of the infective mosquito can be minimized in the villages by cleaning cover around the house and spraying the insides of the house roofs with a residual insecticide. The infected mosquito is sick itself and is incapable of more than a very short flight. No one measure will prove effective; a long term programme of attack from all quarters will be necessary.

(38) Manson-Bahr, P.
1953

The fight against filariasis in the Pacific
Nature, 171, 368-371

The author reviewed the taxonomic status of Ae. polynesiensis and Ae. pseudoscutellaris ad the adaptation of the subperiodic W. bancrofti to these diurnal biters in Polynesia. He also described the environmental sanitation measures carried out by the Mosquito Service, Fiji, as being great work that made the Fijians "mosquito conscious".

He also gave a brief account of the results of trials carried out in Tahiti using DEC prophylaxis and mosquito control measures including environmental sanitation and DDT spraying . After review in the worldwide experience with DEC treatment the author concluded:

"Owing to the uncertainty of the dosage and length of treatment with hetarazan in order to banish microfilariae from the peripheral blood for a sufficient time to render mass application a practical proposition, added to the almost insuperable difficulties which arise in carrying through such a programme in Polynesians, there exists at present a prejudice against this form of causal prophylaxis. The minimal infective mf concentration in the blood (after DEC treatment) for Ae. pseudoscutellaris and Ae. polynesiensis has yet to be determined. According to my observations it is about four microfilariae per 20 mm³ of blood. It appears probable that 'species sanitation' against the main vector, as had been practised in Fiji and Rarotonga, and now in Tahiti, promises to be the most effective measure in the ultimate eradication of Pacific filariasis".

("Hetarazan" = DEC)

(39) Otto, G.F.,
Jachowski, L.A. &
Wharton, J.D.
1953

Filariasis in American Samoa. III.
Studies on chemotherapy against the
nonperiodic form of Wuchereria bancrofti
Amer. J. trop. Med., 2, 495-516
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Diethylcarbamazine is rapidly microfilaricidal but there is no demonstration that the adult worms are killed. The value of DEC as an adjuvant public health measure in the control of filariasis is yet to be established. It may be that periodic treatments of short duration or even single large doses periodically would be of use. However, consideration must be given to the facts that: (1) sudden destruction of microfilariae can produce severe reactions when these embryos are very plentiful, (2) subsequent doses may not be as effective as the initial dose and (3) reduction in the number of microfilariae without their complete elimination could permit an increase in mosquito populations with increased opportunity for transmission.

In contrast to the rapid destruction of microfilariae by DEC, thiacetarsamide failed to produce any immediate reduction in the number of microfilariae in the peripheral circulation. There was actually an increase in the number of microfilariae in the circulating blood during the first few days of treatment. Thiacetarsamide is very slowly microfilaricidal but the results are more permanent and that suggests that the adult worms are killed. This drug must be given intravenously, and apparently daily for not less than 15 days, and thus has limited value as a community-wide public health measures.

(40) Otto, G.F. &
Jachowski, L.A.
1953

Factors in the epidemiology of mosquito-
borne filariasis
ATTI EDL. VI CONGRESSO INTERNAZIONALE
DI MICROBIOLOGIA
Roma, September 1953, 5, 552-

In this presentation to the above mentioned congress, the authors reviewed the factors related to the human population and the vectors of filariasis in certain parts of the world, and in comparison with the subperiodic W. bancrofti transmitted by Ae. polynesiensis. The authors summed up their experience in American Samoa.

As an example of domestic transmission of the periodic form of W. bancrofti by Anopheles darlingi and Culex quinquefasciatus, in the Western hemisphere, discernible differences could not be found in the infection rates of the male and female sexes of the human population, nor was there any evidence that any age-group could be spared. The microfilaremia rises rapidly from early childhood to reach its maximum before puberty, and it was not infrequent to find this maximum within the first decade of life. This highly domestic transmission was found to be amenable to control by residual house spraying.

In contrast, is the transmission of Brugia malayi by Mansonia spp. in Malaysia. In certain areas the breeding grounds of the vectors are situated at some distance from houses where the male population work in the fields until sunset. Hence the bionomics of the vectors and the habits of the people make the male population at the greatest risk of exposure to filariasis infection. In those areas, the mf rates were low in women and children but were found to rise rapidly in males beginning at the age of adolescence. The authors referring to the islands of the South Pacific, stated that domestic transmission of the subperiodic form of W bancrofti by Ae. polynesiensis and Ae. tongae appeared to be almost absent. Because of the failure in controlling these vectors by the common techniques including residual house-spraying, considerable attention was given to the study of bionomics of these vectors and the focality of transmission in American Samoa. The natural and man-made breeding places of the above vectors were enumerated. Resting places used by these vectors during the hot period of the day and at night were described as being under side of the leaves close to the ground or in rock crevices. These vectors were found to be most active shortly after daybreak and in the late afternoon, but they actively feed at any time during daylight hours on overcast or rainy days. Their flight range was given as 100 m. They were described as being bush mosquitos, as they were rarely found in open villages nor entered houses in clearings, but they steadily entered houses for feeding when such houses were surrounded by or adjacent to the bush, although they were never seen to rest there.

Under these conditions, infection rates in the pre-teen age were comparatively low in the principal more open villages., In smaller bush encompassed villages there was a significantly greater increase in the infection rate in females through adolescence and maturity. By far the heaviest infection rates were found in the adult males, being principally occupied in work in plantations and bush covered areas, where the vectors were found to exhibit the greatest feeding activity. The infection rates were found to be highest in smaller bush encompassed villages. The infection rate rises gradually in males from adolescence to middle life where it reaches its maximum and then levels off or declines. This is in contrast to the rapid increase in the infection rate during the first decade of life in the period W. bancrofti.

The authors concluded that transmission of the subperiodic form under the conditions described in American Samoa occurs in bush covered areas and as the principal vector was seen to enter houses only for feeding and rarely seen were to alight on walls, residual house spraying was considered not to offer any appreciable control.

(41) Wright, W.H.
1953

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The chemotherapy of filariasis

In: "Filariasis in the South Pacific".
South Pacific Commission, Noumea, pp. 61-68
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Until recently mass treatment has never been employed in the control of filariasis for the simple reason that no suitable drug was available. Pentavalent antimonials which have proved of some value have to be administered intramuscularly or intravenously and over a considerable

period of time if utmost efficacy is to be obtained. The method of administration alone renders impracticable their employment on any extensive scale for the control of the disease.

The introduction of DEC which can be administered orally, has therefore provided for the first time a drug which lends itself to mass treatment in filariasis.

The author poses ten questions for which answers should be obtained in order to evaluate the effectiveness of DEC as a control measure. They are:-

1. What percentage of the total population will have to be treated before the mf rate is reduced to the non-transmission level?
2. To what extent must the average mf rate be reduced before mosquito transmission is obviated?
3. Will it be necessary to treat only positive individuals or will the entire population have to receive therapy;
4. On an island such as Tahiti with a high index of infection and with a considerable percentage of clinical cases which may be expected to react unfavourably to DEC therapy, what percentage of the population treated will refuse further courses of therapy because of disagreeable reactions?
5. Can a dose rate be determined, within the limit of tolerance, which will be sufficiently effective to reduce the mf rate below the transmission level?
6. How many courses of treatment will be needed to achieve control in any given population group?
7. When more than one vector is present, as in Tahiti, will a given reduction in the average mf rate be sufficient to prevent transmission by all vectors?
8. Will DEC alone provide the answer to control or must it be used concomitantly with other measures?
9. At what intervals is DEC administration necessary to bring about control?
10. Will the relapse rate, refusal of individuals to be retreated because of reactions, the aggregate of persons not treated because of contraindications, and residual infections not detected on blood examinations be sufficient to force DEC administration at intervals over a long period of time so that the cost of control becomes unfeasible economically?

The author discusses in some detail, one particular aspect, namely the relation of the number of microfilariae in peripheral circulation of the individual to infection in the mosquito vector, based on the results of Rosen's work in Tahiti. Microfilariae of W. bancrofti have developed to

the infective stage in C. quinquefasciatus fed on donors with mf counts as low as 2.0 per 20 mm³ of blood. When Ae. polynesiensis (referred to as Ae. pseudoscutellaris) which is a more efficient vector of filariasis in Tahiti than is C. quinquefasciatus, was fed on donors having mf counts as low as 0.6 per mm³ of blood, microfilariae developed to the infective stage. These results bring to the fore the question of the relative importance of the lightly infected individuals in the transmission of the disease.

From Beye's results of the treatment of individuals in Paea district, Tahiti, the dosage being approximately 2 mg/kg thrice daily for 7 days, it is seen that 7 to 12 months after treatment 60% of 101 individuals had mf counts capable of providing infection for Ae. polynesiensis, and that 13 to 16 months after treatment 88% could serve as reservoir hosts for transmission of infection. Though these data do not warrant the abandonment of DEC therapy as a weapon in the control of the disease, they are of importance and should be supplemented by additional information to evaluate more accurately the amount of dependence to place on the drug, and the manner in which it can be most effectively employed.

In conclusion it is stated: "The return of microfilariae to the peripheral circulation of treated individuals after several months and the ability of mosquito vectors, particularly "Ae. pesudoscutellaris", to become infected when fed on individuals with extremely low mf counts raise the question as to the relative efficacy of the drug as a control measure."

(42) Ingram, R.L.
1954

A study of the bionomics of Aedes
(Stegomyia) polynesiensis Marks under
laboratory conditions
Amer. J. Hyg., 60, 169-185

Studies on the bionomics of Ae. polynesiensis in the laboratory at John's Hopkins University, at 26°C. for most of the time, gave the following results:

1. Egg hatching: 5-8 days; some taking 72 days.
2. Effects of drying on hatching: eggs kept moisture for four days after having been laid can withstand desiccation for at least 20 days, but at the end of this period only about 10% hatched.
3. Effect of drying on larvae and pupae: some larvae could survive dryness for four days, and pupae for two days.
4. Effect of salinity on larval development: fourth instar larvae and pupae can develop normally in 1.5% of saline solutions.
5. Duration of the larval and pupal stages: larvae, 4.6 - 9.6 days; and pupae, 1.8 - 2.7 days.
6. Adult feeding - oviposition cycle: feeding, 3-4 days after emergence; oviposition, 4 days after each blood meal, then feeding again 3 days later; the mean number of eggs laid by a female, per blood meal, 72; and the mean number of eggs laid by one female in her lifetime, 230.

7. Adult longevity: At 21.1°, 26.7° and 32.2°C, 50% of females survived for 50, 32 and 17 days, respectively; and males for 44, 23 and 14 days respectively.

(43) Iyengar, M.O.T.
1954
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A scheme for filariasis control in
Western Samoa
South Pacific Commission, Techn. Infn.
Circular No 20
Abstract taken from Iyengar (1960)
Techn. Paper No 129

Ae. polynesiensis is the main vector of filariasis in Western Samoa. The areas of primary importance as regards transmission of filarial infection are those within and around the villages. Emphasis should, therefore, be laid on the prevention of breeding of the vector mosquito in the villages and populated area in order to obtain maximum benefits from the control scheme.

The control measure suggested consists of keeping each village and a peripheral area of 120 metres, entirely free of artificial breeding sites of the vector mosquito, the work being done collectively by the villagers themselves under the guidance of the Filariasis Inspector. To ensure that litter likely to collect rain water does not accumulate subsequently, it is suggested that coconuts and cocoa pods are quartered and that tin cans are pierced at base before they are discarded. As rat-damaged coconuts constitute an important source of Ae. polynesiensis breeding in the plantations, the banding of coconut trees against rats is recommended, both as a measure of preventing loss of the coconut crop as well as to prevent the creation of breeding sites of Ae. polynesiensis.

It may be mentioned that of 276 persons examined on Upolu, 19.2% were positive with microfilaria and 4.5% had elephantiasis. On Savaii, of 87 persons examined, 24.1% had microfilariae and 1.1% elephantiasis. Of 640 Ae. polynesiensis dissected, 11% were positive with all stages of filarial larvae.

(44) Iyengar, M.O.T.
1954 a

Annotated bibliography of filariasis
and elephantiasis
South Pacific Commission,
Techn. Paper No 65

The Conference of Experts on Filariasis and Elephantiasis held in Tahiti in August - September 1951, commended the preparation and distribution of an annotated bibliography on filariasis and elephantiasis and related aspects in the South Pacific area (Document Fil. Conf/4, 17 July 1951), and recommended the progressive compilation of such a bibliography to be circulated at appropriate intervals, to member Governments, territorial administrators, Government and private institutions and individuals actively concerned with these problems. Circulation in mimeograph series was found adequate. The South Pacific Commission endorsed this recommendation and adopted the production of the bibliography in separate parts to cover epidemiology, parasitology, entomology, transmission, clinical and pathology, treatment and control.

The system adopted for the entries of the abstracts is chronological. The names of the authors are arranged alphabetically under each year. This bibliography is the first part. It contains 115 abstracted references which appeared between 1862 and 1954. Although the bibliography is mainly concerned with references on clinical manifestation of filariasis as well as microfilaria rates and periodicity, some papers dealing partly with epidemiological aspects and chemotherapy are also abstracted. Whenever information is given in certain papers on mosquito fauna, vector status, infection rates in mosquitos dissected in nature and experimentally, vector general behaviour and vector control trials, a summary was included.

The bibliography covered most of the islands in New Caldeonian, Micronesian, Polynesian and Papuan sub-regions.

- (45) Iyengar, M.O.T.
1954 b Repartition de la filariose dans la Region
 du Pacifique Sud
 South Pacific Commission,
 Techn. Paper No 66 (Also in English)

The aim of this paper was to bring together the information on filariasis from different part of the South Pacific since such information is either dispersed in numerous publications or given in official reports and files which are not easily accessible to research workers. The paper presents the available information up to 1954 in four sections; for each section there is an introductory review followed by presentation of the relevant data in a tabulated form, as shown in the following:

- Section 1. Distribution and the microfilaria rates recorded in the South Pacific.
The tabulated data are given for localities surveyed in each Island group, comprising the number of subjects examined, the microfilaria rate and the author cited.
- Section 2. Distribution and incidence of elephantiasis.
Similar to the above recording of the tabulated data, the percent of people with elephantiasis is given.
- Section 3. The distribution of the periodic and subperiodic W. bancrofti.
The tabulated data are given for the presence or absence of nocturnal periodicity.
- Section 4. The distribution of vectors of filariasis and records of the infection rates are tabulated.

For each of the first three sections a distribution map with coloured codes is provided. Also for section 4, distribution of mosquito species involved is given in coloured codes classifying them into:

- proven vectors of primary importance
probable primary vectors (as based on epidemiological evidence)
potential secondary vectors

(46) Jachowski, L.A.
1954

Filariasis in American Samoa.
V. Bionomics of the principal vector,
Aedes polynesiensis Marks
Amer. J. Hyg., 60, 186-203

The paper presents field data collected in American Samoa during 1948-1950 on the distribution, habitat, activity, abundance and reproduction of Ae. polynesiensis supplemented by laboratory studies on the development of immature stages, survival and feeding of the adult mosquitos. This paper is considered as preliminary to the work of Ingram, 1954 (42) and others on Ae. polynesiensis.

Methods: Field surveys adopted the method of Byrd et al., 1945 (12) as standardized sampling technique after realizing that other procedures such as man and animal baited traps, light traps at dawn and dusk and sweeping the grass for collecting resting mosquitos were unsuccessful. The landing-biting catches were made by two collectors at designated stations. At each station, the two collectors spent 10 minutes attempting to catch all the mosquitos coming to bite them. When the 10-minute catch was less than 150 mosquitos, a reliable biting index could be estimated, but when the number was greater, the accuracy of the index was doubted as many mosquitos were lost. The density index was expressed as the mean number of mosquitos captured in one third of a man/hour. A laboratory colony of Ae. polynesiensis was established at the John Hopkins University, School of Public Health, United States of America, from eggs brought from American Samoa. The procedures were as follows:

Waxed cardboard cartons lined with a strip of filter paper or paper toweling and partially filled with water were placed in the cages to collect the eggs, which usually were deposited on the wet paper just above the water line. The strips of paper were removed daily and stored for 4 days in tightly covered containers to allow maturation of the eggs. Following this maturation period, they were removed from the container and allowed to dry for 3 days at room temperature. Larvae were hatched by submerging the matured eggs in white enameled pans containing approximately 2 litres of tap water in which 3 or 4 alfalfa pellets (rabbit chow) had been allowed to dissolve for 24 hours. The larvae fed upon the alfalfa pellets. Additional food was added as needed but care had to be taken to avoid over-feeding for, if excessive food was added, a high larval mortality resulted.

Pupae were removed daily and put into small cups. Emerging adults were collected in lantern globes which fitted over the cups or in wire cages into which cups were placed. Pads of absorbent cotton saturated with a solution of sugar (approximately 5 per cent) were placed upon the tops of the cages as a source of food. Arms of human volunteers were exposed to the mosquitoes daily to provide blood meals. In observations on survival of adult females, the frequency of blood meals and the number of eggs laid per blood meal, small plastic vials were used, in each one male and one female was introduced. Mosquitos were provided with sugar solution and arms were offered daily for a blood meal.

The most critical problem in colonizing this mosquito was maintenance of a high relative humidity in the cages. Although the laboratory had controlled temperatures of $26.7 + 2.8^{\circ}\text{C}$. and relative humidities of $70 + 8\%$, an unusually high mortality among the adult mosquitos shortly after emergence continued until the cages were covered with wet cloths.

Results: A summary of the findings is generally given but for certain aspects of importance extracts of the detailed information is made.

1. Distribution

Ae. polynesiensis was collected on all inhabited islands of American Samoa, whether at sea level or on the mountain ridges so long as the environment is suitable for its breeding and provides the adult mosquitos with resting shelters.

2. Diurnal activity

In January 1949, collections of mosquitos were made at hourly intervals for 24 hours at each of 3 stations in and near the village of Mapasaga on the island of Tutuila. The stations were located as follows: (1) in the central clearing of the village approximately 23 m from the nearest house; (2) in a house partially surrounded by vegetation; and (3) along a trail in the banana grove behind the village, approximately 45 m from the nearest house. In November 1949, a similar survey was made at the same stations between 1500 hrs. and 2300 hrs. The collections in the late night were omitted because it was believed that the use of flashlights in the earlier survey had activated mosquitos which normally would not have attempted to feed at night.

The mosquito densities, as judged by these two surveys plotted as 3-hour moving averages, show rather consistent patterns (Figure 1). The few mosquitos caught in the clearing were taken in the early morning and early evening hours. The two series of collections made in the bush vary only in detail.

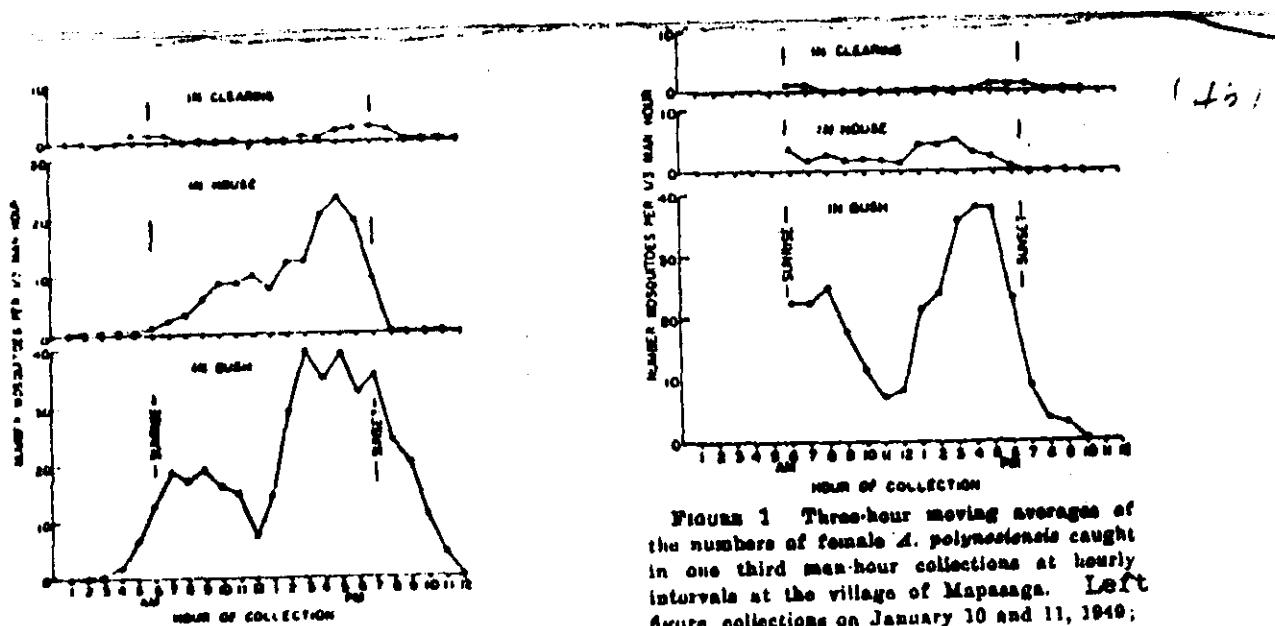


FIGURE 1 Three-hour moving averages of the numbers of female A. polynesiensis caught in one third man-hour collections at hourly intervals at the village of Mapasaga. Left figure, collections on January 10 and 11, 1949; right figure, collections on November 30, 1949.

Both curves are bimodal with the lesser peak occurring in the morning and the greater one in the late afternoon. The numbers of mosquitos on the latter surveys are believed to reflect the destruction of suitable mosquito harborage around the house. Whereas a rank undergrowth was present in January, the area had been cleared and planted in taro in November. However, other unrecognized factors may have been involved.

Comparing the number of mosquitos collected at the 3 stations it becomes obvious that more mosquitos may be found in the bush at almost any hour of the day than in the village proper. Moreover, there is no evidence of an extensive migration of Ae. polynesiensis into the clearing even in the absence of brilliant sunlight.

3. Dispersal

The range of dispersal of Ae. polynesiensis is considered to be 100 yards (m) or less. O'Connor, 1923 (3) found that this mosquito was fairly abundant on one islet, yet absent from two others located only 18 to 91 m away. Amos, 1947 (14) reported that during the heat of the day, Ae. polynesiensis would venture only rarely as far as 23 m into a sunlit area, but that on calm evenings it would travel just short of 91 m. The statements of O'Connor and of Amos are of interest, but they are not supported by data. Both have found how far this mosquito will travel into unfavourable environments, but their statements do not explain the sources of blood meals for infected mosquitos found some distances from villages. Were these mosquitos infected locally, or were they infected in the village? Byrd *et al.*, 1945 (12) showed that the rate of infection with W. bancrofti in mosquitos was greatest in the village and decreased markedly at the periphery of the village. They assumed that all transmission occurred within the village and cited the infection rates as evidence of a flight range of 91 m or less. Since their basic assumption is open to considerable doubt, more direct evidence of the dispersal of Ae. polynesiensis was needed. To obtain this information two experiments were performed in which Ae. polynesiensis were collected, marked with dye, released and recaptured.

Adult female Ae. polynesiensis were collected outside of the test area on the days that the experiments began. They were divided into lots and dusted with a mixture of flour and dye in order to mark the specimens.

The dyes used were gentian violet, eosin and methyl green. Gentian violet proved to be too toxic. The colours were mixed with flour in the proportion of 1 to 25. After dusting, the mosquitos were released in the experimental area.

Recovery of stained specimens was made by collecting mosquitos from human bait by means of hand aspirators. One, 3, 5, 7, 14 and 21 days after the releases, collections were made at each capture station for a period of 10 minutes. The mosquitos that were caught were killed with chloroform fumes in labeled test tubes. In the laboratory, these specimens were spread on a piece of filter paper and a small amount of dye solvent (70% alcohol, 3 parts; glycerin, 1 part; and chloroform, 1 part) was dropped on each. Marked mosquitos were immediately recognized by staining of the filter paper.

These two experiments were performed at the air base of Tafuna, Tutuila, American Samoa. Until World War II, this area had been planted by Samoans in food crops (bananas, papayas and coconuts). During the war, the air base was constructed. By 1950, most of the area, except for roads, airstrip, and small areas around the remaining buildings had reverted to jungle. The terrain is flat. The prevailing wind is from the east. One week prior to each release, the experimental area was sprayed by airplane with DDT emulsion at the rate of 91 gm of DDT per acre. This procedure virtually eliminated the indigenous adult *Ae. polynesiensis* population, but did not affect the immature stages. By the time the experiments began, a new adult mosquito population was appearing again. This procedure proved very helpful for it reduced the numbers of unstained mosquitos in the collections.

The results of these studies are not conclusive and are too few for statistical analysis. Nevertheless, some important information has been derived from them: (1) nearly 75% of all the mosquitos recaptured were taken within 5 days at the points of release; (2) the dispersal that has been observed is apparently slow, because recovery of mosquitos at stations 50 m from the points of release were made after 3 to 23 days and at stations 91 m away after 7 to 14 days; (3) *Ae. polynesiensis* can travel 91 m through the jungle, but this apparently approaches its maximum dispersal; (4) clearings, such as the main roads and the airstrip, seem to act as barriers to the movements of this mosquito; and (5) flight seems oriented along the path of the prevailing winds. Taken collectively, these points strongly suggest that the dispersal of *Ae. polynesiensis* is very limited as the earlier writers have stated.

4. Seasonal variations

There seems to be no definite seasonal variations in the mosquito density. There are apparent effects of the weather on mosquito activity in cleared areas, but not in uncleared areas.

5. Resting places

It was never found resting in any type of house, but was frequently encountered on the underside of leaves of bushes sheltering breeding containers and in crevices of stone walls sheltering pigs.

6. Host preference

It is assumed that if more than one host is available, man is preferred.

7. Breeding sites

It was found to breed in small natural or artificial collections of water, but the most common breeding site was coconut shells.

8. Laboratory observations show that the mean survival of the adult female was 21.2 days at 26.7°C and high relative humidity. The blood meal weighs approximately 1.8 mg and averages 1.3 times the weight of the mosquito. The mean age at the time of the first blood meal was 3.3 days, and successive meals were taken at intervals of about 1 week thereafter. Larval development took 6.7 days at 26.7°C, and the period from the egg stage to adult was 9 days.

(47) Marks, E.N.
1954

A review of the Aedes scutellaris subgroup
with a study of variation in Aedes
pseudoscutellaris (Theobald) (Diptera:
Culicidae)
Bull. British Museum (Natural History),
Entomology, 3, 349-414

The scutellaris subgroup of the present paper is synonymous with Knight & Hurlbut's subgroup I (1949)¹, which the authors define as follows: "Characterized by having the more mesal portions of the abdominal tergal markings sub-basal. In addition, post-spiracular scales are lacking, the scutal longitudinal median line is relatively slender, and the pleural scale patches are arranged in two rather well-defined longitudinal bands (not true of gurneyi, however)".

The following list of the species included by Knight & Hurlbut under their definition, with the addition of one species and one subspecies since described is arranged in chronological order of the date of publication of the names (as either varietal or specific). The original designation is given in parenthesis.

1. scutellaris Walker, 1859 (Culex scutellaris)
2. pseudoscutellaris Theobald, 1910 (Stegomyia pseudoscutellaris)²
3. tongae Edwards, 1926 (Aedes variegatus var. tongae)
4. andrewsi Edwards, 1926 (Ae. variegatus var. andrewsi)
5. aloensis Bonne-Wepster & Brug, 1932 (Ae. (S.) variegatus var. aloensis)
6. horrescens Edwards, 1935 (Ae. (S.) scutellaris var. horrescens)
7. gurneyi Stone & Bohart, 1944 (Ae. (S.) gurneyi)
8. marshallensis Stone & Bohart, 1944 (Ae. (S.) marshallensis)
9. guamensis Farner & Bohart, 1944 (Ae. (S.) guamensis)
10. pernotatus Farner & Bohart, 1944 (Ae. (S.) pernotatus)
11. quasiscutellaris Farner & Bohart, 1944 (Ae. (S.) quasiscutellaris)
12. hensilli Farner, 1945 (Ae. (S.) hensilli)
13. paullusi Stone & Farner, 1945 (Ae. (S.) paullusi)
14. riversi Bohart & Ingram, 1946 (Ae. (S.) riversi)
15. scutoscriptus Bohart & Ingram, 1946 (Ae. (S.) scutoscriptus)
16. hakanssoni Knight & Hurlbut, 1949 (Ae. (S.) hakanssoni)
17. scutellaris katherinensis Woodhill, 1949 (Ae. (S.) scutellaris
katherinensis)
18. polynesiensis Marks, 1951 (Ae. (S.) polynesiensis)

¹Knight, K.L. & Hurlbut, H.S. (1949) The mosquitos of Panape Island, Eastern Carolines (Diptera, Culicidae). J. Wash. Acad. Sci., 39, 20-34

²Marks, 1957 (27) demonstrated that two species had previously been confused under the name "pseudoscutellaris". In this paper "pseudoscutellaris" is used for authors' references which do not discriminate between the two forms. Where the identity of the form is beyond doubt it is referred to under the appropriate pseudoscutellaris or polynesiensis.

Synopsis

The eighteen described and three undescribed members of the Aedes scutellaris subgroup are recognized from the Australasian region and eastern part of the Oriental region. The systematic status accorded to members is reviewed, the diagnostic specific characters critically examined, and the geographical distribution of the subgroup illustrated and discussed.

An original pictorial chart for identification of members of the subgroup indicates also the geographical distribution of various taxonomic characters, the implications of which are considered. The general trend is from west to east but one character shows a north-south distribution. A key to adults is provided for use with the chart, and the inadequate state of present knowledge of immature stages is briefly indicated.

Source and experimental methods of rearing a colony of Aedes pseudoscutellaris Theobald are described. Results are tabulated of a biometrical study of twenty-eight characters, in five series of pseudoscutellaris adults bred from larvae whose environment had been subjected to controlled variation of either temperature or salinity, and in one series of adults from different stock, also bred in controlled conditions. The records are analyzed and their implications discussed.

The results support the specific status accorded to members of the scutellaris subgroup, in that the observed range of experimental variation is not generally of the same magnitude as interspecific differences in the same character. Lack of variation in the basal lobe of the male coxite is evidence of its value in defining species. Two characters should probably be used with caution for delimiting species, since pseudoscutellaris can exhibit both extremes of their development. A complete interruption to the white bands on hind tarsal segments II-IV can be produced by low temperatures of larval environment. Presence or absence of a white streak under the proboscis may be due to differences in hereditary constitution, though larval environment also has some effect.

(48) Rosen, L.
1954

Human filariasis in the Marquesas Islands
Amer. J. trop. Med. Hyg., 3, 742-745

Relatively little information has been available on human filariasis (W. bancrofti) in the Marquesas Islands although it has been known that Ae. polynesiensis, a vector of this parasite elsewhere in Polynesia, occurs on several islands of this archipelago. In June 1952 the author visited the six inhabited islands of the group to make a brief filariasis and mosquito survey.

It was quickly apparent that filariasis is endemic in the Marquesas Islands. On each of the six inhabited islands (Nukuhiva, Uahuka, Uapou, Tahuata, Hivaoa, and Fatuhiva), which together have a population of approximately 3000 individuals, at least 5% of the total population had gross manifestations of elephantiasis. On each island there were individuals with elephantiasis who had never lived elsewhere. In addition, several Europeans who had never been exposed in other endemic areas of filariasis had also acquired elephantiasis in the Islands.

Stained blood films (20 mm^3 of capillary blood) taken in the daytime from a small number of inhabitants of Fatuhiva were examined and 32.2% (19 of 59) were found positive for microfilariae of W. bancrofti. Microfilariae were found in the blood of persons who had never left the island.

Ae. polynesiensis was found on all six inhabited islands. It was of interest that two of these islands, Fatuhiva and Uahuka, did not have rats capable of opening coconuts. The rat-opened coconut is the most important breeding site of Ae. polynesiensis in the Society Islands.

(49) Rosen, L.
1954 a

Observations on Dirofilaria immitis
in French Oceania
Ann. trop. Med. Parasit., 48, 318-328

The following is the summary of the findings:

1. Infection with D. immitis is widespread in French Oceania. Infected dogs were found in the Society Islands, the Tuamotu Islands and the Marquesas Islands.
2. Culex annulirostris and Ae. polynesiensis are important natural vectors of D. immitis in French Oceania.
3. The longevity of Ae. polynesiensis in the laboratory is adversely affected by the developing larvae of D. immitis.
4. Developing larvae of D. immitis were not found in fleas collected from dogs infected with the parasite.
5. The periodicity of the microfilariae of D. immitis is the same in French Oceania as it is elsewhere.

(50) Rosen, L. &
Rozeboom, L.E.
1954

Morphologic variations of larvae of the
scutellaris group of Aedes (Diptera,
Culicidae) in Polynesia
Amer. J. trop. Med. Hyg., 3, 529-538

At least two species of the scutellaris group, Ae. polynesiensis and Ae. pseudoscutellaris, other than Ae. horrescens, can give hairy larvae under certain environmental conditions. Ae. horrescens remains as a distinct species not because of the hairiness of the larvae by which it was detected and for which it was named, but rather because of the characteristics of the male terminalia.

Although the environmental factor responsible for the hairiness of larvae of Ae. polynesiensis was not elucidated, in the Society Islands, it apparently occurs most commonly in tree holes, or a majority of tree holes.

In the Samoa Islands, Jachowski (1951 personal communication to the author) encountered hairy larvae in various types of artificial containers; all of these, however, contained a considerable amount of debris. As demonstrated in the experiments cited in the paper, the factor seems to be associated with the debris in the breeding site but evidently is not solely the result of the physical presence of this debris.

(51) Iyengar, M.O.T.
1955

Distribution of mosquitos in the
South Pacific Region
South Pacific Commission, Techn. Paper
No 86

The paper compiled the available records on the distribution of the mosquito fauna in the South Pacific Region. The subject is given in three parts: (in English and French)

Part 1. A tabular form showing the distribution of genera and subgenera of mosquitos in different islands of the South Pacific Region. This is accompanied by detailed notes on the distribution of species of the following genera: Bironella, Anopheles, Toxorhynchites, Tripteroides, Harpagomyia, Hodgesia, Uranotaenia, Orthopodomyia, Ficalbia, Taeniorhynchus, Aedeomyia, Aedes, Armigeres and Culex. Reference is made to those species which are known to be vectors of human diseases.

Part 2. List of the distribution of mosquito species in the South Pacific Region.

Part 3. The area-wise distribution of species and subspecies.

(52) Jachowski, L.A. &
Otto, G.F.
1955

Filariasis in American Samoa. IV.
Prevalence of microfilaremia in the
human population
Amer. J. Hyg., 61, 334-348

In continuation with their previous investigations indicating entomologically that the transmission of filariasis in American Samoa is essentially sylvatic, the authors conducted a parasitological survey. Thus 2421 persons in ten villages were examined for microfilaria, and many of these were examined as many as 12 times in the course of five years. Each time a sample of 60 mm³ of blood was taken.

Although it is impossible to determine precisely where an individual, who was exposed two or more years previously, actually acquired his infection, still a study of the general ecology of the human population and a statistical analysis of the mf rates in man has provided an insight into this problem. Samoans live in villages which, in general, may be divided into two groups: (1) larger open villages in which the houses are set out in clearings, and (2) either smaller or diffuse bush villages in which the houses are built in, or very close to, the undergrowth. The microfilaria rates for the total population in the open villages are significantly lower than for the population of the bush villages. The youngest age groups

(5 through 9 years) showing appreciable microfilaraemia are closely confined to the village and serve as a crude index of actual transmission in the village and its immediate environment. There is no difference between the two sexes in this age group but the infection rate for both sexes in the small uncleared villages is over twice that in the cleared village.

By native customs there is a marked division of labour between the sexes, men spending a considerable portion of the day outside the village and women continuing activities rather close to their homes.

Until the age of puberty the infection rates are comparable for the two sexes but thereafter the difference is striking. Although in all groups the infection seems to become stabilized in the age group above 35 through 39 years, the levels for the several groups are not the same. The adult males from the small uncleared villages, with their exposure both in the village and in trips and work abroad, have the highest prevalence rates. The women from the cleared villages have the lowest microfilaria rates. The men from the cleared villages whose principal exposure is in the plantations and along the bush trails have about the same rate as the women who live in small bush enclosed villages.

(53) McCarthy, D.D. &
Fitzgerald, N.
1955

Researches in Western Samoa
Trans. roy. Soc. trop. Med. Hyg., 49, 82-89

The paper presents the results of a filariasis survey carried out in Laulii village situated on the north coast of Upolu island, together with the results of blood examination of groups of persons from Apia and from Savai'i, the second island in the country. The survey was based on clinical examination of the villagers and examination of 955 blood samples of 20 mm³ collected by finger prick. Of the slides collected, 426 were from Laulii village, 219 from persons living in and around Apia, 98 from prisoners and 212 from random samples of the population of Savai'i. Detailed data are presented and consolidated findings are shown in the following table in comparison with those obtained about 20 years ago.

Comparison of microfilarial incidence in 1923 by O'Connor (3), and 1953 by the present authors in persons 10 years of age and over:

Upolu	1923		1953	
	Males	Females	Males	Females
No. examined	349	162	275	177
No. positive	236	74	102	34
% positive	67.6	45.7	37.1	19.2
Savai'i				
No. examined	717	839	125	65
No. positive	484	460	50	18
% positive	67.5	54.9	40.0	27.7

The most important finding in this investigation is the great difference in incidence of infection between men and women. While similar differences have been noted elsewhere in the Pacific area they have generally been of lesser degree. It would appear from a comparison with the findings of O'Connor, 1923 (3) and Buxton, 1928 (7) that the incidence of the disease and its separate signs have been undergoing a slow but steady decrease over the past 30 years.

As shown in the table, in Upolu the percentage incidence of microfilaremia in persons over 16 years of age has dropped from 67.6% to 37.1% in males and from 45.7% to 19.2% in females. In Savai'i, which is more sparsely populated than Upolu and whose inhabited coastal area is more closely covered with bush, the decrease, though less than that in Upolu, is none the less striking. In both islands the diminution has been greater in women than in men. Buxton's figures refer to males only, and comparison with the male records of 1953 shows the same recession in general incidence. The percentage of cases incidence of enlarged epitrochlear glands supports this premise.

(54) Nelson, S. & Filariasis in Fiji, 1944 - 55
Cruikshank, J.M. Medical Department, Fiji, Dec. 1955, 50 pp
1955 Abstract taken from Iyengar (1960)
* Techn. Paper No 129

Ae. pseudoscutellaris and Ae. polynesiensis appear to be the main vectors of filariasis in Fiji. They shelter in bush and breed in tin cans, drums, coconut shells and other small containers. The rat-damaged coconut is a more important source of Aedes breeding than the split coconut shell. For the control of Aedes breeding, Toxorhynchites splendens from Java and T. inornatus from Rabaul were introduced into Fiji during 1931 and 1933 respectively. No specimens of T. inornatus have been taken since its introduction in 1933. Small recoveries have been subsequently made of T. splendens. It can be stated that after 22 years, the species T. splendens has become thinly established in certain areas where there are ideal conditions for its survival, namely, a copious rainfall, trees with deep rot-holes or buttresses, and where the undergrowth is not very dense. Its introduction into Fiji would appear to have been of doubtful value. As the chief vector of filariasis does not normally rest inside dwellings, residual spraying of dwellings with DDT would not be justified. As the breeding sites of the mosquito are mostly small containers and rot-holes in trees, their removal and destruction are more effective and less costly than the constant use of larvicides. During 1944 a campaign was launched against the vector mosquitos by a general clean-up of scrub and long grass and the breeding places they harboured. All small containers within the village itself and a peripheral belt of 100 m were collected and buried; coconut shells and husks were piled and burnt. Tree-holes were either filled in with mud and caulking pitch, or cut and drained. The village green was cut to lawn length and bush in the outskirt area cleared. The work was done by the villagers themselves.

Experimental treatment of mf carriers with DEC was carried out during 1952-53. From the results obtained of these trials, the authors concluded as follows:

Administration of DEC more frequently than once a month has not caused a greater reduction of microfilariae in the blood; 50 mg of DEC administered at monthly intervals for one year cause microfilariae to disappear from the blood in 60 to 67% of the carriers; 33 to 40% of the carriers were positive for microfilariae in their blood after one year of treatment with 50 mg DEC once every month; the majority of those not becoming negative for microfilariae in their blood showed a considerable decrease in the number of microfilariae while receiving the monthly treatment with 50 mg DEC. As a prophylactic, a higher dosage than 50 mg at monthly intervals is required to prevent the development of microfilariasis. In males over the age of five years it has dropped from 49.0% in 1925 to 26.2% in 1953, that of hydrocele in males over the age of 15 years from 19.8% in 1925 to 12.8% in 1953, and that of elephantiasis in persons over the age of 20 years from 9.8% in 1925 to 5.5% in 1953.

The reason for this is not known with certainty but it does not appear to have resulted from planned control measures or from educational propaganda. It is, however, now suggested that, with the passage of time the village areas have been slowly cleared through domestic demands for firewood and other purposes. The villages therefore are now more open than formerly and in consequence less attractive to *Ae. polynesiensis* which has retreated with the bush, leaving the villages relatively free as a focus of infection. If this be so, persons living exclusively within the village precincts would receive infected bites at infrequent intervals. This would in turn delay the building up of the quantum of infection to that level at which the various criteria of filarial disease make their appearance. The present investigation has shown that enlarged glands, hydrocele and elephantiasis are now appearing ten years later in the age scale than they did 30 years ago. Furthermore, it is considered that as the women probably spend more of their time in the villages than do the men, and their child-bearing years in particular, this could be one of the principal factors accounting for the low incidence in women and young children. A further probable factor, however, is clothing. Cloth is more widely available now than formerly and with increased standards of living has become more widely used, so that the average Samoan woman of today keeps her body and limbs covered to a greater extent than does man, and more than did the previous generation of women. It would appear that the operation of these factors has slowed the rate of infection and reinfection, and has delayed the building up of the parasite load to that point at which it produces the more gross and disabling forms of the disease.

(55) Otto, F.G. &
Jachowski, L.A.
1955

Problems in the epidemiology and control
of filariasis
WHO unpublished document, WHO/FIL/9

This document is along the same lines as those given by the same authors in a published paper, Otto & Jachowski, 1953 (40) recapitulating the available information on domestic and sylvatic transmission of filariasis and the feasibility of control of both types. Thus citation will be limited to the complementary information that the authors added in the present document.

The authors reiterated for filariasis as for malaria, the interrelated bionomics of the human population and vector population should be fully studied in a given area in order to develop the most effective and economic methods of control with the available resources. Reference was made to domestic situations where the vectors of malaria and periodic W. bancrofti feed on the human population in their homes. This makes the use of residual house spraying a feasible measure of control. In contrast, the authors quoted their experience in American Samoa where they provided evidence that transmission of the subperiodic W. bancrofti by Ae. polynesiensis is mainly in the bush or in bush encompassed villages. Reference was also made to the observations of Byrd, St Amant & Bromberg, 1945 (12) which indicated that Ae. polynesiensis rarely feeds at night but is essentially a day-time feeder. Observations made by Jachowski, 1954 (46) supported this. His findings of mark/release/recapture experiments also confirmed earlier findings that Ae. polynesiensis has a short flight range of about 91 m. The authors further recalled their observations on the biting density and infection rates in Ae. polynesiensis at village clearings, in houses and in the bush, Jachowski & Otto, 1952 (31), as well as observations on the habits of the human population and the mf rates in different age groups and sexes, Jachowski & Otto, 1955 (52). A review was made on the experience obtained in the past for the control of filariasis through vector control measures. The authors indicated that in Samoa during World War II, filariasis was not prevented in military forces by control procedures aimed at interrupting night-time transmission in the military installations and in native villages. During the postwar period, a concerted effort was made to reduce filariasis in Rarotonga (Cook Island) by attacking the vector Ae. polynesiensis in and around villages, Amos, 1946 (13). The effectiveness of mosquito destruction was initially assessed three years later, Davis, 1949 (16). The mf rate was found to be 27% while it was 16% before control measures were introduced as was reported by Hercus & Faine, 1951 (24). With the long prepatent period in filariasis, the full benefit of mosquito control would not be reflected in a reduced microfilariae prevalence in as short a period as three years. In the authors' opinion, little benefit could accrue from a programme of mosquito control directed at the minimum point of transmission, the village, without touching the primary source of infection, the plantations and similar areas frequented by villagers during day time. Since larvicide or any attack on adult vector population by island-wide air or ground spraying was considered impossible and as the effect of chemotherapy was not certain at that time the authors suggested that in the meantime an effort to clear the jungle from the immediate village area and clean up all harbourage and breeding sites could offer protection within the village. The younger children could be completely protected and partial protection can be rendered to the adult population. Although this pattern of control would not reduce the microfilaremia in the segment of the population recurrently exposed elsewhere, it represents an initial step towards ultimate development of adequate filariasis control.

(56) Rosen, L.
1955

Observations on the epidemiology of human
filariasis in French Oceania
Amer. J. Hyg., 61, 219-248

The topics of the investigations carried out during 1950-52 and reported on this paper were outlined as follows:

- (a) the role of each of the local species of mosquitos in the transmission of the infection;
- (b) the quantitative characteristics of the sources of mosquito infection;
- (c) the minimum blood density of microfilariae necessary to infect a significant proportion of vector mosquitos;
- (d) the quantitative characteristics of infection produced in vector mosquitos by various infective blood densities of microfilariae;
- (e) the effect of the filarial infection on the longevity of vector mosquitos.

The investigations (d) and (e) are relevant to the study of the potentiality of resumption of transmission after reducing the mf densities following DEC mass treatment campaigns.

Three study areas were selected for determining the infection and infective rates in wild caught mosquitos, where control measures had never been undertaken. Two areas on Tahiti (Papara and Mairo) and the third was on Makatesais land in the Tuamotu island group.

Results obtained are as follows:

1. Dissection of wild-caught mosquitos: Advanced stages of larvae were found only in Ae. polynesiensis.
2. Experimental infection: Ae. polynesiensis is a more efficient host for the subperiodic form than the period form, whereas C. quinquefasciatus is just the reverse. It was considered that even in the absence of more efficient vectors in Polynesia, C. quinquefasciatus cannot propagate the subperiodic form.
3. Microfilaria prevalence: A single 20 mm³ sample of blood was obtained during the day from each of 2580 persons (almost the entire population of the three study areas). Only 21.7% of the 46 persons with elephantiasis harboured microfilariae. The mf rate among males was 35.2% and among females 27.1%. The rate showed an increase with age until early adulthood. The rate is higher among males except in the age group of less than 15 years and more than 50 years. Microfilaria counts in 20 mm³ of blood varied from 1 to 1296.
4. Periodicity studies: Ten carriers were subjected to blood sampling every two hours for 48 hours. All of them were active during the day and slept as far as was possible under the same conditions. A peak density was in the late afternoon or early evening.

5. Quantitative aspects of the mosquito infection:

5.1 Naturally infected mosquitos

It was found that the mean number of the first stage larva per infected Ae. polynesiensis was 6.7 out of 121 mosquitos of the second stage 5.8 out of 69 mosquitos; and of the third stage, 4.6 out of 43 mosquitos.

5.2 Experimentally infected mosquitos with different level of microfilaria density

Results are given in the table.

Table 1. The susceptibility of A. polynesiensis to infection with Tahitian strains of W. bancrofti

Av. No. mf/ 20 mm of donor's blood at the time of mosq. feeding	No. mosq. dis. 13 days or more days after feeding	% mosq. with larva*	Av. No. of larva per mos- quito	Av. No. of larva per in- fected mosquito	Range No. of larva per in- fected mosquito.	Total No. of larva obs.** (0)	Total No. of larva expected (E)**	Ratio O/E**
0.4	38	5.3	.05	1.0	1	2	1	2
0.6	69	11.6	.1	1.0	1	2	2.7	3
2.1	36	55.6	.8	1.5	1-3	29	5	5.8
3.1	70	64.3	1.3	2.0	1-6	92	14.4	6.8
3.3	49	49.0	1.1	2.3	1-6	56	10.1	5.2
3.5	67	47.9	.8	1.6	1-4	73	15.6	4.7
4.8	13	38.5	.8	2.0	1-3	10	4.1	2.4
5.1	18	50.0	1.1	2.1	1-5	17	6.1	2.8
11.4	17	76.5	2.1	2.8	1-7	36	12.9	2.8
11.5	138	68.1	2.1	3.1	1-14	289.8	105.3	2.8
12.8	66	83.3	3.5	4.1	1-11	231	56	4.1
27.0	66	86.4	3.5	4.0	1-14	231	118.2	2
28.4	23	97.0	6.1	6.3	1-21	201.3	62.2	3.2
31.9	67	82.1	4.5	5.5	1-12	301.5	141.8	2.1
31.9	28	96.4	5.6	5.8	1-15	156.8	59.3	2.6
38.0	76	89.5	4.6	5.1	1-18	349.6	191.6	1.8
52.1	26	88.5	5.1	5.7	1-14	132.6	89.9	1.5
97.4	43	97.7	12.7	13.0	1-42	546.1	277.9	2
167.0	74	94.6	13.4	14.2	1-53	991.6	820	1.2
195.6	22	95.5	18.8	19.7	4-44	413.6	2855	1.4
208.0	36	97.2	16.7	17.2	2-41	601.2	496.8	1.2
533.9	25	100.0	16.4	16.4	3-33	410	885.6	0.5
555.1	54	100.0	21.7	21.7	2-60	1171.8	1988.9	0.6

* All were third-stage larvae except for a few late second-stage larvae in heavily infected mosquitos which also contained third-stage larvae.

**These columns were added to the original table of the author (vide explanation in N.B.)

Table 4

The average number of larvae in *A. polynesiensis*
during various times after feeding on subjects
with Tahitian strains of *W. bancrofti*

Average no. of microfilariae in 20 cu mm. of donor's blood at the time of mosquito feeding	No. of days after landing which mos- quitoes sur- vived	No. of mos- quitoes dis- sected at indicated time after feeding	Average no. of larvae per mos- quito
565.1	12.5 to 13	26	26.0
	13.5 to 14	21	10.9
	14.5 to 15	6	12.7
195.0	12.5	10	22.3
	13.5 to 15	12	18.8
167.0	0.5 to 13	8	25.3
	13*	8*	12.6
	13.5	13	24.2
	14.5	22	14.6
	15.5	14	8.9
	16 to 19	14	4.4
	13.5 to 15.5	22	18.2
07.4	15 to 24	21	6.9

* These mosquitoes were selected at random
from mosquitoes in the lot and were then killed
and dissected.

Table 5

The survival of *A. polynesiensis* after feeding
on donors with Tahitian strains
of *W. bancrofti*

Average no. of microfilariae in 20 cu mm. of donor's blood at the time of mos- quito feeding	Number of mos- quitoes fed	Percentage of mosquitoes surviving		
		6.5 days	9.5 days	12.5 days
0.0	46	100	82	41
0.0	131	91	81	50
0.4	88	86	65	46
0.6	207	99	76	39
2.1	57	97	97	77
3.1	81	95	91	86
3.3	176	70	35	30
3.5	144	98	85	47
4.8	170	15	11	7
6.1	192	94	51	10
11.4	151	83	35	16
11.5	169	98	98	88
12.8	126	96	95	95
27.0	128	84	82	52
28.4	145	90	72	32
31.9	79	100	98	86
31.9	60	100	93	17
38.0	125	98	67	62
62.1	46	96	81	59
97.4	131	84	51	51
167.0	110	96	78	74
195.0	94	96	78	24
208.0	165	90	54	22
533.9	177	91	67	11
565.1	207	94	77	29

A significant proportion of Ae. polynesiensis became infected with mf densities well below those reported by previous workers of whom Manson-Bahr & Muggleton (1952)¹ considered that 4 mf per 20 mm³ of blood was a subinfective density to Ae. pseudoscutellaris in Fiji. The author considered that any density of mf that can be detected 20 mm³ of blood from capillaries can be infective to Ae. polynesiensis.

Regarding the possibility of mosquitos concentrating the microfilariae the author reviewed the results obtained by earlier workers. Manson (1883)² was the first to report that mosquitos ingested a greater number of microfilariae than could be found in the same quantity of blood in the peripheral circulation. Ashburn & Craig (1907)³ stated that C. quinquefasciatus fed on Philippine Island strains of W. bancrofti took up to 40 to 50 times as many microfilariae as there were in an equal quantity of blood obtained by a pin prick.

The author indicated that no direct investigation was made of the claim that mosquitos ingest more microfilariae than can be found in an equal amount of blood obtained by other means. However, there was little to suggest that such a phenomenon occurs to a significant extent in Ae. polynesiensis. Although the data presented in the table refers to mature or nearly mature larvae, evidence from dissections performed on other specimens at shorter intervals after the infective blood meal indicated that practically all microfilariae ingested by Ae. polynesiensis fed on low blood densities of microfilariae complete their development. Mosquitos fed on low blood densities of microfilariae had, on an average, about the same number of larvae as there were microfilariae in about 4 mm³ of the donor's blood. No measurements were made of the amount of blood ingested by Ae. polynesiensis, but from data given by Bahr, 1912 (1) for "Ae. pseudoscutellaris" and from data available for related mosquito species (Bates, 1949)⁴ it appears that most specimens ingest somewhat less than 4 mm³ of blood.

¹Manson-Bahr, P. & Muggleton, W.J. (1952) Further research on filariasis in Fiji. Trans. roy. Soc. trop. Med. Hyg., 46, 301-326

²Manson, P. (1883) The Filaria sanguinis hominis and certain forms of parasitic disease in India, China, and warm countries. H.K. Lewis, London, 133 pp.

³Ashburn, P.M. & Craig, C.F. (1907) Observations upon Filaria philippinensis and its development in the mosquito. Philippine J. Sci., B. Med. Sci., 2, 1-14

⁴Bates, M. (1949) The Natural History of Mosquitos. Macmillan Co., New York, 379 pp.

This small discrepancy may be the result of the mosquitos feeding on the smaller blood vessels which have a higher concentration of microfilariae than do the larger vessels (Gordon & Lumsden, 1939).⁵ Blood from vessels of various sizes would be obtained by a finger prick. Their observations indicated that adjacent capillaries often have widely varying concentrations of microfilariae and that mosquitos may feed in several different ways. This affords an explanation for the extensive variation in the number of larvae found in individual mosquitos fed on the same donor at the same time in the present experiments.

Ae. polynesiensis was not observed to expel blood while in the process of taking a blood meal, but it did expel drops of clear serum-like fluid. Thus, it would appear that the loss of microfilariae in expelled blood which has been observed in Anopheles and Culex quinquefasciatus as was reported by O'Connor & Beatty (1937)⁶ does not occur with Ae. polynesiensis. From the data of the present investigation, there was no evidence that the infectivity of the microfilariae to mosquitos was related to the age and sex of the carrier.

On the basis of the experiments carried out in the Fiji Islands, Manson-Bahr (1952)⁷ reported that the microfilariae which persist in the peripheral blood after the treatment of the host with DEC were so modified by the drug that they were not capable of normal development in their mosquito host. The author indicated that in the experiments with Ae. polynesiensis, some volunteers received one or two courses of DEC, but no adverse effect on development of the parasite in mosquitos was observed.

/N.B. These give for each level of mf density the following:

- the observed number of (O) of larvae recorded in the batch of mosquito indicated, as compiled from the author's detailed data
- the expected number of microfilariae (E) ingested by the batch of mosquito indicated, considering the size of the blood meal, is 1.327 mm^3 according to the estimate made by Bryan & Southgate, 1976 (192)
- the ratio of the observed to the expected number of larvae (O:E).

⁵Gordon, R.M. & Lumsden, W.H.R. (1939) A study of the behaviour of the mouth-parts of mosquitos when taking up blood from living tissue; Together with some observations on the ingestion of microfilariae. Ann. trop. Med. Parasit., 33, 259-278

⁶O'Connor, F.W. & Beatty, H.W. (1937) The abstraction by Culex fatigans of Microfilaria bancrofti from man. J. trop. Med. Hyg., 40, 101-103

⁷Manson-Bahr, P. (1952) The action of Hetraxan in Pacific filariasis. J. trop. Med. Hyg., 55, 169-173

This is to determine whether Ae. polynesiensis in the author's experiments was concentrating the microfilariae. From this analysis, it appears that there was a concentration of microfilariae at different levels of density (with the exception of the levels of 533.9 and 555.1), the highest being at mf levels of $2.1 - 3.5/20 \text{ mm}^3$. This is lower than that reported by Bryan & Southgate (loc. cit.). Pitchon, 1974 a (174) made more elaborate estimations of the expected number of larvae, and also considered that most significant concentration was shown for the mf density levels of $2.1-3.5/20 \text{ mm}^3$. /

5.3 Longevity of experimentally infected mosquitos

There was no recognizable deleterious effect of heavy infection on the longevity of Ae. polynesiensis in the first week after the infective feed. However, it appeared that its longevity was adversely affected near the end of the period needed for the maturation of the larvae. It appears that heavy infections with W. bancrofti larvae do adversely affect the mosquito longevity.

Mature larvae can escape from an infected mosquito, even though the mosquito does not take a blood meal (Pratt & Newton, 1946)⁸

In the present experiments it seemed that a higher percentage of larvae escaped from heavily infected mosquitos than was the case for lightly infected ones.

(57) Bonnet, D.D. &
Chapman, H.
1956

The importance of mosquito breeding in
tree holes with special reference to the
problem in Tahiti
Mosquito News, 16, 301-304

In an effort to determine quantitatively the importance of different types of trees, a total count of the various trees in an area of 100 m by 2000 m. There was a total of 2416 trees in which 84 holes with Ae. polynesiensis larvae were found.

The most important species of trees was the breadfruit (Artocarpus incisa) because of the agricultural practice of "topping" or pollarding, resulting in rot holes. There was an average of 1.7 rot holes per tree and of these, 29.6% contained Ae. polynesiensis larvae.

DDT, lindane and dieldrin were effective for larval control in the tree holes for three months. Filling the holes with cement mortar is excellent for urban areas where the numbers of trees are small, but is of limited use in extensive rural sylvan areas owing to the cost of materials and semi-skilled labour. Over 3500 larvae and adults of Toxorhynchites brevipalpis have been released in Tahiti since 1954 in a single location but no wild bred specimens have been recovered.

⁸Pratt, I. & Newton, W.L. (1946) The migration of the infective larvae of Wuchereria bancrofti within mosquito and their rate of escape under laboratory conditions. J. Parasitol., 32, 272-280

A new method is therefore presented which is cheap, simple and relatively permanent. A fern or similar plant is placed in the rot hole after partial filling with dirt or gravel. The growth of the fern roots the plant firmly in place and water is withdrawn from the hole by transpiration. Preliminary trials of nine months duration have shown its effectiveness in eliminating mosquito breeding.

(58) Bonnet, D.D.,
Kessel, J.F.,
Kerrest, J. &
Chapman, H.
1956

Mosquito collection and dissection for evaluating transmission of filariasis in Polynesia (Tahiti)
Am. J. trop. Med. Hyg., 5, 1093-1102

A method of collection and dissection of mosquitos, particularly Ae. polynesiensis in Tahiti is described in an "Intensive Survey Method". Mosquitos are caught on human bait for 10 minutes period within 10 m of each human habitation in a given area. The most shaded and protected location within this area is selected to increase the probability of catching mosquitos, if any are present. The full 10 minutes of effort are spent at every collection "station" even though there may be the impression that mosquitos are absent. Mosquito dissection is carried out in the field within 3 to 6 hours after capture. All the mosquitos from a single station, i.e. collected in one tube are handled as a group in identification and dissection if they are 10 or less. If there are more than 10 mosquitos a random selection is made. This limitation of numbers dissected was found necessary in order to cope with samples within a reasonable period of time and that large numbers from two or three stations do not unduly "weight" the results.

This "Intensive Survey Method" provides a distributed sample of mosquitos for dissection, while simultaneously the following indications of mosquito densities can be determined: (1) the number of mosquitos captured per minute of capture effort; (2) the percentage of habitations at which mosquitos were captured; (3) the percentage of houses where 10 or more mosquitos were captured during the 10 minute capture interval. By dissection and examination of these randomly collected samples of mosquitos, the percentages of mosquitos with developing and/or infective larvae of W. bancrofti are determined. In addition, the number of developing W. bancrofti larvae per dissected mosquito can be calculated as well as the percentage of houses with positive mosquitos.

In calculating the latter index, capture stations, where more than one positive mosquito is found, are counted only once as a positive station. This avoids weighting the results if several mosquitos had an opportunity to become infected having sheltered in a house with microfilaria carriers. The house index is expressed as the number of positive stations per 100 collecting stations i.e. 100×10 minutes of catching effort. The intensive survey method was regarded as an independent check on the work of the inspectors in charge of DEC distribution. A blood survey provides a satisfactory index but requires longer time and is more expensive. In several instances, the first indication of failure in the drug treatment

programme came from the intensive mosquito survey followed by confirmation by a blood survey. Another advantage was that dissection in the field and demonstration of filarial worms in mosquitos was part of health education of the inhabitants who readily accepted instructions on principles of mosquito control. A two man collecting team consisting of a bait and a collector could cover 36 stations in one day and with 2 collecting teams of four men it was possible to finish one capture round in the average district in Tahiti in less than three days.

(59) Iyengar, M.O.T.
1956

Annotated bibliography of filariasis and
elephantiasis. Part 2
South Pacific Commission, Tech. Paper No 88

This is the second bibliography issued by the author according to the recommendations adopted by the South Pacific Commission. It deals principally with the entomological aspect. A large number of papers on distribution of mosquito fauna (including vectors of malaria, filariasis and dengue fever), description of new species, and identification keys are abstracted. Also abstracted references are giving information on biological observations on certain mosquito species under laboratory conditions as well as field observations on the breeding habits of important vectors of the above mentioned diseases. A few papers showing the results of early attempts for crossing experiments involving members of the Ae. scutellaris group are also quoted.

The bibliography essentially covers the areas of New Caledonian, Micronesian, Polynesian and Papuan sub-regions, but also includes some references on Mansonia spp. as vectors of Brugia malayi in India and Malaysia. It contains 426 references which appeared during the period 1889-1955. As in Part 1, references are arranged in chronological order. Under each year, the papers are in alphabetical order by authors. This system was adopted to show the progress in knowledge from year to year. In addition, there is a list showing the alphabetical order of authors with cross references to the number of the abstract in the text.

(60) McCarthy, D.D. &
Fitzgerald, N.
1956

Habit, habitat and hyperfilarialation in
the epidemiology of filariasis in
Western Samoa
Trans. roy. Soc. trop. Med. Hyg., 50, 58-65

The authors in their paper of 1955 (53), suggested that the difference in mf rates between males and females in Western Samoa might have been due to difference in working and clothing habits, and that the changes in mf density which appeared to have occurred during the years between Buxton's survey reported in 1928 (7), and that recorded by the authors during 1953-1954, suggested possible changes in village environment. This suggestion arose from observations indicating that, while mosquito infestation was slight in the open coastal villages, it was heavy in inland villages and heavier still along bush paths and in plantations, a finding which was in conformity with those of Jachowski & Otto, 1952 (31). The present paper gives a general description of the activities of the various age groups of the Samoans and discusses their possible relationship with the epidemiology of filariasis.

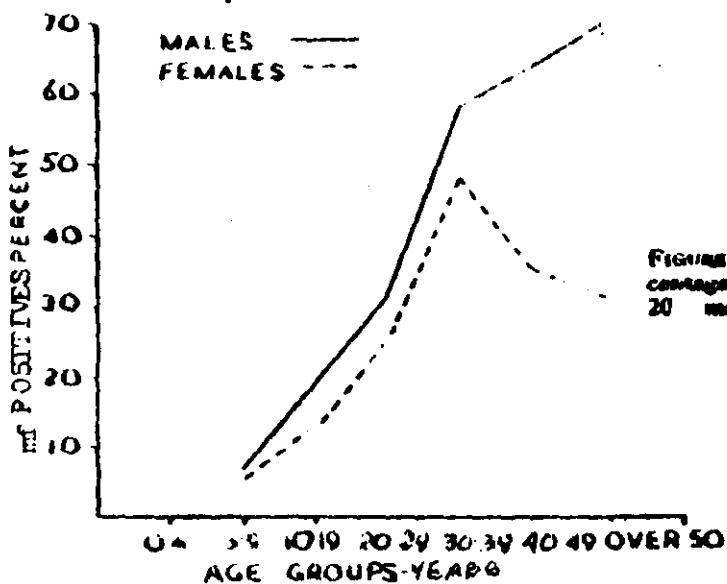


FIGURE 2. Inland villages : Percentage of microfilaria positives in 20 mm. peripheral blood in males and females.

Table 1 : Microfilariae positives in peripheral blood of males and females in coastal and inland villages in Western Samoa, 1953 - 54

	Age-group — Years	MALES							Total
		0 - 4	5 - 9	10 - 19	20 - 29	30 - 39	40 - 49	Over 50	
Coastal villages	No. examined	27	62	140	106	89	63	38	525
	No. positive	—	4	22	62	35	33	14	152
	% positive	—	6.5	15.7	39.0	39.3	55.5	36.8	28.4
Inland villages	No. examined	11	64	102	131	50	22	20	348
	No. positive	—	4	21	41	29	14	16	123
	% positive	—	36.3	18.8	31.3	58.0	63.6	100	30.7
<hr/>									
	Age-group — Years	FEMALES							Total
		0 - 4	5 - 9	10 - 19	20 - 29	30 - 39	40 - 49	Over 50	
Coastal villages	No. examined	31	60	166	81	61	39	33	471
	No. positive	—	4	10	14	14	19	9	70
	% positive	—	6.6	6.0	17.3	23.0	48.7	27.3	15.0
Inland villages	No. examined	17	57	34	56	29	14	16	223
	No. positive	—	3	4	14	14	5	5	45
	% positive	—	5.3	11.8	25.0	38.3	35.7	31.3	23.2

N.B.

Statistical tests have been made on the authors' data:

(a) Difference is not significant ($P > 0.05$)

(b) Difference is significant. ($P < 0.05$)

Table 2 : Average density of microfilariae in 20 mm³ peripheral blood
in positive cases, Western Samoa, by age-groups

Age-group—Years	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 35	36 - 45	Over 45
Huxton's Series 1925 - 26	—	21 (1)	59 (22)	81 (72)	59 (42)	68 (88)	73 (70)	13 (45)
Male	Coastal	—	4 (3)	38 (12)	43 (17)	48 (21)	66 (38)	83 (34)
	Inland	—	13 (7)	28 (18)	66 (23)	68 (21)	57 (19)	80 (19)
Female	Coastal	—	15 (4)	22 (5)	36 (9)	41 (13)	57 (15)	48 (11)
	Inland	—	15 (3)	21 (4)	50 (4)	48 (8)	59 (13)	54 (8)
								75 (5)

The figures in brackets give the number of positive cases.

The difference in the mf rates and the average mf density for different age groups in inland and coastal villages suggests that the latter are not heavy foci of infection but the bush tracks and plantations are the heaviest foci of transmission. The bathing and washing points, particularly those situated at the inland villages are also points of high risk for women and children. The authors emphasized that this factor is almost inherent to inland villages, is absent in the coastal villages. Further, they indicated that plantation areas are situated in the foothills of the island's mountainous core and are surrounded by heavy bush, and within themselves provide shelter and breeding places for Ae. polynesiensis which occur in high density. The authors considered that this factor primarily affects the working men who are continuously engaged thereon, and that women who frequently transport food from plantation to the village as well as those who sojourn periodically for short or long periods with their men are likely to be affected by this environment. In contrast, those who work full time on the sea and reefs are usually few.

/NB: Statistical examination made on the authors' data shows that there was no significant difference between the mf rates of the coastal and inland villages for boys and girls of the age groups 5-9 and 10-19 years, and likewise for men of the age groups 20-29 and 40-49 years. No explanation was given as to the fall in the mf rates of women of the age group over 40 years living in the inland environment unlike males. Perhaps these inconsistencies are either due to the inadequacy of sample sizes of the populations living in the two environments or to the factor of the widespread movement of the populations involving visits for prolonged periods particularly practised by males. The authors indicated that this customs tends to reduce the differences in endemicity of different localities and to conceal the fact that endemicity varies widely in different areas._/

The authors considered that the mf density expressed as the average count per positive case for each age group can provide useful information on the intensity of transmission and can be used to demonstrate changes in filariasis endemicity. The average age group densities as related to the major clinical manifestations suggests that for the development of major signs a certain minimum parasite load should be maintained for some years. In Western Samoa, it is suggested that the minimum parasite load is that equivalent to an average age group count of 60 mf per 20 mm³ blood, and that if this is maintained, hydrocele will appear in the male population 5 years later, and that elephantiasis will first appear approximately 10 years later.

(61) Peterson, G.D.
1956

The introduction of mosquitos of the
genus Toxorhynchites into American Samoa
J. econ. Ent., 49, 786-789

The forest day mosquito, Ae. polynesiensis (hitherto named Ae. pseudoscutellaris) is the principal vector of filariasis in American Samoa. Experiments conducted during the period of Naval administration of American Samoa indicated that Ae. polynesiensis could not be controlled by orthodox methods. The giant predatory mosquitos, Toxorhynchites brevipalpis and T. splendens were introduced in the hope that they might effect a worthwhile degree of natural control of Ae. polynesiensis. The

predatory mosquitos were mass-reared in the laboratory and many thousands were released on the island of Tutuila. Rearing methods and equipment used are discussed. Both species of predatory mosquitos have been recovered from the field indicating that initial establishment has been obtained. It is too early to know the ultimate effect on Ae. polynesiensis.

- (62) Symes, C.B.
1956
*
Observations on the natural history of
filariasis in Fiji
A report to the Secretary of State for the
Colonies on investigations conducted over
the period 1954-56, 126 pp.
Abstract from Iyengar (1960)
Techn. Paper No 129

For some years measures aimed at the reduction of Ae. pseudoscutellaris and Ae. polynesiensis in and around Fijian villages have been in operation. The measures consist of cutting grass and bush within a radius of about 100 m and the elimination of all breeding grounds within that cleared area. These measures were inadequate for the following reasons:

- (a) Ae. pseudoscutellaris and Ae. polynesiensis are not the only vectors; two house-frequenting species, Ae. fijiensis and C. quinquefasciatus, are probably just as important.
- (b) Contact with the mosquito vectors and people, though occurring to a great extent in the houses and in their immediate vicinity, is close also in the bush leading to, and around, the village gardens.
- (c) Success depends upon the enthusiasm of the villagers themselves.

Measures designed to reduce mosquito vectors must be applied against both the bush mosquitos, Ae. pseudoscutellaris and Ae. polynesiensis, and the two house mosquitos, Ae. fijiensis and C. quinquefasciatus. Measures against Ae. fijiensis would consist of cutting down Pandanus within a certain distance (yet to be determined) of houses. C. quinquefasciatus can be reduced in numbers by a vigorous programme of sanitation, including abolition of all surface stagnant water and the proper construction and siting of pit latrines.

The contact made by Ae. fijiensis and C. quinquefasciatus with people is much closer than that made by Ae. pseudoscutellaris and Ae. polynesiensis. An appreciable reduction of Ae. fijiensis and C. quinquefasciatus by insecticidal treatment of houses would reduce transmission of filariasis to the extent that it would die out.

There is no obvious suggestion that DEC has any direct effect on mosquitos. In two men examined 104 weeks and two years respectively, after a full course of treatment, the blood contained microfilariae in such densities as to be capable of infecting mosquitos.

- (63) Bonnet, D. & Mukaida, T.
1957 A copepod predacious on mosquito larvae
Mosquito News, 17, 99-100

Toxorhynchites brevipalpis was introduced into Hawaii as an aid in the control of the forest mosquito Ae. albopictus. For release trials a laboratory colony was established which was seriously affected by high larval mortality in the first and second instars. Efforts were made to provide a variety of microorganisms as food including copepods and first instar larvae of Aedes and Culex sp. Toxorhynchites was found to feed on microorganisms as well as the nauplii of the copepod and young mosquito larvae but it was discovered that the adult copepod preyed voraciously on all mosquito larvae. Tests with Aedes larvae showed that a single copepod could destroy 15 - 20 second instar mosquito larvae in 24 hours. The copepod was identified as the cosmopolitan species Mesocyclops obsoletus. The copepod was not found in nature in tree-holes or other containers in Hawaii, hence would not be considered as a biological control agent for Aedes mosquitos. It is found in pools, swamps and streams and may possibly prey on Culex quinquefasciatus. The observation is reported to warn other workers of the danger of this predator on Toxorhynchites cultures.

- (64) Edeson, J.F.B.,
Hawking, F. & Symes, C.B.
1957 The periodicity of microfilariae. VI.
The response of microfilariae of Wuchereria malayi and W. bancrofti Pacific type to various stimuli
Trans. roy. Soc. trop. Med. Hyg., 51,
359-365

The investigation of Pacific W. bancrofti was carried out at Suva, Fiji. The microfilariae in this Region show no definite periodicity although minor irregular fluctuations occur and slight increases in the counts during daytime has been reported. The results showed that the response of Brugia malayi (referred to as W. malayi) was similar to that of African W. bancrofti previously studied, viz. a fall in number with increased oxygen and with muscular exercise, and no marked change with increased carbon dioxide.

The response of the nonperiodic Pacific type of W. bancrofti differed from that of the periodic African W. bancrofti in that increased oxygen caused a slight rise of the mf count instead of a marked fall.

- (65) Iyengar, M.O.T.
1957 Annotated bibliography on filariasis and elephantiasis. Part 3. Symptomatology, aetiology, pathology and diagnosis of filariasis due to Wuchereria bancrofti and Brugia malayi
South Pacific Commission,
Tech. Paper No 109

This is the third part of the series of bibliography prepared by the author under the auspices of the South Pacific Commission. It contains 868 references, most of which are abstracted. Unlike the previous

bibliographies, it contains references on B. malayi and it has a wider geographical coverage in respect of W. bancrofti. Thus references are quoted from different parts of the world such as Angola, Cameroon, Madagascar and Senegal in Africa; Egypt and Morocco in North Africa, India and Indo-China, Puerto Rico in West Indies, Brazil and Venezuela in South America, Japan and Australia. This is in addition to references quoted from work carried out in Islands of the South Pacific and in Viet Nam and Malaysia on B. malayi. The bibliography deals mainly with papers concerned with clinical aspects, pathological changes associated with filariasis. Early attempts are cited on the application of serological tests such as the skin test using the antigen of Dirofilaria immitis, Litomosoides carinii and other filarial infections as well as the complement fixation test.

Papers dealing with investigations carried out in USA on service-men infected with filariasis in the South Pacific area during World War II are also abstracted.

In chronological order the references are listed from 1716 to 1956 with a few references in 1957. An alphabetical index of authors is also given.

- (66) Iyengar, M.O.T.
1957 a
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A report on an investigation on filariasis
in the Cook Islands
South Pacific Commission,
Techn. Infn Circ. No 21, 15 pp (mimeograph),
Jan 1957
Abstract taken from Iyengar (1959)
Techn. Paper No 126

Of 1851 persons (all ages) from the Cook Islands, 21.6% harboured microfilariae in the peripheral blood (Aitutaki 20.9% and Rarotonga 23.3%). The mf rates for the different villages investigated ranged from 17.7 to 28.2%, and the elephantiasis rates from 1.1 to 6.5%. Elephantiasis of the leg was the most common manifestation. There were 15 cases of elephantiasis of the scrotum, either by itself or in association with elephantiasis of the limbs. Multiple filarial lesions were common. The mf rate was slightly higher among females (22.5%) than among males (20.6%). The elephantiasis rate among females was also higher (4.3%) than among males (3.5%) even when genital affections in the males were taken into consideration.

In the different age-groups, the mf rate showed a progressive rise with increase in age, from 2.5% in the 1-4 year age-group to 46.5% in the age-group 50 years and over. Microfilarial infection was by no means rare among very young children; the earliest age at which microfilariae were present in the blood was a child aged 18 months. The earliest age at which elephantiasis was noted in a young woman aged 21 years. The elephantiasis rate showed a marked and progressive rise from 2.1% in the age-group 20-29 years to 24.2% in the last age-group (50 years and over). Of 420 persons examined above the age of 29, 53.1% had either demonstrable microfilarial infection, or elephantiasis, or both.

Ae. polynesiensis is the only vector of filariasis in the Cook Islands. A natural infection rate of 13% (filaria larvae of all stages) was recorded in this species. Although some specimens of C. quinquefasciatus and of C. annulirostris were found infected, none of them carried filaria larvae older than the first day phase. These species are not of importance as vectors in this area.

Vector density was generally much higher in villages than in bush away from villages. Ae. polynesiensis mosquitos collected in and around houses showed high infection rates in comparison with those caught at a distance of 100 m from habitations. Specimens collected inside houses often showed larvae of the infective stage in the head and labium of the mosquito. Multiple infections with two or three broods of filaria larvae were not unusual in mosquito caught within the villages. These and the finding of microfilarial infection in very young children support the conclusion that transmission occurs primarily in habitations or in their immediate vicinity.

One of the major causes of favouring the high prevalence of endemic filariasis in the Cook Islands is the absence of piped water supply; as a result, the villagers have to store rain water in various types of domestic containers, such as cisterns, barrels, drums, etc. An efficient system of water supply would eliminate the need for such containers. In areas where piped water supply cannot be installed, it is recommended that all domestic water containers should be fitted with proper lids in such a manner as to render them proof against Aedes breeding.

The second major factor is the presence in and around villages of litter such as coconut shells and tin cans which collect rain water and serve as breeding places of Aedes. The maintenance of the village area and a peripheral zone of 100 m beyond it free from containers likely to hold rain water is recommended. The cooperation of the villagers in this work should be enlisted and the governmental agency should stimulate and direct their efforts.

(67) Kessel, J.F.
1957

Disabling effects and control of filariasis
Amer. J. trop. Med., 6, 402-414

In introductory remarks, the author drew attention to the need for collecting accurate information on the prevalence of the carriers of the disease, the transmission rate and the bionomics of the vectors, a knowledge necessary for planning a control programme. The types of surveys carried out in French Oceania before the institution of the filariasis control programme were clinical survey, blood survey, and mosquito survey.

The author presented maps on the basis of which he reviewed the prevalence of clinical filariasis and microfilaremia in the Pacific, Asia and Africa.

Summary from ten filariasis surveys in Society Islands, French Oceania before filariasis control is given in the following table.

Filariasis surveys in Society Islands before control

Clinical Signs	Blood surveys Microfilaria			Mosquito surveys					Potential transmission index*
	% of population	% of population positive	Density per 20 mm ³	Mosqui- tos caught per min.	Mosquito dissection for larvae of <i>W. bancrofti</i>		Density of larvae all stages		
					% + for all stages	% + for infective stage			
<u>With elephantiasis</u>	7.0								
Males with hydrocele	7.0	32	35	0.4	14	5	0.9	90.0	
<u>With lymphangitis</u>	12.0								

*Potential transmission index is determined as follows:

Density of mosquito per minute x mean number of larvae (all stages)
and multiply the product by 250 as a constant factor to give a reasonably
readable large figure.

In collecting epidemiologic data for the maps, a lack of standardization in clinical, blood and mosquito surveys was apparent, and comparison had to be limited to prevalence rate for elephantiasis and microfilaremia. Even here, representative numbers in standard age groups and from all segments of the population were seldom available and suitable correction factors had to be employed to adjust the figures to represent the population as a whole.

Procedures for performing and reporting standardized clinical, blood and mosquito surveys are recommended and tables are presented which show summaries of certain of these results from the Society Islands before the filariasis control programme began. Seven per cent of the population demonstrated elephantiasis, 7% of the males had hydrocele and 12% experienced attacks of lymphangitis. A total of 26% of the whole population showed clinical signs of filariasis and 32% demonstrated microfilaraemia.

A correlation between prevalence of elephantiasis and microfilaraemia in a population as a whole could not always be shown in the South Pacific. A low prevalence of microfilaraemia was associated with a low prevalence of elephantiasis but areas with high microfilaraemia rates did not always show high elephantiasis rates. However, when the density of microfilariae per unit of blood was calculated, it was found that a definite correlation existed. It is suggested, for at least that part of the Pacific where nonperiodic filariasis occurs, that the density of microfilariae in an area may be used as an index to estimate the amount of elephantiasis in that same area.

On the socioeconomic aspects of filariasis, the author indicated that the disabling effects of clinical filariasis in most tropical communities are difficult to evaluate exactly, as filariasis occurs primarily in rural areas where quantitative measurements in man-days or man-hours of time lost from illness are not usually recorded. Even so, economic and social consequences may be assessed under three main headings (1) economic loss, (2) deformity produced, and (3) psychological injury.

In areas similar to Tahiti before the institution of the control programme, where lymphangitis with filarial fever occurred in approximately one quarter of the adult population, with each individual having from 1 to 12 attacks a year and each attack lasting from 1-3 days or longer, the importance is especially manifest if a portion of the population is gainfully employed, as for example on a rubber plantation in Malaya, employing 600 labourers, which reported 150 attacks of filarial fever or lymphangitis a year, each lasting about three days; thus 450 workdays a year were lost (Wilson, 1955, personal communication).

In French Oceania before institution of the control programme among the adult population (i.e. 20 years and above), 27% of the group experienced periodic attacks of lymphangitis, 15% of adult males suffered from hydrocele and another 14% gave evidence of elephantiasis. Of the people with elephantiasis, 58% had one leg and 37% both legs enlarged; 12% had one arm and 5% both arms enlarged. Individuals with the most severe elephantiasis of the legs or scrotum were confined to their homes, and required full time care by their families. Persons with less severe elephantiasis and with hydrocele, while ambulatory in varying degrees, were unable to perform their full quotas of work.

The psychologic effects of these and other deformities were likewise disturbing. People with elephantiasis usually hide or retire to the background, because they are the laughing stock of the community. One of the primitive beliefs in Polynesia supposed that elephantiasis was transmitted through urine, either directly or through food or drink. Women with elephantiasis are less desirable as wives and men with hydrocele or with elephantiasis of the scrotum exhibit an obvious social and procreative handicap.

While it is true that many people throughout the world have microfilariae in their blood but fail to exhibit clinical filariasis, it is also true that the percentage of people who do exhibit disabling effects from the infection are sufficiently numerous in many areas to constitute a tropical health problem of world-wide significance.

- (68) Kessel, J.F.
1957
An effective programme for the control of
filariasis in Tahiti
Bull. Wld Hlth Org., 16, 633-664

From several surveys in the Society Islands, filariasis has been regarded as a public health and socioeconomic problem. In Tahiti, 30% of the population was found to harbour microfilaria, 20% exhibited acute clinical manifestations of lymphangitis and 5-10% showed some degree of lymphangitis. These rates were found to be higher than those recorded in other areas of Polynesia. This justified organizing a filariasis control programme.

The method of "Intensive Mosquito Survey" as described by Bonnet et al., 1953 (58) was applied in Tahiti, as it proved to be suitable not only to designate the existing condition of transmission, but also as one of the tools for assessing the progress of the control programme. A summary sheet of an "Intensive Survey" in the area before the control measures were instituted, is given in Table 1, to be compared with post control data given later.

TABLE 1 ANALYSIS OF INTENSIVE MOSQUITO SURVEY FROM A TYPICAL DISTRICT BEFORE CONTROL MEASURES SHOWING COLLECTIONS AND DISSECTIONS OF AEDES POLYNESIENSIS FOR WUCHERERIA BANCROFTI LARVAE

District: 1

(1) Number of stations		112
(2) Number of mosquitos collected		615
(3) Number of stations with mosquitos	75 or	66.9%
(4) Number of stations with 10 or more mosquitos	20 or	17.8%
(5) Number of stations with mosquito positive for larvae of <u>W. bancrofti</u>	29 or	25.8%
(6) Number of mosquitos caught per minute		0.54
(7) Number of mosquitos dissected		422
(8) Developmental-stage larvae present in mosquitos	56 or	13.2%
(9) Infective-stage larvae present in mosquitos	32 or	7.6%
(10) Density of developmental-stage larvae per dissected mosquito		0.74
(11) Density of infective stage larvae per dissected mosquito		0.19

TABLE 2 FIELD RESULTS SHOWING REDUCTION IN MICROFILARIAE AND IN LARVAE OF *WUCHERERIA BANCROFTI*

District	Years of control	Persons examined	Microfilariae in man*		Mosquitoes dissected	Larvae of <i>W. bancrofti</i> in mosquitoes			Potential transmission index	
			percentage of persons positive	microfilarial density per 20 mm ²		percentage positive all stages	percentage positive infective stages	density		
1	whole district before treatment	0	825	30.0	33.1	422	13.2	7.8	0.74	100.0
	part of district treated	1 2	289 304	7.2 4.9	1.8 0.6	270 280	4.7 2.0	0.0 0.0	0.17 0.076	25.0 4.3
	other part not treated, resurveyed after 2 years		560	31.0	32.0	279	20.7	5.3	1.06	90.0
2	1	2248*	(29.8) 6.1	(23.1) 1.8	270	10.0	2.5	0.51	7.6	
3	2	1317	(30.3) 6.1	(36.9) 0.9	275	6.5	1.4	0.30	7.5	
4	2	874	(29.1) 5.6	(17.0) 1.4	187	0.6	0.0	0.02	0.5	
5	3	332	(43.6) 2.75	(48.1) 0.30	163	0.6	0.0	0.006	0.25	
6	3 4	616 623	(26.2) 3.1 1.8	(25.2) 0.64 0.14	401 65	0.0 1.5	0.0 0.0	0.0 0.06	0.0 0.015	
7	4	173	(27.0) 2.0	(33.0) 0.15	226	0.0	0.0	0.0	0.0	
8	4	322	(35.5) 1.0	(30.0) 0.04	364	0.0	0.0	0.0	0.0	

* The figures in parentheses for districts 2-6 refer to findings before treatment.

As described by Kessel, 1957 (67), the data given in this table was used for calculating the potential transmission index, being used as a measure for assessing the progress. /N.B. It should be noted that the use of this index may be limited to areas where the vector, parasite and environmental conditions are the same. Otherwise more reliance should be placed on the index of infective stage larvae which was adopted by the author in later work elsewhere. /

The transmission index as calculated from the above data is 100.

Control measures and results:

Control measures were carried out on the basis of the results of the mass control programme. They consisted of:

Measures against the parasite: Initially DEC was administered at a dosage of 2 mg/kg three times a day for 7 days. One year after completion of this schedule, it was found that 50.6% of the treated people became positive, 28% with mf counts of class 1-5, 8% in class 11-100 and 13% with more than 100 mf in 20 mm³ of blood. When these were compared with the original positive rates, a marked reduction became apparent. Noting the work of Rosen (56) by which it was shown that successful infection in *Ae. polynesiensis* could be obtained when fed on mf carriers with minimum counts, the reduction in the microfilariae resulting from the above treatment regimen was not found sufficient to warrant success if applied in a control programme. Various other regimens were tried with higher dosages and the final recommended dosage adopted was 6 mg/kg once a month for 24 months for those who were found positive in initial surveys and for 12 months, at least one year after the completion of the treatment, for those still positive.

Measures against the vector: The author reviewed the available information on the bionomics of *Ae. polynesiensis*.

In Tahiti, where the inhabitants do not live in well defined villages but in houses dispersed for the most part along the coast, an effort was made to solicit the aid of the individual householder in clearing the breeding places of his property for a distance of 100 m. This was achieved through health education and organization of a system of supervision by district inspectors as described belows. In certain districts, trials were conducted with various insecticides as a supplement to the sanitation method, Bonnet & Chapman (unpublished) showed that when the insecticides were applied as exterior residual spray, their effectiveness lasted from 4 to 6 weeks. Residual house spraying was ineffective since this vector does not rest in houses. Vector control as a means for control of any vector-borne disease would require a long term continuing programme of intensive sanitation and health education. In the control of filariasis in Tahiti, a combination of vector control and mass DEC administration was considered the most suitable.

The results of the parasitological surveys and those of the intensive mosquito surveys are compiled in Table 2 for eight districts, all of which had been under the control scheme except District 1. Part of this district was subjected to treatment and the other part was left untreated but surveyed for two years after the control measures have been instituted in other districts. The data for 0 years are those collected from surveys

carried out 3 months before the institution of control measures. District 1 is considered as representative of all other districts in the island. The data indicate the gradual reduction in infection as the period of control is extended. Particular reference is made to District 8 in which the mf rate reached 1% from its original level of 35.5% before treatment. Corresponding reduction in mf density is also noted reaching 0.04% per 20 mm³ as compared with 30 before treatment. Entomologically, all mosquitos dissected were negative, thus leading to a zero transmission index. These findings may be compared with those of District 1 for which baseline entomological data are available, and on the assumption that the district was representative of all other districts. Before treatment the percent of mosquitos with infective stage larvae was 7.8 and the transmission index was 100. After treatment of part of District 1, the mf rate and density declined with corresponding reduction in larval density in mosquitos. However, the transmission index was still high and this was explained as being due to the absence of mosquito control measures. Once the programme is well under way, larvae of W. bancrofti diminish rapidly in mosquitos.

However, there were still a few mosquitos with infective stage larvae in Districts 2 and 3, after 1 and 2 years of control respectively. Since the objectives of the programme were to apply rigorous control measures and to assess the results according to the standards available, it was concluded that control measures should continue so long as mf carriers were found or until mosquitos were found negative for larvae of W. bancrofti. At the early stages of the programme, a question was raised as to whether sufficient reduction in mf counts in man as a result of DEC administration could effect a reduction of larvae in mosquitos to indicate adequate control. The data presented would provide the answer and indicate that the programme of control was effective and methods of evaluation were adequate.

Reference was made to Otto, Jachowski & Wharton, 1953 (39), who suggested that persons with mf counts might bring about high mortality in vector populations. These authors cited an example of a village in American Samoa where the entire population was treated with DEC for a period of 14 days after which period the mosquito population more than doubled within three months. To verify this, a trial was carried out in Tahiti, by selecting two areas and collecting base entomological and parasitological data. The whole population of one area was treated with DEC and those of the other area were left untreated; follow up observations were carried out 2 months and 12 months after treatment.

Although there was marked reduction in the proportion of infected mosquitos and in the larval density per dissected mosquito particularly after 12 months in the treated area, no difference was found in mosquito density in the treated and untreated areas. Thus those findings do not support those reported from American Samoa.

Having reviewed the results of the evaluation of control measures in Tahiti, the author discussed the possibilities for conducting a filariasis control programme by vector control measures alone or by DEC mass treatment alone or both measures combined as shown in the following extract.

Jachowski, Otto & Wharton, 1951 (25) reported that nurses in American Samoa who lived in the screened hospital, protected from mosquitos, for a period of five years showed lighter mf rates than their relatives who had continued to live in their natural environment; Samoans who moved to Hawaii where the most common vector for nonperiodic filariasis - Ae. polynesiensis - does not occur, became negative for microfilariae within a period of 10 years. It would seem possible, therefore, that as sanitation methods of dilution of microfilariae in a population are gradually extended, filariasis will automatically decrease.

The improved knowledge of mosquito control that came to light during the Second World War and the discovery of the microfilaricide, diethylcarbamazine, however, have provided new tools with which to hasten the process, and it would seem desirable to apply them to the best advantage whenever possible.

Mosquito control alone:

This is the method that has usually been recommended in the past for a filariasis control programme. It would undoubtedly achieve satisfactory results in areas where it is possible to eradicate a vector. However, it is slow and demands that the filariae in a population, either adult or embryo, be destroyed by natural body immunity mechanisms alone. The report of Jachowski, Otto & Wharton (25) in areas where opportunity for reinfection was discontinued, indicate that a period of from five to ten years is required to eliminate microfilariae from the bloodstream.

Diethylcarbamazine alone:

It is possible to reduce transmission to a low point by the use of DEC without mosquito control (see for example Table 2, District 1, where the field results show a reduction in mf rate from 30.9% to 7.2% after one year of recommended treatment). A corresponding reduction of mf density from 33.1 to 1.8 is observed. No infective stages of W. bancrofti larvae were encountered after one year of treatment in mosquitos in this district, and the density of larvae of all stages was reduced to 0.17.

This method alone, therefore, may be practical to use in areas where mosquito control is difficult or impossible to institute.

The application of mosquito control together with administration of DEC appears to present the greatest potentialities, and is the combination that was accepted for the programme in Tahiti.

The following outline summarized the steps and procedures that were recommended:

- (1) By clinical survey, determine the prevalence of acute and chronic filariasis in the population.
- (2) By blood survey, using the 20 mm³ thick-film method, determine the prevalence of microfilariae in the population. Evaluate these results in terms of (a) frequency distribution of population at the several microfilarial levels; (b) percentage of people positive; (c) microfilarial density.
- (3) By mosquito survey, determine species, important vectors and bionomic characteristics of the same, e.g., breeding habits, feeding habits, dispersal range, resting habits, etc.
- (4) By Intensive Mosquito Survey collect and dissect standardized catches of important vectors - Ae. polynesiensis in Tahiti - to determine mosquito density and density of larvae of W. bancrofti in mosquitos. A potential transmission index may then be calculated.
- (5) Institute mosquito-control procedures by eliminating breeding places for a distance of 100 m around each dwelling.
- (6) Administer diethylcarbamazine at the dosage schedule of 6 mg per kg of body-weight one day each month for one year to both positives and negatives. Negatives are discontinued at the end of one year.
- (7) Repeat (1), (2) and (4) above, each year.
- (8) Continue diethylcarbamazine to all original and current positives, until they have been negative by two annual follow-up examinations or until each has received a full two-year treatment.
- (9) Re-emphasize importance of mosquito control programme following discontinuance of microfilaricide programme.

Table (2) displays representative results from six districts (2,3,4,5,6 and 8) where these combined procedures were applied. It will be observed during the second year in District 4, and Districts 5, 6 and 8, that there was a marked reduction in the findings of the mosquito dissections. In fact, no infective-stage larvae were encountered after this level had been attained. When such results are compared with the parallel results of the blood surveys, it will be seen that 5.6% of the population were still positive for microfilariae in District 4, and that all districts listed later demonstrated still lower percentages. Routine surveys in other treated districts not included in this table likewise demonstrate this same break-point.

Although the objective of this programme has been to reduce mf carriers to zero, this point is not always attainable. The lowest results obtained in the field in this programme were in District 8 where 1% of the population remained positive with an mf density of 0.04. No larvae of W. bancrofti were encountered in standard dissections of mosquitos in this district.

Judging from the data cited for Districts 4 to 8, it may not be necessary to attain this low point in order to interrupt transmission sufficiently to produce the desired reduction in clinical filariasis. While in the control programme in Tahiti it is still planned to achieve as low a percentage of positives as possible with a corresponding low mosquito density, it is proposed for a mass treatment campaign that reduction of persons positive for microfilariae to a maximum of 5% with a corresponding maximal mf density of 1 should be sufficient to reduce transmission to a negligible minimum.

Finally, the author estimated the cost of the control programme comparing the cost of DEC treatment to be given to all people for two years versus the treatment of negatives for one year and the positives for two years. The ratio of the former to the latter was 1.3:1.

(69) Simpson, E.J.B.
1957

Mass therapy in filariasis. A note on the
control in Niue Island
N.Z. med. J., 56, 136-137

The author indicated that measures had been conducted for a number of years in Niue Island for controlling the breeding of mosquitos. During 1954, 748 adult persons were examined and 22.1% were found to harbour microfilariae. No mf count was made. In January 1956, mass DEC treatment was commenced, giving 50 mg dose to every person on the island each month. In November-December 1956, post-treatment survey showed that 2791 persons examined (over 6 years), 2.9% were positive for microfilariae.

The author pointed out that this low percentage cannot be ascribed entirely to the effect of DEC. The Niuean people maintained a high standard of village cleanliness and monthly mosquito control days were applied as a routine, the people realizing the need for improving standards. In addition, every house was sprayed annually with dieldrin, although it was doubtful if this measure much reduced the number of mosquitos, which were largely bush dwelling.

(70) Bonnet, D.D. &
Chapman, H.
1958

The larval habitats of Aedes polynesiensis
Marks in Tahiti and methods of control
Amer. J. trop. Med. Hyg., 7, 512-518

Breeding habitats are classified as natural and artificial. The relative importance of each type of breeding place under the two categories is discussed. Methods of control which have been tried are reviewed; otherwise suggested measures are proposed as summarized in the following:-

Natural breeding sites: 1. Rock holes: There is no known practical method for eliminating mosquito breeding in rock holes in the rugged mountains. In view of the short flight range of Ae. polynesiensis as reported by Byrd et al., 1945 (12) and by Jachowski, 1954 (46), it is suggested that reduction of mosquito population along the coastal areas where most of the inhabitants reside can be made but control measures should not be relaxed.

2. Fallen leaves: Cleaning up is suggested, as practised by Tahitians on their own property.

3. Rat-eaten coconuts: Control should be based on reduction of the rat population, banding of coconut trees with rat guards and cleaning up and destruction of damaged coconuts.

4. Tree holes: Control of mosquito breeding in tree holes is complicated due to their inaccessibility, numbers and permanence. Various methods of control, such as cutting out, filling in with cement or tar, chemical treatment, etc., have been partially successful.

5. Crab holes: Direct application of insecticides to each trap hole is time consuming and of temporary effect. More permanent is the elimination of crabs. The method of using parathion in bread bait is described and the results of preliminary trials were successful. Attention is drawn to the hazard of domestic animals eating poisoned crabs.

Artificial breeding sites: 1. Cisterns, rain barrels, tubes, drums, etc. Control of breeding in tanks and drums is best achieved by screening but this is rather costly and difficult to maintain. Kerosene application every two weeks is suggested and the introduction of Gambusia in large tanks may be feasible.

2. Bottles and tins: These should be stored in covered containers or kept in a dry place until they can be eliminated by burial or dumping into the sea.

3. Car tyres and other junks: Ideally these should be destroyed otherwise treatment with insecticides is recommended.

4. Canoes: Periodic inspection of all beach areas and treatment of all abandoned canoes with a heavy dose of a residual insecticide is suggested.

(71) Burnett, G.F.
1959

Control of land crabs ("Lairo tui") in Fiji
Agr. J., 29, 36-38

The standard type of bait was made by mixing the correct amount of insecticides powder with the dry bran, e.g. for the 5% BHC (presently named HCH) bait, one pound of BHC 50% wettable powder was added to 10 lb dry rice bran. Just before use, this was wetted with sea water until it bound. A piled teaspoonful of the bait was placed at the mouth of each crab hole and after two or more days the latter was closed. As far as possible the holes were visited on the succeeding days and open ones marked with coloured pegs. For up to seven days after baiting the holes were reclosed but after that newly opened holes were left. At the end of the experiment, which was followed for at least three weeks unless it was an obvious failure, the total number of holes opened since the seventh day was taken as the total number of crabs surviving. Care was taken to bait only holes known to contain live and active crabs. Neither DDT nor dieldrin at 2 1/2% approaches complete control. The relative cost of BHC, DDT and dieldrin wettable powders are about 1:2-1/2:12 and so BHC at 5% is not only more effective than the other two insecticides at similar concentrations, but cheaper. It will be noted that two trials each were done with DDT at 5% and BHC at 5%. These were done in pairs, one each during a period with long dry spells when the ground became hard and one each during a period of continuous rain.

In wet weather DDT appears less effective than when dryness reduces the activity of the crabs, while BHC appears equally effective in wet and dry conditions.

Of the other treatments, BHC at 10%, while costing nearly 50% more than the 5% mixture, is not much more effective. Lindane is the highly refined active part of the crude BHC, which is a coarse and irritating product (to mammals at least) and it was thought that crabs might eat lindane more readily than crude BHC for this reason. One half per cent is about equivalent in strength to 5% BHC and why it would be less effective is puzzling. The most likely explanation is the difficulty in mixing so little insecticide evenly in 200 times its weight of bran. The same difficulty was expected with aldrin at 1/2% but either mixing was more thorough or this chemical is more toxic to these crabs. Malathion was tried as a safe representative of the organophosphorus insecticide and pentachlorophenol has shown promise as a contact insecticide for crabs. Both failed as baits.

It is unlikely that one can hope for a complete kill if only because the crabs have to cooperative in their own destruction - if a crab is inactive when the bait is put down this may be dry and unattractive when the crabs finds it. (On the other hand, it is fairly certain that when dry baits are wetted by rain, crabs will feed on them afresh.) Some baits may be buried by actively digging crabs. For these reasons it is not thought worth while to increase the concentration of BHC in the bait over 5%, the extra cost not being matched by increased effectiveness. Aldrin at 1/2% shows promise of being somewhat better and, if available, is to be recommended. DDT and dieldrin are not recommended for baiting "Lairo tui".

The recommended bait is:

Rice bran 10 lb (4.55 kg) (This will treat about 700 crab
50% BHC wettable powder 1 lb (455 g) holes, and costs about .03 d per
or 50% aldrin wettable powder crab.)
1 1/2 oz (42.5 g)
Sea water enough to bind

- (72) Byrd, E.E. & Studies on the epidemiology of filariasis
St Amant, L.S. in Central and South Pacific
1959 South Pacific Commission,
 Techn. Paper No 125

The paper presents the results of investigations on filariasis by the special epidemiology unit, Bureau of Medicine and Surgery, US Navy during 1943 - 44 in American Samoa, Wallis Island, New Hebrides and Solomon Islands, which was submitted as a report in 1945 (11).

1. Vector infection and survival

The authors, through age grading of the parasite in the mosquito, tried to derive inferences on vector survival utilizing also the infection and the infective rates in wild caught mosquito populations.

In American Samoa, Ae. polynesiensis is widespread and showed high infection rates in nature and experimentally while C. quinquefasciatus is much more restricted and showed a lower infection rate. Experimentally only 1% of C. quinquefasciatus harboured infective stage larvae compared with 18.6% in Ae. polynesiensis, which is considered to play a major role in the transmission of filariasis.

Monthly field dissection data of Ae. polynesiensis in Samoa are presented in the following table to show the relationship between the infection and infective rates throughout the seasonal changes during May 1943 - January 1944. Some seasonal fluctuation was noted with marked decrease in the infective rate in September. This was explained by the influx of newly emerged females with the breeding places having been replenished by heavy rains in August after a prolonged dry period in the preceding two months. This was reflected in a lower infection and infective rate, but the proportion of mosquitos surviving to the infective stage from those found positive remained with little change from the previous month.

Monthly dissection record on Ae. polynesiensis from native populated places in Samoa, with the number of specimens carrying infective stage larvae and the percentage survival of mosquitos harbouring this stage of the parasite.

Monthly dissection record on Ae. polynesiensis
from native populated places in Samoa

Month	Number dissected	Number positive	Infection rate %	Number with infective stage	Percentage survival to infectivity	Percentage of positives to survive to infectivity	Estimated probability of daily survival*
May 1943	134	19	14.2	6	4.5	31.6	0.921
June	392	72	18.4	17	4.3	23.6	0.902
July	550	62	11.3	13	2.4	21.0	0.895
Aug	349	61	17.5	14	4.0	23.0	0.900
Sept	678	61	9.7	11	1.6	18.0	0.885
Oct	476	60	12.6	10	2.1	16.7	0.836
Nov	231	29	12.6	8	3.5	27.6	0.879
Dec	422	66	15.6	7	1.7	10.6	0.799
Jan 1944	286	27	9.4	3	1.0	11.1	0.803
Total	3468	457	13.2	89	2.6	19.5	

It is useful to give the following extract which shows the authors' interpretation of subsequent fluctuation in infection and survival of mosquitos.

"From the low rate of survival (1.6%) of all mosquitos for the month of September, a steady increase is noted for October and November, until the 3.5% level is reached. After this there is a decided drop in this rate to slightly above the 1% level, at which level the rate was maintained for the remainder of the period of study. The drop from 3.5% in November to 1.7 and 1.0% respectively during December and January, coincides with the beginning of the rainy season. It is highly probable that the low incidence of infection (9.4%) for Ae. polynesiensis for the month of January (as shown in the table) is influenced by the rainy season (45 cm of rainfall during December 1943 as well as during January 1944). Such a drop in the infection rate for January corresponds to the drop for the month of September, following the heavy rainfall during August. However, during December 1943 and January 1944, a corresponding drop is experienced in the percentage survival of infectivity for all mosquitos as well as for the survival of positive hosts. One explanation is apparent: to change from the dry to the wet season. The climatological factors, characteristic of the rainy season, undoubtedly play a major role in the physiology of both the mosquito host and the developing filaria. In the laboratory the mosquito passes through its developmental cycle to emerge as the adult much quicker (as much as by three or four days) during the rainy season of higher temperature than is true for the opposite and the filaria's developmental time may be reduced by as much as 7 to 10 days from the maximum for the season of lower temperature. Certainly, the increased breeding of the mosquito host during the rainy season counts for the dilution of the mosquito population by unfed recently emerged hosts, and hence, the lower infection rate. Increased temperature, high relative humidity, and heavy rainfall, with a corresponding acceleration in the physiology of both the mosquito and the parasite, in part explain the lowered survival rate of larval infectivity for the beginning of the rainy season.

With the end of the rainy season in May 1943 the percentage survival rates (6th and 7th columns of the table) show a gradual falling off from the 4.5 and 31.6% levels respectively as the dry season continues. It is probably indicated, therefore, that the low survival rates experienced at the beginning of the rainy season gradually recover during that season, and that the season of maximum filarial transmission is during the last half of the rainy and first half of the dry periods. With certain variations the incidence of infection in the mosquito host should remain essentially the same for the months of both seasons."

/N.B.: We have calculated the probability of daily survival following the method adopted by Laurence (1963)¹ and Samarawickrema (1967)² on C. quinquefasciatus with W. bancrofti infection in India and Sri Lanka respectively. /

With this method the probability of daily survival p is calculated as follows:

$$p = \sqrt[n]{\frac{\text{number of mosquitos with infective stage larvae}}{\text{number of infected mosquitos}}}$$

n being the duration of the development of the parasite in the mosquito up to the infective stage. As the author gave an indication that this period is shortened during the hot season, we applied the calculation on the basis of n = 14 days during the period May - September 1943 and n = 10 for the period October 1943 - January 1944. If this assumption is valid, the results show that the average daily mortality during the first period was about 10% while in the second period there was a marked increase in vector mortality during the second period reaching the highest about 20% during December 1943 - January 1944. This supports the authors' view on lower survival rate during this period. /

2. Feeding cycle

The interval between feeding times is mostly 3-4 days.

3. Flight-range

Investigations were carried out on the flight range of Ae. polynesiensis. In all cases mosquitos collected at 136 m away from the village showed very low infection rates or were totally free from infection.

4. Vector control

For the control of Ae. polynesiensis, the authors quote the early attempt of O'Connor, 1923 (3) in the coral islet of Funafuti (Ellice Island group) and gave their experience in another island of this group. The island was the largest in the atoll of Funafuti, and measured approximately four miles in length by no more than half a mile in greatest width. Because of the exigencies of war the entire native population relocated itself on another island, a considerable distance from the one in question. Due to this fact alone the island was considered to be free of filariasis within a few weeks following the wholesale emigration of the native population. However, the presence of a sufficient number of service personnel to utilize practically every square metre of the island's livable surface resulted in a complete destruction of the underbrush and the establishment of a thorough sanitation programme. The complete disruption in the normal routine of the island was accomplished within a very short time so that within a matter of days Ae. polynesiensis completely disappeared.

¹Laurence, B.R. (1963) Natural mortality in two filarial vectors.
Bull. Wld Hlth Org., 28, 229-234

²Samarawickrema, W.A. (1967) A study of the age composition of natural populations of Culex pipiens fatigans Weidemann in relation to the transmission of filariasis due to Wuchereria bancrofti (Cobbold) in Ceylon. Bull. Wld Hlth Org., 37, 117-137

(73) Iyengar, M.O.T.
1959

A review of the literature on the distribution and epidemiology of filariasis in the South Pacific Region
South Pacific Commission,
Techn. Paper No 126

This review in the form of an annotated bibliography in which information pertaining to prevalence of filariasis in the Region and to the vectors has been abstracted from published and unpublished papers. Thus data of clinical surveys and microfilaria rates are summarized. Entomologically, the available knowledge on vector breeding, biting and resting habits are cited, as well as records on infection and infective rates as given in certain investigations. The review covers the area of the New Caledonian, Micronesian, Polynesian and Papuan subregions. Literature was reviewed for the period 1785 - 1959, covering 311 references.

(74) Iyengar, M.O.T.
1959 a

Annotated bibliography of filariasis and elephantiasis. Part 3
South Pacific Commission,
Techn. Paper No 109
(Supplement No 1)

This is a supplement to Part 3. It adds 48 references which the author found after Technical paper 109 was issued. The additional references cover the period 1716 - 1936 and 1954 - 1958. The papers quoted in this supplement deal with clinical manifestations and pathological changes associated with filariasis, but a number of papers dealing with the problem of tropical eosinophilia particularly in the latter period are also included. The geographical coverage as in the main paper is not restricted to the South Pacific Region. The supplement contains corrigenda to the main paper No. 109.

(75) Iyengar, M.O.T.
1959 b

Annotated bibliography of filariasis and elephantiasis. Part 4
South Pacific Commission,
Techn. Paper No 124

This is the fourth bibliography in the series issued by the author according to the recommendations adopted by the South Pacific Commission. From a wide geographical coverage the bibliography compiled and abstracted papers dealing mainly with the operative treatment of filariasis due to W. bancrofti and B. malayi as well as early drug trials involving antimonial, arsenic and other compounds until diethylcarbamazine was discovered in 1947 and its testing and subsequent application in the field. There are papers dealing with the development of animal models for drug trials, namely D. immitis in dogs and Litomosoides carinii in cotton rats. The number of papers cited is 490, commencing 1784 until 1958.

(76) Iyengar, M.O.T.

1959 c

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Filariasis in American Samoa
South Pacific Commission, Techn. Infn.
Circular No 35
Abstract taken from Iyengar (1960)
Techn. Paper No 129

The aim of a filariasis control scheme is the prevention of filarial disease. The eradication of the mosquito vector, or of filarial infection in the human host, is neither practicable nor even necessary. What is needed is the prevention of the establishment of hyperfilarialation in the human host, which is recognized to be the essential factor in the cause of filarial disease. A significant amount of transmission of filarial infection occurs under only one condition, namely the presence of a high density of vector mosquitos in close contact with the human population. Proximity to human habitations is necessary firstly for the mosquito to derive the infection from the human reservoir and secondly, after the period of incubation of the parasite within the mosquito host, for the infected mosquito to transmit the infection to man. The constant reinfection necessary for the establishment of hyperfilarialation in the human host can only occur where a high vector density prevails in close and constant contact with the human population, namely in and around the villages. Measures for the control of filariasis should, therefore, be directed against the vector in and around the villages.

(77) Iyengar, M.O.T.

1959 d

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Combating filariasis in Polynesia
South Pacific Commission, Quarterly Bull.,
April 1959
Abstract taken from Iyengar (1960)
Techn. Paper No 129

The islands in the South Pacific may be grouped under three classes:

- (a) islands entirely free from filarial infection;
- (b) island having filarial infection but with little or no filarial disease; and
- (c) islands with filarial disease.

The number of islands constituting the first class in the South Pacific is comparatively small. In these, the vector mosquito may be totally absent, or its incidence in populated areas too low for effective transmission.

In the second class, the density of vector mosquitos is sufficiently high to establish the infection in the community, but not high enough to produce the high intensity of infection necessary for the onset of filarial disease. The Tokelau Islands, the Tuamotus and the Australs are example.

In the third class, because of the high prevalence of vector mosquitos in and around the villages, there occurs constant contact between the vector and the human host, which serves to step up infection in man to the level at which filarial disease manifests itself. It is not axiomatic that filarial disease occurs wherever the vector mosquito is present, nor is it true that filarial disease occurs in every community in which filarial infection is present. But it is invariably true that wherever a high density of the vector mosquito occurs in close association with human habitations, filarial disease is of common occurrence. For the control of filarial disease, it is not the eradication of the vector mosquito that is necessary, nor even the eradication of the parasite in man, but the breaking of the chain of close association of high vector density with man.

Control of filarial disease in the South Pacific Islands is a matter of carrying out simple measures of village sanitation, namely the elimination of proper protection of domestic rain water containers, and the removal of coconut shells and tin cans for a peripheral area of 120 m.

Another method often advocated is the mass treatment of the population with microfilarial drugs. This, to be effective, involves the administration of the drug one day every month to the entire population for a prolonged period of five years or more. Apart from the enormous cost of staff, drugs, etc. which few territories can afford, it is difficult to force every one, including the healthy persons, to take the drug for such prolonged periods. From the experience gained from extended trials of this procedure, it is being increasingly realised that control of the vector mosquito in the village areas through community effort, supported by the government, offers the most efficient and economical way by which filarial disease can be controlled in the South Pacific.

- (78) Kessel, J.F., Lagret, J., March, H., Bambridge, B. & Chapman, H. 1959 Epidemiology and control of filariasis with special reference to French Polynesia
Proc. 6th Intern. Congress on trop. Med. Mal.: Lisbon, Portugal, 1958,
Instituto Med. Trop., 2, 326-

In this paper the authors summarized the previous findings on the epidemiology and control of filariasis in French Polynesia since the initial surveys were conducted in 1949.

The highlights of parasitological and entomological information as well as control measures and their procedures were recapitulated mainly from Kessel, 1957 (68).

The filariasis control programme combined the following measures:

Mass DEC administration to the whole population, once a month for 12 months in a single dose of 6 mg/kg. After a rest of six months, a blood survey was conducted and positives continued to be treated until they became negative.

Mosquito control by elimination of breeding places within 100 m of each dwelling was implemented. This decreased the adult mosquito population by about two-thirds.

In the current programme in French Polynesia, microfilaremia was quickly reduced and after the third year averaged 3.2% with a mf density of 0.6/20 mm³. Only 0.3% of the mosquitos harboured infective stage larvae. Transmission and new cases of clinical filariasis were likewise reduced to minimum. Before control, the mf rate was 32%, mf density 30, and mosquito infective rate 5%. Also before control, 5.6% of the population in the age-group 0-4 exhibited microfilariae. In 1957 all children examined in this age-group were negative.

The longevity of filarial infections have been observed, and the results in general confirm the observations of Jachowski et al., 1959 (25) that positive individuals unexposed to little or no subsequent infection of W. bancrofti tend to become negative for microfilariae in 5-10 years.

(79) Laigret, J.

1959

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Rapport Annuel, 1958

Institut de Recherches Medicales
de la Polynesie

Abstract taken from Iyengar (1960)
Techn. Paper No 129

Mass DEC treatment was started in Tahiti in 1953. The treatment schedule was 6 mg/kg once a month for 12 months but the positive cases found were treated again for a further period of 12 months. Then the entire population was reexamined and those found to be still positive as well as new comers were treated for one year. However, in 1958, of 19 660 treatments scheduled, 58% escaped because of sickness, refusal, etc. Some attempt was also made to control the vector mosquitos, but no detailed data are furnished.

The end results of five years (1953-1958) are that the mf rate dropped from 30% to 5%, mf density from 33 to 0.8, and mosquito infection rate from 13% to 2.6% and infective rate from 7.6% to 0.8%.

In Papetoai (Moorea Is.), the mass drug treatment schedule was 6 mg/kg once a month for six months, and the positives found were treated for another six months, etc. After one year the mf rate dropped from 24.2% to 4.5%, mf density from 8.4 to 2.4, and mosquito infection rate from 4.6% to 1.8% and infective rate from 1.5% to 0.4%.

In Moorea (excluding the above district) the entire population received 6 mg/kg once a month for 12 months in 1956-1957. Checks done in 1958 showed that the mf rate dropped from 27% to 7.6%, mf density from 14 to 1.3, and mosquito infection rate from 5.9% to 1.7% and infective rate from 1.4 to 0.6%.

In Maiao Island, the mf rate and density dropped from 27.6% and 26.5 in 1949 to 14.4% and 2.9 respectively in August 1950 after the treatment at 2 mg/kg three times a day for seven days.

(80) McCarthy, D.D.
1959

Filariasis in the Cook Islands
N.Z. med. J., 58, 738-748

The paper presents the results of blood surveys carried out in various atolls of Cook Islands, classifying the mf rates by age group and sex and discussing the possible factors influencing the intensity of infection.

The survey was based on examination of 20 mm³ of blood, and the results are given in the following table.

MICROFILARIAL INCIDENCE IN ADULTS

	Males		Females	
	No. Examined	% Positive	No. Examined	% Positive
Rarotonga	390	46.9	446	33.6
Aitutaki	134	53.7	123	47.1
Atiu	77	54.6	73	26.2
Mauke	34	55.8	51	35.3
Manihiki	84	59.5	101	26.8
Rakahanga	71	18.3	66	4.5
Penrhyn	58	15.5	68	5.9
Pukapuka	55	56.4	65	29.2
Palmerston	12	25.0	15	13.3

Of 276 *Ae. polynesiensis* dissected in Aitutaki in 1956, the infective rate was 6.5% and the infection rate was 11.3%; and of 71 mosquitos dissected in Rarotonga in 1957, the infection rate was 2.3%.

(81) Nelson, G.S.
1959

The identification of infective larvae in mosquitos: with a note on the species found in "wild" mosquitos in Kenya coast
J. Helminth., 33, 233-256

Infective larvae from freshly dissected mosquitos were fixed in 70% alcohol containing 5% glycerine and mounted in a very small drop of the fixative on a cover slip which was inverted over a slide with a cavity and sealed with "Euparol". This method was found to preserve larvae with little distortion. The external features usually remain clear but the internal structures do not show clearly. As dissection in the field was not always convenient, the wild caught mosquitos were preserved in 80% ethyl alcohol (hot alcohol being preferred for histological work). The mosquitos were then processed in the laboratory as follows:

1. Mosquitos were transferred through descending dilutions of alcohol to water.
2. Staining with Mayer's acid haemalum for 3 days.
3. Transferred to distilled water for 3 days.
4. Transferred to glycerine until dissected.

5. Dissection of stained mosquitos was made in glycerine under a stereoscopic microscope.

6. The infective larvae were picked up and mounted in glycerine under a coverslip and ringed with "Euparol".

7. Examination of the morphological characters was clearly made under microscope with 4 mm objective but for measuring and detailed observation of the caudal extremities a 2 mm oil immersion objective with a micrometre eyepiece is necessary.

The author gives the advantages of the above method of processing of the mosquitos over other methods usually employed as follows:

- the external and internal characters of all larval stages are well defined
- the dissection of mosquitos can be done in the laboratory under the best conditions
- the position and number of larvae in the mosquito can be accurately determined

The disadvantage was found to be the gradual fading of the stained specimens mounted in glycerine, several other mounting media were tried but all caused some distortion of the larvae.

The author pointed out that only identification of the 3rd stage or infective stage larvae is given. Newton & Pratt (1945)¹ and Wharton (1957)² showed that the 3rd stage larvae move rapidly from the abdomen to the proboscis when the mosquito starts feeding. Therefore, third stage larvae are regarded as infective whether they occur in the proboscis or elsewhere in the mosquitos. These larvae have a well developed cuticle. They are usually very active, lost the skin of the second ecdysis and there is no sign of an anal plug.

¹Newton, W.L. & Pratt, I (1945) Experiments to determine whether infective larvae of W. bancrofti can migrate from the abdomen of the mosquito intermediate host. J. Parasit., 31, 266-268

²Wharton, R.H. (1957) Studies on filariasis in Malaya. Observations on the development of W. malayi in Mansonia (Mansonoides) longipalpis. Ann. trop. Med. Parasit., 51, 278-296

The following table shows the measurements of the infective larvae from experimentally infected mosquitos. It is clear that the length is an important character in differentiating the infective larva. For example Dirofilaria spp with average length less than 100 μ can be easily distinguished from Wuchereria and Brugia and Setaria which have average length more than 1400 μ .

MEASUREMENTS (IN μ) OF INFECTIVE FILARIAL LARVAE FROM EXPERIMENTALLY INFECTED MOSQUITOES

Filarial species	Mosquito host	Technique	Number measured	Mean length	Mean breadth	Mean distance anus to caudal extremity	Mean breadth halfway anus to caudal	Mean anal ratio
<i>W. bancrofti</i>	<i>C. fatigans</i>	glycerine	19	1320	20.8	58.0	14.5	4.0
		haemalum	10	1400	24.4	63.2	15.6	4.1
<i>B. malayi</i>	<i>M. uniformis</i>	glycerine	17	1592	24.8	67.6	14.9	3.8
	<i>M. longipalpis</i>	haemalum	4	1410	22.7	46.7	12.7	3.6
<i>B. pahangi</i>	<i>A. obscurans</i>	haemalum	10	1200	24.0	45.8	16.6	2.9
		glycerine	20	1593	21.8	57.7	13.8	4.1
<i>B. tenuis</i>	<i>Ae. pectinifer</i>	haemalum	14	1330	18.9	47.7	13.2	4.1
	<i>M. uniformis</i>	glycerine	10	1631	24.4	62.0	13.1	4.7
	<i>M. africanus</i>	glycerine	10	1444	22.9	60.5	13.6	4.6
<i>D. sорynedes</i>	<i>Ae. pectinifer</i>	haemalum	10	1468	24.7	56.1	12.1	4.6
<i>D. repens</i>	<i>Ae. aegypti</i>	glycerine	16	881	22.4	33.6	18.2	1.8
		haemalum	20	935	22.4	37.9	18.7	2.0
<i>D. immitis</i>	<i>M. africanus</i>	glycerine	10	820	19.3	38.6	16.8	2.3
<i>S. equina</i>	<i>C. fatigans</i>	glycerine	20	978	20.9	39.2	17.6	2.2
	<i>Ae. pectinifer</i>	glycerine	13	1630	26.6	46.0	17.6	2.0
	<i>Ae. aegypti</i>	glycerine	40	1584	20.9	44.5	17.2	2.7

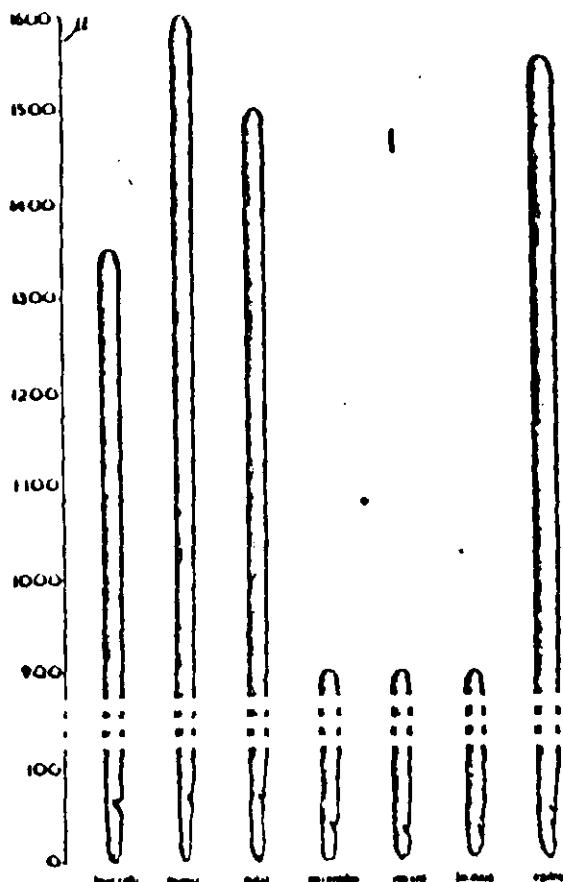


Figure 1. Relative lengths of infective larvae of seven species occurring in mosquitos

This difference is clearly shown in Fig. 1. Various factors affect the length of the larvae; if they are dissected out several days after they have reached maturity they are usually longer than larvae removed on the day following the second ecdysis; on the other hand, in mosquitos with a very heavy infection, physical crowding results in some of the larvae being shorter than normal. Another important factor affecting the length is the species of mosquito host; Kartman (1953)³ has shown that the larvae of D. immitis are longer in C. quinquefasciatus than in Ae. aegypti. In the present experiments the larvae of B. patei were longer in Ae. pombaensis than in Mansonioides.

It is not possible to measure the active living larvae, usually they are measured after being fixed and mounted. With the alcohol-glycerine method there is little shrinkage but with the staining technique especially if the larvae have been fixed with hot alcohol, there is often considerable shrinkage, this probably accounts for the shorter larvae of B. malayi and B. pahangi after haemalum staining as seen in the above table. These various factors are probably responsible for the considerable differences recorded for the length of various filarial larvae in the literature.

³Kartman, L. (1953) Factors influencing infection of mosquitos with Dirofilaria immitis (Leidy, 1856). Experimental Parasitology, 2, 27-28

The position of the anus is an important feature in differentiation; the anal aperture is much nearer the caudal extremity in Dirofilaria than in Wuchereria and the position of the anus in Setaria is intermediate. This feature together with the differences in shape of the larvae between the anus and the extremity have been used by Wharton (1957)² to differentiate B. malayi from D. immitis; he calculated what he has called the "Anal ratio" which is the distance from the anus to the caudal extremity divided by the breadth of the larva half way between those two points. This ratio is useful if only fragments of larvae are available for examination or if the terminal anatomy is not very clear. The "Anal ratio" in Dirofilaria averages approximately 2, and in Wuchereria the ratio is nearer 4.

The most useful character for differentiating the larvae is the shape of the caudal extremity. With very little experience it is possible to recognise even with the low power objective, the cigar shape end of Dirofilaria, which clearly distinguishes it from Wuchereria which has a much more definite narrowing between anus and extremity. Most species of infective larvae have three caudal papillae with one, usually the most prominent, dorsal; the other two are in a lateral or ventral position. The number, shape and size of these papillae are of importance in differentiation. The papillae are often very small and can only be seen by differential focussing under high magnification.

The following key may assist field workers to differentiate infective larvae found in wild-caught mosquitos. The most useful differentiating characters are the length, the position of the anus and the shape of the caudal extremity.

KEY TO THE DIFFERENTIATION OF INFECTIVE FILARIAL LARVAE IN MOSQUITOS

1. Caudal papillae or protuberances present 2
No caudal papillae 9
2. Length more than 1100 μ 3
Length less than 1100 μ 6
3. Three equal bubble-like caudal papillae W. bancrofti
Three caudal papillae of various shapes and size 4
4. Terminal or dorsal papilla prominent 5
All three papillae poorly developed; anal ratio less than 4.5 B. malayi and B. pahangi
5. Terminal dorsal papilla "dog's nose" shape; lateral papillae poorly developed; larva narrows between anus and extremity; anal ratio averages 4.5 B. patei
Terminal papilla large and central; two small lateral sub-terminal alae; anal ratio less than 3 S. equina
6. Anus more than 50 μ from extremity 8
Anus less than 50 μ from extremity 7
7. Three small terminal papillae D. corynodes
One small terminal papilla with or without two very small subterminal papillae D. immitis or D. repens
8. Three prominent terminal papillae D. arbuta
9. Length usually less than 1100 μ , anus less than 50 μ from extremity Foleyella spp.
Length 1000 μ - 1250 μ ; anus more than 50 μ from extremity Flavescens spp.

(82) Rageau, J &
Estienne J.
1959

Enquête sur la filariose à Wallis
Mimeographed document, 37 pp
Institut français, Nouméa

An epidemiological investigation was carried out in 1958-1959 in Wallis where the population was estimated to be about 6000.

1. Results of parasitological and clinical investigation

Of 1029 persons examined (about 1/6 of the total population), by 20 mm³ thick drop of peripheral blood, 20.4% were mf positive. The mf rate in males was 21.8% and in females 19.2%.

The subperiodicity of the microfilaria was confirmed, high counts reaching a maximum at 1600 hours and a minimum at 2400 hours.

The clinical examination of the 1029 inhabitants showed that 9.9% of them suffered from lymphangitis or had elephantiasis. There was no significant difference between the proportion of males and females affected by these symptoms, respectively 8.9% and 10.6%. Over 20% of the persons of the age-group 50-70 years had either lymphangitis or elephantiasis.

2. Results of the entomological investigation

The following five species were identified in Wallis. This was also reported by Byrd et al., 1945 (12) and Byrd & St Amant, 1959 (72).

Ae. (Stegomyia) polynesiensis

Ae. (S.) aegypti

"Ae. (Finlaya) samoanus"

C. quinquefasciatus

C. (C.) annulirostris

/ N.B.: Ae. samoanus was reported only from Samoa, Belkin, 1962 (97). Perhaps it was confused with Ae. oceanicus which appeared in Belkin's records of Wallis Islands. /

Ae. polynesiensis was considered as the main vector transmitting W. bancrofti as well as canine filaria. Of 1435 specimens dissected, 3.7% was found to harbour all larval stages of W. bancrofti and 0.4% to harbour infective stage larvae. The periods of development of Ae. polynesiensis were given as 1-6 days for stage I, 7-12 days for stage II and 13-16 days for stage III.

This vector species was found to be the most voracious man-biting, and much less attracted to animals such as pigs, horses, dogs, cats, cattle and birds. It was found to be most active in biting during day time, particularly when the weather is calm, hot and humid, although it was found also to extend its biting activities to late in the day and even during the night. It was difficult to determine the biting cycle of this vector. Characteristically, it bites man in the verandahs and inside houses, although its density is lower in houses than in the bush. Its density was found to be extremely high in villages surrounded by coconut plantations and bush.

As in Tonga "Ae. samoanus" was found to breed in plant leaf axils such as "Kapa" (Alocasia sp.) and taros (Colocasia and Xanthosoma). It is a night biter with the peak of its biting occurring during the late hours of the night until about 1000 hours in the morning. The authors assumed that due to its nocturnal biting activities and its scarcity, its role in transmission of human filariasis is limited or nil.

3. Animal filariasis

The peripheral blood of five dogs was found to harbour large numbers of microfilariae of Dirofilaria immitis. The infection rate in Ae. polynesiensis was very low, 0.34% of 1435 mosquitos dissected.

4. Experiments of residual spraying with organochlorine insecticides

4.1 Larviciding

The granule formulation of bentonite used contained 5% active ingredient of dieldrin applied on the surface of the water at a dosage of 2 gm/m². The treated waters were irrigation canals of taro palm, tree holes, coconut shells and water drums. A single treatment could destroy all larvae of C. annulirostris in its breeding places in taro palms, C. quinquefasciatus and Ae. aegypti in water drums, Ae. polynesiensis in tree holes. The breeding places remained free of larvae for about 3 months.

4.2 Imagocides

House spraying demonstration was applied to the inside walls of a compound with 0.5% emulsion diluted from an emulsifiable concentrate containing 15% dieldrin. The rate of application was 100 cc per m², i.e. about 0.5 g of dieldrin active ingredient per m². After the treatment, dead Ae. polynesiensis and other insects were recovered. However, the biting density outdoors was not affected.

(83) Beye, H.K & Gurian, J.
1960

The epidemiology and dynamics of
transmission of Wuchereria bancrofti and
Brugia malayi
Indian J. Malar., 14, 415-

The paper deals with subjects in three parts: The first two are a review of the literature.

Part I: Crucial factors in the life cycle of W. bancrofti and B. malayi.

Part II: Epidemiologic characteristics of W. bancrofti and B. malayi.

Part III: Dynamics of transmission. The authors defined the aims of quantitatively characterizing the dynamics of transmission as being a tool for assisting control programmes in evaluating their results at more frequent intervals than the normal practice of 5 to 10 years. Thus an attempt was made to construct a model and the steps for this have been described involving the variables

used and assumptions made commencing with a transmission index defined as an index which "relates the intensity of transmission to human contact with infective vector mosquitos at an instant in time" and a measure termed a "generation index" which is "an expression of the number of fertile female worms to which one fertile female worm gives rise in the course of her life-time". The authors believe that this index which collates all separate variables would give a better picture of the long term condition of infection and the long term effects of any control measures.

(84) Burnett, G.F.
1960

The arrival of Aedes (Ochlerotatus) vigilax
(Skuse) in Fiji
Pacific Science, 14, 389-394

Ae. (Ochlerotatus) vigilax is a serious pest in Australia, New Caledonia and elsewhere. In December 1957 it was found breeding near Suva and within three months it had been found around much of the coast of Viti Levu, the largest Island of the group, thus establishing it as the worst pest species on the coast whenever conditions favoured its breeding. It is believed that it arrived from Sydney or from New Caledonia probably by air, because transport from other areas is very rare.

The species is a very efficient host of the New Caledonian strain of nonperiodic bancroftian filariasis but a poor host of the Fiji strain. One experiment indicated that it could be a good vector of the dog filaria, D. immitis.

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The species is a very efficient host of the New Caledonian strain of nonperiodic bancroftian filariasis but a poor host of the Fiji strain. One experiment indicated that it could be a good vector of the dog filaria, D. immitis.

(85) Burnett, G.F.
1960 a

Filariasis research in Fiji, 1957-1959
J. trop. Med. Hyg., 63, 156-162;
181-192; 208-215

This paper was originally processed as a mimeographed document by the former Colonial Pesticide Unit, Tanzania. The work was considered as an extension of the studies of Symes, 1956 (62) and 1960 (90).

The authors stated that the methods applied were substantially the same as those utilized by Symes (loc. cit.):

- (a) morning fog catch in houses;
- (b) night-bait catch in houses;
- (c) standard bush catch;
- (d) track bush catch;
- (e) selected bush catch;
- (f) garden or plantation selected catch;
- (g) larval survey (including crab holes and leaf axils).

The only important addition has been the use of night-bait catch for collecting night-biting mosquitos. One man, the bait, sat in the house without his shirt. The catcher, smeared with repellent, caught all mosquitos coming to the bait in one hour. Lights in the house were put out and the catcher used a torch. Catches were made for one hour at a time between 1900-2300 hours in different houses.

Track and bush catches were made by two men, one acting as a bait for the other. A standard catch consisted of seven five-minute catch from a house on the edge of the village and proceeding in a straight line to the catching points at increasing distances from the village.

Regarding the fog-catching method, the fogging was usually done in the morning if dissections were required, but sometimes continued into the afternoon when only data of mosquito prevalence were required. Sheets were spread on horizontal surfaces and all windows and doors closed. The interior was then treated with an aerosol of 0.3% pyrethrin and 1.2% piperonyl butoxide in oil, produced by either a Microsol generator or a swing fog machine. After spraying, the house was kept shut for five minutes before searching the floor sheets for mosquitos. The following indices were used by the present author:

Fog catch - The mean number of mosquitos per house.

Bait catch - The mean number of mosquitos per hour.

Bush catch - The mean number of mosquitos per hour (this was done by pooling all outside daytime bait catch which was done according to the standard routine in taking the mean of 12 stations).

1. Epidemiology

1.1 Infection rates in wild-caught vectors

The data of most of the dissections performed on mosquitos collected in and near villages are given in Table 1. The two "bush vectors", *Ae. polynesiensis* and *Ae. pseydoscutellaris*, cannot be distinguished with certainty in the field and were therefore combined. The infection rates were of the same order as those given by Symes, and the total rate was much lower than that of *Ae. fijiensis*. No mature infective stage larvae were found in *C. quinquefasciatus*, and only one early third stage in over 3000 dissections.

1.2 Infections in mosquitos captured in track catch

The catch was made at varying distances from 0 to 400 m from villages. Out of 984 "bush vectors", 6% were infected. The infection rates are as follows:

	0 - 180 m		273 - 364 m	
	No. of mosq. dissected	Infection rate %	No. of mosq. dissected	Infection rate %
On tracks	549	4.6	319	6.3
Off tracks	2025	4.2	1573	4.1

The results obtained by the author confirmed Symes' conclusion in that infection is not confined to the immediate vicinity of the village. They do not suggest that the removal of breeding sites within 100 m of the village will have much effect in controlling filariasis.

1.3 Infections in mosquitos in gardens and plantations

Out of 947 mosquitos dissected, the infection rate was 1.5%, which was much lower than near villages (4.9%). It appears that the risk of infection in a garden or plantation was not negligible, and some workers (i.e. Otto & Jackowski, 1955 (55) in Samoa) consider such places the primary source of infection.

1.4 Estimation of the mean daily mortality of vectors

The detailed calculations made by the author according to the method he adopted for estimation of the mean daily vector mortality are quoted in the following:

The mean daily mortality of vectors can be calculated by considering the proportion of those that take an infective meal which survive to a later stage, after a known interval (assuming

100% development, which is justified for Ae. pseudoscutellaris and Ae. polynesiensis as observed by Symes (loc. cit.). The required data are given in the table. They are best for Ae. fijiensis which was taken as an example. The calculations were based on the fog catch. The mosquitos from the night-bait catch have quite a different history from the others - none of them is newly infected; the 0.4% showing only microfilariae were infected at a previous meal. Because the fog catch was derived from the same population as these, a similar percentage of them would be carrying microfilariae from a previous meal. A correction needs to be made for this in the same way as for control mortalities in insecticide experiments (Abbott's formula) reducing the 10.3% showing only microfilariae to 9.87%. The percentage showing third stage larvae (including mature stages) is 0.36. The probability (*p*) of a mosquito surviving from infection to bear third stage larvae is, therefore, $0.36/9.87 = .0365$.

Table 1. Filarial infections (W. bancrofti) in mosquitos caught in and near villages

<u>Species</u>	<u>Number dissected</u>	<u>All stages</u>	<u>mf</u>	<u>Percentage infected</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>Mature</u>
<u>Ae. pseudoscutellaris</u> and <u>Ae. polynesiensis</u>	2743	4.9	0.76	2.95	0.76	0.22	0.22	
<u>Ae. fijiensis</u>	5858	11.4	7.4	4.0	0.87	0.34	.085	
fog catch only	4139		10.3	3.3	0.78	0.31	.05	
bait catch only	1719		0.47	1.3	1.06	0.40	0.17	
<u>C. quinquefasciatus</u>	3171	5.6	4.0	1.4	0.13	.03	0.0	
fog catch only	2845		4.5	1.5	0.14	0.0	0.0	
bait catch only	326		0.3	0.0	0.0	0.3	0.0	

Symes (loc. cit.) found microfilariae in Ae. fijiensis took 13-15 days to reach the third stage. Most of our dissections were done in the cooler months; a period of 15 days is appropriate and "*p*" becomes p^{15} . The survival rate for this period was taken from Table 1 in Macdonald (1957)¹ as 0.035 which is close to 0.0365 determined above. The corresponding probability of daily survival would be 0.80 or 80%. Thus the mean daily mortality would be 20%.

¹Macdonald, G. (1957) The Epidemiology and Control of Malaria. Oxford University Press, London.

A similar calculation can be made for the other species with necessary modifications. The results are as follows:

	<u>Mean daily mortality, %</u>
<u>Ae. fijiensis</u>	from microfilarial & 3rd stage rates 20
<u>Ae. fijiensis</u>	from 1st & 3rd stage rates 22.5
<u>C. quinquefasciatus</u>	from microfilarial and 2nd stage rates 29
<u>C. quinquefasciatus</u>	from microfilarial and 3rd stage rates 26
<u>Ae. pseudoscutellaris</u>	from 1st and 3rd stage 21
<u>Ae. polynesiensis</u>)	rates

These figures show that C. quinquefasciatus has a lower expectation of life than the other species, which may account for its lesser importance as a vector of the subperiodic W. bancrofti.

/N.B.: Checking the above estimates by recalculation following the method used by Laurence (1963)² on C. quinquefasciatus in India and by Samarawickrema (1967)³ on the same species in Sri Lanka (with periodic W. bancrofti in both studies) on the author's data, the following estimates are given for comparison. The number of infected mosquitos and those with third/mature larvae was obtained by multiplying the percentages of each stage by the number of mosquitos dissected shown in the author's Table 1 above, for the combined fog and bait catch.

Ae. fijiensis: from mf and 3rd stage larvae

Number of 3rd stage/mature stage larvae 25, all stages 668.
If (p) is the probability of surviving through one day and (n) is 15 days

then the probability
of daily survival is

$$p^{15} = \sqrt[15]{\frac{25}{668}} = 0.803 \quad \text{i.e. mean daily mortality of 20\%}$$

²Laurence, B.R. (1963) Natural mortality in two filarial vectors.
Bull. Wld Hlth Org., 28, 229-234

³Samarawickrema, W.A. (1967) A study of the age-composition of natural populations of Culex pipiens fatigans Wiedemann in relation to the transmission of filariasis due to Wuchereria bancrofti (Cobbold) in Ceylon. Bull. Wld Hlth Org., 37, 117-137

From the 1st and 3rd/mature stage larvae with n = 14
(excluding 1 day for mf)

Number of mosquitos with 3rd/mature stage larvae 25
with total stages 1-3, 310

$$P_{14} = \sqrt{\frac{25}{310}} = 0.835 \text{ i.e. mean daily mortality of } 16\%$$

It is clear that the first estimate is comparable to that of the author but the second is not.

C. quinquefasciatus: from mf and 3rd/mature stage larvae

Number of mosquitos with 3rd/mature larvae 1, with total stages 178

$$P_{15} = \sqrt{\frac{1}{178}} = 0.708 \text{ i.e. mean daily mortality of } 29\%$$

This estimate is nearly similar to that of the second estimate made by the author. No comparable estimate could be made for the author's first estimate in view of absence of data on the developmental period (n) up to the second stage.

Ae. pseudoscutellaris and

Ae. polynesiensis : from the 1st and 3rd/mature stages with n = 14

Number of mosquitos with 3rd/mature stages 12,
with sage 1-3, 113

$$P^{14} = \sqrt{\frac{12}{114}} = 0.851 \text{ i.e. mean daily mortality of } 15\%$$

This estimate is much lower than that made by the author for the two species combined, 21%. The reason for this and the above discrepancy is not clear since the author did not indicate whether he obtained the estimate with interpolation from Macdonald's Table 1 or by accurate calculation. /

1.5 The relative importance of vectors

The author concluded that C. quinquefasciatus is of minor importance as a vector and Ae. polynesiensis may be the most important, closely followed by Ae. pseudoscutellaris. Ae. fijiensis is important where it occurs, but is restricted in distribution by its critical breeding requirements.

1.6 Some observations on vector bionomics

Ae. fijiensis did not utilize the cultivated *Pandanus thurstonii* to any extent near the coast, but inland along the Navua River it did so abundantly.

Larvae of *Ae. polynesiensis* were found predominantly in crab holes, infrequently with *Ae. pseudoscutellaris*.

Regarding house-leaving by endophagic mosquitos, Symes concluded from direct observation that many mosquitos which entered houses left before daybreak. This is important when assessing the results of insecticide applications and has been confirmed by comparing the present studies of night bait catches and morning fog catches in the same villages.

1.7 Infection in man and animals

Results of blood surveys of the human population confirmed previous findings that mf rates in girls were higher than in boys, but were higher in adult males than in females.

Microfilariae were found in the blood of mynahs and pigeons, but these are not thought to be a complicating factor. Medication caused a complete disappearance of human filariae from mosquitos but *D. immitis* infection virtually remained to be seen. This was a good indication that no confusion was caused by unknown animal or bird filariae.

2. Experiments on control of mosquito vectors

2.1 Removal of breeding places

The best experiments were done when 2 644 tree-holes were destroyed but found 388 holes (larvae of *Ae. polynesiensis* and *Ae. pseudoscutellaris* in 151 holes) at a post-treatment inspection. This was largely due to new bamboo pig-pens and the fact that 3906 containers of all types destroyed had been replaced in four and a half months by 2040 new ones, 540 of which contained water (132 with larvae).

The large wild species *Pandanus tectorius* and *P. joskei* in the leaf axil of which *Ae. fijiensis* breeds, do not regenerate when cut down, and the fully grown trees are conspicuous enough to be found easily. The young trees are perhaps the major source of breeding, because in the mature trees of *P. tectorius* the stems turn over and the axils no longer hold water, but young trees are not so readily found. Deviation to the cultivated *P. thurstonii* was not common. This is fortunate because this species plays an important part in Fijian economy and there would be considerable opposition to its removal.

2.2 The use of insecticides

Very extensive breeding of *Ae. pseudoscutellaris* and *Ae. polynesiensis* took place in piles of coconut shell split to extract copra. Two methods were tried to prevent breeding in these piles - spraying with 2 1/2% dieldrin suspension (wettable powder in water) and thatching, i.e. covering the top and sides of the piles with several layers of leaves to shed water and hinder ingress of ovipositing females.

Five g pellets containing 16.3% and 2.5% dieldrin and 16.3% HCH (tech.) were used in bamboo pots of 800 - 2000 cc capacity set out in pairs in a forest near Suva.

Only the results of Ae. pseudoscutellaris were reported. Breeding was continuous and almost universal in the control pots, but no larvae were ever recovered from those with HCH during the 39 weeks for which they were observed. The pellets disintegrated to sand within 12 weeks but the dieldrin series showed a small number of larvae from time to time, usually 1st instar, sometimes 2nd, once 4th. These were found after heavy rain which probably washed out dissolved insecticide which took time to replace. There was no evidence (i.e. pupae or pupal skins), that successful breeding took place in the pots with 16.3% dieldrin in the 43 weeks they were observed but in those containing the 2.5% pellets, fourth stage larvae were found in the 34th and 39th weeks.

These pellets might be used to prevent breeding in bamboo stumps and fences and also for flower-vases, anti-ant cups, water butts, beached boats, etc.

For three holes, only 16.3% dieldrin pellets were tried. It was recommended that pellets should not be used regularly for tree holes which warrant permanent attention by draining or filling, but they could be used for rapid sterilization of an area.

Breeding in crab holes (Symes, loc. cit.) might be controlled either by removal of the crabs or direct attack on the mosquito larvae.

The experiment was carried out on Mosquito Island in Suva harbour. This consisted of a soapstone ridge with sandy flats on each side covered by strand vegetation.

Five g of 16% HCH pellets were rolled into all the 241 crab holes found in the semi-isolated western tip of the island and 1917 holes to the north of the central ridge received 5 g pellets of 16% dieldrin. South of the ridge was used as a control. Selected day-time bait catches were made at the same selected points away from adjoining boundaries at intervals governed by the availability of boats.

Experiments were undertaken to determine to what extent land crabs (Cardisoma carnifex) can repopulate an area after it has been subjected to treatment of holes with insecticides and stopping them with earth. The criteria used were the rate of reopening of the holes. The first attempt was made at Koratonga in the dry zone where the method described by Symes, 1960 (90) was adopted. In each of 1198 crab holes 130 cc of 1% lindane in diesel oil was poured through a rubber tube. The method was described as laborious (about 10 holes treated per man-hour). The results showed that 45% of the holes were found to have opened after about 18 months from the treatment. An estimate of the rate of immigration of crabs to the treated area was given as 100 crabs per wet season and from this the author inferred that at this rate it would take about 11 years to repopulate completely a cleared area.

After this initial attempt a second-invasion experiment was made at Navuloa, Rewa, in the wet zone, where the activity of the crabs was unlikely to be restricted by dryness. The area concerned is estuarine and lies between mangrove swamps and slightly rising ground covered by a dense shrubby growth of Leucena glauca which was not favoured by the crabs.

In order to assess crab activity, 200 large holes in a nearby area were stopped and 153 (76.5%) of these were reopened, giving a figure for the proportion of holes actually occupied.

Because it was necessary to start as early as possible in the rainy season, the first baiting was made with 2 1/2% dieldrin as a result of tests reported elsewhere, but as the tests described earlier showed that dieldrin was unsuitable, first 5% DDT and finally 10% HCH were used to rebait reopened holes and tidy up the boundaries of the area. All holes large enough to admit a piled teaspoonful of bait were baited.

The 0.7 hectare contained 3617 holes of suitable size. If 76% of the holes were inhabited a total of about 2760 crabs were treated and the final kill was about 89%.

The area was visited twice over the next nine months, in each case all holes were stopped on one visit and reopened ones counted about a week later. On 17 February 1959, 431 holes were found open and reclosed, but on 23 February only 318 had been reopened. On 14 July 296 were open out of 483 closed six days before. The whole period was wet and the experimental area became rapidly covered with herbage which may have hidden some holes.

Selected day-time catches were made at Navuloa before and after baiting and stopping at holes. No reduction compared with a control are was recorded, but this could have been due to continued breeding in tree holes, of which there were plenty.

Experiment on indoor residual spraying was also undertaken. The village of Mau was sprayed three times with dieldrin emulsion to give mean deposits, chemically estimated, of 0.25, 1.32 and 0.52 g/m². The author estimated that the effect on resting mosquitos lasted at least 3, 9 and 6 months with the above-mentioned dosage respectively and with the corresponding effect on entry as lasting under 2, 3 and 4 months respectively.

2.3 General conclusions on vector control

Sanitation measures had been in the past confined to the vicinity of the village. In view of the new data on infection rates at distances up to 360 m around villages and in gardens that can be situated at several miles, it was concluded that such measures could not possibly succeed. The breeding of Ae. polynesiensis in crab holes was considered as defeating any measures that did not include control of such ecological niche. It has already been shown that the sanitation programme in Fiji for the control of filariasis had had no detectable effect on the microfilaria rates in 56 villages sampled. Further, it was pointed out that attempts made to measure cost/effectiveness of sanitation measures cast doubt on their practicability, even if new breeding places were not created by the inhabitants as rapidly as the old ones were removed and even if they were carried out as efficiently as humanly possible. Thus the extermination of the bush vectors is impracticable and their control is difficult in view of the large number and the wide variety of their small breeding places.

The use of insecticides for the control of adult vector population was not considered feasible because it has to be applied on a wide scale and frequently renewed over a period of many years. House treatment would be quite useless. Therefore resort to larval control had to be sought but as was shown the problem lies in finding and treating all breeding places. It was advocated that when found, they should be dealt with permanently and not temporarily with insecticides. However, it was emphasized that the use of insecticides in controlling bush vectors should be reserved for special situations such as the control of breeding in coconut husks which should be dealt with until they decay and in crab-holes where no alternative method is available. In practice, each village would have to be cleared of crabs in a planned operation, ground vegetation must be cleared to reveal holes, bait applied, reapplied if necessary and holes permanently stopped. To treat a littoral village for 137 m from its boundaries would involve about 10 hectares and perhaps 50 000 holes. To extend this treatment to 366 m may be necessary, involves up to 87 hectares and 190 000 holes. This is a fairly large operation but unless it is done, work expended on other types of breeding place is largely wasted.

Of all vectors, Ae. fijiensis was considered as to offer the best chance for control. Cutting out tall Pandanus reduced numbers considerably. There is some evidence that cutting out will reduce the number of infective mosquitos in a village. Alternatively transmission by A. fijiensis can probably be interrupted by spraying houses with dieldrin at 0.6 - 0.8 g/m² twice a year.

The great objection to vector control as a sole means of eliminating filariasis is the need for highly effective methods, which have to be applied for many years, at least ten, probably twenty. In Fiji the position was exceptionally complex and a correspondingly complicated system of control measures would be required. This makes the use of drugs, which protect equally against all vectors in all situations, an attractive alternative, and one which will give quicker results at a fairly low and diminishing cost.

(86) Iyengar, M.O.T.
1960

Annotated bibliography of filariasis and
elephantiasis. Part 5. Prophylaxis and
control of filariasis due to Wuchereria
bancrofti and Brugia malayi

South Pacific Commission, Techn. Paper No 129

This is the last part of the series of bibliography issued according to the recommendation adopted by the South Pacific Commission. The author concentrates on papers dealing with drug treatment and/or vector control. In addition to the countries of the South Pacific the bibliography cited papers and report from some countries in Asia, Africa, West Indies and South America. Experience with DDT residual house spraying where anopheline mosquitos are common vectors of malaria and filariasis is abstracted. Attempts made to control vectors of the subperiodic W. bancrofti by source reduction or the use of insecticides are summarized. A number of papers deal with Toxorhynchites as a biological control agent. There are several papers giving the experience in controlling C. quinquefasciatus as a vector of the periodic W. bancrofti, while there are others dealing with the control of Pistia for the elimination of Mansonia spp. being the vectors of B. malayi. The bibliography covers 195 references from 1879 to 1959.

(87) Iyengar, M.O.T.
1960 a

A review of the mosquito fauna of the South Pacific (Diptera, Culicidae)
South Pacific Commission, Techn. Paper No 130

With this paper the author aimed at updating the knowledge given in his earlier review (51) of the distribution of mosquitos in the South Pacific Region, in view of the subsequent advances made in studies on the mosquito fauna of this area.

The author described the characteristics and affinities of the fauna as well as the distribution of the genera, species within the area. The important features of the faunas of the four faunistic zones, namely the Papuan, New Caledonian, Micronesian and Polynesian, and their relationship to each other and to the faunas of the neighbouring regions are set out.

In a systematic list, recent synonymy and the range of distribution of each species within the South Pacific Region are provided. For preparing the list of species and their distribution, the author critically reviewed all previous records and included only those which had been confirmed or considered reliable.

For each species listed, notes are given on the basis of its principal geographical distribution, to show whether it is endemic, essentially endemic, Oriental, Australian, Ethiopian-Oriental or cosmopolitan. For species classified as essentially endemic the range of distribution outside of the South Pacific area is indicated.

In the concluding part of the paper lists of species recorded from each of the various islands and island groups of the South Pacific are provided.

- (88) Kessel, J.F. Nonperiodic bancroftian filariasis
1960 Indian J. Malariaiol., 14, 509-519

The paper is a review of the available knowledge on nonperiodic bancroftian filariasis. The review discusses the theories of the origin of this form. Distribution and prevalence of the parasite and elephantiasis in different island groups of the South Pacific are presented. Knowledge on recognized vector species is summarized. Vector control possibilities are discussed and experience with DEC treatment is reviewed.

- (89) March, H.N., Reduction in the prevalence of clinical
Laigret, J., filariasis in Tahiti following adoption of
Kessel, J.F. & a control programme
Bambridge, B. Amer. J. trop. Med. Hyg., 9, 180-184
1960

In 1954, 15 districts and seven areas were consolidated into the island control programme. This programme consisted of mass treatment with DEC (initial course of 12 monthly doses of 6 mg/kg each, with additional treatment to the few with recurrent positive blood films) and mosquito control by elimination of breeding places within 100 m from each dwelling.

It was considered that data to be collected by physical examination for the male population for clinical signs and symptoms of filariasis and blood surveys 10 years after the first surveys of 1949, and five years after the inception of the island-wide filariasis control programme would provide data for comparing prevalence rates in the same districts and areas before and after control. Thus clinical and blood surveys were organized in seven small areas and the results of surveys made before and five years after the commencement of the standardized treatment combined with mosquito control are compared.

Both surveys made on a cross-section of the male population covering clinical manifestations of filariasis. The surveys for both microfilaraemia and elephantiasis covered the total male population of 15 districts, 3390 in 1949 and 1959 for microfilaraemia and 7360 for elephantiasis.

The most important findings are: (a) Overall microfilaraemia was reduced from 37.9% to 6.5%. (b) Elephantiasis dropped from 6.9% to 2.2% for all males and in the significant labouring age group of 20 to 40 years it fell from 5% to 0.6%. (c) Total hydroceles were reduced from 9.8% to 3.2%. (d) Acute filarial lymphangitis attacks fell from 36.0% to 4.0% among males surveyed above the age of 20 years. (e) No new cases of elephantiasis or hydrocele developed following application of control

measures. (f) Thus a marked decrease in total disability among persons suffering from filariasis was apparent in 1959. (g) Mass treatment was well accepted by the population.

It can therefore be concluded that a combined programme of mosquito control and mass chemotherapy with DEC not only greatly lowers the prevalence of microfilaraemia but also is followed by marked reductions of the clinical signs of filariasis.

- (90) Symes, C.B.
1960 Observations on the epidemiology of filariasis
 in Fiji
 J. trop. Med. Hyg., 63, 3-67

The author presented the results of investigations carried out in Fiji during 1954-1956.

1. Field studies

1.1 Mosquito fauna

The results showed that C. quinquefasciatus and C. annulirostris were the commonest mosquitos in houses, followed by Ae. fijiensis.

Ae. pseudoscutellaris and Ae. polynesiensis were found to be predominantly bush mosquitos. Ae. pseudoscutellaris occurred in both coastal and inland areas while Ae. polynesiensis was confined to the coastal parts where it occurred in greater numbers than Ae. pseudoscutellaris. Other species of mosquito were rarely active during daylight, but resting specimens could be found by long searching. Some species, notably Ae. fijiensis and C. quinquefasciatus, became active in the open at early dusk, and among the specimens thus caught were several individuals infected with microfilariae.

An analysis of some routine bush catches indicated that there was no obvious concentration of the adults of Ae. pseudoscutellaris and Ae. polynesiensis in the vicinity of human habitation; local density therefore is probably a reflection of the amount of breeding which proceeds in the area.

1.2 Breeding habits

Ae. pseudoscutellaris was found breeding mostly in tree holes, coconut shells and husks.

Ae. polynesiensis has similar breeding habits but with decided preference to crab holes.

Ae. fijiensis was obtained from axils of the large pandanus (P. tectorius and P. joskei). The smaller pandanus, P. thurstonii whose leaves are utilized for making mats, was used by the mosquito to a much less extent. This species was also found to breed in the axils of taro (Colocasia antiquorum) and in those of the wild taro (Alocasia indica). It is possible that if the large pandanus palms were removed as a control measure in Fiji, Ae. fijiensis would make greater use of the taros and the small pandanus for breeding, as it does in Samoa.

1.3 <u>Life cycle</u>	<u>Eggs hatching period</u>	<u>Duration of larval stage</u>	<u>Duration of pupal stage</u>
<u>Ae. pseudoscutellaris</u>	2-6 days (average 3.2)	5-24 days (average 10)	2 days
<u>Ae. polynesiensis</u>	2-6 days	6-23 days (average 11)	2 days
<u>C. quinquefasciatus</u>	1-2 days	8-24 days (average 14)	2 days

1.4 Host preference

Bloodmeal smears of mosquitos collected from different areas were sent to Lister Institute, London, for precipitin testing. The results were given as follows:

Percentage of positives for human blood

<u>Ae. polynesiensis</u> and <u>Ae. pseudoscutellaris</u> (combined)	42%
<u>Ae. fijiensis</u>	80%
<u>Ae. vexans</u>	89%
<u>C. quinquefasciatus</u>	70%
<u>C. annulirostris</u>	86%

1.5 Animal filarial infections and the possibility of infecting mosquitos

Bird filaria: Filariae were found in the blood of one out of 13 Malayan doves (Streptopelia chinensis) and of 18 out of 112 mynah birds, in which the parasite was Diplostriaena noctti. It is perhaps improbable that mosquitos feed extensively on these birds, and much more probable that their microfilariae undergo development in an ecto-parasite or an inhabitant of the nest such as a mite. No microfilariae were found in the blood of four hawks and 21 pigeons examined, or in that of two collared lorys, four swamp hens, seven magpies, and 14 domestic fowls.

Bats: The blood of 167 cave bats were all negative for microfilariae but 38 of 111 fruit bats (Pteropus hawaiiensis) were parasitised, mostly with Microfilaria fijiensis and a few with Chiropterofilaria brevicaudata (both new species). The author's views were that from the nature of the habits of fruit bats that it is unlikely that developing forms of these fruit bat filariae occur frequently in mosquitos captured in and around villages, although certain species of mosquito may feed on fruit bats while they are resting on trees. It seems unlikely that such fed specimens would be found in village houses and adjoining bush.

The common filaria (Mf. fijiensis) of the fruit bat has developed to maturity in the laboratory in Ae. pseudoscutellaris, Ae. polynesiensis, and Ae. fijiensis, but infection rates have been relatively low.

Dogs: Of 86 dogs examined, microfilariae of Dirofilaria immitis were found in 64. Developing forms of D. immitis have been found in Ae. pseudoscutellaris, Ae. fijiensis, C. quinquefasciatus, C. annulirostris, Ae. aegypti and Ae. vexans, but rates are very low compared with those of W. bancrofti in the first three species named.

Cattle: Of 106 cattle examined, the blood of three showed microfilariae of Setaria species.

Other mammals: The blood was examined of 15 horses, 44 domestic pigs, 12 cats, seven goats, 21 rats (Rattus rattus) and three mongooses. No microfilariae were found in any of these specimens.

Differentiation of developing larvae: The larvae of the human, dog, and bat filariae differ in several ways. Developing larvae of W. bancrofti and the fruit bat filaria are usually found in the thorax of the mosquito, while those of D. immitis are found in the malpighian tubes. Some early third stage larvae of W. bancrofti and the fruit bat filaria may be found in the head and abdominal cavity; third stage, mature or nearly mature D. immitis larvae only are found in the head and thorax.

The mature and nearly third stage larvae of the species bred in the laboratory differed in length. That of W. bancrofti ranged from 1.2 to 1.9 mm, an average of about 1.6 mm. D. immitis larvae varied from 0.84 to 1.27 mm with an average of 1 mm and those of the fruit bat filaria were from 0.52 to 0.85 mm in length with an average of 0.7 mm.

The third stage or mature larva of W. bancrofti has three or four papillae on the tail, and the distance from the tip of the tail to the anus at this part is about three times the width. Third stage and mature larva of D. immitis has only one centrally placed papilla on the tail and the distance from tail to anus is usually less than twice the width at this part. Third stage larvae of the fruit bat filaria apparently have four tail papillae, two of which are more prominent than the others.

1.6 Infection of mosquitos caught at different distances from villages

	Distance from villages	No. mosquitos dissected	% positive with larvae	
			Stages I and II	Stage III
<u>Ae. polynesiensis</u>)	23-46 m	244)		
<u>Ae. pseudoscutellaris</u>)		30)	2.9	0.36
<u>Ae. polynesiensis</u>)	364 m	178)		
<u>Ae. pseudoscutellaris</u>)		60)	7.1	2.52

2. Laboratory studies and human infections

2.1 Mosquito experimental infection

Infection rates - The author gave an account of the results of the experimental infection for each species tested with a detailed tabulation of data. In summary, dead and disintegrating microfilariae and first stage larvae were commonly found from the first day after feeding in Ae. vexans, Ae. aegypti, C. sitiens and C. annulirostris. The destruction of these stages was observed over a long period, up to 15-17 days in the above-mentioned species. C. quinquefasciatus showed an infection rate of 3rd stage larvae of 45% and the mean number of larvae was 2.9 per infective mosquito and 1.3 per dissected mosquito. It was not common to find dead filariae in dissected mosquitos and delayed first stage larvae were seen alive on the 13th day after the infective feed. Ae. fijiensis, Ae. polynesiensis and Ae. pseudoscutellaris showed infection rate of 3rd stage larvae of 76, 82 and 81% respectively with a mean larval density of the 3rd stage per infected and dissected mosquitos in the three above-mentioned species respectively as follows: 9.9/7.5, 15.4/12.5 and 10.7/8.7. These results indicated that the three species were highly susceptible to the infection.

The relationship between microfilaria rate in donors and density of infection in Ae. pseudoscutellaris is as follows:

Blood counts 20 mm ³	No. of mosquitos dissected on and after day on which the first 3rd or mature stage was seen	% of mosquitos with 3rd and/or mature stage	Average no. of 3rd and/or mature stage larvae per infected mosquito
*0.04 to 1	544	7.04	2.3
2 to 24	198	43	4.4
26 to 50	223	78	7.7
55 to 92	128	84	10.5
150 to 681	59	79	12.7

The relationship between microfilaria rate in donors and density of infection in Ae. fijiensis is as follows:

Blood counts 20 mm ³	No. of mosquitos dissected on and after day on which the first 3rd or mature stage was seen	% of mosquitos with 3rd and/or mature stage	Average no. of 3rd and/or mature stage larvae per infected mosquito
* 0.3/8	81	38	2.9
28/50	73	61	4.6
85/143	94	86	11.4
169/681	54	42	12.2

The relationship between microfilaria rate in donors and density of infection in C. quinquefasciatus is as follows:

Blood counts 20 cmm	No. of mosquitos dissected on and after day on which the first 3rd or mature stage was seen	% of mosquitos with 3rd and/or mature stage	Average no. of 3rd and/or mature stage larvae per infected mosquito
* 0.5/25	390	23	1.2
26/50	75	37	2.1
51/100	91	42	2.5
101/169	64	73	3.5

*These low blood counts are the estimated equivalent in 20 mm³ of the numbers of microfilariae actually found in 1 ml of blood from donors.

Microfilaria density and mosquito infection - Though in detail the correlation between blood and mosquito infections was not closely consistent, the grouping of results appears to indicate, as one might expect, a general direct relationship between numbers of microfilariae in blood, and the rates and intensities of infection in mosquitos fed upon such blood. But perhaps this relationship ceases beyond the level of about 200 microfilariae per 20 mm³ when heavy infections may interfere with survival of both the mosquitos and their developing worms.

The infective density of microfilariae - Ae. pseudoscutellaris, Ae. fijiensis and C. quinquefasciatus became infective after feeding on blood counts of from 0.04 to 681, 0.3 to 681 and 0.5 to 169 per 20 mm³ respectively. These mosquitos may thus become infective after feeding on blood with microfilariae so low in numbers that they may not be seen in a 20 mm³ blood sample. In feeding experiments recorded later first stage

developing forms were found in one of 49 and two of 112 specimens of Ae. pseudoscutellaris fed upon a man whose microfilaria count in 1.0 ml of blood had been reduced by diethylcarbamazine from 4050 to nil. It seems that Ae. pseudoscutellaris at least may become infected after feeding upon people whose microfilariae are too few to be detected by ordinary survey techniques.

The author, therefore, emphasized that the data do suggest that, where control measures are being attempted it may not be wise to assume an absence or cessation of infection when blood counts based upon 20 mm³ or even upon 1.0 ml samples, are negative.

Developmental period of W. bancrofti in mosquitos - Cooler weather appeared to have influenced the length of the development period. From January to March with mean maximum and mean minimum temperatures of 30.4°C and 23.9°C respectively, and mean maximum and mean minimum humidities of 93.5 and 66.5% respectively, the average period of development to third stage in Ae. pseudoscutellaris was 12.8 days. In July to September with mean maximum and mean minimum temperatures of 26°C and 20.3°C and humidities of 91.6 and 60.3%, development to third stage took 14.7 days. In the same periods with approximately similar differences in temperatures and humidities the periods of development to third stage were 13 days and 16 days in Ae. fijiensis and 15 and 19 days in C. quinquefasciatus.

Infection and survival of mosquitos - The author referred to previous workers who reported high mortality in mosquitos fed on blood with high microfilaremia, probably due to heavy load of development in filarial larvae. He cited Manson-Bahr, 1912 (1) who concluded that the critical period for the heavily infected mosquitos was after fully mature larvae had entered the head or proboscis and that Rosen, 1955(56) made the same conclusion. The author gave his findings of feeding experiments with blood mf counts of 110 to 681 per 20 mm³ which are summarized as follows:

<u>293 mosquitos that did not die</u>		<u>126 mosquitos that died</u>	
<u>% infected</u>	<u>Mean density/ mosquito</u>	<u>% infected</u>	<u>Mean density mosquito</u>
7.5% with mf	27	62.7% with mf	57*
22% with 1st stage larvae	22	8.7% with 1st stage larvae	17
19% with 2nd stage larvae	17	7.9% with 2nd stage larvae	13.5
42.3% with 3rd stage larvae	15	13.5% with 3rd stage larvae	23

* died in the 24 hours before dissection

From these results, the author indicated that it would seem that the heavy loads of microfilariae (average 57) may well influence the death rate (62.7%). /NB: The author did not name the species involved in these experiments, possibly it was Ae. pseudoscutellaris /.

Intake and loss of microfilariae - In order to determine the intake and loss of microfilariae, the author made counts of the microfilariae in the stomach and thorax of Ae. pseudoscutellaris immediately after feeding upon an infected donor and 12-24 hours after feeding. In two sets of counts batches of 27 and 40 Ae. pseudoscutellaris fed on blood with 105 to 168 microfilariae per 20 mm³, the numbers of microfilariae found in stomach and thorax averaged 50 and 28 in the first hour after feeding, and 23.4 and 14.3 respectively some 13 to 24 hours later. These results indicated that when Ae. pseudoscutellaris feeds on blood containing relatively large numbers of microfilariae it takes in many more microfilariae than would be expected and about half of these are lost in the first 24 hours after feeding.

What appears to be the high intake of microfilariae possibly results from excretion of serum as well as blood cells and microfilariae during the feed; and the rapid loss during the first day may well result from the passing of whole blood with microfilariae during some hours after the feed. Excretion of serum by Ae. pseudoscutellaris during feeding is commonly seen.

Developmental stages in the legs of mosquitos - Some dissections were made on the legs of Ae. pseudoscutellaris which showed the presence of microfilariae as well as the three larval stages. No mosquitos were infected in the legs only. Leg examination was found difficult and it was concluded that it has no great significance on the infectivity rate.

2.2 Infections in the human population

Blood sampling was carried out by Knott's technique using 1 ml blood with some modifications introduced. The technique was compared with the conventional 20 mm³ of blood from finger prick. In 4 men, the 20 mm³ were negative while the corresponding sample of 1 ml were positive. In 27 men, counts of 20 mm³ samples of blood taken from three fingers of the same hand gave an infection rate about 16% lower than that of 1 ml taken from the arm. Counts of microfilariae in 20 mm³ blood from the middle fingers of the right and left hands of 165 persons and about 6% of the right and 2% of the left were negative, but none of the negatives coincided.

The author considered that the 20 mm³ blood sampling technique was inadequate. The 1 ml sampling technique was considered as appreciably better but not sufficiently good. A trial with the filtration technique was therefore recommended. In field surveys, the 1 ml sample usually proportionately gave fewer microfilariae than the 20 mm³ except in the low counts and it gave from 5 to 16% more positives in the low counts than in the 20 mm³ samples.

The results of the surveys showed that the mf rate in the Fijian population sampled was in the region of 30% and that the prevalence of clinical filariasis only was about 5%.

Incidence and intensity of infection by age groups followed roughly the usual pattern, low levels in the early age groups increasing to high levels in 30 years and over. About 4% of the 0-4 age group had microfilariae in the blood, the youngest being between one and two years.

Observations on the numbers of microfilariae in blood over 24 hours confirmed the frequent fluctuations in numbers, and suggested a tendency to a peak in numbers in the afternoon or evening. In order to obtain a rough idea on the effect of exposure to bush conditions where Ae. polynesiensis and Ae. pseudoscutellaris were responsible for transmission of infection, blood samples were examined from some groups of the human population carrying out different activities. In 368 men working in the bush or plantation 44.8% were found to be positive while of 86 men from the same villages who did not spend much time in the "bush" 42% were infected. The degree of infection in 117 men of the first category in Vitilevu, as indicated by the average number of microfilariae in 1.0 ml, was 243 while for 59 men in the second category it was 105.7. This latter difference may have some significance.

2.3 The effect of DEC on infection of mosquitos

In the course of DEC trials observations were made on mosquitos fed on treated persons with low microfilaria densities. The results showed that DEC had no adverse effect on mosquito survival. During the dissection and examination of infected mosquitos, no abnormalities were observed in the condition of the developing larvae, and it has already been stated that DEC did not have any effect on the developmental period.

3. Vector and crab control

3.1 Control of Ae. polynesiensis and Ae. pseudoscutellaris

Elimination of breeding grounds within a radius of 364 to 455 m of villages and settlements would narrow contact between mosquitos and the majority of people very considerably but it would not sever it completely because of the activities of numbers of people engaged in the bush or in gardens and plantations beyond that distance, and in still more distant tree-felling.

3.2 Experiments in the control of crabs

It would seem that in the first series the two dieldrin treatments (120 ml of 2 1/2%, and 120 ml of 1 1/4% dieldrin in diesoline or fuel oil per hole) were satisfactory while the DDT (120 ml of 5% in fuel oil per hole) and diesel oil only, were not. In the second series 120 ml of 0.6% pentachlorophenol appeared to be promising while derris powder (56 g) and derris in oil (120 ml) were not.

- (91) Annual Report of the Government of American Samoa to the
Secretary of the Interior
1961

On pp. 43-45, it was given the mosquito control progress report, November 1958 to May 1961 in the Western District on Tutuila.

Prior to the sanitary inspection programme for eliminating breeding sites, a mosquito survey was made of the district in the period November 1958 - May 1959. Mosquito collections were taken on humans. A 10-minute sampling period was used at each station. All stations were sampled between 0600-0900 hours, the period of optimum morning activity of Ae. polynesiensis. The mosquito density (average rate of capture per minute) was calculated to be 0.325 for the 439 stations surveyed in early 1959. A resurvey made in late 1959 showed a density of 0.1175, a reduction of 46.2%. As the sanitation programme had only been in operation for a few months, it is quite possible that seasonal variation had an effect on this initial reduction. However, a third survey undertaken in November 1960 to May 1961, under similar weather conditions to those of early 1959, revealed a new density of 0.151. This is a 53.5% reduction from the results of the original survey.

- (92) Belkin, J.N.
1961
- Nonperiodic bancroftian filariasis in the South Pacific: its vectors and a hypothesis as to its origin
Abstract Symp. Pap. 10th Pacif. Sci. Congress, Honolulu, pp. 426-427
(Reabstracted with slight modifications)

Nonperiodic bancroftian filariasis is definitely known only from New Caledonia, the Fiji-Tonga-Samoa area and Eastern Polynesia. Manson-Bahr, 1912 (1) demonstrated that on Fiji the predominantly diurnal Ae. (Stegomyia) polynesiensis (as Stegomyia pseudoscutellaris) was an efficient vector and that the nocturnal C. quinquefasciatus (= fatigans) was not. Subsequent studies have shown that Ae. polynesiensis is the major vector throughout its wide range, particularly in Eastern Polynesia. It is now evident, however, that other members of the Ae. scutellaris complex are also good vectors in parts of the Fiji-Tonga-Samoa area. This is probably the Ae. futunae and Ae. cooki, which are the only known or dominant representatives of this complex on some islands with nonperiodic filariasis. True Ae. pseudoscutellaris on Fiji and possibly other described or unrecognized species of the complex may also be vectors within the range occupied by Ae. polynesiensis.

Recent studies by Symes, 1960 (89) and Burnett, 1960 (85) strongly incriminate the predominantly nocturnal Ae. (Finlaya) fijiensis as a vector of nonperiodic filariasis in some situations on Fiji and there is a possibility that some of the other nocturnal species of the kochi group of Ae. (Finlaya) may be vectors, particularly Ae. samoanus or Ae. oceanicus, which have been confused in past epidemiological surveys in Samoa. It seems probable that on New Caledonia the principal vector of nonperiodic filariasis is Ae. (Ochlerotatus) vigilax, a species that bites at all times of the day and night as was reported by several workers.

In view of these recent findings, the simple explanation offered by Buxton, 1928 (7) of the origin of nonperiodic filariasis from the periodic as an adaption to day-feeding mosquitos when infected human populations entered an area without suitable nocturnal vector mosquitos is no longer tenable. The present fragmentary knowledge of the vectors of nonperiodic filariasis is more in line with the hypothesis that this type is the primitive generalized one and that it is relict in the South Pacific. In this area of small land masses and relatively small and fluctuating populations of localized species of mosquitos, the development of nocturnal periodicity and association with one vector species would be of negative adaptive value and therefore the periodic type did not evolve. It seems probable that the nonperiodic type was present among Melanesians long before the entry of Polynesians into the area and that the latter merely acquired and spread these filariae. Even if Polynesians had brought their own filaria it would have had little chance of surviving in competition with one already adjusted to local vectors; it may have died out or may have been absorbed. As the environment was modified by human populations and as different species of mosquitos became associated with "native" populations there was probably a succession of dominant vectors some of which were widely dispersed (notably Ae. polynesiensis) while quinquefasciatus is becoming a vector of nonperiodic filariasis in some urban situations on Fiji, Symes (loc. cit); Burnett (loc. cit).

- (93) Burnett, G.F. &
 Ash, L.H.
 1961 The susceptibility to insecticides of
 disease-carrying mosquitos in Fiji
 Bull. Wld Hlth Org., 24, 547-555

Larval tests

The susceptibility tests presented in this paper were carried out before the WHO instructions were published in 1958. Therefore, the authors adopted the method described by Wharton (1955)¹ for larval testing.

Dosage-mortality regression lines were fitted by eye from which the LC 50 and LC 90 were estimated as shown in the table.

It appears that C. quinquefasciatus and Ae. aegypti are susceptible to DDT, dieldrin and HCH compared with the results obtained elsewhere, although DDT LC 90 for the latter species seems to be higher than that recorded for normally susceptible species. Ae. pseudoscutellaris which is difficult to separate from Ae. polynesiensis showed a different response to DDT, but both species showed complete susceptibility to dieldrin and HCH. While Ae. polynesiensis seems to be quite susceptible to DDT, Ae. pseudoscutellaris showed a much higher LC 90 for DDT with a flatter regression line than that of Ae. polynesiensis. The author provided some evidence on the presence of resistance in this species from laboratory selections and testing some other field populations as will be shown later. Ae. fijiensis showed marked tolerance to DDT as indicated from the values of LC 50 and LC 90 and from the extreme shift of the regression line to the right.

¹Wharton, R.H. (1955). The susceptibility of various species of mosquitos to DDT, dieldrin and BHC. Bull. ent. Res. 46, 301-309

Laboratory selection with increasing concentrations was made on a colony of Ae. pseudoscutellaris which originated from two areas around Suva and maintained in the Filariasis Research Unit since 1955. When the first generation was tested with 1 ppm DDT, only 90% mortality was obtained while this level of mortality was recorded in the above field population with 0.028 ppm concentration. A strain of this species collected from a forest in a mountainous area near Suva showed nearly the same response as that observed with the field population tested for which data are given in Table 1, but was considered by the authors as apparently being the true susceptible population.

Table 1. Dosage-mortality data for larvae of five species of Fijian vector mosquitos, expressed in parts per million of insecticide suspended in water*

Species	p-p' DDT		Dieldrin		gamma-BHC	
	LC 50	LC 90	LC50	LC90	LC50	LC 90
<u>Ae. pseudoscutellaris</u>	0.006	0.028	0.006	0.011	0.020	0.046
<u>Ae. polynesiensis</u>	0.005	0.012	0.006	0.012	0.009	0.020
<u>Ae. fijiensis</u>	0.36	0.65	0.005	0.018	0.007	0.029
<u>Ae. aegypti</u>	0.012	0.036	0.008	0.010	0.010	0.026
<u>C. quinquefasciatus</u>	0.012	0.027	0.004	0.008	0.008	0.024

*Experiments conducted from January to April 1957 and from December 1957 to June 1958

Adult tests

Adult testing was carried out by Busvine & Nash method as per the report of the Expert Committee on Malaria (1954)¹. While the results of adult testing confirmed the results of larval tests for certain species, there were some discrepancies for the others. Ae. polynesiensis appeared to be quite susceptible to DDT as was the case in larval tests.

Ae. aegypti showed a somewhat elevated level of LC 50 and the extrapolated LC 90 with DDT, while it was nearly susceptible in larval tests.

The most conspicuous discrepancy occurred in the results of C. quinquefasciatus, Ae. fijiensis and Ae. pseudoscutellaris. From adult testing, the first species was highly resistant to DDT and dieldrin while larval tests indicated its susceptibility to both insecticides. While the second species in larval tests showed marked tolerance to DDT, the adult tests

¹World Health Organization (1954) Expert Committee on Malaria.
Wld Hlth Org. Techn. Rep. Ser. 80, 30

indicated extreme susceptibility to it. The response of the third species is indistinguishable from that of Ae. polynesiensis in adult tests while in larval tests the latter species was more susceptible. From the colony of Ae. pseudoscutellaris selected for DDT resistance, the authors exposed a batch of 174 females drawn from the 18th generation larvae which were exposed to DDT at 2 ppm. An LC 50 of 1.75 was obtained and the mortality on 3.2% DDT in adult testing was 67%.

/N.B. On several occasions the discrepancy between results of larval and adult testing have been noted and there is some evidence that in larval tests there are many factors that can produce considerable variation in the results. /

(94) Iyengar, M.O.T.
1961

Some aspects of filariasis in the
South Pacific
WHO unpublished document, WHO/FIL/34

This describes the demarcation line between the area of the subperiodic W. bancrofti strain and that of the periodic strain of the species. It further provides information on the prevalence of filariasis and its clinical manifestations in the four subregions of the South Pacific. All the information given in this paper has been detailed in the paper by the same author, 1965 (108).

(95) Kessel, J.F.
1961

The ecology of filariasis
In: Studies on Disease Ecology. J.M. May, 1961. Hafner Publishing Co., Inc., New York, pp. 45-71 and 515-522

The paper is a general review covering five filarial infections of man and a brief reference to dirofilariasis. The five human infections reviewed are: W. bancrofti with its periodic and subperiodic forms, Brugia malayi, Loa loa, Mansonella ozzardi, Dipetalonema streptocerca and Dipetalonema perstans. The geographical distribution of these infections is presented on a map and in tables giving the recognized vectors for each in the different geographical areas. Brief notes are given on each disease, the existence of reservoirs where applicable to certain infections, vector breeding and resting places and biting habits in relation to parasite periodicity.

Factors determining the degree of transmission involving host-parasite-vector relationship are enumerated. A short description is given on clinical surveys, blood sampling methods, vector surveys and methods of presentation of data. Discussion of the socioeconomic factors is included. The possibility of control or eradication of filariasis and the feasibility of vector control and drug administration singly or combined are discussed.

(96) Symes, C.B.
1961

A note on vectors of filariasis in
the South Pacific
WHO unpublished document, WHO/FIL/29

The author presented lists of mosquito species as recorded in different islands or island groups. A note was given on the introduction of Ae. vigilax into Fiji and its spread as was reported by Burnett, 1960 (84).

The author questioned whether this species could invade other adjacent islands in the South Pacific area, and also whether its low infective potential in Fiji would change after longer contact with the subperiodic strain of W. bancrofti.

Further, a list was provided giving the records of natural infections reported in different vectors in the South Pacific. The author suggested that studies be undertaken to elucidate the role of all possible vectors, particularly C. quinquefasciatus, C. annulirostris (in as many islands as possible), Ae. samoanus (in Samoa) and Ae. tongae (in Tonga and Niue). Records of experimental infections in different species were also listed and the author suggested that more experiments should be carried out with mosquitos from different areas, in all seasons and with a variety of donors having different levels of microfilaraemia.

The author gave additional results of precipitin testing for some species. In Fiji, precipitin tests on 404 specimens of Ae. polynesiensis and Ae. pseudoscutellaris gave 146 positive for human blood, none for dog and fowl, one for horse, 10 for pig or sheep or goat or cat or other mammals, and 247 negative to all common mammals. Food sources for the large populations of this species on many small islands normally unoccupied by man, with fauna apparently limited to lizards, rats and a few visiting birds, have yet to be determined.

Of 56 Ae. fijiensis caught in houses and submitted to precipitin tests, all but one had human blood, six had dog and four had fowl blood.

(97) Belkin, J.N.
1962

Mosquitos of the South Pacific
Vols. I and II (608 pp. and 412 pp.)
University of California Press,
Berkeley & Los Angeles,

This is a very important reference book by which the author provided interested workers with a comprehensive review of systematics and distribution of mosquito species of the South Pacific classified under their genera and subgenera. Vol. I is devoted to systematics with keys to genera, subgenera and species with lists of synonyms. The characteristics of the different stages are summarized for each genera and subgenera. A nomenclatural review and detailed description of the adult female and male, male genitalia, pupa and larva are given. A discussion on the systematics, distribution, bionomics and disease relations is also given for each species.

In the introductory part, a general description of different areas of the South Pacific and their mosquito fauna is provided. A general review of bionomics and dispersal as well as relation to disease and economic importance is made. A special section is devoted to techniques related to the collection, preservation and rearing of mosquitos.

Volume II is devoted to distribution lists, maps and illustrations. It is useful to quote the author's views on the Ae. scutellaris group as in the following.

There has been considerable discussion regarding the taxonomic status of the nominal forms in the group. The majority of the workers have regarded these forms as distinct species chiefly because of the clearcut, non-overlapping differences in the male genitalia. Some doubt has been cast on this interpretation by several workers, notably Rozeboom and his students and Woodhill and co-workers on the basis of laboratory hybridization experiments which have shown interfertility, at least in some crosses.

According to these investigators, a complete reproductive barrier is the absolute criterion of a species and, since under laboratory conditions there is partial fertility between some of the forms, these cannot be species. However, it has not been demonstrated that any of the forms crossed experimentally interbreed in nature. Even polynesiensis and pseudoscutellaris, which according to Rozeboom & Gilford (1954)¹ produce an intermediate hybrid progeny in the laboratory without a reduction in fertility, apparently do not interbreed on Fiji, where they occur sympatrically. The author considered that all the forms treated here are distinct species. The fact that the reproductive barrier is not complete and breaks down under certain conditions is, as the author believes, of primary importance in the evolution of the group. Apparently, many of the species have been developed from small populations isolated on individual islands or island groups. Under these circumstances, genetic reproductive barriers with related stocks are not necessarily developed. When two such stocks come together after considerable lapse of time and considerable morphological and physiological divergence, there is a possibility of the establishment of a stabilized hybrid species.

In the past very little attention has been given to the immature stages in this group, and most forms have been described on the basis of differences in ornamentation of females and striking differences in the male genitalia. The author found that larval characters are at least as good as those of the male genitalia for diagnostic purposes and give promise of being of paramount value in establishing a natural classification of the group.

¹Rozeboom, L.E. & Gilford, B. (1954) The genetic relationships of Ae. pseudoscutellaris (Theobald) and Ae. polynesiensis Marks (Diptera, Culicidae). Amer. J. Hyg., 60, 117-134

(98) Brown, A.W.A.
1962

Insecticidal control of filariasis
Bull. Wld Hlth Org., 27, 632-636

The paper reviews the experiences accumulated during 1953-1959 on the control of major vectors in the endemic areas of human filariasis mainly C. quinquefasciatus, Mansonia spp. and some Anopheles spp. in different parts of the world as well as a brief reference to control attempts made in the Pacific area against Ae. polynesiensis and Ae. pseudoscutellaris. A summary of imagocidal and larvicing applications adopted is provided together with information on resistance status in different vectors cited.

Treatment of water pots and holes at the bases of trees with dieldrin pellets gave excellent control against Ae. pseudoscutellaris in Fiji, Burnett, 1960 (85) and Ae. polynesiensis. In the Tokelau Islands piles of coconut shells may be sprayed with dieldrin suspension, while the incidence of fallen and opened coconuts may be minimized by a programme of rat control, Bonnet & Chapman, 1958 (70), crab holes may be eliminated by plugging and baiting the crabs with rice bran containing HCH or aldrin. Although Ae. pseudoscutellaris can develop DDT resistance (Burnett, loc. cit.) no dieldrin resistance has yet appeared in these Aedes vectors.

(99) Kessel, J.F. & Massal, E.
1962

Control of bancroftian filariasis in
the Pacific
Bull. Wld Hlth Org., 27, 543-554

Following the discovery of diethylcarbamazine, filariasis control projects were organized in many parts of the world and notably in a number of islands in the Pacific. Thus a questionnaire was prepared to collect information on the status of filariasis control programmes and sent to the areas in the Pacific where surveys or studies had been known to have been under way.

Twelve replies were received, but not all the questions were answered nor were the accompanying tables completed. However, sufficient information was gathered either from the replies or from published reports. Adding their experience in the filariasis control programme of French Polynesia, it was possible for the authors to prepare a review.

The authors made the following conclusions:

Elephantiasis and microfilaraemia

For the areas of the Pacific reviewed in this paper, it is observed that elephantiasis is for the most part light in Micronesia, heavy in parts of Melanesia such as Netherlands and Australian New Guinea and New Hebrides, and intermediate in Polynesia now that its prevalence in French Polynesia has been greatly reduced by the institution of control programmes in the Society Islands and in the Marquesas.

Microfilaraemia rates prior to control campaigns were likewise highest in Melanesia and French Polynesia, where elephantiasis showed correspondingly high rates. In other parts of Polynesia and in Micronesia, where control programmes have not been instituted, microfilaraemia rates for the most part range from 15% to 20%. There is a lack of correlation between microfilaraemia rates and elephantiasis in these areas, as reported by Iyengar (1959)¹, and by Pipkin (1953)² who points out that in Micronesia the mosquito vectors are poorly adapted and states they "may suffice to keep the infection going, but are seldom able to produce sufficiently heavy infection to commonly produce obvious clinical involvement".

As indicated by Kessel, 1957 (68), a more exact correlation seems to occur between density of microfilariae and elephantiasis, and it is urged that in the future records be kept for further evaluation of this subject.

Mosquito vectors

The mosquitos that transmit bancroftian filariasis in the northwest Pacific, including Micronesia, Polynesia and Melanesia, have been listed and their general distribution shown. Their relationships to human populations and the parasite Wuchereria has been discussed by Belkin, 1961 (92) and 1962 (97).

Effective control programme

Answers to questionnaires from directors of filariasis control projects in the Pacific show that the majority are convinced that the most rapid and efficient control programme consists of combined measures of diethylcarbamazine administration and mosquito control. The details of the procedures to be adopted in each area inevitably depend, for mosquito control, on the bionomics of the mosquitos involved; and, for working out the most convenient schedule for thorough administration of DEC, on the customs and habits of the people.

Recurrent infections reported in this study indicate that DEC is not the perfect drug for eradication of filariasis when given in a single dose for mass treatment. However, until such an ideal drug is found, the advantages accruing from its thorough administration, such as that recommended in the programme in Tahiti against continuous, subperiodic filariasis, appear to outweigh the disadvantages and to warrant its continued use.

¹Iyengar, M.O.T. (1959) A brief review of the epidemiology of filariasis in the South Pacific. In: Proc. 6th Intern. Congresses on trop. Med. Malar., Lisbon, 1958, Lisbon Institute Med. Trop., vol. 2, p 339-

²Pipkin, A.C. (1953) Wuchereria bancrofti in Micronesia (unpublished paper presented at the 8th Pacific Science Congress, Quezon City, Philippines, November 1953)

In some areas, mosquito control seems impracticable under present conditions and control by drug administration alone is recommended. Eleven of the 12 replies stated that mosquito control alone was inadequate for effective filariasis control. The twelfth reserved judgement.

Significant rates from selected indices in a control programme

The authors indicated that it is difficult to determine the exact point at which transmission may be so low that significant clinical manifestations of filariasis cease to occur. The authors cited the arbitrary criteria set for the filariasis control programme of Tahiti based on six indices:

Microfilaraemia rate	5.0%
Density of microfilariae/20 mm ³ of blood (in population as a whole)	1.0
Percentage of mosquitos positive for "all-stage" larvae	5.0%
Percentage of mosquitos positive for mature larvae	1.0%
Density of "all-stage" larvae in mosquitos	0.1
Prevalence of mosquitos (i.e., average number caught per minute on a human bait who sits in the shade for 10 minutes within 10 m of each dwelling)	0.1

The authors further emphasized that it may not be necessary to achieve the cessation of the significant clinical filariasis. The above rates should be regarded as safety limits; if maintained, clinical filariasis should not constitute a public health problem.

Control versus eradication

The encouraging results reported by the directors of filariasis control programmes in the Pacific are gratifying and raise the question whether control programmes should be extended into eradication programmes.

As it is possible that island populations such as are found in the Pacific present more ideal conditions for epidemiological study and institution of effective control programmes than large land areas with concentrated populations, it will be necessary to evaluate each area on its own merits before deciding to convert a control programme into an eradication programme.

Since the above was written, the authors have had the opportunity of hearing the papers on filariasis presented at the Tenth Pacific Science Congress and of discussing with each participant the related problems of control and eradication. In their opinion, the time appears to have come to recommend that in any area where a control programme has reduced the microfilaraemia rate to 5% or less, the launching of an eradication programme should be considered. In the Pacific, the following areas at least would appear to qualify: Taiwan, Niue and Atiue, and the Iles-sous-le-Vent (the Leeward group of the Society Islands) on some of which a microfilaraemia rate of less than 1% has been attained.

(100) World Health Organization
1962

Expert Committee on Filariasis
(Wuchereria and Brugia infections)
Techn. Rep. Ser. 233

The Expert Committee on Filariasis met in Geneva from 25 July to 1 August 1961.

The topics discussed in this meeting were as follows:

1. Epidemiology

1.1 Changes in nomenclature and terminology

Wuchereria and Brugia were separated into two genera. The former contained one species, W. bancrofti, and the latter included three species, B. malayi, B. pahangi and B. patei. The terms of microfilaria periodicity were defined.

1.2 Review of recent advances in epidemiological knowledge

1.2.1 Animal reservoir and experimental infection

1.2.2 Human reaction to infections by animal parasites

1.2.3 Differential diagnosis of developing forms in vectors

1.2.4 Variations shown by local strains of vectors and parasites

1.2.5 Ecology of different vectors

1.2.6 Filariasis and C. quinquefasciatus problems in current programmes of urbanization in areas of endemicity

1.2.7 Dynamics of natural transmission

1.2.8 Incidence and severity of clinical manifestations

2. Standardization of methods and techniques for epidemiological surveys

2.1 Data to be collected from the human population

2.1.1 Presence of microfilariae in the blood with definition of the mf rate and density

2.1.2 Presence of clinical manifestation

2.1.3 Presentation of results

2.2 Data to be collected on vectors

2.2.1 Collection and identification of local species

2.2.2 Determination of vectors: Natural and experimental infections

2.2.3 Vector bionomics

2.3 Filaria infection in domestic and wild animals

3. Therapy and control

3.1 Review of recent advances and experience in therapy

3.1.1 Treatment of the individual patient with DEC

3.1.2 Individual therapy with drugs other than DEC

3.2 Review of recent advances and experience in control

3.2.1 Measures against the parasite: mass treatment

3.2.2 Measures against the vectors:

- (a) sanitation measures
- (b) insecticides: as imagocides and larvicides
- (c) herbicides
- (d) susceptibility to insecticides
- (e) biological control

3.3 Relative merits of parasite and vector control

4. Recommendations

Many recommendations involving research were made under the above-mentioned topics. These were briefly recapitulated at the end of the report and are selectively given below:

4.1 Epidemiology

- (1) Studies on filaria infections in animals
- (2) Studies on developing larvae in mosquitos
- (3) Experimental transmission to man
- (4) Studies in microfilaria periodicity
- (5) Studies on C. quinquefasciatus and strains of W. bancrofti
- (6) Studies on Aedes vigilax and strains of W. bancrofti
- (7) Correlation between mf prevalence rates and mosquito transmission
- (8) Relation between worm load and mf density
- (9) Vector ecology
 - (a) Review of ecology of C.p. pipiens group
 - (b) Taxonomic, bionomic and genetic studies on C. quinquefasciatus

- (c) Evaluation of techniques of mosquito age determination
- (d) Studies on ecology of Mansonia
- (e) Studies on ecology of Ae. vigilax
- (f) Integrated studies on the C. quinquefasciatus problem
- (g) Preferential biting-times, -places, and -sites on body

4.2 Therapy

- (1) Studies to confirm the effect of DEC in individuals
- (2) Studies to improve result of treatment in patients with advanced lesions
- (3) Clinical trials of new drugs

4.3 Control

- (1) Studies on effect of large single doses of DEC
- (2) Control of C. quinquefasciatus in conditions of uncontrolled urbanization
- (3) Studies on vector susceptibility to insecticides and development of resistance
- (4) Studies on control of C. quinquefasciatus by sanitation
- (5) Studies on biological control measures

4.4 Other subjects

- (1) Biochemical research on the metabolic reactions supplying energy required for the motor activity of microfilariae and, wherever possible, of adult worms
- (2) Coordination and support of studies on the clinical evolution of filariasis to include the effect of trauma and bacterial infection on the production of clinical manifestations
- (3) Coordination and support of the use of isotopes in studying the life cycles of the filariae, and in clinical and therapeutic problems
- (4) The Committee endorsed the plans and development of the research programme undertaken by WHO, as proposed by a scientific group on filariasis in 1959, in the fields of: (a) immunochemistry of filariae infections; (b) filaria infections in animals; (c) clinical evolution and therapy of filaria infections; (d) vectors of Wuchereria and Brugia infections; and (e) studies on the effect which malaria eradication activities may have on local epidemiology of the Wuchereria and Brugia infections under the different conditions existing in the different endemic areas.

With regard to immunochemistry of filaria infections the Committee recommended:

- (i) Search for free antigen, using available techniques, in infected humans and animals before and after treatment
- (ii) Comparison of the antigenic structure of microfilariae, mature larvae, and adults by agar-gel diffusion techniques and immuno-eletrophoresis
- (iii) Chemical and physical fractionation and purification of antigens
- (iv) Search for new tests (fluorescent antibody, flocculation tests, etc.) with special emphasis on tests employing minute amounts of blood
- (v) Evaluation of intradermal tests, and serological tests, employing purified antigens, under field conditions
- (vi) Sero-immunological investigations of populations living in endemic areas

5. Additional subjects

The Committee made further recommendations regarding the following:

5.1 Terminology

The Committee discussed the draft of a document on terminology for malaria prepared by the Organization in order to examine the extent to which it covers needs of workers in filariasis. The Committee noted that this was a useful document which requires supplementation by some terms particular to filariasis.

The Committee therefore recommended that consideration be given to the possibility of using this document as a basis for the issue of a supplement prepared by specialists in the field of filariasis.

5.2 Identification of different stages of filarioidea

The Committee stressed the urgent need for a manual on the identification of all stages of the Filarioidea of man.

5.3 Training

The Committee recommended that assistance be given to members of national staff for training in the different techniques associated with filariasis research. This could be done on an individual basis or by the organization of training courses.

5.4 Support for filariasis research

The Committee recommended that assistance be given where necessary to institutes engaged in filariasis research and to control programmes likely to advance knowledge, with the object of supporting their continuation until significant results are obtained.

Several annexes were presented in the Committee's report, as follows:

- Annex 1 Records of the occurrence of Brugia infections in animals in East Pahang, Malaysia; survey results to 30 May 1959,
- after Laing, Edeson & Wharton (1960)¹
- Annex 2 Animals as reservoir hosts for Wuchereria and Brugia infections
- after Buckley & Edeson (1956)² and Edeson & Wharton (1957)³
- Annex 3 Key to the differentiation of immature filarial larvae in mosquitos
- after Nelson, 1959 (81)
- Annex 4 The potential transmission index
- after Kessel, 1957 (68)
- Annex 5 Comparison of prevalence of elephantiasis, percentage of population positive for microfilariae, and density of microfilariae per 20 mm³ of blood in different areas of the Pacific
- after Kessel, 1957 (67)
- Annex 6 Clinical manifestations of W. bancrofti infections in India
- Annex 7 Clinical manifestations of B. malayi infections in different areas
- Annex 8 List of the vectors of human Wuchereria and Brugia infections in nature (in different regions and countries)
- after Raghavan (1961)⁴
- terminology of Stone, Knight & Starcke (1959)⁵

¹Laing, A.B.G., Edeson, J.F.B. & Wharton, R.H. (1960)
Ann. trop. Med. Parasit., 54, 92-99

²Buckley, J.J.C. & Edeson, J.F.B. (1956), J. Helminth., 30, 1-

³Edeson, J.F.B. & Wharton, R.H. (1957) Trans. roy. Soc. trop. Med. Hyg., 49, 409-

⁴Raghavan, N.G.S. (1961), Bull. Wld Hlth Org., 24, 177-195

⁵Stone, A., Knight, K.L. & Starcke, H. (1959) A synoptic catalogue of the mosquitos of the world. Washington, D.C.

Annex 9 Method for the preservation and staining of mosquitos when examining for filarial larvae
- after Nelson (1958)⁶

Annex 10 Suggested methods for experimental infections and the index of experimental infections

Annex 11 Chemotherapy of filariasis and its control by DEC
- from Hawking (1961)⁷

- (101) Burnett, G.F. &
Mataika, J.U.
1964
- Mass administration of diethylcarbamazine citrate in preventing transmission of a periodic human filariasis. II. Results of a blood survey made four years after drug administration
Trans. roy. Soc. trop. Med. Hyg., 58,
545-551

An account is given of the follow-up blood survey made four years after the mass administration of a double course (total dosage 4.8 grams) of diethylcarbamazine citrate to a population of about 1700 people in Fiji. The pre-experimental microfilarial infection rate and mean density in 20 mm³ were 12.2% and 4.05 respectively.

The follow-up (4th) survey included 1430 people. The infection rate had risen from 2.7% to 5.5% in four years and the mean mf density had risen from 0.36 to 0.50. For 507 people present at all four blood surveys the corresponding rates rose from 1.2% to 6.9% (originally 16.0%) and from 0.012 to 0.51 (originally 7.08). It is concluded that disease transmission on a significant scale is unlikely to have resumed yet.

When known positive cases are considered alone, the proportion not cured by treatment with two courses of drugs appears to have risen from 7% to 35% in the four years since treatment. It is known, however, that about 40% of those apparently cured were still harbouring microfilariae in numbers too small for detection by the routine method used, and there has not been any significant increase in the true infection rate. The records of individual subjects show that some had become positive but these were balanced by others who had become negative. The mean mf density had, however, increased about 30 times. The pre-treatment mean mf density among those cured by either one or two courses of drug was very highly significantly lower than among those not cured.

A high proportion, 74% of subjects were lost to the experiment through population movement.

⁶Nelson, G.S. (1958) Bull. Wld Hlth Org., 19, 204

⁷Hawking, F. (1961), The chemotherapy of filariasis and control by diethylcarbamazine. WHO/FIL/25 (unpublished document)

(102) Edeson, J.F.B. &
Wilson, T.
1964

The epidemiology of filariasis due to
Wuchereria bancrofti and Brugia malayi
Ann. Rev. Entomol., 9, 245-268

The paper is a general review summarizing the available knowledge in literature on various aspects of filariasis. The distribution of periodic and subperiod W. bancrofti in the world is mapped as well as the distribution of B. malayi in Asia and Japan. Information on animal reservoirs of the subperiodic B. malayi and hosts for certain Brugia species is given. The paper also discusses the criteria for incrimination of mosquitos as vectors of human filariasis and provides a table listing vector species in different endemic areas which was modified from that given in the report of the Expert Committee on Filariasis, WHO, 1962 (100). The authors, in making this modification adopted a more rigid criteria for inclusion of a species as a vector, i.e. only those in which mature larvae, identifiable either as W. bancrofti or B. malayi, were present in wild mosquitos at the time of capture and in which full development of the parasite has been confirmed in the laboratory.

Parasite - vector relationship is discussed with special reference to barriers to parasite development in the mosquito and the effect of the parasite on longevity of the mosquito host.

Gaps in knowledge needing research investigations are identified and some prospects for filariasis control are suggested.

(103) Galliard, H.
1964

A propos de la prophylaxie de la
filariose lymphatique. Choix
d'une methode
Ann. Soc. Belge Med. trop., 44, 255-266

With the discovery of the remarkable effect of DEC and the availability of contact insecticides, the questions that arise are whether it is indispensable to undertake simultaneously measures against the parasite and the vector or would it be sufficient to act on one or the other. Since the problem is different everywhere, it is not surprising that the concepts of control are divergent. Besides, the public authorities, for economic reasons, look for the least expensive method to adopt which normally turns out to be the least effective.

In tackling this question, the author considers two points when selecting the method of control:

- (a) the exact determination in each region of the vectors of filariasis and their relative importance in transmission, taking into account their susceptibility or refractiveness, their bionomics and reaction to insecticides;

- (b) the study of factors related to man and his environment: the life of the people, their degree of exposure to vector attacks, the climatological conditions, all form the characteristics which can help in predicting whether one or several methods of control will be effective.

After having collected all the information on the distribution of periodic and subperiodic bancroftian filariasis and their vectors in different parts of the Pacific region, the author indicated that elephantiasis was most frequent in the zone where the subperiodic strain existed, i.e. the oriental part of the Pacific, while in New Guinea, Solomon Islands, New Hebrides and the Carolines, cases of elephantiasis were rare, although the mf rate was more than 25%. Also in New Caledonia elephantiasis was rare even though filariasis is subperiodic.

In explaining such characteristics of the disease prevalence, the author emphasized that it is important to consider the intensity of infection as shown by the mf density rather than the prevalence of infection as deduced from the mf rates. There is a clear cut correlation between the intensity of infection and the clinical manifestation of filariasis.

The author reviewed the control programme in Tahiti including the epidemiological investigations that have been carried out to obtain different indices and relevant information, namely: the frequency of clinical cases, the mf rate, the mf density, the breeding and biting habits of the vectors, the density and infection and infective rates in mosquitos, as well as the mean number of larvae of W. bancrofti in dissected mosquitos.

1. Combined control measures: by treatment of the population with DEC and vector control.

1.1 The effect of DEC treatment - In 1958 after five years of drug treatment, the mf rates fell to zero in certain zones, but taking the general results of 3400 persons examined,

- the mf rate was reduced from 37.9% to 6.5%;
- the mf density decreased from 34 to 0.8 per 20 mm³ of blood;
- 99% of the individuals became negative one year after cessation of the control measures;
- 5.6% of the children of the age group 0-4 years were infected before the campaign but none of this age group was found positive in 1957;
- in 1949, in 14% of children of the age group 0-9 years, the mean microfilaria density was 4.1 per 20 mm³ of blood. In 1960 of the children of the same age group who hitherto received no treatment, only 0.9% were infected with a mean mf density of 0.03. The author thus concluded that this provided evidence that transmission of filariasis was reduced to a rate below 1%.

1.2 The effect of the treatment on infection in the mosquito - After five years of the campaign, Ae. polynesiensis, which is the major vector of subperiodic filariasis, showed a 2.6% infection rate versus 13% pre-control and 0.19% infective rate versus 0.8% pre-control and the mean number of larvae per dissected mosquito was 0.11 versus 0.74 pre-control.

1.3 Effect on clinical manifestations - Although it was premature to draw conclusions on the effect of treatment on clinical symptoms such as adenopathy, hydrocele and elephantiasis, as these require many years to show up, it was noted that not a single case of elephantiasis was recorded after the control measures had shown their effectiveness.

2. Vector control alone

The author considered that attempting to reduce the density of Ae. polynesiensis to the critical level below which the transmission of the disease ceases would be very difficult and costly. Wherever mf carriers exist, it is useless to aim at interruption of transmission, and when the critical level is achieved, it is imperative to continue control measures for at least 10 years for the microfilariae to disappear from the human population. DDT spraying, by itself, around human habitation may lead to reduction in the transmission potential, but the effect is of short duration, not more than three months. The application is costly and can only be carried out under certain conditions.

Discussion

The author further debated the views of Iyengar /NB: vide Iyengar, 1959 (77) / that a campaign of vector control by elimination of natural and artificial breeding places through sanitation in the vicinity of human habitation would be effective in reducing the vector and thus the incidence of filariasis.

The supporters of these views indicate that treatment of an entire population with DEC is unrealistic: it requires a long time and is costly because of the need for adequate staff for surveillance of each human habitation. Also, it is not possible to forecast how long the monthly treatment should continue in order to achieve definite results. Therefore the communal effort for vector control can offer an effective and economic measure against filariasis.

In his comments on these views, the author doubted the evidence of the efficacy of sanitary measures or at least they may have been effective in special circumstances where the breeding habitats are not so diverse. As an example, the author indicated that the bionomics of the vector in Tahiti and in the Society Islands is so complex to the extent that water management and the elimination of artificial water containers in a radius of 120 m around houses was inoperative for several reasons: in comparison with American Samoa, for example, the people in the Society Islands live in isolated habitations surrounded by bush and are distributed along the coast. In these islands and also in Tahiti, the central part is volcanic and Ae. polynesiensis can exist from the coastline to 3000 m high and can survive by feeding on wild animals and even if their movement is restricted they are present everywhere. Moreover larval breeding is not confined to

artificial containers but occurs in tree holes, crab holes and in addition larvae are adapted to brackish water. The suppression of breeding in all these habitats is absolutely impossible. In this connexion, the author referred to the observations of Jachowski & Otto, 1952 (31) who indicated that transmission was principally in the bush. Added to these difficulties is the problem of the vectors which breed in leaf-axils as in the Samoas and Fiji.

The author gave further examples of the inefficiency of anti-mosquito measures alone on mf rates as was experienced in Fiji in 1944-1949. In Naura, in 1925, three years after anti-mosquito measures, the mf rate was 29% and increased to 36% in 1932 despite continuation of vector control measures, but after the application of DEC treatment the rate was reduced to 7%.

In Rarotonga, Cook Islands, in 1950, vector control was introduced to reduce the prevalence of clinical filariasis. Six years later the mf rate of 23% was recorded by Iyengar, 1957 (65) which was similar or more than that recorded in 1946. In contrast, in Niue Islands, DEC treatment combined with sanitation reduced the mf rates from 22% in 1954 to 2.9% in 1956 as was reported by Simpson, 1957 (69).

In conclusion, the author referred to the WHO Expert Committee on Filariasis, 1962 (100) after realizing that none of the filariasis control campaigns utilizing exclusively anti-mosquito measures had attained their objectives, endorsed that DEC treatment was the uncontested method to be utilized in the first place in anti-filariasis programmes for reducing the reservoir of infection in the human population, to be accompanied or followed by anti-vector measures.

(104) Nelson, G.S.
1964

Factors influencing the development and behaviour of filarial nematodes in their arthropod hosts
In: Taylor A.F.R. (Editor)
"Host-parasite relationships in invertebrate host"
Symposium of the British Society for Parasitology (2nd), London,
8 November 1963
Oxford: Blackwell Scientific Publication, pp. 75-119

In tabular form the authors showed the superfamilies, families and representative genera in each family classified under the Order Spirurida. For each genus the definitive host and the vector were listed. A further tabulation presented the range of hosts and the type of arthropod vector for each of the genera of Family Onchocercidae. The filarial species known to develop in mosquitos and other arthropods were listed with the site of microfilariae in the definitive host and site of development in the vector shown, and the development of the parasite in the vector from the time of ingestion of microfilariae to the mature stage observed in certain filariae was discussed.

The factors affecting the efficiency of arthropod hosts as vectors were reviewed as classified in the following:

1. Ecological factors: (a) external environment, (b) host preference, (c) site of bite, and (d) biting cycle;
2. Morphological factors;
3. Physiological factors;
4. Pathological factors; and
5. Genetic factors.

(105) Ramalingam, S. &
Belkin, J.N.
1964 Vectors of the subperiodic bancroftian
 filariasis in the Samoa-Tonga area
 Nature, 201, 105-106

This was an initial report on the vectorial status of certain Aedes (Stegomyia) and Ae. (Finlaya) species occurring in American and Western Samoa and Tonga. The work was extended to other species and with the addition of the results of investigations made on the sites of transmission of subperiodic W. bancrofti and on other aspects, a comprehensive paper was published by Ramalingam, 1968 (125). Thus a brief summary of the present report is given, but more detailed information can be obtained from the Abstract No. 125.

To determine the natural infection rates mosquitos were collected by man-bait capture outside houses during daytime and inside houses during night time for the kochi group. Experimental infection was carried out by the conventional method. With Ae. (S.) tongae, adult females raised from immature stages were given a single blood meal on two microfilaria carriers, one with a count of 11/20 mm³ blood and the other with 19. Owing to the difficulty in raising vigorous females from immature stages in the kochi group, wild females were allowed to feed in a local house on three mf carriers having counts of 7, 11 and 11.5 per 20 mm³ of blood. The fully-fed females were caught and held in the laboratory.

The results of natural and experimental infection showed in the following table that Ae. tongae, was definitely established as a vector in Tonga on the basis of natural and experimental infection. Ae. (S.) upolensis, a bush mosquito found only in Samoa, was found heavily infected in nature. As to Ae. samoanus, which was found in great abundance in Samoa only at night in areas surrounded by bush, both natural and experimental infections demonstrated that this species is an important vector. A widely distributed species, Ae. (F.) oceanicus, which was found to be free of natural infection, used to be misidentified as samoanus in previous epidemiological investigations. (Vide Hitchcock, 1971 (137) for further investigation on oceanicus.) A third member of the kochi group, Ae. (F.) South Pacific sp. no. 25, UCLA collection, (named later Ae. tutuilae) was found to bite man occasionally and two specimens were found to harbour 3rd stage larvae.

<u>Species</u>	<u>Locality</u>	<u>Type of infection</u>	<u>No. mosq. dissected</u>	<u>Infection rate %</u>	<u>Infective rate %</u>
<u>Ae. tongae</u>	Tonga	Natural	274	5.8	0.36
		Experimental	12	66.7	50.00
<u>Ae. upolensis</u>	Samoa	Natural	106	9.4	1.89
<u>Ae. samoanus</u>	Samoa	Natural	751	4.8	1.07
		Experimental	10	100.00	100.00

(106) Tamashiro, M.
1964

Observations on the larval ecology of
the Aedes (Stegomyia) polynesiensis
Marks on Aitutaki, Southern Cook Islands
WHO unpublished document, WHO/EBL/22

The paper presents the results of a study carried out during September-October 1963, aiming at delineating the larval habitat of Ae. polynesiensis and the ecological factors involved as well as to survey the associating pathogens, parasites and predators.

Tree holes were found to constitute the major natural larval habitat for Ae. polynesiensis, metal drums used for rainwater storage probably contributing significantly to its population in the vicinity of villages. None of them harboured specific predators of Ae. polynesiensis, the only natural enemies of mosquitos found being omnivorous ones (e.g. dragon-fly naiads, a dytiscid water-beetle and top minnows). A careful search failed to disclose any mosquito pathogens whatsoever. It was considered that these facts, the relatively simple ecology of this small (approximately 28 km²) and isolated island, and the existence of a regular commercial air service, combine to render Aitutaki a suitable site for biological control studies towards the development of an effective integrated control methodology for eventual use against Ae. polynesiensis. Candidate biological control agents for such a purpose would include aquatic predators exhibiting close adaptation to natural and artificial container habitats and fungal (e.g. Coelomomyces) and protozoan (e.g. microsporidian) pathogens of Ae. (Stegomyia) spp.

(107) Chow, C.Y.
1965

Vectors of filariasis: their response,
susceptibility and resistance to
insecticides
WHO unpublished document, FIL/WP/20.65

Attempts to control filariasis by drugs gave promising results but its success depends on total coverage of the population to be treated. Control of vectors of filariasis is rather slow and expensive. A combination of drug administration and vector control has been advocated. Vector control by insecticides necessitates the study of the response and susceptibility of the mosquitos to insecticides.

This paper reviews the available information for the important vector species of filariasis in the Southeast Asia and Western Pacific areas. Among those vectors under review is Ae. polynesiensis, for which the author found no testing had been carried out and refers to a quotation by Brown, 1962 (98) regarding the use of dieldrin pellets in water pots and tree holes. The treatment gave excellent control but the use of larvicides for treatment of small containers was not considered economical or practical.

/N.B.: Burnett & Ash, 1961 (93) published results of tests made with the WHO method. These are not quoted in the present paper. /

(108) Iyengar, M.O.T.
1965

Epidemiology of filariasis in the
South Pacific
South Pacific Commission, Techn. Paper
No 148

The paper presents a comprehensive review of all components of the epidemiology of filariasis in the South Pacific Region. The introductory part comprises a geographical description of the area, its climate, human population census and density with notes on the three major races: the Melanesian, the Micronesian and the Polynesian.

The author devoted a special section for describing the distribution of the subperiodic and periodic strains of W. bancrofti and the total absence of B. malayi. For inexplicable reasons, the latter parasite has not spread out from the island of Ceram where it is endemic, to the mainland of New Guinea, despite a small ocean gap and the presence of Mansonia uniformis in abundance in New Guinea. A review is made on the periodicity and the pathogenecity of the two strains of W. bancrofti. Further notes are made on the existence and distribution of two forms of periodic W. bancrofti, the Micronesian transmitted by C. quinquefasciatus and the Polynesian transmitted by members of the Anopheles punctulatus complex.

Reference is also made to the existence of two forms in the subperiodic strain, the Polynesian which is transmitted by members of the Ae. scutellaris group and the New Caledonian which is transmitted by Ae. (Ochlerotatus) vigilax.

Another section of the paper summarizes the number of the genera/subgenera and species of the mosquito fauna of the South Pacific referring to the author's paper of 1960 (87) and drawing the attention that many new species were described after that date, for which Belkin, 1962 (97) should be consulted. A list of vectors of W. bancrofti and their range of distribution in the South Pacific is provided.

In view of the heterogenous epidemiological pattern of filariasis in the South Pacific, the author divided the region into four epidemiological subregions as follows:

1. The Micronesian Zone (Marianas, Carolines, Marshalls, Gilberts, Nauru and Ocean Island) with periodic W. bancrofti transmitted by C. quinquefasciatus.
2. The Papuan Zone (New Guinea, Bismarck Archipelago, Solomon Islands and New Hebrides) with periodic W. bancrofti transmitted by one or more of the species, An. farauti, An. koliensis, An. punctulatus, An. bancrofti, Mansonia uniformis, Ae. kochi, C. annulirostris and C. bitaeniorhynchus.
3. The Polynesian Zone with nonperiodic W. bancrofti transmitted by one or more of the species, Ae. polynesiensis, Ae. pseudoscutellaris, Ae. tongae, Ae. rotumae, and Ae. cooki; this zone includes Fiji, Rotuma, Ellice Islands and all the island groups extending eastwards from these to Tuamotu Archipelago and Marquesas Islands.

4. The New Caledonian Zone (New Caledonia and Loyalty Islands) with nonperiodic W. bancrofti transmitted by Ae. vigilax.

On the basis of this division, the author made a review of the available information by country and island groups, giving the mf rates, clinical manifestations including the prevalence of elephantiasis. On the vector side, data of infection and infective rates either from field dissections of wild caught mosquitos or from experimental infection are given whenever available. For each island group, the author also cited and discussed the relative importance of different types of vector breeding places. Factors influencing the intensity of transmission in domestic, peri-domestic and bush situations are analysed. Having reviewed the situation in each island groups the author made a conclusive review and final discussion for each subregion based on this.

On the question of intensity of transmission within villages versus lower probability of transmission in bush plantation; the author reviewed the experience of different workers and added the results of his own studies. This also includes the deductions made on the range of flight of Ae. polynesiensis. The results of intensive studies at Tutuila, American Samoa as reported by Byrd & St Amant, 1959 (72) showed that incidence of infection in mosquitos was as high as 25% within the centre of the village itself and in sections of a few villages the infection rate reached 45%.* The infection rates dropped progressively as the distance from the periphery of the village increased reaching 4-5% at 45.5 m and only an occasional infected mosquito was encountered beyond 91 m.

Observations by several workers in the Cook Islands indicate that transmission of filarial infection occurs primarily in the vicinity of habitations. Davis, 1949 (16) failed to find filarial infection in mosquitos caught in plantation areas, while infected mosquitos were invariably found in collections made within the villages. Satchell, 1950 (19) made a comparative study of vector density and the incidence of filarial infection in the vector in three different locations in Ngatangiia villages, viz:

- (a) inside houses where the average density of mosquitos per collection was 23 and the infection rate was 9.1%;
- (b) within a radius of 23 m from houses where the average density was 31 per collection and the infection rate was 6.9%;
- (c) in plantations away from houses but regularly visited by people, where the average density was 55 per collection and the infection rate was 1.6%. From the density levels and infection rates, there were 2.4 times as many infected mosquitos in houses as in plantation visited by people. From the observations of McCarthy, 1959 (80) in the islet of Akaima, Aitutaki, Cook Island where the only resident was a person with moderate microfilaraemia, Ae. polynesiensis caught near his residence showed an infection rate of 25.9% while none was found infected at a distance of 180 m or more from his residence.

Iyengar, 1957 a (66) from studies made in Rarotonga and Aitutaki stated: "Transmission of filarial infection occurs primarily in the vicinity of habitations. High infection rates were noted in Ae. polynesiensis collected in and around houses in comparison with infection rates in mosquitos caught even at a distance of 91 m from habitations. Specimens collected inside houses often showed full-grown filaria larvae of the infective stage in the head and labium of the mosquito, indicating that transmission occurs even inside the house. It is also not unusual to find multiple infections with two or three broods of filaria larvae in mosquitos caught within the village. On the other hand, in mosquitos caught at a distance of over 91 m from habitations, stray infections were noted but never was a multiple infection."

"The finding of filarial infection in very young children also supports the conclusion that transmission occurs in habitations or in their immediate vicinity. In the vicinity of habitations the vector mosquito has close contact with the reservoir of infection as well as with the recipient. As this mosquito has a limited range of flight, such contact is not frequent in areas away from human habitations. While it is possible that stray instances of transmission may occur in areas away from habitations, an epidemiologically significant amount of transmission occurs only in the immediate vicinity of houses."

In this connection, the author discussed the objection raised by Jachowski & Otto, 1952 (31) in American Samoa, and Jachowski & Otto, 1955 (52) to the conclusions of earlier workers that the villages are the main foci of transmission of subperiodic filariasis. As their findings supported the concept of sylvatic foci of transmission, they assumed that the concept of earlier workers seemed to have been derived from incomplete information, misinterpretation or both. The author in commenting on the above objections stated:

"This view is based on their calculated index of transmission, a combination of the two factors, vector density and infection rate in the vector mosquito."

Undoubtedly an index of transmission based on a combination of an estimate of the total vector density and the infection rate in the vector would furnish a reliable criterion for determining the quantum of transmission occurring in any particular locality. Owing to the fact that the vector, Ae. polynesiensis, rests almost exclusively in bush, it is not feasible to make a reliable estimation of the total density of this mosquito in any one area.

This question has been discussed in some detail because of its importance in the epidemiology of filariasis in the Polynesian zone and its bearing on the rationale of filariasis control. It is not contended that transmission of filarial infection does not occur in plantations and bush areas away from habitations. Under certain conditions transmission would certainly occur in plantation areas, as for example when the same areas are visited by man regularly, or if the people camp in any one plantation area for prolonged periods of two weeks or more. Under such conditions the vector population of the particular plantation or bush area has the

opportunity of getting infected and, subsequently when the infection in the mosquito has reached the infective stage, to transmit the infection to man. It is known that this happens in several plantation areas as for example Tokelau, Tuamotu and the northern Cook group. Continued re-infection necessary for hyperfilarialation, however, could only occur in areas where there is close and constant contact of high vector density with the human population."

(109) Kessel, J.F.
1965

Combined control methods in filariasis
WHO unpublished document, FIL/WP/16.65

This was submitted to the Inter-Regional Seminar on Filariasis held in Manila during 22 November to 1 December 1965.

In order to understand the concepts underlying the combined drug and mosquito control for combating filariasis, it is desirable to know the efficacy of each method independently. Since specific trials are lacking, a review of historical events and theoretical accounts may provide relevant information.

The gradual disappearance of filariasis from certain areas in the United States and Australia may be attributed to improved living conditions which resulted in reducing man-vector contact. However, in many endemic rural and urban areas in the world, filariasis does not show rapid disappearance by natural means.

The author compared malaria control and eradication with filariasis control. Early malaria control activities were directed to mosquito vectors. With the development of the malaria eradication measures against the vector and the parasite were combined. For filariasis control the reverse was recommended; first mass drug treatment is to be applied to reduce microfilaraemia to as low as possible and mosquito control is to be applied as much as the local budget permits, either simultaneously or subsequently. If a perfect drug is available filariasis could be soon eradicated with the population response to treatment favouring 100% coverage, but with the available drug, refusals, immigrants and recurrences, the picture is complicated. Thus, a combination of mosquito and drug control has great advantage.

Mosquito control alone: due to the complexity of the life cycle of the main vectors of filariasis, i.e. Culex, Aedes, Mansonia and Anopheles, and with the development of insecticide resistance, mosquito control has never proved to be highly efficient. Coupled with this is the long life span of W. bancrofti which may extend to 10 years. In the South East Pacific the most common vector, e.g. Ae. polynesiensis, breeds in peri-domestic and sylvatic situations in a variety of artificial and natural breeding places, hence eradication of such vectors is extremely difficult and expensive. Based on the knowledge of the flight range not exceeding 100 m, a clean-up campaign to eliminate the breeding places within this range was organized in Tahiti and American Samoa. In Tahiti this measure

could reduce mosquito density from 0.5-1 per minute to less than 0.1. Catches showed that 75% of the houses were free of mosquitos. Aerial spraying and barrier spraying with DDT and other insecticides needed repeated application every three months or longer as in American Samoa where the rainfall is higher than in Tahiti. For long-term results, elimination of the breeding places as described would seem the best.

Drug control: If DEC is thoroughly administered in adequate doses, the microfilaraemia can be reduced in man to the point where transmission becomes minimal. If eradication is to be achieved, perseverance in applying the combined measures would be necessary.

- (110) Laigret, J.,
Kessel, J.F.,
Malarde, L.,
Bambridge, B. &
Adams, H
- La Lutte contre la filariose lymphatique
aperiodique en Polynésie française
Bull. Soc. Path. exot., 58, 895-916

The authors reported the results obtained in French Polynesia of ten years (1953-1964) application of control of subperiodic filariasis.

The control measures consisted of:

- (a) DEC mass administration: the following regimens were given:

In 1953: 6 mg/kg once monthly for 12 months for the entire population.

In 1954: those found positive were again given 12 monthly treatment courses.

In 1961: for simplifying the work of drug distribution and for ascertaining the negativity of the microfilaria carriers and for renewing the interest of the population as well as the personnel of the programme, the previous routine was changed. Each individual received a treatment of 6 mg/kg per day for six days and this was repeated every six months.

- (b) Measure against the vector:

The main vector of epidemiological importance is Ae. polynesiensis which is known to be exophilic and occurs in many heavily inhabited valleys where high humidity and thick bush exist. These conditions ruled out the use of insecticides so, in view of its short range of flight, the control measures applied were based on the destruction of all the breeding places in a radius of 100 m around human habitation.

(c) Educational programme:

Propaganda was intensified for supporting the treatment programme and, at the same time, health education was pursued.

Summary of results

The percentage of infected Ae. polynesiensis was reduced by 90% and likewise its larval density.

The frequency of lymphangitis was reduced by 90% and those of hydrocele and elephantiasis were reduced by 75%.

The mf rate was reduced by 79% while the mf density was reduced in a parallel way.

The authors established that the chances of infection of the children born since the commencement of the campaign was minimal. Nevertheless, they underlined that the effect of control measures by DEC on the adult parasite was insufficient. The authors further indicated the impracticability of treating more than half of the mf carriers due to refusal, adverse drug reactions, cases of drug contra-indications and instability of a proportion of the inhabitants. Therefore, the authors believed that there is a need for a more active drug against the adult filarial parasite which can be easily administered without particular precautions under field conditions.

(111) Ramalingam, S. &
Belkin, J.N.
1965

Mosquito studies. III. Two new Aedes
for Tonga and Samoa
Contributions Amer. Ent. Institute,
1, 1-7

The paper contains the description of two new species, Ae. (Stegomyia) tabu and Ae. (Finlays) tutuilae from Tonga and Samoa respectively. For each species, detailed morphological description of the adult female, male, male genitalia, and the larval and pupal stages is given, along with the necessary illustrations. There are synoptic notes on distribution, bionomics and relation to filariasis transmission as per the following extracts.

Ae. tabu

Bionomics and disease relations: The immature stages of tabu have been collected in the leaf axils of taro (Colocasia) and giant taro (Alocasia), in tree holes and tree fern stumps, in coconut shells and spathes on the ground and in artificial containers. Ae. tabu appears to be a semi-domestic form and bites primarily during the day in the bush surrounding villages. This species (as tongae) has been reported to be naturally and experimentally infected with W. bancrofti on the island of Tongatapu by the authors, 1964 (105).

Distribution: Tonga: Tongatabu Group, Tongatabu, Eua; Ha'apai Group, Tofua, Matuku. Not known elsewhere.

Ae. tutuilae

Bionomics and disease relations: The immature stages of tutuilae have been collected primarily in the leaf axils of Pandanus from sea level to elevations of 500 m. No definite information is available at present regarding the bionomics of the adults of tutuilae. It is possible that the report (Ramalingam & Belkin, 1964, loc. cit.) of two specimens infected with W. bancrofti refers to this species (as Aedes (Finlaya) South Pacific sp. no. 25, UCLA collection) but it is also possible that the specimens in question are true samoanus since the two species cannot be differentiated with certainty in the female.

Distribution: Samoa: Savaii; Upolu; Tutuila, Ofu (Manua group). Not known elsewhere.

(112) Ciferri, F.,
Siliga, N.,
Long, G. &
Kessel, J.F.
1966

A filariasis control programme in
American Samoa
WHO unpublished document, WHO/FIL/66.62

The paper presents the results of clinical, parasitological and entomological surveys carried out in 1962 which indicated that there had been no overall reduction in clinical filariasis, nor in microfilaraemia but possibly a slight increase during the intervening 14 years, during which period no organized filariasis control programme had been implemented in American Samoa. Results of follow-up surveys conducted after the introduction of DEC treatment in the control experiment up to 1965 are discussed and compared with those obtained in the Tahiti mass treatment programme.

It is of interest to note that in 1963, before mass treatment, the village of Aoloau showed an infection rate of 12.5% for Ae. polynesiensis and of 5.9% for Ae. samoanus, as reported by Ramalingam¹, while in 1965 it was 1.5% and 1.7% respectively.

Marked reductions between the 1962 and 1965 results in the percentages of mosquitos infected with larvae of W. bancrofti and in the density of larvae per infected mosquito correlate well with the low densities of microfilariae that occurred in the human population following mass treatment with diethylcarbamazine in the three villages of Amouli, Amanave and Malaeloa (see Table 1).

The conclusion is that with the DEC regimen adopted, despite its complete reduction of the microfilaraemia, marked reduction in the infection rates and the general worm load in mosquitos took place.

¹Ramalingam, S. (1965) The mosquito fauna of Samoa and Tonga and its relation to subperiodic bancroftian filariasis. Ph.D. dissertation in Zoology, University of California, Los Angeles, California, USA.

Table 1. Microfilaria in man and larval infection in mosquitos

Village	1962							
	Persons (40 mm ³ blood film)			Ae. polynesiensis			Mean filaria larva per mosq.	Potential trans-mission index
	No. exam.	% +	Mean mf per positive	Density per min	No. dis.	Infection rate, %		
Amouli	268	14.5	41	0.32	70	12.9	0.47	41
Amanave	260	21.9	74.5	0.46	77	10.3	0.42	51
Malaeloa	296	25	62.5	0.98	115	10.4	0.28	68.6
1965								
Amouli	210	3.3	5	0.45	82	2.4	0.04	4.5
Amanave	231	10.3	15	0.33	73	2.7	0.05	4.1
Malaeloa	245	9.4	6	0.44	187	1.1	0.12	13.2

(N.B.: By retabulation of the authors' data as shown in Table 1, the parasitological data of the entire village are given in order to determine whether there is a good correlation between the infection rates of the mosquitos and those of the human population. It appears that before DEC was administered, mosquito infection rates were nearly similar in the village with the lowest mf rate (14.5%) and those with higher mf rates (21.9% and 25%). Also there was no correlation between the mean mf density per positive person and the mosquito infection rates nor with the mean number of larvae of all stages per dissected mosquito. In fact this latter index was the lowest in the village Malaeloa where the mean mf was 62.5 and the highest in the village Amouli with the lowest mean mf 41. Twenty eight months after treatment mosquito infection rates and the mean number of larvae per dissected mosquito were almost the same in the two villages, Amouli and Amanave, which showed the lowest and the highest mf rates and densities respectively.)

Recurrence of infection was observed in two key districts in Tahiti and two key villages in Tutuila following different regimens of DEC as shown in Table 2.

Table 2. Follow-up surveys of two districts in Tahiti and two villages in American Samoa

District	DEC dosage and schedule	Time	No. pos./no. pers.	pos. %	Mf density per positive exam.
Tautira	6 mg/kg once a month for 26 months	Before treatment	60/60	100	56
		2 years after close, 1956	0/48	0	0
		3 years after close, 1957	60/56	11	1.5
		5 years after close, 1959	15/51	30	6.4
Vairo	6 mg/kg once a month for 18 months	Before treatment, 1956	59/59	100	49
		2 years after close, 1960	14/58	24	7.3
		4 years after close, 1962	7/49	14	3.1
		Before treatment, 1962	55/55	100	62
Amanave	6 mg/kg once a day for 6 days, and once a month for six months Total 12 doses	18 months after close, 1964	17/50	34	4
		28 months after close, 1964	13/50	26	14.5
		Before treatment, 1962	60/60	100	63
		18 months after close, 1964	9/51*	18	2
Malaeloa	6 mg/kg once a day for 6 days, & once a month for 12 months: Total 12 doses	28 months after close, 1965	15/48	31	3.9

*Figure corrected from data given by the authors in another table.

For comparison with the entomological findings, it is of considerably interest that the infection rate in Ae. polynesiensis was similar, being 13.0 in American Samoa and 15.0 in Tahiti. The potential transmission indices also were similar being 95 and 100. This certainly shows that the filariasis relationships existing in these two areas, though widely separated, must have been similar.

In Tahiti, marked reduction in microfilaraemia and mosquito infection rates was observed following mass DEC administration in 1953 with reduced incidence of new clinical cases of hydrocele and elephantiasis. In American Samoa no such reduction was observed during 1948-1963 in the absence of island wide control programme. The results of the current pilot experiment, although encouraging, showed that 12 dose schedule of 6 mg/kg was insufficient to eliminate microfilaraemia and additional 12 doses of 6 mg/kg was proposed.

- (113) Laigret, J., Kessel, J.F., Bambridge, B. & Adams, H. 1966
- Onze ans de chimioprophylaxie par la diethylcarbamazine de la filariose lymphatique aperiodique à Tahiti
Bull. Wld Hlth Org., 34, 925-938

The paper analyses the results of an elevent year study of the DEC application to the entire rural population (25 000 persons) of Tahiti for treatment of nonperiodic bancroftian filariasis. Preliminary work from 1948 to 1953 established a treatment schedule of 6 mg diethylcarbamazine citrate per kilogram of body-weight on one day per month for 12 months. Because of the high endemicity, all those over one year old were treated in 1953; subsequently, only those found in the course of periodic blood surveys to be carriers of microfilariae were treated. In 1961 the treatment was modified, each carrier being given 6 mg/kg daily for six successive days, repeated every six months. The drug control measures were accompanied by the mechanical destruction of the breeding and resting places of the mosquito vector, Ae. polynesiensis, which cannot be effectively and economically controlled by means of insecticides.

Infection and infective rates as determined from periodical dissection of Ae. polynesiensis made throughout 1949-1964 are presented in Table 1.

In order to appreciate the degree of reduction in the basic indices related to the presence of microfilariae in man, clinical manifestation and infection in the vector, the authors arbitrarily fixed the values of all indices recorded during 1949 at 100% level. Subsequent indices were expressed as "relative values", being the proportion of the observed index, relative to its initial level as shown in Table 2, the data of which has been illustrated in Fig. 1.

Table 1: Vector infection and infective rates with *W. bancrofti*

Year	Investigations carried out	No. of mosquitos dissected	Mosquitos with larvae of all stages		Mosquitos with infective stage larvae		Density of larvae per mosquito dissected	
			No.	%	No.	%	All stages	Infective stage
1949	Before any treatment	422	56	13.2	31	7.4	0.74	0.19
1953	Before mass treatment	9981	500	5	122	1.2	1.1	0.31
1955	2-3 years after mass treatment	6165	180	2.9	44	0.7	0.12	0.022
1958	5 years after mass treatment	6754	201	2.9	57	0.8	0.11	0.034
1961	8 years after mass treatment	5597	158	2.8	49	0.8	0.12	0.028
1964	11 years after mass treatment	6308	192	3	35	0.5	0.13	0.017

Table 2: Values of parasitological, clinical and entomological indices of 1958 and 1964 relative to those of 1949

Indice	1949		1958		1964	
	Observed Value	Relative Value	Observed Value	Relative Value	Observed Value	Relative Value
1. mf carriers	29.9%	100	5.3%	17.7	6.8%	22.7
2. mean density mf per person examined	23.4%	100	0.9%	3.9	1.3%	5.5
3. Mean density mf per positive	78.4%	100	16.5%	21	19.6%	25
4. Enlarged epitrochlear glands	40.8%	100	7.7%	18.8	12.4%	30.4
5. Lymphangitis	23.1%	100	1.6%	6.9	1.2%	5.2
6. Hydrocele	9.8%	100	3.2%	32.6	2%	20.4
7. Elephantiasis	7%	100	2.2%	31.4	1.8%	25.7
8. Mosquitos positive (all larval stages)	13.2%	100	2.9%	21.9	3%	22.7
9. Mosquitos positive (infective stage larvae)	7.4%	100	0.8%	10.8	0.5%	6.7
10. Density of larvae (all stages)	0.74%	100	0.11%	14.8	0.13%	17.5

Fig. 1: Evolution of parasitological, clinical and entomological indices under the impact of control measures

Micro-filaraemia	1. mf carriers 2. mean density mf/ person examined 3. mean density mf/ positive
clinical manifestations	4. enlarged epitrochlear glands 5. lymphangitis 6. hydrocele 7. elephantiasis
infection in vector	8. mosquitos positive (all larval stages) 9. mosquitos positive (infective stage larvae)
	10. density of larvae/ mosquito dissected (all stages)
	11. density of larvae/ mosquito dissected (infective stage)

In 1949, 29.9% of the population were mf carriers, the average mf density per 20 mm^3 of blood being 23.4 for all persons examined and 78.4 for carriers. By 1953 these figures had been reduced to 20.6%, 11 and 53.6 respectively, and by two to three years after the mass treatment to 6%, 1.5 and 24.1. Subsequent changes were much smaller, the figures for 1964 being 6.8%, 1.3 and 19.6, practically the same as nine years previously.

The three indices after having been drastically reduced in 1958, showed a slight increase in 1964. The index of the mean mf density per person examined was the most sensitive in showing the effect of the treatment. The amount of reduction in this index in 1958 was about 96% of the initial level of 1949. The symptoms of bancroftian filariasis studied were:

- (a) enlarged epitrochlear glands
- (b) lymphangitis
- (c) hydrocele
- (d) elephantiasis and
- (e) all other symptoms.

Surveys were carried out in 1949, 1958 and 1964. For all the symptoms there were pronounced falls in the prevalence between 1949 and 1958 and then further slight decreases, except in regard to enlarged epitrochlear glands, where there was an increase; possible explanations for this are advanced. The percentage of people with no symptoms of bancroftian filariasis increased from 29.5% in 1949 to 75.3% in 1958 and 80.9% in 1964.

With regard to the vectors, before mass chemoprophylaxis began, 5% of mosquitos were carrying larvae at all stages and 1.2% were carrying infective larvae, the respective densities (larvae per mosquito) being 1.1 and 0.31. These figures fell by 1955 to 2.9%, 0.7%, 0.12% and 0.022%, respectively, and have since remained fairly steady, the 1964 figures being 3%, 0.5%, 0.13% and 0.017%. Two indices slightly increased between 1958 and 1964 namely, the mosquitos positive for all larval stages and the density of larvae of all stages per mosquito dissected. The authors tried to explain this as being a reflection of the small increase in the mf rate and mean mf density/person examined in 1964. The authors referring to the decrease in the other two indices namely, the proportion of mosquitos with infective stage larvae and the density of the infective stage larvae per mosquito dissected, made an assumption that DEC may have an effect on the parasite or the mosquito that could reduce the chances for the developing larvae to reach the mature stage, a possibility that deserves special interest.

The results indicate that, whatever the schedule of treatment employed, DEC is very effective when first used on a heavily infected population. There is evidence that, particularly when the limits of effectiveness are being reached, dosing for one day per month for 12 months is more efficient than dosing for six consecutive days every six months. The drug apparently acts mainly by decreasing the transmission of the parasite because of the great decrease in the number of microfilariae in circulation. The effectiveness of the treatment was such that, within less than five years after mass chemoprophylaxis, bancroftian filariasis was no longer a public health problem in Tahiti.

However, the fact still remains that, once the infection rate is brought down to a certain level, any further reduction becomes very difficult and the slightest relaxation of control measures leads to a renewed rise in mf rates. Below this critical level, the clinical rates continue to improve slowly. In conclusion, the authors pose several questions in relation to the treatment schedule and dose and to the desirability for mass treatment as against treatment of carriers; the answers to these questions should lead to the more effective use of DEC and other drugs in the chemoprophylaxis of bancroftian filariasis in the future.

These questions are summarized in the following:

- (i) Should this monthly schedule be preceded by a few consecutive days' treatment which would rapidly reduce microfilariae in the blood? This would be superfluous since one is concerned with a parasite which can live for several years.
- (ii) Is it necessary to recommend the treatment of the whole population without selection of the mf carriers? This method, without any doubt, is the most effective, but it becomes highly expensive when the number of the mf carriers does not exceed 6% unless the monthly interval between two treatments could be prolonged.

- (iii) Is it possible that a regimen scheduled every two, three or even six months will have sufficient efficacy viz à viz, the facility in administration and the reduction in cost that could only support it? Some practical trials in French Polynesia showed encouraging results.
- (iv) On the other hand, could one not increase the daily dose which normally does not exceed 5-6 mg/kg? It is probable in this case, that not only the microfilariae more rapidly disappear but large numbers of adult parasite be affected. Unfortunately, most people would complain of the strong disagreeable reaction of such doses.

Obviously these are not the only questions that can be posed on the practical and effective way for utilizing DEC. The difficulty in answering these questions is due to the lack of experiences from rigorously conducted field investigations during sufficiently long time. There are many unknown factors concerning the action of this drug on the parasite and the host. Remedyng these gaps in knowledge, will undoubtedly permit the judicious utilization of DEC to the extent that would increase its efficacy. The researches should not overlook other chemicals, particularly the arsenic compounds and stibes. It may be possible that a combination of DEC and other filaricides may lead to success.

(114) World Health Organization
1966

Inter-Regional Seminar on
Filariasis, Manila
WHO unpublished document,
WHO/FIL/66.47

An Inter-Regional Seminar on Filariasis was held in Manila in November 1965 and was attended by participants from 25 countries and territories in the African, Eastern Mediterranean, Southeast Asian and Western Pacific Regions. The aim of the Seminar was to discuss the findings of the participants and other workers and to review these in the light of opinions and recommendations expressed at previous WHO meetings held in 1961¹ and in 1964².

The topics covered in this Seminar were as follows:

1. Country review of filariasis
 2. Epidemiology
- 2.1 Relation of intensity of infection to severity of clinical manifestations in the community

¹WHO (1962) Scientific Group on Filariasis and on Non-Ophthalmological Aspects of Onchocerciasis, Wld Hlth Org. techn. Rep. Ser., No. 233

²WHO (1965) Seminar on the Ecology, Biology and Control of Culex pipiens complex. Unpublished document, WHO/Vector Control/62.125

2.2 Animal reservoir of filariasis with special reference to studies made in Malaysia

- 2.2.1 B. malayi
- 2.2.2 W. bancrofti
- 2.2.3 Filarial infections in animals

2.3 The vector

2.3.1 Determination, confirmation and differential diagnosis of developing forms of parasites in vectors

2.3.2 Bionomics of the vectors with special reference to their breeding, feeding and resting habits, and longevity. (This section mainly dealt with Mansonia spp.)

- Larval habitat
- Adult habitat
- Feeding preference
- Age determination and longevity
- Genetics of the vectors
- Effect of filarial infections on longevity and flight range

2.4 Studies on C. quinquefasciatus and filariasis in Rangoon, Burma

2.5 Rural and urban filariasis

3. Review of methodology of epidemiological surveys in filariasis control

4. Control

4.1 Drug control

4.1.1 DEC: dosage and regimen of treatment, adverse reactions, recurrences

4.1.2 Mel W and other drugs

4.2 Vector control

- 4.2.1 Insecticides
- 4.2.2 Biological control
- 4.2.3 Genetic control
- 4.2.4 Control of C. quinquefasciatus

4.3 Combined control methods

5. Training and coordination

(115) Ciferri, F. &
Kessel, J.F.
1967

Relation of age and sex, and microfilaria density to treatment of subperiodic filariasis with diethylcarbamazine
Am. J. trop. Med. Hyg., 16, 321-328

In American Samoa a study group of 175 mf carriers of varying ages and mf densities, were treated for five or six days at 6 mg/kg and again after six months with a total dose of DEC between 60 and 72 mg per kg of body weight and examined regularly for microfilariae by two 20 mm³ samples of blood at one week, six months, and two and three years after the beginning of therapy.

The frequency of adverse reactions to the first administration of DEC varied directly with the pretreatment mf density of the carriers and with the age group receiving treatment; carriers with initially low counts and in the younger age groups, 0 to 19 years, experienced significantly fewer reactions to DEC than those with higher counts or in the old age groups, suggesting that, whatever the nature of these reactions, they appear to be related to the intensity of the infection and to the length of exposure to mf products.

No correlation could be found between age groups or sex distributions and the percentage of carriers who remained positive one week after therapy or several months or years later. A significant positive correlation, however, was consistently found between pretreatment mf density and percentage of carriers found positive at various intervals after treatment, in that the highest positive rates after treatment were found among the carriers with highest initial counts, indicating that the dosage of DEC may have to be gauged to the pretreatment mf density of the individual person or to the population at risk, in order to insure optimal therapeutic results.

(116) Kessel, J.F.
1967

Diethylcarbamazine in filariasis control
Proc. & Papers Calif. Mosquito Assoc., 35, 12-22

The author commenting on the summaries of Hawking (1955)¹ and (1962)² indicated that there are great variations in the reported reductions of microfilariae following the use of DEC. These variations were observed in two population groups: "total population groups" i.e. those of islands, villages or districts. In this group the variation in the positives noted in the results of follow-up post mass treatment surveys

¹Hawking, F. (1955) The chemotherapy of filarial infections.
Pharmacol. Rev., 7, 279-299

²Hawking, F. (1962) A review of progress in the chemotherapy and control of filariasis since 1955. Bull. Wld Hlth Org., 27, 555-567

was in the range of 1.3-16%. The other group are those found positive before the administration of DEC. The post treatment surveys showed that 8-90% can still be found positive. The author pointed out that the marked differences found in the post treatment rates could be attributed to: (a) different mf rates and densities before treatment, (b) different regimens of DEC administered, (c) different periods of time that elapsed between DEC administration and follow-up surveys. The author having extensive long-term data from Tahiti and American Samoa made an analytical study aiming at a better understanding of the value of DEC.

DEC regimens employed

Tahiti: 6 mg/kg given in one day each month for 12 months, annual blood surveys performed using the average mf counts recorded in two 20 mm^3 thick blood films. All recurrent and new positives found by these annual blood surveys were retreated.

American Samoa: The standard 12 doses recommended in Tahiti were employed but instead of administering 6 mg/kg one day each month for 12 months, each person received first a daily dose for six days. One group was left for six months, then given six daily doses in the seventh month. The other group received their second six doses spread over six months, i.e. one daily dose each month commencing the second month after the treatment began.

Entomological surveys: The method of "intensive survey" of Bonnet et al., 1956 (58) was adopted and the records of the proportion of Ae. polynesiensis found with infective stage larvae are presented in the paper.

The author summarized the data of Tahiti and American Samoa and comparative presentation was made in a series of graphs from which selected extracts with the respective comments are given below together with the author's conclusions.

Figures 1 and 2 are composites and depict the microfilaria rates and average microfilaria counts in rural districts of Tahiti and in rural villages of American Samoa, before and after treatment using surveys by Murray, 1948 (15), Ciferri et al., 1966 (112) and Laigret et al., 1966 (113).

Figure 1 shows: (1) Without mass treatment with DEC as a control measure, there was little change in mf rates during periods of five to ten or more years. (2) Upon mass treatment with DEC, there were sharp decreases in mf rates during a regimen of treatment ranging from 1% to 3% by the regimens employed in Tahiti and American Samoa. (3) Without additional treatment, by the third year the rates had risen to 3.6% in Tahiti and 8% in American Samoa. (4) In Tahiti, where the rule has been to retreat recurrent positives along with new positives, it is seen that 10 years after treatment the mf rate in rural districts is about 5%. In Figure 2 which shows mean mf counts per 20 mm^3 of blood in the same areas, corresponding impressive drops are observed. Of special interest are the low average mf counts following treatment - all below two in Tahiti and below 0.4 in American Samoa.

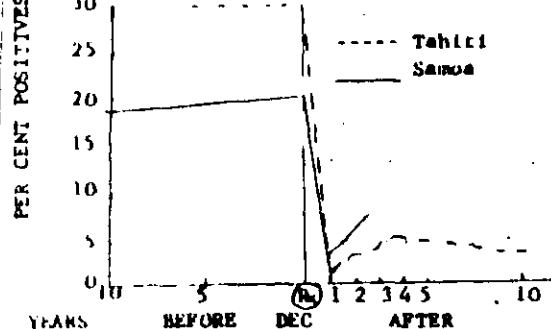


Figure 1 - Microfilaria rates in districts of Tahiti and villages of American Samoa

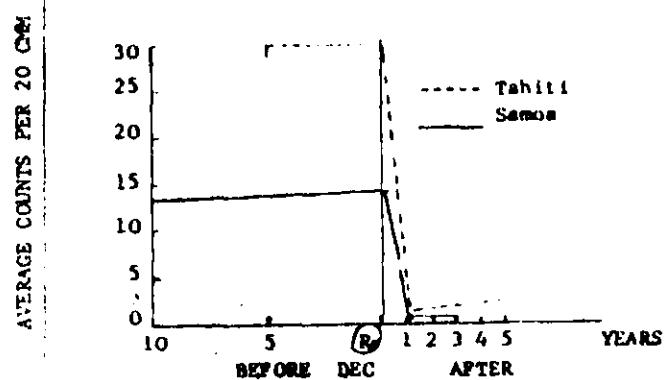


Figure 2 - Microfilaria density in districts of Tahiti and villages of Samoa

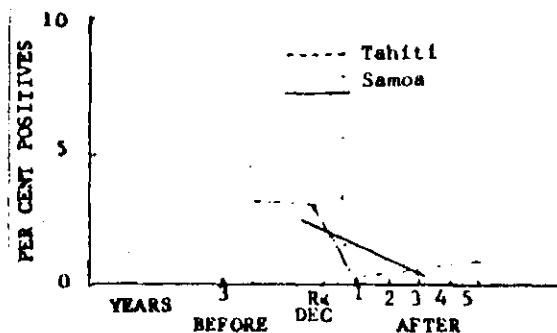


Figure 3 - Per cent of mosquitoes with infective stage larvae before and after diethylcarbamazine

Figure 3 illustrates the percentage of *Ae. polynesiensis* found to harbor larvae of *bancrofti* before and after treatment in rural areas of Tahiti and American Samoa. In Tahiti, Vairao, a district representing rural areas was left without DEC treatment since 1951 to serve as a control. Many base-line studies with the intensive mosquito survey method were conducted and a summary of data of 13 surveys made before DEC mass administration are given in the following table.

Mosquitos dissected	Number positive for		Percentage positive	
	All stage larvae	Infective stage	All stage	Infective stage only
4733	528	147	11.1	3.1

Eight follow-up surveys by identical methods were made during the second and third years after treatment. Four were negative for third stage larvae. These eight surveys are summarized as follows:

Mosquitos dissected	Number positive for		Percentage positive	
	All stage larvae	Infective stage	All stage	Infective stage only
2052	43	12	2.0	0.58

These results showed a significant reduction of infective stage larvae with $P < 0.0005$.

In American Samoa, before the filariasis programme began in 1962, intensive mosquito surveys were carried out by the same intensive method in four rural villages namely Aoa, Amouli, Amanave and Malaeloa. Follow-up intensive surveys were carried out only in the last three named villages in the third year after the completion of DEC mass treatment with 72 mg/kg.

It is of interest to note that the percentage of mosquitos with infective stage larvae dropped from 2.1 (of 327 mosquitos dissected) before DEC to 0.53 (of 375 mosquitos dissected) during the third year following mass chemotherapy. It should be noted that fewer mosquitos were dissected in the three villages in American Samoa than in Vairao, Tahiti and so the significance level of P falls between 0.10 and 0.20. In American Samoa in 1965, following the first mass treatment of the whole island of Tutuila with 12 doses of 6 mg/kg, administered within seven months, it was found after resting for one year, that 3% of the population of six rural villages were still positive, with an average of 0.4 microfilariae per 20 mm³ of blood per person. Instead of following the procedure previously used in Tahiti, i.e. performing an annual island-wide blood survey and retreating the positives only, it was decided that it would be cheaper and probably more effective to retreat the whole population with 12 doses of 6 mg/kg at optional intervals during the second or third year after the end of the previous treatment.

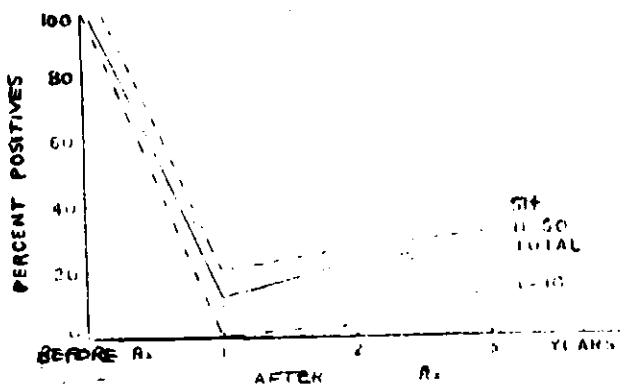


Figure 4 - People positive at different MF. Levels before and after diethylcarbamazine

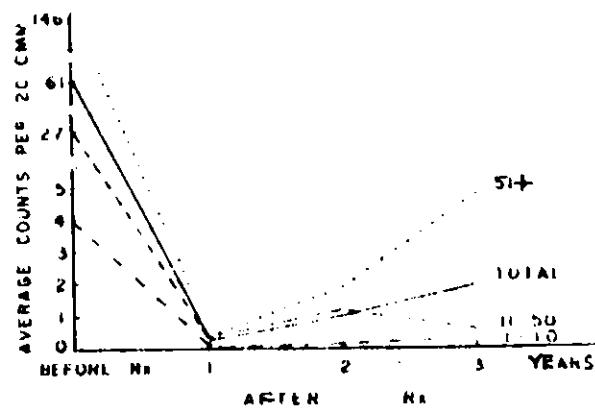


Figure 5 - Average counts per mf. level in people positive before and after diethylcarbamazine

Figures 4 and 5 show an analysis of mf rates and average mf counts before and during three years after DEC in American Samoa for 145 pre-treatment positive individuals grouped according to their pretreatment level. The difference observed in percentages positive at three years between the group with low initial count and the group with high initial count was found to be significant at a multiple test level of $P < 0.005$ (test on all three between group differences made simultaneously). Figure 4 further illustrates the thesis of Ciferri et al., 1966 (112), that an important positive association exists between pretreatment mf density and percentage of carriers found positive after treatment.

Figure 5 shows that recurrences with the highest mf counts are found in the group of people having pretreatment densities of 51 or over. The difference observed in mean counts at three years between the group with low initial count and the group with high initial count was found to be significant at a multiple test level with $P < 0.0001$ (three tests made simultaneously).

Conclusions

Diethylcarbamazine: (a) The success of a mass treatment programme with DEC against filariasis is directly proportional to the amount of the drug prescribed and the thoroughness with which it is administered. It must be remembered that, in any control or eradication programme on a volunteer basis, human factors such as "excusals" or "refusals" and migrations of untreated carriers into an area will influence the results.

(b) Apart from the inconveniences of taking repeated doses of the drug and of the reactions resulting from liberation of excess foreign protein from the destruction of microfilariae, the disturbances are few. Control programmes here described for Tahiti and American Samoa illustrate the reductions of microfilariae to a minimum in controlled treated groups, using two different total dosage levels. As clinical filariasis, such as lymphangitis and filarial fever were also reduced to a low point under these treatments and as few new cases of elephantiasis developed in such controlled programmes, it appears that the importance of filariasis as a disease of public health importance, has been greatly reduced.

(c) This does not mean, however, that mass treatment programmes with DEC have resulted in eradication of filariasis.

(d) A significant question is whether, by applying greater perseverance in the further controlled administration of DEC, it will be possible to assure more effective administration and consequent lower infection rates, which will eventually result in eradication of filariasis.

(117) Laird, M.
1967

A coral island experiment.
A new approach to mosquito control
WHO Chronicle, 21, 18-26

The paper describes parallel field experiments on the biological and chemical control of an important vector of filariasis in Tokelau Islands in the South Pacific.

Only two mosquito species are found on Tokelau islands: Ae. polynesiensis the vector of filariasis and Ae. vexans nocturnus which is present in only one atoll Fakaofo. The mosquitos breed in natural or artificial containers, as well as tree holes including man-made reservoirs hollowed into the lower part of the palm tree trunks, locally called "tungu". Surface water marshes were lacking except for crab holes and the taro swamp in which Ae. v. nocturnus breeds.

Previous studies showed that the islands were free of harmful parasites and natural enemies, nor was there any sign of Coelomomyces fungi.

Three widely separated atolls were selected for the trial:

- Nukunono: for biological control experiment,
- Atafu: for larvicide briquette experiment and,
- Fakaofo: as a control where no treatment was applied.

1. Introduction of the fungi in Nukunono

Operations started in September 1958 with the introduction of the Singapore strain of Coelomomyces stegomyiae. The samples were derived from parasitized larvae of Ae. albopictus. Four kinds of fungi material were supplied:

- (a) The debris from the bottom of laboratory containers in which sporangia-rich remains of parasitized Ae. albopictus larvae had accumulated.
 - (b) The sediment from Singapore tree-holes from which infected larvae had been taken.
- The material of these two batches was heated to induce hatching of any eggs it might contain, so that no insect could inadvertently be introduced to the Tokelau islands.
- (c) The bodies of parasitized Ae. albopictus individually dried on filter papers.
 - (d) The living larvae of Ae. albopictus exhibiting the fungus sporangia. Those larvae which remained alive after transportation were killed.

Laboratory inoculum of the fungus could produce infection in the second and third instar larvae of Ae. polynesiensis in a field laboratory on Nukunono.

2. Seeding

Every islet of the atoll was systematically searched for mosquito larval habitats. In all 761 permanent or semi-permanent larval sites, notably tree-holes including "tungu" were seeded with fungal inoculum.

Periodic microscopic examination of different inocula showed that viable Coelomomyces sporangia remained plentiful.

3. The use of dieldrin briquettes on Atafu

On Atafu, a larvicidal trial was carried out, using dieldrin-cement briquettes, each weighing about 20 g and made according to the following formula:

2 parts of cement, 5 parts of coral sand and 3 parts of dieldrin (50% water-dispersible power)

A briquette was placed in each larval habitat discovered, irrespective of the permanence of the habitat. In all, 6500 such habitats were treated, among them 125 drums and tanks used mainly for domestic water storage in the village. More than half the habitats were rat-gnawed coconuts, which were especially abundant on Atafu and were a major source of Ae. polynesiensis there. The day after the briquette was introduced, a larval mortality of 100% was noted in every mosquito habitat checked.

4. Post-treatment assessment surveys

4.1 The first survey: at the end of 1959

This provided the first evidence that Coelomomyces had become established on Nukunono (two of 11 "tungu" containing Ae. polynesiensis yielded 27 parasitized larvae) and revealed the continuing effectiveness of the dieldrin-cement briquettes on Atafu. On this atoll, 31 domestic water drums and tanks still containing briquettes were without any mosquito larvae, while, out of 49 lacking briquettes, 25 harboured developing larvae of Ae. polynesiensis (51%).

4.2 The second survey: April 1960

At Nukunono: 118 of 667 "tungu" and natural tree-holes seeded with Coelomomyces inoculum in 1958, were relocated. Sporangia-packed larvae were collected from eleven of these, and viable resting sporangia identified in the bottom debris of three more. Furthermore, proof of natural dispersal from hand-seeded habitats was obtained, for parasitized larvae were found in two halved coconut shells a short distance from three Coelomomyces-positive "tungu". It was thus evident that the fungal pathogen was now established, at a level well above that prevailing in nature at Singapore.

In preliminary trial in Singapore in 1958, it was estimated that parasitized larvae were found only in 2% of the containers, while at Nukunono 9.3% were positive.

All the 1960 Coelomomyces findings concerned only three of the islets of Nukunono atoll. On these, biting collections yielded appreciably fewer adult Ae. polynesiensis than they had 18 months previously. Catches were repeated at the same sites and same times of the day, the 1960 mean for the whole atoll being only half the 1958 mean.

At Atafu: Twenty-three of the village water drums still held dieldrin-cement briquettes. Twenty-two of them (96%) were free from Ae. polynesiensis, while of the 103 other domestic containers located, only 18 (17%) lacked larvae.

In many cases, household water containers in the Tokelaus are replenished two or three times a week from the large central village tank (for which the church roof acts as a catchment area). Even though they are often completely emptied before refilling, larvae have a good chance of surviving the short interim period in the water film that clings to the bottom of an up-ended container. The author remarked that many of the drums and tanks searched held very few larvae which could be located after prolonged inspection using a powerful torch.

Numerous briquettes were relocated in tungu and natural tree-holes, and a few were also found in the rat-gnawed coconuts in which they had been put in 1958. All these coconuts proved to be rotten and far beyond the stage of holding liquid and serving as habitats for mosquito larvae. Of 50 "tungu" that contained briquettes, 31 (62%) lacked larvae, as compared with a 100% larval incidence in 25 "tungu" without briquettes.

On Atafu, where rats were commoner than on the other two atolls and where a higher percentage of the mosquito population originated from rat-gnawed coconuts, adult catches gave a mean of 90.5 per 15 minutes, by comparison with the 1958 figure of 123.1. On certain islets of this atoll, "tungu" and tree-holes produce the bulk of the mosquitos because of a local scarcity of rats, and the incidence of adult mosquitos there was below the level of the overall figure.

4.3 The third survey: July 1963

Ae. polynesiensis larvae were collected from 35 container habitats on Nukunono. These specimens were sent to a leading authority on Coelomomyces, who recorded parasitized larvae from 13 (37.1%) of the samples - a fourfold increase over the 1960 figure.

It was also found that, even after almost five years, dieldrin-cement briquettes remained larvically effective on Atafu.

5. The public health risk of the larvicide

In October-November 1963, fat biopsies were taken from two volunteers from each of six households at Atafu which had used briquette-containing tanks exclusively for their water supply over the preceding five years. Analysis showed no trace of dieldrin detectable in any of these samples. Further, seven samples from 20 inhabitants of Atafu were taken in October 1965 and were sent for analysis by electron-capture gas chromatography. The analysis revealed no evidence that any health hazard had been created by the 1958 larviciding experiments on Atafu which fully supported the toxicological assurances that had been given at the outset of the projects.

In conclusion, the project demonstrated the feasibility of practical integrated vector control methods combining selective chemical procedures with novel biological measures.

(118) World Health Organization
1967

Instructions for the collection
and forwarding of bloodmeal smears
of mosquitos for identification of
the hosts by precipitin test
WHO unpublished document, ME/67.8

This document was prepared with the aim of assisting field workers for following the correct procedures for sampling blood meal smears of mosquitos from different biotopes, the method of preparing the smears on filter papers and the packing and dispatch of these to the Imperial College Field Station, Silwood Park, Ascot, Berks, UK. The laboratory of this

station has been supported by WHO for carrying out the precipitin testing with standardized procedures. Workers who wish to avail of this service are required to contact the WHO Regional Office in their area. Copies of the document and the record forms are available upon request to WHO Headquarters through the Regional Offices.

(119) World Health Organization
1967 a

Expert Committee on Filariasis
(Wuchereria and Brugia
infections), Second Report
Techn. Rep. Ser. No. 359

The WHO Expert Committee met in Geneva from 19 to 24 September 1966.

The topics discussed in this meeting were as follows:

1. Some recent advances in knowledge on filariasis

1.1 The parasites

1.2 Clinical manifestations

1.2.1 Relation to developmental stages of worms

- Elephantiasis
- Relation of lesions to number of worms

1.2.2 Eosinophilic lung

1.2.3 Geographical variations

2. Methodology in epidemiological assessment

2.1 Standardization of techniques and methods

- The presence of microfilariae in the blood
- The presence of filaria larvae in mosquitos

2.1.2 Entomological

(i) The human blood index

(ii) Vector density relative to man

(iii) Receptivity of the vector to infection

(iv) Survival of the vector

- Parous rate determination, Detinova (1962)¹

- Charts-probability of daily survival of mosquitos and the expectation of infection life from Garrett, Jones & Grab (1964)²

- (v) Use of the proportion parous among adult mosquitos in control schemes.
- (vi) Natural infections in the vector and determination of the survival rate from the number of mosquitos harbouring different developmental stages of the parasite, Laurence (1963).³

2.1.3 Clinical

2.1.4 Immunological

2.2 Selection of methods to be used in surveys

2.3 Presentation and analysis of parasitological survey data

- Microfilaria rate
- Microfilaria density

3. Chemotherapy

3.1 Present status of diethylcarbamazine in filariasis control

3.2 Present status of Mel W.

3.3 The development of drug screening

3.4 Testing of new compounds in man

4. Vector control

4.1 Assessment of vector control methods

4.1.1 Control of Anopheles species

4.1.2 Control of Aedes species

4.1.3 Control of Mansonia species

4.1.4 Current control practices against C. quinquefasciatus

4.2 Review of current research and its trends

- Ecology and biology
- Studies on insecticide resistance and genetics
- Genetic control
- Biological control

5. Orientation to filariasis control

5.1 Advantages and disadvantages of chemotherapy and vector control

- combined control methods

5.2 Relation of filariasis control to malaria control

5.3 Clinical filariasis and the control programme

6. Terminology

7. Research needs

Recommendations

1. Control: Pilot control projects should be established in different geographical areas to assess the effectiveness of chemotherapy and vector control, singly or combined under different epidemiological conditions.

2. Chemotherapy: Because existing filarial drugs have certain limitations for mass treatment projects, the fullest support should be given by WHO to the development of new formulations (e.g. medicated salt) of the drugs at present available and of new antifilarial compounds by fostering and assisting in suitable clinical trials.

3. Vector: Present research on vector biology and control, especially in the field of vector ecology, the development of new insecticides, resistance problems, and genetic control methods, should be continued and encouraged.

4. Immunological tests: The usefulness of filarial antigens for immunological tests in endemic as well as non-endemic areas should be evaluated.

5. Identification of filarial parasites: Field workers require reference centres at which parasitological material can be identified. The need for help is most urgent in the identification of the larval stages of the filarial worms in the vectors. WHO should assist in the establishment of such centres.

6. Animal models: Adaptation of Brugia species or Wuchereria bancrofti to small laboratory animals should be attempted in order to satisfy the need for additional information on the biology of the human filariae and to facilitate screening of new chemotherapeutic agents.

Annex: Mathematical analysis of parasitological data

1. Method of drawing log-probit regression line of frequency distribution of microfilaria count.

2. Microfilaria positive grade and determination of correction factor.

¹Detinova, T.S. (1962) Age-grouping methods in diptera of medical importance. Wld Hlth Org., Monogr. Ser. No. 47

²Garrett-Jones, C. & Grab, B. (1964) Bull. Wld Hlth Org., 31, 71-86

³Laurence, B.R. (1963) Bull. Wld Hlth Org., 28, 229-234

(120) Chow, C.Y.
1968

Vectors of filariasis in the
South Pacific
WHO unpublished document, WPR/FIL/1

The paper is the first of a series of reviews by the author summarizing information on the vectorial status, bionomics and control of the following mosquitos: Ae. (S.) polynesiensis, Ae (S.) pseudoscutellaris, Ae. (S.) tongae, Ae. (O.) vigilax, Ae. (F.) samoanus, Ae. (S.) upolensis, Ae. (F.) fijiensis, Ae. (S.) cooki, Ae. (S.) rotumae and Ae. (S.) futunae.

The following recommendations were made for conducting studies on the vectors taxonomy, vector determination/confirmation, bionomics and control.

1. Taxonomy: Ae. polynesiensis was separated from Ae. pseudoscutellaris by Marks, 1951 (27). Belkin, 1962 (97) mentioned that the taxonomic status of the former species is still open to question, although it has been regarded as a full species. Ae. horrescens is a distinct species but it has been confused in the past with the hairy forms of the above-mentioned two species. It is therefore suggested that a reference centre be established to identify or confirm the identification made by different field workers on mosquitos collected from the South Pacific.

2. Vector determination/confirmation: Ae. fijiensis was regarded by Symes, 1955 (90) as an important vector in Fiji while it was considered by some other workers as only a vector of minor importance, Iyengar, 1965 (108). This may be further investigated. Also there is still no published information on the relative importance of Ae. polynesiensis and Ae. pseudoscutellaris.

3. Bionomics: Little information is available on the bionomics of vectors of the subperiodic W. bancrofti, hence more observations are needed.

4. Control: Before undertaking vector control trials, it is necessary to collect information on vector breeding, feeding and resting habits as well as their susceptibility to insecticides. It is hoped that vector control trials which started in Western Samoa will determine whether such method of control is practical, effective and economical.

(121) Hairston, N.G. &
Jachowski, L.A.
1968

Analysis of the Wuchereria bancrofti
population in the people of
American Samoa
Bull. Wld Hlth Org., 38, 29-59

Studies on intestinal helminths have established reliable values relating the number of eggs in the faeces with the number of worms present. Similar studies on filarial infections are hampered by the fact that the relevance of data of microfilarial counts remains undetermined for many reasons. The first and most obvious reason is that direct count of the number of adult worms present in the people cannot be made. A second reason is the failure to find a relationship between the severity of

symptoms such as elephantiasis and the number of microfilariae per unit volume of blood. The authors indicated that this applies to individuals and refer to the WHO Expert Committee on Filariasis, WHO, 1962 (100) regarding the relationship between the mean mf density and the frequency of occurrence of symptoms, when the entire human population is considered. The authors considered that this distinction between the situation in individuals and that of the population has given rise to confusion and pointed out that the mean mf density in the population is not always related to prevalence. This is most probably due to heterogeneity in exposure with the result that some people acquire much heavier worm burden than would be expected from the proportion of people positive in the entire population. A third reason arises from the lack of uniformity in interpreting mf counts because of the extreme variation that exists in counts from person to person and from time to time with the complications that periodicity can bring about.

The existence of a strain of W. bancrofti with little or weak periodicity offered an opportunity to study other sources of variation in mf counts. Thus data collected in American Samoa over a period of 4 1/2 years during September 1948 - March 1953 are analysed in the present paper. During that period, individuals were examined repeatedly but always at the same time of day in order to minimize minor diurnal variations, hence it did not influence the results. The results of this investigation are presented in four parts. Part I demonstrates the long-term variations in mf density in individuals followed up and shows that a pattern exists. Parts II-IV deal with the nature of the pattern and its explanation, with an analysis of the differences found between individuals. An attempt is made to explain the extreme differences in mf density that exist between individuals when a survey of the whole population is made. Further, the authors developed an approach to estimate worm burdens from mf densities.

Part I: Analysis of microfilaria density in individual cases

Analysis of the mf densities recorded on the same persons at short intervals indicated that the microfilariae are not randomly distributed in the blood stream as the current theory postulates. A plausible explanation is derived from the problem of the size of the microfilaria being 200-300 u by 6 - 8.5 u in diameter moving in capillaries 10 u or less in diameter. Only a slight retardation would be necessary to give a disproportionately high density of microfilariae on the arterial side of the capillary bed. The number of microfilariae in a measured volume of blood from a skin puncture would thus be determined in part by the exact source of blood and this, in turn, would be determined by several factors involved in the technique of blood sampling, such as the exact size of the incision, its depth, the pressure exerted by the collector and the amount of blood taken, all of which could influence the source of blood of consequently the number of microfilariae per unit volume of blood. Thus it could be assumed that the blood taken by venepuncture would have a lower mean mf density than the blood taken from a skin puncture. This was reported by different observers who had not obtained uniform ratios for the two densities. Data of Hawking & Thurston (1951)¹ indicated that the ratio of mf density in skin to

¹Hawking, F. & Thurston, J.P. (1951) Trans. roy. Soc. trop. Med. Hyg., 45, 307-340

that of venous blood of a monkey infected with Dirofilaria sp. is of the order of 1.1: 1, Yorke & Blacklock (1917)¹ reported a ratio of 2:1 with periodic W. bancrofti and data of Amos quoted by Kessel, 1957 (67) indicate a ratio of 50:1. It makes a great deal of difference whether the blood comes from the arterial or the venous side of the capillary bed.

If half comes from each side, the density on the arterial side is double that of venous side, then finger punctures will give a density 1.5 times that found in the venous blood. This value was considered as a compromise between the findings of the above authors with the exception of that of Amos. This ratio has been used for calculating the number of microfilaria in the body of an adult person having a density of 1 mf/mm³ in the finger puncture.

Analysis of the detailed data collected over 4 1/2 years from periodical examination of many subjects indicate that the development of the microfilaraemia takes the form of a wave-like progression of the counts increasing during 3-24 months until a definite peak is reached, subsequent to which a decrease of shorter duration occurs. There was no evidence indicating that the peaks occurred during a particular season and the pattern appeared in all ages and both sexes. This would explain the sharp variations observed in the mf densities in the course of field investigations. The authors advanced the hypothesis that this pattern is a reflection of the reproductive activity of one or more female parasites. This required a long average interval between the mosquito infective bites until fully reproductive female worms are developed, otherwise there would be such a high proportion of overlapping infection that the trend described above would be difficult or impossible to detect.

II. Estimation of the number of reproductive female worms per person

Statistical analysis of data collected from the examination of the same persons indicated that the maximum mf density was of the order of 70 per 60 mm³ of blood or multiples of this number. From this it was concluded that a single female worm reaches a peak output of microfilariae to produce a density of 70/60 mm³ of finger puncture blood. Microfilarial output is not reduced by any possible crowding effect up to a density of at least 14 females. Thus, from an average number of examinations of each person harbouring microfilaria a reasonably accurate estimate of the number of actively reproducing female worms can be obtained. From those cases examined in the present investigation, a mean of 4.67 reproducing females of W. bancrofti per infected person is estimated. When the population is divided into sex and age groups under uniform exposure, the calculated worm load comes to 6.91 per man, 6.07 per woman and 2.93 per child. These figures are considered minimum. When the data of three villages different in the intensity of transmission were examined, the average worm load per positive male was estimated to be 5.93 in the village with lower transmission and 8.32 in the two villages with higher transmission. The number of positive women and children was too small to give valid estimates.

¹Yorke, W. & Blacklock, D.B. (1917) Ann. trop. Med. Parasit., 11, 127

If it were possible to confirm the conclusion that a single female W. bancrofti is capable of producing enough microfilariae to raise their density to 70 per 60 mm^3 of blood, the conclusion would have important implications for studies of the dynamics of transmission, as well as for estimates of worm burden such as those which have been made. Therefore, confirmatory evidence from any source is worth examining.

Although direct evidence from independent sources is not available, it is nevertheless possible to consider whether the estimate is realistic. At least two approaches are available. The first of these, which will be considered in detail below, is to consider the reproductive capabilities of other parasitic nematodes of comparable size. It will be shown that W. bancrofti, according to the conclusions drawn, produces larvae at about the same rate as hookworms produce eggs, when the reproductive products are put in terms of percentage of the parent volume per day. The second approach is to consider the effects of natural selection in arriving at an optimal mf output per female worm. It may be considered axiomatic that, within physiological limits, natural selection will have operated to bring about the maximal average reproductive success per female worm. This average reproductive success is dependent upon survival through the mosquito, and it has been shown repeatedly in mosquito feeding experiments that both high and low densities of microfilariae are deleterious to success in producing third stage larvae. From among the numerous studies, data of Rosen, 1955 (56) have been selected as most pertinent, since the same vector (Ae. polynesiensis) and the same strain of W. bancrofti were used as are concerned in the present study. The factor reflecting the average success of larvae may be listed as follows:

- (i) the proportion of mosquitos infected after a blood meal;
- (ii) the survival of mosquitos after feeding;
- (iii) the survival of larvae in infected mosquitos;
- (iv) the ratio between the density of mf in the blood and the average number carried by a mosquito which has fed on that blood.

Influence of microfilarial density upon effectiveness of transmission of subperiodic *W. bancrofti* by *Ae. polynesiensis*

No. of microfilariae per 60 mm ³ of blood	Proportion of mosquitos infected (a)	Proportion of mosquitos surviving to development of 3rd stage larvae (b)	No. of 3rd stage larvae per mosquito/ No. of larvae in 3 mm ³ of blood (c)	Relative contribution (i.e. a x b x c)
1 - 3	0.08	0.65	1.25	0.065
4 - 15	0.33	0.65	2.31	0.495
16 - 30	0.65	0.65	1.62	0.684
31 - 60	0.80	0.59	1.53	0.722
61 - 150	0.88	0.54	1.27	0.604
151 - 300	0.90	0.47	0.82	0.347
301 - 600	0.95	0.41	0.65	0.253
601	1.00	0.22	0.35	0.077

Calculations made from data in Rosen, 1955 (56)

Rosen showed that all these factors were influenced by the mf density in the blood. At low densities (1-15/60 mm³), few mosquitos became infected; at high densities (more than 150/60 mm³), both survival of mosquitos and the ratio of larvae reaching the third stage of development to the number presumably ingested were low. The details are given in the above table. The average success of larvae through the mosquito phase of the life cycle is 10 times as great for intermediate densities as for either high or low densities. The mf densities at which survival through the mosquito is greatest are those which are estimated to be achieved by one or two female worms. From these considerations, based on natural selection, it would be expected that reproduction would be adjusted to produce the frequency of densities at which transmission would be optimal. From the distribution of the estimated numbers of actively reproducing females among blood positives, it was shown that 30% of all positive cases are estimated to be carrying single mated females, and that nearly half carry either one or two mated females. Thus, the rate of reproduction leading to the most efficient mosquito transmission is such that the maximum number of effective human carriers is maintained, and expectations based on natural selection also indicate that the estimates are realistic. It must be emphasized that neither source of evidence demonstrates the accuracy of the estimates that we have made. They could only indicate serious discrepancies, probably of the order of a factor of 2-5. More accurate checks must be obtained from other sources.

III. The reproductive history of female worms

By examination of individual records of cases which showed a complete or nearly complete history of rise and decline of mf density (based on examination of 60 mm³ of blood), an estimate of 2-2 1/2 years has been calculated as being the duration of the patent period. Considering the rate at which people became negative after being removed from the endemic area, an average annual loss of 0.30 - 0.33 of the positive cases is estimated. If the assumption that the rate of loss is constant can be accepted, then the average duration of the patent period can be calculated as 2.5 - 2.9 years. The decline in the mf density after the peak was examined. There were 15 cases in which a sudden decline occurred. Many of the negatives had some microfilariae left but below the threshold of detection. The average exponential rate of decrease was 0.757 per month. The increased rate of loss of the microfilariae from the blood is interpreted as occurring after the female has stopped producing microfilariae. If this is accepted, the mean length of life of the microfilariae in the blood is 1.88 months or 56.4 days.

On using the above mentioned ratio estimated for the mf count in finger puncture to be that found in the venous blood, the authors calculated the mf number in the body of a man weighing 55 kg as 49 000 of which 36 000 in the blood that is not in the arterioles and capillaries and 12 400 in the blood of the arterioles and capillaries on the basis of a density of 1 mf/60 mm³. Based on this and the previous estimate that a single female W. bancrofti produces sufficient microfilariae to raise the density in skin puncture to 70/60 mm³, an estimate of the maximum standing crop per female worm is 70 x 49 000, i.e. 3.43 million microfilariae was made.

The number of microfilariae in the blood at any moment represents the opposing factors of rate of output by the female worm or worms and the death rate of microfilariae in the body. The latter has been estimated as amounting to an exponential rate of 0.757 per month. Thus, the finite loss rate would be 1 - 0.757 or 0.531 per month. Through mathematical calculations, the authors estimated the production of microfilariae by a female worm as 1.82⁷ during its life time, at a rate of 75128 per day. However, the authors made allowance for the possible premature death of some worms and adjusted the worm production to 1.32 x 10⁷ microfilariae or 6.6 x 10⁶ female microfilariae assuming a sex ratio of 1:1. From the cases that showed a peak of microfilariae substantially lower than 70/60 mm³ and assuming that is correctly interpreted as representing death before completing the normal reproductive life, their survival could be estimated from the height of the peak of the microfilaria density.

From these survivals, the mean exponential death rate can be estimated as 0.02 per month during the first seven months after detectability and 0.05 per month thereafter until the end of the normal reproductive period.

IV. Epidemiological rates and estimation of the true worm burden

An estimate of the rates of acquiring and losing infection may be estimated from age prevalence data. The two stage catalytic model of Muench (1959)¹ was not found suitable for the data of American Samoa since it assumes that a person who has lost his infection will never become positive again. In the present study there were 14 persons who went from positive to negative and vice-versa and there was a larger number of apparently overlapping infections. Through the reversible catalytic model that assumes constant rates of acquiring and losing infection, analysis of data could be made. Using Muench's monogram which apparently applies to the subperiodic *W. bancrofti*, an estimate of the instantaneous rate of becoming positive per day and that of becoming negative per day was given respectively as follows: for men 15 years of age and older 0.074 and 0.05; for women 20 years of age and older 0.053 and 0.097 and for children of both sexes below 15 years of age 0.037 and 0.122. In estimating the worm burden, several steps of calculations were made and the underlying assumptions discussed. Regarding the estimate of unmated female worms in relation to the proportion of people with symptoms of filariasis, the authors raised an important point quoting Wartman (1947)² and Trent (1963)³ and indicated that unmated worms could provide the most reasonable and possible explanation for the high frequency of symptoms in the absence of microfilariae among service men who contracted the infection in the Pacific area during World War II. Thus, it is not feasible to attribute the presence of symptomatic cases which are microfilariae negative to the presence of dead worms alone, while the role of unmated female worms has been shown. Having estimated the proportion of people with unmated female worms and taking into account the determined distribution of the estimated number of actively reproducing female worms among the blood positive people, the distribution of unmated female worms in people with negative blood could be deduced. An estimate was also made for the number of people without mated or unmated females. Combining all the estimates for the distribution of female worms among the different age groups and sexes of the human population, the worm burden was worked out for each group. No estimate was done for the male worms. Assuming an equal sex ratio, the mean number of worms per person was estimated as 8.20 for the male sex (15 years old and older), 4.36 for the female sex (20 years old and older), and 1.62 for the children of both sexes below 15 years and the mean number per infected person was respectively estimated for the above mentioned age groups as 11.18, 7.70 and 4.02. The authors also provided estimates for the worm burden in the village with high transmission rate as the mean per person of 7.04 and per infected person 9.64 and for the two villages with higher transmission rate as 10.24 per person and 13.5 per infected person.

¹Muench, H. (1959) *Catalytic Models in Epidemiology*, Cambridge University Press.

²Wartman, W.B. (1947) *Medicine*, 26, 333-394

³Trent, S.C. (1963) *Amer. J. trop. Med. Hyg.*, 12, 877-887

From these results, the authors concluded that the distributions of the worm burden reflect a combination of three factors:

- (i) the distribution of mosquito-infective bites among people,
- (ii) the distribution of infective larvae among mosquitos,
- (iii) the probability that a given infective larvae will be transmitted in any given bite.

Thus, the distributions are potentially important in understanding of the transmission of the filarial parasite.

They show "clumping" as there is a tendency for some individuals in the same population to readily acquire more worms while others acquire less than would be expected by chance.

In the final discussion, the authors revived the idea of the "critical transmission level" as was discussed by Beye & Gurian (1960)¹ and referred to the theory of net reproduction rate being equal to unity for any parasite population that is at equilibrium, regardless of how much the rate of transmission exceeds the critical level. When transmission is going on at a higher rate than the minimum required to maintain the parasite population, there must be some breaks acting on the parasite curtailing its reproduction. These may be attributed to crowding effects either in the human host or in the mosquito vector. In the present study involving the subperiodic *W. bancrofti*, there has been no evidence of crowding effect in the human host, but in view of the data of Rosen (*loc. cit.*) on the infection and survival of *Ae. polynesiensis*, the wastage of the reproductive potential is quite likely to be in the mosquito host. Mosquitos ingesting a large number of microfilariae have a low survival and those which survive have a lower number of infective stage larvae than expected. Thus heavily infected people represent a great loss to the parasitic population because the chance of transmission from such people is much reduced. In this connexion, it is relevant to determine the distribution of worms among the human population. If the transmission rate is reduced, the proportion of heavily infected people is consequently reduced, the loss to the parasite population becomes proportionately less and an equilibrium is set up with a net reproduction rate of 1. There must be, therefore, a wide range over which compensating mechanisms operate. At lower grades of transmission, another factor becomes important which is the probability of the transmitted female worm becoming mated. When this perpetuates, and the critical transmission level is reached, the parasite population sinks to zero.

¹Beye, H.K. & Gurian, J. (1960) Indian J. Malar., 14, 415-440

Finally, the authors proposed that using the approach adopted in this paper and in papers by Hairston, 1962¹ and 1965², the analysis would be complete if it includes numerical estimates of all factors involved in the parasite life cycle, particularly vector biting rates and the survival of larvae in the naturally infected mosquito. Further, it would be equally important if the analysis is extended to other areas with the same parasite and hosts but with varied rates of acquisition of the infection. A study of this type would, with advantage, elucidate the dynamic of transmission and assist the control efforts.

(122) Hairston, N.G. &
De Meillon, B.
1968

On the inefficiency of transmission of
Wuchereria bancrofti from mosquito to
human host
Bull. Wld Hlth Org., 38, 935-941

The authors having suspected that many bites by infective mosquitos are probably required to develop microfilaraemia, since in the area of Rangoon where for several years the WHO Filariasis Research Unit had been actively engaged in vector control measures, no infection appeared in certain groups of people despite long exposure to mosquito bites. Thus an attempt was made to quantify the probability of success of the larval parasite and its survival through the life cycle in the mosquito and the production of microfilariae in man. An index for the efficiency of transmission was regarded as the fraction of:

$$\frac{\text{No. of people becoming positive per year}}{\text{Total no. of bites by infective mosquitos per year}}$$

The data of the WHO Filariasis Research Project were utilized and a mathematical approach was applied involving certain assumptions. For calculating the denominator, the data of the biting rate of C. quinquefasciatus in Rangoon over 24 hours and by season and the data of the mosquito dissections giving the proportion of mosquitos with third stage larvae of W. bancrofti were used. As the average number of bites per person per day was 227, the number of bites per person per year amounts to 82 873. With an average of 0.0036 third stage larvae per mosquito per year, the number of infective bites per person per year was estimated as 298.

¹Hairston, N.G. (1962) Population ecology and epidemiological problems. In: Wolstenholme, G.E.W. & O'Connor, M. ed., Bilharziasis. London, Churchill, pp. 36-62

²Hairston, N.G. (1965) On the mathematical analysis of schistosome populations. Bull. Wld Hlth Org., 33, 45-62

For estimating the numerator no direct observations were conducted on a cohort of people who were negative and followed up until they became positive to establish the annual rate of becoming positive. Therefore, the authors resorted to age-prevalence data using the catalytic model of Muench (1959)¹ to calculate this rate. The use of Muench's models depends upon several assumptions. The most fundamental is that the epidemiological situation has remained constant for the length of life of the oldest age-group considered. In the case of Rangoon, this assumption is valid for less than 25 years, since endemic filariasis was virtually unknown there before 1941.

Data from various surveys carried out by the Filariasis Research Unit between 1959 and 1967 indicate that over the past nine years changes in prevalence have not been demonstrated. In the present calculations, all age-groups above 20 years have been pooled. The second assumption is that the rate of acquiring the parasite does not vary among age-groups. The validity of this assumption cannot be demonstrated, but there appears to be no reason to question it. A third assumption that will be made is that people who are blood-positive become negative at a constant rate. The choice among Muench's models depends upon one further assumption - that prior infection does not alter the rate at which negative people become positive; Hairston & Jachowski, 1968 (121) have shown that this assumption seems valid for subperiodic *W. bancrofti*, and that good fits to observations can be obtained by the use of the reversible catalytic model of Muench.

Age-prevalence data for three ethnic groups, Burmese, Indians and Chinese living in the Kemmendine Experimental area of Rangoon were analysed. The annual rate of becoming positive was calculated as 0.0094, using the reversible catalytic model. With the two stage-catalytic model which assumes that a person who has lost his infection never becomes positive again, the rate was calculated as 0.012. These values were taken as the range for calculating the efficiency of transmission index. Thus, the index ranges between $3.15-4.03 \times 10^{-5}$ or 24 814 - 31 746 bites would be needed to produce microfilaraemia. This estimate was based on the analysis of age-prevalence data with the Burmese constituting about 93%. For several reasons, the authors considered the estimates quite exaggerated. When the calculation was made on the data of the Indians who showed significantly higher microfilariae prevalence rates than those of the Burmese and bearing in mind that the biting rates were more representative of the exposure of the Indians than the Burmese, the index of the efficiency of transmission came down to a range of 17 036 - 24 814 bites using the two values of the above annual rates of becoming positive.

As there was a possibility that an unknown proportion of the human population has such a low density of microfilariae that cannot be detected by the routine sampling methods used in the blood surveys and since new techniques for sampling a larger volume of blood gave microfilaria counts four times as high as those recorded by the normal sampling method, a mathematical correction of the age-prevalence data was made for the Indian population.

¹Muench, H. (1959) Catalytic Models in Epidemiology, Cambridge University Press.

Using the above mentioned two catalytic models on the revised prevalence data, the annual rate for becoming positive was calculated as 0.018 with the reversible model and 0.02 with the two-stage model. With these two annual rates, the index of the efficiency of transmission was calculated as 16 566 and 14 903 respectively, and the authors approximated the average as 15 500 infective bites that would be necessary to produce a case of microfilaraemia.

As this estimate was surprisingly high, the authors applied step-by-step analysis for determining the fate of the parasite from its leaving the mosquito until it reaches maturity and mates in the human host. Experiments made in Rangoon and elsewhere indicated that 41.4% of the infective larvae leave the mosquito at the moment of biting the host and that 32% succeed in penetrating the skin, i.e. 0.1325 larvae succeed in reaching the tissues of the human host at a single mosquito feed. Further the authors worked out the probability of a randomly selected infective mosquito bite that would give rise to male and female larvae reaching the tissue of the human as 0.0325 host. Subsequently, the death rate of the worm during maturity in the human host was calculated during the pre-patent period (estimated to be a minimum of eight months and four days) as 0.00147. This estimate was based on data of B. malayi in experimental animals since no such data are available for W. bancrofti. By adopting the estimate made by Hairston & Jachowski (loc. cit.) for the death rate of the mature female worm of subperiodic W. bancrofti as being 0.02-0.05 per month, the mean length of life of the adult worm was estimated as 2-4 years. Combining the probability of receiving both sexes of the worms at a single mosquito bite with the probability of the immature worm to surviving to maturity i.e. 0.0325×0.00147 yields an efficiency index of 4.78×10^{-5} or put in the inverted form as 20 921 infective bites needed to cause a single case of microfilaraemia.

This estimate fits well with the estimate made from the age-prevalence and the entomological data, both are surprisingly high and the authors could not find any explanation except that a proportion of people who are apparently negative in the study area of Rangoon must be harbouring immature or dead worms. Skin tests carried out by the Filariasis Research Unit showed that a large proportion of people gave positive reactions but whether this is due to W. bancrofti cannot be ascertained.

Having experienced the difficulty in explaining the apparent inefficiency of the parasite in Rangoon, the authors drew attention to the fact that they made certain assumptions that may not be strictly valid and that they had to use data of Brugia in the absence of similar data on W. bancrofti. The authors further indicated that W. bancrofti is the only filarial parasite in man and the vector.

(123) Hitchcock, J.C.
1968

UCLA Mosquito studies in Tonga, 1968
New Jersey Mosq. Exterm. Assn. Proc.
56th Annual Meeting, pp. 116-123

Prior to the current study, only one species of mosquito, *Ae. (Aedimorphus) nocturnus* had been reported from Niuatoputapu (Ramalingam, 1965).¹ Immature and adult specimens of five additional species were collected in 1968 and identified as: (1) *Ae. (Finlaya) oceanicus*; (2) *Ae. (Stegomyia) aegypti*; (3) *C. (Culex) annulirostrus*; (4) *C. quinquefasciatus*; and (5) *C. sitiens*. In addition, numerous specimens of *Ae. scutellaris* group, adult and immature stages, were taken on Niutoputapu, and adults were taken on Tafahi and Niuao'ou. However, no definitive determinations will be disclosed until intensive larval surveys are completed during field studies in June 1969.

Biting and landing densities: the standard 10-minute human bait collections were made at alternate houses yielding sample stations representing 50% of the houses. The relative size of the village is shown by the number of stations and the results of the survey are given in the following table:

	<u>Hihifo</u>	<u>Vaipoa</u>	<u>Falchau</u>	<u>Kolokakala</u>
Number mosquitos captured (Number stations)	453 (62)	369 (26)	1115 (19)	367 (14)
% Stations density 1 or more (% stations density zero)	36.1 (19.4)	61.6 (3.9)	100.0 (0.0)	7.15 (0.0)
Biting-landing density per minute	0.73	1.42	5.9	2.6
% mosquito dissected	56.6	48.0	16.7	4.4
% infected all stages	6.5	2.3	0.54	4.4
% infected third stage	0.72	0.0	0.0	1.8
Mean no. all stages larvae/dissected mosquito	0.38	0.16	0.0054	0.18
Potential transmission index of Kessel, 1957 (68)	68.5	55.8	7.8	120.6

¹Ramalingam, S. (1965) The mosquito fauna of Samoa and Tonga and its relation to subperiodic of bancroftian filariasis. U. Calif. Press, Ph.D. Thesis

The village Kolokakala, with areas having some bush, yielded the second highest density index but had the highest infection and infective rates.

(124) Laurence, B.R.
1968

Elephantiasis and Polynesian origins
Nature, 219, 561

The author made a historical review of the information collected by early explorers to Eastern and Western Polynesia on elephantiasis and tried to trace how W. bancrofti was introduced to the area. In the course of the review, the author gave an account of the periodic and subperiodic forms of this parasite, their distribution in the Pacific area, and their vectors, describing the adaptation that must have occurred for the subperiodic form to be transmitted by daytime biting vectors of the Ae. scutellaris group.

(125) Ramalingam, S.
1968

The epidemiology of filarial transmission in Samoa and Tonga
Ann. trop. Med. Parasit., 62, 305-323

1. Vector studies: Results of experimental and natural infections in mosquitos are given in Table 1.

Ae. polynesiensis is the principal vector in the South Pacific area. Ae. upolensis is restricted to Samoan islands and plays an important role in transmission in interior and coastal villages and plantations closely surrounded by bush. It is considered a bush mosquito, is a diurnal biter and feeds readily on man.

Ae. tabu is much like Ae. polynesiensis in its breeding habits, and is an important vector in Tonga. It is a strictly diurnal biter and was not found resting indoors. It is a bush mosquito, most abundant in plantations.

Table 1. Showing the natural and experimental infections of mosquitos with *Wuchereria bancrofti* in Samoa and Tonga

Locality and species	No. dissected	Mosquitos positive		Mosquitos positive	
		All stages of larvae	Per cent.	Stage III larvae	No.
American Samoa:					
<u>Ae. (S.) polynesiensis</u>	1274	66	5.2	13	1.0
<u>Ae. (S.) upolensis</u>	48	3	6.3	1	2.1
<u>Ae. (F.) samoanus</u>	371	20	5.4	7	1.9
<u>Ae. (F.) oceanicus</u>	76	0	0	0	0
<u>Ae. (F.) tutuilae</u>	2	1		1	
<u>C. quinquefasciatus</u>	18	0	0	0	0
<u>C. (C.) annulirostris</u>	3	0	0	0	0
<u>Ae. (F.) samoanus*</u>	10	10	100	10	100
<u>Ae. (F.) tutuilae*</u>	1	1		1	
Western Samoa:					
<u>Ae. (S.) polynesiensis</u>	407	34	8.4	12	2.4
<u>Ae. (S.) upolensis</u>	59	7	11.9	1	1.7
<u>Ae. (F.) samoanus</u>	380	17	4.5	1	0.3
<u>Ae. (F.) oceanicus</u>	60	0	0	0	0
<u>Ae. (Aedim.) nocturnus</u>	2	0	0	0	0
<u>C. (C.) quinquefasciatus</u>	51	0	0	0	0
<u>C. (C.) annulirostris</u>	8	0	0	0	0
Tonga:					
<u>Ae. (S.) tabu</u>	274	16	5.8	1	0.4
<u>Ae. (S.) aegypti</u>	19	0	0	0	0
<u>Ae. (F.) oceanicus</u>	13	0	0	0	0
<u>Ae. (Aedim.) nocturnus</u>	3	0	0	0	0
<u>C. quinquefasciatus</u>	76	0	0	0	0
<u>C. (C.) annulirostris</u>	1	0	0	0	0
<u>Ae. (S.) tabu⁺</u>	12	8	66.7	6	50

*Experimental infections with wild adults

⁺Experimental infections with reared adults

Ae. samoanus was recorded only from both islands of Samoa. There can be little doubt that the species is a highly efficient vector, judging from the infective rates in wild caught and experimental infection. It was found to be abundant in the interior villages and some coastal village closely surrounded by bush. As will be shown in transmission studies, this species in such villages could even be more important than Ae. polynesiensis. It is a leaf axil breeder, a nocturnal biter and rests primarily outdoors although a few specimens were found resting indoors.

Ae. tutuilae was only reported from Samoas islands. It was found to be a leaf axil breeder and is thought to be a nocturnal feeder. Additional information is needed on its incrimination and bionomics.

As to C. quinquefasciatus, the author referred to the conflicting reports regarding its importance in the transmission of the subperiodic form of W. bancrofti. From his observations in Tonga and the Samoas, it appeared that this species is not a vector of significant importance. Its greatest density was found around ports and in densely populated islands.

2. Transmission studies: Reference was made to the controversy over the sites where the greatest amount of transmission of filariasis occurs in Samoa from the time of O'Connor, 1923 (3) who indicated that transmission occurred in villages which was followed by Byrd & Bromberg, 1945 (12) who stressed that the villages are the hyperendemic foci of infection. This was further supported by Iyengar, 1959 (76) but was opposed by Jachowski & Otto, 1952 and 1953 (31 and 40) who provided evidence through the utilization of an index termed "transmission potential" that transmission is in wild ecological niches and that the high microfilaria rates in bush villages was due to the extension of the human habitation to the mosquito habitat. These authors also correlated mf rates in different age groups and sexes of the human population with their localities and their contact with bush conditions. McCarthy and Fitzgerald, 1956 (53) working in Western Samoa gave support to the last named authors. In view of this, the present author organized a study in American and Western Samoa aiming at verifying the sites of transmission.

Eleven villages and the town of Apia were selected for intensive mosquito survey adopted from Bonnet et al., 1956 (58). Since the author found that the index "transmission potential" of Jachowski & Otto, 1953 (40), i.e. mosquito density X % of mosquito infected did not relate in any way to the mf density in the human population, he used the "potential transmission index" of Kessel, 1957 (68). This index takes into account the number of developing larvae in mosquitos since it was found in Tahiti that the number of these larvae in the infected mosquitos decreases as the microfilaria density in the human population drops.

Potential transmission indices for each species and for all species combined as well as each of the representative area selected for the study are shown in Table 2. It should be noted that four of the villages in American Samoa, namely Amanave, Amouli, Malaeloa and Aoa were selected for a DEC trial. Hence, their data represent post-treatment indices. They were not used for comparison with those of other villages, but with their pre-treatment data.

2.1 Transmission in open villages versus bush villages

American Samoa: Considering the villages alone, transmission in bush villages was much higher than in the open villages. The high rates in these villages were associated with transmission by both Ae. polynesiensis and Ae. samoanus, and in certain cases by Ae. upolensis also. For example, in Aoloau the transmission index of Ae. samoanus of 116.5 was much higher than that of Ae. polynesiensis of 79. The addition of a night-biting vector in the bush villages increases the transmission and the mf rate in these villages.

In the open villages, Ae. polynesiensis played the major role in filariasis transmission. This was particularly true on Tutuila where Ae. samoanus breeds almost exclusively in the leaf axils of the creeping plant, Freycinetia spp., which occurs only in the native bush and jungle.

Table 2. Showing the potential transmission index of *Aedes (S.) polynesiensis*,
Aedes (S.) upoluensis, and *Aedes (F.) samoanus* in various villages in
 American and Western Samoa

Locality		Mosquito density*				Infection rate†				Filaria density‡				Transmission index***			
		<i>Ae. poly-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>	<i>Ae. upo-</i>								
		<i>niensis</i>	<i>samoanus</i>	<i>lensis</i>	<i>samoanus</i>	<i>niensis</i>	<i>lensis</i>	<i>samoanus</i>	<i>niensis</i>	<i>lensis</i>	<i>samoanus</i>	<i>niensis</i>	<i>lensis</i>	<i>samoanus</i>	<i>niensis</i>	<i>lensis</i>	<i>samoanus</i>
American Samoa - Tutuila																	
Aolosau	July 1963	BV	0.3	0.01	1.0	12.5	5.9	1.0	0.5	79	116.5	195.5					
Asau	Mar	1963	BV	1.2	0.1	3.0	15.6	8.1	3.5	0.7	0.1	202.5	18.4	87.6	308.5		
Aoa	July	1962	BV	0.7			17.3			1.1		200.8	not done		200.8		
Amouli	July	1962	OV	0.3	P		18.2			0.2		12.6					
Amavea	July	1962	OV	0.5	P	0.8	10.3	8.8		0.4	0.2		40.8				
Malaelia	July	1962	OV	1.0	P	1.0	10.4			0.5	0	0					
Western Samoa - Upolu																	
Alesia	Apr	1963	BV	0.8	0.2	0.7	9.4	10.0	9.3	0.8	0.2	0.2	162.3	6.9	39.6	208.7	
Manumu	Apr	1963	BV	0.4	0.1	0.5	12.9	6.7	4.1	0.6	0.6	0.1	55.2	89.5	16.7	161.4	
Solaoalo	Apr	1963	OV	0.2	P	0.1	8.6			0.1	0.1	0.1	105				
Apia Town	Apr	1963	OV	0.2	P	2.1	0.2	10.8	27.3	6.7	0.1	0.1	115	5.2	8.3	13.5	
										0.2	0.4		121.5				
- Savaii																	
Aopo	Apr	1963	BV	0.4	0.02	9.1	6.8	33.3	0	0.2	0.4	0	13.5	2.1	0	15.6	
Asau	Apr	1963	BV	0.1	0	2.0	0		5.5		0.3	0		151.7	151.7		

*Average number of mosquitoes per minute

†Percentage dissected mosquitoes containing larvae

‡‡Average number of larvae per dissected mosquito

+++Mosquito density x filaria density x 250

P = Plantation

BV = Bush village

OV = Open village

Aedes samoanus played an important part in transmission in the two bush villages studied.

Western Samoa: As in American Samoa, transmission in the bush villages of Western Samoa was much higher than in the open villages. Table 2 shows that this was generally true except in the village of Aopo. This exception is explained later. The epidemiology of filarias in Western Samoa was slightly different in the leaf axils of pandanus besides those of Freycinetia. As pandanus was commonly grown in nearly every village, Ae. samoanus played a role in transmission in the open villages as well as in the bush villages. For instance, in the village of Solosolo, the density of Ae. samoanus was slightly higher than that of Ae. polynesiensis. In Asau and especially in Aopo, on Savaii, the density of Ae. samoanus was exceedingly high. In fact, in one of the stations indoors, in the village of Aopo, 237 Ae. samoanus were collected within a period of 10 minutes (2000-2010 hours). These two villages were notorious among the inhabitants of Western Samoa for their high mosquito densities. A total of 100 Ae. samoanus was dissected from Aopo but they were all negative. It is suspected that the greater proportion of the Ae. samoanus were freshly emerged and were taking blood for the first time. This could be the reason for the apparent low transmission potential index in Aopo. Asau, which was more like a bush village than an open village, showed a very low density of Ae. polynesiensis, and Ae. samoanus played the major role in filariasis transmission.

2.2 Transmission in villages versus plantations

Samoas: From the previous section, it is clear that in the bush villages, most of the transmission occurred in the village itself and there was a high rate of transmission during both the day and the night. Some transmission did occur in the plantations as well. It is in the open villages that the old question arises, "Where does transmission occur, in the village or in the plantation?" From the evidence collected during this study, it is clear that the amount of transmission in the two areas varied a great deal from village to village. Transmission was probably not restricted either to bush and plantations or to the village alone. Transmission did occur in both places and the relative proportion depended on the particular ecological situation at the time.

Mention must also be made of the important socioeconomic changes that have occurred in American Samoa since the time that Jachowski carried out his investigations (1948-1950). Much construction and development has taken place on Tutuila; roads have been extended and a number of Western-type buildings, including schools, offices and apartment houses have been built. The men no longer spend a good part of the day in plantations, but most of the able-bodied ones now work for the Government or in industry, many in the urban area. They work mostly in the bay area (Pago-Pago), or on roads, construction sites and so on during the day and return to their villages at night. During weekends, they may work in the plantations which are now being worked for the most part by the women and the older men. They buy the part of their food that they cannot produce, even importing taro into Tutuila from the Manua group of islands and from Western Samoa.

A garbage pick up scheme has been functioning for several years for the villages on the southern side of Tutuila. The changes must necessarily affect the transmission of filariasis in Tutuila either directly or indirectly.

Similar changes are taking place, but much more slowly, in Western Samoa where an agricultural economy still prevails. Most of the exports from Western Samoa are agricultural products, e.g. copra, bananas, cacao and vanilla. This socioeconomic structure requires most of the men to work in the plantations following traditional practice.

N.B.: The author did not explain the epidemiological situation in the town of Apia with a potential transmission index of as high as 121.5 for Ae. polynesiensis, the only vector recorded in the township.⁷

Tonga: In Tongatabu, intensive mosquito surveys were made in two villages and in the town of Nuku'alofa. One of the villages (Hofoa) is situated on the coast and the other (Matahau) in the interior. Both villages were similar, i.e. the houses were situated on both sides of the road. The area around the houses was only partly cleared and often the bush was not far from the houses. The vector situation was simple as Ae. tabu was the only vector on Tongatabu. The transmission indices of Ae. tabu in the two villages were Hofoa - village 67.5, plantation 43.7; Matahau - village 97.5, plantation 87.0.

This situation recalls the open villages in Tutuila. Transmission occurred in both the village and the plantation on Tongatabu.

3. Periodicity studies

The author carried out observations on periodicity in two villages, Aoloau, a bush village where Ae. samoanus showed a high potential transmission index (Table 2), and Amanave, an open coastal village where the diurnal biter Ae. polynesiensis was the only vector. In the former village, three blood smears of 20 mm³ each were made every two hours throughout the 24-hour period from each of six of microfilaria carriers with low, medium and high density, while in the latter village, only two smears of the same volume, were taken from four similar microfilaria carriers. The results showed that the periodicity pattern was the same in carriers from the two villages; it was essentially compatible with that reported by Rosen, 1955 (57) and Iyengar, 1955 (51). Thus, it appeared that in Tutuila, there was no shift in the mf density to correspond with the maximum biting activity of the predominant vectors. As the mf density remained high until 2200-2400 hours and Ae. samoanus becomes active after sunset and its biting peak is reached around 2300 hours, there was ample opportunity for it to become infected and for Ae. polynesiensis to pick up the infection during the day.

4. Observations on Dirofilaria immitis

Of 10 dogs examined by 20 mm³ blood smears, five were positive for this parasite in American Samoa, where developing and infective stage larvae of this parasite were found only in two species of mosquitos, Ae. polynesiensis and Ae. samoanus. In Tonga, no dogs were examined, and none of the mosquitos dissected harboured D. immitis.

The following criteria was used to separate the larvae of W. bancrofti from D. immitis if the latter was found in mosquitos dissected:

Throughout the survey, mosquitos harbouring only microfilariae were considered to be negative as the microfilariae may have been derived from a blood meal on the bait.

In the first stage (sausage) and second stage, the site of development was the sole criterion, W. bancrofti occurring in the muscles of the thorax and D. immitis in the Malpighian tubules of the abdomen.

The third stage larva of W. bancrofti was distinguished by the presence of three and sometimes four anal papillae instead of only one as found in D. immitis, and by a greater length, about 1600 μ instead of 1000 μ .

(126) Suzuki, T. & Maung, T.M.
1968

Review of entomological activities in the filariasis control pilot project in Western Samoa
WHO unpublished document,
WPR/FIL/6

The filariasis control pilot project in Western Samoa was started in August 1965. Since then, the assessment of mass drug administration with DEC has been conducted by blood surveys, skin-test surveys, entomological and clinical surveys. Though no entomologist was assigned to the project, a considerable amount of data on entomological assessment of MDA and on bionomics of vector mosquitos has been compiled by WHO consultants. This paper presents the data available at the project so the situation can be assessed and future activities planned.

1. Mosquito species in Western Samoa

According to the recent extensive survey in 1963 by Ramalingam (1965)¹, the following nine species belonging to three genera were found in Western Samoa:

Ae. (Finlaya): samoanus, tutuilae, oceanicus

Ae. (Stegomyia): aegypti, polynesiensis, upolensis

C. quinquefasciatus, annulirostris, sitiens

This list covers the whole mosquito fauna in Western Samoa at present, though some others: C. samoensis and Mansonia fijiensis, were recorded in Upolu Island according to Belkin (97).

The infection rate in the above three main species collected by human bait catches is shown in Table 1. All the data in the table are those before mass drug distribution was undertaken. Similar data by Ramalingam (loc. cit.) and Belkin (loc. cit.) are shown in the table for comparison.

As to the other species, no record on filariasis infection is available in pretreatment status of the present project. According to Ramalingam (loc. cit.) the other species, Ae. oceanicus, C. quinquefasciatus and C. annulirostris were proved negative.

According to the data in Table 1, it is apparent that Ae. polynesiensis is the most important vector in Western Samoa. Ae. upolensis may be the next in importance, but since its density is rather low in or near villages, its transmission potential may not be very high. From the low infective rates given in Table 1, it appears that Ae. samoanus has relatively short longevity.

¹Ramalingam, S. (1965) The mosquito fauna of Samoa and Tonga and its relation to subperiodic bancroftian filariasis. U. Calif. Press, Ph.D. Thesis.

TABLE 1

INFECTION RATE OF THREE MOSQUITOS SPECIES IN WESTERN SAMOA
BEFORE MASS DRUG ADMINISTRATION

	Dissected	Number of mosquitos	
		Infected (infection rate)	Infective (Infective rate)
<u>Ae. polynesiensis</u>			
Present Project (1965)*	1120	106 (9.46%)	29 (2.60%)
Ramalingam & Belkin (1964)	407	34 (8.35%)	12 (2.95%)
Belkin (1962)	251	21 (8.37%)	9 (3.58%)
<u>Ae. samoanus</u>			
Present Project (1965)*	466	20 (4.29%)	4 (0.86%)
Ramalingam & Belkin (1964)	380	17 (4.29%)	4 (0.86%)
Belkin (1962)	359	15 (4.18%)	1 (0.28%)
<u>Ae. upolensis</u>			
Present Project (1965)*	176	13 (7.39%)	3 (1.70%)
Ramalingam & Belkin (1964)	59	7 (11.9%)	1 (1.69%)

Note: *By D.D. McCarthy

2. Breeding places

The main breeding sources of three vector mosquitos and four non-vectors in Western Samoa were briefly described.

Ae. polynesiensis has a wide variety in its breeding sites, both natural and artificial. The most common ones producing abundant mosquitos are coconut shells, crab holes and tree holes.

The breeding sites of Ae. samoanus are restricted to leaf axils of several kinds of trees. In addition to Freycinetia and Pandanus, it was found that Ae. samoanus breeds in the leaf axils of Colocasia esculenta. Abundant mosquitos were found in all villages, especially in the interior ones. According to Ramalingam (loc. cit.), this species is not common in American Samoa because of scanty breeding in Freycinetia and Pandanus. In contrast, the species is very common in Western Samoa. This is mainly due to the extensive breeding in these plants. There has been an increase of C. esculenta plantations since the last hurricane, as the people found that it withstood the hurricane much better than the other types of plantations. It is emphasized here that the role of Ae. samoanus in filariasis transmission in Western Samoa should not be underestimated.

Ae. upolensis is not common in Western Samoa and it is rather difficult to find out the breeding sites. According to Ramalingam (loc. cit.), its larvae were collected only in a fern tree-stump. This species should be described as a forest mosquito. Though the infection rate of the species is sometimes high, the infection potentials seem rather low, because of less chance to bite humans.

3. Resting habits

Any of the three vector mosquitos could not, or rarely be observed resting for a long time in the houses both in daytime and night time. Inspection of "fales" (native house) shows no evidence of the mosquitos resting indoors. Neither do they rest in modern types of dwellings which have walls. However, on three occasions, several Ae. polynesiensis were seen to rest on mats on the floor of the "fale", but not for more than a minute.

Adults of polynesiensis were observed resting in some shelters protected from wind and sunshine near the breeding places, e.g. on the under surface of fresh leaves, on dried leaves on the side of the inside coconut shells and on the ground in the vicinity of crab holes.

No observation has been made as yet, on the resting habits of the other two vector mosquitos in the present project.

4. Biting cycle

Results showed that polynesiensis increased their activity twice in the day, once in the early morning and once in the later afternoon.

The number of mosquitos caught was always highest in the bush station and lowest in the clearance section. Thus, bush or plantation was the most favorite environment for polynesiensis to attack human bait, the house was next and open clearance last.

It should be noted that although polynesiensis was found to be most active in the daytime, a few were biting humans at the night. In the early hours of the night, the number of polynesiensis per man hour was 6 at 20.15 and 6 at 21.20 h. This may have been partly due to the influence of a torch used for the collection. Thus, if humans use a light, mosquitos may attack at night though in smaller numbers than in the day.

Ae. samoanus is known to be nocturnal in its habits. In night catches in Solosolo, Ae. samoanus were first collected at 19.55 h. They gradually increased until at 23.00 h the rate was 241.5 per man hour. Thus, the peak activity of samoanus is at about 23.00 h.

Ae. samoanus was found to bite humans occasionally during the day. In an extensive survey from 8.30 h to 18.30 h, seven samoanus were caught, six in the morning and one in the afternoon; four were in houses, two in bushes and one in clearance. Since 4400 minutes (10 minutes x 440 times) were spent in daytime collection, the density of samoanus was estimated as 0.095 per man hour, an extremely low activity for the daytime.

5. Entomological assessment of MDA

MDA in Western Samoa was started in August 1965 and ended in July 1966, though pilot studies in four pilot control areas with various drug distribution methods were carried out prior to this, from November 1964 to April 1965.

The blood surveys covering all villages have continued since December 1966 up to the present time for the purpose of the assessment. Entomological assessment has thus been carried out in relation to blood surveys. The mosquitos caught were brought to the laboratory, and all or a part of them were dissected for infection of filarial larvae.

Data collected from December 1966 to April 1968 on Ae. polynesiensis and Ae. samoanus are compiled in Table 2, including those collected before drug distribution.

In Ae. polynesiensis, the number of infected mosquitos, or those that harbour all stages of filarial larvae, was 18 out of 2425 mosquitos, showing the infection rate of 0.74%. The number of the infective mosquitos, or those harbour only third stage larvae, was only two out of 2425 mosquitos, giving the infective rate of 0.082%.

In Ae. samoanus, two infected mosquitos with all stages of the larvae were found in a total of 152 mosquitos dissected, and no infective mosquito was found.

Kessel & Massal, 1962 (99) discussed the target level for control of transmission of subperiodic bancroftian filariasis, and in the project in Tahiti they presented six important indices which were set as arbitrary points which should not be exceeded.

These arbitrary control levels by the above authors and the levels in the present project after control are listed below for comparison.

	<u>Arbitrary control level (by Kessel & Massal)</u>	<u>Present project (after control)</u>
1. % positive for all-stage larvae	5%	1.32% (<i>Ae. samoanus</i>) 0.74% (<i>Ae. polynesiensis</i>)
2. % positive for mature larvae	1.0%	0.00% (<i>Ae. samoanus</i>) 0.082% (<i>Ae. polynesiensis</i>)
3. Density of mature larvae	data not given	0.013 (<i>Ae. samoanus</i>) 0.017 (<i>Ae. polynesiensis</i>)
4. Prevalence of mosquitos (No. per minute)	0.1	1.03 (<i>Ae. samoanus</i>) 0.77 (<i>Ae. polynesiensis</i>)

In the present project in Western Samoa, it is apparent that the levels are far lower than those presented by Kessel & Massal, except prevalence of mosquitos. Higher density of vector mosquitos in the present project seems to be natural, because so far no vector control measures have been carried out.

MDA thus carried out in Western Samoa could reduce the infection rate to about 1/13 in *Ae. polynesiensis* and 1/3 in *Ae. samoanus*, and the infective rate to about 1/32 in *Ae. polynesiensis* comparing with those before the control procedure. It may be concluded that the control measures by MDA have proved to be effective, so far entomological assessment in two species of the vector mosquitos are concerned.

6. Site of transmission

In an extensive survey of mosquitos during December 1966 to April 1968, catches were usually done (1) in bushes or plantation, (2) in and near houses and (3) in open clearances. In Table 3, density of mosquitos, infection rate and potential transmission index were listed in each collection site. Potential transmission index (PTI) was calculated by the formula of Kessel, 1957 (68).

As mentioned earlier, density of mosquitos was highest in bushes followed by that of houses and was the lowest in clearances. However, the infection rate was 1.36% in houses and 0.67% in bushes, i.e. 2.0 times higher in houses than in bushes. This may have been due to two reasons: one, the mosquitos close to human dwellings may have more chance to pick up microfilariae, resulting in a higher infection rate in mosquitos collected in or near houses; the other reason could possibly be due to a larger proportion of a young nulliparous population in bush mosquito population; since the main breeding sources of *Ae. polynesiensis* would be in the bushes. In these observations, no infected mosquito could be found in open clearances.

As shown in Table 3, PTI was 5.68 in houses, being 1.8 times higher than in bushes. The main sites where filariasis transmission would occur are still questionable. Jachowski & Otto, 1952 (31) indicated that they are in the bush, and Iyengar, 1965 (108) on the contrary, pointed out that transmission would occur mainly in villages. Ramalingam, 1968 (125) showed conclusively that "transmission does occur mainly in both places and not just in one and the relative proportion depends on the particular ecological situation".

The higher infection rate and PTI in mosquitos caught in or near houses, than in bushes, might suggest the probability of intensive transmission just in or near the dwellings. However, most of the villages in Western Samoa, especially those interior villages far from the coast, are closely surrounded by bushes, sometimes each house is in the midst of bushes or plantations. The particular location of villages or houses in Western Samoa suggests the frequent contact between humans and mosquitos in bushes or plantations. Accordingly, the probability of the transmission may be high also in bushes.

7. Seasonal prevalence of infection rate and density of *Ae. polynesiensis*

In order to know the prevalence of the infection rate according to season or period in which they were dissected, the records of dissection were arranged with 3 to 5 months interval. No trend in seasonal prevalence of the infection rate was observed. This may show the stability of filarial infection in the mosquitos when the mf rate in the human reservoir is very low.

Monthly indices of the density of *Ae. polynesiensis* caught in bushes or plantations showed that they were abundant from January to August but they declined from September to December.

8. Density and infection rate in *Ae. samoanus*

Though only seven *Ae. samoanus* were collected in daytime from 09.30 h to 16.30 h, one was found to be infected. The density of *Ae. samoanus* in night-time collection from 19.55 h to 22.0 h was very high, giving 115 per man hour or 1.92 per minute. The density would increase if catches were continued into the night during this observation. Potential transmission index of *Ae. samoanus* in night-time collections was calculated to be 3.31, slightly higher than that of *polynesiensis* in daytime collection which was 3.18.

Infection rate of Ae. samoanus collected during both day and night was 1.3%. This rate was higher than that of Ae. polynesiensis (0.74%). Though rather scanty in or near Apia, Ae. samoanus could be collected abundantly in most of the villages, especially those surrounded by bushes with many pandanus trees.

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Belkin (1962)	251	21 (8.37%)	9 (3.58%)
<u>Ae. samoanus</u>			
Present project (1965)*	466	20 (4.29%)	4 (0.86%)
Ramalingam & Belkin (1964)	380	17 (4.47%)	1 (0.26%)
Belkin (1962)	359	15 (4.18%)	1 (0.28%)
<u>Ae. upolensis</u>			
Present project (1965)*	176	13 (7.39%)	3 (1.70%)
Ramalingam & Belkin (1964)	59	7 (11.9%)	1 (1.69%)

Note: *By D.D. McCarthy

TABLE 2
SUMMARIZED RESULTS OF ENTOMOLOGICAL ASSESSMENT OF MASS DRUG ADMINISTRATION

	Number of mosquitos		Infection		Infective		Number of filarial larvae	Density, number per man hour	PTI
	Caught	Dissected	Number of mosquitos	%	Number of filarial larvae	%			
<u>Ae. polynesiensis</u>									
Before MDA* (1965)	-	1120	106	9.46 (A)	-	29	2.60 (A)	-	-
After MDA** (Dec. 1966 to (Apr. 1968)	3381	2425	18	0.74 (B)	40	2	0.082 (B)	2	46.0 3.18
B/A				1/12.8			1/31.7		
<u>Ae. samoanus</u>									
Before* (1965)	-	466	20	4.29 (A)	-	4	0.86 (A)	-	-
After** (Dec. 1966 to (Apr. 1968)	372	152	2	1.32 (B)	42	0	0 (B)	0	62.0 3.35
B/A				1/3.1			0		

- Note: (1) *By D.D. McCarthy
 (2) **By Tin Maung Maung
 (3) PTI represents potential transmission index
 (4) - represents no data available

TABLE 3

DENSITY AND INFECTION RATE OF AE. POLYNESIENSIS CAUGHT
IN VARIOUS TYPES OF LOCALITY (POST-CONTROL STATUS)

Locality	Total no. of mosquito caught	Total time of collection (minute)	Density		No. of mosquito dissected	Infection			No. of filarial larva	PTI
	Per hour	Per minute	No. of mosquito	%						
Bush	2543	2930	52.1	0.87	1 793	12	0.67	26	3.15	
House	629	880	42.9	0.71	441	6	1.36	14	5.68	
Clearance	203	590	20.6	0.34	185	0	0	0	0	
Total	3375	4400	46.0	0.77	2 419	18	0.74	40	3.17	

Note: (1) PTI represents potential transmission index

(2) Six mosquitos collected in night-time are excluded from the table.

(127) Ciferri, F., Siligan, N.,
Long, G. & Kessel, J.F.
1969

A filariasis control programme in
American Samoa
Amer. J. trop. Med. Hyg., 16,
321-327

The paper is the formal publication of the results of investigations on filariasis carried out in American Samoa during 1962-1965 which was initially processed as a WHO/FIL/66.62 (Abstract No. 112). Unlike that document, the present paper deals exclusively with the results of clinical and parasitological surveys. The results of the entomological investigations have been omitted as they were published by Kessel, 1967 (116). In the present paper, the presentation of the clinical and parasitological data has been modified and more clear discussion of the results has been made.

Complete clinical and blood surveys were conducted in 1962 in four villages of Tutuila Island, American Samoa, with the purpose of assessing the public health importance of filariasis in the island and evaluating the need for mass treatment of the population with diethylcarbamazine.

Pre-treatment surveys showed that no overall decrease of clinical or haematological filariasis had occurred since 1943-45, when the same villages were surveyed by Dickson and Murray, in the absence of a formal control programme. The prevalence of elephantiasis in the population surveyed was 3.4% compared with 2.6% in 1943 and 2.8% in 1945. The hydrocele rate in the male population was 7.1% compared with 6.3% in 1943. The mf rate was 20.4% and the mean and medium mf count per positive were respectively 64 and 26 mf per 20 mm³ of blood, compared with an mf rate of 17% and mf density of 57 in 1945.

Persons in the village were treated with DEC to a total dose of 72 mg per kg distributed according to three schedules. In essence, all villages received one-half of the dose over a period of six consecutive days and the other half over the ensuing 6- to 12-month period. Post-treatment surveys indicated a prompt reduction of mf rates and densities in all villages, more pronounced initially in the village receiving monthly doses; later on, however, mf rates and counts reached comparable levels in the four villages regardless of the schedule adopted. It was concluded, therefore, that in long-term control programmes and in the absence of additional therapy, the schedule of administration was not the most significant factor in the reduction of mf rates. The data instead, suggested that there was some correlation between the degree of filarial infection in the villages before treatment and the results obtained three years after treatment in that the best results appeared in the village with the lowest initial mf rate and counts, when given the same amount of DEC over the same period of time.

As the data also showed that most positives after DEC therapy occurred among original carriers, it was suggested that temporary therapeutic failures are probably the results of an adequate ratio between dosage of DEC and pre-existing worm burden.

(128) Saugrain, J. &
Outin-Fabre, D.

1969

Etude comparative des incidents
d'administration de la diethyl-
carbamazine ordinaire de la
diéthylcarbamazine sous son
conditionnement enduit
Médecine Tropicale, 29, 67-69

In experiments carried out in Tahiti, the authors tried DEC tablets coated with a varnish of cellulose acetophthalate which were especially prepared to overcome the digestive troubles commonly observed with uncoated DEC tablets.

To 940 persons coated tablets were given and to 430 ordinary DEC tablets. A dosage of 6 mg/kg was given to all persons under observation irrespective of whether they were positive or negative for microfilariae. It was unfortunate that a certain number of the coated tablets were broken by the people in charge of drug distribution in order to adapt the dosage to the body weight.

The side reactions were classified into three types of incidents:

- febrile with aching + headaches
- febrile with aching + headaches + vomiting
- individual vomiting

The results showed that:

(1) The total number of incidents with coated DEC was much lower than the number recorded with ordinary DEC, 7.76% and 14.75% respectively.

(2) 25 cases of vomiting were noted after taking the coated tablets. The vomiting occurred 4.8 h after taking the coated DEC instead of 1/2-2 h with ordinary DEC.

(3) In cases of individual vomiting, 8 women were negative for infection and were given broken coated tablets. It does not seem that the presence of the parasite provoked vomiting, since in 37 persons who had taken ordinary DEC, 30 were negative and 7 were previously positive and became negative.

(4) The vomiting incident was 2.65% with the coated DEC versus 13.25% with ordinary DEC.

(5) The febrile/aching cases + headaches were observed in microfilaria carriers. The difference between incidence of those symptoms with coated and ordinary DEC was slight. In fact, it is the chemical compound itself which caused the microfilaricidal activity.

In conclusion, the authors indicated that although their trial was limited, it gave encouraging results that warrant the use of coated DEC in antifilariasis programmes.

(129) Desowitz, R.S.,
Chularerk, P. &
Palumbo, N.E.
1970

Evaluation of a simplified membrane
filtration technique for the
diagnosis of canine filariasis
S.E. Asian J. trop. Med. publ.
Hlth., 1, 231-232

Chularerk & Desowitz (1970)¹ devised a simplified membrane filtration concentration technique. As a preliminary investigation prior to applying the technique in an endemic area of human filariasis, an assessment of its efficiency for the diagnosis of canine filarial infection has been carried out and the results are presented in this paper.

Heparinized venous blood was obtained from dogs in Honolulu. One ml of each blood sample was concentrated by the membrane filtration technique. Two linear 20 mm^3 thick blood films were also made from each blood sample. The smears were dehemoglobinized and stained with Giemsa.

Of the 92 blood samples examined, twenty-nine (31.5%) were found to have microfilariae in the 40 mm^3 blood film. In all but one positive blood film, microfilariae were found in both 20 mm^3 smears. Concentration of 1 ml of blood by membrane filtration revealed an additional 16 positive samples to give a total mf rate of 47.8%.

In the samples in which the thick films were negative but were found to be positive on filtration, the number of microfilariae counted on the membranes ranged from 1 to 33. Since the concentration technique employs a 50 times greater volume of blood than the 20 mm^3 smear, it would appear that even one microfilaria in 1 ml of blood can probably be detected by this method. Larger amounts of blood can be concentrated and it would be of interest to determine the actual volume of blood required before a negative diagnosis can be confidently made.

It is estimated that trained technician can process 35 to 40 blood samples a day using the technique that the authors have described. It is felt that this number can be increased appreciably by the use of simple mechanical aids such as a press to facilitate passing the hemolyzed blood through the filter. These accessories are now being designed.

¹Chularerk, P. & Desowitz, R.S. (1970) A simplified membrane filtration technique for the diagnosis of microfilaremia. J. Parasit., 56, 623-624

(130) Hitchcock, J.C.
1970

Evaluation of filariasis mosquito surveys based on the physiological age of the vector
J. Parasit. (Proc. 2nd Intern. Congr. Parasit.) (Section 1), 56, 149

The physiological age composition of the "scutellaris" group of Aedes (Stegomyia) was determined for each of the four villages on the Ninatopulapu Island Group in the Kingdom of Tonga. The accrued data indicate that an accurate field mortality rate can be extrapolated; this may have application throughout the tropical South Pacific. The Ninatopatapu Group, known to be highly endemic for bancroftian filariasis is located between $173^{\circ}42'$ and $173^{\circ}48'$ west latitude and $15^{\circ}50'$ and $16^{\circ}0'$ south longitude. A filariasis mosquito survey, utilizing standard biting-landing collections, was made in each village during May and June 1969. The physiological age of each of the 880 mosquitos dissected was determined by Polovodova's method prior to searching for filarial larvae in all stages of development. Of the 669 parous female mosquitos dissected, the percentage by age group for all villages was: 1-parous (1-p), 60.6%; 2-p, 26.6%; 3-p, 9.4%; 4-p 2.95% and 5-p, 0.4%. Continuing to exclude the nulliparous females which were biting for the first time, the overall W. bancrofti infection rate for all stage larvae in the host mosquitos was 8.08%. Twenty-nine point six% of the W. bancrofti infected mosquitos were 1-p; 33.4%, 2-p; 24.1%, 3-p; 9.3%, 4-p; and 3.7%, 5-p. However, 3.95% of the 1-p mosquitos were infected with all stage larvae; 10.2% of the 2-p; 20.6%, 3-p; 25%, 4-p; and 66.7% of the 5-p mosquitos were infected. Fifty percent of those infected had first-stage larvae, 38.9% had second-stage larvae, and 11.1% third stage. It was found that 51.9% of the infected mosquito hosts acquired W. bancrofti microfilaria during their first blood meal (BM 1), 35.2% (BM 2), 9.26% (BM 3), and 3.7% (BM 4). Knowledge based on the physiological age of the mosquito host offers new insight and accuracy to the evaluation of the epidemiology of filarial transmission.

(131) Kessel, J.F.,
Tompkins, H. &
Jones, K.
1970

Recent studies on the control of filariasis in American Samoa
J. Parasit., 56 (Section 1), 185-186

This is an abstract of the contribution made by the authors to the Second International Congress of Parasitology, 1970, Washington. The work was fully published by Kessel et al., 1970 (132).

Filariasis surveys performed by U.S. Navy groups in American Samoa between 1943 and 1953 contributed much to our knowledge of Pacific subperiodic filariasis. Without introducing control measures, resurveys in identical villages begun in 1962, i.e. some 20 years later, showed slightly higher results, e.g. elephantiasis rates increased from 2.8% to 3.4%, mf rates from 20% to 22%, and median mf densities from 22 to 29. See Ciferri et al., 1969 (127).

(132) Kessel, J.F., Siligan, N.,
Tompkins, H. &
Jones, H.
1970 a

Periodic mass treatment with
diethylcarbamazine for the control
of filariasis in American Samoa
Bull. Wld Hlth Org., 43, 817-825

During 1943-1953, many investigations were carried out on bancroftian filariasis in American Samoa which showed an elephantiasis prevalence of 2.6% in persons aged 5 years or more, and an mf rate of 20% with MfD50 of 22. During 1962-1963, surveys in 5 villages showed an elephantiasis prevalence of 3.4% and an mf rate of 26% with MfD50 of 29, among persons over 5 years of age. These rates are somewhat higher than those shown above, 20 years previously. Therefore, it was decided to organize a Filariasis Pilot Control Programme in 1962 with an initial single total regimen of 72 mg of DEC per kg given in 12 doses of 6 mg/kg over a period of 6 months to the population of 5 villages (as shown below), with the first treatment applied during August 1962-January 1963. In August 1963, a Mass Treatment Project of Tutuila was inaugurated. Pretreatment blood surveys were based on averages of 2 thick blood films of 20 mm³ each. Final blood surveys were based on averages of 3 thick films of 20 mm³ each.

Mosquito surveys and dissection methods followed those of Bonnet et al., 1956 (58) but consideration is given in this paper to the percentage of Ae. polynesiensis positive for the infective stage larvae of W. bancrofti.

It should be emphasized that with the exception of the five villages of the Pilot Control Programme namely, Amouli, Amanave, Malaeloa, Aoa and Aoloau, all other 47 villages of Tutuila were given two periodic mass treatments; the first commenced in September 1963 and continued to early 1964 and the second commenced in August 1965 and continued in 1966. Amouli and Amanave were entered in the mass treatment project in August 1965 when the second regimen of 72 mg/kg were given, while Malaeloa remained without a second mass treatment as a control village. Table 1 indicates that at the end of 3 years without any additional doses of DEC, the mf rate had increased to 7.3% after it had dropped to 4.1% one year after the mass treatment. This constituted a warning that without further mass treatment high infection rates might recur.

The results of repeated mass treatment are presented in Table 2 for three villages of the Pilot Control Programme during 1962-1968. The data illustrate that without a second mass treatment, high infection rates may continue. The following comments are given on the results of each of the three villages.

TABLE 1

PILOT PROGRAMME, 1 MASS TREATMENT
WITH 72 MG OF DIETHYLCARBAMAZINE
PER KG; ALL AGES

Villages surveyed	Years of survey	No. of persons examined	Microfilaria rate (%)	MfD50
Surveys before mass treatment				
Amouli)	1962-63	1191	21.0	20
Amanave)				
Surveys 1 year after mass treatment				
Malaeloa)	1963-64	894	4.1	2
Aoa)				
Surveys 3 years after mass treatment				
Aoloau	1965-66	975	7.3	2

TABLE 2

MICROFILARIA RATES AND MEDIANES BEFORE AND AFTER FIRST AND SECOND REGIMENS OF DIETHYLCARBAMAZINE

Village	Before treatment with diethylcarbamazine June 1962			After treatment with diethylcarbamazine August 1965			1967-1968.		
	Median		No. ^a	Median		No. ^a	Median		No. ^a
	No. ^a	%		and range	No. ^a		%	and range	
Amouli ^b	40/268	15.0	12	7/214	3.3	1	0/313	0.0	0
			1-385			1-22			
Amanave ^b	59/269	21.9	33	25/233	10.7	2	2/241	0.8	1
			1-384			1-107			1-9
Malaeloa ^c	74/296	25.0	24	25/233	10.7	2	20/217	9.2	4
			1-618			1-55			1-60

^aNumber positive/number examined

^bFirst mass treatment, August 1962-January 1963; dosage 72 mg of diethylcarbamazine per kg. Second mass treatment, August 1965-January 1966; dosage 72 mg of diethylcarbamazine per kg.

^cFirst mass treatment, August 1962-January 1963; dosage 72 mg of diethylcarbamazine per kg. No second mass treatment, village treated as control.

TABLE 3
BLOOD SURVEYS IN MASS TREATMENT PROJECT, BEFORE AND 2 YEARS AFTER
EACH REGIMEN OF DIETHYLCARBAZAMINE

Valige	Before mass treatment				After mass treatment			
	No.	Rate (%)	Median	Range	1966	Rate (%)	1967	Rate (%)
Chavara	16/62	26	8	2-662	6/172	2.9	0/162	0.0
Total	37/302	36	31	1-283	14/283	4.9	1/268	0.4
Atao	43/211	20	9	1-150	2/262	0.8	0/278	0.0
Uitama	7/40	18	18	2-343	5/110	4.5	1/98	1.0
Alotau	19/111	17	20	2-144	8/308	2.9	2/298	0.7
Total	122/667	21	24	1-662	36/1133	Rate: 3.1% Median: 4 Range: 1-50	4/1105	Rate: 0.36% Median: 2 Range: 1-9

" Number positive, number examined

Amouli

- (1) a lowest pre-treatment mf rate of 15.0% and a lowest MfD₅₀ of 12;
- (2) 3 years following the first regimen of 72 mg DEC per kg, a lowest post treatment mf rate of 3.2% and an MfD₅₀ of 1;
- (3) no microfilaraemia 2 years following the second mass treatment regimen with DEC.

As already pointed out by Ciferri & Kessel, 1967 (115), individuals with the highest mf rates and lowest MfD₅₀ values respond most successfully to DEC. This is probably the first village to show interruption of transmission especially as no infective-stage larvae of *W. bancrofti* were found in the mosquitos dissected. Fig. 1 illustrates a close positive correlation between the drop in the mf rate from 15% in 1962 to 3.3% in 1965 and 0 in 1968, and the drop in infective-stage larvae rate of *W. bancrofti* from 2.1% in 1962 to 0.58% in 1965 and 0 in 1968.

Amanave

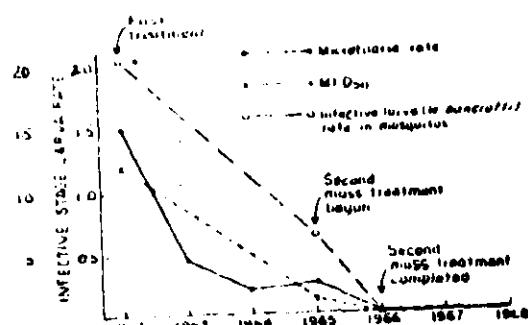
- (1) an intermediate pre-treatment mf rate of 21.6% and a highest MfD₅₀ of 33;
- (2) 3 years after the first regimen of DEC, a high post-treatment mf rate of 10.7% and an MfD₅₀ of 2;
- (3) 2 years after the second regimen of DEC, a low mf rate of 0.8% and an MfD₅₀ of 1.

Malaeloa

- (1) a highest pre-treatment mf rate of 25.0% and an intermediate MfD₅₀ of 24;
- (2) 3 years after the first regimen of DEC the same post-treatment mf rate and MfD₅₀ as at Amanave;
- (3) the high mf rate of 9.2% and the high MfD₅₀ of 4 were maintained in 1965-66 with no second regimen of DEC.

In summarizing annual follow-up surveys in a control programme, the positives originate from several sources such as light infections having been overlooked, people refusing to take the drug or being excused from treatment for personal or medical reasons, unexamined positive cases among immigrants, new infections, recurrences and reinfections.

FIG. 1
MASS TREATMENT WITH DIETHYLCARbamAZINE
IN VILLAGE OF AMOULI, AMERICAN SAMOA



Mass treatment project: Five villages were selected for follow up in this project after the first mass treatment which was given in September 1963 and the second mass treatment which was given 2 years later. The results of blood surveys are given in Table 3. As shown, 3.1% of 1133 persons examined remained positive after the first mass treatment. This is about the same rate found in the Pilot Control Programme. The second blood survey conducted in 1967 showed an mf rate of 0.36% indicating a further drop.

TABLE 3

BLOOD SURVEYS IN MASS TREATMENT PROJECT,
BEFORE AND 2 YEARS AFTER EACH REGIMENT OF DIETHYLCARBAMAZINE

Village	No. ^a	Before mass treatment			After mass treatment			Rate (%)
		Rate (%)	Median	Range	1965	Rate (%)	1967	
Onenoa	16/82	20	8	2-562	5/172	2.9	0/162	0.0
Tula	37/107	35	31	1-283	14/283	4.9	1/268	0.4
Alao	43/211	20	9	1-150	2/262	0.8	0/278	0.0
Utumea	7/46	15	18	2-343	5/110	4.5	1/99	1.0
Alofau	19/111	17	20	2-144	9/306	2.9	2/298	0.7
Totals	122/557	21	24	1-562	35/1133	Rate: 3.1%	4/1105	Rate: 0.36%
						Median: 4	Median: 2	Median: 1-9
						Range: 1-50	Range: 1-9	Range: 1-9

^aNumber positive/number examined

In 1968, a survey was carried out in 12 other villages including Amouli and Amanaye of the Pilot programme. Only two persons were found positive out of 1053 examined giving an mf rate of 0.2% which is slightly lower than that recorded in the above mentioned five villages. Mosquitos dissected from the 12 villages during 1967-1968 were all negative for the infective stage larvae of W. bancrofti. If subsequent follow up surveys to be conducted in 1970 confirm these low levels, some important questions will be raised:

- should a third identical mass treatment be administered?
- or should annual or other periodic blood surveys be conducted and only current positives, or past positives, or both be treated?

In the light of the findings obtained from the investigations of American Samoa, the author further proposed criteria for initiating surveillance as shown in the following extract.

Control versus eradication

Many filariasis control programmes based on the use of diethylcarbamazine have been undertaken in different parts of the world, of which some have been appropriately designed and continued for an adequate length of time, one such programme was begun in French Polynesia by Beye et al., 1953 (34) and another was undertaken in parts of Japan by Sasa (1963)¹ and Fukushima (1967)², and a third is the programme in American Samoa described in this report; all show that marked reductions in filariasis were achieved. For further progress, when simultaneously the mf rates fall to 1% or less, the MfD₅₀ falls to 1 or less and intensive mosquito surveys show an infective-stage larva rate of 0.5% or less, often 0, and if these falls are associated with a decline in clinical disease that indicates that filariasis is no longer an important public health problem, criteria for surveillance should be standardized and procedures for changing from control to eradication programmes should be established.

(133) Ramachandran, C.P.
1970

A guide to methods and techniques in
filariasis investigations
Institute for Medical Research, Kuala
Lumpur, Bulletin No. 15, 38 pp.

In this guide, the author compiled all important procedures that would assist the field worker in carrying out an assessment of the filariasis situation. On the basis of the results, planning of control measures and their evaluation can be made.

The author drew attention to the fact that the choice of methods depends largely on the intended objectives. Thus, a method may fulfil the objectives of one study but may not be sufficient for another type study with different objectives. While an attempt should be made to standardize the epidemiological procedures, the reasons for which studies are required should be borne in mind in the first place.

¹Sasa, M. (1963) Pilot experiments in the control of bancroftian filariasis in Japan and Ryukyu. Bull. Wld Hlth Org., 28, 437-454

²Fukushima, H. (1967) Selective treatment of bancroftian filariasis. Acta med. Univ. Kagoshima, 9, 25-32

The guide covered the following techniques and procedures.

General information: Before carrying out the parasitological and entomological investigations, it is necessary to collect the following information:

- (a) The country and its topographical features
- (b) The people, their way of life and socioeconomic aspects
- (c) The climate

The parasitological investigation

1. Population sample

In large areas with a variety of conditions, a preliminary survey should be conducted in a small cross-section of the population. Statistical advice should be sought for planning such survey on the basis of which the proper information can be collected. Proformas are proposed for recording house and population census and for recording blood examinations and clinical surveys.

2. Microfilarial/clinical survey

A general outline is given for collection of blood films, their protection and staining.

2.1 Presentation and analysis of parasitological data

- 2.1.1 the microfilaria rate
- 2.1.2 the microfilaria density

2.2 Presentation of clinical data

2.3 Survey of animals for filariasis

2.4 Staining methods for thick blood films for microfilariae of Brugia and Wuchereria spp. in Giemsa stain

2.5 Knott's concentration method for detection of microfilariae

2.6 Examination of chylous urine for microfilariae

3. Examination of pathological materials

Preservation of filarial worms and examination.

4. Dissection of experimentally infected mosquitos and method of experimental inoculation of animals

4.1 Dissecting mosquitos for the infective stage larvae

4.2 Dissecting experimentally infected mosquitos for obtaining large numbers of infective larvae

4.3 Technique for experimental inoculation of animals with infective stage larvae

5. The detection and identification of filarial larvae in mosquitos with a key for identification

6. Preservation of mosquitos for later dissection

The entomological investigation

1. Survey of mosquito population breeding with a proforma proposed for recording data on surveys of breeding places.

2. Methods for estimating the numbers, activities and vector potentials of adult mosquitos.

2.1 Adult mosquito catches in and around inhabited houses in endemic areas

2.1.1 Preliminary hand catches of adult mosquitos inside houses known to contain filaria infected persons with a proforma proposed for recording the respective data.

2.1.2 24-hour catches inside houses on man

2.1.3 Laboratory processing of mosquitos collected with proforma for recording the respective data

2.1.4 Indices of filarial infections in mosquitos

- (a) infection and infective rates
- (b) transmission index by Wharton (1962)¹

infective bite rate = no. of vectors per man per hour (or day or year) X mature larva rate

infective load or dose = infective bites X average number of mature larvae found

- (c) potential transmission index by Kessel, 1957 (68)

2.2 24-hour catches on man outside houses: near houses at varying distances from houses, in the bush and forest and in the open. The following methods used by various workers were outlined:

- (i) half-hour or one hour catches at 10 meters from occupied houses
- (ii) 5-minute catches at 45-meters intervals along radii through bush starting in village and ending at 450 meters or so

¹Wharton, R.H. (1962) Inst. Med. Res. Malaya, Bull. No. 11

- (iii) 5-minute catches at 45-meters intervals along used paths and tracks leading to gardens and plantations
- (iv) catches over a variety of times in gardens
- (v) half-hour or one hour catches on platforms at selected heights on trees, etc.

2.3 Space spraying of occupied houses or rooms

2.4 Catches in especially constructed experimental huts or traps

2.4.1 The human bait trap

2.4.2 Catches from outside resting shelters (natural and artificial)

2.5 Catches on animals, animal houses and traps with animal baits

2.5.1 The animal bait trap

2.5.2 Catches on animals and in animal quarters

3. Identification of blood meals in wild caught mosquitos to determine the human blood index: method of collection, preparation, packing and despatch for analysis - the interpretation of results
4. Differentiation of nulliparous and parous mosquitos
5. Determination of infective potential of confirmed or suspected vector: experimental infection and the respective index
6. A brief outline on insecticide resistance and genetic studies in vector mosquitos

Laboratory and headquarters' activities

The author gave an outline of the functions of the headquarters of a filariasis programme with a list of supplies and equipment as well as the formulae of fixatives and stains.

- (134) Chow, C.Y.
1971
- A review of mosquito vectors of
subperiodic Wuchereria bancrofti
WHO unpublished document, WPR/VBC/6

This is the second review which is along the same lines as the first in 1968 (107) but with the addition of two more vectors, Ae. tabu and Ae. tutuilae and updating of the data on infection and infective rates. All this information has been compiled in the published review made by the author in 1973 (156). In the present document, the author summarizes data of susceptibility tests carried out by Suzuki (unpublished) in Western Samoa in 1970, all of which have been recompiled in Chow & Suzuki, 1974 (165).

Further, the author made proposals for research studies to be undertaken in the South Pacific area which are on the whole similar to those proposed in his paper of 1968 (*loc. cit.*). However, some additional aspects have been proposed as summarized in the following:

- Dispatch of egg batches of *Aedes* mosquitos by national and WHO staff to a recognized institution to study the genetic relationship between closely related species, in view of the difficulties encountered in separating them morphologically.
- The ecological studies should include observations on the range of flight, dispersion and age grouping of vector population.
- Susceptibility tests on adults and larvae of vectors should be undertaken. Large scale vector control trials should be implemented utilizing environmental sanitation, ground or aerial application of insecticides, biological and genetic control.

(135)	Denham, D.A., Dennis, D.T., Ponnudurai, T., Nelson, G.S. & Guy, F. 1971	Comparison of a counting chamber and thick smear method of counting microfilariae <i>Trans. Roy. Soc. trop. Med. Hyg.</i> , <u>65</u> , 521-525
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The authors while studying microfilaria densities found the preparation and examination of large numbers of stained blood films cumbersome and time consuming. Thus they developed a counting chamber method. The following extracts summarize the findings and relevant points discussed.

Materials and methods

Chamber: Counting chambers of two sizes were constructed - one for the examination of 20 mm^3 of blood, the other for amounts between 20 and 100 mm^3 . The 20 mm^3 examination chamber consists of a well approximately 1 mm deep, 25 mm in length and 15 mm wide. To facilitate counting, the base of the chamber contains parallel lines (etched or diamond cut) spaced at 3 mm intervals. The 100 mm^3 examination chamber differs only in that the length of the well is 45 mm. The chambers are simply constructed by cutting strips of glass from a standard microscope slide and fixing these by means of a mounting medium around a lined area on another standard sized slide, Figure 1. Glass cutting can be circumvented by ringing the lined area of the glass slide with a viscous, rapidly setting mounting medium such as Depex®. The hardened medium itself serves as the walls of the chamber.

A few drops of water are placed in the well (approximately 100 mm³ for 20 mm³ blood specimens) and the aliquot of blood is discharged into and mixed with this. Cover slips were initially used but were later discarded when it was found that they made observations more difficult. The active microfilariae are easily counted in either the lower power field of a conventional light microscope or, preferably, the field of a dissecting microscope at about 35 times magnification for Brugia, Wuchereria or Loa-sized microfilariae.

When avian blood, which is resistant to haemolysis, is examined a haemolytic agent such as Teepol^R is added to the water. With rapidly clotting blood it is sometimes necessary to use a heparin solution to avoid clots forming in the pipette.

Thick films: All glass slides were scrubbed with an abrasive soap, thoroughly rinsed in both tap water and dried with an oil-free cloth prior to use. 20 mm³ blood films of three different surface areas were used: 8 cm² (i.e. two, 2 cm squares); 3.14 cm² (i.e. a 2 cm diameter circle); 3.0 cm² (2 linear strips 50 mm x 13 mm); as shown in Fig. 1. Blood films were dried overnight at approximately 35°C prior to dehaemoglobinization. Dehaemoglobinization times were kept to a minimum (approximately 3 minutes for 8 cm² films, 5 minutes for 3 cm² films). Films were then treated with a rapid Romanowsky stain (Wright's). Stained parasites were counted with the medium power (x 40) of a binocular microscope.

Comparative studies: 3-5 cc samples of peripheral blood obtained by venipuncture were collected in Sequestrene^R tubes. Using 20 mm³ pipette aliquots each of the following preparations was examined for microfilariae: (1) counting chamber; (2) 8 cm² area thick films; (3) 3.14 cm² area thick films; (4) 3.0 cm² area strip (Sasa type) films. Five of each preparation were examined for each blood specimen taken during a longitudinal study of B. pahangi in a cat (K17); 10 of each preparation were examined for single sample enumerations of W. bancrofti in human blood (T53406, T53515); and 25 of each preparation were examined in single sample determinations of B. pahangi in two cats (L17 and K68). Chamber counts and 8 cm² area thick film counts were each performed five times on separate specimens of blood from a patient with Loa loa microfilaraemia (T52853).

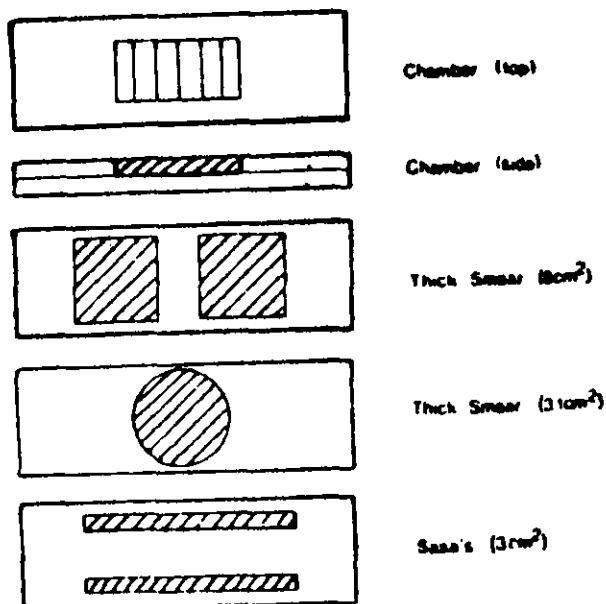


FIG. 1. Diagram of counting chamber, and illustrations of thick smear methods employed.

Results and discussion

In every instance, the mean mf count obtained by the chamber-count method exceeded that of the 8 cm^2 area thick film (significance to a level of $P > 0.01$ for a single sample of *B. pahangi* determinations but $P = 0.01$ for single sample *W. bancrofti* counts). Usually, this difference was between 15 and 20% of the figure found in the counting chambers as can be seen in Figures 2, 3. In all instances, the mean chamber count was significantly ($P > 0.01$) greater than that obtained with the circular 3.14 cm^2 or 3.0 cm^2 area strip type thick films (i.e. the most commonly used size in survey work). The mean counts on 8 cm^2 area thick film were in each instance greater than those obtained with 3.14 cm or 3.0 cm^2 area films (level of significance $P > 0.01$ in all but one instance).

The counting chamber method proved to be more sensitive than, and as reliable as, the use of wet or stained blood films. Direct slide examinations of 20 mm^3 blood samples under cover slips give poorly reproducible and falsely low counts attributable primarily to "streaming" of parasites to the periphery of the film, and to microfilariae being obscured by formed blood elements such as small clots. Also, unless actively motile, parasites are easily missed by this method.

Perhaps one of the most significant findings of the present study was that a substantial number of parasites are lost during the preparation of the stained smear or go undetected during the examination of the stained blood films. The deficit was found to be inversely proportional to the size of the surface area of the films and is well illustrated in Figures 2-3 by comparison of the two types of thick smears. The common hazard of loss of entire portions of the blood film during dehaemoglobinization and staining was avoided by careful removal of all grease from the surface of the glass slides and thorough overnight drying of the spread films. The loss of microfilariae was, therefore, selective and not due to the loss of blood components generally.

Most of the microfilariae were lost during the dehaemoglobinization process and examination of the bath by a membrane filtration technique revealed the presence of many of the "missing" microfilariae. The number recovered by filtration was inversely proportional to the surface areas of the films being prepared. It seems likely that the parasites become detached from the films and float off into the bath. However, the numbers of microfilariae recovered from the dehaemoglobinization bath do not fully account for the discrepancy between the results obtained with the chamber and thick smear counting methods and it is probable that other microfilariae are lost during the staining and rinsing processes. Increasing the time of dehaemoglobinization increases the number of parasites lost, but smear thickness (as determined by surface area) exerts greater relative effect. Apparently microfilariae adhere less firmly to the surface of the slide as the thickness of the blood film is increased. Careful examination of thick smears sometimes reveals the "ghostly" outline of a parasite which has floated off during preparation. On occasions microfilariae with identical shapes were found a little away from this outline.

Adhesion of microfilariae is also affected by the type of anticoagulant used in the collection of the venipuncture samples. Liquid heparin reduces adhesion while there was no difference between films made from blood collected in Sequestrene^R and those prepared from blood not exposed to an anticoagulant. The greater the excess of heparin used the greater the number of parasites that were lost. This would be of no significance under conventional survey conditions, but might be important in experimental situations where one is trying to avoid counting errors caused by "medusa head" clumping of *W. bancrofti* and *Loa loa*.

When species identification is required, a vital stain (such as New Methylene Blue) can be added to the chamber contents.

It should be noted that the surface area of the 8 cm² thick smear is much larger than that of the conventional smear used in malaria and filariasis field surveys where in the majority of cases, a surface area of 2.4 cm² is made. A small surface area avoids blood clotting during film spreading and shortens the time of examination of such films. It is shown however (Figures 2 and 3) that although the large thick film gave between 80-90% of the counts made by the chamber, the normal thick film gave only 65-75% and the strip method was even less.

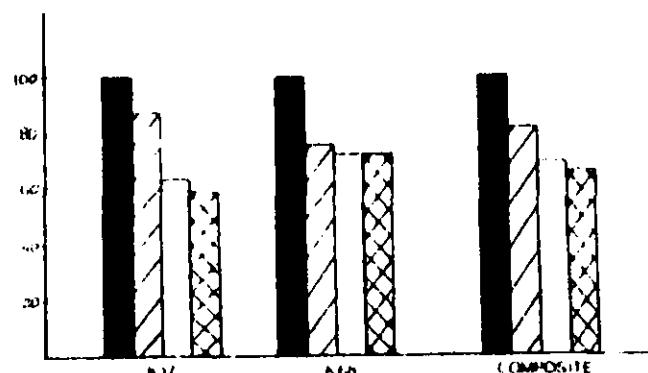


FIG. 2. Comparative results of repeated single sample determinations of *B. pahangi* microfilariae in cats, relative efficiencies of the methods, expressed in percentages. Chamber (solid black); 8.0 cm.² thick smear (diagonal lines); 3.14 cm.² thick smear (solid white); 3.0 cm.² thick smear (cross-hatch).

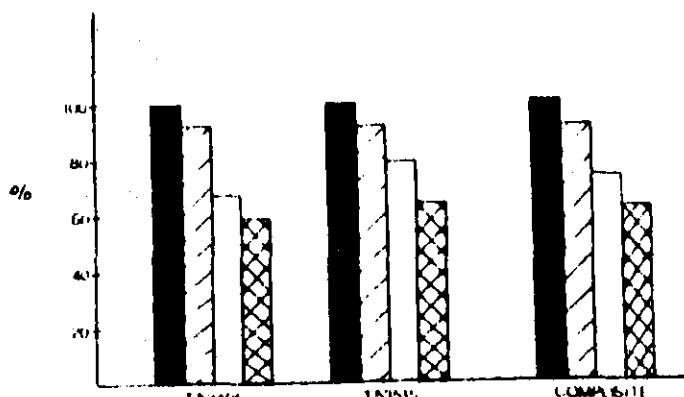


FIG. 3. Comparative result of repeated single sample determinations of *W. bancrofti* microfilariae in two patients, expression and notation of results as in Fig. 2.

It is common to find 20 to 30% of mf carriers in a survey with three or less microfilariae per thick smear preparation (Sasa et al., 1970¹; Kessel, 1957 (68); Nelson, G.S. unpublished) and this percentage frequently doubles after the administration of drugs as a control measure. If these results can be extended to field conditions, it seems likely that some persons with a low parasitaemia may go undetected as a result of the inefficiency of the standard stained film methods and that better assessments might be made with a chamber counting procedure. Where a single species is present in any particular area this method could have practical field utility.

(136) Galliard, H.
1971

Effet du diethylcarbamazine dans la filariose lymphatique au début de la campagne propylactique à Tahiti
Bull. Soc. Path. exot., 64, 340-343

In a communication to the author, J. Lagraulet indicated that DEC may be used as a test similar to the Mazzotti reaction in onchocerciasis. He utilized a dose of 10 mg and reported that the reaction to this dosage was generally weak and could be tolerated. It was characterized by headaches, aching and sometimes vomiting or high temperature, but did not involve a lymphangitis attack. The author's previous findings, Galliard & Mille, 1949 (18) were totally different from those of Lagraulet. Since no note was taken of this publication, the author decided to recapitulate the reactions hitherto noted and by this method to find out the differences between them and the present findings. The author summarized his study as follows:

"Twenty-three years ago, in Tahiti and other French Polynesian islands, treatment of filariasis with diethylcarbamazine determined frequently clinical inflammatory symptoms, sometimes acute, in asymptomatic carriers as well as in cases of advanced clinical disease.

Systemic reaction, chills and fever, lasted a short time. Oedema, pruritus, bullous eruption, enlarged and painful lymph nodes, enlarged lymphatic cords on the limbs, abscesses, funiculitis were observed frequently. Lymphangitic attacks occurred in some cases.

Actually, according to the different authors who published since on the subject, and recently J. Lagraulet, treatment by DEC does not determine such accidents any more.

We believe that continuous mass treatment of the population has considerably reduced the rate of reinfection and was also a cause of desensitization of all the people treated."

¹Sasa, M. et al. (1970) The filariasis control programmes in Japan and their epidemiological analysis of microfilariae survey data.
In: Recent Advances in Researches on Filariasis and Schistosomiasis in Japan. Ed.: Sasa, Tokyo, University of Tokyo Press, pp. 3-72

(137) Hitchcock, J.C.
1971

Transmission of subperiodic filariasis
in Tonga by Aedes oceanicus Belkin
Trans. roy Soc. trop Med. Hyg., 65,
408 pp.

A night-biting vector of subperiodic filariasis has been found in the Kingdom of Tonga for the first time. Ae. (Finlaya) oceanicus was thought to be refractory to W. bancrofti throughout its range. Other members of the kochi group in the subgenus Finlaya however have been found to be efficient vectors of W. bancrofti. In the nearby island groups of Fiji and the Samoas, Ae. fijiensis and Ae. samoanus are efficient vectors of subperiodic W. bancrofti while Ae. tutuilae is a possible vector.

During 1969, 84 specimens of Ae. oceanicus caught biting at night in a house at Kolokakala, Tafahi, Tonga were dissected and two were found naturally infected with third-stage larvae of W. bancrofti. One was a 4-parous female with six larvae (four in the thorax and two in the head) and the other was a 3-parous female with three larvae all in the head). Because of the difficulty in raising adults of Ae. oceanicus from the immature stages, wild caught females were collected from man bait capture at night and fed the next morning on a microfilaria carrier (mean mf was 155 per 20 mm³). Of the 14 females that fed on the carrier, six were dissected when moribund or soon after their death and the remaining eight were dissected after 24 days from feeding. Of five females which were dissected during the period 18 hours to 10 days three had immature stages in the thorax and an additional female had six early third-stage larvae in the thorax.

Of the remaining eight females dissected after 24 days from feeding, three had 1, 8 and 2 third-stage larvae respectively; and the other five were negative. Of 35 females that did not feed on the carrier and were held for 21 days, two were found to harbour third-stage larvae, one with 10 larvae and the other with 12 larvae distributed in the head, thorax and the abdomen. The observed third-stage larvae of both naturally or experimentally infected Ae. oceanicus agreed with the published description of W. bancrofti and with the larvae dissected from mosquitos collected during diurnal surveys in earlier investigations in 1968-69 in Ninatoputapu group of islands in Tonga.

(138) Huang, Y.M. &
De Meillon, B.
1971

A brief survey of the Aedes (Stegomyia) scutellaris group of species (Diptera, Culicidae)
Unpublished document, 15 pp.
S.E. Asian Mosquito Project, Smithsonian Inst., Wash., D.C.

The report gives a brief account of the eight species groups of the subgenus Stegomyia to show the position of the scutellaris group. As it is extremely difficult to separate albopictus and scutellaris, they are treated in the report as one group, thus combining sub-groups I and II of Knight and Hurlbut. World distribution of the scutellaris group in the

different faunal areas where it has been recorded is mapped. Experiences in South East Asia are cited. The situation of the group in the South Pacific areas is reviewed and a list of the 17 species and two forms hitherto known is provided with the name of the type locality and the museum where the type material is deposited. In view of several taxonomic problems particularly the taxonomic status of several species in the scutellaris group, the report presented a plan for collecting material for taxonomic studies from three areas of significance in the South Pacific.

(139) Kessel, J.F.
1971

A review of the filariasis control programme in Tahiti from November 1967 to January 1968
Bull. Wld Hlth Org., 44, 783-794

The paper reviews the programme of control of subperiodic filariasis in Tahiti which was based on the use of DEC and as a secondary measure, the elimination of mosquito breeding places within 100 m of each household. The object of the study was to answer the question as to why during some 12 years of systematic control, the mf rate has persisted at a level of about 3-5%.

The procedures adopted for evaluating the progress of control measures were:

Blood surveys: Before DEC was administered, the surveys were based on sampling 20 mm³ of blood from finger pricks. Post treatment follow-up surveys were based on the examination of an average of 2 to 3 blood films of 20 mm³ volume each.

Early and current data have been reassessed according to the method recommended by the WHO Expert Committee on Filariasis, 1967 (119) for estimating the MFD₅₀.

Mosquito surveys: The "intensive survey method" of Bonnet et al, 1956 (58) was adopted. A number of special criteria was proposed and the potential transmission index was utilized for assessing the impact of control measures on the infection in mosquitos. In the present paper, the assessment was based on the percentage of mosquitos found with infective stage larvae of W. bancrofti.

The results showed that in the untreated area of Vairao, the mf rate in 1950 was 30.9% and MFD₅₀ was 28. In 1956, i.e. after six years without the administration of DEC, there was no significant change in these values. Subsequently, the administration of DEC with the regimen and schedule used in Tahiti resulted in reduction in mf rate to 3% and MFD₅₀ to three after four years. In the treated districts of Mataiea and Tautira, the mf rate in 1950 before the treatment was respectively 39% with MFD₅₀ of 23 and 27% with MFD₅₀ of 18. By 1958, the third year after the mass treatment, these indices were 4.9% for Mataiea with MFD₅₀ of 4.5, and 3.3% for Tautira with MFD₅₀ of 4. Some ten years later, after only those found positive in the annual blood surveys had been treated, the mf rate stood at 5.2% in Mataiea and 4% in Tautira with MFD₅₀ value of 3.5 in both districts. The latter showed an increase to 4.1 in 1968 in

Tautira. When the results of blood and mosquito surveys are compared, there seems to be a positive correlation between the mf rate/MfD₅₀ and the rate of infective stage larvae as shown in Table 1. When comparing the results obtained in Tahiti with those obtained in Japan and American Samoa, it appears, within limits, that the success of DEC treatment for filariasis is related to the ratio between the mf rate and DEC dosage.

The mf rates and densities were described as being low in Japan, intermediate in American Samoa and high in Tahiti. The author further compared the results of periodic treatment of only the positives as was the case in Tahiti with the periodic mass treatment as was practised in American Samoa and Japan, and further compared between the concepts of control and eradication of filariasis as per following extracts.

In the programme that began in 15 districts in Tahiti in 1953, it was recommended that 6 mg of DEC per kg of body weight should be administered once a month for 24 months. Subsequently, annual follow-up blood surveys were undertaken and only the positives were retreated. Current reports from Tahiti still show an overall mf rate of about 4% and an MfD₅₀ of approximately 4.

In American Samoa, periodic mass treatment with a total regimen of 72 mg/kg was recommended every two years until treatment was no longer needed. Follow-up surveys some 18 months after each mass treatment showed that following the second round of treatment, the mf rate had dropped to less than 0.38%, Kessel *et al.*, 1970 (132). A third mass treatment will be necessary.

Fukushima (1967)¹, working in Kagoshima Prefecture, Japan, where there was an initial mf rate of 11.2% before DEC treatment and an MfD₅₀ of 6, reported "eradication" of filariasis following three mass treatments between 1960 and 1965 with a total of 72 mg of DEC per kg of body weight in each mass treatment.

Kessel *et al.* (*loc. cit.*) reported the first instance of interruption of transmission in American Samoa, which lasted at least two years in the village of Amouli. This village had shown a low pre-treatment mf rate of 15% and a MfD₅₀ of 12. Two mass treatments of 72 mg/kg were given, the first in 1962-63 and the second in 1965-66.

As yet, there is no uniformity of opinion among investigators regarding the desirability of filariasis control compared with filariasis eradication. Possibly, the reduction of microfilaremia to 4% or less and an MfD₅₀ of about 4.0 is sufficient to keep clinical filariasis down to a level at which it is no longer an important public health problem. If this is in fact the case, then only control of the type practised since 1953 in Tahiti is necessary. If, however, transmission can be interrupted in a few small areas (e.g. villages, districts, or small islands), as shown in Amouli, American Samoa, then it may be possible to expand such areas to involve whole districts, as reported by Fukushima (*loc. cit.*). Treatment of entire larger islands or countries also seems to be feasible.

¹Fukushima, H. (1967) Selective treatment of bancroftian filariasis.
Acta Med. Univ. Kagoshima, 9, 25-32

When mf rates are 1% or less, the MfD₅₀ is also 1.0 or less and when standard mosquito surveys in these same areas reveal the absence of infective-stage larvae in all mosquitos dissected, it would appear to be opportune to standardize procedures for initiating an eradication programme. For either control or eradication of filariasis, agreement on definitions and terms to be used in discussions should be achieved and it is hoped that attempts to draw up a glossary on filariasis will be continued.

In planning an eradication programme, the usual problems arise; they include questions of the costs and importance of filariasis in comparison with those of other disease problems in the area, and the amount of interest shown by the administration of the area. Above all, an adequate working budget and a well-trained field director are essential to the programme.

Table 1. Correlations of blood surveys and intensive mosquito surveys in Tautira, Tahiti*

Mass treatment with diethylcarbamazine	Blood surveys for microfilaraemia in man			Mosquito surveys for infective-stage larva	
	No. positive/ no. examined	Rate (%)	MfD ₅₀	Mosquitos positive/ mosquitos dissected	Percentage positive
before treatment (1950)	156/583	26.6	18.0	147/4733	3.1 ^a
<hr/>					
after treatment (year; no. of years)					
(1953; 1)	35/576	6.1	6.0	6/1495	0.4
(1958; 5)	19/570	3.3	4.0	0/116	0.0
(1966; 13)	32/794	4.0	3.5	0/80	0.0
(1968; 15)	33/739	4.5	4.1	1/299	0.3

^aControl district of Vairao, 1953-56 substituted since method for mosquito collections was not yet standardized in 1950.

*Although the author did not name the species of mosquito in the text, the data presented should be considered as being for Ae. polynesiensis.

(140) Lagraulet, J. &
Thooris, G.
1971

Réaction à la diéthylcarbamazine
chez les porteurs de microfilaires
de Bancroft (Etude préliminaire)
Bull. Soc. Path. exot., 64, 343-346

The authors thought that the Mazzoti test of DEC might be useful to detect the microfilariae of W. bancrofti in Polynesia since this parasite has never been found to be associated with any other filarial infection, unlike the situation in Africa where the application of this test was found to be impossible in view of the complications arising from the association of onchocerciasis and bancroftian filariasis.

The authors gave 41 adults harbouring microfilariae of W. bancrofti one tablet of DEC to each (100 mg). Twenty-nine percent of them had troubles, the reactions were generally slight, characterized by cephalgia in particular and sometimes with vomiting or fever. No lymphangitis was observed.

(141) Mahoney, L.E. &
Kessel, J.F.
1971

Treatment of failure in filariasis
mass treatment programmes
Bull. Wld Hlth Org., 45, 35-42

Most of the previous work in filariasis control has utilized prevalence data obtained from cross-sectional studies based on examination of 20-60 mm³ thick blood film. Because of the insensitivity of this sampling method, the prevalence data are underestimates of the true prevalence, particularly when the mf density is low as in the case of post-treatment with DEC mass drug administration. Incidence measures reversion rates, i.e. from positive to negative and from negative to positive within a given period of time. The important objection to the exclusive use of prevalence index is that it represents the risk of infection provided that equilibrium conditions prevail. Because the equilibrium is disturbed under control measures, particularly by drug treatment against microfilaria, it is essential to monitor current incidence as well as prevalence. The authors utilized incidence data derived from longitudinal observations in American Samoa, for demonstrating the failures in the mass DEC administration programmes. The authors redefined the term used to describe the failures in drug treatment as will be indicated below.

Persistent microfilaraemia: This is defined as the number of individuals originally positive who show microfilaraemia during or immediately after commonly used course of treatment with DEC. These cases should be identified before tracing other causes of apparent treatment failures. Analysis of the occurrence of mf one week after treatment in four villages with a dose of 6 mg/kg for six days showed that 32% of 175 reappeared as positive one week after receiving the treatment and that the proportion of persistent mf rises significantly with pre-treatment level of mf density. There was no significant difference related to the effect of age and sex. Prevalence data are adequate to describe the persistence of mf, but incidence data are necessary to distinguish it from other phenomena.

Recurrence: This term is defined as the reappearance of mf acquired from previous infection after apparently successful treatment. The clearance of mf shows that DEC is effective on this stage of the parasite circulating in the blood. The return of microfilaraemia within an interval shorter than the prepatent period (generally agreed to be somewhat less than one year) may be explained by a number of hypotheses; (i) that adult parasites were not affected at all by the drug, (ii) that adult female parasites were reversibly damaged or sterilized by treatment but could regain some reproductive capacity, (iii) juvenile female parasites present during the treatment are not affected by the drug and have since begun reproduction, Otto *et al.*, 1953 (39); McGregor & Gilles, 1956.¹. In all of the above cases, recurrence within the pre-patent period implies that the drug is effective on the microfilaria but is not completely effective on adult or juvenile worms. In the four above mentioned villages, recurrence was assessed in a sample of 111 treated positives who became negative just after treatment, and were followed up at six months and one year. Of these, 23 became positive again at six months and four more at one year, despite further treatment in some villages given during the year. In view of the length of the prepatent period, it is unlikely that any of those becoming positive at six months or one year represent infections acquired after the original treatment.

Treatment schedules, as in Ciferri *et al.*, 1969 (127): (a) 6 mg/kg daily for six days, a 1-year rest, and then 6 mg/kg daily for six days; (b) 6 mg/kg daily for six days, a 6-month rest, and then 6 mg/kg for six days; (c) 6 mg/kg daily for six days, then 6 mg/kg once monthly for six months. Analysis of data showed that there was a statistically significant relation between recurrence rate and the level of pretreatment mf density. There was also a statistically significant difference between villages, probably attributable to variations in treatment schedules discussed by Ciferri *et al.* (*loc. cit.*). In addition, there was a statistically significant decline in recurrence from the first to the second half of the year. In all villages, the incidence of recurrence decreased in the second half of the year. The decline in incidence, therefore, seems to be independent of the differences between treatments. However, with the small number of cases in the second half of the year, differences in recurrent rates between treatment methods cannot be demonstrated after six months. Incidence was significantly lower in one village during the whole year, and particularly so in the first six months when the inhabitants were receiving additional monthly doses of DEC. Recurrence may, therefore, be reduced by monthly treatment (Schedule shown above).

¹McGregor, I.A. & Gilles, H.M. (1956) Diethylcarbamazine control of Bancroftian filariasis. Follow-up of a field trial in West Africa. *Brit. med. J.*, 1, 331-332

New infections: This is defined as "Infections acquired since treatment cannot become manifest until the passage of a time interval equivalent to the pretreatment period". They can be estimated by measuring the incidence of microfilaraemia in successfully treated individuals beginning at least a year following treatment when recurrence further declines and its effect becomes small. Incidence of new infections was estimated in a sample of 828 persons from five villages in American Samoa, of whom 157 were originally positives, OPs, and 671 were originally negative, ONs. This sample consisted of all persons treated with 11-12 doses of DEC who had their blood films taken before and at 1, 2 and 3 years after treatment and were negative at the one-year survey. Of the 157 treated OPs, 49 (31%) became positive during the succeeding two years. Of the 671 treated ONs, 19 (2.8%) became positive in the two years following the one-year examination when they were negative. The difference between the incidence of OPs and ONs is highly significant. Analysis of data showed that there was no significant difference in incidence with age either in the OPs or the ONs. At all ages, the incidence of mf was greater in the OPs than in the ONs. Differences in incidence by village among OPs were significant (lowest being 18% and highest in the order of 35 and 49%), while those among ONs were not. In all villages, incidence was greater among the OPs. Among the OPs, incidence in males was 37% and in females 26%; among the ONs the corresponding figures were 3.7% and 1.9% respectively. There is a progressive increase in incidence of new infections according to the original level of microfilaraemia as shown below and this difference was found to be highly significant.

Pretreatment MF/20 mm ³	Incidence in years 2 & 3
0	2.8%
1-10	14%
11-50	34%
over 51	48%

Incidence of microfilaraemia among the OPs was 17% in each of years 2 and 3. As some of the incidence in year 2 among the OPs might have been attributable to recurrence, a reduction of 5% as being the most liberal estimate of the residual recurrence was made bringing the incidence of reinfection of year 2 to 12%. Nevertheless, this figure was not found to be significantly different from that of year 3. Among the ONs, however, there is a clear increase of incidence of new infections from 0.3% in year 2 to 2.5% in year 3, the difference being highly significant.

The authors assembled the results of the study in one graph, Fig. 1 which shows composite curves of incidence by time and the original level of microfilaraemia. The highest points at the left represent exclusively recurrence, those at the right almost exclusively new infections. The low points at year 1 on all curves represent the overlap of both phenomena when recurrence has fallen nearly to zero and most of the infection acquired after treatment has not yet become patent. Both recurrence and new infection contributes substantially to treatment failure. As has been shown above, there is about a two-fold difference in risk of new infection according to village with a slight difference in risk by sex. These findings

indicate that there are differences in the environmental conditions favouring transmission. There is also 10-fold difference in risk between the OPs and the ONs. This is not a dichotomous situation, but rather a continuous increase in risk proportionate to the original level of microfilaraemia.

These findings raise some important questions:

(a) The findings of differential incidence by village associated with higher predominance in males support the hypothesis of Jachowski & Otto, 1952 (31) that transmission principally occurs in plantations and the bush. Profound changes have occurred in the socioeconomic conditions in American Samoa since the time of the work of the above authors. Ramalingam, 1968 (125) reported that most men work outside village environment for cash. Therefore, it can be assumed that the incidence is now shifting to women and older men who continue to work in the plantation and in the bush, but this did not show in the data of the pilot programme. It is possible that transmission occurs in other sites in the new work environment.

(b) It has been observed that a large and consistent association occurred between the three phenomena, i.e., persistence, recurrence and new infections on one hand, and the original level of microfilaraemia on the other. This may have been due to differential susceptibility of the human population to filariasis infection or caused by a complex of factors including differential exposure by occupation, housing and life style. In any case, it has been shown that the highest incidence of microfilaraemia apparent after treatment occurred among those who were previously infected. This would indicate that the reversible catalytic models proposed by Hairston & Jachowski, 1968 (121) must be further refined to take into account the unequal risk of filarial infection in the different groups. Furthermore, the present data indicate that transmission, as assessed by incidence, is not randomly distributed in the population. Therefore, a filariasis eradication programme aiming at reducing the incidence below a pre-determined critical level within an entire area may allow transmission to continue considerably above the critical level in the subgroups at high risk whose infection could continue indefinitely and thus the eradication programme would fail.

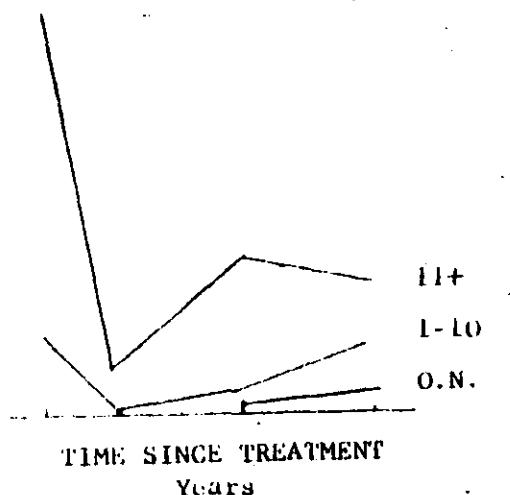


Fig. 1 Incidence of microfilaremia by time since treatment and by level of original microfilaremia. Because of different time-periods of measurement all rates have been reduced to person-years at risk.

These findings are of some interest to control programmes now in progress. The rationale behind mass treatment programmes has been somewhat as follows: mass treatment of the population will increase the rate of reversion, so that fewer positives are available to infect mosquitos; this will decrease the number of infective bites received by individuals in the population, and decrease the numbers of new cases. It is often overlooked that these changes in reversion rate may be only temporary. Given the same environmental circumstances favouring transmission, it is possible that the infection will return to its former level of endemicity as soon as mass treatment ceases. This is illustrated quite clearly by the rising incidence rates in this study that began a year after treatment. Successful control programmes should plan to maintain control pressures through environmental control or drug treatment over long periods of time, unless there is evidence that transmission has been reduced below critical level. Original positives experience the majority of infections acquired after treatment. In view of this, environmental studies and control measures should focus on living areas and work activities of this group. In addition, it might be worthwhile to arrange special drug treatment for this group over and above that given to the general population.

(142) Mataika, J.U.,
Dando, B.C.,
Spears, G.F.S. &
MacNamara, F.N.
1971

Mosquito-borne infections in Fiji.
I. Filariasis in northern Fiji:
epidemiological evidence regarding
factors influencing the prevalence
of microfilaraemia of Wuchereria
bancrofti infections
J. Hyg., Camb., 69, 273-286

In 1966, the Medical Department of the Government of Fiji began a filariasis control programme. It was decided that a survey should be conducted to provide baseline information on which the control programme could be evaluated. The survey was begun in 1967 and the present paper outlines the procedures adopted and presents the data associating the prevalence of microfilaraemia with climate, ethnic groups, age and sex, household and housing density. A sero-epidemiological survey of antibody of dengue virus was simultaneously conducted, the results of which were published by Maguire et al. (1971)¹.

Climate and social factors: Vanau Levu is the second largest island in Fiji. A chain of hills about 600 m in altitude forms the backbone of the island. The hills lie across the flow of the SE trade winds, thus the windward side is exposed to high rainfall of an average of about 2.54 m on the coast increasing to about 5 m inland. On the leeward side of the island

¹Maguire, T. et al. (1971) Mosquito-borne infections in Fiji.
II. Arthropod-borne virus infections. Journal of Hygiene, 69, 287-296

the rainfall decreases to about 2.03 m on an average per year along the coast with pronounced seasonal variation and dry periods prevailing during the cooler months of the year. The climatic difference in the two areas is reflected in vegetation cover. On the windward side, the area is heavily wooded and coconut plantations are common. On the leeward side, the hill forest gives way to extensive grassland with the cultivation of sugar cane. Mangroves are more extensive on the northern coast than on the southern, more steeply rising coast line. The island of Taveuni is smaller than Vanua Levu and its both sides are humid and exposed to high rainfall. Coconut plantations are extensive and there are more Fijians than on Vanua Levu. Koro island is situated south of Vanua Levu but its climate is similar to Taveuni.

The population of Fiji is nearly equally divided between those of Fijian origin and those of Indian origin. The Fijian population live largely in well-kept village communities of about 100 inhabitants. In recent years, there has been an increasing tendency to break away from village life and individuals build their houses near their farms in relative isolation. Such dwellings are referred to as "settlements". The men are mainly engaged in agricultural work and in copra production while women spend most of their time fishing on the reef since most villages are close to the sea. Even women from inland villages make frequent visits to the coast. The dwellings of Indians are usually relatively scattered, and most of sugarcane cultivation is carried out by Indians and is concentrated on the northern side of Vanua Levu. In copra-producing areas, Indian men are largely occupied on plantations, while the women are engaged in domestic duties and are well covered with clothing. In sugar-producing areas, women frequently assist men on plantations, and children assist their parents when not attending schools.

Survey methods: Two surveys were carried out. The first was made on Taveuni island, southern Vanua Levu and Koro island during 1968. The second survey was made on northern Vanua Levu during 1969. In the first survey of 40 villages, 37 were selected at random and three by deliberate choice to cover areas otherwise very poorly represented. In the second survey, four inland and four coastal villages as well as four offshore islets were selected by deliberate choice on the northern Vanua Levu island. Blood surveys were conducted during daytime. As far as possible, capillary blood was taken. The latter was applied to the offshore islets and Indian school children in northern Vanua Levu. Three thick smears each of 20 mm³ blood were made.

Epidemiological grouping associated with climate and local geography: It should be mentioned first that the authors found that their results did not contradict those obtained by previous workers, Nelson & Cruickshank, 1955 (54); Symes, 1960 (90); and Burnett, 1960 (85) in that the epidemiology of filariasis remained fairly stable for a considerable period of time.

In presenting their data, the authors indicated that for Fijians, the results derived from inhabitants of inland villages, settlements and estates were combined. Since Indians do not live in villages, their respective data apply to settlements and estates.

The findings also confirmed those of Symes, 1960 (loc. cit.) in that a lower prevalence of microfilaraemia was noted on the northern side of Vanua Levu than on the southern side and that still lower prevalence was observed in inland villages. The authors attributed this difference to climate which on the northern side is drier and has a longer season of low rainfall. Whether north or south, the difference between coastal and inland areas could be noted within 1.6 miles (2.57 km) from the coast. The change was probably due to the decline of Ae. polynesiensis away from the coast and its replacement inland by small numbers of Ae. pseudoscutellaris. It appears that there was little or no transmission among Indians living in sugarcane plantations in northern Vanua Levu.

Difference between ethnic groups: The results of the survey showed that the prevalence of microfilaraemia was always higher among Fijians than among Indians living under similar geographical and climatic conditions, Table 1. Even when the mf rates of the two ethnic groups living in settlements are compared slightly higher rates were observed among Fijian males than among Indian males. The explanation given by the authors is cited.

"Nevertheless, the fact that the maximum prevalence among Indian males was reached at a young age, the observation that elephantiasis among Indians was more prevalent than among Fijians, Mataika et al., 1971 (143) and the report by Maguire et al. (loc. cit.) that the prevalence of dengue antibodies among Indian males was no less than among Fijian males under comparable circumstances suggest that the lower prevalence in Indians could be due to a higher recovery rate, a situation perhaps similar to that producing the differences between the two sexes in Fijians."

It should be mentioned that no data were given to show that the maximum prevalence among Indian males was reached at a young age.

Table 1. Prevalence of microfilaraemia and microfilaria density among Indians and "other races" of all ages

Area	Race	Males			Females		
		No. ex.	% +	Mf.D. geom. mean	No. ex.	% +	Mf.D. geom. mean
Tavauni	Indian	130	11	26	141	14	9
S. Vanua)	Indian	160	10	4	156	3	3
Levu)	Other	104	18	4	100	10	4
N. Vanua)	Indian	189	0	/	67	1	/
Levu)	(Age 15-22)						

Sex difference: The authors refer to differences in mf rates between male and female sexes observed by other workers in previous bancroftian filariasis surveys and that these differences were attributed usually to the different way of life of the two sexes, McCarthy & Fitzgerald, 1956 (60). In the present surveys, the authors found the most marked difference was recorded among Indians on the southern Vanua Levu island, Table 1. They explain that the difference could have been due to the different habits of the two sexes. Women are extensively covered by clothes and they do not work frequently in plantations. This was supported by the data of Maguire et al., 1971 (loc. cit.) which showed that 4% of the women were positive for dengue antibodies, compared with 10% in the male, which is taken as an indication of the lower exposure to mosquito bites. However, the author emphasized that the lower exposure of women to mosquito bites by virtue of their cover by clothes or by working in the village of fishing on the reefs, may not offer the entire explanation, and their statement in this respect is quoted below.

Women have acquired dengue antibodies at least as frequently as their men folk and presumably from the same species of mosquitos as those transmitting filariae (Maguire et al., loc. cit.). Rates of recovery from filarial infection which were higher in women than in men could result in the observed differences in prevalence of microfilaraemia.

In this connection, the authors made an estimate of the infection and recovery rates among males and females of Fijians living in three different epidemiological areas as shown in Table 2.

Table 2. Infection (a) and recovery (b) rates indicated by microfilaraemia among Fijians in three different epidemiological areas in northern Fiji and used to construct mathematical models

Sex		Area	
		Taveuni and Koro	Southern Vanua Levu
		Coastal	Inland
Both M. and F.	Infection rate	0.085	0.080
Male	Age	15+	15+
	Recovery rate	0.100	0.110
	Asymptote of mf prevalence	0.46	0.42
Female	Age	7.5-40	7.5-40
	Recovery rate	0.230	0.240
	Asymptote of mf prevalence	0.27	0.25

Prevalence = $(1 - e^{-(a+b)t})a/(a+b)$ where a = infection rate, b = recover rate, t = years of exposure

Age differences: The general pattern of age prevalence was comparable to those observed in previous surveys in that microfilaraemia was absent among persons under 5 years of age and that the rate remained low between 5-15 years of age but increased rapidly thereafter reaching a maximum in the 40-age group.

Infections in Fijian households in villages

Size of household: For the areas of Taveuni and Koro islands, coastal southern Vanua Levu and inland Vanua Levu, Fijian households were studied according to the number of occupants and the number of these who were found to be microfilaria positive. The mean infected proportion of the household was calculated by dividing the mean number of mf carriers in a household in a given occupancy by the number of these occupants. These figures were comparable between the households of different sizes. The mean expected number of mf carriers was estimated by computer analysis employing Monte Carlo simulation. The expected number of mf carriers in households of different sizes was compared with the observed, in order to determine whether transmission of filariasis is intrafamilial. If it were, large households having a greater chance of one of their members introducing the diseases, would show a higher proportion of microfilaria carriers than would be expected in small households. The data did not support this hypothesis since the proportion of mf carriers in households were very close to those which could have been expected in small households. The data did not support this hypothesis since the proportion of mf carriers in households were very close to those which could have been expected by chance in a random distribution of the population of similar age-sex composition and risk of infection. The authors having found the evidence that transmission of filariasis in the environments studied in Fiji was not predominantly intrafamilial, inferred that this could give support to the findings of Burnett (loc. cit.) on the insignificant role of the peri-domestic species, *C. quinquesfasciatus* in filariasis transmission in Fiji.

Clustering of infected household: The aim of this study was to determine whether some households irrespective of their size, had more or less their random share of infection. Fig. 1 shows that the spread of the observed distribution of households with specified number of infected individuals was greater than could be expected, indicating that some houses did have more than their random share of infections while others went free. Although the difference between the observed and the expected was found to be statistically significant in the case of Taveuni/Koro and in coastal villages in the southern part of Vanua Levu, the difference was not significant in the case of inland villages. However, the epidemiological significance of this difference was considered to be of slight importance.

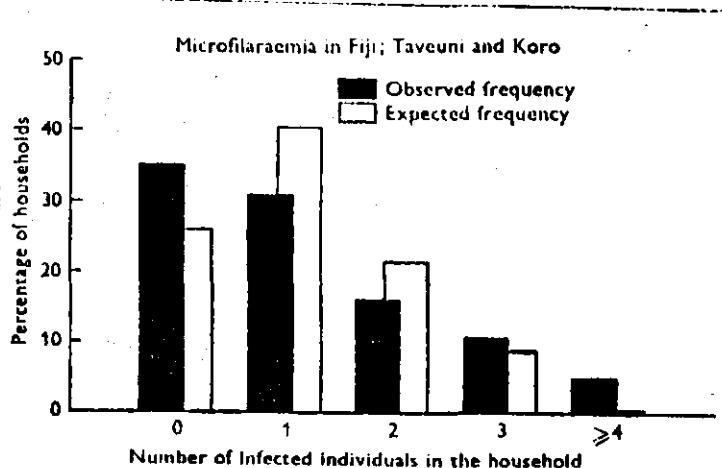


Fig. 1. Household infections.

(143) Mataika, J.U.
1971

Mosquito-borne infections in Fiji.
III. Filariasis in northern Fiji:
epidemiological evidence regarding the
mechanisms of pathogenesis
J. Hyg., Camb., 69, 297-306

During a filariasis survey conducted in northern Fiji in 1968-1969 examinations were made for microfilaraemia, enlarged lymphnodes and elephantiasis. Analysis of the mf densities at different ages and the number of anatomical sites showing lymph gland enlargement or elephantiasis have been used to provide evidence on the clustering of infections and pathogenesis.

Although there is no evidence of clustering of risk of infection, there is evidence favouring the clustering of adult filariae in individuals. Nevertheless the number of sites of lymph node enlargement do not correspond with this finding and statistical evidence suggests that lymphnode enlargement is not necessarily associated with the near presence in the body of adult filariae, whether dead or alive.

Males of Indian ethnic origin showed a higher prevalence of elephantiasis than males of Fijian ethnic origin, but women of either ethnic race showed prevalences lower than those of men.

The onset of elephantiasis at a site does not directly reflect the number of infections sustained in the local area, but it appears that filariasis first induces for a limited period a proneness to elephantiasis. During this period a random and discrete event may induce the onset of elephantiasis. The nature of the event is unknown, but it probably is not trauma.

(144) Southgate, B.A. &
Desowitz, R.S.
1971

Comparative efficacy of the stained blood film, counting chamber and membrane filtration techniques in the determination of microfilarial rates and microfilarial densities
WHO unpublished document, WHO/FIL/71.91

These investigations were carried out in Fiji and Western Samoa.

Materials and methods

1. Counting chambers were made in Fiji from glass slides as described by Denham *et al.*, 1971 (135). Sixty mm^3 of finger-prick blood was placed in the chambers using 20 mm^3 pipettes, and the blood haemolyzed by mixing with 0.5 ml tap-water. Counts of microfilariae were made with a binocular dissecting microscope at 50 x magnification. At the same time circular 3 x 20 mm^3 thick blood films of 3.14 cm^2 area (2.0 cm diameter) were prepared, dried overnight, stained with Giemsa, and counted.

2. The Millipore^R membrane filtration technique was carried out by a modification of the method described by Chularerk & Desowitz, 1970¹ and Desowitz *et al.*, 1970 (129). Sixty mm³ thick-films of finger-prick blood were prepared for comparison and, in some cases, 60 mm³ of venous blood and/or finger-prick blood were counted by chamber as well.

Conclusion

1. Both the counting chamber and the Millipore^R membrane filtration techniques are more sensitive and more efficient at detecting cases of microfilaraemia than the conventional 60 mm³ stained thick blood film technique.

2. Both techniques are easy to use under tropical field conditions. Both are easily mastered by field technicians, and as many people can be examined daily as by conventional methods.

3. In both treated and untreated areas of subperiodic or nonperiodic bancroftian filariasis, mf rates and mf densities are considerably higher than has been hitherto suspected. Revision of mathematical models of the transmission of filariasis may be necessary as a result of these observations.

4. Microfilaraemia persists in some 20% of previously positive subjects treated with DEC. In a higher (*circa* 70%) percentage of initially resistant cases, retreated microfilaraemia persists after a second full course of treatment.

Recommendations for further research

(a) A longitudinal community study should be carried out in an area of high endemicity, starting before MDA and continuing for several years after MDA. Such a study would compare the membrane filtration, counting chamber and blood-film techniques. Data obtained on cases of residual microfilaraemia would be used as a basis for retreatment. Beqa Island, Fiji, where MDA is scheduled to start in March, 1972 would be ideal for such a study. It has a population of 1500, is compact and relatively easily accessible, has a low level of population migration, and has a highly cooperative population.

(b) A more extensive survey of post-treatment microfilaraemia should be carried out in an area where pre-treatment data are good and where adequate drug dosages have been observed to be administered.

Western Samoa would be ideal for this purpose.

(c) An entomologist experienced in *Aedes* of the Pacific area and in colonization of mosquitos in field conditions should be employed to determine the infectivity of low-level pre- and post-treatment mf carriers to mosquitos. This work is essential to an understanding of the epidemiology of potentially recrudescent filariasis.

¹Chularerk & Desowitz (1970) *J. Parasit.*, 56, 623

(d) Investigation of the possible immunological differences between DEC successes and failures in view of the demonstration that the drug works for producing an opsonin-like effect (Hawking, 1950¹; Hawking *et al.*, 1950)². Conceivably, failure of DEC to clear microfilariae could be done to a partial failure in the immune system of the human host.

(145) World Health Organization 1972 A project on the biology, ecology, systematics and naturalistic control of filariasis vectors in the Pacific area. Report of an advisory working group
WHO unpublished document, PD/72.7

A group of three scientists and four members of the WHO Secretariat met in Geneva on 21-25 June 1971 to discuss and plan an investigation on the Ae. scutellaris group of the subgenus Stegomyia in the South Pacific.

As is well-known, members of the Ae. scutellaris group of the subgenus Stegomyia serve as the primary vectors of subperiodic W. bancrofti in many islands in the South Pacific. These mosquitos are particularly difficult to control with insecticides. The larvae breed in a variety of small inaccessible habitats including artificial containers tree holes, coconut husks, crab holes and the like. On most islands removal or destruction of larval habitats is impracticable.

This group of mosquitos presents an interesting example of incipient speciation. Distinct populations seem to be evolving on different island groups, although most of these forms retain similar habits. Hybridization studies have demonstrated that reproductive barriers between some of the so-called species are incomplete, and in the laboratory mating between forms occurs fairly readily. Nevertheless, a type of non-reciprocal infertility between members of the scutellaris group has already been described. In general it is clear that genetic work on this group is still at a very early stage and much more research has to be accomplished in this field. This would apply equally to studies on the biology of the scutellaris group.

In view of the above it is proposed that a long-term project of approximately five years be initiated with primary emphasis on the Ae. scutellaris group, and possibly related vector species, in which the following components should be part of a coordinated investigation:

- (1) biological and ecological investigations;
- (2) genetic studies; and
- (3) taxonomic investigations.

¹Hawking, F. (1950) Some recent work on filariasis. Trans. roy. Soc. trop. Med. Hyg., 44, 153-192

²Hawking, F., Sewell, P. & Thurston, J.P. (1950) The mode of action of Hетразан on filarial worms. Brit. J. Pharmacol., 5, 217-238

This long-term project should have the following fundamental objectives:

- (1) the more precise identification of vectors of filariasis in the islands of the South Pacific,
- (2) the sorting out of the members of the *Ae. scutellaris* group as a requirement for control experiments based upon genetic mechanism, and
- (3) the investigation of the possible correlation between the taxonomically and genetically well-defined species on the one hand and their ecological characteristics on the other.

On this issue, the meeting proposed the following plan of a project to be supported by WHO.

Proposed schedule of work and methods:

1. Taxonomic and related studies

These studies should be concluded on reared specimens with associated skins of larvae and pupae, eggs, progeny rearings and adults captured by any means available. The material should largely be prepared in the field for transmittal to the Southeast Asia Mosquito Project, Smithsonian Institution, Washington. The object of these studies was to undertake a taxonomic revision of the *scutellaris* subgroup to arrive at a better definition of the identity of filariasis vectors.

2. Genetic studies

Colonies of the species required should be established in addition to those already being maintained. Cross-breeding experiments should be conducted between these colony strains to obtain data on insemination rates, cross-insemination sterility, and genetic and cytoplasmic incompatibility, including a search for non-reciprocal infertility. These studies will be carried out at The Johns Hopkins University, Baltimore.

3. Field survey and investigations

(a) To carry out intensive larval surveys and obtain individual rearings of *Ae. scutellaris* subgroup species and forms, with associated skins of larvae and pupae.

(b) To collect and despatch material for progeny rearing and colonization for taxonomic, genetic and related studies by the laboratories designated above under 1 and 2.

(c) To obtain long series of topotypic material for conservation and studies by the designated laboratories.

(d) To collect data on the biology and ecology of the mosquitos (e.g. on population dynamics, breeding habitats, biting behaviour, infection status), by spot visits and in long-term study areas.

- (146) Huang, Y.M.
1972

A redescription of the holotype male
of Aedes (Stegomyia) tongae with a note
on two topotypic females
Proc. ent. Soc., Washington, 74, 338-342

The name Ae. tongae Edwards 1926 has caused much confusion. At least two species were being mistaken for tongae Edwards as reported by Belkin, 1962 (97), and Ramalingam & Belkin, 1965 (111).

According to the latter, the description and figures by Belkin (loc. cit.) for "tongae" are actually those of another species which they named tabu. Thus, no detailed description and figures of true tongae are available at the present time.

By examining the specimens kept in the British Museum (Nat. Hist.), London, the holotype male of Ae. (S.) tongae Edwards from Ha'apai, Tonga, is redescribed and illustrated. Two topotypic females of this species of Buxton and Hopkins expedition to Ha'apai, Tonga, South Pacific, 1925 are also described in the paper so that the identity of Edwards' tongae should no longer remain in doubt.

- (147) Lagraulet, J., Pichon, G. & Cuzon, G.
1972

L'elephantiasis aux Iles Marquises
Bull. Soc. Path. exot., 65, 437 - 446

In the Marquesas, where the incidence of microfilaraemia varies from 1 to 40% according to the valleys, the authors have studied 35 cases of elephantiasis and observed the following facts:

In this archipelago elephantiasis is a rather frequent complication. It affects men more than women. Of 55 elephantiasis cases studied, 37 were men (8.2% of the old people aged 40-69 years suffered from elephantiasis. The youngest case was 32 years old). It is most frequently localized in the lower limb (leg), being 77.2%. Elephantiasis cases are mostly negative for microfilariae (83% of the cases). This is a normal phenomenon observed in the chronic stage of other filarial infections.

- (148) Lagraulet, J., Pichon, G., Outin-Fabre, D., Stanghellini, A. & Moreau, J.P.
1972 a

Enquête épidémiologique sur la filariose lymphatique
Bull. Soc. Path. exot., 65, 447 - 455

The authors have carried out a survey on filariasis in the Marquesas. 18.4% of the individuals had a positive microfilaraemia. A thick drop taken from the ear showed up patients who had not been positive by the finger-prick sample. Out of 2706 inhabitants, 49 had elephantiasis (2.8%), the most frequent location being the lower limb (81.7%).

Elephantiasis was more frequent in European people or in markedly European crossed individuals. In 1971, 3.6% of the population presented lymphangitis attacks. Hydroceles, adenolymphoceles and chyluria were very rare.

(149) Moreau, J.P.J. &
Outin-Fabre, D.
1972

Essais in vitro de la diethylcarbamazine
I. Activite sur les microfilaires de
Wuchereria bancrofti var. pacifica
II. Activite sur les larves
infestantes de W. bancrofti var.
pacifica
Bull. Soc. Path. exot., 65,
93-98, 98-103

Diethylcarbamazine action is tried in vitro on microfilariae of W. bancrofti var. pacifica maintained in the medium 199 with HANKS solution and 10% colt sera. The survival time is significantly different when the DEC concentration reaches 200 ug per ml, that is a level forty times higher than the level found in the circulating blood after ingestion of 10 mg/kg. It is established that DEC effects an important and rapid decrease in the number of circulating microfilariae. However, DEC seems to have no action in vitro and it is difficult to affirm that this drug is directly toxic to microfilariae.

DEC activity tried in vitro on infective larvae of W. bancrofti var. pacifica obtained from experimentally infected Ae. polynesiensis using the medium mentioned above. This medium allows the maintenance of 50% of infective larvae for 33 days at 24°C and for 13 days at 37°C. DEC at a conceantration accepted by human patients has no action in vitro on the survival of larvae. It is the same for the microfilariae. The mode of action of DEC is still unknown.

(150) Moreau, J.P., Cuzon G.,
Pichon, G., Outin-Fabre, D.
& Lagraulet, J.
1972

Serum proteins in filariasis of the lymphatic system caused by Wuchereria bancrofti var. Pacifica
Electrophoretic analysis and quantitative immunochemical determination of A, M, G and E immunoglobulins
Bull. Soc. Path. exot., 65, 456 - 463 and WHO unpublished document, WHO/FIL/72.100

The original report was processed in the WHO/FIL series in English and then was formally published by the authors in French as shown above. The authors explained the purpose of the investigation as follows:

"The pathogenesis of the clinical manifestations of lymphatic filariasis is still largely unknown and gives rise to considerable controversy, although it seems to be universally conceded that immunopathological processes are involved. However, the very nature of these processes needs elucidation. A possible first approach to the problem is to examine the serum proteins of persons suffering from filariasis. In this study we used two methods of attack: electrophoretic analysis and determination of immunoglobulin levels. The relative isolation of the islands of French Polynesia and the facts that only one type of human filariasis exists in this territory makes the study of particular interest".

From the results which were compared with the findings of other workers, the authors concluded:

"Mf + subjects who had no chronic clinical symptoms and had never been treated showed a definite increase in gamma-globulins. A more sensitive analysis using disc electrophoresis in polyacrylamide gel confirmed the increase in globulins, but no characteristic protein discs could be identified by this technique in the Mf + group.

Immunological analysis showed an increase in IgG and IgE globulins. There seems no doubt that IgE globulins play a part in manifestations of the immediate hypersensitive type observed in lymphatic filariasis. This is not to say that they are the only factors responsible. Indeed, as seen above Mf + subjects also had increased IgG globulins, some fraction of which may be anaphylactic antibodies of the heterocytrophic type".

- (151) Oldham, M., Lusk, E.E.
& Womeldorf, D.J.
1972
- Residual activity of various
insecticides in tree holes
Proc. 4th Annual Conf. Calif. Mosq.
Control Assoc., 40, 69-71

Although the field trials with insecticides for controlling the tree hole breeding mosquito, Ae. sierrensis, in California, United States of America had no direct relationship with the situation in the South Pacific, it was felt that the abstract of results of trial may serve useful reference to the workers in the latter area.

The authors referred to the experiences obtained by Brannau (1964)¹. It was mentioned that DDT gave a minimum of three years' control.

The present authors tried four insecticides: chlorpyrifos 4E, fenthion, temephos 4E and propoxur 70% w.d.p. It was concluded that chlorpyrifos is the only one offering the potential of long lasting residual activity.

¹Brannau, T. (1964) Control of tree hole mosquitos in Alameda Country.
Proc. Calif. Mosq. Control Assoc., 32, 53-54

- (152) Outin-Fabre, D.,
 Saugrain, J.,
 Stanghellini, A.
 & Pichon, G. Une experience pilote de campagne
 antifilariaenne en milieu insulaire
 (Moorea, Polynesie francaise)
Bull. Wld Hlth Org., 46, 253-256

Filariasis caused by Wuchereria bancrofti var. pacifica has been a serious public health in French Polynesia for many decades. In 1956 the island of Moorea adjacent to Tahiti was chosen as the site of a mass chemotherapy campaign. At that time the mf rate was 27% with a mean mf density per carrier as shown in the table.

Table 1. Consolidated data of the Moorea pilot experiment

	<u>Before 1956</u>	<u>In 1957 1 year after the mass campaign</u>	<u>In 1966 9 years after only treating the carriers</u>	<u>In 1966 18 months after the mass campaign</u>	<u>In 1971 3 years after completion of the mass campaign by 18 days' treatment to carriers</u>
Microfilaria rate	27	7.6	73	2.2	1.1
Mean of mf density per carrier	52	17.5	18.9	23.88	10.35
MfD50	-	-	3-4	8-9	5
Incidence (per 1000)	-	-	8.6	1.53	2.06
<u>Aedes infected by larvae of all stages, %</u>	13 ^a		2.25 ^b		0.21
<u>by infective stage larvae, %</u>	7 ^a		0.84 ^b		0.00

^agiven by analogy to Tahiti

^bobtained by an entomological investigation carried out in Moorea in 1959 on 3205 mosquitos

For one year (between 1956 and 1957) a monthly dose of 6 mg of DEC per kg of body weight was distributed to the whole population over 1 year age. As a result of the campaign, the mf rate fell to 7.6% with a mean mf density per carrier of 17.5. On the basis of these results, it was decided to treat only positive carriers identified in annual surveys during the rest of the campaign.

In 1966, a survey showed that the mf rate (7.3%) and the mf density per carrier (18.9) had remained practically stationary. It was recognized that treatment schedules limited to positive carriers only present certain risks and a new pilot mass chemotherapy campaign was started in Moorea (population 4300). Two zones were designated; in zone 1, carrier discovered in a 1966 survey received 4 treatments at 2-month intervals of 6 mg of diethylcarbamazine per kg between July 1966 and January 1967. In zone 2, carriers received similar treatment from June to December while the rest of the population received a single dose of 6 mg per kg in September-October.

A survey in zone 1 in April-September 1967 showed that the number of carriers was little changed - namely, 6.85% against 6.58% - and the mean mf density was 14.15 against 18.85. In zone 2, however, the mf rate fell from 7.7% to 4.1% and the mf density from 18.85 to 14.15. From April 1967 in zone 2 and August 1967 in zone 1, mass treatment was given to the entire population. A single dose of 6 mg/kg was given every 2 or 3 months to all persons, including carriers. This programme was planned to last 3 years, i.e. a total dosage of 72 mg/kg. After 18 months the mf had fallen from 5.12% to 2.20% and of 207 carriers in 1967, 123 were negative, 33 were still positive, and 51 escaped the survey. The mf rate in children aged 1-14 years in 1969 was 2.32% compared with 13.03% in 1967, while the rate in persons aged 15-24 years fell from 17.39% to 12.79%. The number of new cases fell from 33/4 044 (8.16 per 1000) before the treatment to 6/3 905 (1.54 per 1000) after treatment. However, the mf density in carriers rose and the proportion harbouring 30-100 microfilariae increased from 7.24% to 14.34% while the Mfd50 rose from 3-4 to 8-9. An 18-day course of treatment for carriers was therefore started; the treatment schedule being 12 progressive daily doses of DEC, then 6 daily doses of 6 mg/kg, followed by single monthly doses of 6 mg/kg for 1 year.

At the beginning of 1971, after 3 years of mass treatment, there were 49 carriers out of a population of 4361 (1.12%), the mean mf density was 10.35, and the Mfd50 was 5. Taking into consideration the fact that 7 carriers out of 49 (14.3%) refused treatment, the prevalence of carriers in Moorea can be estimated at 1% compared with 7% during the treatment of carriers only and 2.2% after 18 months of renewed mass treatment. The number of new infections during the last 18 months of the trial was 9 (2.06 per 1000), but no schoolchild became infected.

An examination of 470 Ae. polynesiensis mosquitos collected in the neighbourhood of carriers' homes at the beginning of 1971 showed that only one contained a stage 1 larvae and that none harboured infective larvae. No vector control measures were taken against Ae. polynesiensis during the mass chemotherapy campaign.

(153) Sasa, M.
1972

Assignment report, 26 July to
20 September 1972
WHO unpublished report, Western
Samoa 2201

The author served as WHO consultant to assess the results of filariasis control in Western Samoa. The following are his findings and conclusions.

During the pre-treatment blood survey carried out in Western Samoa in 1964-1965 covering some 10% of the population, an overall mf rate of about 20% and an MfD-50 of about 20 per 20 mm^3 were observed. However, analysis of the age and sex distribution of the rates and densities estimated the intensity of infection to be very high, and nearly half of the male adults as well as one-third of the female adults were found to be mf carriers.

The first round of mass drug administration covering the whole country was begun in August 1965, using a dosage scheme of 5 mg/kg, weekly for 6 weeks followed by monthly doses for 12 months, totalling 18 doses and 90 mg/kg. The eighteen dose coverage was rather poor, only 12% in some sample. While, however, this was against misleading figure in evaluating the efficiency of dose coverage. By analysis of the frequency distribution, it was demonstrated from the same population that some 80% took 12 or more doses. From the figures of treatment failure indices, it was also estimated that the majority of the population was covered by effective doses.

Remarkably reactions in both mf rates and densities were achieved as a result of the first mass drug administration. At the country-wide post-treatment blood survey carried out in 1967, the overall mf rate had dropped to 1.63% with an MfD-50 of 2, per 20 mm^3 . In the individual case analysis of 258 Mf cases, a high cure rate of 92.2% and a low recurrence rate of only 5.5% were obtained. These results suggest that the campaign carried out in Western Samoa was probably more effective and successful than those reported from American Samoa and Tahiti. (Table 1)

However, a further detailed analysis of the blood survey discovered that a fraction of the people had been left untreated or had been treated only with insufficient doses. Especially high mf rates, about 5%, were seen among young adult age-groups, particularly in males. This justified a second round of MDA.

Mainly because of the shortage of time after completion of the second MDA, sufficient information for evaluation of the results has not yet been accumulated. The mf rate so far observed from the blood surveys in 11 villages is 0.19%, and it is assumed that a further remarkable reduction in the intensity of infection has been achieved.

A number of valuable and useful data have been assembled from the basic studies on the bionomics and control of the vectors. In general, control of the vectors of the South Pacific form of filariasis seems to be more difficult than those in other endemic areas, and the need for continuation of further basic research is emphasized.

In general, the activity and cooperation of the people in Western Samoa, especially the village women's committee, has been excellent. However, it is felt that improvements are required, especially in the methods of epidemiological evaluation of the results. Some of the reporting forms and systems are considered to be too complicated and, therefore, impracticable for use by the field workers, or rather meaningless even when adequately reported. Some improvements in the methods of reporting and statistical analysis of the dose coverage records and blood survey data are also recommended.

Recommendations

After carefully reviewing the work done and considering the present situation, the following recommendations are made:

1. Before considering the need for another round of MDA, a trial should be made to interrupt transmission by means of a thorough search for mf carriers, treating them, and using all possible measures to reduce the vectors.
2. The blood surveys should be intensified so that all the villages are covered within three to four years.
3. Microfilaria carriers should be thoroughly treated and their blood examined in follow-up visits. They should be admitted to district hospitals, and given a short period of treatment such as 4 mg/kg three times a day for six days (72 mg/kg in total).
4. The results of blood surveys, treatment and follow-up blood examination of mf cases and other records should be statistically analysed in a way which will be useful and meaningful for evaluation of progress. Also, a further statistical analysis is required to assess the results of the second round of MDA, so that the coverage be shown by frequency distribution of each dose. A yearly survey should be carried out in the four indicator villages (the preliminary study area).
5. The health education programme in vector control should be strengthened, with emphasis on environmental sanitation, so as to improve the temporary breeding places of Ae. polynesiensis. The limited use of insecticides in certain breeding places, such as DDT in tree holes and Abate in water tanks, is also recommended.
6. A mosquito survey should be undertaken of selected villages and their environment, with emphasis on the ratio and number per house of the breeding places of Ae. polynesiensis and Ae. aegypti.
7. Ae. polynesiensis should be periodically and systematically dissected for filarial infection, and when possible, for age determination.
8. Since it is very possible that effective control of filariasis can be achieved if the whole population is covered by a blood survey, all the positive cases adequately treated, and the vector population reduced further, the need for another round of MDA should be discussed about two years from now, based on the results of a review of the progress, made in implementing the above recommended procedures.

TABLE 1. COMPARISON OF mf POSITIVE RATES AND mf DENSITIES OF
SAMPLE STUDY POPULATIONS BEFORE AND AFTER MASS DRUG ADMINISTRATION

Country/ Area	Year of blood surveyed	Relation to DEC treatment	Population surveyed	Amount of blood examined	BLOOD SURVEY RESULTS			
					Number examined	Number positive	Percent positive	MfD - 50
WESTERN SAMOA	1964-5	Before trt	Villages	20	12 196	2 370	19.43	21.0
	1966	Mid trt	"	20	18 717	262	1.40	2.1
	1967	After 1 yr	"	20	42 697	696	1.63	2.7
	1968	After 2 yrs	"	20	8 974	44	0.49	2.7
			"	40	1 221	5	0.41	-
			"	60	5 371	71	1.32	4.8
			Emigrants	40	2 207	92	4.17	3.7
			"	80	3 506	119	3.39	5.8
	1969	After 3 yrs	Villages	60	7 393	129	1.74	7.6
			Emigrants	80	3 064	107	3.49	6.1
1972	After 2nd round	Villages	60	3 776	7	0.19	-	-
*AMERICAN SAMOA	1962-3	Before trt	Special	20 x 2	1 191	251	21.07	20.0
	3-4	After 1 yr	study	20 x 3	894	37	4.14	2.0
	5-6	After 3 yrs	areas	20 x 3	957	71	7.42	2.0
	7-8	After 2nd round		20 x 3	554	2	0.36	-
**TAHITI	1949-50	Before trt	Special	20	1 157	386	33.36	23.0
	1958	After 3-4 yrs	study	20	1 283	54	4.21	5.2
	1966-8	After 10- 12 yrs	areas	20 x 2 or 3	1 770	90	5.08	3.7

*Re-arranged from Tables 2 and 3, Kessel *et al.*, 1970 (132)

**From Kessel, 1971 (139)

(154) Saugrain, J.
& Outin-Fabre, D.
1972

Bilan de vingt années de lutte
contre la filariose sub-
périodique de Bancroft en Polynésie
française
Bull. Wld Hlth Org., 46, 249-252

Filariasis caused by Wuchereria bancrofti var. pacifica has been a serious public health problem in Tahiti for many decades, and in 1949 a research institute was established to attack the problem. At that time the mf rate was over 30%, the mean mf density was 78; and 7% of the population was suffering from elephantiasis, while 13% of Ae. polynesiensis were infected by larvae of all stages and 7.4% contained infective larvae.

Between 1953 and 1956 mass chemotherapy with DEC was begun in Tahiti and by 1956 the mf rate had fallen to 6%, with mean mf density of 24.1, and only 0.7% of Ae. polynesiensis contained infective larvae. In 1956 it was decided to end mass treatments and to continue to treat only positive carriers identified in annual surveys, three different regimens being tested. In 1964 the mf rate was 7.2% with a mean mf density of 19, and 0.67% of Ae. polynesiensis had infective larvae. The rate of elephantiasis in the population was 1.8%.

These results were not considered satisfactory and in 1967 MDA was started in the neighbouring island of Moorea. The number of inhabitants was 4297. The regimen chosen was 1 dose of 6 mg/kg every 2 to 3 months for all the population over 1 year of age. To avoid certain side-effects, the drug was coated with cellulose, which dissolved only in the intestine. An educational programme was also started. Annual blood examinations were made and positive carriers were given curative treatment consisting of a progressive doses of DEC for 12 days, followed by daily dose of 6 mg/kg for 6 days, then a single monthly dose of 6 mg/kg for the next 12 months.

At the beginning of 1971 the mf rate had fallen to 1%, no Ae. polynesiensis were carrying infective larvae, and there were no new cases among schoolchildren or other residents of Moorea. Since mass chemotherapy was able to arrest transmission in Moorea, it was decided in 1968 to extend the campaign to Tahiti, and in 1970 the first results were as encouraging as those in Moorea. Some of the smaller islands are now also being treated successfully.

It should be noted that although entomological studies have been carried out, the vector mosquito is a rural, exophilic species and direct attacks against the adults with insecticide have failed; antilarval measures also failed to influence transmission rates.

(155) Thieme, J.C. & Penais, L.
1972

Filariasis control project in
Western Samoa
South Pacific Bulletin, 22, 17-18

The objectives of the filariasis control project were to determine feasible methods for controlling filariasis in Western Samoa and to launch a nation-wide control programme based on such methods.

It was agreed to implement MDA, by using DEC given to everyone over one year of age, the dose depending on their body weight. The drug was given in divided doses, first on a weekly basis and then monthly. The first round was given in 1965 for thirteen and a half months in 18 separate doses.

The results, after the first round, showed a dramatic reduction of mf rate from 19.06% in 1965 before the control measures to around 1%. Infection rates in mosquitos dropped from 2.5% to 0.082%.

This reduction of mf rate was very encouraging but if it was left as it was the rate could gradually rise again. This was proved by a survey in 1969 which showed that the mf rate stood at 2.84%, although still very much lower than before control measures.

To keep check on this re-escalation of the mf rate and if possible to reduce the rate still further, a second round of MDA was launched in January 1971 which was planned to cover the whole country.

Every village formed drug distribution teams and each month the village women's team administered to everybody in the village DEC tablets and saw to it that they were taken. In some villages, fines were levied on those who missed one of their monthly doses. Thus, during the first round of MDA, over 95% of the population took the drug and it was hoped to achieve higher coverage with the second round.

(156) Chow, C.Y.
1973

Filariasis vectors in the
Western Pacific Region
Z. Tropenmed. Parasit., 24, 404-418
(Initially WHO unpublished document,
WPR/VBC/10, 1973)

The paper is the final review of the available knowledge on vectors of filariasis due to W. bancrofti and B. malayi in the whole range of the Western Pacific Region. It collates and updates the information presented earlier in the previous reviews by the author. It deals with 37 species belonging to the genera of Anopheles, Culex, Mansonia and Aedes. Lists are presented to show the species which are considered vectors of periodic and subperiodic W. bancrofti and periodic and subperiodic B. malayi. Distribution lists present mosquito species by area and classify them into important, minor and suspected vectors. Data of mosquito dissections are presented in tabular form showing infection and infective rate as recorded in wild caught mosquitos and/or experimental infection with cross reference to the name of the investigator. Synoptic notes are given for each vector on breeding, feeding and resting habits, citing authors. The following notes are extracted for vectors of bancroftian filariasis in the South Pacific area together with notes on vector control.

1. C. quinquefasciatus is the main vector in most of the urban areas in sub-tropical and tropical zones where period W. bancrofti occurs. In the South Pacific, there are conflicting reports regarding its importance as a vector of periodic W. bancrofti. It was reported as an important vector in the Caroline Islands, the Marianas, Gilbert Islands and Nauru. The practical importance of this mosquito in the transmission of subperiodic W. bancrofti is doubtful, although it was reported that C. quinquefasciatus can be a vector of this type of filariasis to a limited extent in Tahiti and in Fiji.

2. Ae. cooki is probably the vector of subperiodic W. bancrofti and is the only species of the Ae. scutellaris group in Niue. It breeds in rain water containers, coconut shells and tins. Biting man takes place outdoors in the daytime.

3. Ae. fijiensis is considered a vector of subperiodic W. bancrofti in Fiji. Little epidemiological evidence supports the view that this mosquito plays an important role in the transmission of filariasis. However, J.C. Hitchcock, in his personal communication of 12 February 1973, stated that it could be an efficient vector particularly in areas where the density of Ae. polynesiensis and Ae. pseudoscutellaris is low. It breeds predominantly in the leaf axils of Pandanus and less commonly in the axils of Alocasia indica. This mosquito bites man at night.

4. Ae. futunae is considered as the main vector in the Futuna group where it is more abundant than Ae. polynesiensis. Little knowledge is available on its ecology.

5. Ae. oceanicus - Hitchcock, 1971 (137) reported that in Tonga this mosquito was found naturally infected with subperiodic W. bancrofti. This was supported by experimental infection. It breeds in the leaf axils of Pandanus and taro (Colocasia sp.). It is an indoor night biter.

6. Ae. polynesiensis is the most important vector of subperiodic W. bancrofti, wherever it occurs. The breeding sites are artificial water containers, as well as tree holes, crab holes and canoes. It has also been found breeding in the leaf axils of Pandanus. Ae. polynesiensis is usually a day-time biting mosquito which feeds mainly on man, with a minor peak at 0800 hours and a major peak at 1700 - 1800 hours. A small number also bite at night. Although this mosquito feeds mostly in the open, it also enters houses to bite, but does not often remain there. It rests in shaded vegetation, crab holes, rat-eaten coconut etc.

7. Ae. pseudoscutellaris is a vector of subperiodic W. bancrofti in Fiji and is very close to Ae. polynesiensis in morphology. Ae. pseudoscutellaris breeds most probably in tree holes, bamboo stumps, and crab holes. It is a day biter.

8. Ae. rotumae is the only species of the Ae. scutellaris group in Rotuma and is considered, based on epidemiological grounds, the vector of subperiodic W. bancrofti. It breeds in artificial water containers, like drums, tins and coconut shells.

9. Ae. samoanus is the second important vector of subperiodic W. bancrofti in the Samoas. It breeds mainly in the leaf axils of Freycinetia. In Western Samoa, it can breed also in Pandanus. It is a night biter, with a peak of activity during the third quarter of the night. In the day time, this mosquito rests mainly outdoors and only a few have been collected in houses. A considerable number can be found resting at night in both European houses and Samoan "Fale".

10. Ae. tabu is a vector of subperiodic W. bancrofti only in Tonga and was earlier reported as Ae. tongae. It breeds in tree holes, artificial containers, coconut shells and leaf axils of taro (Colocasia sp.). This is primarily a forest mosquito. It bites only in the day time, with a peak between 1000 - 1200 hours. It rests outdoors, probably in tree holes and grass.

11. Ae. tongae - J.C. Hitchcock, WHO entomologist stationed in Tonga, stated in his personal communication of 22 February 1973 that Ae. tongae is not a confirmed vector and it is not yet certain whether or not Ae. tabu is in fact a different species from Ae. tongae. Ae. tongae breeds in rain-water containers, coconut-shells, tins and tree holes. It is a day-biting mosquito.

12. Ae. tutuilae is suspected of being a minor vector of subperiodic W. bancrofti in the Samoan Islands. Further studies are required before it can be definitely incriminated as a vector. It is difficult to separate the female of this species from that of Ae. samoanus. It breeds almost exclusively in the leaf axis of Pandanus. The mosquito bites probably at night.

13. Ae. upolensis - Although this mosquito was found naturally and experimentally infected with subperiodic W. bancrofti in the Samoan Islands, its practical importance in the transmission of filariasis seems doubtful because of the few specimens collected by human bait. It breeds in fallen tree trunks, fern tree stumps, and tree holes. This is mainly a forest mosquito and feeds on man in the day time.

14. Ae. vigilax is a vector in New Caledonia and the Loyalty Islands where Ae. polynesiensis and its allied species are totally absent. It is primarily a brackish water breeder, but is also found in rock holes and fresh water pools. It is mainly a diurnal mosquito. It rests outdoors during the day in grass and low vegetation.

Notes on vector control

It is realized that for filariasis control drug treatment alone can give promising results. In Western Samoa, MDA yielded a great reduction in the mf rate and the infective rate of the vector mosquito, Ae. polynesiensis, which was reduced from 2.5% to 0.08%. Infective mosquitos were only found three and a half years later. However the success of this method depends on the satisfactory coverage of all persons concerned, which is difficult to obtain.

It is not possible to outline a single control measure against all the filariasis vectors which involve about 60 mosquito species and have a very diverse ecology. Current methods of mosquito control are based largely on the use of insecticides. The increasing occurrence of mosquito resistance to DDT and other insecticides and the fear of environmental pollution from persistent pesticides have stimulated and intensified research on the development of alternative methods, such as biological and genetic control. However, it is realized that most alternative methods will not become operational in the near future. At present alternative methods might be employed as an adjunct to insecticide application which can first suppress the mosquito density to a very low level.

The control of C. quinquefasciatus by the use of adulticides is difficult because of the natural tolerance to DDT, dieldrin and other insecticides of this species. Over 60% of this mosquito rest on furniture, clothing, mosquito nets, hangings, etc. which are usually not sprayed. Therefore, application of larvicides is the most promising method. In Rangoon, Burma, in a field trial with fenthion 50% emulsifiable concentrate at a dosage of 1 ppm, a reduction of 98% in the number of adult mosquitos was obtained. The fundamental measure for controlling C. quinquefasciatus is efficient sanitation.

For the control of Ae. polynesiensis, indoor residual spraying is ineffective because of its exophilic and exophagic habits. Kessel, 1957 (68) mentioned that exterior residual spraying in Tahiti had some effect against adult mosquitos for four to six weeks. The removal of coconut shells and other containers would contribute to a reduction of the mosquito density but it depends too much on the cooperation of the public to be practicable. Treatment of crab holes with pesticides, like dieldrin and pentachlorophenol, appears to be promising, Symes, 1960 (90). Biological control with Coelomomyces fungus was introduced to Tokelau Islands for the control of Ae. polynesiensis larvae, Laird, 1967 (117), but further studies are required.

In Western Samoa, small-scale trials on the control of Ae. polynesiensis and Ae. samoanus with insecticides were undertaken (Suzuki, T., 1972 report to WHO). Abate was employed as larvicide and malathion as fog. It was concluded that unaccessible and undetectable breeding sites scattered in bushes were mainly responsible for the residual population of Ae. polynesiensis. Difficulties were also encountered in applying larvicides to the leaf axil of Freycinetia where Ae. samoanus was breeding.

(157) Desowitz, R.S.
1973

Epidemiological investigations on filariasis in Fiji and Tonga including a small additional survey in Western Samoa
WHO unpublished document,
WHO/FIL/73.113

The objective of the investigations were outlined as follows:

1. To compare the results of a blood survey by Millipore^R concentration and 60 mm³ thick blood-film techniques in a situation of hyperendemic filariasis, i.e. a more than 20% microfilaraemia rate by blood films. This phase of the study was carried out mainly in Niuatoatapu Island of the northern Tonga group.
2. To carry out a blood survey by Millipore^R concentration and 60 mm³ thick blood films in Beqa Island where the first round of mass drug administration with DEC (total of 90 mm/kg) had just been completed.

In addition, a small survey was carried out in Western Samoa.

Methods

The Millipore^R membrane concentration method used in this study has been described by Desowitz (1971)¹. The only change in methodology was the use of a simple press designed at the University of Hawaii to facilitate processing the haemolyzed blood. With this press, approximately twice as many specimens can be processed as by hand pressing and the assistance of a

¹Desowitz, R.S. (1971) Notes on the simplified membrane filtration method for the diagnosis of microfilaraemia (Unpublished document, WHO/FIL/71.90)

villager, trained in an hour or so, permitted 50-60 samples to be processed within an hour. Citrate, which was found to be a useful anticoagulant was again employed and of the more than 1000 samples processed only 4 to 5 did not haemolyze adequately. One technical problem which was encountered concerned the storing of processed filters before staining. Usually the filters were stained within 24 hours of processing, dried, stored, and mounted several weeks to two months later. These filters gave very satisfactory, readily identifiable preparations of the microfilariae. In one instance, however, it was impossible to stain the membranes of samples collected in Niuatoputapu on the day of the author's departure until 2 weeks later. These membranes were found to have a fungus growth that destroyed the microfilariae. Thus, in the future, precautionary measures in the form of storage in a box with desiccant and antifungal agent should be taken whenever it is not possible to stain the membranes shortly after processing.

In view of the loss of microfilariae during staining of thick films, Denham *et al.*, 1971 (135); Southgate & Desowitz, 1971 (144), a somewhat different method was adopted, satisfactory trials having been previously carried out with *Dirofilaria immitis* microfilariae in Hawaii. The 3 x 20 mm³ streaks were made fairly thin, dried and fixed in methanol. The fixed films were stained with Giemsa, dried and, before examination, coated with immersion oil to clear them. The cleared films were examined with a 10x objective and the stained microfilariae were very clearly seen. It is believed that with this method, a minimal loss of microfilariae resulted.

Conclusion

1. The present investigation further confirmed the high sensitivity of the Millipore^R membrane concentration technique for the detection of low grade microfilaraemia. The development of a simple syringe press facilitated processing of the membranes and, under field conditions, permitted twice as many samples to be processed per hour as compared to hand squeezing.
2. Millipore^R concentration indicated that in hyperendemic situations such as Tonga, the true microfilaraemia rate is probably at least 70%. A finding considered to be of major significance is the high microfilaraemia rate of 71% in Tongan children of the 5-9 year age-group. It was shown that this rate does not appear to change from 5 to over 50 years, the only difference being that with progressive age, more individuals tend to develop higher, blood film detectable, microfilaraemias.

Recommendations for further research

1. Comparative blood-film/Millipore^R concentration studies have now been carried out in hypoendemic and hyperendemic situations. The data collected so far suggest that, for adult age-groups the 60 mm³ blood-film rate should be multiplied by a factor of 2 or 3 to obtain an estimate of the total rate that includes the low grade microfilaraemias. The present study suggests that this factor does not apply to younger age-groups. It is felt that further comparative blood-film/Millipore^R concentration studies should be carried out in various endemic areas, with particular attention being paid to differences between age groups. Investigations have not yet been carried out either in areas of periodic *W. bancrofti* or *B. malayi* and it is recommended that comparative diagnostic/epidemiologic studies should be undertaken in areas as New Guinea, Africa and Malaya. Africa might be of particular interest in that it would also allow trials to determine whether species identification in mixed infections can be made by Millipore^R concentration.

Consideration should also be given to multidisciplinary studies in which immunological and clinical aspects as well as "diagnostic" epidemiology would be investigated.

2. It is strongly recommended that the longitudinal study of the treated population of Beqa Island be continued. The monthly mass drug administration will continue until July 1974 and the next survey by Millipore^R concentration should be carried out at that time. Thereafter, investigations should be made every other year for a period of 8-10 years.

3. It is again recommended that entomological investigations be carried out to determine the infectivity of low-level pre- and post-treatment microfilaria carriers to mosquitos. As stated by Southgate & Desowitz (loc. cit.): "This work is essential to an understanding of the epidemiology of potentially recrudescent filariasis".

(158) Desowitz, R.S. &
Southgate B.A.
1973

Studies on filariasis in the Pacific
2. The persistence of microfilaremia
in diethylcarbamazine treated
populations of Fiji and Western
Samoa: Diagnostic application of
the membrane filtration technique
SE. Asian J. trop. Med. publ. Htlh.,
4, 179 - 183

The authors introduced modifications to the membrane filtration technique which was originally described by Chularerk & Desowitz (1970)¹. In this investigation, the authors compared the membrane filtration technique using 1 ml of venous blood, 3 x 2 cm thick blood films made from 60 mm³ samples of haemolyzed blood also from finger prick examined by the counting chamber described by Denham et al. 1971 (135).

Western Samoa: Blood samples were taken from 61 adults who were previously positive before the start of the mass DEC campaign, all were shown to have taken a full course of 72 mg/kg of DEC during 1965-1970. The present study was carried out in May 1971. The results showed that 23% of these people were mf positives by the membrane filtration technique. The majority of the infections were of low density undetectable by the 60 mm³ thick blood film and the more sensitive finger-puncture blood examined by the counting chamber. The routine 60 mm³ stained thick blood film detected only one fifth of the number of cases detected by the membrane filtration technique. If only 20 mm³ thick blood film were examined, then only one of the fourteen infections would have been detected. In the 3 samples that were positive by all 3 techniques a total of 318 microfilariae were found in the 60 mm³ thick films, 389 in the finger-puncture-blood counting chamber, 310 in the venous-blood counting chamber, and 5017 on the membranes, giving a ratio of 1.03: 1.25: 1.00: 16.18 respectively, or as an equivalent-volume ratio 1.03: 1.25: 1.00: 0.97. Since 16.67 times more is examined in a 1.0 ml sample than in 60 mm³, these ratios indicate that:

- (a) few, if any, microfilariae were lost in processing blood in the filtration procedure,

¹Chularerk, P. & Desowitz, R.S. (1970) A simplified membrane filtration technique for the diagnosis of microfilaremia. J. Parasit., 56, 623-624

(b) the concentration of microfilariae in venous blood was only slightly less than in the peripheral circulation.

Fiji: Mass DEC administration, 8 doses of 5 mg/kg, was given to the population between January 1969 and January 1971. Fourteen days after the completion of this course a 60 mm^3 ($3 \times 20 \text{ mm}^3$) Giemsa-stained blood film was made from each individual. Anyone found to be positive was given a second full course, and, in a few cases, a third course was necessary for complete clearance as deemed negative by $2 \times 60 \text{ mm}^3$ stained thick films. The present investigation was carried out in April 1971. Venous blood for membrane filtration and finger-puncture blood for 60 mm^3 stained thick films were taken from 64 individuals. As in Western Samoa, the membrane-filtration technique proved to be 5 times as sensitive as the 60 mm^3 blood film.

Of the 64 individuals whose blood was sampled, 17 were known to have remained positive after the first course of treatment, and had been given another therapeutic course. By January 1971 the blood films from all patients were negative for microfilariae. The results of the present survey showed that 3 of the 17 (17.6 per cent) were blood-film positive and 12 of the 17 (10.6 per cent) positive by membrane filtration.

The authors reviewed the available information on drug failure, indicating that there has been considerable variation in results given in different reports. While Kessel, 1967 (116) showed that the percentage of persisting low microfilaremia was 13 and 26 in Tahiti and American Samoa respectively, Kessel *et al.*, 1970 (132) stated that 3.5% of the treated positives in American Samoa remained positive. The authors referring to Ciferri & Kessel, 1967 (115) who found that 11% of the patients with pre-treatment mf counts of 1-10 mf in 20 mm^3 of blood remained positive, six months after treatment, but in patients with pre-treatment densities of more than 200 mf, 62% of parasitaemia persisted. This may indicate that the variations noted in the persistence of parasitaemia probably reflect difference in the pre-treatment densities. All these findings were based on examination of 20 or 40 mm^3 blood films while the present investigations made by the authors in Western Samoa and Fiji showed that by using 1 ml blood in the membrane filtration technique, there may be five times or more persisting cases of parasitaemia after DEC treatment than in the case of examinations made by the conventional thick blood films.

The significance of these relatively large numbers of persistent, mostly low density, post-therapeutic microfilaremias has yet to be determined. The "occult" infections detectable only by concentration methods such as membrane filtration, may be the source of the relapsing microfilaremias noted by other investigators: Sasa (1963)²; Burnett & Mataika, 1964 (101); Laigret *et al.*, 1966 (113) who suggest that there may be a class of "resistant" infections which do not clear even after two or three repeated full therapeutic DEC courses. It is of interest to confirm the existence of DEC-refractory bancroftian microfilaremias and to elucidate the responsible cause. It is possible that these cases of repeated therapeutic failure are due either to a true form of drug-resistance on the part of the microfilariae or alternatively to an immunological defect on the part of the host in that the mode of DEC action is believed to be related to an opsonin-like action and phagocytosis in the host.

²Sasa, M. (1963) Pilot experiments in the control of bancroftian filariasis in Japan and Ryukyu. Bull. Wld Hlth Org., 28, 437-454

The authors suggest that the significance of post-treatment mf carriers on persistence of transmission should be investigated by feeding batches of mosquitos on volunteers with low microfilaraemia, and that a follow up should be made on such persons in order to determine whether microfilaraemia would temporarily or permanently increase in these individuals and thus they become a source of infection in mosquitos.

Finally, the authors recommended the use of the membrane filtration technique as a useful epidemiological tool, since the examination of 20-60 mm³ stained thick blood films particularly when prepared under field conditions, proved to be inadequate.

(159) Desowitz, R.S.,
Southgate, B.A. &
Mataika, J.U.
1973

Studies on filariasis in the Pacific. 3. Comparative efficacy of the stained blood-film, counting-chamber and membrane-filtration techniques for the diagnosis of Wuchereria bancrofti microfilaraemia in untreated patients in areas of low endemicity
S.E. Asian J. trop. Med. publ. Hlth., 4, 329-335

In untreated hypoendemic areas of Viti Levu Island, Fiji with low microfilaria rates and densities, the membrane-filtration and counting-chamber techniques for the detection and measurement of microfilaraemia were found to be decidedly superior to stained 60 mm³ blood films.

An unexpectedly low co-positivity between membrane-filtration and counting-chamber technique results was observed; possible reasons for this observation are discussed and some recommendations for further research are made.

(160) Hairston, N.
1973

Assessment of filariasis in Western Samoa
Assignment report submitted to WHO/WPRO

The author was assigned as WHO consultant to Western Samoa during 2-31 July 1973 to assess the progress of filariasis control.

Without entering into the mathematical calculations and the related assumptions made by the author, the following quotations are selectively made to summarize the findings and views of the author.

1. Estimation of the number of mf carriers in Western Samoa

The author used the data collected by the project during 18 months after the second DEC mass treatment, when 11 506 persons were examined by 60 mm^3 of blood and 0.19% were found positive. From this, he inferred that among the 145 000 inhabitants of Western Samoa, there should be 276 people who have sufficient microfilaraemia to be detected by the routine method employed. Using the data of the survey made by Bryan & Southgate (1973)¹ including the mf density, he established a correction factor and made an estimate for the mf carriers in Western Samoa, as if blood examinations were done on the basis of the membrane filtration technique. Thus, the number of mf carriers (at whatever density) was estimated to be 788 assuming that the filtration method would detect 2.75 times as many as the routine method and 1875 assuming that the ratio of the former to the latter method was 5.5:1. (N.B.: Cf Bryan & Southgate (loc. cit.) regarding the estimate of mf carriers).

For the lower estimate, the author estimated that about 75% of the mf carriers would have less than 1 mf per 60 mm^3 of blood and for the higher estimate 85% would have such low counts. The two estimates were taken as the extreme limits in assessing the impact of human infection on the mosquito phase as shown below.

2. The infection of mosquitos

The author used the data of the experimental infection of *Ae. polynesiensis* reported by Rosen, 1955 (56). He further adopted an estimate of the size of bloodmeal per mosquito as 1.7 mm^3 and that mosquitos were capable of concentrating microfilariae to a factor of 2.35, i.e. each mosquito is capable of acquiring a number of mirofilariae that can occur in 4 mm^3 blood at each feeding. An estimate was made for the frequency distribution of people with different mf densities. The calculation was made for the two extreme estimates of the mf carriers, 788 and 1875. By a convenient method of calculation, the author made an estimate of the proportion of mosquitos that are likely to be infected from those mf carriers. The results of all calculations indicated that, if every person in Western Samoa were bitten once each by *Ae. polynesiensis*, 200-260 mosquitos would become infected. When considering the mean biting density as recorded from different areas and seasons, the estimate would be that in Western Samoa 74 270 - 95 274 *Ae. polynesiensis* can become infected daily. It is obvious that very few people contributed to this and the author cautioned that the observed infection rates of mosquitos might therefore differ from the theoretical expectations, depending on the proximity of catch to one or more of the 788-1875 mf carriers, and especially those with easily detectable microfilariae. The author then roughly calculated the probability of daily survival from which a daily mortality of 30% was indicated (taking a figure of 0.4 from the parous rate and apparently a 3-day period was taken as the duration of the gonotrophic cycle). Taking a figure of 11 days as the developmental period of the parasite in the mosquito, then only 3.5% of the mosquitos would survive to the infective stage.

¹Bryan, J.H. & Southgate, B.A. (1973) Assignment report published in 1976 (Abstract No. 192)

As the mosquito with mature parasite at 11 days would need an additional three days before it actually feeds, the author estimated that this reduces the proportion of surviving mosquitos to 1.5% of those becoming infected. A more important source of reduction in the number of mosquitos is the loss of infective larvae during feeding for which De Meillon *et al.* (1967)¹, estimated from experimental evidence that only 41% of the infective larvae leave the mosquito during one complete feeding and according to Ewert & Ho (1967)², only 32% of the larvae deposited on the skin succeed in penetrating. When vector mortality and the loss of larvae are taken into account, the most accurate estimate is that on an average day 548 mosquitos become infective and ready to bite effectively. On the assumption that male and female parasites are equally abundant and on the basis of random assortment, the probability would be that among those bites introducing two larvae each, 25% would consist of two males, 25% two females, and only 50% would result in bisexual infections. The final results of the calculations showed that about 208 potential bites each day could result in active patent infections. The author further indicated that the actual number will be fewer considering that some mosquitos will bite non-human hosts, the proportion of which cannot be estimated in the absence of quantitative data on the sources of blood meals of Ae. polynesiensis.

3. Transmission to humans

The parasite which actually succeeded in penetrating the skin must survive the period of development and find mates before the infection becomes patent with microfilariae circulating in the blood. In the absence of a suitable experimental host for W. bancrofti, the author utilized the data of Edeson & Buckley (1959)³ on the survival to maturity of the related parasite B. malayi. If this is accepted, the calculations based on the infective bites, showed that at least 739.49 human infections become mature in an average year. Nearly all of these are with single parasite, but they provide an opportunity for further active cases when any are infected by parasites of the sex opposite to the one already mature. The author further remarked that neither the cases nor the mosquitos are randomly distributed, but tend to be clustered in certain areas. Some of these areas are already known to the personnel of the project, and infected mosquitos have been found since the end of the second mass treatment campaign in Solosolo and Aleisa villages in Apia Division. Such area of higher transmission would be expected to develop rapidly into sources of infection for the rest of the country. It appears therefore necessary to implement further measures against the parasite.

¹De Meillon, B., Hayashi, S. & Sebastian, A. (1967) Bull. Wld Hlth Org., 36, 81-90

²Ewert, A. & Ho, B.C. (1967) Trans. roy. Soc. trop Med. Hyg., 61, 659-662

³Edeson, J.F.B. & Buckley, J.C.C. (1959) Ann. trop. Med. Parasit., 53, 113-119

4. The possible methods

The foregoing analysis indicated that there are sufficient mf carriers with sufficient mf densities and abundance of the vector to bring about an endemic situation unless further efforts were made against the parasite.

4.1 Mass treatment

After considering the prospects of mass treatment, the author's views implied that it appeared that DEC mass administration has failed to reach the same small groups of positive people and it would be expected to reach few of them if tried again, therefore, it was not recommended.

4.2 Vector control

The author reviewed the views of previous consultants who urged that vector control should be a component in anti-filariasis programmes. The results of the insecticide trials carried out in Western Samoa were described as being of transient benefit whether directed against larvae or adult vectors. Therefore, he gave attention to the possibility of destruction of the breeding places within 100 m of houses being the distance considered in the Pacific area as the range of flight of Ae. polynesiensis.

With two technicians, the author conducted several transects across each of five villages selected to represent the variety of conditions in Samoan villages in general. Each transect was 5 m wide, and each started either at the sea or at the centre of the village and proceeded in a straight line to a point 100 m beyond the last habitation. All potential breeding sites along the transects were tallied according to type (tree hole, tin can, coconut shell, etc.). The potential of each kind of site for mosquito production was already available in reports from the project. It is thus possible to estimate the importance of each kind of breeding site to the mosquito population of each kind of village.

A preliminary classification of villages was established, and a tally of 58 villages on both Upolu and Savai'i was made to help in providing an estimate of the overall importance of each kind of larval habitat.

Breeding sites were classified according to the possibility of destruction or at least emptying periodically. It was considered that automobile tyres, coconut shells, tin cans, oil drums, sea shells, bottles, fallen leaves and empty cacao pods fell into this category. It would be impractical to empty tree holes, rock holes, crab holes, and the leaf axils of domestic plants: taro, giant taro and pandanus. Ae. polynesiensis does not breed extensively in the domestic plants, and its use of crab holes is the subject of a separate study shown below. The following table shows that 76.7% of its breeding places could be destroyed, excluding crab holes.

<u>Kind of container</u>	<u>Percentage contribution of larvae of Ae. polynesiensis</u>
Tree hole	22.2
Rock hole	1.1
Auto tyre	1.8
Coconut shell	8.7
Tins	64.5
Oil drum	1.0
Sea shell	0.4
Bottle	0.1
Fallen leaf	0.1
Cacao Pod	0.1

A crude estimate of the time required to empty or destroy these habitats, based on the time required for each transect and the overall dimensions of several sample villages. The maximum that one person could accomplish in one day would be the destruction of habitats in 4500 - 7500 m², depending on the density of vegetation. Thus, on the first round, it might require diligent workers one month each to cover one village of average size. At a pay rate of 10 Western Samoan Tala per week, 15 120 Tala (\$25 200 US) would be required to empty or destroy 76.7% of the Ae. polynesiensis habitats. Economically, such a proposal does not seem feasible, but some larval destruction might be achieved through the organization of the village Women's Committees. The effectiveness of this kind of habitat destruction could be attempted in one small village, the results to be tested by the standard adult mosquito-catching method. A control village of similar size and initial catch rate should be followed.

The mass application of insecticide is not recommended.

(N.B. - Some action should be sought against the leaf axil breeder Ae. samoanus, particularly where it predominates.)

Crab holes

In some areas, notably Mulinu'u Point in Apia, the majority of Ae. polynesiensis breeding seems to take place in the water at the bottom of holes made by crabs. One crab hole was dug out in order to see its configuration and dimensions. The one chosen had previously been shown to contain larvae of Ae. polynesiensis. At the surface of the ground, the hole was 7.5 - 8 cm in diameter and nearly circular in cross-section. It sloped at an angle of about 45° for about 25 cm and then descended almost vertically. At 75 - 80 cm from the surface, ground water was reached. The crab was found in a globular chamber 15 - 20 cm in diameter, and 7 cm below the surface of the water.

Some useful information was provided locally which revealed some behavioural traits of the crabs which might lead to measures against them. The crabs, which come out of their holes at night, pick up dead vegetation and carry it back to the holes with them. It is suggested that placing in front of each hole grass soaked in DDT emulsion might lead the crab to carry it down with the result that both crab and mosquito larvae would be killed. Thereafter, a small earth plug in the entrance of the hole would prevent any further breeding by mosquitos. [N.B. Vide Burnett, 1960 (85) regarding the difficulty in finding and dealing with all crab holes.]

Search for and treatment of positive cases

The present hope of the Health Department and of the WHO team is that the remaining active cases of filariasis in Western Samoa can be located and treated, so as to stop the infection of mosquitos completely. In theory, this approach has much more to recommend it than does mass treatment, and from the practical standpoint, it appears to be economically more feasible than vector control.

In order for the location and treatment of positive cases to be effective, the coverage of the population by blood examination must be exceptionally good, and the whole process should be completed within a period too short for the endemic condition to rebuild to an appreciable degree. Three years appear to be a satisfactory period.

(161) Hitchcock, J.C. &
Roseboom, L.E.
1973

Cross-breeding of Aedes (S.)
polynesiensis with an autogenous
species of the Aedes scutellaris
group
Bull. Wld Hlth Org., 49, 367-370

A biting-landing collection of the Tafahi species was made at 1030 hrs on 30 June 1970 in a plantation on the north western slope of Tafahi, some 800 m uphill from the island's only village of Kilokakala and at an elevation of about 180 m. Tafahi is a high conical volcanic island about 3.2 km long, rising abruptly to 610 m. It is located at 15°51' S and 173°43' W, about 8 km from Niuatoputapu but over 160 km from any other island.

The collected adult females were allowed to feed, and then taken back to Niuatoputapu to oviposit. A colony was established on Niuatoputapu. Autogeny was first observed in this colony on 2 August 1970 among the second generation of adults. A sub-colony was established at the University of California, Los Angeles, California, USA, and a second was started in April 1971 at John Hopkins University, Baltimore. The latter has been maintained almost entirely without blood meals, and indeed the females show a reluctance to bite. The larvae are fed commercial guinea pig food pellets.

The strain of Ae. polynesiensis used was one from Samoa that has been maintained in the laboratories at John Hopkins University since 1958.

Rearing and breeding

In order to obtain virgin adults, pupae were taken from the colony rearing pans and, after preliminary sexing by size, transferred in groups of 3-5 to test tubes until the adults emerged. In most test tubes, the adults were of one sex; mixed groups were discarded. Breeding cages consisted of 3.8 litre cardboard cartons, covered at the top with bobbinet and with a cloth sleeve fastened on the side. Female and male mosquitos aged 1-2 days were placed in appropriate combinations in the cages, at a male/female ratio of about 2:1. A 10% sucrose solution was provided as a maintenance diet. The autogenous Ae. polynesiensis were allowed to engorge on blood, while no blood was offered to the autogenous Tafahi females. In all crosses involving hybrid females obtained from the Tafahi female x Ae. polynesiensis cross, blood was also withheld. Insemination rates were determined by microscopic examination of the spermathecae of samples of females taken from the breeding cages after egg laying had been completed. A small glass dish lined with paper towelling was placed in each cage as an oviposition trap. Eggs were counted with the aid of dissecting microscope, and the average number of eggs per female was calculated. The papers containing the eggs were placed in bowls of water. Newly hatched larvae were counted and transferred to rearing pans, and the adults reared from these larvae were counted.

A summary of the findings is quoted in the following:

"An autogenous species belonging to the Ae. (Stegomyia) scutellaris subgroup was found on the island of Tafahi, Kingdom of Tonga. A subcolony was established at John Hopkins University, Baltimore, Md., USA, where cross-breeding experiments were conducted with the Samoan strain of Ae. polynesiensis. The cross between Tafahi females and Ae. polynesiensis males produced viable hybrid progeny, which were inbred through five generations. The reciprocal cross was not successful. F₁Tafahi x Ae. polynesiensis hybrid males were backcrossed successfully to Tafahi females but of the many eggs produced by backcrossing these F₁TP males to Ae. polynesiensis females, only 0.7% hatched. Of the eggs produced by the F₂TP male x Ae. polynesiensis female backcross, about 7% were viable. The results indicate a close genetic relationship between the Tafahi species and Ae. polynesiensis. The one-directional compatibility observed suggests the existence of cytoplasmic factors for sterility, which might eventually be useful in the control of members of the Ae. scutellaris complex."

(162) Ricossé, J.H. &
Picq, J.J.
1973

Indications cliniques des
filaricides
Méd. Afrique noire, 20, 877-897

Concerning the subperiodic W. bancrofti, the authors reviewed the experiences obtained by DEC mass treatment in French Polynesia and American Samoa with special reference to the criteria laid down by Kessel et al., 1970 (132), which propose that when the mf rate is reduced below 1% and the mf density drops below 1, there should be a clear-cut regression in the clinical manifestation at which point the disease is no longer a public health problem.

For overcoming the side reaction of DEC, the authors referred to the trial of Saugrain & Outin-Fabre, 1969 (128) from which it was suggested that coating DEC tablets with acetophallate cellulose the frequency of drug reaction becomes minor.

In the authors' conclusions, DEC remains the basic drug for treatment or prophylaxis of lymphatic filariasis.

However, for ameliorating the action against the filarial infections researches aimed at rapidly developing new compounds which could act simultaneously as microfilaricides and macrofilaricides. This would lead to a more rapid and effective control. Moreover in the control campaign at a regional level, the treatment of patients which aims as reducing or eliminating the parasite should be combined with measures against the vector.

(163) Rozeboom, L.E.,
Rosen, L. &
Ikeda, J.
1973

Observations on oviposition by
Aedes (S.) albopictus Skuse and
Ae. (S.) polynesiensis Marks in
nature
J. med. Ent., 10, 397-399

One study area was an old Chinese cemetery in the suburbs of Honolulu, Hawaii. High grass, shrubs, and trees furnished abundant shelter for mosquitos. Adjacent houses and commercial establishments indicated the availability of human and domestic animal hosts for blood-seeking mosquitos. Twenty-two ovitraps were placed in a regular grid pattern, about equidistant from one another, on or close to the ground beneath bushes, vines, trees, rock piles, an abandoned washing machine, and a jeep automobile body. These ovitraps consisted of the black-painted wide mouth jars described by Fay & Eliason (1966)¹ except that instead of a paddle for oviposition, the inside was lined with a strip of rough brown paper toweling, and the liquid consisted of tap water, without the addition of ethyl acetate or other attractant. The paper strips containing the eggs were removed, dried and sent to Baltimore where they were examined microscopically. The eggs were counted, and the pattern of their distribution on the oviposition surface was plotted.

The traps were set out on one day, and the paper strip removed the following day. Thus, each strip contained the numbers of eggs deposited within 24 hours. As oviposition probably occurred especially during the daylight hours, for convenience a given collection is referred to below as a "trap day".

Observations on Ae. polynesiensis were made on the island of Taiaro, in French Polynesia. In three locations, where adult catches revealed the presence of Ae. polynesiensis, some ovitraps were placed on the ground in the shelter provided by the bases of tree trunks, buttressed roots, and ferns or other ground vegetative cover; other ovitraps were placed between tree branches arising within 1.2 m (4 ft) above the ground. In order to demonstrate that Ae. polynesiensis females would oviposit in these paper-lined traps, several were exposed for two to three days. The numbers of eggs deposited in each of eight ovitraps ranged from 35 to 279 during that period. Thereafter, the paper strips in all of the 19 traps were removed daily and the eggs counted.

Thus the daily collection of the ovitraps provided information on the oviposition habits of natural populations of Aedes (S.) albopictus and Ae. (S.) polynesiensis. The females seldom laid all of their mature eggs in a single oviposition; instead they appeared to move from trap to trap, leaving behind each time only a few of the eggs they were capable of producing. It is possible that most of a given clutch is deposited, in several containers, during a single "trap-day"; however, we do not know whether there are interruptions of a day or more between the successive layings of a single clutch. This type of oviposition behaviour on the part of these small-container-breeding species may have arisen as a result of its possible survival value; it must be taken into account in field studies on oviposition attractants or repellents.

¹Fay, R.W. & Eliason, D.A. (1966) A preferred oviposition site as a surveillance method for Aedes aegypti. Mosq. News, 26, 531-535

(164) Southgate, B.A.
1973

Studies on filariasis in the Pacific.
1. A field trial of a counting
chamber technique for the
determination of microfilarial rates
and densities
S.E. J. trop. Med. publ. Hlth., 4,
172-178

In the present study, the author compared the counting chamber technique of Denham *et al.*, 1971 (135) with the stained blood-film technique in a remote rural area of Fiji in April 1971 where bancroftian filariasis was known to be endemic. The following information is extracted:

- (a) to compare mf rates and densities obtained by the two techniques;
- (b) to compare the operational aspects of the two methods, particularly the number of persons capable of being examined daily;
- (c) to determine the acceptability of the counting chamber technique to field staff in an endemic area.

Material and methods

Counting chambers were prepared in Suva, Fiji. Only the larger size of chamber well, 1 mm x 15 mm x 45 mm was used. 0.5 ml of tapwater was placed in the well, and then 60 mm³ of capillary blood obtained by finger puncture was added, and haemolyzed by thorough mixing. In preliminary studies, heparinized pipettes were used, and haemolytic agent, Teepol^R, was added to the tapwater but neither procedure seemed to offer any advantage, and they were not used in the main study. Counting was carried out at x 50 magnification, with a dissecting microscope.

A further 60 mm³ of capillary blood was taken from the same puncture wound and used to prepare 3 thick films each of 20 mm³ on a single glass slide; each film was carefully smeared out into a circle of 2 cm diameter, i.e. an area of 3.14 cm². Blood for the counting chamber and for thick films was taken alternately first and second from the finger puncture wound, to avoid any possible bias in the results from the slight delay in taking blood for the second technique. Blood samples were collected between 0730 hours and 1700 hours. Blood films were dried overnight under insect-proof covers, and then carefully wrapped in tissue paper and transported back to Suva. They were then dehaemoglobinized for 10 minutes in distilled water, stained for 30 minutes in a 1:10 solution of Giemsa, and finally examined at x 40 magnification with a binocular compound microscope. In order to reproduce the conditions commonly encountered in field surveys, the glass slides used in this study were cleaned immediately before use by wiping with a clean cloth and tissue paper, but were not subjected to the very careful cleansing regime used by Denham *et al.* (loc. cit.).

Summary of results and discussion

It is clearly very desirable when carrying out field surveys for filariasis to obtain mf rates and densities as close as possible to those which actually occur in the populations studied. Most techniques used in the past have had serious deficiencies; as Denham *et al.* (*loc. cit.*) pointed out, microfilariae were readily lost at various stages of preparing and staining blood films, even when scrupulously careful techniques were employed. This has the effect of reducing the proportion of the population found positive, since a number of individuals with low mf counts will be missed; it also leads to considerably lowered counts being recorded even in those persons who are found to be positive.

Attempts to increase the sensitivity of microfilarial determinations by using larger volumes of blood have generally led to technical difficulties in field use, to a great reduction in the number of persons who can be studied per day, and to the necessity of obtaining blood by venepuncture, which may be refused in many parts of the world.

Use of the counting chamber technique as described in the present studies obviates these difficulties and objections. In a population in Fiji suffering from highly endemic subperiodic bancroftian filariasis, 29.5% more subjects were detected with microfilaraemia than with a stained blood-film method. The mean mf density of positive subjects was about 60% higher using the counting chamber; when the total numbers of microfilariae found by the two techniques in the whole population studied are considered, it can be seen from the table that about 51% were lost in the stained blood films. These figures are rather greater than those reported in a laboratory study of *B. pahangi*, *W. bancrofti* and *Loa loa* by Denham *et al.* (*loc. cit.*). However, these authors paid meticulous attention to cleanliness of slides and care in handling dehaemoglobinization and staining of blood films; in the present study, only the normal care in technique possible in field studies was observed.

Most significantly of all, in view of the objections to using the arithmetic mean in comparing such highly skewed distributions as mf densities, the median mf density (MfD_{50}) was calculated for the results of each technique, as recommended by Sasa (1967)¹ and Sasa *et al.* (1970)²; as can be seen from the table, the MfD_{50} obtained by the counting chamber is some 2.3 times greater than that obtained from stained blood films.

The counting chamber technique proved easy to use in field conditions, and positive individuals were able to see live microfilariae in their blood samples very shortly after undergoing finger puncture; this led to an exceptionally high level of population cooperation.

¹Sasa, M. (1967) Bull. Wld Hlth Org., 37, 629-650

²Sasa, M. *et al.*, (1970) In: Recent Advances in Researches on Filariasis and Schistosomiasis in Japan. Univ. Tokyo Press, 3-72 pp.

In terms of the number of persons examined per day, the counting chamber proved superior to the thick blood film. While it is true that blood films can be collected in a given time from more people than can be examined by the counting chamber, the counting chamber gives a higher work-rate when allowance is made for the subsequent processing and examination of the film.

Two potential disadvantages of the counting chamber are the need to use artificial illumination of the microscope in areas of nocturnally-periodic filariasis, and the problem of identification in areas where two or more species of microfilaria occur. However, it is considered that the speed, ease, accuracy and sensitivity of the counting chamber method outweigh these disadvantages. The counting chamber appears to be an excellent technique for comparative epidemiological studies of microfilaraemia, particularly where pre- and post-treatment surveys are being conducted, or where data are being collected for the construction of mathematical models of filariasis transmission.

Results of a comparison between blood-film and counting-chamber techniques on Beqa Island, Fiji, April 1971

Number of persons examined	Number positive	Percentage positive	Range of micro- filariae in all positive cases		Total micro- filariae in all positive cases	Mean number of microfil- ariae per 60 mm ³ in positive cases	MfD ₅₀
			1 to 608	12 130			
Blood-film technique	820	261	31.8%	1 to 608	12 130	46.5	8.8
Counting- chamber technique	820	338	41.2%	1 to 982	25 056	74.1	20.0

(165) Chow, C.Y. &
Suzuki, T.
1974

Filarialis vectors and their control
in the South Pacific
WHO unpublished document, WPR/Fil/9

The paper is a review of the vectors of filariasis in the three subregions: The Papuan, the Micronesian and the Polynesian, recapitulating from Chow, 1973 (156) in brief notes what has been known about the relative importance of different vectors namely Anopheles punctulatus, C. quinquefasciatus, C. annulirostris, Ae. scutellaris group and other Aedes spp. in their areas of distribution. An additional note was made in connection with successful experimental infection of subperiodic W. bancrofti in Ae. cooki by Hitchcock (unpublished) and the detection of first and second stage larvae of this parasite in wild caught mosquitos of this species by Suzuki (unpublished report to WHO). The authors further

recapitulated the information available on vector control operations or trials involving some of the above-mentioned vectors. An important addition to the above recapitulated information is the summary of unpublished and published data of the susceptibility tests carried out on various Aedes spp. (Tables 1 & 2).

Table 1. LC-50 values (%) of insecticides of female
Aedes mosquitos in the South Pacific

Insecticide	Country	Year	<u>Ae.</u> <u>polyne-</u> <u>siensis</u>	<u>Ae.</u> <u>pseudo-</u> <u>scutellaris</u>	<u>Ae.</u> <u>fijiensis</u>	<u>Ae.</u> <u>aegypti</u>	References
DDT	Fiji	1959	0.70	0.72	0.24	1.28	Burnett & Ash, 1961 (93)
	Fiji	1974	1.5	-	-	-	Suzuki (unpublished)
	W. Samoa	1971	0.35	-	-	-	Suzuki & Sone (unpublished)
Dieldrin	Fiji	1959	-	0.124	0.054	-	Burnett & Ash, 1961 (93)

Table 2. LC-50 values (ppm) of insecticides of
Aedes larvae in the South Pacific

Insecticide	Country	Year	<i>Ae. polyne- siensis</i>	<i>Ae. pseudo- scutellaris</i>	<i>Ae. fijiensis</i>	<i>Ae. samoanus</i>	<i>Ae. oceanicus</i>	<i>Ae. aegypti</i>	References
DDT	Fiji	1957-58	0.005	0.006	0.36	-	-	0.012	Burnett & Ash, 1961 (93)
	W. Samoa	1970-71	0.0031 0.011	-	-	0.0040 0.0064 0.0076	0.0030	-	Suzuki & Sone (unpublished)
Dieldrin	Fiji	1957-58	0.006	0.006	0.005	-	-	0.008	Burnett & Ash, 1961 (93)
	W. Samoa	1970-71	0.0043 0.015	-	-	0.0015 0.0023	0.0038	0.0083	Suzuki & Sone (unpublished)
HCH	Fiji	1957-58	0.009	0.020	0.007	-	-	0.010	Burnett & Ash, 1961 (93)
Malathion	W. Samoa	1970-71	0.051	-	-	0.10	0.023	-	Suzuki & Sone (unpublished)
Fenthion	W. Samoa	1970-71	0.0025	-	-	0.0017	0.0028	-	Suzuki & Sone (unpublished)
Fenitro- thion	W. Samoa	1970-71	0.0062	-	-	0.0042	0.0071	-	Suzuki & Sone (unpublished)
Diazinon	W. Samoa	1970-71	0.042	-	-	0.027	0.041	-	Suzuki & Sone (unpublished)
Abate	W. Samoa	1970-71	-	-	-	0.00072	0.00082	-	Suzuki & Sone (unpublished)

Note: Two or three figures in one column mean the results obtained in different localities

(166) Desowitz, R.S.
1974

The application of a membrane filter concentration method in filariasis surveys in the South Pacific Area
WHO unpublished document, WHO/FIL/74.131

1. The comparative efficacy of diagnosis of microfilaraemia by examination of 60 mm³ finger-prick blood and by membrane filter concentration of 1 ml venous blood, has been assessed by surveys of untreated and treated populations in endemic areas of the South Pacific.
2. It has been shown that in a hyperendemic situation (Tonga), the mf rate, as diagnosed by the membrane filtration technique, is approximately the same in all age groups sampled. However, a great proportion of the children (5-9 years of age) had mf densities too low to be detected by 60 mm³ stained thick blood film diagnosis. In this age group, nearly eight times as many infections were detected by concentration as by thick film examination.
3. Membrane filter concentration detected 1.5 to 3 times as many microfilaraemias in adults exposed to hyper- and hypoendemic filariasis as did diagnosis by 60 mm³ blood film examination.
4. In a small survey of patients with gross elephantiasis, a low-grade microfilaraemia detectable by membrane filter concentration only was commonly observed.
5. In adult populations that had been subject to filariasis control campaigns, membrane filter concentration detected 3 to 6.5 times as many persistent microfilaraemias as did diagnosis by 60 mm³ thick film examination.
6. Recommendations are made as to the parasitological techniques to be employed in surveys of treated populations, untreated populations, and for immuno-epidemiological studies.

(167) Desowitz, R.S. &
Hitchcock, J.C.
1974

Hyperendemic bancroftian filariasis in the Kingdom of Tonga: the application of the membrane filter concentration technique to an age-stratified blood survey
Amer. J. trop. Med. Hyg., 23, 877-879

A survey carried out in Tonga, an area of hyperendemic subperiodic *W. bancrofti* filariasis, compared the diagnostic efficiency of the membrane-filtration as stained blood film techniques. Membrane filter concentration of 1 ml blood revealed an mf rate that was approximately the same for all age groups, from 5 to 9 years old to over 50 years old about 70%. The mf rate by examination of stained 60 mm³ thick blood films was lower for all

age groups. Membrane filter concentration detected 7.8 times as many infections as thick film diagnosis in the 5 to 9 year old group, 4.8 times in the 10 to 14-year old group, 2.4 times in the 15 to 20 and 21 to 50 year old groups and 1.6 times in the over 50 year old group. Concentration revealed the presence of microfilariae in the blood of 5 of 8 patients with gross elephantiasis, whereas microfilariae were found in the stained thick film of only one of these individuals.

(168) Maung, T.M.
1974

Clinical aspects of filariasis
WHO unpublished document, WPR/FIL/10

The incubation period may vary and clinical signs may be seen one month after infection. The pathogenesis of filariasis can be summarized as stages of inflammation, obstruction, hyperplasia and fibrosis, mainly affecting the lymphatic system initially but later involving other tissues.

Similarly, the clinical manifestations can be described according to the pathological process. Thus, during the inflammatory stage, lymphangitis, lymphadenitis, allergic manifestations, abscesses and sinuses develop.

In the obstructive stage, swelling of the tissues due to fluid tension occurs; this swelling puts on pressure. Hydrocele, lymphatic varices and chyluria are signs of obstruction.

In the hyperplasia stage, new tissues grow and hence true elephantiasis develops. Warty growths of the skin are seen.

Ultimately, fibrotic elephantiasis is the end result. Other signs of filariasis may be present and may mimic other diseases. Occult filariasis is a host reaction causing hypereosinophilia and lesions in the lung, liver and spleen without circulating microfilaria.

(169) Maung T.M.
1974 a

Assignment report, February 1972 to
December 1974
WHO unpublished document, WPRO-2201
(ICP/MPD/04)

This document reports the activities of the WHO intercountry team in the project area in South Pacific. The report covers Western Samoa, American Samoa, Ellice Islands, Niue, New Hebrides and Solomon Islands. The results of assessment of the mass drug administration in Western Samoa have been updated and presented in detail in an unpublished paper by Maung & Penaia, 1976 (198). To avoid duplication, the results of some entomological surveys in the above mentioned island groups as well as the results of vector control trials given in the present report are not abstracted since they have been given in detail in Suzuki's assignment report, 1976 (207).

1. Western Samoa

The first round of MDA commenced in 1965 by administering 18 doses of DEC at a dosage of 5 mg/kg, once a week for six weeks, followed by once a month for 12 months.

A second round commenced in 1971 by administration of the drug once a month for 12 months at a dosage of 6 mg/kg.

The WHO Intercountry Filariasis Team was involved in assessment of the coverage and effects of the second round.

1.1 Assessment of the drug coverage during the second round

- (a) The population coverage for the entire country was 98.7%. Out of 132 583 persons registered, 130 954 took the drug in one or more doses.
- (b) The population coverage for Apia Division was 98.77%, for Upolu Division 99.00% and for Savaii Division 98.00%.
- (c) The 12 doses coverage or full prescribed dose coverage was 51.1% for the permanent residents. Out of 119 337 persons who did not leave their original residence throughout the campaign, 61 066 persons took the drug regularly and completed the full prescribed course.
- (d) In Apia Division, the 12 doses coverage percentage was 50.41%; in Upolu Division, 50.62%; and in Savaii Division, 52.65%.

1.2 Assessment of the post control blood surveys

Blood surveys after the second round were carried out throughout the country.

Assessment of the results showed that in 1972, the mf rate was further reduced to 0.19% (7 persons out of 3778 examined) to 0.14% in 1973 (7 persons out of 5145 examined) and to 0.11% in April 1974. This final reduction of 0.11% has been achieved from 19.1% before any control measures were adopted.

2. American Samoa

The writer visited in November 1973.

It was found that from April 1972 to May 1973 a total of 18 611 persons were examined of whom 174 were found to be residual microfilarial positives (0.93%) with mean mf density of 10.7/20 mm³ of blood. The recurrent lymphangitis rate was 1.1%, the elephantiasis rate at the moment is 0.9% and hydrocele rate 2.1%.

Visitors from filariasis endemic areas to American Samoa are required to have a filariasis clearance certificate. Those not having one must have their blood tested at the filariasis centre. Those found microfilaria positive are treated free of charge, retested and when negative are given a clearance certificate. This is useful for local people going abroad, for untreated locals returning from abroad, and for persons arriving from highly endemic areas where no control is practised.

3. Ellice Islands

Filariasis control in the Ellice Islands began in 1972. Prior to this, preliminary blood, clinical and entomological surveys were conducted in 1968 in the islands of Funafuti and Vaitupu. Microfilaria rates were 20.65% and 34.04% respectively; elephantiasis rates were zero percent in Funafuti and 4.7% in Vaitupu. Mosquito dissection in Funafuti showed that 3.2% of Ae. polynesiensis harboured W. bancrofti larvae in all stages of development but no mosquitos with infective larvae were found. In Vaitupu the infection rate for Ae. polynesiensis was 9.2% and the infective rate 2.0%.

3.1 Preliminary surveys

In 1972-73 country-wide filariasis surveys were conducted prior to MDA. The results are shown in the table. A sample of 60 mm³ of blood was taken from each person, in three linear smears, dried, dehaemoglobinized in water for two minutes and stained with 10% Giemsa stain.

PERCENTAGES

Island	mf rate	Filarial fever	Hydrocele in males	Elephantiasis rate	<u>Ae. polynesiensis</u> Infection	Infective
Funafuti	14.71	4.27	2.79	0.62	13.37	2.67
Vaitupu	32.90	22.19	6.99	2.76	10.30	1.33
Namumea	22.90	25.00	7.77	1.11	2.8	0.00
Namumaga	31.26	33.27	9.81	3.02	2.5	0.55
Nui	20.78	22.80	14.76	2.04	16.5	0.00
Niutao	14.97	26.80	3.31	0.91	4.2	0.00
Nukulaelae	12.57	9.11	2.84	0.63	6.1	3.0
Nukufetau	12.88		Not available yet			

3.2 Mass drug administration

MDA was conducted by using diethylcarbamazine citrate at a dosage of 6 mg/kg once a week for 12 weeks followed by once a month for 12 months (total of 24 doses). All islands beginning with Funafuti, except Mululaelae and Mukufetau, were completed at the time of this report.

Drug coverage for Funafuti was 91% for population coverage and 78% took 24 doses. The dose coverage per unit population was 83%. Post control blood surveys were carried out 2-8 months after completion of MDA. Blood examination results are shown in the following table. Post-control clinical surveys were carried out only at Funafuti in February 1974. No acute cases of filariasis were found. Chronic cases remained, as expected.

Blood examination results before and after MDA
in the Ellice Islands (excluding untreated visitors)

<u>Island</u>	<u>Before control</u>	<u>After control</u>
Funafuti	14.71	1.18
Vaitupu	32.90	0.66
Nanumea	22.30	1.08
Nanumaga	31.26	0.70
Nui	20.78	0.18
Niutao	14.97	0.94
Nukulaelae	12.57	MDA in progress
Nukufetau	18.88	MDA in progress

4. Niue

Prior to the filariasis control programme begun in July 1972, preliminary blood surveys were carried out. A total of 4408 blood smears were examined, showing an mf rate of 16.31% and an average mf per positive of 30.36.

Pre-control clinical surveys were conducted at Alofi General Hospital. Filarial fever attacks were suffered by 76 out of 4408 persons examined (1.72%). Eleven persons had enlarged epitrochlear glands (0.23%), 44 males out of 1631 had hydrocoele (2.7%). Six persons had elephantiasis of the lower extremities, two females had elephantiasis of the breast, giving an overall elephantiasis rate of 0.41%.

(170) Maung, T.M.
1974 b

Filariasis control by the application
of mass drug administration in
Western Samoa, Ellice Islands and Niue
WHO unpublished document, WPR/FIL/11

This unpublished document was presented to the Fourth Joint WHO/SPC Seminar on Filariasis and Vector Control, Apia, Western Samoa, July 1974. On the basis of Maung's assignment report, 1974 (169), the paper presents a synopsis of assessment surveys carried out in the above mentioned island groups.

(171) Muller, R.L. &
Denham, D.A.
1974

A field technique for the recovery and
preservation of infective filarial
larvae from their vectors
Trans. roy. Soc. trop. Med. Hyg., 68,
8-9

The dissection of mosquitos for infective larvae of W. bancrofti or B. malayi and of blackflies for those of Onchocerca volvulus forms a necessary part of any transmission study. The usual technique of individual dissection is laborious and larvae are often lost or damaged. In the present technique, large numbers of insects can be examined, free of extraneous matter, and processed quickly. Also, sufficient larvae can be collected at one time in a physiologically normal condition for experimental infections to be attempted, in order to determine the final hosts and the identity of any non-human larvae obtained.

The necessity for such a technique is becoming increasingly apparent with the realization that not all filarial larvae in vectors are of human origin. Non-human larvae have been found in vectors of filariasis in Sri Lanka, Kenya and Peninsular Malaysia and in the vectors of onchocerciasis in Cameroun, Liberia and Uganda. Reliable criteria for identifying larvae are of particular importance when calculating transmission indices, or in producing mathematical models for the study of the dynamics of transmission.

The method used for the recovery of larvae is a modification of techniques used in many research laboratories and gives a high recovery rate. In three batches of naturally infected Ae. pombaensis and seven batches of Ae. aegypti experimentally infected with B. pahangi, a total of 1341 mosquitos were examined and 657 larvae obtained. Only 18 larvae were found above the sieve by subsequent dissections (2.7%). In other experiments in which Ae. aegypti were left for two instead of three hours, 1069 larvae were obtained and 103 (8.8%) were left behind.

Technique

1. Insects are immobilized by cold or by a pyrethrum spray, then sorted into separate species. All females of one species are crushed by gently rolling with a test tube on a glass or perspex plate in physiological saline. This is repeated for each species separately.

2. Insects are transferred to sieves (bolting silk, pore size approximately 50 µm, No. 0 from J. Stanair, Manchester), glued across half of a plastic cup and suspended in a glass funnel. The fluid is retained by means of a clipped tube below the funnel. There must be no air bubbles below the sieve. Each sieve is left for three hours at room temperature. If larvae are being collected for infection experiments, a tissue culture medium (e.g. medium 199 from Wellcome Reagents Ltd.) incubated at 37°C should be used instead of saline.

3. About 1 ml is run into a Syracuse watch-glass (made from the bottom of a dented test tube) and examined for larvae under a stereoscopic microscope.

4. Most of the saline is removed with a pasteur pipette and replaced by fixative. TAF (formalin 7 ml, triethanolamine 2 ml, distilled water 91 ml) is excellent but hot 70% alcohol containing 10% glycerol can be used. Leave fixative for five minutes. Larvae may be stained with Meldola's blue (new fast blue R) but they may be examined equally well unstained under phase-contrast.

5. Fixative is removed with a fine pipette and replaced by 96% alcohol containing 5% glycerol and the watch-glass left in an incubator at 37°C for about 30 minutes until only pure glycerol is left (or it can be left overnight at room temperature).

6. Larvae are transferred with a mounted cat's whisker to a small drop of anhydrous glycerol on a clean 22 mm² cover slip. Excess glycerol is removed with a very fine pipette, leaving only a smear.

7. The cover slip is turned over onto a cavity slide and sealed around and under the edge with mounting medium. For cheapness, three short pieces of glass wool can be used instead of a cavity slide, or a small chamber made.

(172) Pichon, G.
1974

Etude de la réduction parasitaire chez
différents vecteurs naturels ou
expérimentaux de filarioses
C.R. Acad. Sc., Paris, 278, Série D,
3095-3097

The author cited Rosen, 1955 (56) for the results of experimental infection of Ae. polynesiensis with subperiodic W. bancrofti which indicated that the mean number of infective larvae per mosquito decreased as the number of mf infected increased. The author further referred to the phenomenon named as "limitation" as reported by Brengues & Bain (1972)¹ in Ae. aegypti versus the development of periodic W. bancrofti and Setaria labiatopapillosa, indicating that the number of microfilariae that can traverse the stomach wall in the vector decreases as the number of microfilaria ingested increases. Similar observation was reported by

¹Brengues, J. & Bain, O. (1972) Passage des microfilaires de l'estomac vers l'hémocèle du vecteur, dans les couples W. bancrofti-An. gambiae A, W. bancrofti-Ae. aegypti et Setaria labiatopapillosa-Ae. aegypti. Cah. ORSTOM, Ent. méd Parasit., 10, 235-250

Philippon & Bain (1972)² in another parasite/vector couple Onchocerca volvulus and Simulium damnosum. In contrast, Brengues & Bain (*loc. cit.*) reported in A. gambiae/W. bancrofti the reverse of the above phenomenon which they named "facilitation" indicating that the proportion of microfilaria that can succeed in reaching the haemocele increases as the number of microfilariae ingested increased.

The author, therefore, made an initial attempt for working out the above mentioned relationships mathematically. His study showed that if:

x is the mean number of microfilaria ingested

y is the mean number of the parasite that succeed in penetrating the stomach wall and reaches the infective stage larvae

then the reverse of y/x could be considered as a linear function of x as in the following equation:

$$\frac{y}{x} = \frac{1}{H} x + \frac{1}{J}$$

with J and H being both constant, independent of the number of mf ingested, and the following equation could consequently be derived.

$$y = \frac{JHx}{H + Jx}$$

Thus, it appears that the relationship between the number of mf ingested by a vector and the number of infective larvae produced can be represented by hyperbolic function.

Further elucidation is given in subsequent papers.

(173) Pichon, G.
1974 a

Relations mathématiques entre le
nombre des microfilaires ingérées et
le nombre des parasites chez
différentes vecteurs naturels et
expérimentaux de filariose
Cah. ORSTOM., Ent., méd.,
Parasit., 12, 199-216

Although only descriptive, this formula seems to fit satisfactorily with all the studied couples, and allows a numerical evaluation of the parasite vector relationships.

Inferences of this finding on the experimental, epidemiological and evolutive viewpoints are discussed.

²Philippon, B. & Bain, O. (1972) Transmission de l'onchocercose humaine en zone de savane d'Afrique occidentale. Passage des microfilaires d'Onchocerca volvulus dans l'hémocèle de la femelle de Simulium damnosum. Cah. ORSTOM, sér. Ent. méd. Parasit., 10, 251-262

The author, in studying the mathematical relationship between the number of microfilariae ingested and the number of larvae produced in the vector in different parasite/vector couples, utilized the data of Rosen (1955)¹ of the experimental infection of Ae. polynesiensis with subperiodic W. bancrofti which were carried out in Tahiti. When he compared the mean values of the 23 experiments of Rosen and the theoretical mean values mathematically calculated by him, he found a highly significant value of χ^2 , and tried to find out the reasons for such disparity. He indicated that many factors of heterogeneity can produce a high χ^2 value of testing the goodness of the fit. It is certain that the 23 experiments were not simultaneously carried out and undoubtedly variation in temperatures may have had an influence on the infection rates. Nothing can be said about the genetic homogeneity of the 23 populations of Ae. polynesiensis whether they originated from wild caught parents or from laboratory colonies which unavoidable could have undergone a process of selection. Furthermore, there was considerable variation in the microfilaria density of the donors as noted from the detailed data of Rosen for which Hairston & Jachowski, 1968 (121) showed that a markedly high variance not conforming with Poisson distribution. For reducing the effect of the vectors of heterogeneity, the author resorted to regrouping the data of Rosen. However, examination of the detailed data of Rosen was made in order to see whether there was a systematic discrepancy from the theoretical estimates.

Table 1: Testing the goodness of the fit of data of Rosen (1955)
 by the formulae: $y = \frac{25.25X}{X + 142.4}$ X mean number of
 mf per 20 mm³ of blood)

Density of mf	Number of mosquitos dissected	Yc	Yo	Total number of larvae		$\frac{(Nyc - Nyo)^2}{Nyc} = x^2$	NS
		Expected mean no. of larvae	Observed mean no. of larvae	Ny expected	Nyc observed		
0.4	38	0.07	0.05	2.7	1.9	0.23	NS
0.6	69	0.1	0.1	6.9	6.9	0.0	NS
2.1	36	0.36	0.8	13.0	28.8	19.2	TS
3.1	70	0.53	1.3	37.1	91	78.5	TS
3.3	49	0.57	1.1	27.9	53.9	24.1	TS
3.5	96	0.60	0.8	57.6	76.8	6.2	S
4.8	13	0.82	0.8	10.7	10.4	0.0	NS
5.1	18	0.87	1.1	15.6	19.8	1.13	NS
11.4	17	1.86	2.1	31.6	35.7	0.53	NS
11.5	138	1.88	2.1	259.4	298.8	3.6	NS
12.8	66	2.08	3.5	137.3	231	63.9	TS
27.0	66	4.02	3.5	265.0	231	4.4	S
28.4	33	4.19	6.1	138.3	201.3	28.8	TS
31.9	67	4.62	4.5	309.5	301.5	0.20	NS
31.9	28	4.62	5.6	129.3	156.8	5.84	S
18.0	76	5.33	4.	405.1	349.6	7.57	S
52.1	26	6.76	5.1	175.8	132.6	10.5	TS
97.4	43	10.24	12.7	440.3	546.1	25.5	TS
167.0	74	13.64	13.4	1 009.4	991.6	0.28	NS
195.6	22	14.61	18.8	321.4	413.6	26.4	TS
208.0	36	15.00	16.7	540.0	601.2	6.9	S
533.9	25	19.94	16.4	498.5	410.0	19.3	S
555.1	54	20.10	21.7	1 085.4	1 171.8	6.8	S

For this the author calculated the expected number of larvae that can be theoretically produced by each batch of mosquitos fed on the 23 microfilaria carriers of different counts as shown in Table 1. Testing the goodness of the fit by χ^2 for each of the 23 experiments, there appeared eight agreements between the expected and observed number of larvae, five discrepancies with a significant difference at probability level of 0.01 - 0.05 and 10 discrepancies with a significant difference at a probability level of 0.01. Among the 15 discrepancies, there lies the experiments which were made with microfilaria density higher than 10. These did not show a systematic difference between the observed and expected number of larvae, the former was inferior to the latter in four experiments and superior to the latter in six experiments. This could have been due probably to lack of homogenous conditions in the experiments. The other five discrepancies were those of experiments carried out with a mean mf density of 2.1 - 3.5 in which the observed number of larvae much exceeded that of the expected. This would lead to suspecting a systematic factor whereby the "concentration" of the microfilariae by the mosquitos occurs at low mf densities. This phenomenon was a point of controversy. Rosen concluded that it did not exist in his experiments whereas Bryan & Southgate (1973)⁴, found that Ae. polynesiensis in their experiments carried out in Western Samoa contained larvae 12 times the number of microfilaria that could have been ingested from a volunteer with a very low mf count. From the calculations by the author of Rosen's data, the highest concentration was shown to occur in the experiment made with a mean mf density of 3.1, the observed number of larvae was 2.5 times higher than the expected. However, this phenomenon did not seem to occur with lower mf densities.

The author concluded that further studies are needed on the influence of different factors on the constant H including the phenomenon of concentration of the microfilariae by mosquitos which seems to intervene in the case of low microfilariaemia.

¹Bain, O. (1971) Transmission des filariose - Limitation des passages des microfilaires ingerees vers l'hemocèle des vecteurs; interpretation. Ann. Parasit., 46, 613-631

^{2, 3}Vide references in Pichon, 1974 (172)

⁴Bryan, J.H. & Southgate, B.A. (1973) Assignment report submitted to WHO, published in 1976 (192)

(174) Pichon, G.,
Perrault, G. &
Laigret, J.
1974

Rendement parasitaire chez les
vecteurs de filarioses
Bull. Wld Hlth Org., 51, 517-524

It is well known that, in the biological cycle of the Filaroidea, the parasite does not multiply in the vector host. On the contrary, in a given intermediate host the infective larvae are always fewer than the microfilariae ingested: this reduction in the number of parasites during their life in the vector is termed parasite reduction, and the ratio between the number of infective larvae and the number of microfilariae ingested is known as the parasite yield. The parasite reduction seems to occur mainly on passing the stomach wall, and two types of parasite reduction have been (Fig. 1): (a) in most cases (Aedes, Culex, and Simulium) "limitation" occurs: the viability of the microfilariae, or the parasite yield drops as the number of parasites increases;

Fig. 1: Curves representing the phenomena of limitation and facilitation

(b) in the Anopheles gambiae A- Wuchereria bancrofti partnership, the parasite yield increases when the number of ingested microfilariae increases: this is "facilitation". A mathematical formula for the quantitative analysis of these two phenomena is presented and their possible influence on the control of W. bancrofti populations is discussed. An annex presents a theoretical mathematical model showing how a parasite population would develop in an isolated individual surrounded by a stable vector population, depending on whether the vectors give rise to facilitation or limitation.

Regarding the regulation of the parasite in the vector, the author gives as examples A. gambiae as the vector of periodic bancroftian filariasis in rural areas of Africa and Ae. polynesiensis as the vector of the superperiodic type in Polynesia. In both vectors, it is rare to find more than one or two infective stage larvae whatever the endemicity level of the disease. It has been shown that the parasite yield in the two vectors is fundamentally of two different categories, increasing in Anopheles and decreasing in Aedes. The observed low numbers of infective stage larvae in both cases in nature can be attributed to different mechanisms; the mortality of highly infected individuals in Anopheles and the limitation which protects the vector from the effect of hyperparasitism in Aedes.

Fig. 2 represents the parasite yield obtained from the two vectors theoretically whether in limitation or facilitation, on the assumption that vector mortality in the two cases is equal, but being proportionate to the number of microfilaria that have traversed the stomach wall.

Fig. 2: Theoretical estimation of the influence of vector mortality due to Parasitism (B) on the production of infective stage larvae assuming that the mortality is proportionate to the number of microfilaria that passed through the stomach wall in the case of limitation or facilitation.

A = absence of vector mortality due to parasitism

In conclusion, the facilitation mechanism seems to be a factor beneficial to the control of filariasis in areas where this disease is transmitted by anopheline mosquitos, such as West Africa. The viability of the microfilariae in the vector is in fact lower where the microfilaria density is reduced, which occurs as a result of mass chemoprophylaxis; once a certain threshold is crossed, eradication can theoretically be achieved spontaneously and become a permanent state. On the other hand, the presence of the limitation phenomenon in Aedes means that when the number of microfilariae is reduced, the parasite yield increases towards unit. Thus, the fact that it was not possible to eradicate filariasis in a Polynesian island where transmission is due to Ae. polynesiensis, is not necessarily attributable to inadequacies in the application of mass DEC treatment. In such cases, it will generally be possible to obtain the best results only by a combination of mass treatment and vector control. However, even if eradication is achieved, the risks of reintroduction will make the situation unstable if the vector population is not kept at a low density.

(175) Rakai, I.M., Naseru, J.D.,
MacNamara, F.N. &
Pillai, J.S.
1974

Mosquito-borne infection in Fiji.
IV. Biting times for village
mosquitos and human filaria
transmission potential of Aedes
polynesiensis and Aedes
pseudoscutellaris
J. med. Ent., 11, 588-594

During 1969 the authors, after having noted the paucity of information on the biting cycle of the majority of mosquito species in Fiji conducted man biting studies in two villages on the southeast coast of Viti Levu island. Also, they conducted studies on the two main vectors of subperiodic filariasis Ae. polynesiensis and Ae. pseudoscutellaris with the aim of establishing whether any differences in their distribution and vectorial efficiency could be detected under either general climatic or local areas in and around Fijian villages.

A summary of the findings is given under the headings "biting cycle" and "vector studies".

Biting cycle

Table 1. Mean biting rate per hour for seven mosquito species over eight periods of two-hour duration (expressed as percentages of total activity)

Species	Periods*							
	1	2	3	4	5	6	7	8
<u>Ae. polynesiensis</u>	22.24	18.27	23.17	13.25	3.66	3.17	4.99	11.24
<u>Ae. pseudoscutellaris</u>	22.98	21.40	25.36	14.39	2.03	3.06	3.61	8.86
<u>Ae. nocturnus</u>	4.16	2.91	4.01	7.20	14.17	23.03	20.60	23.92
<u>Ae. vigilax</u>	3.36	4.40	4.20	11.03	17.72	20.93	20.89	17.47
<u>C. quinquefasciatus</u>	0	1.03	0	15.03	25.19	29.93	21.71	7.17
<u>C. annulirostris</u>	0.61	0.96	0.93	13.78	23.84	24.13	22.55	13.19
<u>C. sitiens</u>	0	0	0	4.56	22.23	30.58	29.48	13.15

*Key to periods: 1 = 0700-0900, 2 = 1000-1200, 3 = 1300-1500, 4 = 1600-1800,
5 = 1900-2100, 6 = 2200-2400, 7 = 0100-0300, 8 = 0400-0600 hr.

As shown in the table, the present observations confirm that Ae. polynesiensis and Ae. pseudoscutellaris are diurnal biters showing similar patterns of biting cycle. These findings are similar to those of Jachowski, 1954 (46) and Ramalingam, 1968 (125) in American Samoa in respect of Ae. polynesiensis which showed sharp increases in biting after dawn reaching a peak in the early afternoon and tapering off after sunset to a low level that persisted throughout the night rising again before dawn.

C. quinquefasciatus showed a nocturnal biting activity as is known elsewhere. The day time activity was only 1.03% recorded during 1000-1200 hours. The peak of its biting at night was during 2200-2400 hours.

One thousand and ninety one Ae. polynesiensis from southern coastal areas were dissected and examined for larvae of W. bancrofti. There was no significant difference in the percentage of mosquitos infected according to the time of the day.

The numbers of dissected mosquitos that were infected with larvae of W. bancrofti at different stages of development showed that the mean number of larvae of each stage for all infected mosquitos at all sites were as follows: stage 1 larvae, 4.0; stage 2 larvae, 2.8; and stage 3 larvae, 1.0. In this series there were no mosquitos infected with more than one larval stage.

The authors indicated that Ae. polynesiensis appears to be adapted to a brackish environment which restricts its distribution to spray zone along the coast. Therefore, they believed that where the numbers of Ae. polynesiensis were highest, the important factors were a low level of salinity due to spray and a lower rainfall with less effect of washing away what salinity there may be.

In support of this hypothesis the observations made at villages situated more than 0.8 km from the coast where Ae. polynesiensis was not found and was replaced by Ae. pseudoscutellaris.

As found by previous workers, the biting activity and presumably numbers of Ae. polynesiensis were highest in the bush away from the village. The author further stated that the risk to man of becoming infected in the bush was also greatest. For, although the percentage of mosquitos caught within the village and found to harbour larvae was higher than that found elsewhere, the ratio of numbers of mosquitos carrying first stage larvae to those carrying second or third stage larvae was also higher, indicating a higher mortality rate of mosquitos in the village area. Whether this difference persisted throughout the year was not known.

The alternative explanation given by the authors for the fewer village mosquitos with second and third stage larvae was that after their first blood meal in the village, subsequent blood meals are taken in the bush, the reverse tendency being absent or diminished. The authors considered that irrespective of whether any of the two assumptions was correct, the final result is the same.

The number of mature larvae per mosquito is of importance in considering the multiplicity of bites required to induce an infection with both male and female worms. In the authors' opinion it is impossible to say whether the number of mature larvae in a mosquito represents the total number that have reached that stage or the remainder after one or more mature larvae have left the mosquito during previous biting activity, including probing during the collection. The authors' conclusion was that, since the mean number of mature larvae is less than two, it is probably unusual for more than one mature larvae to gain access to the human body by any one infective bite.

/N.B.: De Meillon et al. (1976)* showed from experimental observations on C. quinquefasciatus that only about 41% of the infective larvae would leave the mosquito during one complete blood feed._/

* De Meillon, B., Hayashi, S. & Sebastian, A. (1967) Bull. Wld Hlth Org., 36, 81-90

(176) Southgate, B.A.
1974

A quantitative approach to parasitological techniques in bancroftian filariasis and its effect on epidemiological understanding
Trans. roy. Soc. trop. Med. Hyg.,
68, 177-186

The author, having noted the inadequacies of measuring infection rates in the human population by detection of microfilariae in samples of peripheral blood which have been recognized for many years, reviewed the literature on attempts made to develop improved techniques.

Sedimentation methods using volumes of blood ranging from 1 to 10 ml have been found to increase the detection rates, but since such methods are difficult to use under field conditions, they have not been widely applied. The author also referred to two new techniques which have been developed in recent years; the counting chamber developed by Denham et al., 1971 (135) and the membrane filtration technique described by Chularerk & Desowitz (1970)¹. Comparative studies conducted in Fiji, Western Samoa and Tonga, Southgate, 1973 (164); Desowitz & Southgate, 1973 (158), and Desowitz, Southgate & Mataika, 1973 (159), and Desowitz, 1973 (157), involving the conventional blood films, counting chambers and the membrane filtration technique showed that the prevalences of microfilaraemia were much higher using the membrane filtration technique and that the age at which a prevalence plateau was reached was much lower than expected.

Subsequently, the authors decided to carry out a simultaneous trial in Fiji of four field techniques for the diagnosis of microfilaraemia, the objective being to obtain comparative epidemiological profiles of a population, rather than to evaluate new techniques under field conditions.

Materials and methods

Sites of survey: The study was carried out in June 1971 in two villages on the south coast of Viti Levu, the principal island of the Fiji group; the villages were situated approximately 80 km west of Suva, the capital of Fiji, and were known to be highly endemic by the Fiji Filariasis Control Team.

Time of blood collection: Work in the villages was carried out between 0730 hours and 1700 hours; in view of the aperiodicity or diurnal subperiodicity of bancroftian microfilaraemia in Fiji, it is felt that no significant errors have been introduced by collecting blood samples over a 9 to 10 hour period.

Techniques of blood examination: The epidemiological population profiles obtained by using four different techniques were compared. The traditional 20 mm³ blood films were prepared by drawing finger-tip blood from a stylet puncture into a pipette; the blood was then expelled onto a glass slide and carefully made into a circular film of 2 cm diameter (3.14 cm² area). After overnight drying under insect-proof covers, the blood films were dehaemoglobinized for 10 minutes in distilled water, fixed in methanol,

and stained for 30 minutes in a 10% solution of Giemsa. 60 mm³ films were prepared similarly using a 60 mm³ pipette and making three films on one glass slide, each from 20 mm³ of blood treated as above; dehaemoglobinization fixation and staining were carried out as for the 20 mm³ films. Blood films were examined with a compound microscope at X 50 magnification. Counting-chamber examinations of 60 mm³ finger-prick blood were carried out exactly as described by Southgate (loc. cit.); membrane filtration examinations were carried out exactly as described by Desowitz & Southgate (loc. cit.).

Results and discussion

The author presented his results in a series of tables giving the mf rates obtained by the four techniques as well as the mf density following the method recommended by Sasa (1967)¹ and WHO report of the Expert Committee on Filariasis, 1967 (119). Graphs were also presented and the regressions were calculated for the microfilaria density/20 mm³ and 60 mm³ and 1 ml venous blood. Data and important points discussed are extracted as follows:

As shown in Tables 1 and 2, the percentage of the microfilaria positive population rises from 22.1% to 67.8% with the more sensitive techniques. Further, the prevalence of microfilaraemia, Table 1 has reached a plateau at the age of about 10 years when the highly sensitive membrane filtration technique was used.

¹Sasa, M. (1967) Bull. Wld Hlth Org., 37, 629-650

Table 1. Numbers and percentages of persons positive for microfilaraemia by age and sex group

Age in years	No. of persons present	Positive by 20 mm ³ blood-film						Positive by 60 mm ³ blood-film						Positive by 60 mm ³ counting chamber						Positive by 1 ml membrane filtration							
		Number		M	F	%	Number		M	F	%	Number		M	F	%	Number		M	F	%	Number		M	F	%	
		M	F				M	F				M	F				M	F				M	F				
0-4	36	35	0	0	-	-	2	0	5.6	-	7	2	19.4	5.7	13	15	36.1	42.9									
5-9	32	32	6	5	18.8	15.6	7	9	21.9	28.1	9	12	28.1	37.5	22	21	68.7	65.6									
10-19	20	41	7	9	35.0	22.0	8	9	40.0	22.0	11	10	55.0	24.4	16	32	80.0	78.0									
20-29	31	39	14	4	45.2	35.9	21	17	67.7	43.6	22	17	71.0	43.5	25	31	80.6	79.5									
30-39	20	27	8	6	40.0	22.2	11	7	55.0	25.9	15	19	75.0	70.4	16	20	89.0	74.1									
40-49	13	19	5	4	38.5	21.0	7	5	53.8	26.3	7	5	53.8	26.3	10	15	76.9	78.9									
50-59	6	6	2	1	33.3	16.7		2	50.0	33.3	3	2	50.0	33.3	5	4	83.3	66.6									
60-69	3	4	0	0	-	-		1	-	25.0	0	1	-	25.0	2	1	66.6	25.0									
70-	1	1	0	0	-	-		0	-	-	0	0	-	-	0	0	-	-	-								
Total	162	204	42	39	25.9	19.1	59	50	36.4	24.5	74	68	45.7	33.3	109	139	67.3	68.1									

Table 2 The descriptive epidemiology of microfilaraemia in a community produced by four different survey techniques

Technique	Percentage prevalence in population	MFD ₅₀	Regression parameters for Figures 1-3				
			a	b	r	SE(r)	$\frac{r}{SE(r)}$
20 mm ³ blood film	22.1	3.2	4.353	1.182	0.983	0.224	4.398
60 mm ³ blood film	29.8	3.9	4.321	1.172	0.984	0.209	4.719
60 mm ³ counting chamber	38.8	19.0	3.370	1.260	0.993	0.196	5.061
1 ml membrane filtration - venous blood	67.8	34.0	3.423	1.045	0.993	0.183	5.438

The author further indicated that although the figures for the 5-9 years old age-group are slightly lower than those given for the subsequent 5 age-groups extending from 10-59 years, it can be seen that prevalence increases steadily with each increasing year of age within this group, and in fact 10-year old children showed prevalence rates for both males and females as high as any in the whole population. From the age of about 10 years onwards, it is only mf densities that show marked fluctuations rising to peaks in both sexes in the age group 30-39, and then declining fairly rapidly in females, much more slowly in males.

The relative insensitivity of the two blood-film techniques in detecting microfilaraemia is clearly demonstrated in Table 1, where the lack of sensitivity gives rise to a totally false age and sex specific prevalence profile of the population. Prevalence appears to be nil or very low in the young age-groups, and then increases steadily to a peak which is reached around the age of 30 years. This is followed by a plateau of about 10 years duration, and then a steep fall in prevalence in females and a much more gradual fall in males. Comparison with the figures given by the 1 ml venous blood membrane-filtration technique make clear the very large difference in prevalence figures given by the various techniques. Although it is not claimed that membrane-filtration methods achieve 100% sensitivity in detecting microfilaraemia, it seems unlikely that many cases were missed, and it is logical and more relevant to formulate the patterns of the epidemiology of filariasis from these results rather than from the vastly lower prevalence figures and the very distorted age and sex picture obtained by stained blood-film techniques. It is also clearly advisable to take account of mf density distributions as well as simple prevalence figures based on positivity and negativity when building up a picture of a local epidemiological situation.

In this connexion, the author referred to the account made on the epidemiology of filariasis in Fiji by Mataika *et al.*, 1971 (143). In spite of considerable local variation in the epidemiological pattern, it was possible to draw a general picture based on examination of 20 mm^3 and 60 mm^3 stained blood films and the picture drawn closely conformed with that demonstrated in the present study. Plausible explanations could be found for the various epidemiological features observed such as differences in the activities of groups of populations affected in Fiji and some other areas of the South Pacific.

The author pointed out that his study implies that considerably more peri-domestic transmission is occurring than had been previously thought and suggested that careful studies of mosquito biting patterns and infection rates in and around homestead are urgently indicated; possibly the role in transmission of such species as Ae. fijiensis and Ae. samoanus should be reviewed again, in spite of much previous work on these two vectors.

With regard to the mf density, the author referred to Table 2 which gives the correlation coefficient (r) of the regression line of the cumulative percentage of microfilaria positive cases against microfilaria density on a log-probit scale; the standard error of r for each technique, and the ratio $r:SE(r)$. It can be seen that some unexpected results are produced by using four very different techniques to examine a population

simultaneously. The steady climb in percentage prevalence is readily understood, but the relative values of the MfD₅₀ for the 20 mm³ and 60 mm³ blood-film examinations and the 60 mm³ counter-chamber technique are very difficult to explain, particularly as all three examinations were performed on finger-prick blood, presumably largely capillary in origin. Similarly, the relatively low MfD₅₀ value of 34.0 produced by a membrane-filtration examination of 1 ml of venous blood supports the suggestion made by Desowitz, Southgate & Mataika (loc. cit.) that venous blood concentrations may be lower than capillary concentrations in the absence of DEC therapy, but higher after such therapy.

The author felt that Table 2 constitutes a system of epidemetrics as defined by Moshkovsky (1961),¹ and as such, can be recommended for future use in describing epidemiology in bancroftian filariasis; if the seven epidemetrics-percentage prevalence, MfD₅₀, a, b, r, SE(r) and r : SE(r) were routinely calculated and published, it would not be necessary to publish diagrams of the regression lines, once the method had become familiar and widely accepted. It must always be borne in mind, however, that the quantitative epidemetrics discussed in this paper refer strictly to microfilaraemia and not to filariasis. A fruitful field of research for the coming years is the relationship between microfilaraemia, pathology and clinical manifestations in a community.

Apparently rather small changes in the techniques of epidemiological measurement in estimating the prevalence and densities of microfilaraemia in human population can produce quite remarkable changes in understanding of the epidemiology of the disease. Clearly the change in understanding of the epidemiology has very serious implications for control programmes.

A programme aimed for example at MDA of all persons found positive on a 20 mm³ blood examination is only going to reach a small proportion of infected people and operational situations of high intensity of transmission are probably best dealt with by mass chemotherapy of a whole population, regardless of presence or absence of worms. Similarly, if control by insecticides is contemplated a much higher degree of efficiency would have to be obtained where 70% of the population rather than 22% are acting as a reservoir of infection, particularly as this additional 48% of the population discovered by an improved technique will be harbouring rather low microfilarial counts of precisely those levels which may be most efficient in infecting mosquitos without causing mosquito damage and premature mortality before the completion of the extrinsic cycle of development.

¹Moshkovsky, S.D. (1961) J. Hyg. Epidem. Microbiol. Immunol., Prague, 5, 129

(177) Suzuki, T. &
Sone, F.
1974

The bionomics of filariasis vectors
in Western Samoa
Jap. J. sanit. Zool., 25, 251-257

This paper reports the results of studies on the biting activities and the seasonal prevalence of the two main vectors of filariasis Ae. polynesiensis and Ae. samoanus.

Biting activities

The findings of Jachowski, 1954 (46) and Ramalingam, 1968 (125) on the morning and late afternoon biting activities of Ae. polynesiensis in American Samoa were confirmed by the present study. The lower peak was from 0800 h to 0830 h and the higher peak from 1700 h to 1830 h. The outdoor biting density was generally higher than the indoor biting density. There was no clear relationship between biting activities and the temperature and relative humidity.

/N.B. The depression of biting activities at mid-day seems to coincide with relatively lower humidity than that observed in early morning and evening./

The authors referred to Ramalingam (loc. cit.) who reported that the highest peak of biting activity of Ae. samoanus in American Samoa occurred at 2300 h. Their studies showed that Ae. samoanus bites man throughout the night starting at 1900 h with a peak between midnight and 0330 h. Also there was no distinct relationship between biting activities and the temperature and relative humidity.

Although Ae. polynesiensis is a well-known daytime biter, it was also caught in considerable numbers at night. The number caught in a Samoan type house in the coastal village on Upolu Island around midnight (five mosquitos/man hour) was even slightly higher than those caught around noon (three/man hour).

Seasonal prevalence

Reference was made to Jachowski (loc. cit.) who reported that no evidence of seasonal fluctuation in density of Ae. polynesiensis was observed in American Samoa.

The present studies show that the density of Ae. polynesiensis was positively correlated with rainfall; high density of mosquitos tended to occur two weeks after a heavy rainfall.

The main breeding sites of Ae. polynesiensis in the survey areas are tree holes, coconut shells and discarded tins. These are usually small but hold enough rain water to permit oviposition and larval development.

The highest density peak of Ae. samoanus occurred during May. There was again no relationship between the density, temperature and relative humidity. There appeared to be some relationship with rainfall but it was not as distinct as in the case of Ae. polynesiensis.

The breeding sites of Ae. samoanus in Western Samoa were confined to leaf axils of two kinds of plants: the common Pandanus and Freycinetia. It was noted that even during the dry season most of the Pandanus axils usually held some water.

(178) World Health Organization
1974

Expert Committee on Filariasis
Third report
Techn. Rep. Ser., No. 542

The WHO Expert Committee met in Athens from 8 to 13 October 1973.

The topics discussed in the meeting were as follows:

1. Distribution and prevalence of lymphatic filariasis
(Wuchereria and Brugia infections)

1.1 Areas of decreasing prevalence

Possible factors reviewed were:

- 1.1.1 Mass treatment using diethylcarbamazine (DEC)
- 1.1.2 Vector control
- 1.1.3 Malaria control
- 1.1.4 Socioeconomic development

1.2 Areas of increased prevalence

2. Evaluation of control measures

2.1 Chemotherapy

- 2.1.1 Preparations and dosages of DEC
- 2.1.2 The effect of treatment
 - Effects on the parasite
 - Effects on the disease
 - Side-effects

2.1.3 Evaluation surveys

2.1.4 The principles of treatment

- (a) mass administration of the drug to the total population;
- (b) selective administration of the drug to cover a segment of the population found infected in the pre-treatment surveys;
- (c) the provision of medicated food or beverages to be consumed by the population at risk.

2.2 Experimental chemotherapy

2.2.1 The screening of compounds for evidence of activity

- Model infections employed

2.2.2 Current filaricidal drugs

2.2.3 Activity of drug against microfilariae

2.2.4 Activity of drugs against immature and adult parasite

2.2.5 Activity of drugs against microfilariae and macrofilariae

2.2.6 Drugs for further studies

2.3 Control of vectors

2.3.1 Chemical control

2.3.2 Biological control

2.3.3 Genetic control

2.4 Sanitation, urban environmental improvement and health education

2.4.1 Sanitation and urban environmental improvement

2.4.2 Health education

3. Methods for epidemiological assessment

(For statistical planning of surveys - vide WHO Techn. Rep. Ser., 1966, No. 336¹ and for entomological studies as an integral part of epidemiological assessment - vide Ramachandra, 1970 (133))

3.1 Assessment of clinical manifestations in surveys

3.2 Parasitological and immunodiagnostic procedures in surveys

3.2.1 Pre-control surveys

3.2.2 Post-control surveys

- Mass chemotherapy

- Vector control only

3.3 Parameters for an analysis of the dynamics of transmission

3.3.1 Parameters relating to human population

- direct method for calculating the index of human infectivity;

- indirect method for calculating the infectivity index of human populations from the distribution of microfilaria density among carriers

3.3.2 Parameters relating to vectors

(i) Parameters relating to the infection of the vector

(ii) Parameters relating to the development of filarial larvae in vectors

(iii) Parameters relating to the infection in man

3.3.3 Parameters relating to the development and reproduction of filariae in man.

4. Other filarial parasites

4.1 Problems of taxonomy

4.2 Loa loa

4.2.1 Taxonomy

4.2.2 Clinical features

4.2.3 Treatment and prophylaxis

4.2.4 Control

4.3 Dipetalonema perstans

4.3.1 Clinical features and pathogenicity

4.3.2 Treatment

4.4 Dipetalonema streptocerca

4.4.1 Pathogenicity and treatment

4.5 Mansonella ozzardi

4.5.1 Pathogenicity and treatment

5. Research proposals

5.1 Epidemiology

5.2 Chemotherapy

5.3 Pathophysiology

5.4 Immunology

5.5 Vector control

5.6 Vector ecology and bionomics

5.7 Miscellaneous research proposals:

- training of auxiliary personnel in techniques most useful in filariasis research;
- investigations on taxonomic status, transmission, pathogenicity and epidemiology of new species of human filariae including Wuchereria lewisi in Brazil and Timor filaria from Timor Island;
- longevity of microfilariae and adults of different species of the filarial parasites in man;
- further investigation on possible animal models for W. bancrofti and O. volvulus;
- further evaluation of the technique of mass separation of third stage larvae from mosquitos and including assessment of its utility in other vectors, e.g. Culicoides and Simulium
- precise taxonomic definition and life cycle studies of human and animal filariae known to be potentially zoonotic.

6. Recommendations

6.1 Epidemiology

The Committee noted that, although excellent work on filariasis is being carried out by many individuals and in many institutions, there is a need for the international coordination of all these efforts, WHO is fulfilling this role. However, further and more detailed multidisciplinary research on the epidemiology of filariasis, including research on all aspects of the parasite, the vector, and the host should be carried out. For this purpose, the Committee recommends to WHO the establishment of multidisciplinary field research teams. The studies should continue for at least five years in an endemic area.

6.2 Longitudinal studies on major parasitic diseases in Africa

The Committee welcomed the initiative taken by WHO in making plans to establish a major project in Africa for longitudinal studies on parasitic diseases of public health importance, with emphasis on research in chemotherapy. At the same time, it recommended that continuing support be given to the WHO/MRC/Tanzania Bilharziasis Chemotherapy Centre in Tanga, where there are unique opportunities for collaboration with local research organizations already involved in extensive studies on bancroftian filariasis.

6.3 Computerized bibliography on onchocerciasis and filariasis as well as related infections in animals

The Committee noted that a comprehensive and relatively inexpensive computerized bibliography of the world literature of onchocerciasis, filariasis, and related infections in animals is being prepared by the WHO International Reference Centre for Filarioidea in the London School of Hygiene and Tropical Medicine to facilitate research in the field. It recommended that WHO should assist in the distribution of the bibliography to all workers with an interest in these fields, especially those in the developing countries.

6.4 Training

Being aware of the critical importance of supervisory and management techniques, the Committee recommended that training courses in these techniques should be instituted for medical and auxiliary personnel responsible for epidemiological, parasitological and entomological studies as part of filariasis control schemes.

6.5 Control schemes

In view of the success achieved by the WHO Filariasis Research Unit in Rangoon, in the control of C. quinquefasciatus, the Committee recommended that the techniques developed in this project should be applied in other areas in conjunction with an adequate parasitological and epidemiological evaluation. Such a scheme could be integrated with the longitudinal studies recommended in paragraph (1) above. Owing to the ecological differences of

filariasis in various parts of the world, it is recommended that a series of similar investigations should be carried out in areas with different vectors and different species of filaria where suitable facilities exist, e.g. the Kingdom of Tonga in the Pacific, the East African coast in Tanzania and Kenya, Upper Volta and Liberia in West Africa, and the Comoros Islands.

6.6 Research

- Filarial parasites
- Disease
- Vectors

WHO should continue to encourage and support all aspects of basic research in relation to the filarial parasites, the diseases they produce, and their vectors. It was noted that very little work has been done on the biochemistry of the parasites. The Committee therefore recommended to WHO that support should be given to studies in this field.

6.7 Development projects of water resources

The development of water resources for irrigation and domestic use often results in an increase in the number of vectors of human and animal diseases, including filariasis. The Committee recognized WHO's role in preventing such health hazards and recommended that due consideration should be given to filariasis at the planning stage of such projects.

Annexes

Annex 1 - The distribution of filarial infections in man and their vectors with a tabulated summary compiled from Hawking & Denham (1971),² Hawking (1973, a, b and c)³ and from Iyengar, 1965 (108)

Annex 2 - Protocols for filariasis surveys

Annex 3 - Methods for diagnosis of microfilaraemia

1. Methods for the preparation of blood films

2. The counting chamber technique

after Denham et al., 1971 (135) - Southgate, 1973 (164) - Desowitz, Southgate & Mataika, 1973 (159) - Manson-Bahr & Wijers (1972)⁴ and Crans (1972)⁵

3. Membrane filter concentration methods

3.1 Membrane filtration technique

after Bell (1967)⁶ - Chularerk & Desowitz (1970)⁷

3.2 The Nuclepore filter technique

4. DEC provocative test

after Katamine, Tamura & Moriguchi (1952)⁸, Sasa et al. (1963)⁹, Sullivan & Hembree (1970)¹⁰, Partono et al. (1972)¹¹, Manson-Bahr & Wijers (loc. cit.)⁴

¹WHO (1966) Sampling methods in morbidity surveys and public health statistics. Tenth Report of the WHO Expert Committee on health statistics.

²Hawking, F. & Denham, D.A. (1971) The distribution of human filariasis throughout the world. Part 1. The Pacific Region, including New Guinea. WHO/FIL/71.94; published in 1976 (195)

³Hawking, F. (1973a) The distribution of human filariasis throughout the world. Part II. Asia. WHO/FIL/73.114

(1973b) Part III. Africa. WHO/FIL/INF/73.3

(1973c) Part IV. America (A summary). WHO/FIL/INF/73.2

⁴Manson-Bahr, P.E.C. & Wijers, D.J.B. (1972) Trans. roy. Soc. trop. Med. Hyg., 66, 18

⁵Crans, W.J. (1972) A rapid technique for the determination of microfilaraemia in filariasis carriers (unpublished document, WHO/FIL/72.98)

⁶Bell, D. (1967) Ann. trop. Med. Parasit., 61, 220-223

⁷Chularerk, P. & Desowitz, R.S. (1970) J. Parasit., 56, 623-624

⁸Katamine, D., Tamura, Y. & Moriguchi, Y. (1952) Nagasaki Igakkai Zasshi (Bull. Nagasaki med. Ass.), 27, 232-234

⁹Sasa, M. et al. (1963) Jap. J. exp. Med., 33, 213-243

¹⁰Sullivan, T. & Hembree, S. (1970) Trans. roy. Soc. Med. Hyg., 64, 787-788

¹¹Partono, F. et al. (1972) S.E. Asian J. trop. Med. publ. Hlth., 3, 366-370

(179) World Health Organization/
South Pacific Commission
1974

Report on the 4th Joint WHO/SPC
Seminar on Filariasis and Vector
Control, Apia, Western Samoa,
1-10 July 1974

The seminar was attended by participants from 13 countries and areas. The aims of the Seminar were to review the new developments that had taken place in the South Pacific regarding the filariasis situation as well as the dengue/dengue haemorrhagic fever with a view to promoting mosquito surveillance, particularly Ae. aegypti, and planning long-term measures for vector control.

A number of working documents was distributed, the list of which was annexed to the report. It was indicated that copies of the papers could be made available for interested workers upon request.

The topics covered in the Seminar were as follows:

1. Review of filariasis programmes in the South Pacific

From the information made available by 11 countries and areas a summary of the filariasis situation was presented in an annex to the report.

2. Epidemiology methods used in the study of filariasis

2.1 Standardization of methods

2.2 Alternative methods of blood examination

2.2.1 The counting chamber

2.2.2 Stimulation methods

2.2.3 Membrane filtration technique

2.2.4 Immunodiagnostic methods

2.3 Clinical manifestations

3. Vector species of filariasis

3.1 Vector bionomics

3.1.1 In the periodic W. bancrofti areas

3.1.2 In the subperiodic W. bancrofti areas

3.2 Vector control

3.2.1 Control of "Anopheles punctulatus" complex

3.2.2 Control of C. quinquefasciatus

3.2.3 Control of Aedes species

3.2.4 Insecticide susceptibility tests

/N.B. Tables showing the available results of tests made on Aedes larvae and adults were those shown in Chow & Suzuki, 1974 (165)./

4. Mass drug administration in the control of filariasis

4.1 DEC

4.1.1 Disadvantages of DEC

4.1.2 Advantages of DEC

4.1.3 Formulations and dosage

4.2 Organization of mass drug administration

4.3 Results of mass drug administration

5. Surgical treatment

6. Research in filariasis

6.1 Current research in the South Pacific

6.1.1 Fluctuation in microfilaria density

6.1.2 Vector transmission

6.2 Trends

6.2.1 Surveys of human filariasis

6.2.2 Zoonotic filariasis that may cause infection to men: Dirofilaria immitis, D. repens, and Onchocerca species of cattle and horses

6.2.3 Animal models

7. Prospects of filariasis control

8. Dengue/Dengue haemorrhagic fevers in the South Pacific

8.1 Current information

8.2 Vector survey and distribution

8.3 Vector control

9. Conclusions

After having reviewed the recommendations made during the filariasis seminar held in Apia in 1968, the following conclusions were reached:

9.1 At least one round of mass drug administration with diethylcarbamazine citrate at a dosage of four to six mg/kg body weight should be used in each country/area where filariasis is known to occur. The total dosage given should be not less than 72 mg/kg body weight. The timing of the dosage should be determined by local conditions. Post-treatment survey and retreatment should be performed as outlined in the Third Report of the WHO Expert Committee on Filariasis.¹ The resurvey may include a sample survey using a concentration method;

9.2 WHO and the SPC should consider supporting further large-scale trials of a single dose of diethylcarbamazine citrate given at long intervals. Suitable areas for such trials can be found in the Kingdom of Tonga;

9.3 Studies should be undertaken on the epidemiological significance of very low levels of microfilariae. Western Samoa is a suitable area for such investigation;

¹Wld Hlth Org. Techn. Rep. Ser., 1974, No. 542

9.4 Further studies should be conducted on other methods of filariasis diagnosis, including aerological and immunological methods;

9.5 Surgical treatment of hydrocele and elephantiasis of the extremities and genitalia now gives more promising results and surgeons should be encouraged to use the latest techniques. Information regarding these technique should be readily available, and they should be demonstrated at suitable centres;

9.6 There should be greater cooperation between countries and areas to ensure that migrants are not microfilaria carriers;

9.7 When possible, surveys for the identification of animal filariae should be carried out;

9.8 More investigations should be carried out on the determination/ confirmation and bionomics of filariasis vectors, as well as methods for their control;

9.9 A reference collection of insects of public health importance in the South Pacific should be established in a suitable centre, e.g., the Institut de Recherches medicales "Louis Malardé", Papeete, Tahiti. This Institute is also able to provide training facilities, particularly for mosquito identification. A note on methods of collection and the despatch of specimen should be prepared and sent to entomological workers in the South Pacific;

9.10 It is of the utmost importance to have continuous basic information on the distribution and density of Ae. aegypti, as well as other Stegomyia species involved in dengue fever/dengue haemorrhagic fever transmission. The information should include the Breteau and premise indices of vector species and should be transmitted to WHO and the SPC for correlation and dissemination;

9.11 National programmes on vector control on a long-term basis should be established as soon as possible in countries and areas where there is a risk of an outbreak of dengue fever/dengue haemorrhagic fever. If possible, equipment for ULV spraying and insecticides of ULV grade should be made available, particularly for emergency use;

9.12 Training courses on the surveillance and control of vector-borne diseases in the South Pacific should be organized and conducted by WHO/SPC when requested by the countries and areas;

9.13 The SPC should be requested to publish a technical guide booklet for the use of public works engineers, health inspectors, architects, contractors, etc., on the effective measures to be taken and the methodology to be used in avoiding the creation of new breeding sites for vector mosquitoes, and also for the destruction or alteration of existing sites in all rural and town development programmes;

9.14 There is a great need for the exchange of epidemiological and technical information on vector-borne disease in the South Pacific. It is essential for countries and areas to provide WHO and the SPC with the necessary information as soon as possible for correlation and dissemination.

9.15 Administrative and logistic support should be provided by governments so that control measures may be carried out more effectively.

(180) Buck, A.A. & Zahar, A.R.
1975

Visit to USA, Pacific and South East Asia Regions for reassessment of the filariasis programme of WHO,
1-26 April 1975
WHO unpublished report

The report presented for discussion the information gathered during the visit to the meeting of the Informal Consultation on Research on Filarial Infections (Abstract No. 190).

Concerning the Pacific Region, the authors reported the situation of filariasis in two projects, Western Samoa and Tonga. From the former, the early results of blood surveys carried out after the second mass DEC treatment as was only available from 14 rural districts (0.02%) was reviewed. The need for developing a filariasis surveillance system was highlighted. The evaluation of vector control trials carried out in Western Samoa was discussed and the need for well planned trials for vector control by environmental sanitation in peridomestic situations as well as ULV ground application was emphasized. From Tonga, where no control programme was hitherto carried out, the available information was compiled. The crude prevalence rate was recorded as 20% by the conventional blood examination technique with age-specific peaks of mf rate as high as 70% in persons aged 40 years and older with little difference between the male and female sexes.

Hydrocele rate was of the order of 6% and lymphangitis was occurring at a rate of 1%.

The principal activities of the WHO entomologist assigned to the project in Tonga were reviewed which were mainly concentrated on collection of material of the Ae. scutellaris group for taxonomic studies by Smithsonian Institution together with some field observations on biting-landing rates of above mentioned groups and other culicine mosquitos, their breeding habits and the associated pathogens and predators.

The activities of the WHO intercountry team for epidemiological surveillance in Fiji and other island groups were reviewed.

From a summary of discussions held at the WHO Regional Office for the Western Pacific, Manila, the need for developing a strategy, procedures and staffing for carrying out epidemiological surveillance in filariasis control programme where low mf rates were recorded following the application of DEC mass treatment to the total population was considered as a top priority.

The report also reviewed the results of crossing experiments carried out with members of the Ae. scutellaris group in the Division of Medical Entomology, John Hopkins University, Baltimore, Maryland.

(181) Buck, A.A.
1975

Mission of Dr A.A. Buck, Epidemiological Methodology and Clinical Pathology, Division of Malaria and other Parasitic Diseases, WHO Headquarters, to Western Samoa and Tonga, 5-29 August 1975
Unpublished report to WHO

The objectives of the mission are briefly summarized in the following:

Western Samoa: To analyse the existing data for deficiencies in treatment coverage and to identify high risk groups in the general population; to assess the efficacy of the current surveillance system in tracing and treating the remaining microfilaria carriers; to analyse the data for detecting treatment failure amongst those who had received the drug under medical supervision during the two mass treatment campaigns of 1964-1971; to estimate the prevalence of "true" infections by identifying low density carriers using the Millipore filtration technique; finally to make recommendations for applied research and related activities aiming at a realistic and economic surveillance programme in Western Samoa.

Tonga: preparation of the filariasis control programme.

Western Samoa

Population samples: 20 mm^3 blood samples had been used up to 1968. Thereafter the sensitivity of the diagnostic method was increased by collecting 60 mm^3 blood samples. Proper adjustment to 20 mm^3 was made for comparing the crude microfilaria rates. The representativeness of the population samples was examined, the population census figures of 1966 serving as standard. This was done to detect deficiencies in the age and sex distribution that might have introduced bias when the estimated mf rates was extrapolated to the entire population. Age and sex distribution was determined from the 1966 census and compared with the corresponding figures of the pre-treatment sample of 1964 and the post-treatment sample of 1967 covering the first mass drug administration. In comparing the age and sex distribution the two samples showed deficiencies in the youngest age-group 0-4 years while the 5-9 age group was over-represented. Thereafter, the post-treatment sample showed excellent agreement and the pre-treatment sample also showed good agreement with the age and sex distribution of the general population. From a practical point of view, for comparing the mf rates the two population samples were found to be adequate.

Treatment coverage: Analysis of data of the average total dose of DEC administered to all residents of the 15 health districts was made for the first MDA with a target dose of 5 mg/kg for 18 months (90 mg/kg) and for the second MDA with a target dose of 6 mg/kg for 12 months (72 mg/kg). In general, the overall drug coverage had been sufficient with a minimum and

maximum dose of 56 and 71.6 mg/kg in the first round and the minimum and maximum dose in the second round was 51.7 and 60.7 mg/kg respectively. Through ranking, the percent of the population which had completed the treatment seemed to be correlated with the average total dose of DEC received particularly in the second round. Data of the population of each village and the average total dose of DEC were examined after converting the latter into equivalent values expressing the dosage in mg/kg in order to remove differences in body weight associated with age and sex. Large differences were found in the average total dose of DEC among individual communities with a minimum of 19.3 mg/kg in one village and a maximum of 86.2 mg/kg in another. Further, examination of the frequency distribution of 151 villages in relation to the average total dose received showed that about 10% of the communities had received less than an average dose of 45 mg/kg of DEC in the first round. When the data were recalculated to show the treatment coverage by population size disregarding individual villages, it was found that about 4% or 2600 persons had taken no drugs at all and that 50% of the population or 32 598 had received more than 70 mg/kg in the first round and this can be regarded as excellent results. Preliminary data on drug coverage for the second round from 20% random sample of the general population indicate that drug coverage had been better in rural than in urban communities. In the latter difficulties arise from the highly mobile segment of the population.

For determining the degree of deficiency in drug coverage by age and sex and to trace the reasons for not taking the drug, data of three villages selected at random were analysed. From this it was clear that DEC coverage was the poorest in the highly mobile group of young adult males. Similarly, young females for reasons of pregnancy and absenteeism combined accounted for their having missed the treatment. The very old people also constituted significant deficiencies in treatment coverage. Further analysis of data for the frequency of having missed the treatment by one or more doses in the course of 12-14 months for specified reasons, showed that temporary absence due to travel or business affairs was the most important single cause for having missed the treatment at a given date, followed by change of residence, illness and pregnancy.

Due to lack of data that would permit direct comparison between the reduction in the mf rates and densities and the total DEC doses received, indirect comparison was made utilizing age specific mf rates of two villages as recorded after the first round. Negative correlation between the DEC dose and post treatment mf rates was evident. Therefore, DEC doses in relation to the level of mf densities prior to treatment must be considered in the long-term evaluation of filariasis control projects based on mass treatment. This finding deserves careful consideration in appraising a recent proposal advocating a single dose application of DEC for mass treatment. It is also indicated that there is a need for a sufficiently long period of follow-up because the frequency of relapses appears to increase as the time after treatment increases.

In conclusion, there appear to be various high-risk groups in the population that should be the target of intensified surveillance. They are:

1. the identified villages with poor treatment records;
2. all young adult males and females when arriving at a new residence;
3. systematic follow-up of pregnant women;
4. children of school age attending boarding schools;
5. old persons who may be chronically incapacitated to attend the clinics for treatment.

The utilization of the Millipore filtration technique: During the author's mission, surveys were initiated to cover about 10% of the total population above the age of 10. Initial results from the first three localities examined, surprisingly showed a very high mf rate (54.5%), which is two times higher than those recorded before the mass treatment using the conventional blood examination method. Full results were awaited in order to determine whether this was due to poor treatment coverage in the villages under references, or if the results are representative of all Western Samoa.

The entomological aspects: The author examined the entomological findings obtained by the WHO Entomologist during 1966-1975. The entomologist also presented proposals for research studies to be undertaken in Western Samoa to fill in gaps in knowledge which he identified by reviewing the literature. A summary of these together with the author's comments is given as follows:

1. Taxonomic studies need to be continued and to be extended to the Ae. (Finlaya) group as difficulties have been experienced in separating Ae. tutuilae from Ae. samoanus.
2. Breeding habitat: In addition to the number of the actual and potential vector breeding sites in an area, information on the average breeding capacity would be helpful in deciding on the priority to be given for control among different breeding sites. The studies are particular important in high risk areas.
3. Density of adult vectors: Intensive density studies on Ae. polynesiensis and Ae. samoanus in high risk areas involving mass separation of third stage larvae in comparison with other areas as well as studies on the seasonal prevalence were suggested, but it was found that these studies are time and labour consuming, hence should be regarded as last priority.
4. Flight range of Ae. polynesiensis and Ae. samoanus: Information on the flight range is important not only from transmission studies point of view but also for developing vector control strategy.
5. Vector resting habits: The human blood index is one of the essential parameters in the study of the dynamics of transmission of filariasis. A high priority should be given to collecting mosquitos from outside resting shelters, particularly Ae. polynesiensis. Studies on resting habits of Ae. samoanus indoors is the key to decide whether residual house spraying in the Samoan type of houses when applied to poles would be effective.

6. Parous rate determination: A high priority should be given to this as a measure of vector longevity, which is an important parameter in the study of the dynamics of transmission.

7. Gonotrophic cycle or blood meal interval: Determination of this interval by mark/release and recapture experiments is suggested and should be applied to the above mentioned vectors. Also it is suggested that observations should be made to determine whether Ae. polynesiensis would take more than one blood meal for developing each batch of eggs particularly the first one.

8. Life-cycle studies: Laboratory studies were suggested particularly for Ae. samoanus and construction of life tables for both of the above mentioned species from field studies was proposed.

9. Transmission studies

9.1 Confirmation of vector incrimination: Dissection of wild caught mosquitos and experimental infection were suggested in respect of Ae. tutuilae and Ae. oceanicus. It was found that such confirmation can be better obtained by mass separation of the third stage larvae.

9.2 Infection and infective rates of Ae. polynesiensis and Ae. samoanus:

This was rated as the first priority in view of the relevance of such determination to the entomological surveillance of filariasis in areas of high risk. Mass separation of the third stage larvae was recommended in view of the extremely low infection rates in mosquitos. Before applying this technique in Western Samos, it should be compared with the conventional dissection technique in untreated areas with high or moderate endemicity of subperiod W. bancrofti, for example, in Tonga.

9.3 Possibility of transmission from ultra-low microfilaraemia; This was considered as high priority.

10. Mathematical model of filariasis transmission: Mathematical estimation of the threshold of vector density below which transmission could not take place, was recommended. Since it is rather difficult to suppress the density of the above mentioned two vectors to a very low level, estimation of the threshold density level, if properly made, could reveal the target vector density for suppression.

11. Vector control

11.1 Susceptibility of vectors to insecticides: Since insecticides have recently been applied extensively for the control of Ae. aegypti, larval and adult testing is recommended.

11.2 Effect of new insecticides for control of vector breeding: No feasible chemical control method is available at present for controlling Ae. polynesiensis in crab holes.

11.3 Field control trials: Suggestions were made for conducting trials involving source reduction with community participation, application of larvicides such as Abate to unmovable breeding sites, i.e. drums, tree holes etc., and ground ULV application using malathion or fenitrothion.

11.4 The possible use of bed nets treated with insecticides: In villages with high Ae. samoanus density, it was found that about 95% of the houses use bed nets. Impregnation or spraying of the bed nets should be tried as it may prove to be the only means for controlling this vector which comes to bite at night in the Samoan type of houses.

11.5 Biological control: Studies on the effectiveness of Coelomomyces fungi and Toxorhynchites should be considered for long-term research.

RECOMMENDATIONS

1. The services of a statistician is needed for making better use of the many valuable data on filariasis and its control collected during the past 11 years. Attempts should be made to re-analyse the data to provide information on the following:

- (a) cohort studies linking prevalence and pre-control mf densities with the DEC dose received and with interim and post-control mf rates and densities as well as with residual low-density microfilaraemia as detected by the Millipore concentration method;
- (b) if possible, the data should also be re-analysed for the frequency and types of adverse side-reactions to DEC treatment with special consideration of age, sex, pregnancy and co-existing diseases and disability;
- (c) to permit better monitoring of the surveillance programme in Western Samoa, all new data should be recorded on standard forms and if possible be pre-coded for analysis by computer;
- (d) new information from the Filariasis Office should be made available promptly to all Medical Officers concerned to facilitate the follow-up of the remaining mf carriers for treatment.

2. The complete results of the ongoing surveys by the Millipore filtration technique should be made available for analysis with the assistance of WHO/HQ.

3. The diagnosis of microfilaraemia by the Millipore filtration technique should be verified by an expert using a random sample of the positives and negatives.

4. The post-treatment periodicity patterns need to be reevaluated by a small-scale study on volunteers.

5. Nothing is known about the level of transmission of filariasis at present in Western Samoa. Close cooperation between entomologists and epidemiologists should be established and the scope and protocols for the proposed studies should be thoroughly reviewed by the Regional Office jointly with HQ.

6. Following the completion of the present cross-sectional investigations on filariasis prevalence by the Millipore method, further selective studies on the presence of microfilaraemia should be made in children under five years of age. These children were born after termination of the second mass treatment campaign and can serve as indicators of transmission since 1971.

7. Clinical trials with filaricidal drugs other than DEC (Mebendazole, Levamisole, Lampit) are recommended to evaluate their usefulness in the treatment of patients with residual microfilaraemia who have received adequate total doses of DEC.

Tonga

Sufficient epidemiological base-line data as needed for future evaluation of a filariasis control project are not available. WHO assistance should focus on planning and conducting the filariasis control programme. The WHO team for epidemiological surveillance of communicable diseases in Suva, Fiji should coordinate these activities.

(182) Dietz, K
1975

An epidemiological model for
filarial infections
Unpublished document to WHO,
prepared for the Informal
Consultation on Research on
Filarial Infections, 5-9 May 1975
with an appendix giving
mathematical formulae

The present paper describes an epidemiological model for filarial infections which allows the calculation for a given set of parameter values of:

- (a) the critical man-biting rate below which transmission cannot maintain itself;
- (b) the critical microfilaria density below which the infection would disappear, without vector control ("breakpoint");
- (c) the average microfilaria density;
- (d) the age prevalence of infections;
- (e) the necessary number of infective larvae to produce one new case of microfilaraemia.

The model concentrates on endemic equilibria as a first step to a fully dynamic model which would describe the time dependent behaviour of age distributions of microfilaria densities. The equilibrium analysis is adequate both for an understanding of endemic situation before intervention

and for the selection of long-term control strategies. The model takes into account explicitly the chance for male and female parasites to mate in the mammalian host and differential mortality of the vector as a function of the number of microfilariae ingested. The model makes no attempt to describe disease due to filarial infections. The parameters will be defined in a general way so that they may be applied to any host-parasite-vector system for which the assumptions are considered valid.

1. Model assumptions

The author based the model assumptions mainly on papers by Beye & Gurian, 1960 (83) and Hairston & Jachowski, 1968 (121).

1.1 The human population

Assumption: a stable exponential age distribution corresponding to an age-independent death rate μ . The size of the population is constant.

1.2 The parasite population in the definitive host

Assumptions: - Exposure to mosquito bites is uniform,

- constant in time, - independent of age and sex of the mammalian host,
- the sex ratio of infective stage larvae is 1:1.

λ - denotes the average rate at which infective larvae of either sex enter the organ of the human host in which mating takes place "inoculation rate".

T_1 - denotes the mating period of males and females. Mating is polygamous.

ϑ - constant mf production rate of a fertilized female at the end of the interval

δ - constant mf death rate

1.3 The vector population

Assumption: the vector population has a constant size.

m - denotes the ratio between the size of vector population and the mammalian host.

Assumption: in the absence of filarial infection, the vector population has an age independent death rate.

F - denotes duration of regular bloodmeal intervals.

Assumption: at each bloodmeal vectors make a random choice of the host.

a - denotes the probability of host choice

b - denotes the probability that a vector survives one feeding cycle F .

1.4 The parasite in population in the intermediate host

T_2 - denotes the number of feeding cycles required for maturation period of the parasite in the vector to become infective.

There is evidence that the presence of larvae increases mortality and reduces mobility of the vector.

Assumption: these effects are produced during the first feeding cycle after ingestion of the microfilariae.

c^n - denotes a factor by which the normal probability of vector survival is reduced due to parasitism, where n is the number of ingested microfilariae, and c is a constant between 0 and 1; it expresses the probability of survival in the presence of n microfilariae.

b - denotes the probability of infective stage larvae (which have at least spent T_2) to leave the vector during a bloodmeal.

1.6 Transmission of the parasites

f - denotes the probability that an infective stage larva which has left the vector during a bite reaches the organ in the mammalian host where maturation and mating takes place.

g - denotes the probability that a microfilaria is ingested by a vector during one bloodmeal.

The mathematical equations of the model are described and the author used input parameter values based mainly on data of Hairston & de Meillon, 1968 (122) for assessing the behaviour of the model.

These parameters are given as follows:

<u>Symbol</u>	<u>Definition</u>	<u>Values</u>
μ	Human death rate (with an expectation of life of 50 years)	0.02/year
T_1	Worm mating period	2 or 5 years
p	Mf production rate	$2.5 \times 10^6/\text{year}$
c	Death rate of fertilized female parasite (estimate of 4 years life expectancy)	0.25/year
u	Mf death rate (mf to live 6 weeks)	9/year
F	Vector feeding cycle	2 days
a	Host choice probability (assuming to feed exclusively on man)	1
p	Probability of vector surviving one feeding cycle	0.64
T_2	Maturation time of infective stage larvae	5 feedings cycles
c	"Differential survival parameter"	0.85, 0.70
b	Probability of loss of an infective stage larva during one bloodmeal	0.4
f	Probability that an infective stage larva successfully enters the host	.001, .005
g	Probability that an mf is ingested by a vector	.002, .0004

2. Results and conclusions

With these parameters, various model calculations were obtained and the author produced a series of graphs from which the following results are summarized:

2.1 The microfilaria density and the infective stage larvae are approximately a linear function of the inoculation rate per year within the range chosen.

Increasing the interval T_1 (from 2-5 years) while other parameters remain the same, produces an increase in the microfilaria density. Because of the linear relationship between the inoculation rate and the microfilaria density, the curve of the infective stage larvae may be considered as a function of microfilaria density. The infective stage larval density shows a unimodal shape and its maximum value decreases for increasing value of T_1 (from 2 to 5 years) and increases for increasing value of c (from 0.70 to 0.85).

Thus there is an optimum microfilaria density for which the infective stage larval density is the highest.

The lower mf rate in (b) is a result of the lower values of c, f and g; Macdonald (1965)¹ indicated that there is a critical size of the parasite population, i.e. "breakpoints" below which the parasite population would die automatically and above which it would tend to grow to a stable equilibrium.

The principles underlying this concept can be explained as follows: If a microfilaria carrier is introduced to a given population living under a level below the critical level of vectorial capacity, transmission of filariasis may not lead to the development of an immediate outbreak of cases and may go back to zero. If the vectorial capacity goes higher than the critical level, the introduction of a microfilaria carrier to a population, transmission may or may not lead to an outbreak of cases depending on the density of microfilariae. If above the breakpoint, then it may lead to a stable endemic equilibrium.

In his conclusion, the author emphasized that the paper should be considered as a first step towards a quantitative theory of filarial endemicities which would permit the explicit calculation of the critical parameter values for stable equilibria. The present assumptions should be modified in order to test the sensitivity of the conclusions derived from them. Such sensitivity analysis includes non-homogeneous vector contact rates within the host population and/or different pairing mechanism in the definitive host.

(183) Desowitz, R.S.
1975

Immunoglobulin levels in an untreated population living in an area of hyperendemic bancroftian filariasis (Tonga) and in a population subject to a filariasis control programme (American Samoa)
WHO unpublished report,
WHO/FIL/75.134

Having noted that concentrations of IgG were observed in filariasis and onchocerciasis patients, it was found interesting to carry out a quantitative analysis of the different classes of the immunoglobulins in the untreated population of Tonga, an area where bancroftian filariasis was hyperendemic and in American Samoa where the population had been protected by an antifilariasis programme which seemed to have been effective.

¹Macdonald, G. (1965) The dynamics of helminth infections, with special reference to schistosomiasis. Trans. roy Soc. trop. Med. Hyg., 59, 489-506

The concentrations of immunoglobulins were measured in 168 serum samples, 117 from the inhabitants of Tonga and 51 from the inhabitants of American Samoa. In the two groups in all age-groups, it was observed that the average concentrations of IgG and IgE were of medium level while those IgA and IgD were of normal levels, with regard to the population of Tonga, apart from the general associations between heavy microfilaraemia and the maximum concentration of IgE, it seemed that there was a relation between the quantity of other classes of immunoglobulins and the intensity of infection. In addition the results indicated that in an antifilariasis programme, the apparent success was not reflected by a reduction in the concentration of IgG and IgE.

In conclusion, it can be stated that quantitative tests of immunoglobulins cannot necessarily be foreseen to be involved in studies of the epidemiology of filariasis. Nevertheless, the present work puts in perspective the need for more intensive research on the specific immune response in immunoglobulins which is a function of the clinical and parasitological condition of the human host.

(184) Fain, A.
1975

Résumé et analyse de la filariose
dans la région du Pacifique
Unpublished Report to WHO

This is an internal document, prepared by the author as WHO Consultant, for reviewing and analysing the filariasis projects in the Western Pacific Region where WHO had been involved either in a country project or by assigning consultants and/or WHO Inter-country Advisory Team. In preparing the summary and analysis, the author consulted all the available published and unpublished documents kept in WHO files at Headquarters. The report covered the following countries: Ellice Island, Niue, French Polynesia, Fiji, Western Samoa, American Samoa, New Hebrides and Solomon Islands. Where information is available the summary gives a brief geographical description of the area under review, the chronological development of a filariasis control programme, analysis of the parasitological clinical and entomological data. Reference is also made to any vector control attempts that were undertaken in certain countries. The author also made certain recommendations which are cited in the covering review for each country or island groups.

(185) Huang, Y.M.
1975

A redescription of Aedes (Stegomyia)
pseudoscutellaris (Theobald) with a
note on the taxonomic status of
Aedes (Stegomyia) polynesiensis
Marks (Diptera: Culicidae)
Mosq. System., 7, 87-101

The topotypic material of Ae. pseudoscutellaris from Suva, Viti Levu Island, Fiji have been examined, and both sexes, larva and pupa are redescribed and illustrated together with a note on all stages of Ae. polynesiensis from the same area, Suva, Fiji. It has been possible to analyse and evaluate such a highly variable species as pseudoscutellaris and to compare it with polynesiensis. Diagnostic morphological characters for

separating the two species are tabulated. The aim of this paper is to help entomologists, epidemiologists and other field workers in recognising the two species more easily, thus facilitating investigation on their ecology, behavior and role in transmission of filariasis in Fiji.

(186) Moreau, J.P.,
Radanieina, R.,
Barbier, P.
1975

Activité du levamisole dans la filariose de bancroft. Evolution de la microfilaremie au cours d'une cure de 12 jours après un recul de 45 jours
Méd. trop., 35, 451-455

Twenty seven carriers of W. bancrofti microfilariae received gradual doses of levamisole during four days and then 3 mg/kg per day during eight days. The microfilaraemia fell rapidly for all patients. This count reached zero for 21 of them the last day of the cure. The rate of microfilaraemia reduction was 98.5%. Forty-five days later this rate was 93.11%. This is interesting because levamisole is a polyvalent drug against intestinal nematodes and other filarial infections and the multiple parasitic helminthes infection is very frequent in filariasis endemic areas. For mass treatment, shorter cures may be suggested with a monthly single dose later.

(187) Pichon, G., Prodhon, J.
& Riviere, F.
1975

Recherche d'une loi de distribution des microfilières ingérées par des moustiques piquant un filarien.
Premiers résultats
C. R. Acad. Sci. Paris, 280, Série D, 717-719

Several workers indicated that the number of microfilariae ingested by vectors feeding on a single mf carrier varied considerably. The distribution of the mf ingested does not follow either Poisson distribution or log-normal. Bearing in mind that the usual statistical test can allow certain deviations from normal, the author felt that it would be desirable to find out with precision the nature of such distribution for more profound evaluation of the parasite yield in the vector and the effect of the parasite on vector longevity under natural conditions.

Procedures: Three experiments were conducted on sufficiently large samples and as far as possible under standardized conditions. Mosquitos used in these experiments were laboratory reared, kept unfed for 48 hours after emergence. They were fed on the arm of an mf carrier of subperiodic W. bancrofti. Before and after the feeding experiments the mf density was estimated in 20 mm³ blood from finger pricks. For eliminating the effect of periodicity the feeding was terminated after half-an-hour.

Two batches of Ae. polynesiensis (AP) were fed on mf carriers given the initials E and K. The counts of the two carriers were respectively 40/20 mm³ for the feeding experiment on E (AP/E) and 350/20 mm³ for feeding

experiment on K (AP/K). The third experiment (AA/E) was conducted with *Ae. aegypti*. As this mosquito engorges much more rapidly than *Ae. polynesiensis*, the maximum duration of the blood meal could be limited to 1.5 minutes. The engorged females were dissected within 48 hours from the time of taking the blood meal. The remaining females were frozen to prevent the development of microfilariae.

Results: It appeared that the extreme fluctuation in the number of mf ingested was not related to the amount of blood taken by the mosquito, since certain mosquitos which were well engorged harboured much less mf than the average, while others were found to harbour large numbers of mf in a very small quantity of bloodmeal. Table I summarizes the data obtained from the three experiments. Since the arithmetic mean is equal to the standard deviation, it is likely that the distribution of the mf ingested would follow another law than the Poisson distribution which implies that the mean equals the variance. The authors further found that adjustment to log-normal distribution does not give a good fit and tried to put a theoretical law for the distribution of the microfilariae ingested which would need more elaboration. The experiments indicate, however, that the distribution is the same irrespective of the mosquito species employed. The distribution did not seem to depend on the duration of the blood feed (which is more than three minutes in *Ae. polynesiensis*) nor did it depend, as explained above, on the amount of blood ingested (in *Ae. polynesiensis* about twice that of *Ae. aegypti*).

The author concluded that it is too soon to give a theoretical interpretation for such distribution which seems to tally with a heterogeneous distribution of the microfilariae in the capillaries of the human host and the existence of two ways of drawing the blood by the vector, and the author discussed the available information and the assumptions made by other workers in this respect. /N.B.: More detailed presentation of data of these experiments and the results of more elaborate analyses and interpretation which was pursued by the authors are given in Pichon *et al.*, 1975 (189)./

TABLE I

<u>Mosquitos</u>			<u>Microfilariae ingested</u>			
<u>Experiment</u>	<u>Dissected</u>	<u>Range</u>	<u>Arithmetic mean</u>	<u>Geometric mean</u>	<u>Mode</u>	<u>Standard deviation</u>
AA/E	193	0-28	3.84	2.47(*)	0-3	4.28
AP/E	239	0-85	11.45	6.85(*)	1	12.82
AP/K	394	0-409	45.83	27.32(**)	8-11	45.92

* Mean of Williams

** $\bar{x} \neq 0$

(188) Pichon, G., Prodhon,
J. & Rivière, F. avec
la collaboration technique
de Chebret, M., Thirel, R.
& Tetuaniu, A. et avec la
collaboration stastique de
Doue, F., Lemaitre, D. &
Dejardin, J.
1975 a

Distribution des microfilaires
ingérées par les moustiques
WHO unpublished document,
WHO/FIL/75.139

It has usually been observed that in experimental infection, extreme variability occurs in the number of microfilariae ingested by the vectors. If the microfilariae are ingested at random from the source of infection where they are also distributed at random, their distribution would follow a Poisson series for which the mean should be equal to the variance. It is always observed that the value of the variance is quite excessive which indicates a phenomenon named by the author as "surdispersion" - over-dispersion following Bliss & Fisher (1953)¹.

The fluctuation in the amount of blood ingested by each individual mosquito of the same species does not appear to be the reason for this over-dispersion. On the other hand, Gordon & Lumsden (1939)² showed that the distribution of the microfilaria in the capillaries of the vertebrate host is extremely heterogeneous. An indirect proof is also given by Hairston & Jachowski, 1968 (121) who analyzed the results of Rosen, 1955 (56). Successive samples of peripheral blood, taken at very short intervals to eliminate the effects of periodicity of the microfilaria showed that the higher the mf level of the subject, the higher the over-dispersion. This can be explained by the heterogeneity of the mf densities in the surrounding capillaries. In fact, this unquestionable heterogeneity in the mf distribution in the vertebrate host should add to the very controversial hypothesis of a heterogeneity in apparently homogeneous groups of vectors, i.e. certain individuals would be capable of concentrating the microfilaria, that is, to ingest a higher number than which would be obtained by mechanical sampling of an equal volume of capillary blood. The heterogeneity of the type of bite (pool feeding and capillary feeding, Gordon & Lumsden, 1939)² of the same species is a factor which should not be ignored.

¹ Bliss, C.I. & Fisher, R.A. (1953) Fitting the negative binomial distribution to biological data. Biometrics, 9, 176-200

² Gordon, R.M. & Lumsden, W.H.R. (1939) A study of the behaviour of the mouth-parts of mosquitos when taking up blood from living tissues, together with some observations on the ingestion of microfilaria. Ann. trop. Med. Parasit., 33, 259-278

Over-dispersion presents a number of inconveniences for the interpretation of results, particularly in comparing the mean number of microfilariae ingested because the usual statistical tests are based on the hypothesis of a certain stability of variance. This difficulty is partially remedied when the logarithms of the number of microfilaria ingested are taken which led to considering the geometrical mean as a measure of the central value as adopted (Duke & Lewis, 1964)¹ (Lawrence, 1966)². But after the findings of Philippon & Bain (1972)³ the present study indicates that the adoption of a log-normal law constitutes only a first approximation.

In previous work by the first author (Abstract No. 173), it was shown that in a given parasite/vector couple the mean number of microfilariae having crossed the stomach wall of the vector can be related to the mean number of microfilariae ingested by the use of a mathematical formula including two parameters J and H which measure the degree of reciprocal parasite/vector adaptation. If such a formula permits a better perception of the influence of the parasitic yield on diverse epidemiologic characteristics of bancroftian filariasis, it has the inconvenience of being essentially descriptive, having until now no theoretical base and above all it concerns only the central value (the median) which is insufficient for developing a mathematical model for prediction. Taking into account the considerable fluctuations which affect both the microfilaria ingested and the resulting infective larvae, it is important to know what are the expected variations around these central value.

With the idea of perfecting a mathematical formula for evaluating with precision the mean number (with statistical confidence) of infected larvae produced by mosquitos having fed on mf carriers, the authors attempted to find a law for the ingestion of microfilaria which allows for the estimation, with a minimum of parameters, of the probability $P(x)$ that a mosquito has absorbed $x = 0, 1, 2, 3 \dots$ microfilariae.

Materials and methods

Details of the experiments given by the authors in 1975 (Abstract No. 187) have been elaborated as follows:

Eight experiments were carried out with sufficiently large samples and under conditions as homogeneous as possible.

Laboratory-reared mosquitos deprived from sugar solution were fed on arms of volunteers (E, K, R, Rt & N) with filaria of subperiodic forms of W. bancrofti, each with a different level of microfilaremiae (ranging from 0.52 to 321 mf/20 mm³ blood).

The mf density was measured by examining at least 12 thick drops of 20 mm³ of blood taken from finger-pricks, immediately before and after the experimental infection of the mosquitos.

¹Duke, B.O.L. & Lewis, D.J.(1964) Ann. trop. Med. Parasit., 58, 83-88

²Laurence, B.R. (1966) J. Helminth., 40, 337-342

³Philippon, B. & Bain, O. (1972) Transmission de l'onchocercose humaine en zone de savane d'Afrique occidentale. Passage de microfilaries d' Onchocerca volvulus dans l'hémocèle de la femelle de Simulium damnosum. Cah. ORSTOM, Sér. ent. méd. Parasit., 10, 251-261

To eliminate all influence of the periodicity of the microfilaria the feeding experiment was terminated after 30 minutes. The engorged females (even partially engorged) were soon sorted out. For assessing the influence of the length of the meal on the form of the distribution, the feeding period was limited to 1.5 minutes per test with Ae. aegypti which engorges much more rapidly than the other two species studied, Ae. polynesiensis and C. quinquefasciatus.

The engorged females were dissected in a fresh state up to 48 h. after the blood meal. The remaining females were frozen to stop the digestion of microfilaria. The microfilariae ingested were counted under the microscope.

TABLE I. GLOBAL RESULTS OF THE EIGHT EXPERIMENTAL INFECTIONS

Mosquito carrier	AA/E*	AP/K	AP/E	AP/R	AP/RT**	OP/N	CP/E	CP/R
Mf density	x	321.00	75.91	2.65	0.52	110.37	29.00	3.89
N:Total of mosquito dissected	193	394	239	310	306	514	220	255
Mean mf	3.84	45.92	11.45	0.75	0.078	20.39	8.35	0.76
Standard deviation	4.21	47.42	12.82	1.11	0.281	27.79	9.81	1.11

* Meal interrupted at the end of 1.5 minutes.

** RT treated four days before the experiment with a dose of 400 mg DEC.

Results: Data obtaining from the above experimental infection are shown in Table I. For the analysis of these data, the authors adjusted the negative binomial distribution and made the mathematical calculations accordingly.

Conclusions: Anscombe (1950)¹ points out that at least four different processes can produce a negative binomial distribution. Its sole application does not permit conclusions to be made on the phenomenon it describes. It merely indicates that the presence of one microfilaria in a mosquito increases the chances of observing others in the same mosquito, which could provoke a heterogeneous distribution of microfilariae in the capillaries, an attractive force varying from one mosquito to another, or a combination of these two possibilities.

The parameter m (i.e. the mean number of mf) seems to depend only on the mf density of the carrier and on the mean volume of blood ingested by a given species of mosquito. The geometric law of ingestion thus will be useful for trying to resolve the controversial question of an eventual "concentration" of microfilariae by their vectors. In all eight experiments the distributions fitted the geometrical law: $P(x) = m^x / (m + 1)^{x+1}$. This particular case of the negative binomial law is defined by only one parameter, the mean number m of ingested microfilariae.

¹Anscombe, F.J. (1950) Sampling theory of the negative binomial and logarithmic series distributions. Biometrika, 37, 358-382

Over-dispersion is such a general phenomenon concerning the distribution of parasites in their hosts that Crofton (1977)¹ proposed the inclusion of this characteristic in the definition of parasitism; also this author considered the negative binomial law as a "fundamental model" at least for metazoan parasites. This law seems to describe effectively the distribution of adult W. bancrofti filaria in the human host (Hairston & Jachowski, loc. cit.). From the results of the present investigation, the authors confirmed its utility with a view to elaborating a coherent mathematical model on the epidemiology of W. bancrofti filariasis.

Because of its remarkable simplicity, the geometric law will undoubtedly facilitate considerably the construction of such a model.

According to information published by various authors, geometric distribution seems to describe adequately the mf density pattern for other vector-parasite combinations.

(189) Pichon, G., Prodhon, J.
& Riviere, F.
1975 b

Rendement parasitaire chez les vecteurs de la filariose.
3. Influence combinée de la mortalité vectorielle due au parasitisme et du surpeuplement parasitaire

Institut de Recherches Médicales
"Louis Malarde", Papeete, Tahiti, 27 October 1975. Réf. No. 496/IRM/J.5 (Manuscrit No. 360/360/IRM/J.5 après corrections) Also issued as unpublished document WHO/FIL/76.140

In the light of the previous findings, Pichon, Prodhon & Rivière, 1975 (187) regarding the law of the distribution of the microfilariae ingested by mosquitos, the authors re-examined the data obtained by Wharton (1957)^{2,3} from his experimental studies on the development of B. malayi in its principal vector Mansonia (Mansonioides) longipalpis in Malaysia.

Particular reference was made by the authors to the conclusions of Wharton as shown in the following:

1. There was very little loss of microfilariae when traversing the stomach wall, practically all reached the haemocoel of the mosquito in 12 hours after the blood meal, Wharton (1957)¹.

¹Crofton, H.D. (1971) A quantitative approach to parasitism, Parasitology, 63, 343-364

²Wharton, R.H. (1957) Studies on filariasis in Malaya: Observations on the development of Wuchereria (=Brugia) malayi in Mansonia (Mansonioides) longipalpis. Ann. trop. Med. Parasit., 51, 278-296

³Wharton, R.H. (1957) Studies on filariasis in Malaya: The efficiency of Mansonia longipalpis as an experimental vector of Wuchereria (=Brugia) malayi. Ann. trop. Med. Parasit., 51, 422-439

2. The average number of larvae in *M. longipalpis* dissected at 10.5-11 days after feeding on the mf carrier (i.e. the normal period for the larvae to reach the infective stage) was directly proportional to the number of microfilariae ingested and that the mean number of larvae per mosquito was approximately five times the number of microfilariae ingested per mm³ of blood.

3. It appears that there is selective mortality among mosquitos with heavily infected mosquitos, Wharton (1957)¹.

4. With overcrowding of the parasite and its lethal effects, a proportion of larvae was prevented from reaching maturity, Wharton (1957). Also the "crowding" effect was reported by Rosen, 1955 (56).

The authors considered that there was some contradiction between Wharton's conclusions Nos. 2 and 3 for it cannot be conceived that the mortality of hyperparasitized mosquitos could not have any repercussion on the average number of larvae in the surviving mosquitos.

The authors further indicated that data of Wharton compiled in Table 1, confirm the conclusion No. 3, i.e. the mortality of mosquitos significantly increases as the number of microfilariae ingested increases. There should therefore be, contrary to conclusion No. 2, a diminution in the average number of larvae in the batches of the most heavily parasitized mosquitos. Wharton noted such a deficit as shown in Table 2, but attributed it to the lack of young larvae in those mosquitos.

Contrary to the other vector/parasite couple where the phenomena of limitation or facilitation exist, the absence of reduction of the microfilariae when crossing the stomach wall as shown in conclusion No. 1, simplifies considerably the statistical calculations and enables the quantitative evaluation of the combined effect of differential vector mortality and the "overcrowding" of the parasite on the probability of a microfilaria ingested to reach the mature stage, i.e. the parasite yield, P. For this, the basic theoretical assumption adopted by the authors was as follows:

If it is admitted that each supplementary larva affects in a constant manner the probability of survival of mosquitos, then the probability s of a mosquito to survive with x number of larvae, follows a negative exponential, Dietz, 1975 (182):

$$s(x) = m \theta^x \quad (x = 0, 1, 2, \dots)$$

where $0 < m, \theta < 1$

m represents the probability of survival of non-infected mosquito (natural mortality), and θ represents a coefficient of survival under the presence of the filarial parasite which generally depends on the reciprocal adaptation of vector/parasite couple under consideration.

After carrying out a series of mathematical calculations and tests of significance, Tables 1 and 2, the authors summed up their conclusions as shown in the following which were supported by mathematical statements.

When the ingested microfilariae have a probability of traversing the stomach wall independent from their numbers (i.e. there is no limitation or facilitation), the law of exponential vector mortality due to parasitism Dietz, 1975 (181) has the following consequences when it is applied to the geometric distribution of the microfilariae ingested of Pichon, Prodhon & Rivière (loc. cit.).

- a) The proportion s of mosquito surviving is a hyperbolic function of the mean number of microfilariae ingested
- b) The distribution of larvae in the surviving mosquitos follows a geometric law
- c) The mean number of infective larvae Z of this distribution is a hyperbolic function of the mean number of microfilariae ingested X . The mean number of larvae Z in the surviving mosquitos is always lower than the mean number of microfilariae ingested and tend towards an upper limit H which is uniquely determined by the coefficient of mortality due to parasitism θ .

On the other hand, for the couple *M. uniformis/B. malayi* where the "overcrowding" of the parasite, the combination of this factor and differential vector mortality gives rise to a parasite yield P varying exponentially with the mean number of microfilariae ingested.

Experiment No.	Ave. No. of mf ingested X	Initial No. of mosquitos N	Number of surviving mosquitos		
			Observed N'	Expected(a) N'1	Expected(b) N'2
23	0.13	47	41	35.28	40.95
33	0.40	40	34	30.03	34.78
24	1.60	62	53	46.55	53.91
37	1.65	23	23	17.27	20.00
25	1.85	22	20	16.52	19.02
36	8.5	12	10	9.01	10.17
38	8.5	15	12	11.26	12.71
32	11.5	17	16	12.76	14.29
18	51.0	16	10	12.01	12.03
20	58.5	34	12	25.53	25.08
21	112.5	28	12	21.02	18.11
17	125.0	21	10	15.77	13.21
			X ² d.d.1	19.38 10	10.79 10

Table 1. Survival of mosquitos as function of the number of microfilariae ingested X (After Wharton (1957)²).

Comparison of the number of surviving mosquitos observed N' :

(a) with the expected number N'_1 calculated on the assumption that mortality is independent from X

The χ^2 is significant ($P = 0.05$)

(b) with the expected number $N'_2 = m N / (1 + (1 - \theta)x)$ on the assumption that mortality is dependent on X

with m (probability of natural survival) = 0.86957

θ (coefficient of survival under X) = 0.99694

The χ^2 is not significant ($P = 0.40$)

/N.B. The term θ of the mortality coefficient due to parasitism is equivalent to that of Dietz (182) who gave it the term C^n , and defined it as being the probability of survival in the presence of n microfilariae. If this factor has a value of 1, there will be no vector mortality due to parasitism. The present authors made an estimate for this factor as being = 0.99694. Applying this estimate to the experiment No. 17 in Table 1, i.e. with the highest mean microfilariae ingested of 125 (0.99694 125 = 68%) would mean a reduction of 32% in the natural probability of survival even with a value of this factor close to 1._/

Experiment No.	No. of mosquitos dissected N'	Ave. No. of mf ingested X	Ave. No. of larvae in the surviving mosquitos Z_0	Ave. No. of larvae in the surviving mosquitos Z_c
23	41	0.125	0.10	0.123
33	34	0.4	1.00	0.39
24	53	1.6	1.30	1.56
37	23	1.65	1.65	1.27
25	20	1.85	2.25	1.80
12	16	4.5	4.1	4.35
7	30	6.5	6.7	6.25
13	15	7.0	9.9	6.72
36	10	8.5	7.7	8.13
38	12	8.5	8.3	8.13
16	22	10.0	2.0	9.51
32	16	11.5	1.0	10.90
6	11	15.5	20.0	14.52
9	13	16.0	16.9	14.97
8	14	26.5	18.8	24.06
18	10	51.0	47.9	43.35
20	12	58.5	54.4	48.77
21	12	112.5	87.8	82.40
17	10	125.0	80.9*	89.05

* Z_0 significantly inferior to X.

Table 2. Comparison of the estimated average number of microfilariae ingested X, the average number of larvae in mosquitos that have lived to the maturation of the parasite Z_0 and the average number of larvae expected Z_c in the mosquitos that have lived to the maturation of the parasite, following a hyperbolic law:

$$Z_c = q\theta X / 1 + q(1 - \theta) X \text{ with } q = 0.9834$$

and $\theta = 0.99694$, data from Wharton, 1957²

(190) Suzuki, T. & Sone, F.
1975

Filarial infection in vector mosquitos
after mass drug administration in
Western Samoa

Trop. Med., 16, 147-156

The paper presents the data of infection and infective rates in two main vectors of filariasis in Western Samoa, *Ae. polynesiensis* and *Ae. samoanus*, which were recorded from December 1966 - December 1970 after the completion of the first round of mass DEC administration. The MDA was carried out from August 1965 to September 1966, with a dose of 5 mg/kg once a week for six weeks followed by once a month for twelve months. No vector control measures were undertaken.

Table 1 shows the pre-control data and the progressive highly significant reduction in the infection and infective rates during the post-treatment period. Infective larvae were found in Ae. polynesiensis in 1966 and in 1970 but no infective larvae were found in Ae. samoanus.

Table 1. Infection rate in mosquitos before and after the first round of mass drug administration in Western Samoa

Species/Year	No. of mosquitos dissected	Infection rate (all larval stages)			Infective rate (third-stage larvae)		
		No. of mosquitos positive	% positive	No. of larvae found	No. of mosquitos positive	% positive	No. of larvae found
<u>Ae. polynesiensis</u>							
Before mass drug control							
1963 ^a	407	34	8.35	-	12	2.95	-
After mass drug control							
1966-1967 ^b	2 381	17	0.71	39	1	0.042	1
1968	466	3	0.64	5	0	0	0
1969	865	4	0.46	5	0	0	0
1970	578	2	0.35	3	2	0.35	3
Total	4 290	26	0.61	52	3	0.070	4
<u>Ae. samoanus</u>							
Before mass drug control							
1963 ^a	380	17	4.47	-	1	0.26	-
After mass drug control							
1966-1967 ^b	98	2	2.04	2	0	0	0
1968	80	0	0	0	0	0	0
1969	9	0	0	0	0	0	0
1970	961	1	0.10	1	0	0	0
Total	1 148	3	0.26	3	0	0	0

a Cited from Ramalingam, 1968 (125)

b For 1966, dissection was made from 16 December to the end of the year

Table 2. Infection and infective rates of mosquitos and number of villages with infected or infective mosquitos in each district after the campaign

(a) Ae. polynesiensis

Island/District	No. dis- sected	Mosquitos			Villages			
		No. in- fected	No. in- fective	No. surveyed	No. with infected mosquitos	No. with infective mosquitos		
Upolu Island								
Northwest districts								
Apia	1 932	12	1	54	11	1		
Leulomoega	264	2	0	10	2	0		
Falelatai	379	2	0	11	2	0		
Fagaloa	86	1	1	2	1	1		
Lufilufi	727	7	1	11	5	1		
Sub-total	3 388	24	3	88	21	3		
		(0.71%)	(0.089%)		(23.9%)	(3.4%)		
Southeast districts								
Lefaga	145	0	0	6	0	0		
Safata	177	1	0	8	1	0		
Falealili	206	1	0	12	1	0		
Aleipata	205	0	0	7	0	0		
Sub-total	733	2	0	33	2	0		
		(0.27%)	(0%)		(6.1%)	(0%)		
Total for Upolu	4 121	26	3	121	23	3		
		(0.63%)	(0.73%)		(19.0%)	(2.5%)		
Savai'i Island								
Faasalelaga	17	0	0	2	0	0		
Fagamalo	23	0	0	3	0	0		
Safotu	21	0	0	2	0	0		
Sataua	55	0	0	6	0	0		
Salailua	29	0	0	4	0	0		
Satupaitaea	24	0	0	2	0	0		
Total for Savai'i	169	0	0	19	0	0		
		(0%)	(0%)		(0%)	(0%)		
Grand total	4 290	26	3	140	23	3		
		(0.61%)	(0.070%)		(16.4%)	(2.1%)		

(b) Ae. samoanus

Island/District	No. dissected	Mosquitos			No. surveyed	No. with infected mosquitos	Villages No. with infective mosquitos				
		No. infected	No. infective	No. surveyed							
Upolu Island											
Northwest districts											
Apia	278	0	0	14	0	0	0				
Leulomoega	1	0	0	1	0	0	0				
Falelatai	24	2	0	2	2	0	0				
Fagaloa	0	0	0	0	0	0	0				
Lufilufi	170	1	0	3	1	0	0				
Sub-total	473	3	0	20	3	0	0				
		(0.63%)	(0%)			(15.0%)	(0%)				
Southeast districts											
Lefaga	105	0	0	7	0	0	0				
Safata	150	0	0	4	0	0	0				
Falealili	2	0	0	1	0	0	0				
Aleipata	15	0	0	1	0	0	0				
Sub-total	272	0	0	13	0	0	0				
		(0%)	(0%)			(0%)	(0%)				
Total for Upolu	745	3	0	33	3	0	0				
		(0.4%)	(0%)			(9.1%)	(0%)				
Savai'i Island											
Faasaleleaga	30	0	0	1	0	0	0				
Fagamalo	97	0	0	2	0	0	0				
Safotu	67	0	0	2	0	0	0				
Sataua	10	0	0	1	0	0	0				
Salailua	83	0	0	4	0	0	0				
Satupaitea	116	0	0	3	0	0	0				
Total for Savai'i	403	0	0	13	0	0	0				
		(0%)	(0%)			(0%)	(0%)				
Grand total	148	3	0	46	3	0	0				
		(0.26%)	(0%)			(6.5%)	(0%)				

Records of infected and infective mosquitoes during post-control

During post-control surveys, infected and infective mosquitoes were found in Upolu island but none were found in Savai'i, as shown in Table 2. Infected Ae. polynesiensis was recorded from 23 villages out of 140 surveyed, 16.4%, but the infective specimens of this species were recorded from three villages, 2.1%. Infected Ae. samoanus were recorded from three villages out of 46 surveyed, 6.5%.

Relation between drug distribution coverage and mosquito infection rates

Three indices were introduced to represent the coverage: "population coverage", the percentage of people who took one dose or more of the drug; "dosage consumption", the ratio of the number of doses actually taken to total doses which should have been taken (population X 18 doses); and "complete dose coverage", the ration of the people who took the full 18 doses to the entire population. These indices are shown for all districts except Apia in Table 3, and the infection rates are summarized for the three main areas in Table 4. The authors referred to the data of the two tables as indicating that the infection rate of Ae. polynesiensis was the highest in northwest Upolu, next in southeast Upolu and nil in Savai'i. Drug population coverage was in the reverse order i.e. the lowest in northwest Upolu, next in southeast Upolu and highest in Savai'i.

Table 3. Coverage of drug distribution in district in each first round of mass drug administration in Western Samoa¹

Island/District	Dosage Population	Complete coverage (%)	consumption (%)	doses coverage(%)
Upolu Island				
Northwest districts				
Leulumoega*	9 380	92.57	71.00	26.55
Faelatai*	5 646	89.50	62.17	7.35
Fagaloa*	1 503	94.74	74.89	10.78
Lufilufi*	5 306	93.78	67.67	23.05
Southeast districts				
Lefaga	1 258	94.52	77.91	57.71
Safata*	3 950	96.08	58.85	0
Falealili*	6 237	95.22	62.55	0
Aleipata	1 700	97.24	69.06	22.88
Savai'i Island				
Faasaleleaga	7 211	95.16	68.89	10.73
Fagamalo	2 066	96.18	79.08	21.49
Safotu	5 127	96.18	76.65	40.37
Sataua	4 487	98.04	78.79	14.75
Salailua	5 125	99.65	79.51	34.03
Satupaitea	6 800	96.84	78.14	44.00
Total	65 796	95.12	71.01	21.42

¹Data not available for Apia district

*District with infected mosquitos

Table 4. Coverage of drug distribution and the infection
and infective rates in mosquitos after
the campaign in different areas

Area	Population coverage (%)	Coverage			Infectivity					
		Dosage consumption (%)	Complete dose coverage (%)	No. dissected	<u>Ae. polynesiensis</u>		<u>Ae samoanus</u>		No. infected	No. infective
Geographical areas										
Northwest	92.22	68.18	19.65	1 456	12 (0.82%)	2 (0.14%)	195	3 (1.54%)	0	
Upolu Island*										(0%)
Southeast	95.67	63.75	8.48	733	2 (0.27%)	0 (0%)	272	0 (0%)	0	
Upolu Island										(0%)
Savai'i Island	96.93	76.11	82. 9	169	0 (0%)	0 (0%)	403	0 (0%)	0	
Savai'i Island										(0%)
Areas of different infectivity										
Districts with infected mosquitos*	93.28	65.93	13.40	1 839	14 (0.76%)	2 (0.11%)	347	3 (0.86%)	0	
Districts with no infected mosquitos	96.86	75.83	29.02	519	0 (0%)	0 (0%)	523	0 (0%)	0	
All of Western Samoa excluding Apia district										
14 districts	95.12	71.01	21.42	2 358	14 (0.58%)	2 (0.085%)	870	3 (0.34%)	0	
14 districts										(0%)

*Excluding Apia district

Statistically the authors indicated that the coverage in the six districts in which infected mosquitos were found was significantly lower than in the eight districts where no infection was found in the mosquitos dissected, but there was no significant difference in the infection rates in either vectors among the different geographical areas. Further, the authors referred to the highest coverage in a district in which infected mosquitos were found as being 96.08% for the population coverage, 74.89% for the dosage consumption and 26.55% for the complete dosage coverage.

/N.B. From the authors' data the relationship between the three coverage indices and the positivity of the districts for mosquito infection does not seem very elucidating nor quite consistent. This can be seen from the following recompiled data of Upolu Island.

	Infection rate	Infective rate	Population coverage %	Dosage consumption %	Complete dosage coverage %
Northwest districts					
Fagaloa	1.16(86)	1.16	94.74	74.89	10.78
Lufilufi	0.96(727)	0.14	93.78	67.67	23.05
Leulomoega	0.76(264)	0	92.75	71	26.35
Falelatai	0.53(379)	0	89.5	62.17	7.35
Southeast districts					
Safata	0.56(177)	0	96.08	62.55	0
Falealili	0.49(206)	0	95.22	58.85	0

(Figures between parenthesis represent the number of mosquitos dissected)

From the above, it seems that the index of "complete dosage coverage" is more indicative of the influence of coverage on infection in mosquitos. In four cases out of six the presence of positive mosquitos was associated with no or very poor complete dosage coverage. However, pooling the data district-wise may mask important relationships between coverage and the occurrence of infection in mosquitos. Buck, 1975 (181) showed that large differences were found in the average total DEC dose between individual communities. Therefore, it would be useful to have a closer look into the condition of drug coverage, the presence of cases of untreated or persisting microfilaraemia in individual villages showing infection of mosquitos particularly with infective larvae. Although the present paper deals with the infection in the vectors in the post treatment of the first round of the DEC campaign, it would be important to follow up the situation in localities in which infection in mosquitos persisted or reappeared after the second round. For example, as shown in the detailed data provided by Suzuki and annexed to Buck's report (loc. cit.), the village Fusi in Lufilufi district, Upolu, showed an infection rate of 2.17% of 82 *Ae. polynesiensis* dissected after the first MDA and 0.75% infective rate (688 dissected) in the same vector and 0.45% infective rate in *Ae. samoanus* (688 dissected) during the post-treatment period of the second MDA 1972-1975./

Degree of reduction of the rate of the infective stage larvae

The authors indicated that the difference between the infection rates of Ae. polynesiensis during the pre-and post-treatment periods was found to be highly significant. The pre-control ratio of the infective to the infection rate of the same vector was found to be significantly higher than the post control ratio, 1: 1.8 and 1: 8.7. The authors suggested that for the entomological evaluation of the filariasis control, more reliance should be put on the infective rate.

Time of appearance of infective mosquitos post-control

The first of the three infective Ae. polynesiensis in the post-control survey was found in 1966, only three months after the completion of the MDA. Thereafter, no infective mosquitos were found for more than three years. It should be noted that from July 1967 to the second half of 1968, residual positive persons detected in blood surveys were treated by drug administration on a daily basis. The early reappearance of the first infective mosquito is probably due to the residual positive cases.

The other two infective mosquitos were found at least 3-1/2 years after the completion of the MDA.

The relative efficiency of Ae. polynesiensis and Ae. samoanus

From Ramalingam data (loc. cit.) shown in Table 1, higher infection and infective rates were recorded in Ae. polynesiensis than in Ae. samoanus. From the ratio of the infective to the infection rate, being 1: 2.8 for Ae. polynesiensis and 1: 17 for Ae. samoanus, the author inferred that Ae. polynesiensis is much more efficient than Ae. samoanus and suggested that experimental infection should be carried out to confirm this.

/N.B. Ramalingam 1968 stated that due to difficulty in raising vigorous females of Ae. samoanus in the laboratory, experimental infection was carried out on wild caught mosquitos which were fed on mf carriers with count of seven and 11 per 20 mm³. All 10 Ae. samoanus which survived showed infective stage larvae after 10-11 days. /

(191) World Health Organization 1975

Research on filarial infections
WHO unpublished document, MPD/75.5

An informal consultation was held in Geneva from 5-9 May 1975 on the WHO research programme of filarial infections.

The progress of ongoing research control projects of filariasis due to W. bancrofti and B. malayi in the African, the American, South East Asian and the Western Pacific regions was reviewed, and studies on other filarial infections namely Loa loa, Dipetalonema perstans, D. streptocerca and Mansonella ozzardi as well as on other nematodes Dracunculus medinensis were also discussed.

Information on the activities of the WHO Collaborating Centre for Filarioidea at the London School of Hygiene and Tropical Medicine was presented, which included collection and identification of filarial material, research on laboratory models, experimental chemotherapy, development of parasitological techniques, studies of the parasite in the vector and the technique for detection of infection in mosquitos and the provision of training facilities. The centre also made notable progress in the preparation of the computerized bibliography on filarial infections.

Problems of vector control were also discussed notably the control of C. quinquefasciatus, the main vector of filariasis in urban areas and a special reference was made to control of this vector in Rangoon, Burma.

The consultation made several recommendations for strengthening research on filarial infections which are briefly outlined below:

1. Support to current studies on the epidemiology and control of filarial infections:

W. bancrofti and B. malayi: in India, Indonesia, Kenya, Tanzania, Senegal (Central Africa), Tonga and Western Samoa. Support was also recommended to stimulate parasitological/clinical/entomological surveys in the American region.

Other filarial and nematode infections

Studies need to be encouraged on

Loa loa: studies on the reported nocturnal periodicity in man should be intensified and more investigations need to be carried out in Zaire where infection rates are high.

D. streptocerca in Brazil and the Caribbean area in respect of the clinical features, animal reservoir and vectors.

D. medinensis: Longitudinal studies should be encouraged in areas where this parasite exists in Africa, the Arabian peninsula and India. Methods for controlling Cyclops should be developed.

2. Support to research on immunology of filariasis

- 2.1 for isolation of specific filarial antigens from all possible stages of the parasite in man and from experimental animals.
- 2.2 for evaluation of current serological tests.
- 2.3 for collection and storage of selected sera from endemic areas of single filarial infections.
- 2.4 for developing simple serological techniques to be used in the field.
- 2.5 clinical immunology: a study of the mechanism of immunity, tests for antibody and antigen are required.
- 2.6 for more progress to be made in developing animal models for immunological studies.

3. Support to research on chemotherapy and the need for clinical trials

- 3.1 for improving methods of distribution of DEC in filariasis control programmes and for developing corticosteroids or immunosuppressants to control the reactions experienced with this drug.

- 3.2 for conducting therapeutic trials.

- 3.3 for developing new antifilarial drugs.

4. Support to research on vector ecology, genetics and control

4.1 in different geographical areas

In Africa:

Vector ecology and control: for stimulating trials and testing new insecticides.

Laboratory investigation: for determining the relative susceptibility of different members of the An. gambiae complex, An. funestus and C. quinquefasciatus from various geographical areas to W. bancrofti infections.

In South East Asia:

Vector ecology and control: for stimulating the planning of efficient and economic chemical control programmes against C. quinquefasciatus based on the experience already gained from the control of this vector in urban environments. More studies are needed on the transmission of B. malayi and its vector An. barbirostris in Indonesia.

In South Pacific:

Vector ecology: for stimulating studies on the distribution of the aquatic stages of different vectors in natural and man made habitats.

Vector control: for stimulating the implementation of trials for control of vectors by environmental sanitation with community participation, and by ULV insecticide application and by biological control agents such as Toxorhynchites.

Laboratory investigation: for obtaining more data on the susceptibility of members of the Ae. scutellaris group to W. bancrofti and the relative importance of confirmed and potential vectors.

4.2 specific vector studies

- for the correct identification of filarial larvae in dissected mosquitos making use of the facilities of the above mentioned WHO Collaborating Centre.
- for assessing the technique of mass separation of third stage larvae from mosquitos in the field.
- for improving cryo-preservation of microfilariae of W. bancrofti and other filarial parasite for utilization in mosquito experimental infection.
- for further genetic studies on C. quinquefasciatus strains and on the Ae. scutellaris group with a view to developing strains of vectors refractory to filarial infections.
- for further study on the mechanisms of destruction of the filarial parasite in refractory and susceptible strains of mosquitos.
- for the development of cytogenetic: gene-enzyme systems and immuno-diagnostics for the differentiation of members of the sibling species with special references to the Ae. scutellaris group and C. pipiens complex.
- for speeding-up the development of chemical, biological, genetic vector control methods to be implemented in field trials as integrated measures including environmental sanitation.

5. Training:

For the existing staff, newly recruited staff and teaching staff, with field training in either reorientation or degree courses.

(192) Bryan, J.H. &
Southgate, B.A.
1976

Some observations on filariasis in
Western Samoa after mass administration
of diethyl-carbamazine

Trans. roy. Soc. trop. Med. Hyg., 70,
39-48

(Originally, most part of this paper
submitted to WHO as assignment report of
WHO consultants in 1973)

Two mass DEC campaigns took place in W. Samoa in 1964-1965 and 1971 with a rather high level of population coverage. Maung & Penaia, 1976 (198) estimated the coverage to be 89% in Apia and 95.6% in the rest of the country.

The authors did a survey between February and April 1973 to determine:

- (a) what proportion of mosquitos could be infected by feeding on an ultra-low density microfilaria carrier and
- (b) whether mosquito infections derived from low level carriers who had been treated with a full course of DEC were capable of full development to the infective stage in the mosquito mouthparts.

1. Blood examination techniques

The membrane-filtration technique was performed as described by Desowitz & Southgate, 1973 (159) and the counting-chamber technique was performed as described by Southgate, 1973 (164).

2. Entomological techniques

All work was carried out on wild-caught Ae. polynesiensis in an uninhabited area near Apia. No attempt was made to rear mosquitos from eggs for these experiments because the insectary had become contaminated with insecticide and because the length of time for conducting the experiments was limited.

As wild-caught females were used for the feeding experiments, it was important to ensure that the mosquitos used were not infected with W. bancrofti larvae before the start of these experiments. Over 300 wild-caught mosquitos were dissected on the day of capture. A further 50 were fed on the investigators and dissected 7-10 days after feeding. No filarial larvae were detected in these mosquitos.

2.1 Feeding experiments on the human volunteer

The volunteer had received during the previous mass DEC campaigns the following dosage schedule of DEC:

1966-67: Six doses at weekly intervals of 5 mg/kg body weight, followed immediately by 12 doses at monthly intervals of 5 mg/kg body weight

1971: Twelve doses at monthly intervals of 6 mg/kg body weight

For feeding on the volunteer, up to 80 unfed female mosquitos were placed in a cup, covered with mosquito netting. Three or four cups were placed along in the forearm of the volunteer, with the netting tops next to the skin, for periods of 20 min. After this time, partially and fully engorged females were removed with a sucking tube and placed in the containers described above. These containers were examined daily, and dead insects in a suitable condition for dissection were removed and dissected; the dead mosquitos rapidly became covered with fungus which made dissection difficult in some cases.

2.2 Dissection of the mosquitos

When a mosquito died before the blood meal was digested, the gut contents were smeared on to a glass slide, dehaemoglobinized, fixed with methyl alcohol, stained for 20 min. with 10% Giemsa and examined for parasites.

When it became apparent that infective larvae were appearing in the mouthparts on the 12th day after feeding at the ambient temperatures involved, any surviving mosquitos were killed and dissected on the 12th or 13th day after feeding.

3. Findings and discussion

The findings can be summarized as follows:

<u>No. mosq. fed</u>	<u>No. mosq. dis.</u>	<u>No. mosq. found positive for W. bancrofti</u>
1802	670	61

Number of W. bancrofti larvae found: 80
Infective larvae was found from 11th day onwards.

The average size of the blood meal in Ae. polynesiensis was measured by weighing batches of mosquitos before and after feeding and found to be 1.327 mm³. The authors state that Ae. polynesiensis does not expel blood during feeding although occasionally drops of clear serum-like fluid were expelled and that it is unlikely that the actual amount of blood ingested be much greater than the above figures.

/N.B.: The 670 dissected Ae. polynesiensis had thus ingested about 889 mm³ of blood, representing theoretically an average load of 4.45 mf (5 mf/1000 mm³) but actually they had ingested at least 80 mf, which indicates a very high vectorial efficiency in concentrating the microfilariae with mean actual intake of about 17 fold the expected number of mf as shown below to be compared with 12 fold estimated by the authors.

A more detailed comparison of the density of mf in blood and in mosquitos bloodmeals during each of the five feeding experiments shows the following relationship:

Mf density mf/1000 mm ³	No. mosquito dissected	observed	W. bancrofti expected	ratio obs./exp.
5	167	23	1.1	20.9
4	150	14	0.8	17.5
8	143	26	1.5	17.3
6	153	12	1.2	10.0
2	57	5	0.15	33.3
Total	25	670	80	4.75
				(16.8) mean

From 10 fingerprick examinations 60 mm³ each, i.e. a total of 600 mm³ of blood, 3 mf were found and from 5 examinations of 1000 mm³ each, i.e. a total 5000 mm³ of blood, 25 mf were found suggesting an even distribution of the mf in the whole blood.

From the distribution of larvae in the infected Ae. polynesiensis, it may be possible to assume that the mf intake was as follows:

50 ♀ with 1 mf each	50 mf
7 ♀ with 2 mf each	14 mf
2 ♀ with 3 mf each	6 mf
2 ♀ with 5 mf each	10 mf

In the following table, the expected frequencies were calculated according to Poisson distribution (PD) and negative binomial distribution (NB) are statistically compared with the observed values of the distribution of the mf in the experimental mosquitos:

No. of mosquitos with	Observed	Expected PD	χ^2 d.f = 1	Expected NB	χ^2 d.f = 1
0 mf	609	594.2	0.37	601.37	0.097
1 mf	50	71.3	6.36	61.60	2.184
2 mf	7	4.3)))
3 mf	2	0.2)))
4 mf	0	0.005	10.06	7.03	2.242
5 mf	2	0.006)))
	670	670.011	16.79	670	4.523
			P < 0.005		P < 0.05

From the above it is clear that Poisson distribution does not fit in well with the observed data but the negative binomial is more appropriate although the difference between the observed and the expected by this distribution is still significant at 5% probability level. The negative binomial distribution fits in well with the frequency of mf, but the poorest fit is in the frequencies of higher infection in mosquitos. Pichon et al., 1976 (201) has found that the negative binomial distribution is more representative of the condition of infection in mosquitos./

The author noted that with such low wormloads the mortality of mosquitos in the laboratory was independent of their infection with W. bancrofti. Infective larvae were found in mosquitos from the 11th day onwards and the distribution of W. bancrofti positive mosquitos amongst those dissected every day between infective feed and 12 days later does not suggest that DEC treatment given in 1966-67 and 1971 interfered with the development of W. bancrofti in the mosquito in 1973.

During this experiment the authors surveyed 93 people of which 92 were known to have been infected before the DEC mass drug campaign. Twenty-three people were found positive by the blood filtration technique, 17 of them having counts of 10 or less than 10 mf/ml of blood. A child born in January 1972 and then 14 months old was found positive, with 34 mf/ml of blood.

It is of interest to give the theoretical estimates made by the authors for the number of mf carriers in Western Samoa and the number of infective larvae that can be produced daily in Ae. polynesiensis.

The number of microfilaria carriers:

The authors applied two methods:

The first: using the formula $M = Pxyz$ where

M = the number of microfilaria carriers in the whole Western Samoa
P = the population of Western Samoa 145 000
x = the proportion of the population alive at the start of MDA 0.75
y = the minimum estimate of the mf rate at the start of MDA, 0.19
z = the proportion of the previous microfilaria carriers, known to be microfilaraemic at the end of second mass DEC treatment using the membrane filtration technique 0.23

Thus the number of microfilaria carriers would be

$$= 145\ 000 \times 0.75 \times 0.19 \times 0.23 = 4\ 753$$

The second: using a correction factor which is the ratio between the microfilaria prevalence rate obtained by the membrane filtration technique and the examination of 60 mm^3 of fingerprick blood for which two estimates 2:1 and 6.5:1 taken from data collected from other areas in the South Pacific. Applying the correction factors to the observed prevalence rate 0.19% in 11506 persons examined in 1971, the number of the microfilaria carriers comes to with the correction factor of 2 = 0.38% of the total population i.e. 551. with the correction factor of 6.5 = 1.235% of the total population i.e. 1235.

The authors favoured the first estimate, i.e. 4753, since there have been no studies carried out on whole populations using the above-mentioned techniques simultaneously in areas where DEC has been administered in such high dosage or to such a high proportion of the population as in Western Samoa.

/N.B. vide Hairston, 1973 (160) for his estimates of the total number of mf carriers./

The number of infective larvae produced daily in Ae. polynesiensis

The formula used was $M m a p n i b$

M = the number of microfilaria carriers in the whole 4753 population

a = the average number of humans bitten by one mosquito/day
(not available in Western Samoa)

ma = mean man biting density daily, 200

p = probability of daily survival, 0.80 (after Burnett, 1960^a(85))

n = duration of the development of the parasite in the mosquito, 14 days

i = the proportion of mosquitos surviving the n period of (14 days), 09 taken from the present study)

b = the mean number of infective larvae per infected mosquito, 1 (taken from the present study)

Thus the number of infective larvae produced daily

$$= 4753 \times 200 \times (0.80)^{14} \times 0.09 \times 1 = 3764$$

or 1 374 annually.

The authors in their conclusion directed the attention to importance and great need for surveillance of the human and vector population in Western Samoa for several years to come in view of the implications of their experimental findings. They recommended that if resumption of transmission occurs, it should be dealt with promptly either by resumption of mass drug administration or by some method of vector control.

/N.B. vide views of Hairston, 1973 (160) regarding mass drug administration and vector control./

The authors also drew attention to the possibility of the existence of DEC refractory strain as was reported by Desowitz & Southgate, 1973 (158) and therefore an alternative drug is urgently needed.

(193) Desowitz, R. S. &
Una, S. R.
1976

The detection of antibodies in human and animal filariasis by counter-current immunoelectrophoresis

WHO unpublished document, WHO/FIL/76.141

Of the various serological techniques employed for visualization of precipitins, counter-current immunoelectrophoresis (CIEP) appears to be the most sensitive. It is also simple and rapid to perform, permitting a relatively large number of serum samples to be tested at the same time.

In the present study, CIEP, which has not been previously applied to the serology of filarial infections, was employed for the detection of antibodies in human and animal filariasis. CIEP, using soluble antigens prepared from Dirofilaria immitis adult worms and microfilariae was applied to sera from 24 persons living in an hyperendemic area for bancroftian filariasis (i.e. Te'ekiu village, Tonga) and from cats and dogs infected with D. immitis.

The results obtained seemed to indicate that the level of microfilaraemia was related to the stage-specific antibodies produced by the host. In D. immitis-infected animals it appeared that suppression of the microfilaraemia was associated with anti-microfilarial precipitating antibody, that animals with moderate levels had antibody only to adult antigens, and that in heavy parasitaemias there were antibodies to both adult and microfilarial stages. The same pattern was observed in the 24 persons from a hyperendemic area; negative individuals and those with occult infections had antibody to microfilarial antigen while those with high parasitaemias had antibody to the adult male D. immitis antigen. The heterologous response of sera from humans exposed to and/or infected with W. bancrofti was in keeping with the hypothesis that for nematodes there may be a greater antigenic relationship between the same stage of different filarial species than between different stages of the same species. In conclusion, the usefulness of CIEP as an adjunctive serological method for diagnosis will depend on further development of poly-stage antigens as well as on the elucidation of species-antigenic relationships.

(194) Desowitz, R. S.,
Berman, S. J. &
Puloka, T.
1976

Hyperendemic subperiodic bancroftian
filariasis: a search for clinical and
immunological correlates of
microfilaraemia

Bull. Wld Hlth Org., 54, 565-571

A study was carried out in the Kingdom of Tonga, an area of hyperendemic bancroftian filariasis, to determine whether correlations could be made between microfilaraemia, as diagnosed by membrane filter concentration, and immunological (skin test, immunoglobulin levels) or clinical findings. There was no relationship between the presence or degree of microfilaraemia and any clinical manifestation or skin test reaction. The skin test positivity rate for microfilaraemic and amicrofilaraemic individuals was approximately the same for all age groups. Among those aged 0 to 4 years, 48% of mf positives were negative in the skin test. The highest average IgG and IgE levels were found in the groups with the highest mf densities, i.e. in children with a history of fever and in adults with a history of lymphangitis/lymphadenitis. Over a period of a year, the mf density changed significantly in 18 (34%) of 53 adults.

(195) Hawkins, F. & Denham, D.
1976

The distribution of human filariasis throughout the World. Part I. The Pacific Region including New Guinea

Trop. Dis. Bull., 73, 347-373

The paper is one of the series dealing with the world distribution of six filarial infections excluding onchocerciasis. The information compiled in the paper was obtained from a survey made by the International Filariasis Association. In this survey specialists and other persons who had first hand knowledge on the situation of filarial infections in each country were asked to provide information. The information has been supplemented by a review of recent literature. In this paper which deals with the Pacific area, the bibliographies issued by the South Pacific Commission particularly those prepared by Iyengar were consulted. Little has been added to these from the new information available up to 1971.

The paper gives an introductory review of the types of human filariasis in the Pacific area and their vectors. Definitions of terms used in the paper are given, the division of the South Pacific area into four zones of Iyengar, 1965 (108) is adopted. The available information given for each country, island or island group covers the following:

- short description of the area, population census, parasite species and type
- distribution and prevalence of the parasite, clinical manifestations
- vectors
- control measures: by DEC and the available information on vector control.

(196) Hitchcock, J. C.
1976

Final report on field investigation on
filarial infections
Project MPD-025, Nuku'alofa, Tonga,
1971-1975

Unpublished report to WHO, 150 pp. with 3 appendices

According to the recommendations made in WHO document PD/72.7 (Abstract No. 145) a project was implemented with its base laboratory in Tonga and the author was assigned as WHO entomologist to the project.

This report gives in great detail, the mosquito collection made by the author mainly from the Kingdom of Tonga and some other islands of the South Pacific. Table 1 shows the area covered by the survey and Table 2 shows the material of different species shipped by the author to the Smithsonian Institution for taxonomic studies. It is anticipated that when these studies are completed, the findings will be prepared for eventual publication.

In the present report the author annexed the following information:

- (a) Methods of collecting, rearing, maintaining, storing and shipping of mosquitos.
- (b) The results of a comprehensive filariasis survey made at a village, Ha'akiu, Nava'u island, Tonga in 1975, comprising biting/landing collections, relative abundance of mosquitos in houses, mosquito dissection, age composition of biting/landing collection of Ae. cooki, mosquito dissection for filarial infection, day-time house resting, larval surveys, microfilariad and clinical surveys.
- (c) The results of an investigation on dengue fever made in Tonga during February-May 1974.

Until formal publication of the taxonomic studies is made, the author highlighted the following information which was gathered from his or previous observations as well as from the early findings of the Smithsonian Institution.

1. New taxonomic findings

- 1.1 Ae. (Stegomyia) pseudoscutellaris (Theobald) was redescribed.
- 1.2 Ae. (S.) polynesiensis Marks is a good biological species.
- 1.3 Ae. (S.) tongae Edwards was redescribed.
- 1.4 Ae. (S.) tabu Ramalingam and Belkin is a subspecies or polymorphic form of Ae. tongae.
- 1.5 Ae. (S.) cooki is a good biological species.
- 1.6 Ae. (S.) sp. Tafahi form will be described as a new species.
- 1.7 Ae. (S.) sp. Wallis form (sp. 22 of Belkin, 1962) is closely related to the Ae. (S.) sp. Tafahi form and may be a new species.
- 1.8 Ae. (Finlaya) oceanicus Belkin and not Ae. (F.) samoanus (Gruenberg) is the member of the Ae. (F.) kochi group in the Wallis Islands.

2. New distribution records

- 2.1 Ae. (S.) tongae occurs in the Fiji Islands. This should be taken with reservations. The material sent to the authors from Fiji were only adult and no immature stages were provided. Further verification would be needed.
- 2.2 Ae. (S.) polynesiensis is in the Wallis Islands.
- 2.3 Ae. (S.) cooki occurs in the Tonga Islands.
- 2.4 The mosquito fauna of the Horne Islands: Ae. futunae, Ae. polynesiensis, Ae. oceanicus, C. quinquefasciatus, C. annulirostris and C. sitiens.
- 2.5 Ae. (S.) aegypti does not occur in the Horne Islands.
- 2.6 The mosquito fauna of the Wallis Islands.
- 2.7 Ae. (S.) sp. Wallis form is not the primitive form of the Ae. (S.) scutellaris group in the Wallis Islands.

3. New findings on vector status

- 3.1 Ae. (S.) cooki on Niue Island was shown to be a vector of subperiodic W. bancrofti by experimental infection.
- 3.2 Ae. (S.) cooki was shown to be a vector of subperiodic W. bancrofti as well as D. immitis, based on natural infections.
- 3.3 Ae. (S.) tongae (Ae. (S.) tabu) finally confirmed as a natural vector of W. bancrofti, it was also for the first time, shown to be a natural vector of D. immitis.
- 3.4 Ae. (S.) sp. Wallis form may be a more important vector of W. bancrofti in the Wallis Islands than Ae. (S.) polynesiensis.
- 3.5 Ae. (S.) futunae is not an efficient vector of subperiodic W. bancrofti in the Horne Islands.
- 3.6 Ae. (S.) sp. Tafahi form and Ae. (Finlaya) oceanicus were shown to be natural vectors of both W. bancrofti and D. immitis in Tonga just prior to the project.
- 3.7 Members of the Ae (Stegomyia) scutellaris group are efficient vectors of dengue viruses in the area.
 - 3.7.1 Ae. (S.) tongae (Ae. (S.) tabu) was a proven vector of Dengue 2 virus in Tonga and a probable vector on epidemiological grounds for Dengue 1.
 - 3.7.2 Confirmation that Ae. (S.) cooki was the major vector of Dengue 2 on Niue Island on epidemiological grounds.
 - 3.7.3 Ae. (S.) cooki was the major vector of Dengue 1 in Ha'akiu Village in the Vava'u Group on epidemiological grounds.
 - 3.7.4 Ae. (S.) sp. Tafahi form was the major vector of Dengue 1 on Niutoputapu and Tafahi Islands in Tonga.

The author made several suggestions for vector control measures.

TABLE 1. Total mosquito specimens derived from surveys by species,
developmental stage and number of collections

Species	No. Collections	Specimens	Whole Larvae	Larval Skins	Whole Pupae	Pupal Skins	Adult Male	Adult Female
<u>Ae. (S.) scutellaris</u>								
group*	602	19 461	9 799	2 211	567	2 868	1 684	3 413
<u>Ae. (S.) aegypti</u>	156	2 707	1 215	86	144	128	610	524
<u>Ae. (F.) oceanicus</u>	46	693	438	53	8	80	47	67
<u>Ae. (A.) nocturnus</u>	34	327	173	19	21	30	31	53
<u>C. quinquefasciatus</u>	160	2 688	1 879	26	96	78	229	380
<u>C. annulirostris</u>	27	375	338	6	6	6	5	14
<u>C. sitiens</u>	10	90	82	3	3	1	-	1
<u>C. sp.</u>	1	5	4	1	-	-	-	-
<u>Tripteroides</u>								
<u>purpuratus</u>	3	26	25	1	-	-	-	-
<u>Toxorynchites</u> sp.	2	8	-	2	2	2	2	-
	1 061	26 380	13 953	2 408	847	3 193	2 608	4 452

* Includes: (1) Ae. cooki; (2) Ae. futunae; (3) Ae. polynesiensis; (4) Ae. pseudoscutellaris; (5) Ae. rotumae; (6) Ae. tabu; (7) Ae. tongae; (8) Ae. upolensis; (9) Ae. sp. Wallis form; and (10) Ae. sp. Tafahi form.

TABLE 2. The islands surveyed and from which specimens of the *Scutellaria* group were studied

Island Group	Island	Type locality	Individual rearings	Eggs for pregnancy rearing	Species present
FIJI ISLANDS	(1+6) Viti Levu (Taveuni-1968)	<u>Ae. pseudoscutellaris</u> <u>Ae. polynesiana</u> <u>Ae. horrescens</u>	+	-	<u>Ae. pseudo</u> , <u>Ae. polynesiana</u> <u>Ae. polynesiana</u> , <u>Ae. horrescens</u>
Lau Group Southern	Ogea, Lau Group		-	-	<u>Ae. tongae</u> , <u>Ae. polynesiana</u>
"	Moce, Lau Group		-	-	<u>Ae. tongae</u> , <u>Ae. polynesiana</u>
"	Totoya, Lau Group		-	-	<u>Ae. tongae</u> , <u>Ae. polynesiana</u>
Northern	Meiteubu, Lau Group		+	-	<u>Ae. polynesiana</u> , <u>Ae. tongae</u>
"	Vanuabalavu, Lau Group		+	-	<u>Ae. polynesiana</u> , <u>Ae. horrescens</u>
KINGDOM OF TONGA	(28)				
Tongatapu Group	(3)	Tongatapu Eua Pangaimotu	<u>Ae. tabu</u>	+	<u>Ae. tongae</u> , (<u>Ae. tabu</u>)
"				+	<u>Ae. tongae</u> , (<u>Ae. tabu</u>)
"				+	<u>Ae. tongae</u> , (<u>Ae. tabu</u>)
Haapai Group	(13)	Lifuka Tofata Uiha Luehoko Kauvai-Na'ono Rukusamu Foa Uenukuhahaki Tofanga Limu Uenukuhihifo Luangahili Uoleva	<u>Ae. tongae</u>	+	<u>Ae. tongae</u> <u>Ae. tongae</u>
Vava'u Group	(3)	Vava'u Utungaki Pengai Metu		+	<u>Ae. cooki</u>
"				+	<u>Ae. cooki</u>
"				-	<u>Ae. cooki</u>
Niuatoputapu Group	(8)	Niuatoputapu Tafahi Hunganga Makautu'utu'u Tevili Muhunono Muhusalingsa Motulangi	Tafahi form	+	<u>Ae. sp.</u> Tafahi form <u>Ae. sp.</u> Tafahi form
Miufo'ou Island	(1)	Miufo'ou		+	<u>Ae. sp.</u> Tafahi form
WESTERN SAMOA	(1)	Upolu	<u>Ae. upolensis</u>	+	<u>Ae. upolensis</u> , <u>Ae. polynesiana</u>
NIUE ISLAND	(1)	Niue	<u>Ae. cooki</u>	+	<u>Ae. cooki</u>
WALLIS ISLANDS	(2)	Uvea	Wallis form	+	<u>Ae. sp.</u> Wallis form, <u>Ae. polynesiana</u>
"		Mukuhifale		+	<u>Ae. sp.</u> Wallis form, <u>Ae. polynesiana</u>
HORNE ISLANDS	(2)	Aofifi Futuna	<u>Ae. futunae</u>	+	<u>Ae. futunae</u> , <u>Ae. polynesiana</u>
"				+	<u>Ae. futunae</u> , <u>Ae. polynesiana</u>
NOTUMA GROUP	(1)	(Notuma)	<u>Ae. notumae</u>	+	<u>Ae. notumae</u>

(c) Islands from which specimens were studied but not visited by the author during the tenure of the project

Specimens of *Ag. polynesiensis* from type locality collected and reared by the author in 1961.

Only *An. hercegensis* was not studied by the author during the tenure of the project and individually reared by Mr. Ismael Pabón, Holloman, Nuevo Leon.

Specimens collected and individually reared by Mr Isimeli Rakai, Wellcome Virus Research Laboratory, Suva, Fiji

(197) Hoyer, L.C. & Rozeboom, L.E.
1976

Inheritance of autogeny in the Aedes scutellaris subgroup of mosquitos
J. Med. Ent., 13, 193-197

Five species or populations of the Ae. scutellaris group of mosquitos were used in this work: Ae. polynesiensis from Samoa; Ae. pseudoscutellaris from Fiji; Ae. cooki from Niue Island; Ae. sp. (Tafahi); and Ae. sp. (Niuafou). The last two originated in the islands of Tafahi and Niuafou, Kingdom of Tonga.

Stock colonies were maintained in 0.028 m³ (1 ft³) wire mesh cages in separate rooms of an air-conditioned insectary at approximately 27°C and about 80% RH. Anautogenous colonies were offered a weekly blood meal from an anaesthetized guinea pig; a 10% sucrose solution was provided as a maintenance diet for both autogenous and anautogenous colonies as well as for experimental adults. Larvae were reared in uncrowded pans; pupae were removed daily and transferred to the colony cages for emergence.

For each trial, larvae were reared in uncrowded pans, and the pupae, after preliminary sexing by size, were placed in test tubes in groups of 4 or 5. The newly emerged adult males and females were transferred to separate holding containers for not more than 48 hours before being placed into breeding cages. Breeding cages were cylindrical, 3.8 liter (1 gal) cardboard cartons with a muslin sleeve in the side and a fine mesh netting on top. Each breeding cage received an equal number of males and females up to, but not exceeding, 30 pairs. After a three day mating period, the anautogenous parent females were offered an opportunity to obtain human blood, and all anautogenous as well as autogenous females were placed individually in 2.54 x 7.62 cm shell vials. Each vial contained a strip of moist paper toweling; the top was covered with gauze, on which was placed a pledget of cotton saturated with a 10% sucrose solution. Moist paper towels were placed over the vials to prevent drying.

Ovaries of all females failing to oviposit after ten days were removed and the follicles measured. Females ovipositing or showing follicle development equal to or greater than 0.2 mm were scored as being autogenous, while all other females were scored as anautogenous.

The following is an abstract of the findings:

Three autogenous populations (Aedes cooki, Ae. sp. (Tafahi), and Ae. sp. (Niuafou) and two anautogenous populations (Ae. polynesiensis and Ae. pseudoscutellaris) were crossed to determine the mode of inheritance of autogeny in the Aedes scutellaris and subgroup. Females of Ae. sp. (Tafahi) and Ae. cooki when mated with Ae. pseudoscutellaris males, produced F₁, F₂ and backcross progeny in which ratios for autogeny were statistically compatible with the hypothesis of a single dominant autosomal gene for autogeny. However, in the cross between Ae. pseudoscutellaris females and Ae. cooki males, and in that between Ae. sp. (Niuafou) females and Ae. pseudoscutellaris males, the F₁, F₂ and backcross progeny showed autogeny ratios that did not support the single factor hypothesis. The latter also was true of progeny resulting from crosses between females each of Ae. sp. (Tafahi), Ae. cooki and Ae. sp. (Niuafou) and Ae. polynesiensis males. These results appear to support the hypothesis that several alleles contribute varying degrees of autogeny.

In conclusion, although proof is lacking, it appears the most logical explanation of seemingly erratic results is that several alleles of variable strength influence the expression of autogeny in these Ae. scutellaris group populations.

Furthermore, in certain combinations, as in the cross between Ae. sp. (Tafahi) females and Ae. pseudoscutellaris males, they may function together so as to resemble a single autosomal dominant factor.

(198) Maung, T.M. & Penaia, L.
1976

Filariasis in Western Samoa by the mass drug administration method
Unpublished report of WHO Epidemiological & Surveillance Team for the South Pacific

In this report, the authors briefly described the chronological development of the mass DEC administration campaign, they noted the type of housing, some habits of the people and enumerated the vectors of subperiodic filariasis in Western Samoa. A brief reference was made to the existence Dirofilaria immitis infecting about 50% of the dogs. A full account of the procedures adopted in the campaign and detailed results of the epidemiological surveys were given.

1. Procedures

Mass drug administration was given to the entire population above 2 years of age using DEC at a dosage of 5 mg/kg once a week for 6 weeks, followed by once a month for 12 months, i.e. a total of 18 doses. A second round of MDA was made at a dosage of 6 mg/kg to the entire population above the age of one year, making a total of 72 mg/kg.

Blood, clinical and entomological surveys were carried out before and after the mass treatment rounds treating all mf positives when found during blood surveys.

No vector control was applied except for a few limited scale trials (the results of which are given by Suzuki & Sone in an unpublished report, 1976) (Abstract No 209).

2. Results

The first MDA was made during June 1965- July 1966 and the second round during January - December 1971. Treatment was given from house-to-house in some areas, while in others people were asked to gather together in once place for taking the drug. Drug reactions encountered were:

- (1) Fever, malaise, rashes and general discomfort.
- (2) Local signs - inflamed arms or legs, rarely leading to lymphangitis. There were rare cases of precipitation of signs (a swelling appearing in a limb or scrotum for the first time) and exacerbation of signs (further increase of a swelling that had already existed).

Idiosyncrasies to the drug itself were:

- (1) A feeling ranging from tranquilizing effect to drowsiness.
- (2) Gastric irritation.

2.1 Drug administration coverage during the first MDA (1965-1966)

Analysis of the records of 76 903 persons covering over 50% of the population, including the principal town of Apia and 150 villages out of approximately 270 is shown in Table 1.

It appears that good population coverage was achieved and that rural areas had better population coverage than the urban area of Apia; likewise dose per unit population (i.e. % of the total number of doses taken by people in relation to the total target doses prescribed). The completed course coverage (i.e. % of persons who completed the number of doses prescribed, 18 doses in the first MDA) was unsatisfactory. It was estimated as only 20.4% of the whole population completed the 18 doses.

TABLE 1. Analysis of drug administration coverage of approximately 50 percent of the population during the first MDA, 1965

Area	No. of persons whose records were analysed	DRUG COVERAGE		
		Population coverage (%)	Dose per unit population (%)	*Completed course (%)
Apia	11 107	9 889 (89.03)	118 581 (59.31)	1 580 (14.22)
Rest of the country	65 796	62 901 (95.60)	841 009 (71.01)	14 092 (21.41)
TOTAL	76 903	72 790 (94.65)	959 590 (69.32)	15 671 (20.37)

*Completed course is those completed eighteen doses

With detailed analysis of the records of 7 888 persons throughout the country and 2862 persons in preliminary study areas, the reason for this poor complete dose coverage could be traced. In the preliminary study area, although 71.7% of the population took 16 doses, none took 17 or 18 doses. Throughout the country, 13 doses were taken by 74.88% of the population, after which the number of doses taken declined appreciably as shown in Table 1(a).

TABLE 1(a).

Analysis of drug administration coverage of sample population by the number or doses taken for the First and Second MDA

No. of doses	First MDA (1965 - 1966)		SECOND MDA (1971)	
	Preliminary Study Area		All Areas	
	No. of cases	Cumulative percentage	No. of cases	Cumulative percentage
18	-	-	1956	24.79
17	-	-	786	34.76
16	2052	71.7	581	41.12
15	301	82.2	223	44.95
14	57	84.2	260	40.25
13	51	86.0	2101	74.88
12	30	87.0	98	76.12
11	40	88.4	73	77.05
10	66	90.7	112	78.47
9	69	93.2	108	79.84
8	28	94.1	144	81.66
7	31	95.2	96	82.88
6	19	95.9	79	83.88
5	24	96.7	83	84.93
4	24	97.6	101	86.21
3	26	98.5	97	87.44
2	18	99.1	306	91.32
1	26	100	331	95.52
0	0	100	353	100.00
TOTAL	2862		7888	28 687

Further enquiry revealed that the date of the 13th dose of drug administration was soon followed by a major devastating hurricane. This period coincided with the 17th dose in the preliminary study areas, as they commenced the drug administration a month earlier. Due to the effect of the hurricane, people in many areas were occupied with reconstruction including the drug distribution teams of the women's committee. Some villages were affected more than the others, while a few villages escaped without any great damage and destruction. As a result, the 18-dose completed was not satisfactory. However, on studying the cumulative percentages of doses taken by the people, it can be seen that about three quarters of the whole population took at least 12 doses, equivalent to 72 mg/kg.

Analysing the coverages by areas, apart from the rural-urban difference, the poorest coverage was mainly in plantations. In these places, labourers lived in scattered dwellings. No village existed as such, hence there was no village women's committee. The drug was administered through plantation managers who did or did not do a good job. Besides, many of the labourers were itinerant and moved whenever they completed their few months' work. The absence of village women's committees and movement of people were the main causes of inadequate coverage among such people.

Travelling outside Western Samoa was another cause of disruption of the full treatment course. Initially plans were laid for drug treatment to be given at ports to arrivals by sea or air and to follow up with further doses, but this never materialized.

2.2. Drug administration coverage of the second round, 1971

The second MDA was planned to commence in January 1970. While they were received in time, the stocks of drug arrived poorly packed and the tablets showed considerable deterioration and had to be returned. It took about one year to receive the new stocks and this jeopardized the preparations made for commencing the round, including public information, census and registers. However, the drug distribution registers of the second round were more comprehensive than those of the first round, hence better analysis of data could be made.

Analysis of the records of 132 583 persons (90.19%) of the population showed that the population coverage was 98.77% and the completed course coverage was 46.06% (Table 2).

Dose coverage was analysed from the records of 28 687 persons taken at random from all health districts (Table 1a). It was found that 255 persons (0.89%) did not take the drug at all. 28 432 persons took one or more doses (population coverage 99.12%) and 13 429 persons (46.82%) took the full twelve doses as prescribed.

Doses per unit population were not evaluated as the infective rate in mosquitos was nil in these areas before the second MDA, hence there was no point for comparison before and after treatment.

TABLE 2. Analysis of drug administration coverage of approximately 90% of the population during the second MDA, 1971

Area (Health Division)	No of persons whose records were analysed	DRUG COVERAGE		
		Population coverage (%)	Dose/Unit population*	Complete coverage**(%)
Apia	45 609	44 950 (98.55)		20 212 (44.31)
Upolu	46 424	45 961 (99.00)		21 704 (46.75)
Savaii	40 550	40 043 (98.74)		19 150 (47.22)
Total	132 583	130 954 (98.77)		61 066 (46.06)

*This was omitted for the second MDA as the infective rate in mosquitos in specified areas were nil before the second MDA

**Complete courses are those who completed twelve doses

Untreated and incompletely treated persons:

As mentioned above, 0.89% (or 255 persons) did not take any drug during the second MDA. These were:

Refusals: Complete refusals were rare - 0.13%. These were the people who refused taking the drug after hearing of its side effects and those who refused on religious grounds despite intensive health education.

Absentees: A lot of movement in Western Samoa from village to village or between the two islands as well as travel abroad accounted for a number of persons missing the treatment.

Incompletely treated persons: During the second MDA, the above data showed that about 59.94% of the people did not complete the total doses prescribed. The reasons as disclosed from questionnaire survey were: fear of continuing the treatment after having experienced side reactions; temporary or permanent absenteeism; relaxed interest for continuing the treatment; failure of the team to distribute the drug particularly during an influenza epidemic. The most important group is that of absentees from their villages during both MDA rounds.

Side reactions of DEC: No drug reaction observations were carried out during the first MDA. During the second MDA, drug reactions studied by the authors are shown in Table 3.

TABLE 3. Study of reactions due to DEC during the second MDA in the villages of Nofoalii, Pesega and Lepea

Month of drug administration	Size of sample	REACTIONS					
		Fever	Rashes	Abocess	Enlarged glands	Swelling of limbs	Hydrocoele
First	2761	23	43	3	7	1	2
Third	2403	11	21	0	2	0	1
Sixth	2008	3	2	0	1	0	0

2.3 Results of blood surveys

2.3.1 Special study areas before treatment

Four villages, namely Falevao, Lalomauga, Solosolo and Toamua were blood-surveyed by examining 20 mm³ blood from each person. The results showed an mf rate of 22.7%, 23.5%, 19.1% and 21% respectively.

Out of 2862 persons, 2077 were examined, of whom 439 were mf positive (21.1%). There were 1009 males examined, of whom 230 were positive (22.7%); and 1068 females were examined, of whom 209 (19.56%) were positive.

The youngest mf positive was a child, three years old. From the age group 65 years and above there were 15 males of whom 23 were positive. Out of 25 females in this age group, 10 were positive. The average mf density was 53.9 per positive; the MfD 50 value was 19.

2.3.2 Country-wide blood surveys before treatment in 21 villages

Out of 10 129 persons examined, 1931 were found positive (19.06%). Of 4957 males examined, 1051 (21.20%) were positive. Of 6 222 females examined, 880 (14.14%) were positive, showing a 3:2 ratio of preponderance of male positives. The average mf count per positive was 57.9 and the MfD 50 value was 21.40 for males above the age of 35 years and 30 for females over the age of 50 years.

2.3.3 Mid-treatment surveys (First MDA)

Six months after the first MDA, a total of 18 717 persons were examined within the following six months. 262 (1.39%) were found positive. 174 out of 9989 males (1.74%) and 88 out of 8728 females (1.0%) were found positive.

2.3.4 Post-treatment blood survey in special study areas

Blood surveys in 1967 in the special study areas showed 42 out of 2237 persons positive, a reduction of the microfilaria rate from 21.13% to 1.87%.

2.3.5 Country-wide after treatment blood surveys

These surveys were carried out from 1967 onwards except in 1970 and 1971. In 1968, the sample of blood taken from each persons was increased from 20 mm³ to 60 mm³. (A correction factor was worked out theoretically but never applied, except for the results of 1969 examinations.) The reasons for the change of volume of the blood was that the microfilaria density was greatly reduced after the drug administration. When the surveys were also meant to find residual mf positives for follow-up treatment, it was necessary to increase the volume of blood.

The mf rate reduced from 19.06% to 1.62% after the first round MDA and to 0.24% in 1972 after the second round. Thereafter, there was an apparent increase in the mf rate, especially in 1974 when the rate rose to 2.12%. Detailed data of blood surveys carried out during 1965-1976 are shown in Table 4, and mf densities before and after MDA in Table 5.

TABLE 5. Mf densities before and after MDA are given below:

		<u>Per positive</u>	<u>Per person examined</u>
Before treatment	(per 20 mm ³ blood)	57.9	19.00
After 1st MDA	(" ? " ")	13.3	0.21
After 2nd MDA '72	(" 60 " ")	88.06	0.21
1973	(" 60 " ")	4.71	0.06
1975	(" 60 " ")	41.79	0.88
1976	(" 60 " ")	30.95	0.46

(N.B. The authors stated that commencing 1968, 60 mm³ blood films were sampled, but no date was given to show whether the level of density was recorded before or after sampling of 60 mm³ of blood. From the data given in the Plan of Operations of 1976, it appears that these records were obtained one year after completion of MDA, i.e. 1967 when 20 mm³ of blood were still continued to be sampled.

According to the authors, the above results indicate the interference in the reduction of mf densities by the influx of untreated persons, some of whom had very high mf counts. From the regression lines of the cumulative distribution of the mf density drawn by the authors, the MfD₅₀ that can be depicted for the pre-control, post-MDA I and post-MDA II (Jan 72-June 73) respectively were about 19.6 per 20 mm³ blood and about 10 per 60 mm³ blood.).

TABLE 4. Microfilaria rates among blood surveyed population in
Western Samoa - 1965 - 1976

YEAR	No. examined			No. Microfilaria Positive			Percent			Positive Total	Remarks
	Males	Females	Total	Males	Females	Total	Males	Females			
1965	4957	6222	10129	1051	880	1931	21.20	14.14	19.06		Prior to first MDA 20 cm.
1966	9989	8728	18717	174	88	262	1.74	1.00	1.39		Mid-treatment
1967	21663	21034	42697	454	241	695	2.10	1.15	1.62		Post-treatment (First MDA)
1968	11526	10047	21573	253	99	352	2.19	0.99	1.63		Commencement of 60 cm. sample
1969	5144	5315	10457	172	64	236	3.34	1.20	2.26		
1970	No			SURVEYS							
1971	No			SURVEYS							Second MDA
1972*	3156	3505	6361	11	4	15	0.35	0.11	0.24		(Post-treatment. Second MDA)
1973*	2441	2704	5145	5	2	7	0.20	0.07	0.14		
1974*	14434	15838	30272	77	23	100	0.05	0.15	0.33		
1975*	5336	6163	11499	168	76	244	3.15	1.23	2.12		
1976*	1532	2117	3649	26	26	52	1.70	1.22	1.43		

* Conducted by the National Staff.

2.4 Clinical surveys

The authors indicated that they had no opportunity to conduct clinical surveys prior to the control campaign nor did the project conduct such surveys. The clinical surveys were begun at the end of 1966. Thus there are no comparative data to indicate the regression of the clinical manifestations under the DEC mass drug administration. The post-treatment data of the prevalence of hydrocele and elephantiasis are shown in Table 6.

TABLE 6. Hydrocele and elephantiasis cases found during clinical surveys
1967-1969

Year	Elephantiasis			Hydrocele		
	No. examined	No. of elephantiasis	Percent	No. examined	No. of elephantiasis	Percent
1967	21 883	289	1.32	2 386	101	4.06
1968	9 155	162	1.76	4 123	146	3.54
1969	2 331	42	2.80	995	32	3.21
Total	33 369	493	1.48	7 604	279	3.67

Chyluria is rare. Only 4 cases were seen between 1967 and 1969.

The youngest age for hydrocele was a male, aged 17 years, and the youngest age for elephantiasis was a male, aged 26 (elephantiasis of left leg and left hand).

2.5 Microfilaria positive case-finding and treatment

The authors emphasized that after two rounds of MDA, residual mf positives remained. Whether they were positive in spite of complete or incomplete treatment (drug failures) was not known as follow-up history taking was very poor. There were also those who either never took the drugs during both rounds of MDA, or were out of the country during these campaigns. Such people who had been microfilaria positive remained so for many years. They should not be confused with drug failures. It was hoped to treat these mf positives when found during surveys, but due to administrative difficulties, many of them remained untreated. If only proper treatment could be made on these residual mf positive cases, there would not be as high a residual positive rate as there is now.

(199) Merlin M., Carme, B.,
Kaeuffer, H. & Laigret, J.

Activité du levamisole (solaskil)
dans la filariose lymphatique à
Wuchereria bancrofti (var. pacifica)
Bull. Soc. Path. exot., 69, 257-265

Since "Levamisole" (L Tetramisole) is known to be an antihelminth drug, it was decided to try it in a small scale trial for treatment of mf carriers of subperiodic W. bancrofti. Ten positives were selected from those screened in routine surveys. The dose given to each was 6 mg/kg per day for three days. The 10 persons were followed up by sampling 5 blood smears of blood 20 mm³ each from finger pricks at 15, 30, 60 and 90 days after treatment and side-effects were recorded.

The results were compared with previous observations on 8 positives given a single dose of DEC of 6 mg/kg and a control group of 8 positives left untreated.

A 6 mg/kg daily dose of levamisole was given during three days to ten carriers of W. bancrofti in Tahiti.

No action against adult worms was noticed. The immediate microfilaricide action was at least equivalent to the action of DEC.

However, the decrease of microfilaremia was not so long with Levamisole than with DEC given to a lower dose.

Lastly, the amount of reactions after a treatment by levamisole is notable.

(200) Moreau, J.P. & Picq, J.J.
1976

Chimiothérapie des filarioSES lymphatiques
applications pratiques et données récentes
Med. Trop., 36, 373-377

The authors made a comprehensive review of literature on the chemotherapy of human filariasis, from the time of discovery of DEC until recent attempts made to test some drugs with antifilarial activity or with new compounds in animal models and in man.

1. Mass DEC campaigns: A review was made on the different regimens given and the side reactions observed in several countries and areas in the Pacific Region, namely in Tahiti, Kessel, 1957 (68); Laigret et al., 1965 (110); Outin-Fabre et al., 1972 (152); Saugrain et al., 1972 (154); and in American Samoa, Kessel et al., 1970 (132). Reference was also made to the experience obtained from mass campaign with DEC against W. bancrofti as was reported from Ryukyu islands in Japan (Sasa, M., 1967)¹ and to the observations made with DEC in Malaysia (Wilson, 1969)² against B. malayi.

¹Sasa, M. (1967) Bull. Wld Hlth Org., 37, 629-250

²Wilson, T. (1969) Bull. Wld Hlth Org., 41, 324-326

2. DEC medicated salt: The experience of control of bancroftian filariasis with DEC added to cooking salt as tried on mf carriers (prisoners) is cited, namely Hawking (1967)¹ who gave DEC in salt at concentrations of 0.1, 0.2 and 0.4% and obtained better results than in the case of administering DEC tablets; and Davis & Bailey (1969)² who gave mf carriers in Tanzania daily salt intake containing 0.1% DEC at a dose of 14 mg DEC to each person for 6 months, i.e. a total 2.52 g (or 42 mg/kg for a persons weighing 60 kg), resulting in a reduction of 90% in the microfilaraemia. The authors also quoted a field trial with medicated salt in India (Sen et al., 1974)³, where 140 mf carriers of W. bancrofti were given a daily dosage of salt containing 0.25% DEC for 11 weeks. The tolerance of this dosage was found to be good and the reduction in the microfilaraemia reached 83%. However, mosquitos fed on some persons found positive during the treatment could develop the parasite to the infective stage larvae.

3. The mode of action of DEC: After reviewing several papers, the authors deducted that the mode of action of the drug is not well known and it appears that the microfilariae would go the internal organs where they would be attacked by macrophages. DEC does not show activity in vitro against microfilariae nor the infective stage larvae, and the drug has no action on adult worms in vivo.

4. Other antifilarial drugs: The authors reviewed a few papers on suramin dealing with its testing against Onchocerca volvulus and W. bancrofti. Regarding the latter, they referred to the work of Thooris (1956)⁴ in French Oceanica, giving 1 gm of the drug intravenously at weekly intervals for 7 weeks. A reduction of 20% in the microfilaria was obtained at the end of the treatment and progressively the reduction reached 95% after one year. Nevertheless, administration of the drug by this method should be reserved for cases of severe and repeated attacks of lymphangitis. The authors further cited the experience with the arsenic compound, Mel W, indicating that it was abandoned due to two deaths from encephalopathy.

5. Testing new drugs:

In experimental animals: The authors referred to some papers dealing with preliminary screening of some compounds in experimental animals, such as derivatives of piperazine, tetramisole, metrifonate, suramine through subcutaneous injection, nitrofurantoin and some new arsenic compounds. These trials would be useful for B. malayi but a suitable animal model for W. bancrofti is a long standing hope.

¹Hawking, F. (1967) Bull. Wld Hlth Org., 37, 405-414

²Davis, A. & Bailey, D.R. (1969) Bull. Wld Hlth Org., 41, 195-208

³Sen, A.B. et al. (1974) diethylcarbamazine medicated salt in the chemotherapeutic control of filariasis due to W. bancrofti in an open community. Indian J. med. Res., 62, 1181-1189

⁴Thooris, G. (1956) Le traitement expérimental de la filariose à W. bancrofti en Oceanie française par la suramine (naphuride de sodium). Bull. Soc. Path. exot., 49, 311-316

In man: The authors quoted some trials with L-tetramisole (levamisole) namely those of Zaman et al. (1973)¹ and Moreau et al. ((1975)² and with mebendazole, Chantin et al. (1957)³. Of these compounds tested in experimental animal and man only L-tetramisole which has a wide spectrum antihelminthic action showed interesting activity against human lymphatic filariasis.

- (201) Pichon, G., Prod'hon, J.
& Riviere, F.
1976
- Influence de la "surdispersion" et
de l'état sexué sur la dynamique des
populations de parasites
Institute de Recherches médicales
"Louis Malarde", Papeete-Tahiti,
document réf. no. 106/IRM/J.S, 5 pp
(unpublished)

The authors follow on from their findings of 1975 (188) referring to the phenomenon of overdispersion as defined by Crofton (1971 a & b)⁴. They also referred to another important characteristic (no 5) in the dynamics of transmission of the human parasitic helminths which is the probability of the two sexes of the nematode to meet and mate in the human host. This probability is assumed to diminish rapidly when the parasite density is very low and on the basis of this, projects aiming at eradication of filariasis have been operating and searching for a critical level below which the parasite population spontaneously disappears. Reference was also made to Macdonald (1965)⁵ who determined the importance of the sexual status in helminths on the assumption that both sexes of the parasite are distributed at random. From this, the authors reanalyzed the data of Macdonald and arrived at the following conclusions:

¹Zaman et al. (1973) Treatment of W. bancrofti with levamisole (correspondence). Trans. roy. Soc. trop. Med. Hyg., 67, 610

²Moreau, J.P. et al. (1975) Activité du lévamisole dans la filariose de Bancroft. Evolution de la microfilarémia au cours d'une cure de 12 jours et après en recul de 45 jours. Med. trop., 35, 451-455

³Chantin, L. et al. (1975) Bull. Soc. Path. exot., 68, 198-204

⁴Crofton, H.D. (1971) a. A quantitative approach to parasites.
Parasitology, 62, 179-193
b. A model of host-parasite relationships.
Parasitology, 63, 343-364

⁵Macdonald, G. (1965) The dynamics of helminth infections with special reference to schistosomes. Trans. roy. Soc. trop. Med. Hyg., 59, 489-506

The distribution of the parasites in their hosts generally shows a variance value much superior than that which can be observed with a random distribution. The influences of the theoretical phenomenon termed overdispersion on the probability of the male and female parasite to meet and mate has been investigated comparing the results obtained with Poisson distribution and those which were obtained by applying the negative binomial distribution. It was shown that overdispersion tends to confer to a great stability on the parasite population.

- (202) Pichon, G., Prodhon, J., & Riviere, F.
1976 a
Hétérogénéité de l'ingestion des parasites sanguicoles par leurs vecteurs:
description quantitative, interprétation et conséquences
Note No 357/IRM/J 5/Projet de note,
Papeete
28 juin 1976 (Unpublished document)

The authors following on from their experimental observations of 1975 (187 & 188) regarding the difficulty in understanding and interpreting the heterogeneous distribution of the microfilariae ingested by the vector, discussed the various experiences and theories made in this respect. Even when the experimental conditions were homogeneous (vectors feeding simultaneously on the same subject), the variance of the observations was not equal to the mean. These two parameters should be equal if the distribution was random. Interpretations made by other workers were briefly reviewed. The experimental work followed that described by the authors (1975) (loc. cit.). Mathematical manipulation of data of the experimental observations and other vector parasite couples, led the authors to confirm that the distribution of the microfilariae ingested by a vector population on the same host at the same time, and whatever the vector susceptibility to infection may be, follows a geometric law, which could arise from the retardation of the microfilariae in the capillaries. This retardation could be sufficient to produce such distribution. The influence of this factor must not be overlooked considering that a microfilaria is 200 μ long and 6-8.5 μ wide and it has to go through capillaries of 10 μ in diameter as also noted by Hairston & Jachowski, 1968 (121) quoting from McCarthy, 1956 (60) and Burton (1964)¹.

¹Burton, G.J. (1964) Ann. trop. Med. Parasit., 58, 333-338

(203) Pichon, G., Merlin, M.,
Fagneaux, G., Rivière, F.
& Laigret, F.
1976 b

Etude de la distribution des densités
microfilariaennes dans les foyers de
filariose lymphatique
Institut de Recherches médicales
"Louis Malardé", Papeete-Tahiti,
document No 196/IRM/J 5. 20 pp
(unpublished)

The author referred to the importance of evaluating the reservoir of microfilaraemia for appreciating the progress of a filariasis control scheme. In highly endemic zones, classically systematic examination of the peripheral blood is carried out by taking calibrated samples of the size of 10, 20, 40 or 60 mm³ blood for making thick smears. It has been commonly observed that within a focus the density of microfilariae varies greatly from one individual to the other, sometimes exceeding 2000 mf per 20 mm³ blood. Previously, comparison of data had been difficult because each worker used different criteria for delivering an index for the microfilaria density such as the arithmetic mean of mf count per person examined or per positive, or on the basis of the geometric mean or the median count.

The authors critically reviewed the different experiences obtained with the method proposed by the Expert Committee on Filariasis, 1967 (Abstract No 119) for estimation of MFD 50 from log-probit regression line of the cumulative frequency of microfilaria density. Also the review covered the application of the negative binomial distribution, which was applied in some parasitic helminths by other workers and in W. bancrofti by Hairston & Jachowski, 1968 (121). Searching for a suitable negative binomial/theoretical model, the authors found the method of truncated negative binomial to be most suitable and applied on the detailed data of French Polynesia collected during 1950-1964, indicating that all the villages from which the data were utilized were subjected at least once to DEC treatment from 1954 onwards. The authors' conclusions are summarized in the following:

The pattern of W. bancrofti mf density in capillary blood, to a community level, is significantly different from a log-normal distribution. A good fit is obtained with a truncated negative-binomial law, the k exponent of which is estimated to be 0.3. This value does not seem to be affected by the endemic level, by microfilaricide mass-treatment or by the blood-samples volume. A table and a diagram are of interest on this model: given the MFD₅₀, one can evaluate the detection rate, and the optimum blood-sample volume.

These results, likely to apply to other important parasitic diseases, should encourage elaborated statistical research.

(204) Ramalingam, S.
1976

An annotated checklist and keys to
mosquitos of Samoa and Tonga
Mosquito Systematics, 8, 298-318

A historical review is given of the work done on the mosquitos of Samoa and Tonga. A total of 15 species belonging to the genera Aedes, Culex, Coquillettidia and Toxorhynchites is known to occur in the area, 13 species in Samoa and 8 in Tonga. Information for each species is provided with respect

to the original description, stages described, biology and distribution. Where necessary, a taxonomic discussion is provided. Keys for the identification of adults, male genitalia, pupae and larvae are provided.

(205) Ramalingam, S. & Belkin, J.N.
1976

The immature stages of Aedes (F.)
samoanus and the status of
Toxorhynchites in American Samoa
Mosquito Systematics, 8, 194-199

In introducing this paper, the author made a useful historical review of the status of members of the Ae. kochi group. Aedes (F.) samoanus (Gruenberg, 1913) was described from four females collected at Apia, Western Samoa. At that time it was the only member of the kochi group from Samoa until Belkin, 1962 (97) described Ae. (F.) oceanicus. Subsequently a third species, Ae. tutuila Ramalingam & Belkin (111) was added to this group. The bionomics and vector status of this species were described by Ramalingam & Belkin, 1964 (105) and Ramalingam, 1968 (125). The larval description attributed in the past to Ae. samoanus by Stone & Bohart (1944)¹ and Marks (1947)² is actually that of Ae. oceanicus. The description of the larvae and pupae of Ae. samoanus remained unpublished. From collections made by the authors in Samoa and Tonga in the 60's, a large number of these stages and about 60 individuals reared, a detailed description has been made for the larvae and pupae of Ae. samoanus.

On Toxorhynchites the authors made a historical review of its introduction during the 50's into American Samoa from Hawaii in the hope of controlling Ae. polynesiensis. In 1955 two species were introduced, T. brevipalpis (Theobald 1901) and presumably T. splendens (Weidemann, 1819). Peterson, 1955 (61) reintroduced these two species but did not observe their long-term effect. Extensive collections made in 1963 revealed that neither T. brevipalpis nor T. splendens occurred in American Samoa. Instead, T. amboinensis (Doleschall, 1857) was found to be quite common. It was explained that T. brevipalpis either disappeared by itself or as a result of competitive displacement by T. amboinensis. The introduction of T. splendens was apparently a misidentification of T. amboinensis. This was confirmed by Belkin who examined specimens from the Hawaii colony and the misidentification of Toxorhynchites in Hawaii was reported by Steffan (1968)³ and (1975)⁴.

¹Stone, A. & Bohart, R.M. (1944) Studies on mosquitos from the Philippine Islands and Australasia (Diptera, Culicidae). Proc. entomol. Soc. Wash., 46, 205-225

²Marks, E.N. (1947) Studies of Queensland mosquitos. Part I. The Aedes (Finlaya) kochi group with description of new species from Queensland, Bougainville and Fiji. Queensl. Univ. Pap. Dep. Biol., 2, 66 pp

³Steffan, W.A. (1968) Hawaiian Toxorhynchites (Diptera: Culicidae). Hawaii. entomol. Soc. Proc., 20, 141-155

⁴Steffan, W.A. (1975) Systematics and biological control potential of Toxorhynchites (Diptera: Culicidae). Mosquito Systematics, 7, 59-67

T. amboinensis breeding mainly in leaf axils of taro apparently had little effect on Ae. polynesiensis which does not utilize this type of breeding place. The only species breeds in this leaf axil is Ae. oceanicus but its larval density in this site always remained very high. The authors thus concluded that although T. amboinensis has been able to establish itself in American Samoa, it has not been successful as a biological control agent in suppressing the population density of a single mosquito species.

(206) Sasa, M.
1976

Human Filariasis. A Global Survey of
Epidemiology & Control
University Park Press, Baltimore, London,
Tokyo, 819 pp

This is a textbook on filariasis which covers all filarial infections in man due to Wuchereria bancrofti, Brugia malayi, Loa loa, Dipetalonema perstans, D. streptocerca, Mansonella ozzardi and Onchocerca volvulus.

For each of these infections, the author gives the geographical distribution, a description of the adult parasite, microfilariae, pathology, symptomatology, diagnosis, vectors, treatment and control. Where applicable the available information on morphological forms, physiological races and ecological types of major filarial infections as well as records of Brugia species in man and animal are cited.

A special section is devoted to mosquito vectors of human filariasis discussing vector-parasite relationships, filarial races and main mosquito vectors and their control.

Likewise a section is devoted to simuliid vectors of onchocerciasis, their bionomics, species complexes and Simulium control measures previously and currently applied.

By region and by country a wide review of literature is made covering the past and present situation of the disease epidemiology, vectors and the results of control efforts.

A special chapter is devoted to methodology of filariasis study and control comprising the following topics:

Methods for survey and control of filariasis

The dynamics of transmission of filariasis
Epidemiological survey methods of human populations
Entomological survey methods of vector populations
The control of filariasis
Properties of main chemicals to be used for the control of filariasis

Analysis and evaluation of filariasis survey data

Statistical methods in the epidemiology of filariasis
Comparison and evaluation of the rates
Analysis of the microfilaria density
The efficiency of detection of microfilariae
The infectivity potential of human populations
Analysis of the microfilarial periodicity
Methods for evaluation of filariasis control programmes

Experimental methods of filariasis studies

Experimental filariasis in laboratory animals
Experimental chemotherapy
Experimental immunology

(207) Suzuki, T.
1976

Final report of Intercountry
Filariasis Team (ICP/MPD/004)
WHO unpublished report
This report should be read in
conjunction with Maung (1974a)
Abstract No. 169

1. Western Samoa

The first round of mass drug administration began in 1965 with 18 doses of DEC given at a dosage of 5 mg/kg once a week for six weeks, followed by once a month for twelve months.

The mf rate prior to control was 19.1%. The infection rate in the principal vector Ae. polynesiensis was 8.35% and infective rate, 2.95% as determined by Ramalingam in 1964. After the first round, the mf rate dropped to 1.63%. Infective rate in mosquitos dropped to 0.08%. By 1969, the mf rate had increased slightly to 2.26%.

A second round commenced in 1971 giving the drug once a month for twelve months at a dosage of 6 mg/kg.

1.1 Post-control entomological studies

During the period 1972-1975, a total of 2513 Ae. polynesiensis collected from Upolu Island were dissected for filarial infection. In the village of Solosolo three mosquitos collected in September 1972 were reported to harbour six larvae of all stages (two mosquitos with infective stage larvae). Also in September in Aleisa two mosquitos were reported to harbour seven larvae of all stages and one with three infective stage larvae. As these larvae were not species identified by any authoritative source, there is doubt as to their being W. bancrofti larvae.

Should those larvae be W. bancrofti, then the overall infection rate of Ae. polynesiensis during the period 1972-1975 would be 0.24% (6/2513), and infective rate, 0.12% (3/2513).

1.2 Aedes aegypti survey and control

Ae. aegypti surveys were conducted in a village of Tanumalala in 1972, in Apia Town in 1973 and in 9 localities in June-July 1975, by single-larva-per-container survey method.

The Breteau index was 146.7 in Tanumalala, and 6.0 in Apia in 1973. In 1975, the indices ranged between 20.0 and 214.3, the highest being in Apia.

Although sporadic cases of dengue fever have been reported since March 1975, the outbreak appeared to have started in Savaii Island in mid-July 1975. It spread to Upolu Island, mainly in Apia Town. Following the outbreaks in Savaii, two vector control teams were organized in early August. In addition to the application of Abate and disposal of unnecessary water containers, 5% malathion solution with kerosene was applied by fogging machines, mainly inside houses, and ULV grade malathion by Holder machines, mainly around the houses.

A tentative analysis of the expense of the vector control activities during the period 7 August to 6 September 1975 was made. The total cost per capita was WS\$ 0.049 (equivalent to US\$ 0.082).

2. American Samoa

The epidemiologist paid a visit to this area in November 1973 to review the filariasis control operations and to advise on future plans (see Maung, 1974, loc. cit.). The entomologist visited the area in June and September 1975 to make an Aedes survey and to advise on control plans for dengue fever.

From the Aedes survey made in June 1975 the Breteau index in the village of Pagopago was 10.1.

An outbreak of dengue fever occurred in July 1975, with 131 clinical cases. The first round of vector control was started in July and completed in the middle of August. A ULV application of malathion was made by Fontan machines inside and outside each house. Abate 1% sand granules were applied as a supplementary measure. After the first round of insecticiding, the Breteau index dropped to 0 at the beginning of September in Pagopago village.

3. Ellice Islands

Filariasis control in the Ellice Islands commenced in 1972 (see Maung, 1974, loc. cit. for the results of the parasitological/clinical surveys).

3.1 MDA was conducted using diethylcarbamazine citrate at a dosage of six mg/kg, once a week for 12 weeks followed by once a month for 12 months (a total of 24 doses).

The MDA was first commenced in Funafuti in July 1972, and then to all the islands. Administration was carried out by the island women's volunteers. Mid-and post-control entomological assessments were carried out. In October 1972, when 12 weekly doses had been administered, one Ae. polynesiensis with two first stage larvae was found after dissecting 301 mosquitos (0.33%). The post-control assessment in February 1974 revealed no infected mosquitos after 444 dissections.

3.2 Aedes survey and control

A single-larva-per-container survey of Aedes aegypti was carried out and Breteau indices determined: in June 1972 in Funafuti, 53.8; in October in Vaitupu, 78.0; in February 1974 in Nukulaelae, 47.8.

Abate 1% sand granules were applied to containers at a dosage of 1 ppm in Funafuti and Nukulaelae in February 1974.

In Funufuti, 26 containers (19.3%) out of 135 were found harbouring Ae. aegypti larvae 9 1/2 weeks after application.

In Nukulaelae, two drums (6.9%) out of 29 containers were found harbouring Ae. aegypti larvae two weeks after application.

It was confirmed that most of the containers with larvae had been thoroughly washed by the owners during the test period.

4. Niue

A preliminary visit was made to Niue by the epidemiologist in April 1971, on the request of the Director of Health Services, Niue. After studying the situation (no 5) a plan of operation was drafted to commence a filariasis control programme in July 1972.

The team visited Niue in August 1972 (see Maung 1974 for the results of parasitological/clinical surveys, loc. cit.).

MDA was conducted in June 1972 on the same basis as the Ellice Islands.

During the surveys in August 1972, Ae. aegypti larvae were found in Niue for the first time not only in urban areas but also rural villages. They were found in water receptacles for household use and in artificial water containers such as canoes and bowls.

(208) Suzuki, T. & Sone, F.
1976

Breeding habits of vector mosquitos
of filariasis and dengue fever in
Samoa
Unpublished report to WHO. A
summary of the detailed unpublished
report was processed as
WHO/FIL/77.144 (WHO/VBC/77.658)

1. Methods

In most surveys twenty to thirty (or sometimes more if there are enough) third or fourth stage larvae were collected from each breeding site. In leaf axils of plants those collected from one bundle of the same kind of plant were usually pooled in a bottle.

Efforts were concentrated to collect larvae from water containers near residential areas or plantations; those breeding either in containers located far from human activities or in non-container habitats were rarely collected. Sometimes no collections were made from the very common habitats of Aedes larvae such as coconut shells even if they were found. Therefore, the number of breeding sites shown in Table 1 does not reflect the frequency of the positive sites in the country.

Special surveys were made on water-collecting drums and leaf axils of the Pandanus plant, the results of which are shown in Table 2 and 3 respectively.

A special survey of crab holes was made in six coastal villages of Upolu and Savaii Islands. About two litres of water (if water was less than two litres, as much water as could be collected) was pumped up from each hole with a plastic tube connected to a bottle and a suction pump. Water was more easily pumped up when the tide was high because the water level in the hole fluctuates with the tide. The distance from the ground surface to the water level was usually from 30 cm to 1.8 m when measured along the crooked hole.

2. Results

A total of 70132 were collected from 876 breeding sites. During the survey, the following ten species in three genera were found.

<u>Ae. (Stegomyia) aegypti</u>	<u>Ae. (F.) oceanicus</u>
<u>Ae. (S.) polynesiensis</u>	<u>C. (Culex) pipiens fatigans</u>
<u>Ae. (S.) upolensis</u>	<u>C. (C.) annulirostris</u>
<u>Ae. (Finlaya) samoanus</u>	<u>C. (C.) sitiens</u>
<u>Ae. (F.) tutuilae</u>	<u>Toxorhynchites (T.) brevipalpis</u>

2.1 Breeding habits and distribution of Stegomyia mosquitos

In Western Samoa, the larvae of Aedes (Stegomyia) mosquitos breed in artificial and natural containers or collections, but rarely in leaf axils of plants. It can be concluded that Ae. aegypti prefers artificial containers, especially drums, tyres and motor parts in the close proximity of houses. They were found all over the country, not only in the populated and civilized town area such as Apia, but also in the rural and inland areas of Savaii Island.

Ae. polynesiensis seems to be flexible in its breeding habits. It was found in a wide range of both artificial and natural containers, but the preferential breeding places were natural containers. It is the only species breeding in crab holes, and is the predominant breeder in tree holes, coconut shells, rock holes, canoes and tin cans. It was also collected from leaf axils of Pandanus and taro plants, but in small numbers.

Adult density of Ae. polynesiensis is rather high all over the country, except in the inland high altitude areas far from human activities, where neither artificial containers nor coconut trees are present. Its density is extremely high in the coastal areas with positive crab holes, sometimes reaching the density of 400 to 500 mosquitos per man-hour on human bait. In such areas, crab holes may play a major role producing the adult population of Ae. polynesiensis.

Unlike the other two Stegomyia, Ae. upolensis larvae were rarely collected, partly because the present collections were made mainly in the close proximity of human activities. This species is undoubtedly a forest mosquito. The role of Ae. upolensis in actual transmission of the filariasis is open to question, since man-mosquito contact might be much less than Ae. polynesiensis or Ae. samoanus.

2.2 Breeding habits and distribution of Finlaya mosquitos

In Western Samoa, all the three Aedes (Finlaya) mosquitos are exclusive breeders in leaf axils of plants, and each species has their favourite plant(s). Ae. samoanus is the only species breeding in Freycinetia axils. It also breeds in Pandanus axils, but abundantly only on Upolu Island. Ae. tutuilae larvae breed only in Pandanus axils, preferring young axils located in the upper part of the plant. This species is the minority of the three Finlaya mosquitos. Ae. oceanicus larvae breed in taro, pineapple and Pandanus plants.

Pandanus axils harbour, in general larvae of three Finlaya mosquito species, i.e. Ae. samoanus, Ae. tutuilae and Ae. oceanicus. However, the breakdown of the three species in the axils is geographically inconsistent.

Ae. samoanus larvae were found predominantly in the Pandanus axils of Upolu Island, constituting 74.0% of the total larvae collected. In Savaii Island, only 4.4% was Ae. samoanus and Ae. oceanicus was predominant (77.2%). In addition, in the northern parts of Savaii, no Ae. samoanus larvae have ever been collected from the axils so far; and in the eastern and southern Savaii, Ae. samoanus larvae were present in the axils, but much less than Ae. oceanicus larvae. In the two small islands of Apolima and Manono, which are located between Upolu and Savaii, no Ae. samoanus larvae were collected from the axils, Ae. oceanicus being predominant.

In Tutuila Island of American Samoa, which is located east of Upolu, it was reported by Ramalingam (125) that Ae. oceanicus larvae were never collected from Pandanus axils, although they were abundant in Freycinetia axils.

Therefore, the distribution of Ae. samoanus larvae in Pandanus axils seems geographically not gradual but patchy; that is, from east to west, negative in Tutuila, positive and predominant in Upolu, negative both in Manono and Apolima, positive but scarce in the southern and eastern parts of Savaii, and negative in the northern parts of Savaii.

2.3 Role of Freycinetia and Pandanus axils in producing adult population of Ae. samoanus

As far as larvical application concerns, it is essential to know what habitat plays a major role for producing adult population.

The following observations on the density of female Ae. samoanus are given:

- (1) High density of Ae. samoanus was observed in inland villages which are located more than 100 metres away from the coast, than in coastal villages. Average density of Ae. samoanus per man-hour was 61.0 in 47 stations of coastal villages; and 169.8 in 37 stations in inland villages.
- (2) High density of Ae. samoanus was also observed in the stations close to forests, than those far from the forests. Average density per man-hour was 159.5 in 54 stations less than 500 m away from forests; and 17.9 in 30 stations more than 500 m away from forests.
- (3) Although no or scarce breeding of Ae. samoanus was observed in Pandanus axils of Savaii Island, density of Ae. samoanus was higher in Savaii, which is covered, in general, by more dense forests than Upolu Island. Average density per man-hour was 502.3 in 14 stations of Savaii, while 108.9 in 84 stations of Upolu.
- (4) Even in the northern parts of Savaii, where no Ae. samoanus breeds in Pandanus axils, high density of Ae. samoanus was recorded.

Taking the above observations into consideration, it can be presumed with reasonable certainty, if not definitely, that for producing adult population of Ae. samoanus, Freycinetia might play a major role, at least in the areas less than 500 m away from forests. Unfortunately, most of the villages of Western Samoa are located in the above-mentioned areas. It should be pointed out that Freycinetia axils are one of the most difficult habitats to be treated by larvicide, because the plant grows in forests and the axils are found as high as 20 m above the ground.

Table 1. Prevalence of mosquito species in various habitats of Western Samoa

Habitat	No. of sites with larvae	No. of larvae collected	<u>Ae. poly-</u> <u>nesi-</u> <u>ensis</u>	<u>Ae. negy-</u> <u>pti</u>	<u>Ae. upol-</u> <u>ensis</u>	<u>Ae. samo-</u> <u>anus</u>	<u>Ae. tutu-</u> <u>ilae</u>	<u>Ae. ocea-</u> <u>nicus</u>	<u>Culex</u> <u>spp.</u>
Artificial water containers and collections									
Drum	113	6582	779 (11.8%)	3479 (52.9%)	0	0	0	0	2324 (35.3%)
Tyre and motor parts	37	4622	1110 (24.0%)	1066 (23.1%)	0	0	0	0	2446 (52.9%)
Canoe	6	695	488 (70.2%)	0	0	0	0	0	207 (29.8%)
Tin can	10	231	226 (97.8%)	1 (0.4%)	0	0	0	0	4 (1.7%)
Concrete pool	8	235	140 (59.6%)	0	0	0	0	0	95 (40.4%)
Miscellaneous	6	280	123 (43.9%)	0	0	0	0	0	157 (56.1%)
Sub-total	180	12645	2866 (22.7%)	4546 (36.0%)	0	0	0	0	5233 (41.4%)
Natural water containers and collections (Excluding leaf axils)									
Tree hole	162	7314*	7290 (99.7%)	12 (0.2%)	1 (0.01%)	0	0	0	9 (0.1%)
Coconut shell	40	3283	2502 (76.2%)	0	0	0	0	0	781 (23.8%)
Crab holes	59	1068	1068 (100%)	0	0	0	0	0	0
Rock hole	5	152	76 (50.0%)	0	0	0	0	0	76 (50.0%)
Miscellaneous	3	27	27 (100%)	0	0	0	0	0	0
Sub-total	269	11844	10963 (97.6%)	12 (0.1%)	1 (0.008%)	0	0	0	866 (7.3%)

Table 1. Prevalence of mosquito species in various habitats of Western Samoa
(cont'd)

Habitat	No. of sites with larvae	No. of larvae collected		Ae. poly- nesi- ensis	Ae. aegy- pti	Ae. upol- ensis	Ae. samo- anus	Ae. tutu- ilae	Ae. ocea- nicus	Culex spp.
<u>Leaf axils of plants</u>										
Pandanus	299	26899	53 (0.2%)	0	0	18557 (69.0%)	2252 (8.4%)	6037 (22.4%)	0	0
Preycinetia	18	717	0	0	0	717 (100%)	0	0	0	0
Taro	105	17914	3 (0.02%)	0	0	2 (0.01%)	0	17909 (99.9%)	0	0
Pineapple	5	113	0	0	0	0	0	113 (100%)	0	0
Sub-total	427	45643	56 (0.1%)	0	0	19276 (42.2%)	2252 (4.9%)	24059 (52.7%)	0	0

Note: * Toxorhynchites brevipalpis (2 larvae, 0.03%) were excluded from the breakdown.

Note: * Toxorhynchites brevipalpis (2 larvae, 0.03%) were excluded from the breakdown.

Table 2. Results of special survey of water-collecting drums in Western Samoa

Type of village	No. of villages under survey	No. of houses under survey	No. of houses with drum(s)	Total no. of drums	Total drums with larvae	No. of drums with larvae per 100 houses
With no pipes water supply	6	192	61 (31.6%)	344	97 (28.2%)	50.5
With pipe water supply	9	413	23 (5.6%)	39	10 (25.6%)	2.4
Overall	15	605	84 (13.9%)	383	107 (27.9%)	17.7

Table 3. Results of a whole year survey of mosquito larvae
in the 23 registered Pandanus plants

Date	No. of surveys	Total no. of larvae	Relative prevalence of each species %			
			<u>Aedes samoanus</u>	<u>Aedes tutuilae</u>	<u>Aedes oceanicus</u>	<u>Aedes polynesiensis</u>
Jul-Sept 1970	5	2775	79.1	9.2	11.7	0
Oct-Dec 1970	4	1991	83.6	11.9	4.5	0
Jan-Mar 1971	4	1491	88.3	7.9	3.8	0
Apr-Jun 1971	5	2042	94.0	2.9	3.0	0.1
Overall	18	8299	85.5	8.1	6.4	0.02

Table 4. Results of special survey on crab holes for breeding of Ae. polynesiensis larvae

Village	No. of holes	No. of holes with water	Number	Holes with larvae	
				Proportion to total holes examined	Proportion to holes with water
Mulinuu	60	25	17	28.3%	68.0%
Moataa	30	16	6	20.0%	37.5%
Vaiala	30	4	0	0	0
Samoa	6	1	0	0	0
Faailoloo	10	9	0	0	0
Lalovi	10	2	0	0	0

(209) Suzuki, T. & Sone, F.
1976 a Laboratory and field tests of
insecticides against vector mosquitos
of subperiodic filariasis in Western Samoa
Unpublished report submitted to WHO

Since this report has not been published, it has been found useful to make the following extracts involving the methods used in vector control trials and the detailed results obtained.

1. Insecticide susceptibility tests of vector mosquitos

Susceptibility tests of adult and larval mosquitos to insecticides were undertaken from 1970 to 1971 using WHO test kits, following the standard test methods recommended by WHO. DDT was tested against female Ae. polynesiensis collected in Luatuanuu - Lousoalii area of Upolu Island in 1971. The LC-50 was estimated to be 0.35%. With other Aedes larvae tested, no sign of resistance was shown. The LC-50 level of each insecticide tested was slightly lower in Ae. samoanus larvae than Ae. polynesiensis or Ae. oceanicus larvae.

2. Laboratory tests on persistence of larvicides in containers

2.1 Tests with plastic bowls under ambient weather conditions

Persistence tests of four insecticides formulations, i.e. 75% DDT wettable powder, 5% fenthion sinking granules, 5% fenthion floating granules, and 1% Abate sand granules, were undertaken under ambient weather conditions from September 1970 to March 1971. After the 28th week, the tests were terminated, due to the accidental loss of the bowls. Each insecticide was added to a plastic bowl of 1,000 ml. capacity filled with 800 ml water, together with 100 g soil, so as to give three concentrations of active ingredient, i.e. 50 ppm, 500 ppm and 5000 ppm for DDT, and 12.5 ppm, 50 ppm and 200 ppm for fenthion, but 12.5 ppm only for Abate.

The bowls were set on the ground, half-shaded by a nearby tree, in the backyard of the senior author's residence in Apia. Throughout the test period, the bowls were left in the same place. Under such conditions, the bowls were almost empty after continuous dry and hot weather, and refilled or overflowing after heavy rain, simulating containers in the field.

Fortnightly, 100 ml water, or as much water as possible, was transferred from each bowl to a glass vessel, and tested with *Ae. polynesiensis* larvae. DDT was most effective, persisting 24 weeks with 50 ppm, and fenthion both sinking and floating granules was next, persisting 10 weeks with 50 ppm, or 18 weeks with 200 ppm.

2.2 Tests of Abate sand granules in drums and buckets

2.2.1 Influence of overflow of water on the effectiveness

Twenty grammes each of 1% Abate sand granules were applied to three 44-gallon drums filled with water. The drums were allowed to stand outside the laboratory, but protected from the rain by the roof extension. In order to simulate addition of rain water under natural conditions, the following procedures were used: In Drum A, 40 litres of tap water were added gently and excess allowed to overflow, daily, from Monday through Friday (200 litres per week). Similarly, 10 litres were added to Drum B (50 litres per week), but no water was added to Drum C.

Once a week, 100 ml water was transferred from the upper surface of each drum to a glass vessel and tested with *Ae. polynesiensis* larvae. Bioassay tests were also done weekly, using field-collected *Ae. oceanicus* larvae, in order to estimate the concentration of Abate present in the water of the drums. The procedure of the bioassay was as follows: the water from the drums was diluted with tap water, so as to give mortality of *Ae. oceanicus* between 20% and 80%. Twenty-five larvae were released into the dilution, and mortality count was taken after 24 hours. Two replicates were made at the same time. Applying the average mortality to the log dosage - probit mortality regression line of Abate alcohol solution with *Ae. oceanicus*, which had been established in advance as a calibration line, the concentration of Abate which remained in the drum water was estimated.

In Drums A and B, in which water was added, more than 90% mortality was obtained till the 4th week of the application; while in Drum C, in which no water was added, more than 90% mortality was obtained at the 9th or last week.

2.2.2 Influence of rusted iron plate in the water on the effectiveness

Tests were undertaken to find out the influence of iron rust to the concentration of Abate in the water. Two plastic buckets were used: one of them was filled with 10 litres of water together with heavily rusted iron plate (about 150 g) and the other, filled with only 10 litres of water. One ppm of 1% Abate sand granules were applied to each bucket. Bioassay tests using *Ae. oceanicus* larvae were made weekly, by the same method.

Based on the estimated concentration of Abate in the bucket with no rusted plate, the average reduction of Abate concentration in the water with the rusted plate was estimated as 69% in the first week, 60% in the second week, 42% in the third week, and 58% in the fourth week.

Thus heavy iron rust reduces the effectiveness of Abate in water, the average reduction being 57%.

3. Field observations of persistence of larvicides in different types of breeding places

3.1 Persistence of DDT applied to tree holes, Pandanus and taro plants

Twenty-two positive breeding sites located along the northern coast of Upolu Island were found: 13 tree holes, two tree stumps, five bundles of Pandanus plant, and two bundles of taro plant, Alocasia sp. On 10 February 1970, 5% DDT suspension was applied to the above sites, pipetting with a dosage of 50 ppm or 500 ppm, or spraying with knapsack sprayer. Species found breeding before the application were Ae. polynesiensis in tree holes and stumps, Ae. oceanicus in taro axils, and the mixed population of Ae. samoanus, Ae. tutuilae and Ae. oceanicus in the Pandanus axils.

Observations on the reappearance of larvae were made on a fortnightly basis in the first 28 weeks, followed by once every four weeks till the 76th week after the application. Both after one year and after 1 1/2 years, the water in the treated tree holes and stumps, together with the mud on the bottom, was transferred to the laboratory and tested with Ae. polynesiensis larvae.

With DDT spray or 500 ppm application, no advanced stage larvae reappeared in the tree holes or stumps until the 60th or 76th week (the last observation). With 50 ppm application they reappeared at the 32nd week in one tree stump and after the 56th week in a tree hole; but they did not reappear until the 76th week in the other two holes. Sometimes newly hatched larvae were found in the treated holes, but no advanced stages were observed in subsequent observations.

The mortality tests of the water from the treated holes and stumps revealed that DDT remained even in the sites which dried up for several weeks. A mortality of 100% was found in all ten holes with 500 ppm application, and in one of three holes with 50 ppm, after one year; and four of five holes with 500 ppm and one of two holes with 50 ppm, after 1 1/2 years. It seems likely DDT persists longer in tree holes than in tree stumps.

In the leaf axils of Pandanus and taro plants, the larvae reappeared the 10th to 18th week after the application, much earlier than in tree holes or stumps. Prevalence of the species in Pandanus axils was different between pre-and post-control surveys. In the pre-control survey, the relative prevalence of Ae. samoanus, Ae. tutuilae and Ae. oceanicus in 304 larvae was 30.6%, 10.9% and 58.5% respectively; while in the post-control surveys, the prevalence in 1753 larvae was 17.9%, 26.8% and 55.4% respectively.

3.2 Persistence of DDT applied to crab holes

A small test was undertaken to know the persistence of DDT suspension applied to crab holes, in Mulinuu, during the period March to June 1970. Five hundred millilitres of 1% DDT suspension was poured into each of five

crab holes harbouring Ae. polynesiensis larvae. The results showed that no larvae were found in the treated holes, as long as ten weeks after the application.

3.3 Persistence of Abate applied to drums

A field test was undertaken in Tunumalala, an inland village with no piped water supply, to know the duration of effectiveness of 1% Abate sand granules applied to water-collecting iron drums (44-gallon capacity), during the period August to December 1972.

The different dosages were adopted: one application of 20 g of the granules to each of 9 drums which contained water more than half full; and the outer application of 10 g of the granules to each of 35 drums, containing water half or less than full. The former is equivalent to 1 ppm of Abate and the latter to 0.5 ppm.

Before the application, a single-larvae-per-container survey was undertaken with all the drums of the houses under test. After the application, inspection of the treated drums was made on a weekly basis till the 17th week. When larvae were found some were collected and identified. If larvae were first found in any drums, inquiries were made from the owner on whether the drums were cleaned, and if so, when it was done.

In the pre-control survey of 15 houses, 192 drums were found containing water, 44 or 22.9% of which harboured mosquito larvae. Relative prevalence was 50.0% for Ae. aegypti, 20.5% for Ae. polynesiensis and 29.5% for C. quinquefasciatus. The results showed that application of the granules to the drums at the dosage of 1 ppm was effective for at least three months; and the application of 0.5 ppm was effective for about two months.

Cleaning of the treated drums greatly reduced the effectiveness. If, once cleaned, reappearance of the larvae took place in the week following the cleaning at the earliest, and in the fifth week at the latest, the average period from the cleaning to the reappearance being 2.8 weeks.

The relative prevalence of the larvae during the post-control surveys was 56.4% for Ae. aegypti, 34.2% for Ae. polynesiensis, and 9.4% for C. quinquefasciatus. After the application, Ae. polynesiensis apparently increased at the expense of C. quinquefasciatus, but it is not possible to conclude whether the increase of Ae. polynesiensis is due to the direct effect of the application, or due to the other factors such as seasonal fluctuation.

4. Small-scale field trials on vector control

Two limited-scale field trials on vector control were undertaken: one, in April 1971 using DDT and the other in April 1972 using Abate and malathion. At the time of the trials, the whole country had already been covered by mass drug administration. Therefore, only entomological surveys were carried out but no dissection of mosquitos.

4.1 Trial by application of DDT

The trial was made in an area covering two adjacent villages, Luatuanuu and Lousoalii, located in the northern coast of Upolu Island. Main breeding sites for Ae. polynesiensis in the area were tree holes, coconut shells, drums, etc., and those for Ae. samoanus were axils of Pandanus and Freycinetia plants.

Nine hundred and fifty litres of DDT suspension were sprayed with three power sprayers to all the accessible and detectable breeding sites, as far as 300 metres away from the last house of the area, and 100 litres of DDT kerosene solution were applied with three fogging machines to all the houses and surrounding bushes.

Twenty catching stations were registered in the trial villages 12 for day-biting mosquitos and eight for night-biting ones. Mosquito collections on human bait were made on a weekly basis at the registered stations at the fixed time, during the period from eight weeks before to 14 weeks after the application. Thirty-two sites harbouring larvae were registered in the area before the application, and checked weekly till the 14th week of the application, for the reappearance of larvae.

Overall density of Ae. polynesiensis, the sole species caught in the daytime collection, was 25.4 per man-hour, in the pre-control surveys. Reduction of Ae. polynesiensis after the application, based on the pre-control level, ranged from 33% to 98%, the average being 64%.

In the night surveys, mainly Ae. samoanus, but also some other species, i.e. Ae. oceanicus, Ae. polynesiensis and C. quinquefasciatus, were collected. Overall density of Ae. samoanus per man-hour was 209.7 before control. Reduction of the density after the application, based on the pre-control level, was slight in the first four weeks, but was comparatively high on and after the sixth week. Average reduction of Ae. samoanus density from 6th to 16th week was 60%.

Through all the post-control observations on the registered breeding sites, no advanced instar larvae were detected though newly hatched larvae were found in some registered sites at the 10th week after application.

/N.B. Since no parallel observations were carried out in an untreated check area the results of this trial should not be taken as conclusive._/

4.2 Trial with application of Abate and malathion

The trial was made in Mulinuu village of Upolu Island, located at the top of a small peninsula, projecting to the sea 1.5 km long. In the area, the density of Ae. polynesiensis breeding mainly in crab holes, was extremely high, but at night there were no species although some C. quinquefasciatus were caught. A barrier zone was established between the treated area and the base of the peninsula, and Meatea village, about 3 km apart from the treated area, was selected as the check area.

Five thousand one hundred litres of 0.05% Abate emulsion (0.5 g/l) prepared from Abate 500D, were poured into the breeding sites of Ae. polynesiensis, mainly crab holes, in both treated area and barrier zone, with the target dose of 500 ml per crab hole; 250 litres of 6% malathion solution in kerosene were applied with three fogging machines to cover the whole treated area as well as the barrier zone, but not open clearance. The fogging was carried out two or three times within an interval of 2 to 3 days.

Twelve catching stations were registered, 6 in the treated area, 2 in the barrier zone, and 4 in the check area. Mosquito collections on human bait were made on a weekly basis at the registered stations at a fixed time in the morning, during the period from 4 weeks before to 11 weeks after the application.

In order to know the breeding of Ae. polynesiensis larvae in crab holes, 10 holes each were randomly checked at two stations in the treated area and one station in the check area, on a fortnightly basis from 3 weeks before to 12 weeks after the application.

The overall density per man hour of Ae. polynesiensis before application was 354.6 in the treated area, and 98.1 in the check area. One day after fogging, the density in the treated area was reduced to 19, the reduction rate being 95%, but it rose to 98 after one week and to about 130 in the second and third weeks.

/N.B. It is difficult to interpret the data after that period with sharp fluctuation in the treated and check areas for which no explanation is offered by the authors._/

Before the application, 28 out of 40 holes in the treated area were harbouring Ae. polynesiensis larvae (70%). One week after the application, no positive holes were found, but two weeks after, one of the 20 holes was found positive. The overall positive rate of the crab holes was 19.3% after the application.

/N.B. The authors do not give any observations on the effect of the insecticidal treatment on the crabs._/

- (210) Beckett, E.B.,
Boothroyd, B. &
Macdonald, W.W.
Rickettsia-like microorganisms
in members of the Aedes scutellaris
complex
Trans. roy Soc. trop. Med. Hyg., 71
109

Rickettsiae present in the gonads of Culex pipiens have been implicated in the cytoplasmic incompatibility which exists between different populations of this species (Yen, J.H. & Barr, A.R., 1971)¹. Similar cytoplasmic incompatibility is shown by members of the Ae. scutellaris complex (Smith-White, S. & Woodhill, A.R., 1954)², and the ovaries from

¹Yen, J.H. & Barr, A.R. (1971) Nature (London), 232, 657

²Smith-White, S. & Woodhill, A.R. (1954) Proceedings of the Linnean Society of New South Wales, 79, 163

four members of this group were examined with the electron microscope to see whether rickettsia-like microorganisms were present; C. quinquefasciatus was used as control. Microorganisms with the structural characteristics of rickettsiae were found to be numerous in C. quinquefasciatus, quite common in Ae. polynesiensis, less common in Ae. malayensis, rare in Ae. tabu and have not yet been identified with certainty in Ae. cooki. Electron micrographs were exhibited which showed the appearance of the microorganisms in the species in which they were found.

(211) Chow, C.Y.
1977

Filariasis studies in the
Western Pacific Region
WHO unpublished document, WPR/VBC/19

The paper briefly gives the distribution of filariasis and its vectors in the whole Western Pacific Region and summarizes studies carried out in certain countries and areas with reference to control measures undertaken by drug and/or by vector control. A note was made on the South Pacific area as follows:-

Literature on the survey and control of filariasis in the South Pacific area is considerable. The South Pacific Commission has issued several annotated bibliographies. A detailed review of the epidemiology and control of the disease was made by Iyengar, 1965 (108), Kessel & Massal, 1962 (99) respectively. More up-to-date information on the filariasis situation and control programmes has been provided by the WHO Regional Office for the Western Pacific in 1968 (235) and in 1974 (179).

Only W. bancrofti occurs in the South Pacific; a demarcation line existing between the periodic and subperiodic forms, and there appears no overlapping of the ranges of their distribution. A detailed description of mass drug administration, the only control measure, in Western Samoa is given as an example for filariasis control in the South Pacific.

Two rounds of MDA were carried out in 1965-1966 and in 1971. The mf rate dropped from 19.1% to less than 1%. However, it increased considerably in a period of 3-4 years after the completion of each round. No vector control measures were undertaken.

Since the mf rate has increased considerably after the completion of each round of MDA and it is not possible to undertake further rounds of drug distribution, it is necessary to determine what other control measures, particularly for vectors, can be undertaken. A research project is, therefore, being undertaken with a donation from the Sasakawa Memorial Health Foundation and cooperation by the Government of Samoa and the Japanese Overseas Cooperation Volunteers. The objectives are to determine the true rate of infection at present, the dynamics of transmission, and alternative feasible control methods.

(212) Engber, B. & Pillai, J.S.
1977

Toxorhynchites amboinensis as
biological control agent of vector
mosquitos
Unpublished document, 6 pp

The unpublished report presents the results of a preliminary investigation on Toxorhynchites recently carried out in Western Samoa. A review of the literature on the earlier attempts to utilize Toxorhynchites as a biological control agent in some Islands of the Pacific was given:

Paine, 1974 (10) giving an account of the successful introduction of T. splendens and T. inornatus into the Fiji islands;

Steffan, 1968¹ giving the various introductions of Toxorhynchites spp. made into the Hawaiian Islands;

Peterson, 1956 (61) describing the release of T. amboinensis (misidentified as T. splendens) and T. brevipalpis in American Samoa, but only the former species has been established, citing Ramalingam, 1976 (205).

It is probable that T. amboinensis was accidentally introduced into Western Samoa from American Samoa and became established along the northern coast of Upolu Island. The present investigations were aimed at assessing the efficiency of the larvae of this species as predators of the larvae of Ae. polynesiensis, the vector of the subperiodic bancroftian filariasis, and those of Ae. aegypti, the vector of dengue fever, bearing in mind that there has been some evidence suggesting that T. amboinensis is very effective in reducing the density of the above-mentioned species in large containers but not eliminating their breeding.

Methods and materials

Approximately 45 tyres were numbered with paint and stacked in piles of 3 and 4 around a 1/2 hectare, tree-shaded plot. Twenty tins were also numbered and scattered about the plot. Mosquito breeding was allowed to establish itself naturally in these containers and three months after introduction the first samples were taken. The tyres were divided into four groups and one group was sampled each week; this was one in sequence so that at least 28 days separated any two samples dates for a given tyre. Sampling was usually conducted on Monday. At the time of sampling the entire water contents of the tyre was removed with a pump. Water volume and temperature were recorded and the liquid poured through a fine strainer to remove all larvae and pupae. Immature stages of Toxorhynchites were usually returned to their respective tyre with a small volume of water. All other immature stages were taken to the laboratory in containers labelled to indicate the tyre of origin. In the laboratory 3rd and 4th instars and pupae were counted and identified. Smaller instars were counted only. All data were recorded on an index card for the tyre involved. A number of tyres were liberated and 36 remained to be sampled for a full year. Tins were sampled randomly and scored only for the presence or non-presence of Aedes species and/or Toxorhynchites. The total number of samples taken from 45 tyres during July 1975 - August 1976 was 438.

¹ Steffan, W.F. (1968) Hawaiian Toxorhynchites (Diptera: Culicidae). Hawaii. entomol. Soc. Proc., 20, 141-155

Results and discussion

While the breeding of Toxorhynchites in tyres was fairly high (30%), the breeding in tins was minimal. Comparison of the average number of vector larvae in tyres were Toxorhynchites positive with that of the tyres which were Toxorhynchites negative showed a reduction of slightly more than 50% in vector breeding. The authors noted that although 77% of vector breeding occurred at densities falling within the frequency intervals of 51-200 larvae, such densities occurred less than 25% of the time when any Toxorhynchites larvae were present. /N.B.: By re-analyzing the data given in this paper, the above density class occurred at an average frequency of 59% of 132 tyre samples when Toxorhynchites was present at a density ranging between 1 and 8 per positive tyre. In these 132 tyre samples this frequency showed a decreasing order from 78.6% with the increasing frequency of Toxorhynchites reaching 43.8% when the predator larvae were present at a density of 8. The data also showed that the above-mentioned density class was recorded at a frequency of 84.7% of the total number of tyre samples (306) which did not contain any Toxorhynchites. /

The authors concluded that Toxorhynchites could be an effective agent against vector species in their larval habitat, although not to be 100% effective which is the case with most of the control measures. Further work was suggested to determine the factors that influence the distribution and the choice of oviposition sites of Toxorhynchites. Also further search should be made for other species of this predator that may be suitable for controlling mosquito breeding in leaf axils and small containers. The authors advocate that the use of one or more species of Toxorhynchites combined with source reduction would be the most economical, practical, long-lasting and ecologically safe vector control measure in small islands.

(213) Huang, Y.M.
1977

The moquitos of Polynesia with a pictorial key to some species associated with filariasis and/or dengue fever
Mosq. System., 9, 289-323; also
WHO/FIL/76.143, WHO/VBC/76.654, 1976

In order to assist field workers in identifying mosquito vectors of filariasis and dengue in Polynesia, the author attempted to make the key precise and as simple as possible. To avoid confusion with very common and similar species in the area a few additional characters are given for certain species or species groups. The highly variable characters of Ae. scutellaris group make the identification of certain species extremely difficult; some can only be identified by the examination of the male terminalia. The author draws the attention of the user of the key to the importance of obtaining final confirmation and/or determination of a species from specialists particularly for new distribution records, new vector species or new species.

A map of the South Pacific area covered by the key is provided and a list of 43 species and forms is given showing 19 known or suspected vectors. Further, the paper provides lists of the species by island or island groups.

Morphological features used in identification are illustrated for guiding the examination of the specimens.

The pictorial key is preceded by a non-pictorial key to the genera, subgenera and species. Both pictorial and non-pictorial keys are presented for the adults and larvae.

(214) Owen, R.R.
1977

Differences in the migration patterns of Brugia pahangi microfilariae in susceptible and refractory members of the Aedes scutellaris group
Trans. roy. Soc. trop. Med. Hyg., 71,
110

Studies in the migration of B. pahangi microfilariae in members of the Ae. scutellaris complex have shown that it is possible to distinguish between susceptible and refractory species by analysis of the pattern of migration of the microfilariae over the first three hours following a blood meal.

In susceptible species such as Ae. polynesiensis and Ae. tabu the curve obtained by plotting the logarithmic mean percentage of microfilariae in the thorax at 30-minute intervals for three hours shows that migration continues throughout this period and, after approximately an hour, there is a constant rate of migration of $15.92 \pm 2.5\%$ per hour. Comparative studies using a susceptible (SS) strain of Ae. aegypti gave similar results; the migration rate between one and three hours post feed in the SS strain was $23.85 \pm 0.6\%$ per hour and the three-hour migration level of 80.6 (67.2-96.8) is very similar to that of Ae. polynesiensis and Ae. tabu 95.1 (86.4-100) and 88.4 (68.0-100) respectively.

In the refractory species of Ae. malayensis (Singapore strain) and the refractory hybrid from the cross Ae. malayensis Q X Ae. scutellaris the curves obtained were of the "plateau" type and indicated that migration ceases at approximately one and a half hours post feed. The levels of migration attained at three hours post feed in these refractory members and in the refractory (BAH) strain of Ae. aegypti are similar 52.5 (37.5-73.6), 53.2 (40.9-69.2) and 51.8 (37.0-72.6) respectively.

As yet, no explanation has been found to account for the different patterns of migration in susceptible and refractory species, but it is evident that continuous migration at a constant rate up to nearly 100% in three hours is characteristics of susceptible mosquitos, while a zero rate after one and a half hours at about 50% is typical of refractory species.

(215) Partono, F. & Idris, K.N.
1977

Some factors influencing the loss of
microfilariae from stained thick blood
films

SE. Asian J. trop. Med. publ. Hlth., 8,
158-164

The authors noting that comparative studies involving the counting chamber technique and thick blood films carried out by Denham et al., 1971 (135) and Southgate, 1973 (164) and Sucharit & Vutikes (1975)¹ have given conflicting results, decided to carry out an investigation with the aim of elucidating the possible factors that might influence the loss of microfilariae during dehaemoglobinization and staining of thick blood films.

Materials and methods

An asymptomatic bancrofti carrier was used in all experiments, except once when a carrier had a mixed infection of W. bancrofti and the Timor microfilaria, Brugia timori.

In all studies, finger blood samples were collected between 2200 to 2400 hours. New microscope slides for standard preparation of the blood films were first soaked in 95% alcohol for one hour, washed with soap, thoroughly rinsed with clean water and dried with an oil-free cloth. For comparative studies, some "corroded" slides, and slides cleaned only with alcohol ("unclean" slides) were used. Slides considered to be "corroded" were ones that appeared clean after processing with alcohol and soap, but by tilting at certain angles a metallic sheen or tinge was observed. It was found that these slides absorbed Giemsa stain during processing.

Venous blood was used in experiments testing the effects of anti-coagulants. One portion of blood not treated with an anti-coagulant served as a control while the remaining portion was mixed with one of the following test anticoagulants:

- (1) a mixture of 6 mg ammonium oxalate and 4 mg potassium oxalate (5 ml of blood);
- (2) 1 ml 5% solution sodium citrate (10 ml of blood);
- (3) 143 U.S.P. unit heparin (10 ml blood).

Venous blood with or without anti-coagulants was kept in dried glass vials for only a brief period. The glass vial was slowly but constantly rotated with one hand to provide an even distribution of the microfilariae. Using a 20 ul pipette, aliquots of blood were evenly and thinly spread on to microscopic slides.

¹Sucharit, S. & Vitukes, S. (1975) Comparison of counting chamber, Sasa and standard smear methods of counting Brugia pahangi microfilariae from cat blood. S.E. J. trop. Med. publ. Hlth., 6, 437

Except otherwise stated, the blood films were dried overnight at room temperature (27-31°C), dehaemoglobinized in a vertical position for 3 to 5 minutes (without frequent redipping or flushing), air dried, fixed with methanol for one minute, and stained for 10 minutes in a 1:10 solution of Giemsa. The dehaemoglobinization fluid was passed through a 5 μ diameter Nuclepore^R filter. The glass container used for dehaemoglobinization was thoroughly with distilled water twice and all wash fluid also passed through the same filter (Filter 1). The Giemsa solution used for staining blood films was filtered in the same manner through a second Nuclepore filter (Filter 2). Each filter was mounted on a microscopic slide with the side containing the microfilariae facing downward, stained with 15 drops Giemsa stock solution for one minute, followed by 30 drops of pH 7.2 buffer solution for 8 minutes. The stained filter was rinsed by pressing with one finger to prevent floating.

Stained parasites were counted under low power (60X) of a compound microscope. If no microfilariae were recovered from either filter, it was assumed there was no loss of microfilariae during dehaemoglobinization and staining of blood films.

Results and discussions

(a) The effect of the position of blood slides during the dehaemoglobinization and deviation of dehaemoglobinization and drying

The results showed that loss of microfilariae from the standard blood films was not associated with the slides being dehaemoglobinized in a vertical or horizontal position. Likewise dehaemoglobinization up to 30 minutes and drying-up to 178 hours before dehaemoglobinization had no effect.

(b) The effect of anti-coagulants on the loss of microfilariae

Oxalated citrated and heparinized blood were tested. Clean slides were used and the smears dried overnight; slides were dehaemoglobinized in both the horizontal and vertical positions for periods ranging from 1 to 5 minutes. In each experiment an aliquot of venous blood untreated with anticoagulants served as a control. The results showed that 26% to 69% of the microfilariae were lost with the greatest loss occurring during dehaemoglobinization (Table 1). There was little difference in the result using various anticoagulants or different positions of the slides during dehaemoglobinization.

(c) The effect of duration of drying and associating temperature on loss of microfilariae from anticoagulated blood films

Results showed that there was an inverse relationship between the duration of drying and the number of microfilariae lost at room temperature and at 37°C. An increase in temperature, however, resulted in a decrease of the drying time required to reduce the loss of microfilariae. In these experiments the blood films were dehaemoglobinized for 3 to 5 minutes.

(d) The effect of slide cleaning and corrosion

While no loss of microfilariae was observed with clean and uncorroded slides, a small microfilariae loss, 4% was encountered with "unclean" (alcohol cleaned only) slides and 10% with "corroded" slides. The combined effect of anticoagulants and "corroded" slides with the films of dried overnight at room temperature, in desiccator and in an incubator at 37°C, resulted in a loss of 93%, 85% and 73% of the microfilariae, respectively (Table 2).

The authors compared their results with those of the above-mentioned workers. They refer to the loss of microfilariae of 15-40% found in the work of Denham *et al.* (*loc. cit.*) with blood films having a surface area of less than 3.14 cm². The authors explained the difference between the results of Denham *et al.* and their findings as being partly due to difference in technique, but mainly because of the use of anticoagulants.

Referring to Southgate (*loc. cit.*) the authors did not use anticoagulants, yet he estimated a 51% loss of microfilariae from his slides. His results might have been due to the use of slides not meticulously cleaned or the use of a relatively small surface area of his 20 ul blood films.

Sucharit & Vitukes (*loc. cit.*) did not observe any loss of microfilariae from their thick blood films, although they used heparin as an anticoagulant.

The authors could not find an explanation to account for the difference in results obtained by these workers and their findings.

TABLE 1. Effect of anticoagulants and the loss of microfilariae from thick blood films

Slide position	Dehaem. time (min)	Anti Coagulant	No. of blood films examined	No. mf/20 ul Range	No. mf in Mean	No. of mf in F1	No. of mf in F2	Mf% loss
Vertical	3-5	None*	10	6-14	9.4	0	0	0
Vertical	4-5	Oxalate	20	0-11	3.8	70	0	48
Horizontal	1	Oxalate	10	0-13	4.2	43	0	51
Horizontal	3-5	Oxalate	20	0-14	4.9	77	0	44
Vertical	3	None*	10	8-24	13.5	0	0	0
Vertical	3	Citrate	10	0-10	5.0	68	0	58
Horizontal	1	Citrate	10	2-10	8.7	30	0	26
Vertical	3	None*	10	9-24	15.7	0	0	0
Vertical	3	Heparin	10	0-10	4.1	90	0	69
Horizontal	1	Heparin	10	3-11	6.5	85	0	57

*Control

TABLE 2. Combined effects of temperature, humidity and "corroded" slides on oxalated blood films and the loss of microfilariae

Drying time (hours)	Temperature	Desiccator	No. of blood films examined	No. of mf/20 ul	No. of mf in P1	No. of mf in P1	Mfx loss
				Range	Mean		
10*	Room	-	10	3-16	9.4	11	0
10	Room	-	10	0-3	0.7	91	0
34	Room	-	10	0-10	3.2	66	0
10	Room	+	10	0-6	1.5	85	0
34	Room	+	10	0-8	2.6	62	0
10	37°C	-	10	0-10	2.9	79	0
34	37°C	-	10	2-11	6.5	25	0
							73
							28

*Control

(216) Rooney, D.E.
1977

A study of the chromosomes of members of the Aedes scutellaris group with particular reference to the differences revealed by Giemsa C-banding
Trans. roy Soc. trop. Med. Hyg.,
71, 110

Chromosomes from brain cells of early fourth instar larvae of the Ae. scutellaris group and from a tissue cell culture of one of the species, Ae. malayensis, have been examined using the Giemsa C-banding technique of Sumner (1972).¹

The chromosomes number of all species is 2n=6. As in other mosquitos, there is somatic pairing of homologues and the three pairs are of different lengths, the smallest being the sex chromosomes X and Y. The Y carries the male determining locus M and it is the same length as the X.

The chromosomes are metacentric or slightly submetacentric, and C bands occur in all centromeric regions. In addition, there is an intercalary band which occurs on one or both sex chromosomes, depending on the sex of the larva. This sex difference is being investigated more fully.

¹Sumner, A.T. (1972) Experimental Cell Research, 75, 304-306

In all cells analysed from the Ae. malayensis cell line Mos 60 (Varma, M.G.R., Pudney, M. & Leake, C.J., 1974)¹, the intercalary band is absent from one of the sex chromosomes. This observation may indicate that there has been selection for this karyotype by the artificial environment of the cultures.

The long-term aim of the study is the elucidation of evolutionary relationships among the species of the Ae. scutellaris group by means of chromosomes banding patterns and an analysis of meiosis in hybrids.

(217) Self, L.S.
1977

Report on a field visit to Tonga
WHO unpublished document,
WPR/VBC/FR/15

A summary of findings and recommendations is extracted as follows:

1. Filariasis control programme

A country-wide mass drug administration programme using diethylcarbamazine tablets (50 mg) at 5 mg/kg was commenced in May 1977. Twelve weekly doses are to be followed by 12-monthly doses. Information available on the first six weekly doses shows that over 90% of the approximately 80 000 inhabitants took the drug.

1.1 Pre-control microfilarial and clinical filariasis rates

Finger-prick blood film (60 mm^3) examinations made in 1976 and 1977 on Tongatapu, Eua, Ha'apai and Vava'u, the four main island groups of Tonga, showed pre-control mf rates of 20.4% in males (4665 individuals) and 14.2% (5215) in females. These same individuals also were examined for clinical signs of filariasis. In males, prevalence rates for hydrocele and elephantiasis were 2.4% and 0.3%, respectively. Amongst females, elephantiasis rate (0.12%) was lower.

Hydrocele and elephantiasis rates (both sexes) were about twice as high on the smaller island groups, in comparison with Tongatapu where 70% of the total population of the Kingdom (about 99 000) live.

1.2 Filariasis rates and infected mosquitos in four indicator villages

Blood and clinical surveys and also mosquito collections have been recently carried out in Hofoa, Vaotu'u, Utulau and Fatumu villages, located on Tongatapu island. Pre-control mf rates were 26.4% in males (556) and 15.8% (618) in females. Hydrocele rate in males was 3.1%, and the elephantiasis rate in males and females was 0.18%.

¹Varma, M.G.R., Pudney, M. & Leake, C.J. (1974) Trans. roy Soc. trop. Med. Hyg., 68, 374-382

Three months after MDA, the mf rates in males and females were only 1.6% and 0.84%, respectively. Further evidence for control effectiveness was derived from comparing the results of mosquito dissections before and after MDA. In March 1977, 2.3% of 129 Ae. tabu were infected (all larval stages) with W. bancrofti, and 0.78% were infective. From late May to October 1977, 899 additional specimens were dissected and one was found (in June) to have one infective stage larva, thus giving an infective rate of 0.11% for the six-month period after MDA began.

2. Bionomics of Aedes tabu

Routine collections of mosquitos were carried out from March to October 1977 in the four indicator villages mentioned above.

Human bait catches of 30 minutes' duration in the morning (52 collections) showed Ae. tabu densities were the highest in the bush (24.9 females per man-hour), lowest inside house (8.8), and intermediate near to houses (15.6). Some Ae. aegypti also were collected inside houses.

Ae. tabu larvae were found in crab holes, tree holes, coconut shells, artificial container, leaf axils of Pandanus and also leaf axils of two important root crops: taro (Colocasia) and small kape (Alocasia). The pandanus plant is an unusual breeding site for species of the Ae. scutellaris group to which Ae. tabu belongs while Ae. (Finlaya) oceanicus was found in its normal pandanus habitat.

Empty DEC drug cans converted into simple ovitraps by painting them black. About 25 cans with hard board strips were placed in houses, near houses and on coconut trees in the bush in order to monitor egg-laying activity. The results could lead to a selective method of vector control by placing a biodegradable insecticide, such as Abate, inside cans situated in areas with high oviposition activity.

Little is known about adult resting sites. Large mango trees which often have fruit oozing droplets of sugar are good sites for human bait collections and it is suspected that some adults may rest in the thick, shady branches. Clusters of large pandanus plants, grown for mats, are common in some villages. They also may provide potential resting sites for Ae. tabu and Ae. oceanicus, the latter is a night biting filariasis vector.

Ae. tabu was found to feed on dogs. The necessary steps to differentiate carefully Dirofilaria immitis from W. bancrofti in mosquito dissections have been taken.

3. Agricultural pesticides and spray equipment

Taro is grown in large quantities; it is a popular food throughout Tonga and is exported to New Zealand. Malathion, diazinon and carbaryl are sometimes sprayed for leaf-hopper control. Trichlorfon is used for scab moth control on bananas.

The Ministry of Agriculture is also involved in control of rodents, which damage root crops and coconuts. Rat-eaten coconuts are widely distributed and abundant, providing good breeding sites for Ae. tabu.

There are many knapsack power mist dusters in Tonga and 60 additional ones recently arrived in Nuku'alofa. These sprayers have been utilized for vector control. Knapsack compression sprayers are also available and used in the plantations for pest control.

4. Vector control and spray equipment

An anti-mosquito campaign on Tongatapu was carried out by the Ministry of Health in late 1975 and early 1976 when the first cases of dengue fever were diagnosed clinically. A village clean-up campaign was launched, supported by health education and distribution of pamphlets, for eliminating breeding sites such as coconut shells, tins, discarded tyres, tree stumps and other receptacles which hold water. Villagers were advised to change water in flower vases frequently, and they are also shown how to mosquito-proof rainwater cisterns. In addition, 400 litres of 95% malathion were applied with four Fontan back-pak sprayers in 12 localities, and some water containers were treated with Abate sand granules.

Many yards had a clean and tidy appearance. Also, perforated galvanized iron sheets which are shaped like a funnel allow rainwater to flow and enter the large cisterns but apparently not mosquito adults.

In Nuku'alofa, a 5% dichlorvos solution has been used for fly control using the above-mentioned agricultural mist dusters adopted for spraying. The airport received international flights and aerosol sprays are used for disinsecting incoming aircraft.

5. Training

Training of national personnel is needed for vector control, rodent control, Aedes surveillance and control, and safe use of pesticides.

6. Conclusions and recommendations

The initial stages through which the mass drug administration campaign begun in May 1977 for filariasis control are very promising, and a sharp decline in mf rates and infective mosquito rates was recorded. The acceptance of the drug by more than 90% of the population has been partly due to health education efforts which have included weekly radio broadcasts. This increased public awareness of the importance of filariasis should lead to greater public interest in eliminating mosquito breeding sites. Present efforts on the environmental sanitation aspects of health education should be continued and strengthened in order to derive the greatest possible benefits of the drug campaign.

Since Ae. aegypti and Ae. tabu occur in the same villages, control measures directed against one of these species would, to some extent, affect the other. Additional information on the distribution of both of these species in Nuku'alofa could be used to pinpoint those localities with the highest densities of Ae. aegypti and the greatest risk for dengue outbreaks. Thus, when the short supplies of insecticides have to be used for timely prevention of dengue outbreaks, applications can be made to pre-determined high risk localities and near schools and hospitals.

When time and transport facilities permit, the filariasis entomological team should incorporate the following activities in their schedule:

- all day and all night mosquito collection;
- mass dissection of Ae. tabu and Ae. oceanicus for infective larvae;
- systematic larval surveys to obtain more information on the species of mosquitos which breed in pandanus plants within the village perimeter;
- monitoring or ovitraps placed in different ecological situations.

Determining whether efforts made by the Ministry of Agriculture to control rodents also results in some degree of mosquito control.

Efforts should continue to obtain a vehicle-mounted ULV machine since a town such as Nuku'alofa could be treated in one day if necessary.

(218) Shibuya, T.
1977

Assignment Report to Western Samoa
WHO unpublished document,
SMA/TDR/001

The author was assigned as a WHO consultant to Western Samoa from 16 September to 8 December 1977 with the following objectives:

1. To study the data collected by the national filariasis control team since 1972 and to select some sample areas for investigation.
2. To examine in the sample areas all people over the age of one year for microfilaraemia using the highly sensitive Nuclepore concentration technique.
3. To compare the results of the Nuclepore concentration technique with those of the conventional 60 mm³ blood film technique.
4. To compare the microfilaria density in venous blood with that obtained from a finger-prick taken at the same time from the same person.
5. To train staff in the use of the Nuclepore concentration technique.
6. To evaluate the abilities of the Filariasis Control Team with a view to the planning of the large scale survey.
7. To formulate recommendations for future programmes.

Materials and methods

As a result of the review of the available reports since 1972, four villages/areas were selected as sample areas for the present study. These areas were selected on the basis of their geographical location as well as for the prevailing mf rates detected in 1975 as shown in the following:

	<u>Mf rate*</u>
a) Vailu-utai	1.47%
b) Matautu (Lefaga)	0.00
c) Vaipapa & Afolau	6.6%
d) Apai & Satuilagi	11.11%

*Using 60 mm³ blood film (finger-prick) technique

Prior to the actual survey of the above villages a census was taken in the selected villages, houses were mapped and numbered, inhabitants were identified and numbered individually under their house number.

From villagers of one year and older, samples of 1 ml venous blood were obtained by venepuncture for examination by the Nuclepore concentration technique. In Vaipapa and Afolau plantation and in Apai and Satuilagi villages slightly more venous blood was taken for preparation of 60 mm³ blood smears for comparing the two techniques. Also, wet specimens prepared from venous blood were examined on the spot; if these were positive or if the persons was suspected to be positive, another 60 mm³ blood film was prepared by finger-prick, for comparing mf densities in venous and peripheral blood using 60 mm³ blood films.

In Matautu (Lefaga) village, positive cases were revisited so that a further specimen of venous blood and also a specimen from finger-prick could be compared.

The Nuclepore filter technique was carried out in such a way that contamination by previously examined positive specimens was avoided. The following precautions were taken:

- (a) filter paper holders were carefully washed with a brush after each use;
- (b) when the syringe was filled with 0.1% sodium bicarbonate, care was taken not to contaminate the bicarbonate solution with blood from the specimen. To avoid contamination completely when sampling blood from Apai and Satuilagi, the syringe was disconnected from the filter-holder, the plunger was removed from the syringe and the syringe was reconnected to the holder, 0.1% sodium bicarbonate was added by pouring it from a bottle with a spout and only then the plunger re-inserted and pushed for the final specimen;
- (c) the tip of the tweezers handling the filter-paper was washed in water after each use and wiped dry with a clean paper towel; and
- (d) staining was done with a drop of 0.1% Azur II solution instead of soaking the specimen in Harris haematoxylene.

The blood films were prepared with 60 mm^3 and stained by Giemsa solution on the following day.

Conclusions

1. The results of the present study indicate that it may be incorrect to assume that the present mf rates in Samoa can be derived from the surveillance results obtained since 1971, which show an overall mf rate of 0.72% by 60 mm^3 blood slides (Table 1). The present mf rate by 1 ml venous blood samples in the selected pilot area was 5.7%
2. The mf rates using 1 ml blood samples and 60 mm^3 in this study were surprisingly similar (98% and 83% respectively, out of 53 persons examined), indicating that the smaller quantity of blood is quite suitable for detecting many mf carriers, especially the heavier ones, so that they could be given individual treatment.
3. With the Nuclepore filter concentration method, the ratio of low density cases to all positive cases was 22.2%. The data indicate that a critical density of approximately 27 microfilariae per 1 ml is equivalent to about 1 microfilaria per 60 mm^3 blood volume.
4. From blood examination of children born after the second round of mass drug administration, it was clear that transmission has been continuing and in some areas heavy infection is still present. (Three positives were found among children of the 5 year old age group examined by the Nuclepore technique; one showed an mf count of 2272 per ml of blood.)
5. It has been considered that mf density is higher in peripheral blood than in venous blood, so as to facilitate transmission by mosquitos. Therefore, in this study the numbers of microfilariae in 60 mm^3 peripheral blood and 60 mm^3 venous blood were compared. It was found that no significant difference of mf density occurred between the two groups.

Recommendations

1. A total population blood survey in systematically selected random sample villages, stratified according to geographical location, population density and previously determined microfilaria rates, is necessary to determine the real prevalence of the filariasis infection rate in Samoa, using the Nuclepore and blood film methods.
2. Further studies should be carried out on the role of low density microfilaraemia, both epidemiologically and entomologically. The work of the entomologist in determining quantitatively the importance of carriers of different intensities as sources of infection to mosquitos will be of considerable significance.
3. Investigations should be made to determine whether there is anything peculiar about the young children found positive in the present investigation and whether they were especially heavily exposed to transmission for any reason.

Table 1. Summary of mf rate by 60 mm³ blood film
in 1971-1977 in Samoa

Year	No. exam.	No. pos.	% pos.
1971	1 222	4	0.33
1972	6 270	15	0.24
1973	13 485	19	0.14
1974	28 844	104	0.36
1975	11 507	248	2.16
1976	3 562	48	1.35
1977	5 637	62	1.10
Total	65 938	477	0.72

4. On the basis of the results of the present study, the importance of adequate treatment and treatment follow-up was emphasized. Thus, the recording of drug-taking should be improved in order to ascertain if actual drug failures take place, and statistical analysis of available data should be made to help improve control strategy.

5. Blood surveillance activities of the filariasis control section should preferably cover all villages in Samoa within a period of three years. The blood survey mentioned above should be invaluable in being able to predict the actual total number of mf carriers from the results of surveys on small quantities of blood.

6. With 90 positive cases of filariasis identified in this study, case control studies should begin as soon as possible. This applies not only to the cases but also to all other residents of the villages examined who were found negative and from whom a random selection of control partners should be made to achieve proper matching for such variable as age, sex, occupation, residence, etc. The goal is to obtain some scientifically reliable clues about the causes responsible for persistent microfilaraemia.

(219) Suzuki, T.
1977

Preliminary studies on blood meal interval of Ae. polynesiensis
WHO unpublished document,
WHO/FIL/77.149, WHO/VBC/77.669
(Published in 1978 in Jap. J. Sanit. Zool., 29, 167-174)

The author having noted that no studies have been carried out on the duration of the blood meal interval in the field and that the available information came from laboratory observations by Jachowski, 1954 (46) and Ingram, 1954 (42) carried out the present attempt. The paper presents the results of preliminary investigation on the blood meal interval as determined by two methods, the first was made by mark/release and recapture experiments and the second was by the size of developing larvae of W. bancrofti in wild caught Ae. polynesiensis from Tuvalu (formerly Ellice Islands).

(1) Observations by mark-and-release experiments

Material and methods

Preliminary mark-and-release experiments were carried out from December 1973 to January 1974 in the backyard of the author's residence in Suva, Fiji, which was located close to a swamp and heavily populated with Ae. polynesiensis. The capture and recapture were made in a limited area of about 10 m², and the release was made in the centre at the same square. Very few human blood sources were available for mosquitos in the area, except the human bait of the present experiments. Ae. polynesiensis was caught while coming to bite a human bait. After feeding on the arm of the collector, the mosquitos were lightly anaesthetized by chloroform. Part of the catch was allowed a partial blood meal.

Three dye solutions were used for marking, i.e. methylene blue, metanil yellow and crecyl violet. Dye solution (2%) was prepared by dissolving the dye in the mixture of ethyl alcohol and water (1:1). The solution was sprayed onto the anaesthetized mosquitos by means of a small perfume atomizer. The marked mosquitos were allowed to fly out naturally from a paper cup at the release spot. The approximate time for each procedure was as follows: collection 06.30 - 08.30 h; feeding 08.30 - 10.00 h; marking 10.00 - 11.00 h; and release 11.30 h.

In the first series of experiments, marking and release were made on three consecutive mornings, each morning with a different colour. In the second series, on the first morning, marking was made with blue colour on fully-fed mosquitos, and on the second morning, with yellow colour on fully-fed mosquitos and purple colour on partially-fed mosquitos. In the first series of experiments, recapture on human bait was made every morning starting at 07.00 h for about two hours, from the day following the last release until the eleventh day. In the second series, in addition to recapture in the morning, a recapture was also made in the afternoon of the day of the release of yellow- and purple-marked mosquitos. During the recapture of mosquitos, care was taken to collect only the mosquitos which started feeding on human bait. Recaptured mosquitos were spread on sketch-paper. A small amount of a manifesting agent consisting of ethyl alcohol, glycerine and chloroform (3:3:1) was dropped on each mosquito which was then squashed with forceps. By this procedure, the marking was easily identified.

It was confirmed by a cage test that a few mosquitos sprayed with the dye solution died, mostly without recovering from the anaesthesia, but most of the recovered mosquitos survived for 13 days, with a similar mortality to the unmarked control.

During the period of the experiments, the weather was fine almost every day, except for occasional rain showers during the second series; the mean daily maximum and minimum temperature was 31.7°C and 25.4°C, respectively.

Results

The total number of fully-fed mosquitos released after marking was 449, of which 40 (8.9%) were recaptured; and of 64 partially-fed mosquitos released, 30 (46.9%) were recaptured. In the first series of experiments, 1301 mosquitos were recaptured during an 11-day survey; and in the second series, 1409 were captured during a 13-day survey.

The results of the experiments with fully-fed mosquitos are shown in Table 1 and Figure 1. In the figure, the first peak was observed three to four days after release; and the second peak six to eight days after release. It is reasonable to assume that the mosquitos forming the second peak have finished one blood meal in the field before recapture. Therefore, the interval of two consecutive blood meals is estimated to be three to four days.

The mean daily maximum and minimum temperature during the experiment was 31.2°C and 26.0°C respectively.

Dissection of field-caught mosquitos

Females of Ae. polynesiensis were collected on human bait in six islands of Tuvalu, i.e. Nui, Niutao, Nanumea, Naumanga, Nukulaelae and Nukufetau, mainly by the local filariasis control team during the period November 1972 to May 1974. Immediately after collection, the mosquitos were blown into the mixture of alcohol and glycerine, and were kept in the solution until staining. Staining, dissection, identification and measurement of the developing larvae were done by the author using the same procedure as in the experimental infection studies.

Results

Size of developing larvae in the experimentally-infected mosquitos

The mean length and width of developing larvae are shown in Table 2 and Figure 2 on each day from day one to day seven, and on each two days from day eight to day 13. On a day-size graph, the mean length of the larvae forms a parabola-like curve, as shown in Figure 2.

TABLE 2
MEAN LENGTH AND WIDTH OF DEVELOPING LARVAE OF W. BANCROFTI
IN EXPERIMENTALLY-INFECTED AE. POLYNESIENSIS

Day	No. of larvae measured	Mean length in micron	Mean width in micron
1	28	256	5.2
2	100	168	6.9
3	105	126	11.6
4	48	120	17.6
5	39	164	17.3
6	30	218	21.8
7	37	260	26.1
8-9	80	380	26.3
10-11	72	521	28.0
12-13	33	637	26.7

In the experiments with partially-fed mosquitos, 64 mosquitos were released. In the afternoon of the day of release, 26 or 40.6% were recaptured, about six hours after the partial blood meal. At about 24 hours after the partial blood meal, three mosquitos were recaptured; and about 48 hours after the meal, one was recaptured. Therefore, it can be concluded that a good part of the mosquito population which fed once, but not to repletion could easily visit hosts again as early as six hours after the partial blood meal.

TABLE 1. NUMBER OF MOSQUITOS RELEASED AND OF MARKED MOSQUITOS RECAPTURED
(Fully-fed mosquitos only)

Series and Exp. No.	No. of mosquitos released	No. of marked mosquitos recaptured (Days after release)											
		1	2	3	4	5	6	7	8	9	10	11	12
1- (1)	116		7	1					2				
(2)	105		2		4		2	1			1		
(3)	76				4		1	2	1			1	
11-(1)	98			1	4	1							
(2)	54			2	2			1					
TOTAL	449	0	2	10	15	1	3	4	3	0	1	1	0
													0

Note: The frame in the table shows the period within which recapture and identification is possible.

2. Studies by size of developing filarial larvae in mosquitos

Materials and method

An experimental infection of subperiodic *W. bancrofti* with *Ae. polynesiensis* was undertaken during the period February to March 1974, in Nukulaelae Island, Tuvalu where filariasis was endemic. Females of *Ae. polynesiensis* collected on human bait in the bush of an inhabited islet, were fed on two volunteers with respectively 360 and 122 microfilariae per 60 mm³ of peripheral blood.

The experimentally-infected mosquitos were caged in paper cups at room temperature, but with higher humidity. Every day until day 13, a few live mosquitos in the cups were killed with chloroform, and kept in a mixture of 70% ethyl alcohol and glycerine (19:1) for at least one hour. After staining for two days with 0.05% Azur-II solution, they were dissected under a dissecting microscope. The length and width of the developing larvae were measured with a micrometer attached to a compound microscope.

Estimate of blood meal interval in wild caught Ae. polynesiensis

Estimate of the duration of the developmental stages of filarial infection was made on 45 Ae. polynesiensis with developing larvae collected from Tuvaly islands, by applying the mean length and width of the larvae in each mosquito to the calibaration curve shown in Figure 2. Since all the mosquitos were collected on human bait when they intended to take a blood meal, the duration of infection in each mosquito could be equal to n times ($n = 1, 2, 3 \dots$) of the interval of two successive blood meals.

In Figure 3, four peaks are demonstrated: the first one on day three to day four; second, day six to day seven; third, day nine to day ten; and fourth, day 11 to day 12, although the last two peaks were low. From the first and second peaks, the mean interval of two successive blood meals can be estimated at three to four days.

During these studies, double infection was observed in two mosquitos, one from Nui, and the other from Nukufetau. In the former mosquito, the duration of infection was estimated at 6.1 days for the first infection and 2.7 days for the second. In the latter mosquito, the duration was 9.1 days for the first infection, and 6.7 days for the second.

From the above it can be seen that two different methods gave the same estimate of 3-4 days for the blood meal interval. On this basis and as the present observations showed that the developmental period for the parasite in Ae. polynesiensis was at least 12 days, it was concluded that Ae. polynesiensis coming to bite humans while harbouring infective stage larvae should have completed at least 3 feeding cycles, or in other words they should be at least 3-parous mosquitos.

The author compared this estimate with the findings of Jachowski (loc. cit.) who reported that in Ae. polynesiensis under laboratory conditions with a mean temperature of 26.7°C, the interval between two blood meals was 7.3 - 7.6 days. Further comparison was made with those of Ingram (loc. cit.) who also reported about seven days for this interval in the same species under laboratory conditions at a mean temperature of 26.7°C, but defined this interval as being 4 days from the blood meal to oviposition and 3 days from oviposition to the next blood meal. The author tried to explain the discrepancy between this and his estimate as being possibly due to longer time taken from oviposition to a blood meal in captive mosquitos in the laboratory even though mosquitos were provided with a blood source daily in the above investigations, compared with mosquitos in the field which would readily feed immediately after oviposition.

/N.B.: Jachowski (loc. cit.), unlike Ingram (loc. cit.) did not define the interval between the period from the blood meal to oviposition and from oviposition to the next meal. From his observations on the number of eggs laid per female, he stated that 7 days after the blood meal, eggs were collected. Thus it seems that the 7 days period was meant to be from the blood meal to complete oviposition. Jachowski also stated that in observations on survival and feeding frequency etc., mosquitos were provided with cotton wool pads saturated with sugar solution and human blood was offered daily from the arms of the operator. It is not clear whether the

sugar solution was continuously provided as in the case of his other observations. If so, the delay in oviposition could have been due to maintenance of the mosquitos on sugar solution after a blood meal and it is useful to quote De Meillon *et al.* (1967)¹ who reported that cane-sugar solution at about 10% concentration delayed oviposition of *C. quinquefasciatus*. Mosquitos that had fed on this solution continued to oviposit to the tenth day after the blood meal and that by the fifth day 45% of these had laid to be compared with 98% oviposition rate in the gravid mosquitos that had been maintained on water only after taking the blood meal. It was also found that the oviposition rate of mosquitos fed on water of 0.4% sugar solution was significantly higher than that of the other groups which were maintained on higher concentrations on day 3 after the blood meal. There was no significant difference between groups of mosquitos that were maintained on 1.6% concentration and those which were kept on higher concentrations. In Ingram's experiments, it was stated that mosquitos were offered a blood meal daily, but they also had access to a slice of apple or 5% sugar solution. This practice did not seem to delay the period taken from blood feeding to oviposition given as about 4 days and the delay in taking the next feed remains inexplicable. /

(220) Tompkins, N. & Williams, T.R.
1977

A comparative scanning electron microscope study of the eggs of four *Aedes acutellaris* complex species. Laboratory demonstration exhibited at the Liverpool School of Tropical Medicine, Thursday 18 November 1976
Trans. roy. Soc. trop. Med. Hyg.,
71, 109

Taxonomically useful characters are found in the ornamentation of aedine egg surfaces revealed by scanning electron microscopy (Brust, 1974²; Hinton & Service, 1969³). However, if general appearance alone is considered it is not always possible to distinguish between taxa at the species level, e.g. five species of *Aedes (Stegomyia)* have been found to be similarly patterned (Matsuo, K., Yoshida, Y. & Lien, J.C., 1974⁴). In these species which included *Ae. albopictus*, the dorsal egg surface has a polygonal pattern, each polygon containing a large central tubercle and a number of smaller peripheral tubercles. Polygons are replaced by a more elongated pattern on the egg's lateral surfaces and are absent, or succeeded by other structures, ventrally.

¹De Meillon, G., Sebastian, A. & Khan, Z.H. (1967) Cane-sugar feeding in *Culex pipiens fatigans*. *Bull. Wld Hlth Org.*, 36, 53-65

²Brust, R.A. (1974) *J. med. Ent.*, 11, 459-466

³Hinton, H.E. & Service, M.W. (1969) *Ann. trop. Med. Parasit.*, 63, 409

⁴Matsuo, K., Yoshida, Y. & Lien, J.C. (1974) *J. med. Ent.*, 11, 179-188

A survey of Ae. scutellaris complex eggs obtained from stocks maintained in the Liverpool School of Tropical Medicine revealed no marked departures from the pattern outlined above, but suggested that quantitative differences might distinguish the species examined. Four were selected for further study: albopictus, cooki, malayensis and tabu. Air-dried eggs were examined after coating (Au-Pd) on the paper on which they were laid. Micrographs were taken of areas of the dorsal surface at magnifications of about 2000x, the direction of viewing being judged to be normal to the surface.

The results of counting the number of peripheral tubercles in polygons wholly visible on the micrographs are given below. Logarithmic values were taken for a one factor analysis of variance that showed a highly significant difference between samples ($P < 0.001$). A Student Newman Keul test on the data indicated that two species, malayensis and tabu, were not significantly different in number of peripheral tubercles ($P > 0.05$), but that albopictus and cooki were significantly different from each other and from the first pair of species ($P < 0.05$).

These results cannot be considered conclusive as the small numbers of eggs examined were drawn from batches laid by an unknown number of females and conceivably, by only one female. Nevertheless, only Ae. tabu failed to conform with the results of the earlier survey (observations on this species were limited by poor behaviour of eggs in the SEM). Further investigations would be worthwhile.

	<u>albopictus</u>	<u>cooki</u>	<u>malayensis</u>	<u>tabu</u>
Eggs	9	7	8	8
Polygons scored	43	34	64	17
Mean number of tubercles	17.56	11.35	15.56	14.82
Range	10-28	4-17	9-24	11-21
Variance	9.92	8.90	10.50	6.52

(221) Townson, H.,
Meredith, S.E.O. &
Thomas, K.
1977

Studies of enzymes in the Aedes
scutellaris group
Trans. roy. Soc. trop. Med. Hyg.,
71, 110

The authors are currently studying a number of enzymes in adults from laboratory colonies of seven species of the Ae. scutellaris group - malayensis from Bangkok and Singapore, scutellaris from New Guinea, pseudoscutellaris from Fiji, polynesiensis from American Samoa, cooki from Niue, tabu from Tonga and the as yet unnamed form from Tafahi (Macdonald, 1976).¹

There are major differences in the esterases of the group. Several species can be differentiated by the main esterase, including polynesiensis and pseudoscutellaris which are sympatric in Fiji. Laboratory-produced hybrids of these two species can be distinguished from either parent without difficulty.

¹ Macdonald, W.W. (1976) Symposia of the British Society for Parasitology, 14, 1-24

α -glycerophosphate dehydrogenase divides the group into two sections, malayensis and scutellaris in one, the remaining five species in the other - a division which also applied to mating characteristics, comparative morphology, geographical distribution and filarial susceptibility. The possibility that this metabolically important enzyme is concerned with filarial susceptibility, whilst remote, is being investigated. F_1 hybrids of scutellaris ♀ and Tafahi form ♂ have three enzyme bands suggesting that the α -GPDH molecule is dimeric. Since the F_1 male hybrids have proved infertile, it has not been possible to check for sex-linkage of this enzyme. The recent discovery and isolation of a sex-linked white-eye mutant in the Tafahi stock (Wade, J.O., personal communication) will allow linkage tests to be carried out with back-crosses of F_1 hybrid females. There are as yet no autosomal markers for the group.

Alcohol dehydrogenase allows the separation of the apparently closely related species polynesiensis and Tafahi form. The F_1 male hybrids from polynesiensis ♀ X Tafahi form ♂ are being intercrossed and back-crossed to provide information on the linkage of this enzyme. Lactic dehydrogenase and glucose-6-phosphate dehydrogenase have different electrophoretic forms in some of the species.

We are aware that our laboratory colonies may well show less polymorphism of enzyme types than could be found in field populations. In addition, it is possible that the widespread species polynesiensis may show differences in enzyme characteristics over its range. Nevertheless, there is already evidence of considerable biochemical divergence in this morphologically rather uniform group.

(222) Wade, J.O. &
Macdonald, W.W.
1977

Compatible and incompatible crosses
within the Aedes scutellaris group
Trans. roy. Soc. trop. Med. Hyg.,
71, 109

The crossing relationships among seven species of the Ae. scutellaris group were illustrated. Each of the seven species - Ae. polynesiensis, Ae. pseudoscutellaris, Ae. tabu, Ae. scutellaris, Ae. malayensis, Ae. cooki and a specie from Tafahi Island - was given the opportunity to mate in both directions in cages of 30 cm³ with each of the other species. The insemination rate and the egg hatching rate were recorded. Compatibility was based on the number of egg hatches which hatched in relation to the number of females which were inseminated and laid eggs. The crosses were scored as highly compatible, moderately compatible, of low compatibility, or incompatible.

The seven species examined fell into three groups: Ae. polynesiensis, Ae. pseudoscutellaris and Ae. tabu; Ae. scutellaris and Ae. malayensis; and Ae. cooki and the Tafahi species. In each group there was high compatibility in reciprocal crosses between the individual species, and the species within any group showed similar compatibility relationships to those in the other two groups. For example, males of both Ae. cooki and the Tafahi species were highly compatible with females of all other species, whereas those of Ae. polynesiensis, pseudoscutellaris and tabu were incompatible or of low compatibility with all other species.

An analysis has not yet been made of hybrid fertility or sterility, but in at least a few crosses the hybrid offspring are fertile.

(223) Richard, C.
1977

Sanitary engineering and mosquito control
South Pacific Comm., Noumea,
Information Document No 42, 1976
(Noumea, Caledonia)

The author made synoptic notes and tables showing the distribution and ecology of vectors and suspected vectors of filariasis as well as of vectors and suspected vectors of dengue fever in the South Pacific Region.

The author, with simplified illustrations avoiding mathematical formulae used in hydrology, described the sanitary engineering methods for controlling mosquito vectors in urban environments such as C. quinquefasciatus and Ae. aegypti and mosquito vectors in rural areas such as Ae. vigilax and the Anopheles punctulatus complex as well as other pest mosquitos by drainage with special reference to road construction and agriculture.

No specific measures were made for vectors of filariasis of the Ae. scutellaris group.

(224) Buck, A.A.
1978

Visit to Research Institutions in the USA, countries and areas in the South Pacific and to Papua New Guinea
WHO unpublished assignment report,
9 October to 9 November 1977

These are extracts from the author's reports on visits to several countries in the Pacific Region with the aims of fact-finding and promotion of cooperation in research and control of certain parasitic diseases.

1. French Polynesia, Institut de Recherches médicales "Louis Malardé, Papeete, Tahiti

While the subperiodic filariasis and other parasitic infections still rank high within the group of locally important endemic communicable diseases, their relative significance for public health has now become secondary to health problems caused by chronic conditions.

Filariasis

Subperiodic bancroftian filariasis is the only endemic filarial infection of man in French Polynesia, with the exception of sporadic infections with the larvae of the dog heart worm Dirofilaria immitis. Control of filariasis has covered all of French Polynesia which encompasses the Society Islands of which Tahiti is a part, as well as the Austral, Marquesas and the Tuamoto Islands.

In 1977 the estimated total mf rate on the Islands was 1.5%, using standard 2 x 40 mm³ blood slides, obtained by finger prick. The decrease from 4% in 1974 to 1.5% in 1977 was achieved by annual mass treatment of the entire population with a single dose of DEC. At present, the prevalence of microfilaraemia is still higher in the population of the Marquesas group where the corresponding residual microfilaria rates were 13 - 15% in 1974 and 5% in 1977. Population coverage by mass treatment is said to have been good, averaging 75%. Pregnancy, infancy, overt disease and incapacitations due to other causes are contra-indications fro DEC treatment.

The newly adopted strategy of annual, single-dose treatment of the entire population of the Islands as compared with the previous practice of treating only the known carriers has yielded satisfactory results. Before 1974 the residual prevalence of microfilaraemia has remained constant at 4.5%. After changing the strategy to annual mass treatment there has been a steady decrease in prevalence of infection combined with the disappearance of new cases of elephantiasis and a decrease of filarial fever, lymphangitis and hydrocele. The experience with drug combinations including levamisol have been discouraging.

In the Filariasis Unit of the Institute there is a wealth of carefully collected field data on the disease and its manifestations before and after treatment. These data have been collected over a period of 20 years and they await a comprehensive analysis.

Medical Entomology Unit

For many years Dr Pichon has conducted quantitative studies on the dynamics of transmission of superperiodic bancroftian filariasis and of the bionomics of its vector *Ae. polynesiensis*. He has developed a mathematical model for the type of endemic filariasis that is found in French Polynesia. In addition to his work on *W. bancrofti* the entomologists are also investigating the dynamics of the transmission of the dog heart worm *D. immitis*.

The second major activity of the Entomology Unit concerns the epidemiology of dengue, especially population dynamics of *Ae. aegypti* and the possible role of different vectors in the transmission of the viruses that cause dengue and dengue haemorrhagic fever.

The Unit spends a considerable amount of time on research on the biological control of *Ae. polynesiensis* using predatory larvae of *Toxorhynchites*. Mass rearing of *Toxorhynchites* larvae started in 1976 and is now yielding about 1000 larvae per week. In order to be able to start a limited experimental control programme, Dr Pichon would like to increase the capacity of larvae rearing to about 3000 to 4000 per week.

2. Department of Health, Pago Pago, American Samoa

The following are the questions asked by the authorities:

- (a) How to improve the Filariasis Control Programme in American Samoa?
- (b) What diagnostic tests (standard and concentration methods) should be recommended for routine use in epidemiological surveys?

- (c) How and where can health workers be trained in the control of filariasis?
- (d) How the international cooperation in surveillance and control of filariasis can be improved in the South Pacific?

American Samoa consists of two major Islands, Tutuila and Manoa. The history of filariasis control began in 1962 when Dr Kessel and his associates from the University of California, San Francisco, started epidemiological baseline studies for a mass treatment campaign with DEC. The crude mf rate before treatment was 25%. Mass drug administration of DEC with a total dose of 84 mg/kg body weight was started in 1963. The first evaluation study was carried out in 1964. After the first round of DEC, the mf rate had fallen to less than 1%. Because of relapses and new infections, a second mass-treatment campaign of the total population was carried out in 1968. Following the departure of the Public Health Officer who had been in charge of the filariasis programme, surveillance activities were temporarily interrupted. After the appointment of a new physician for the filariasis control programme, a second census and prevalence survey of the population was carried between 1970 and 1973. At that time the mf rates in different parts of the country were found to range between 0 and 3.2%. Beginning with 1973 only non-randomly selected population samples have been examined. These data have been supplemented by passive surveillance which provided data on filariasis from the examinations of all persons who had applied for the job. In this group of able-bodied young adults 3.8% were found positive for microfilariae of W. bancrofti in standard blood tests in 1976. The findings of a five-village study on the Island of Manoa indicated that the mf rate in males over 40 years of age exceeded 10%.

The prevalence of the clinical manifestations of filariasis, including elephantiasis, lymphangitis, hydrocele and filarial fever has declined but has not yet disappeared. Examinations of children born after the mass treatment campaigns have revealed that active transmission of filariasis in the population has continued. The special survey included only children who had been born between 1 July 1975 and 31 July 1976. Of the 3790 children examined, 11 were found to be carriers of microfilariae of W. bancrofti. Based on the impressions of the physicians of the Filariasis Team, there is a high rate of DEC drug failures. Of the 67 cases found positive in 1976 and subsequently treated with an adequate total dose of DEC, 15 or 22.4% were still found to have persistent microfilaraemia after one year of observation.

A comparative study between residents with birth places in either American Samoa or Western Samoa revealed that there was a higher frequency of infections among those born in Western Samoa. The Government of American Samoa requires all immigrants from other South Pacific islands to present a document to the immigration authorities in which the absence of filarial infection in adequately stained blood slides is certified. According to observations made by the Health Department of American Samoa a relatively high percentage of immigrants with negative certificate were found positive for microfilariae on re-examination.

The standard diagnostic method for filariasis as used in American Samoa is based on the examination of 60 mm³ blood slides. Sub-samples using the Millipore concentration technique with 1 ml of blood are examined regularly. Of the 11 young children found positive in a recent survey, one child was 1 year old, nine were in the age group between 5 and 9, and one boy was 12 years old.

3. Samoa

The visit to Samoa had the single purpose of collaborating in the planning and implementation of the proposed WHO/Samoa Filariasis Research Project. Preparations for the establishment of a WHO-sponsored research project on the epidemiology and control of filariasis in the South Pacific in Apia, Samoa, have been under way since 1975.

The main objectives of the WHO/Samoa Filariasis Project is to seek answers to the following two questions:

- (1) After adequate mass treatment with good population coverage, how high is the present incidence and prevalence of filariasis in the different administrative sub-divisions of Samoa?
- (2) What needs to be done to keep filariasis under control in the future and to prevent a resurgence of the disease?

A number of independent observations were made in the recent past which suggest that the prognosis made on the basis of results obtained immediately after mass treatment had been too optimistic and that there have been relapses due to incomplete treatment in the highly mobile population groups, drug failures and new infections. Epidemiological surveys to determine the actual filariasis situation were made independently by Dr Vermeulen's team in follow-up examinations of the population samples selected by the WHO/Samoa Tuberculosis and Leprosy Survey (1974/75), and concurrently, by the team of Dr Shibuya, WHO consultant. The preliminary data from Shibuya's studies, 1977 (128) lend support to the suspicion that active transmission of filariasis has continued in Samoa and that new infections have occurred in children who were born after termination of the mass treatment campaign. Unfortunately, different diagnostic methods have been used by the investigators of the two concurrent studies which makes it difficult to compare the results of the two concentration techniques.

The filariasis situation in French Polynesia, American Samoa and Samoa shows many similarities. All three have had strong filariasis control programmes which were based entirely on mass treatment of the entire population with diethylcarbamazine. In each case there has been a dramatic decline of the mf rate immediately after mass treatment. This was followed by a more-or-less pronounced increase of the frequency of microfilaraemia thereafter. While there have been differences in opinion to interpret these relapses as either drug failures or reinfections or new infections, there is unanimity among those concerned that a new and effective strategy of filariasis control and surveillance is needed to meet the new situation.

A well concluded project on the epidemiology and control of post-treatment filariasis in Samoa can be expected to yield results that are of relevance also to other countries and territories in the South Pacific that face similar problems.

The author's observations and recommendations were as follows:

1. The various independent opinions about the final shape, objectives and scope of the WHO/Samoa Research Project on Filariasis, need to be consolidated into a single, realistic and scientifically sound research plan. The common goal should be the determination of the present prevalence, distribution and dynamics of filariasis in all parts of Samoa, including the medical, parasitological and entomological aspects of the disease. This should be followed by the development of a practical, economical and culturally acceptable control strategy. In order to achieve this goal, all of the data collected by the different investigators should be made freely available to members of the WHO/Samoa Research Team for analysis and interpretation.

2. Priorities of the WHO/Samoa Research Project should be directed to:

(a) the statistically sound quantitative measurement of the mf rate and of the clinical manifestations of filariasis in representative population samples of all population groups of Samoa;

(b) an epidemiological study of parasitologically positive cases and negative control subjects matched for age, sex, place of residence and for the procedure used to diagnose microfilariae in blood samples. This case/control study will provide data and clues on the causes of microfilaraemia especially whether the positive cases have received less treatment, have travelled more widely and frequently, are exposed to certain occupational risks, can be considered as drug failures, have had more intense infections before treatment, show familiar aggregation, etc. The results showing statistically significant differences in the frequency of one or more of these characteristics can then be used immediately for revising the control strategy, or for designing prospective studies in which new methods of control and surveillance can be tested; and

(c) development of an adequate control strategy through research in which various methods can be compared for efficacy, costs, feasibility for large-scale application, acceptability by the local population and as an international measure. These control methods combine chemotherapy, sanitation, vector control, health education, etc.

(225) World Health Organization
1978

Report on the Working Group
on Subperiodic Bancroftian
Filariasis
Apia, Samoa
1-4 May 1978

The meeting was attended by temporary advisers from nine countries and areas, mainly in the South Pacific.

Developments in filariasis in the South Pacific since the seminar held in 1974 (179) in Apia were reviewed. It was noted that a very significant achievement has been made by MDA with DEC in almost eliminating filaria disease (i.e. elephantiasis). The residual problem is how to maintain and consolidate this advance by cleaning the remaining mf carriers and stopping transmission.

The Group made the following conclusions and recommendations:

1. On parasitology, chemotherapy and epidemiology

1.1. Standardization of blood sampling techniques

Finger-prick method should be used for routine surveys in nation-wide programmes, and the use of 60 mm³ of blood sample is recommended. Filtration method should be used mainly for special studies, particularly for the detection of low density microfilaraemia. Both the millipore and the nucleopore filtration techniques now in use should be compared under field conditions in the South Pacific as to their reproducibility and cost-efficiency.

1.2 Studies on different diethylcarbamazine treatment schedules

This should be conducted in a centre or hospital in the South Pacific. Schedules to be tried should include:

(a) routine 72 mg/kg doses given over 12 days;

(b) annual single-dose treatments at 6 mg/kg;

(c) four-monthly treatments at 6 mg/kg;

(d) a control group; and

(e) during and after each course microfilarial prevalence and density rates should be reassessed at sufficiently frequent intervals to enable the persistent post-DEC microfilaraemia to be distinguished from reinfection microfilaraemia.

A careful longitudinal study of the effects of a single-dose (6 mg/kg) DEC treatment, repeated annually, should be carried out in a previously-untreated community infected with subperiodic W. bancrofti.

1.3 Investigation of drug failure

Relapses, residual positives and new infections should be investigated to identify the existence and extent of drug failures. A retrospective case-control study on approximately 100 cases of microfilaraemia carriers detected in recent surveys of the six villages in Samoa for age and sex should be carried out. Cases which have true persistent post-DEC microfilaraemia should be further investigated carefully with regard to ability to absorb DEC, humoral and cellular immunological competence, intrinsic susceptibility of microfilariae to DEC, and periodicity of microfilariae.

1.4 Statistical analysis and data processing

A WHO consultant should be made available to advise on practical and economical methods of data processing and to develop a standardized form for filariasis surveillance. Workshops on statistical analysis and data processing especially for filariasis study may be organized by WHO.

1.5 Comprehensive and multidisciplinary studies

Longitudinal studies on microfilaria carriers should be made at suitable places on the dynamics of transmission, the characteristics of microfilaria carriers, vector competency and ecology, etc. These studies should last at least three years to determine the existence of patterns of microfilaraemia in the population.

1.6 Filariasis clearance certificate

Although such certificates have had their usefulness during the early period of filariasis control, it may no longer be necessary to continue in the future this time-consuming, expensive and often annoying practice. WHO is requested to advise the governments concerned to have more effective and convenient methods of surveillance and control that do not require routine certification for absence of filariasis infection.

1.7 Immunological and pathological studies

Study of human lymphocytes antigen (HLA) from patients with various grades of W. bancrofti infection (microfilaraemia, amicrofilaraemia, elephantoide, etc.) might be carried out at the Institut Louis Malardé which will shortly have the necessary expertise for this test. Specimens could be collected from various sources in the South Pacific.

Attempts to maintain and culture in vitro various stages of W. bancrofti might be undertaken by the Walter and Elizabeth Hall Institute, Melbourne, Australia working in conjunction with sources in Papua New Guinea and elsewhere. This work will be aimed at obtaining, identifying and purifying exo-antigens and characterizing them immunochemically with the object of developing specific and sensitive immunodiagnostic tests. Pure W. bancrofti standard sera should be obtained from Pacific island cases to assist in testing the antigens.

1.8 Mathematical charts for depicting the true levels and densities of microfilaraemia

From data obtained at Institut Louis Malardé, predictions have been made on the proportion of a community likely to be positive for microfilaria in 60 mm^3 blood samples based on the results obtained with 20 mm^3 samples. This mathematical theoretical distribution based on small blood volumes may be applicable to other areas where residual infection exists after mass drug administration. Further studies should be encouraged to complete this work and to extend a model to include the results of venous blood samples and mosquito filarial intake.

2. On vector identification, ecology and control

2.1 Vector identification and reference centres

Although a few pictorial keys to mosquito fauna in the South Pacific are available, a more simple and accurate key or a series of keys for the various biogeographical subareas should be prepared for field workers for the identification of vector species.

As soon as identification reference centres in the South Pacific become functional, WHO should obtain reference materials for these centres from certain institutions, such as the Smithsonian Institution, where WHO contributed for years to the provision of biological material.

2.2. Mosquito dissection methods

Mass dissection technique could constitute the main entomological tool for evaluation of the results of mass drug administration. In certain circumstances mass dissection should be used side by side with individual dissection - one complementing the other. Mass dissection method should therefore be evaluated with the filariasis vectors of the South Pacific under laboratory and field conditions.

2.3 Vector ecology and bionomics

Due to a definite paucity of knowledge of vector gonotrophic cycle, longevity, range of dispersal and host preference in the South Pacific, more studies should be undertaken. Investigations should also be made on the preferential types of vector-breeding habitats in order to know their relative importance and productivity.

2.4 Infectivity of ultra-low microfilaraemia in major vector mosquitos

Experimental infection should be made on laboratory-bred and wild-caught vector mosquitos with carriers of low and ultra-low microfilaraemia. In-depth studies focusing on major vectors in selected areas such as Ae. polynesiensis in French Polynesia, Fiji and Samoa, Ae. samoanus in Samoa and Ae. fijiensis in Fiji should be undertaken.

2.5 Vector control

Vector control efforts on a long-term basis should be primarily based on environmental sanitation together with health education. Assistance should be provided on safe and effective means of storing water drums and tanks, without providing additional opportunities for mosquito breeding. Incentives might be provided for the disposal of coconut husks and their local processing into charcoal or utilization as fuel sources. However, other control methods should also be considered, particularly for those vectors breeding in plant axils, crab holes and tree holes.

Timely ULV spraying with non-residual insecticides may have to be applied to high-risk areas for killing outdoor resting infective mosquitos.

Feasibility studies with insect growth regulators or insecticides for the control of mosquito larvae breeding into crab holes should be carried out on Fiji. Certain biological control agents have been tried on a small-scale basis with encouraging results in French Polynesia by the Institut Louis Malardé and in Samoa by the Department of Microbiology, University of Dunedin. Large-scale field trials with Toxorhynchites mosquitos, Coelomomyces fungi, and mermithid nematodes should therefore be strongly supported.

3. On exchange of information

It is suggested that WHO and SPC may undertake the task of analysing and disseminating information on filariasis, vector biology and control, etc. in order to keep governments and territories informed of the latest developments in this field.

4. On training

A number of national filariasis campaigns have suffered setbacks primarily due to lack of adequate number of health workers who are responsible for the implementation and supervision of the control programme. Recruitment and training of additional health staff should be encouraged at all levels.

(226) Edgar, S.A.,
Beye, H.N. &
Mille, R.
1952

A preliminary report on a
"periodic tendency" of microfilariae
of Wuchereria bancrofti observed in
Tahiti, French Oceania
Am. J. trop. Med. Hyg., 1, 1009-1019

During the present study, of 26 persons examined at different hours of the day, 24 exhibited much greater mean numbers of microfilariae in late afternoon or evening (with a possible peak around 1900 hrs) than in the morning.

The authors suggested that, if a blood sample of only 20 mm³ is taken for filariasis survey in the South Pacific area, it would be better to make smears in the afternoon than in the morning.

Reports concerning positive or negative evidence of density of microfilariae of the South Pacific W. bancrofti vary considerably. Bahr in his report to the London School of Tropical Medicine in 1912 stated that the filaria of Fiji was of non-periodic type.

(227) McCarthy, D.D. (collating
and editing)
1953 (year of issue
not stated)

New Zealand Medical Research
in the South Pacific, 116 pp.

This is a report of the work of Research Expeditions sent to Western Samoa, and Rarotonga and Pukapuka of the Cook Islands during 1948-1953 by the Medical Research Council of New Zealand. Abstracts on filariasis survey are made in the following:

1. Western Samoa

In 1953, of 955 persons examined in Apia and Savaii, 23.7% were positive for microfilariae. The earliest age at which microfilariae were encountered in the blood was seven years in the case of males and nine years in the case of females. The earliest age at which any evidence of filarial infection was seen was three years, when filarial glands was recorded in a male. No microfilariae were found in his blood. The incidence of infection mounts steadily as age increases from 2.6% in the 0-4 age group to 68.6% in the age group over 50 years.

2. Rarotonga

Of 120 children examined in 1949, 27.5% had mf.

3. Pukapuka

During the present survey of 440 persons, 28.1% had microfilariae. The earliest age found with mf was two years. The earliest age at which elephantiasis was encountered was 16 years among the males and 26 years among the females. This also conforms to the pattern found in Savaii and Rarotonga.

(228) Iyengar, M.O.T.
1958
*

An investigation on filariasis
in Niue
South Pacific Commission,
Techn. Infn. Circ. No 30

Of 748 adults examined in 1954, the mf rate was 22.1%. Village clean up work has been in progress for a few years, and since 1956 DEC was given to the entire population once every month.

In 1957 the mf rate dropped to 2.7% in the population of all ages, and the elephantiasis rate was. 3.4%.

Ae. cooki (referred to as Ae. tongae) is probably the vector.

(229) McCarthy, D.D.
1959 a

The endemicity of filariasis in the
Pacific Island Dependencies of
New Zealand
N.Z. med. J., 58 (No 328), 757-765

An index of filarial endemicity is described. This index has been called the Reservoir Index or the Infective Density Index. It is in effect the average number of mf in 20 mm³ blood carried by every individual in the Standard Population Group. This Group is composed of 100 persons in whom the various age groups are represented in the same proportion as they occur in the general population and is obtained either from an official census or from a sample census.

This index can compare prevalence and intensity in different localities and between males and females, and can indicate changes in endemicity in the same area over periods of time.

(230) South Pacific Commission
1960

Summary of the report of the Study Group on Filariasis, Nouméa, 1959
South Pacific Commission
Techn. Infn. Circ. No 42

On the recommendation of the First South Pacific Conference and of the Research Council, a conference of specialists on filariasis was held at Papeete, Tahiti in 1951. The present study group was to assess the progress in filariasis study and control in the region with special reference to the recommendations of the Tahiti Conference.

Attached to the report is a paper by M.O.T. Iyengar on "A brief review of the epidemiology of filariasis in the South Pacific" which was presented to the 6th International Congress on Tropical Medicine and Malaria, held in Lisbon in September 1958, and detailed information on this subject may be referred to his paper, 1965 (108).

(231) Iyengar, M.O.T.
1960 b

Summary data on filariasis in
the South Pacific
South Pacific Commission,
Techn. Paper No 132

This paper present summary data on the W. bancrofti microfilaria rates, elephantiasis rates, microfilarial periodicity, and mosquito infection rates (natural and experimental) for different localities for the period 1880-1960, together with the name of author/s or investigator/s and the year. The sources of the information include, besides published papers, numerous documents such as confidential reports of investigations undertaken during World War I, unpublished official reports and personal communications.

(232) Norman-Taylor, W.
1963

Bibliographie commentée de la
recherche médicale dans le Pacifique
sud
South Pacific Commission,
Techn. Paper No 142

Under the filariasis section, 115 papers published during the period 1924-1962 were listed. For most of them, no abstracts were made by the author because they have been already included in Iyengar's bibliographies.

(233) Laigret, J.
1965

Consideration sur les crises de
lymphangite récurrente survenant au
cours de l'évolution de la filariose
lymphatique à Wuchereria bancrofti
subpériodique
Arch. Institut Pasteur, Tunis, 53,
389-398

In the course of the long evolution of lymphatic filariasis, the lymphangitis attacks which are purely caused by the parasite, are more complicated by the intervention of streptococcal infection. Observations made in Tahiti combining DEC treatment with long acting penicillin and desensitization with a filarial antigen supported this view.

- (234) McCarthy, D.D.
& Carter, D.G.
1967 (year of issue
not stated)
- Report on filariasis in the
Tokelau Islands
Part I. General description and
control - 1965
Part II. Assessment of results -
1967
Mimeographed report, 18 pp
(probably submitted to the Tokelau
Administration)

Mass treatment was done with DEC at 5 mg/kg, weekly for six weeks followed monthly for 12 months. As 93.7% of all mf carriers had occurred among those of ten years of age and over, assessment survey was made of this group. One year after MDA, the mf rate was reduced from 25.7% to 1% among males and from 17.6% to 0.4% among females. The mf density had fallen from 15.6/20 mm³ to 0.07 among males, and from 7.2 to 0.01 among females.

- (235) World Health Organization
1968
- Report on the Second WHO/SPC
Joint Seminar on Filariasis,
Apia, Western Samoa
6-12 August 1968
WPR/Fil/7

The objective was to offer participants from 10 countries and areas in the South Pacific an opportunity to discuss their own and other findings and experience as well as to review the recommendations expressed at previous WHO meetings, and SPC conferences.

The topics covered the following:

1. Review of filariasis and its control in the South Pacific
2. Epidemiology
 - 2.1 Epidemiological surveys
 - 2.2 Immunology
 - 2.3 Entomological surveys
 - 2.4 The vectors of filariasis in the South Pacific
3. Control
 - 3.1 Drug control
 - 3.2 Vector control

4. Assessment of methods and results of the filariasis control pilot project in Western Samoa

5. Training

6. Recommendations

The following recommendations were made:

- (1) Epidemiological surveys in filariasis investigations should follow the standard procedures laid down in the Second Report of the WHO Expert Committee on Filariasis¹ in order to obtain comparable results and maximum efficiency.
- (2) More emphasis should be given to entomological surveys and dissections in order to determine/confirm the vectors species. Intensive studies on the vectors' bionomics and field trial of new insecticides for control methods should be made.
- (3) Establishment of a reference centre for identification of mosquitoes (especially of certain complex which may have to be studied on a genetic basis) and for determination of filaria larvae found in mosquitoes, particularly in the South Pacific area, is highly desirable.
- (4) Early detection and treatment of filariasis cases arriving in areas in which control operations have been instituted is strongly recommended in order to prevent reintroduction of infection.
- (5) If, in follow-up surveys after a complete round of treatment, a significant number of positive persons, either recurrences, new infections or newly imported cases are observed, repeated mass treatment should be considered.
- (6) In compliance with the suggestion contained in the Second Report of the WHO Expert Committee on Filariasis, the importance of the total dosage of diethylcarbamazine in mass drug campaigns is stressed. The total amount of the drug administered should not be less than 72 mg/kg body weight.
- (7) Because of the considerable movement of population in South Pacific, exchange of information on endemicity and control activities, by way of reports and discussion, should be stimulated.
- (8) Recognizing the importance of training, assistance from international sources, in addition to the training of national staff, is highly desirable. Preparation and distribution of individual study material is also considered necessary.

¹Wld Hlth Org. techn. Rep. Ser., No 359, 1967

- (236) Lagrault, J., Barainas, M. & Fagneau, G.
1972
Hétérogénéité de la répartition des microfilaires dans le sang périphérique chez les malades atteints de filariose de Bancroft et aperçu général sur la filariose aux Marquises
Bull. Soc. Path. exot., 65, 698-703

The authors briefly reviewed the problem of filariasis in Marquesas. In adults, 5% elephantiasis was recorded and other clinical manifestations were highly prevalent indicating severe endemicity of the disease. Blood films were sampled at five different body sites from each of 22 patients. The highest microfilaria count was found in the finger blood. However, the authors emphasized the importance of sampling blood from the ear lobe as this allowed detection of 9.5% of mf carriers who were negative in finger blood.

- (237) Moreau, J.P., Cuzon, G.,
 Pichon, G., Outin-Fabre, D. &
 Lagraulet, J.
 (avec la collaboration
 technique de Mme N. Lefbevre
 et Mlle S. Lee Sang)
 1972 a

Les protéines sériques du filarien
 lymphatique à Wuchereria bancrofti
 var. pacifica. Etude électropho-
 rétique et dosage immunochimique
 des immunoglobulines A, M, G, et E
Bull. Soc. Path. exot., 65, 456-463

The study by electrophoresis of sera of people who had a lymphatic filariasis by *W. bancrofti* var. *pacifica*, showed a definite increase of gamma globulins. These patients were carriers of microfilariae but had no chronic lesions and did not receive any treatment previously. The dosage of immunoglobulins reveals an increase of IgG and IgE.

- (238) Outin-Fabre, D.,
Moreau, J.P., &
Stanghellini, A.
1972 a
Physionomie actuelle de l'endémie
filarienne en Polynésie et son
contrôle. Recherches en cours.
Médecine Afrique Noire, 19, 89-92

The authors reviewed the history of filariasis in Polynesia. Briefly they described the ecological characteristics of island groups. The impact of the DEC mass campaign in Tahiti carried out during 1949-1956 on mf rate and density and on the clinical manifestation is summed up. The reduction in the infection and the infective rate in Ae. polynesiensis is also given. Similar data are given for the period 1956-1967 where the campaign was directed to treatment of mf carriers in rural areas where the vector is present. The mass DEC campaign which was commenced in the island of Moorea in 1967 is also described and the respective data are summarized. These data are more or less the same as those given in Abstract No. 113 for Tahiti and Abstract No. 152 for Moorea.

(239) Lagrault, J.
1973

Prophylaxie et traitement de la
filariose lymphatique en Polynésie
française.

Bull. Soc. Path. exot., 66, 311-320

The author reviewed the filariasis control programmes in French Polynesia which continued for 25 years and made certain remarks on the difficulties encountered in the problem of refusal of DEC administration by the local population. The reaction provoked by DEC even though trivial sometimes makes the treatment very unpopular. Health education through the cooperation of the nurses, teachers, local police, village chiefs and priests is required. Priests in particular can play an important role in this respect. Of the other difficulties is the problem of accessibility of the islands which was found to complicate the application of the treatment programme. DEC tablets must be given by the filariasis control agent to the inhabitants at their domicile who should ensure that the drug is swallowed. For this the island can be divided into two categories:

(a) Islands with difficult accessibility: (such as in Marquesas and Tahaa). The treatment needs a lot of time and cannot be undertaken by a single agent passing from one locality to another as generally practised. Therefore, it is inevitable that reliance should be made on certain members of the community to distribute the drugs such as the teachers, priests, gendarmes etc. Mass treatment of the whole population should be made with a monthly dosage of 6 mg DEC/kg for one or two years.

(b) Islands with easy accessibility (and close to Tahiti): treatment of mf carriers should eventually be followed by mass drug administration. The author further summarized the data depicting the filariasis situation hitherto prevailing in different island groups during 1970-1972.

On vector control, the author indicated that elimination of various types of breeding places around houses is feasible and effective on account of the short range of flight of Ae. polynesiensis being less than 60 m.

The use of repellents for self protection was proposed. Diethyl-phthalate or diethyl-toluamide is effective for 4-5 hours. Thus two applications daily can considerably reduce the number of vector bites. The author considered surgery is valuable and even indispensable and should be considered as complementary to therapy.

(240) Lagraulet, J., Barsinas, M.,
Fagneaux, G. & Teahui, M.
1973

Estat actuel de la filariose aux
Marquises et différents aspects
épidémiologiques
Bull. Soc. Path. exot., 66, 139-155

The Marquesas islands are situated far from Tahiti and due to difficulties in transportation the initial filariasis investigation was carried out late. In 1962, a blood survey was carried out and 16.6% of 4227 were found positive with 25.4 mf per 20 mm^3 carrier. Four filariasis agents were sent for treatment. DEC was administered at a dosage of 6 mg/kg for six days at six monthly intervals. Of 608 examined, 97.6% were negative but the treatment was not pursued.

In 1969, it was decided to review the problem of filariasis in the Marquesas. An agent was posted for 2 1/2 years during which period he collected 4229 blood films from 31 valleys and six inhabited islands. The results of the investigations carried out by the authors are summarized in the following:

1. Entomological investigations

In 1970, a preliminary investigation was carried out in an untreated endemic zone before the implementation of the DEC mass campaign. In one valley in Tahuata island the infection rate (species not mentioned but it is assumed to be *Ae. polynesiensis*) was more than 20%. From limited observations, the infection rates varied greatly from one valley to another. In the study carried out by G. Pichon which will be published in detail separately, the infection rate seemed to correspond well with the prevalence of microfilaraemia in the human population.

2. Parasitological investigation

All the inhabitants of six islands were subjected to blood examination by Giemsa stained thick smears of 20 mm^3 from finger pricks. Two such smears were taken from each individual and the mean mf was worked out from the reading of the two smears.

Of 5059 persons examined during 1969-1971, 35.2% were positive. The authors termed the mf prevalence rate as the rate of infestation (RI) and the mf density per positive person as the degree of infestation (DI). In one and the same island the RI varied greatly in different valleys, the highest range of mf rate recorded was 1-90% while the lowest range was 24-36%. The DI also varied in different valleys. The highest variation of the mean mf count per 20 mm^3 ranged between 13 and 94 in one island while the lowest variation ranged between 4 and 12 mf per 20 mm^3 in another. The frequency distribution of mf count per 20 mm^3 showed that the carriers of 9-16 mf were the most frequently encountered while the heavily infected carriers of 129 to 513 mf only represented 4.9% of the positives.

2.1 Microfilaraemia in the untreated zones

Even in the population which was not treated in four islands considerable variation was observed between blood examination made at intervals of a few months during 1971 and 1972. Examination of 453 persons selected at random showed that the proportion of people who became negative was 6% and those who were negative and became positive was 7.1%. However, 40.8% of the positives showed an increase in the mf count while the count decreased in 5.9% of the positives. The extreme variation in the mf count recorded was:

14 mf in 1971 versus 145 in 1972
258 mf in 1971 versus 5 in 1972

2.2 Microfilaraemia in the treated zones

In Ta Huata island, the mf carriers were given 18 days treatment regimen of 6 mg/kg one year before they were subjected to a follow-up blood examination. Of 46 treated persons 41.3% became negative. The mf count decreased to more than half of its original level in 36.9% of the positives.

In Hiva Oa island, all the mf carriers received an initial treatment of 18 days followed by one day treatment (6 mg/kg) every three or four months. One year later, only 31 carriers were examined and 87.1% were found negative. The mf count decreased to half of its original level in two persons while it increased in two other carriers. As reported by other workers, the carriers having initially very high mf counts did not always become negative.

The above results showed that microfilaraemia exhibited great variation. One can assume cyclic variation but this has never been demonstrated. All these variations do not facilitate the epidemiological investigations and show that several blood examinations would be required for reliably assessing the degree of endemicity of filariasis.

(N.B. The authors should refer to Hairston & Jachowski, 1968, (121, last para. of Part 1) who provided an explanation for the variation in mf densities.)

3. Clinical investigation

In December 1971 and in February 1972, the authors clinically examined 401 and 553 persons respectively recording also the history of any clinical signs. Detailed analysis of data was made particularly with regard to the relationship between the clinical manifestations and microfilaraemia.

Briefly, the results showed that the clinical manifestations of filariasis are more frequent in the mf negative persons than in the mf positives. The lymphangitis and elephantiasis are often localized in the lower limbs. The adenopathy is frequent and often does not seem to relate to filariasis. The clinical signs are more abundant in the elderly age groups. The authors established four epidemiological types in Marquesas based on a combination of different levels of RI and DI. It was surprising to note that in certain zones the clinical manifestations were frequently high although the RI and DI were low.

Further, the authors indicated that in the island of Nuku Hiva while 11 cases of elephantiasis were recorded 15 years ago, there are only three cases at present. The inhabitants pointed out that mosquito biting was much more heavy in the early days. There are a number of swamps drying up without the intervention of man. This phenomenon is observed at several places in Marquesas, and similar observations were also made in the island of Tahaa. The authors tried to provide an explanation for this phenomenon. It is well known that the seriousness of filariasis situations correlates with vector density. Since a few years ago, there has been a progressive diminution in humidity, a condition which is unfavourable for mosquito propagation. In certain areas this phenomenon could be correlated with the thinning of vegetation. For example, trees and shrubs are destroyed or damaged by cattle, goats, and wild horses principally in Ua Huka Island and certain sectors of Nukuhiva Island. Soil erosion subsequently follows. This was particularly observed in two uninhabited islands.

However, the animals are certainly not the only cause of such ecological modifications which correspond with the changes in the epidemiological situation. The diminution in filariasis endemicity could be correlated with the amelioration of the living standards and hygiene. The inhabitants of Marquesas now well recognize the breeding places of Ae. polynesiensis and destroy them as much as possible. The banding of coconut trees for rat control has also played a role in larval control. An investigation on hygrometric conditions in different valleys as well as effective entomological observation would merit consideration. These will elucidate the differences observed in the epidemiological situation.

- (241) Carme, B., Kaeuffer, H. &
Laigret, J.
1976
Eosinophilie et filariose
lymphatique en Polynésie
française
Bull. Soc. Path. exot., 69, 438-445

A significant hypereosinophilia usually poses an interesting argument for presumptive diagnosis of lymphatic filariasis. The present paper deals with the examination of 278 Polynesian people infected with *W. bancrofti pacifica*. Six types of patients were selected: carriers of microfilariae, patients with elephantiasis, patients with lymphangitis attacks, new infections, carriers of microfilariae recently treated with diethylcarbamazine and, at least, 100 people without filariasis. The results which were observed differ in some aspects from the ideas usually put forward.

- (242) Carme, B., Pichon, G.,
Kaeuffer, H. &
Laigret, J.
1976 a

L'invasion filarienne dans la
filariose lymphatique
Méd. trop., 36, 299-305

Filarial invasion in lymphatic filariasis is differentiated into two phases:

(i) The parasitic invasion: This is the phase of the development of the parasite from the time of penetration of the infective larvae into the human host to the maturation of the adult worms.

(ii) The clinical invasion: This is the phase which starts from the appearance of the first symptoms until the illness.

The authors reviewed the literature dealing with the penetration of the infective larvae into the skin of the host, migration and the development of the larvae to a mature parasite in the lymphatics. The success of parasite invasion is signaled by the appearance of microfilariae in the peripheral blood. The period needed for the production of microfilaremia in the infected persons is very variable as it depends on many factors for which different authors were cited. Many authors of which Brengues (1973)¹ dealing with lymphatic filariasis in West Africa estimated that microfilaremia is rare in children below five year. Jordan (1952)² and Abdul-Cader *et al.* (1966)³ provided evidence for the presence of microfilariae in infants aged 3-8 months. Dondero, Mullin & Balasingam (1972)⁴ inoculated three volunteers sub-cutaneously each with 50 infective larvae of a strain of *B. malayi*. In only one volunteer microfilaremia was established after 17 weeks.

Regarding the subperiodic *W. bancrofti* the authors found a child aged one year originating from Marquesas Island with 201 mf per 20 mm³. Observations made by Wartman (1947)⁵ and Zuckerman & Hibbard (1945)⁶ towards the end of World War II, showed that mature adult worms were extracted by ganglia biopsy from army personnel who resided in the endemic zone of Polynesia for three months to one year.

On the clinical invasion, the authors described the initial appearance of non-specific symptoms which are difficult to ascribe to lymphatic filariasis, the intermediate manifestations ending with the acute stage. The latter consists of acute genital symptoms, lymphangitis, adenitis and allergic respiratory manifestations due to eosinophilia.

The authors further discussed the factors that influence the success and speed of parasitic invasion and the intensity of the clinical invasion. From their conclusions, the filariasis invasion essentially depends on the intensity of infection and host receptivity. These parameters are not mutually exclusive but dependent on each other. Their influence on the parasitic and clinical invasion is schematically illustrated in Table 1.

Table 1. The influence of the intensity of infection and the receptivity of the host on the filariasis invasion

HOST - PARASITE RECEPTIVITY			
Intensity of infection	Weak	Weak	Important
		Parasitaemia 0 Clinical + or 0	Parasitaemia + Clinical 0
	Important	Parasitaemia + or 0 Clinical ++	Parasitaemia ++ Clinical +

The filariasis invasion therefore presents two extreme conditions:

(a) The first is a clinical invasion which manifests itself without a parasite invasion. The host-parasite adaptation fails. This is described as occult filariasis or filariasis without microfilaremia, citing Beaver (1970)⁷.

This is detrimental to the parasite as it does not assure its reproduction and survival. On the other hand it is distressing to the human subject who has to bear the clinical manifestations. This condition is observed among the subject coming from non-endemic regions to an endemic zone.

(b) In contrast, the second condition is distinguished by successful parasite invasion evidenced by the presence of microfilariae in the circulation although without any clinical manifestation. The clinical invasion properly speaking does not take place. This represents a good host-parasite adaptation and these can be regarded as "healthy carriers". This condition is frequently observed among subjects living always in old endemic foci. This is a favourable condition for the parasite as it reproduces and survives, and for the human host as he does not have any complaint. However, these are the persons that represent the reservoir of infective cases. It is due to this adaptation that the foci of filariasis are implanted, develop and pose a severe and widely distributed problem.

¹Brengues, J. (1973) La filariose de Bancroft en Afrique de l'Ouest, Thèse multigr. Thèse de Sciences. Orsay.

²Jordan, P. (1952) Wuchereria bancrofti. Correspondence to the Editor. Trans. roy. Soc. trop. Med. Hyg., 46, 207-208

³Abdulcader, M.H.M., Rajakone, P., Rajendran, K. & Aponso, L. (1966) Age, sex and house distribution of Wuchereria bancrofti microfilaraemia in Ceylon. Am. J. trop. Med. Hyg., 15, 519-522

⁴Dondero, T.J., Mullin, S.W. & Balasingam, S. (1972) Early clinical manifestations in filariasis due to Brugia malayi: observations on experimental infections in man. S.E. Asian J. trop. Med. publ. Hlth., 3, 569-575

⁵Wartman, W.S. (1947) Filariasis in American armed forces in World War II. Medecine, 26, 333-394

⁶Zuckerman, S.S. & Hibbard, J.S. (1945) Clinicopathologic study of early filariasis with lymph nodes biopsies. US Naval Bull., 44, 27-36

⁷Beaver, P.C. (1970) Filariasis without microfilaraemia. Am. J. trop. Med. Hyg., 19, 181-189

- (243) Kaeuffer, H., Carme, B., & Laigret, J.
1976
Intérêt de l'hémagglutination passive et perspectives in matière de filariose lymphatique
Bull. Soc. Path. exot., 69, 244-257

The authors analyzed the data of 219 sera that they tested in passive hemagglutination, with an antigen of *Dirofilaria immitis* proteic extract, in French Polynesia. Besides its light sensitivity, this method does appear very interesting. It points out:

- First, that there is a gaussian distribution of the results found at various dilutions, both by "filarian" and "non filarian" people. Therefore, this distribution is a feasible and practical parameter for evaluating the filariasis transmission in different populations.

- On the other hand, there is an inverse correlation between the presence of microfilariae in the blood and the level of immunological response for lymphatic filariasis.

- (244) Kaeuffer, H., Carme, B., & Merlin, M.
1976 a
Etude comparative de trois méthodes de mise en évidence des microfilaires sanguicoles, appliquées à la filariose lymphatique
Feuillets de Biologie, 17, 65-69

The studies were made in Papeete, French Polynesia. In the first investigation 61 patients were arbitrarily chosen. They were either old carriers who became negative after DEC treatment or subjects with very low microfilaraemia. The three methods: Giemsa stained 20 mm^3 thick smear, the membrane filtration technique of Chularerk & Desowitz (1970)¹ and the haemoconcentration technique of Ho Thi Sang & Petithory (1963)² by centrifuging haemolized blood, were used. The techniques were concurrently performed on each subject. Five thick smears were taken from each subject.

In the second investigation 70 patients suspected of being infected as they showed eosinophilia and intermediate clinical manifestations were examined by five thick smear and haemoconcentration technique. The results of the first investigation are shown in Table 1.

Table 1. Blood examination of a homogeneous group of patients

METHODS	Number of carriers examined	%
Thick smears		
1. 20 mm ³	8	13.14
2. 40 mm ³	12	19.67
3. 60 mm ³	12	19.67
4. 80 mm ³	13	21.31
5. 100 mm ³	14	22.95
Filtration 1000 mm ³	21	34.42
Haemoconcentration 5000 mm ³	29	47.54

From this table it can be seen that the percentage of positives increases according to the sensitivity of blood examination method, the haemoconcentration technique giving the best result. It should be noted that the subjects were arbitrarily chosen and had a low microfilaraemia, the MfD 50 was 2.

The results of the second investigation are shown in Table 2.

Table 2. Results of blood examination of 70 suspected filariasis cases

METHODS	Number of carriers examined	%
Thick smears		
1. 20 mm ³	4	5.71
2. 40 mm ³	5	7.14
3. 60 mm ³	5	7.14
4. 80 mm ³	5	7.14
5. 100 mm ³	6	8.57
Haemoconcentration 5000 mm ³	15	21.42

From the above, it can be seen that the percentage of positive persons is low with the examination of two thick smears that the haemoconcentration technique detected three times the number of positives.

Conclusions: The results certainly demonstrate the superiority of the membrane filtration technique and the haemoconcentration method for detecting the parasite carriers but their practical application in the field is difficult and they are often resented by the inhabitant. The usual method of two thick smears of 20 mm³ each has the advantage of its simplicity but in a zone of weak endemicity it becomes incapable of revealing the dynamic changes in parasitaemia.

¹Chularerk, P. & Desowitz, R.S. (1970) J. Parasitol., 56, 623-624

²Ho Thi Sang & Petithory, R.S. (1963) In: Golvan, Y.J. & Drouhet, E. Technique en Parasitologie et en Mycologie. Ed. Flammarion (1972), pp. 135-138

(245) Merlin, M., Fiviere, F.,
Kaeuffer, H. & Laigret, J.
1976 a

25 ans de campagnes de masse
antifilarriennes en Polynésie
française
Med. trop., 36, 631-640

The paper presents a concise but complete review of the history of filariasis control programme in French Polynesia since its inception in 1949-1953 and adds the results of various investigations carried out up to 1974-1975. The initial data collected in 1949 are cited from the paper of Laigret et al. (113). The methods of blood sampling are described. The entomological techniques utilized are outlined as shown in Kessel (67). The control measures are outlined as follows:

(a) Anti-larval measures: The programme is continuing up to the present. It consisted of the mechanical destruction of the breeding places of Ae. polynesiensis through health education of the inhabitants utilizing radio, television, journals, magazines and courses in schools. These measures proved effective in the inhabited zones. For controlling the inaccessible breeding places, the use of biological control agents is being investigated.

(b) DEC treatment: This consisted of:

- Mass treatment of all the inhabitants of the age-groups over one year during 1953-1956 using a monthly dosage of 6 mg/kg for 12 months. Those found positive were subjected to the same dosage for another year.

- Treatment of mf carriers up to 1964 using the 6 mg/kg dosage with various regimens: 12 monthly doses, six daily doses repeated every six months, and a single dose once every two months. The results were not encouraging.

- In 1967 it was decided to resort to mass treatment giving a dose of 6 mg/kg every three months to the whole population except the infants below one year. Those found to be positive were given a dosage of 6 mg/kg for 12 days followed by the same dosage for six days.
(N.B. The authors did not define the lapse of time between the two treatments.)

- In 1968 systematic chemoprophylaxis was applied to school children at monthly intervals for the scholastic year of nine months.

The above mentioned schemes in theory are excellent but in practice they represented a heavy undertaking, hence abandoned.

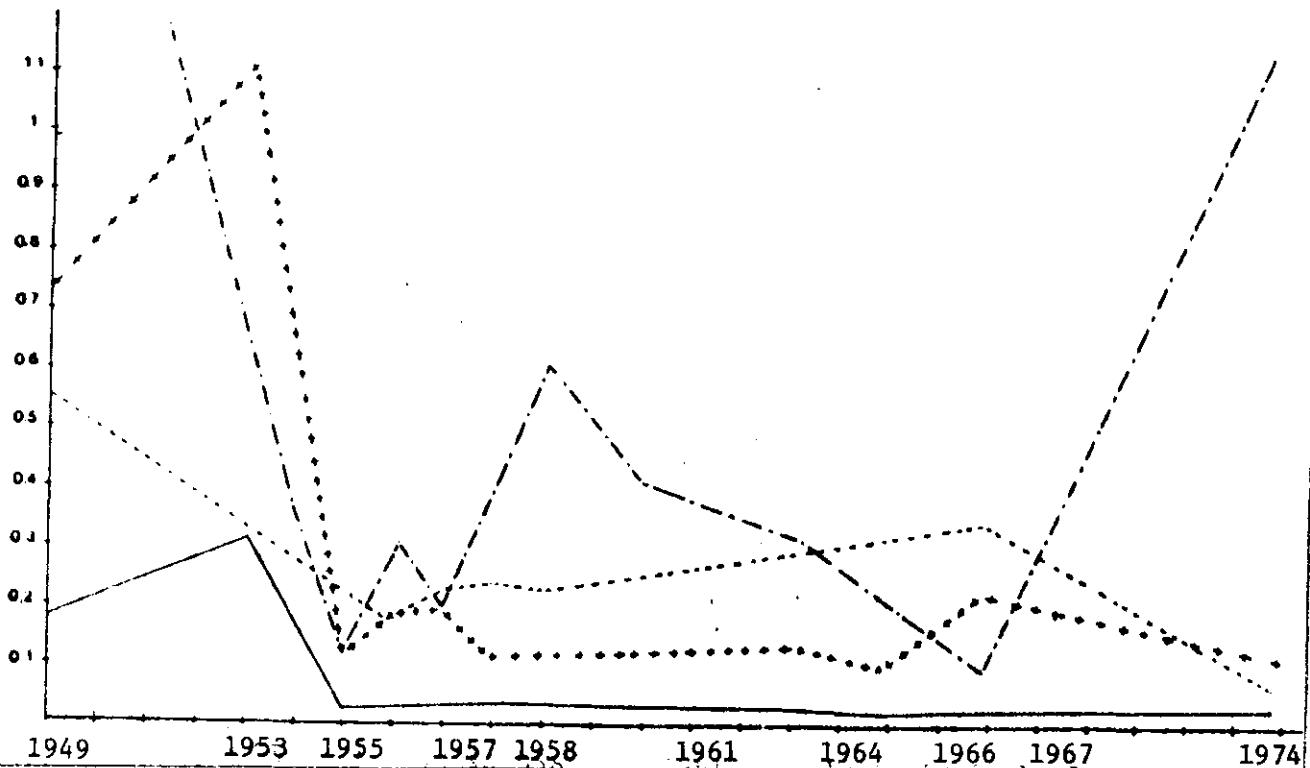
- In 1972 mass treatment was reinstated giving a single dose of 6 mg/kg to all populations with the exception of infants, pregnant women and those breast-feeding.

The present situation:

1. Entomological investigations

(N.B. The authors gave the infection and infective rates in *Ae. polynesiensis* as 5.04% and 1.8% respectively with a mean of infective larvae as 0.12 per mosquito dissected but did not indicate during which year these data were recorded. The authors graphically presented data of mosquito density and dissection as shown in Fig. 1, but unfortunately, they give only one scale which seems to be for the density of *Ae. polynesiensis* per minute. Further, no discussion of these findings was made, except perhaps for vector density.)

Fig. 1



Results of entomological investigations during 1949-1974

- Number of mosquitos captured per minute
- +++++ Number of larvae of *W. bancrofti* per mosquito dissected
- _____ Number of infective larvae per mosquito dissected
- Percentage of mosquitos with infective stage

Regarding larval control, the authors pointed out that the investigation carried out in 1974 in the rural area of Paea showed that 24.1% of the human habitations had larval breeding places. The work of the entomologists during 1949-1956 concentrated on the control of the principal breeding places of *Ae. polynesiensis*, i.e. coconut shells. The increase in urbanization, the reduction in copra production due to lowering of prices and the systematic bandaging of coconut palm trees against rats, all contributed to a considerable reduction of this type of breeding place, hence the reduction of *Ae. polynesiensis* adult density. Since 1970, another phenomenon emerged. *Ae. aegypti*, the main vector of dengue fever, which shares with *Ae. polynesiensis* the same breeding places, i.e., the artificial containers, is mainly an urban mosquito. In Paea, tin cans constituted 31.8% of the artificial breeding places. A competition between the two species must have occurred in favour of *Ae. aegypti* on account of the rapid development of its aquatic stages being shorter by two days than that of *Ae. polynesiensis*. Thus, the latter species has been almost absent in the urban environment.

Two other measures had an impact on the density of the Polynesian mosquito namely, the connexion of all houses with piped water supply which eliminated the storage of rain water and the removal of household refuse by the inhabitants eliminated numerous artificial breeding places.

2. Clinical investigation

From clinical point of view filariasis endemicity does not pose a problem at present, the elephantiasis rate recorded is 0.37% versus 7% in 1949. These are old cases which existed for more than 10 years. An investigation which is still under way showed that tentatively 10 cases of elephantiasis appeared between 1970 and 1974. Other clinical manifestations are rare.

3. Parasitological investigation

In Tahiti, after recording a definite amelioration in 1953, the situation remained stable in the rural zones and has been continuing to improve in the urban zone. In the islands and archipelagos, the results have been mediocre or good and spectacular depending on the efficiency of the personnel in charge and the intensity and continuity of the measures applied.

Conclusions

After discussing the advantages and inconveniences of different drug regimens giving examples from experiments and investigations carried out in Moorea, Tahaa and Tahiti islands the authors drew the following conclusions:

- In the past filariasis in French Polynesia had been a major public health problem. The impact of the disease on the local economy was felt. After 25 years of control directed against the vector and the parasite the endemicity of the disease stabilized to an acceptable level. The control strategy based on mass chemotherapy with DEC giving a single dose treatment produced a desirable effect in the treated population.

- In view of the limitation of personnel, mass treatment is the rewarding method. The treatment of mf carriers poses heavy constraints. Besides which, the methods of detection are not sufficiently sensitive to detect all the carriers. The treatment of carriers only, although theoretically accepted, is not effective in practice.

- With the endemicity reaching stability at a very low level, it is possible that vector control may markedly disrupt this equilibrium leading to eradication as was proposed by Pichon, Perrault & Laigret (174). The efforts to be made in the field of health education of the public and biological control experiments would contribute to achieving this aim.

(246) Carme, B., Pichon, G.,
Merlin, M. & Laigret, J.
1977

Longévité des filaires lymphatiques:
A propos d'une filaire Wuchereria bancrofti toujours féconde après 40 ans d'existence
Méd. et Maladies infect., 7, 254-257

The authors present an exceptionally fortunate observation on a patient native of Tahiti who, 40 years after having left this filariasis endemic area, still harboured in her blood microfilariae of W. bancrofti. This exceptional longevity is analyzed comparatively with the information existing on this aspect. The authors indicated that this very important longevity frequently found in the trematodes is not classical in a nematode. They conclude on the other hand that this parasite longevity represents one of the most serious obstacles to the eradication of lymphatic filariasis in areas where such an action has been attempted.

(247) Carme, B., Pichon, G.,
Merlin, M. & Laigret, J.
1977

Rôle des intraporteurs de microfilaires dans la transmission de la filariose lymphatique
Méd. et Maladies infect., 7, 375-376

A male aged 32 who had never been abroad arrived in Tahiti in 1972. At the beginning of January 1975 he presented symptoms of adenitis and three days later developed lymphangitis which was rapidly resolved by incision.

Examination of his blood by the methods of five thick smears of 20 mm³ each, millipore filtration technique of 1 ml of venous blood and haemconcentration of 5 ml of venous blood, was negative. Examination of the pus from the incision of his abscess did not reveal any filarial debris. Eosinophilia was 220 per mm³ and 4% of the white cells. In contrast his serological reaction by passive haemagglutination technique using an antigen a protein extract of D. immitis at 1/64 dilution was positive.

A batch of laboratory reared Ae. polynesiensis was used for xenodiagnosis. These were dissected after 15 days and one was found to harbour five infective larvae of W. bancrofti.

(N.B.: The authors did not give the number of mosquitos dissected.)

The results showed that despite the absence of microfilariae in this person as examined by the most sensitive technique, the experiment showed that he was potentially infected. There is no point in proposing this method for routine detection of microfilariae. However, the trial showed the possibility of studying the dynamics of infection in mosquitos on the subjects with very low microfilaraemia. It does not constitute any danger to the volunteer since healthy mosquitos are used for a laboratory colony.

There is a need for investigating this aspect of filariasis infection in endemic zones where the disease is transmitted by Aedes mosquitos since there is an indication that parasite yield increases in these mosquitos while the microfilariae in human blood are extremely low as was proposed by Pichon, 1974 (173). Moreover it seems that these mosquitos are capable of concentrating the microfilariae in the blood of donors with extremely low microfilariae as was suggested by Bryan & Southgate, 1976 (192). These aspects represent an obstacle for the eradication of filariasis in the affected regions notably in French Polynesia where the control has been based on DEC treatment which has no action on the adult worm at the dosages utilized. However, the fact that eradication has not been achieved in this region after 25 years of control is not necessarily attributable to the inadequacy of the mass treatment but the long life of the adult worm, which plays an equally important role as shown by Carme et al., 1977 (246)

(248) Parc, F., Rivière, F.,
Roux, J. & Laigret, J.
1978

Méthodes simplifiées de récolte des
formes larvaires de Wuchereria
bancrofti Cobbold (var. pacifica):
leur préparation pour
immunofluorescence
Bull. Wld Hlth Org., 56, 305-308

In order to provide antigenic material in sufficient quantities for immunological studies, the authors developed a simple technique for extracting infective stage larvae of W. bancrofti from Ae. polynesiensis raised in an insectary. Experimentally infected mosquitos were caught and after anaesthetization were held under physiological saline solution for 12-24 hours. In this time the infective larvae emerged from the mosquitos and could be collected. The suspension of larvae was then introduced under slight pressure into a short sealed section of rat thoracic artery in order to obtain homogeneous distribution of the larvae in the artery walls. Frozen sections of the artery were then suitable for immunofluorescence tests. For the collection of microfilariae, a modification of Sawyer & Weinstein's method (1963)¹ was used. Blood from a highly parasitized subject was collected in a citrated bottle, and, after lysis of the red cells with saponin, was centrifuged. Treatment of the sediment with streptolysin then released the living microfilariae, which when taken up in physiological saline solution were ready for use in immunofluorescence tests.

¹Sawyer, T.K. & Weinstein, P.P. (1963) Studies on the microfilariae of the dog heartworm Dirofilaria immitis: separation of parasites from whole blood. J. Parasitol., 49, 39-45

(249) Engber, B., Sone, P.F.
& Pillai, J.C.
1978

The occurrence of Toxorhynchites
amboinensis in Western Samoa
Mosquito News, 38, 295-296

The genus Toxorhynchites is not indigenous to the islands of the eastern South Pacific. Efforts were made to introduce mosquitos of this genus and resulted in the establishment of T. splendens in American Samoa, Petersen, 1956 (61). This species was later shown to be T. amboinensis, Ramalingam & Belkin, 1976 (205).

In 1970, this mosquito was found for the first time during larval collection in Western Samoa, assuming the result of an accidental introduction from American Samoa. Its preferential breeding sites in W. Samoa are the larger artificial and natural containers where Ae. polynesiensis and Ae. aegypti usually breed. Contrary to the situation in American Samoa (Ramalingam & Belkin, loc. cit.), the leaf axils of taro (Colocasia spp.) and ta'amu (Alocasia spp.) are not a major source of breeding for T. amboinensis in W. Samoa. Evaluation of its being a biological control agent for Ae. polynesiensis and Ae. aegypti is being made.

More information may be referred to their unpublished report, 1977 (212).