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Epidemiology of subperiodic bancroftian filariasis in Samoa 8 years after control by mass treatment with diethylcarbamazine*

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In 1979, a microfilarial prevalence study was conducted in a population of 8385 persons inhabiting 28 villages in Samoa using both the nuclepore filtration (NP) method (with 1 ml blood) and the fingerprick (FP) method (with 60 mm³ blood). The overall prevalence rate was 4.5% by the NP method and 3.8% by the FP method. The average microfilarial prevalence in males was 2.3 times higher than in females, and the rate among males aged 30 years and over was as high as 20%. The positive cases were found to be concentrated in certain households.

The median microfilarial density (MfD-50) for the whole of Samoa was 18.6 using 60-mm³ blood samples (males, 21.4; females 14.2). While the MfD-50 of any village has a positive association with the microfilarial prevalence rate of that village, a relatively high MfD-50 was noticed among young people under 20 years of age together with low prevalence rates.

The negative binomial distribution was fitted to the data on the distribution of microfilarial counts in Samoa and gave a better fit than the log-normal distribution. The data having been fitted to the negative binomial, the number of false negatives could be determined as 9% of the estimated number of positives in the survey population when the NP method was employed and about 25% with the FP method.

Further studies revealed that 15.1% of the microfilaria carriers presented some clinical manifestation, the most common being an attack of filarial fever (13.1%). The average duration of a fever attack was 3.5 days and the total period with fever/person/year averaged 27.1 days.

Samoa lies in the South Pacific between latitudes 13° and 15° south and longitudes 171° and 173° west (Fig. 1). The two main islands, Upolu and Savaii, which cover 2825 km², are of volcanic origin and their natural vegetation is tropical rain forest. Most of the 160 000 population inhabit these two islands. Roughly 90% are native Samoans (Polynesian race) most of whom live in houses made of posts and thatched roofs without walls, which favour a high exposure to mosquito bites. Most Samoan villages are found near the coast but an increase in the cultivation of coconuts, bananas, taro, etc. has led to destruction of forests and the development of new inland villages.

Control activities against lymphatic filariasis due to diurnally subperiodic *Wuchereria bancrofti* began in 1964. A blood survey in 21 villages throughout the

* This study forms part of the WHO/Samoa Filariasis Research Project.

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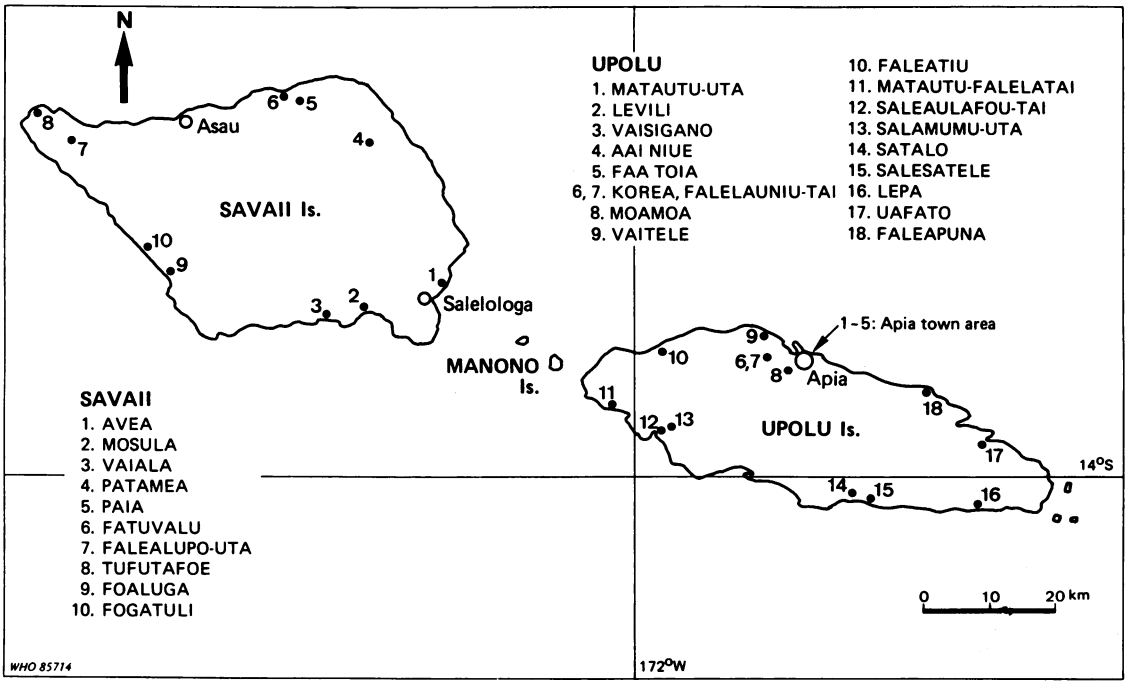

Fig. 1. Location of the 28 villages selected for the microfilarial prevalence study.

country was conducted in 1965 to obtain baseline data before the first mass treatment with diethylcarbamazine citrate (DEC-C). In all, 10 129 persons were examined by the fingerprick method (20 mm^3 blood); the microfilarial prevalence rate was 19.1% and the median microfilarial density (MfD-50) about 24.

The first mass DEC-C treatment was carried out from August 1965 to October 1966, using a dosage of 5 mg/kg body weight administered once a week for six weeks, followed by one dose a month for 12 months (total of 18 doses, 90 mg/kg) to all persons above the age of 2 years. In this campaign, 94.6% of the population was covered by at least one dose but the complete 18 doses were taken by only 20.4% of the total population.[a] After this treatment, a fingerprick blood (20 mm^3) survey, conducted in 1967 on 42 697 people, showed that the microfilarial rate and the MfD-50 had fallen to 1.63% and 2.7 respectively.

The second mass DEC-C treatment was started in January 1971 with a dosage of 6 mg/kg body weight; this was given once a month for 12 months (total of 12 doses, 72 mg/kg) to everyone aged one year and above. While 98.8% of the population took at least one dose, 46.1% of the population took the complete 12 doses.[a] The microfilarial rate, assessed this time by 60-mm^3 films of fingerprick blood, dropped sharply to 0.24% in the follow-up study in 1972. Unfortunately, in the years following the second mass treatment, and despite the continuing active treatment of known cases by the Samoan national team, there was again a gradual increase in the microfilarial rate. The changes in the rates between 1964 and 1976 are summarized in Table 1, based on data from Sasa[b] and Tin Maung Maung & Penaia.[a]

The WHO/Samoa Filariasis Research Project was started in 1976, and towards the end of 1977 the nuclepore membrane filtration technique (using 1 ml of venous blood) was employed by Shibuya et al. (*1*) for the first time in Samoa. Blood surveys by the new method revealed many low-density microfilaria (mf) carriers who had not been detected by the conventional fingerprick method using 60 mm^3 of blood. The overall rate of microfilaraemia in six sample villages was 5.7% and the proportion of low-density

[a] TIN MAUNG MAUNG & PENAIA,. *Filariasis control in Western Samoa by the mass drug administration method*. Unpublished WHO report, 1976.

[b] SASA, M. WHO assignment report, 1972.

Table 1. Prevalence rates of microfilaraemia and median microfilarial density (MfD-50) between 1964 and 1976 in Samoa[a]

Year	Method[b]	No. of persons examined	Microfilaria prevalence rate (%)	MfD-50
1964	20-mm³ FP	2 077	21.1	19
1965	20-mm³ FP	10 129	19.1	24
1965 / 1966	First mass treatment (see text, p.870, for details)			
1967	20-mm³ FP	42 697	1.63	2.7
1968	20-mm³ FP	8 974	0.49	2.7
	60-mm³ FP	5 371	1.32	4.8
	Other method	6 934 (emigrants only)	3.12	
1969	60-mm³ FP	7 393	1.74	7.6
	Other method	3 064 (emigrants only)	3.49	
1970	No blood survey			
1971	Second mass treatment (see text, p.870, for details)			
1972	60-mm³ FP	6 361	0.24	
1973	"	5 145	0.14	
1974	"	30 272	0.33	
1975	"	11 499	2.12	
1976	"	3 649	1.43	

[a] Data from unpublished reports by Sasa (1972) and Tin Maung Maung & Penaia (1976).
[b] Fingerprick (FP) blood smear with 20 mm³ or 60 mm³ blood.

carriers (defined as carriers with $\leqslant$ 10 mf/ml) among the mf-positive subjects was 22.2%.

The present paper records data on the following epidemiological aspects:

—the prevalence of microfilaraemia and the median microfilarial density eight years after the second mass drug treatment in 1971, employing both nuclepore filtration and fingerprick methods;

—the incidence and prevalence of clinical manifestations among the known mf-positive subjects.

MATERIALS AND METHODS

A total of 28 sample villages representative of the whole of Samoa were carefully selected for the present study (Fig. 1). All the villagers, except infants under 1 year old, were registered individually and then examined first by the fingerprick (FP) method and, a few minutes later, by the nuclepore filtration (NP) method. In the FP method, a 60-mm³ blood sample was made into three linear smears on a slide, dried overnight and, without dehaemoglobinization or alcohol fixation, stained with Giemsa. The NP method was carried out on 1 ml of blood taken from the median cubital vein. The samples were filtered through a 3-μm porosity membrane and stained with Azur II, after which the microfilariae were counted.

The blood samples were collected between 13h00 and 19h00; these hours were selected on the results of a microfilarial periodicity study. With a few exceptions, all the villagers were checked by the FP method; the NP method was impracticable in many of the small infants and very fat women.

The MfD-50 was derived from data using fingerprick blood by the application of the least squares method, after confirming reasonable linear relations on log-probit paper. In most of the calculations, data points in the probit range 4.0–6.0 were used because a big deviation from linearity was often found beyond this range.

About 90% of the microfilaria carriers were questioned by the project doctors or nurse about the occurrence of selected symptoms since 1971. Attacks of fever were regarded as filarial only when lymphangitis and/or lymphadenitis accompanied them. Cough and asthma were considered to be of filarial origin if they accompanied a filarial fever attack. Inquiries were also made about elephantiasis, hydrocoele and chyluria. The number of hydrocoele cases was probably underestimated owing to the

Table 2. Microfilaria prevalence rates determined by the NP[a] and FP[b] methods in 28 villages in Samoa (from Nov., 1978 to Nov. 1979)

	Population	No. examined	Attendance rate (%)	No. positive		Prevalence rate (%)	
				NP	FP	NP	FP
Upolu Island	6301	5372	85.3	205	173	3.8	3.2
Apia town area (5 villages)	(2067)	(1615)	(78.1)	(11)	(10)	(0.7)	(0.6)
Other areas (13 villages)	(4234)	(3757)	(88.7)	(194)	(163)	(5.2)	(4.3)
Savaii Island (10 villages)	3444	3013	87.5	176	142	5.8	4.7
Total	9745	8385	86.0	381	315	4.5	3.8

[a] Nuclepore (NP) filtration method with 1 ml blood.
[b] Fingerprick (FP) method with 60-mm^3 blood smear.

unwillingness of some persons to submit to examination.

In the investigation of new clinical cases appearing after the second mass drug treatment in 1971, all positive cases visiting the Filariasis Clinic under the Filariasis Research Project as well as those found in the present surveys (in 1979) were interviewed by the project doctors concerning the onset of their symptoms. In order to estimate the number of working days lost because of the disease, these cases were also questioned about the duration (days) and frequency (times/year) of the attacks of filarial fever.

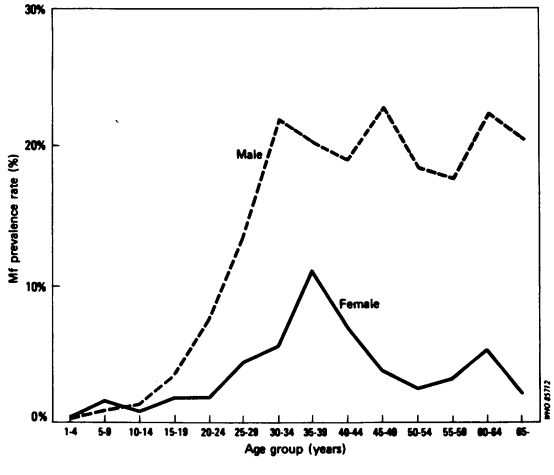

Fig. 2. Distribution of microfilarial prevalence rates (determined by the NP and/or FP methods), by sex and age group.

The present study commenced in November 1978 and was completed in April 1980.

RESULTS

Prevalence of microfilaraemia

A summary of the microfilarial prevalence rates is given in Table 2. A total of 9745 people, roughly 6.1% of the population in Samoa, was covered by the study. Of these, 8385 were actually examined by the NP and/or FP method, giving a total attendance rate of 86.0%. The overall prevalence rate in Samoa was 4.5% by the NP method (381 positive) and 3.8% by the FP method (315 positive). The highest rate recorded was 12.9% by the NP method in a village in Upolu.

Savaii (NP, 5.8%; FP, 4.7%) showed a higher prevalence than Upolu (NP, 3.8%; FP, 3.2%). This is due to the fact that Upolu includes an area (Apia town) which has a large population with a very low prevalence rate. The prevalence rate in Upolu, excluding Apia town, was similar to that of Savaii (NP, 5.2%; FP, 4.3%).

The prevalence was analysed by sex and age (Fig. 2). The following three points were clearly established:

(*a*) The mf-positive rates for both sexes under 25 years of age were markedly lower than those for other age groups.

(*b*) The average mf prevalence in males was 2.3 times higher than in females. Only in the age group 5–9 years did the females show a higher positive rate than males, but this was not statistically significant ($0.1 < P < 0.2$).

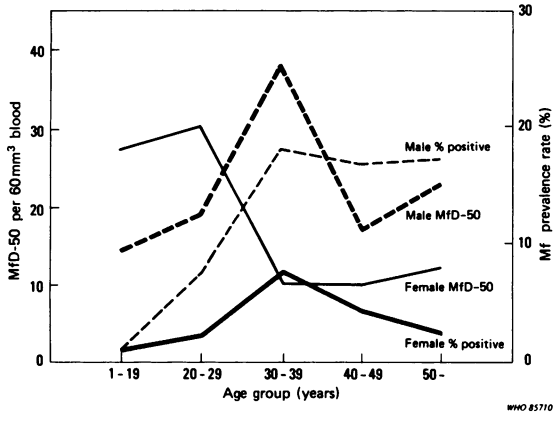

Fig. 3. Relation between microfilarial prevalence rates and densities (MfD-50 per 60 mm^3), by sex and age group.

(*c*) The mf-positive rate among adult males aged 30 years and over was as high as 20%.

There were 17 positives (4.4% of the total positives) in the age group 1-8 years old, all of whom were regarded as having been newly infected since the latest mass treatment in 1971. The youngest carrier found was a 3-year-old girl.

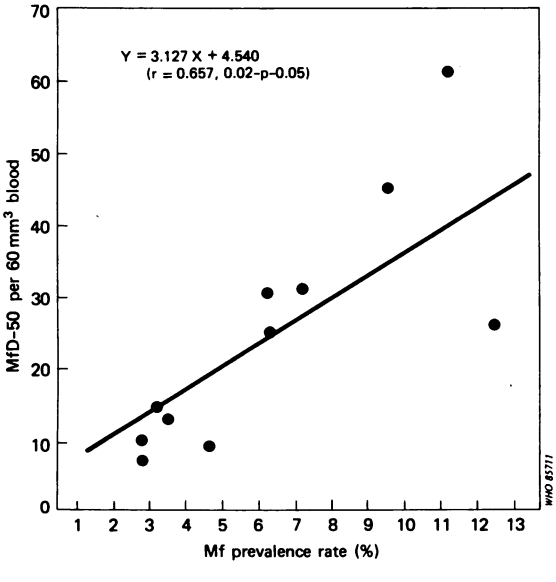

Fig. 4. Relationship between microfilarial prevalence rates and densities (MfD-50 per 60 mm^3), in 11 villages.

Microfilarial density

The MfD-50 of the population examined in 1979 was analysed by sex and age (Fig. 3). Three points were noticed:

(*a*) the average median density was 18.6 (60 mm^3) (males, 21.4; females, 14.2); (*b*) there was no relation between the mf-positive rate of a given age group and the corresponding MfD-50; (*c*) the MfD-50 among females under 30 years of age was remarkably high in spite of their having the lowest mf-positive rate.

A parallel relationship between the microfilarial prevalence rate and the MfD-50 in 11 villages is shown in Fig. 4.

Familial concentration of mf-positive cases

The 387 mf-positive cases identified in the course of the survey were recorded according to their households within each village. The occupants from a total of 965 households were examined so that the average number of cases per household was 387/965 = 0.401. Without information on the distribution of cases by size of household and on the distribution of households by size, it is still possible to approximate to the expected distribution of cases per household. If it is assumed that the cases are independently distributed with regard to household, then the probability of there being k per household is given by the Poisson probability,

$$P(k) = e^{-m}m^k/k! \qquad \text{where } m = 0.401$$

No. of positives	0	1	2	3	4+	Total
No. of households						
Observed	694	191	60	11	9	965
Expected	646.2	259.1	52.0	6.9	0.8	965.0

It is obvious that there is a tendency for positive cases to concentrate or accumulate in some households.

Analysis of the distribution of microfilarial counts

Among the 387 persons found to be positive for microfilariae it was possible to obtain a valid count from 358 by the NP method. The distribution of these counts is shown in Table 3. By the method of Pichon et al. (*2*) a negative binomial distribution was fitted to our data using a value of 0.3 for the exponent, as recommended. The fit to the data is excellent ($0.6 < P < 0.7$). Also shown is the fit of the more customary log-normal distribution. The degree of fit is not good ($P < 0.001$) and, as is common, a

Table 3. Frequency distribution of microfilarial counts obtained by the NP method (1 ml blood) and corresponding negative binomial distribution (mean of truncated distribution = 524.330; exponent = 0.3) and log-normal distribution (mean = 2.043; S.D. = 0.938)

Microfilarial count	Observed frequency	Negative binomial		Log-normal	
		Expected	Chi-square	Expected	Chi-square
1	11	13.214	0.371	8.338	0.850
2	12	8.584	1.359	6.004	5.988
3-4	13	11.999	0.084	10.421	0.638
5-6	9	8.774	0.006	9.161	0.003
7-8	8	7.074	0.121	8.112	0.002
9-10	7	6.000	0.167	7.314	0.013
11-20	29	21.729	2.433	28.583	0.006
21-30	17	15.076	0.246	20.728	0.670
31-40	10	11.854	0.290	16.242	2.399
41-50	11	9.892	0.124	13.500	0.463
51-60	13	8.550	2.316	11.259	0.269
61-70	6	7.565	0.324	9.841	1.499
71-80	8	6.805	0.210	8.717	0.059
81-90	4	6.198	0.779	7.658	1.747
91-100	4	5.700	0.507	6.838	1.178
101-200	30	41.077	2.987	45.208	5.116
201-300	25	26.579	0.094	25.042	0.000
301-400	22	19.642	0.283	16.493	1.839
401-500	17	15.443	0.157	11.918	2.167
501-600	12	12.589	0.028	9.108	0.918
601-700	15	10.511	1.917	7.346	7.975
701-800	10	8.925	0.129	5.975	2.711
801-900	2	7.675	4.196	4.937	1.747
901-1000	4	6.666	1.066	4.260	0.016
1001-2000	31	36.479	0.823	22.848	2.909
2001-3000	18	13.242	1.710	9.591	7.373
3001-4000	6	5.524	0.041	5.320	0.087
$\geqslant$ 4001	4	4.634	0.087	17.338	10.261
Total	358	358.000	22.855	358.000	58.903

departure from agreement occurs at the extremes of the range. Having fitted the negative binomial, it is possible to determine the size of the class with zero count — the "false negatives" — at the time of survey. The number of these is estimated to be 36.7; that is, the number of false negatives amounts to 9.3% of the estimated number of positives in the survey population when the NP method is used.

A similar form of analysis was carried out on the 315 who were positive by the FP method (Table 4). As before, the fit to the log-normal distribution is not good ($0.001 < P < 0.005$), but the fit to the negative binomial, though close, is not good either ($0.01) < P < 0.025$). If an estimate of the number of false negatives is attempted, the result is 100.6 which corresponds to 24.2% of the estimated number of cases present in the population surveyed by the FP method. Confirmation of this figure is given by the observation that, of the 381 cases found positive by the NP method during the survey, only 315 cases were judged positive by the FP method. In other words, 17.3% of the subjects found positive by the NP method were judged to be negative by the FP method. If the number of positives by the NP method is adjusted to allow for the false negatives due to that method, then the percentage of false negatives due to the FP method rises to 25%.

Table 4. Frequency distribution of microfilarial counts obtained by the FP method (60 mm^3 blood) and corresponding negative binomial distribution (mean of truncated distribution = 64.171; exponent = 0.3) and log-normal distribution (mean = 1.278; S.D. = 0.746)

Microfilarial count	Observed frequency	Negative binomial		Log-normal	
		Expected	Chi-square	Expected	Chi-square
1	30	26.013	0.956	22.000	2.902
2	17	16.805	0.002	15.485	0.148
3	20	12.805	4.043	13.721	2.873
4	14	10.499	1.167	12.115	0.293
5	4	8.974	2.757	10.847	4.322
6	10	7.878	0.571	9.823	0.003
7	10	7.047	1.237	8.807	0.162
8	2	6.391	3.017	8.080	4.575
9	5	5.858	0.126	7.316	0.733
10	6	5.414	0.063	6.914	0.121
11-20	27	39.574	3.995	48.044	9.218
21-30	29	25.962	0.356	28.717	0.003
31-40	22	19.310	0.375	19.418	0.343
41-50	27	15.246	9.062	14.145	11.683
51-60	9	12.469	0.965	10.867	0.321
61-70	11	10.439	0.030	8.633	0.649
71-80	9	8.886	0.001	7.100	0.508
81-90	3	7.658	2.833	5.823	1.369
91-100	7	6.665	0.017	4.925	0.874
101-200	27	36.785	2.603	25.482	0.090
201-300	10	13.585	0.946	9.752	0.006
301-400	7	5.760	0.267	5.056	0.747
$\geqslant 401$	9	4.977	3.252	11.929	0.719
Total	315	315.000	38.641	315.000	42.662

Clinical manifestations of infection

The clinically identified cases were analysed by microfilarial counts and the results (Table 5) showed no significant difference in the occurrence of either a fever attack or "any symptom", which included cases with any clinical manifestation(s), in relation to the microfilarial count. In Samoa many of the chronic clinical cases, most of whom have been treated, are usually found to be negative for microfilariae.

In Table 6 the clinical manifestations are classified by sex and age group. The difference in the occurrence of "any symptom" ($0.2 < P < 0.3$) and of fever attack ($0.6 < P < 0.7$) by sex was not significant. However, the age group under 25 years had significantly fewer cases with "any symptom" compared with the age group 25–49 years ($P < 0.025$); and the latter age group had significantly fewer cases with "any symptom" compared with the age group 50 years and over ($P < 0.025$).

The relationship between clinical manifestations, microfilarial counts, and age group was also studied (Fig. 5) and showed that mf carriers under 50 years of age, with a count of 20 mf/ml or less, were practically free of any clinical signs and that it takes about 20 years for mf carriers to have any clinical manifestation at the present degree of endemicity. The youngest clinical case found in the present study was an 18-year-old boy with a high mf count ($\geqslant$ 200l/ml).

A limited investigation on whether new clinical cases have been occurring, since the second mass treatment in 1971, was carried out by questioning patients concerning the onset of their symptoms.

Table 5. Number of cases with clinical manifestations in relation to microfilarial counts determined by the NP method (1 ml of blood)[a]

	No. of persons with microfilarial counts/ml of:					
	1-20	21-100	101-500	501-1000	⩾ 1001	Total
Fever attack with lymphangitis and/or lymphadenitis	7 (9.7)[b]	5 (8.3)	14 (16.1)	3 (7.5)	15 (23.4)	44 (13.6)
Cough or asthma among the above fever cases	1 (1.4)	0 (0.0)	3 (3.4)	0 (0.0)	2 (3.1)	6 (1.9)
Elephantiasis	1 (1.4)	0 (0.0)	1 (1.1)	0 (0.0)	1 (1.6)	3 (0.9)
Hydrocoele	2 (2.8)	0 (0.0)	1 (1.1)	2 (5.0)	0 (0.0)	5 (1.5)
Chyluria	0 (0.0)	0 (0.0)	2 (2.3)	0 (0.0)	0 (0.0)	2 (0.6)
Any symptom[c]	7 (9.7)	5 (8.3)	18 (20.7)	5 (12.5)	15 (23.4)	50 (15.5)
Total	72	60	87	40	64	323

[a] Twenty-one cases (including one hydrocoele and a fever case) were excluded because of inaccurate mf counts.

[b] Figures in parentheses are percentages against the total in each group of mf counts.

[c] This includes cases with any clinical manifestation(s).

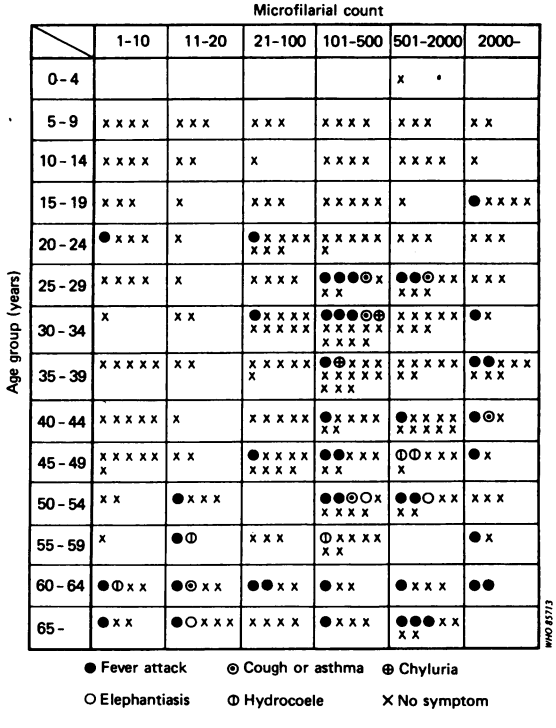

Fig. 5. Occurrence of clinical manifestations analysed by age group and microfilarial counts by the NP method; 21 cases including a hydrocoele case (54 years) and a fever case (26 years) were excluded owing to inaccurate counts.

Forty-eight outpatients who visited the Filariasis Clinic and 12 patients from our surveys provided more or less reliable information. The results are summarized in Table 7. As all the 27 elephantiasis cases had had previous fever attacks, the figures in Table 7, each of which stands for one clinical symptom, total 87. These findings indicate that the manifestation of clinical signs and symptoms was continuing in the late 1970s in Samoa.

The number of working days lost because of attacks of filarial fever was studied by interviewing 65 patients as to the duration (days) of their fever and its frequency (times/year); 56 of them were outpatients in the Filariasis Clinic and the rest were found by the present study. The results indicated that the average duration of a fever attack was 3.5 days and that the total period with fever/person/year averaged 27.1 days.

DISCUSSION

Prevalence and density of microfilaraemia

The nuclepore filtration method in the present study detected 21% more mf carries than the finger-prick method, a result similar to that of Wang & Fan (*3*) who found 26% more carriers by millipore filtration than by blood smear. In contrast, the results of Desowitz & Southgate (*4*). Desowitz et al. (*5*), Southgate (*6*), and Sajidiman et al. (*7*) indicated that the 1-ml millipore membrane filtration technique

Table 6. Distribution of clinical manifestations among mf-positive cases, classified by sex and age group

	Sex		Age group (years)			
	Male	Female	1–24	25–49	⩾ 50	Total
Fever attack with lymphangitis and/or lymphadenitis	33 (13.7)[a]	12 (11.7)	3 (3.45)[a]	21 (12.3)	21 (24.4)	45 (13.1)
Cough or asthma among the above fever attack cases	5 (2.07)	1 (0.97)	0 (0.00)	4 (2.34)	2 (2.33)	6 (1.74)
Elephantiasis	3 (1.24)	0 (0.00)	0 (0.00)	0 (0.00)	3 (3.49)	3 (0.87)
Hydrocoele	6 (2.49)	–	0 (0.00)	2 (1.17)	4 (4.65)	6 (1.74)
Chyluria	2 (0.83)	0 (0.00)	0 (0.00)	2 (1.17)	0 (0.00)	2 (0.58)
Any symptom[b]	40 (16.6)	12 (11.7)	3 (3.45)	25 (14.6)	24 (27.9)	52 (15.1)
Total	241	103	87	171	86	344

[a] Figures in parentheses are percentages against the totals of males, females and age groups.
[b] This includes cases with any clinical manifestation(s).

Table 7. Number of clinical manifestations (fever attack, elephantiasis and hydrocoele) and their year of onset

	Up to 1969	1970–71	1972–73	1974–75	1976–77	1978–79
Fever attack	30	6	2	2	5	11
Elephantiasis and hydrocoele	15	0	*1+3*[a]	1	*3+2*[a]	*4+2*[a]
Total	45	6	6	3	10	17

[a] Figures in italic are cases of elephantiasis/hydrocoele who had had fever attacks before the mass treatment with DEC-C in 1971.

could detect 2-5 times (or 200–500%) more carriers than the fingerprick (60-mm^3 blood smear) method. It is difficult to explain the discrepancy between the results obtained by these various groups of workers.

The overall prevalence of mf-positive persons eight years after the last mass DEC-C treatment was as high as 4.6% by the NP and/or FP methods (3.8%) by the FP method only); the microfilarial prevalence rates for males and females were 6.6% and 2.7%, respectively. The validity of these crude prevalence rates was tested against the age-stratified standardized population (1976 census) in Samoa. The adjusted rates, 4.7% for all Samoa (7.0% for males and 2.2% for females), did not differ greatly from the crude rates, suggesting that the present study was satisfactory in minimizing sampling bias.

The change of microfilarial prevalence from 0.24% in 1972 (60-mm^3 FP method) to the 1979 level of 3.8–4.6% can be attributed to the still high degree of vector-human contact. In Samoa, *Aedes polynesiensis*, which is a day biter, and *Aedes Samoanus*, a night biter, transmit filariasis by day and night all the year round.[c] Possibly an increase in the numbers of *A. polynesiensis*, which breeds in artificial containers such as drums, cans, discarded tyres, etc., might be another factor leading to an increase in microfilarial prevalence as Samoan life-style becomes modernized. In any case, the resurgence of filariasis since 1974 shows that even the very low degree of endemicity represented by a prevalence of 0.24% in 1972 cannot be regarded as a point at which the disease becomes self-eliminating.

The average annual incidence of new mf-positive persons was worked out in the age group 1–7 years old on the assumption that there was no change in the population size for each component age in those 7 years, using the formula:

$$I = \left(\sum_{i=1}^{7} (1000 \times N_i)/(i \times P_i)\right)/7$$

[c] SAMARAWICKREMA, W. A. WHO assignment report, 1980.

where I is the annual incidence per 1000 population, N_i is the number of positives at age i, and P_i is the population examined at age i. The result showed that the average annual incidence was 1.02. When the calculation was made for the age group of 3–7 years, i.e., excluding the ages of 1 and 2 years which had no positive cases, the incidence was 1.43.

Age–sex distribution of the microfilarial prevalence in 1979 was like that in a typical area of medium endemicity (*8*), i.e., a remarkably low prevalence rate among young people (under 20 years old), with a slight female dominance among those aged under 10 years, and a much higher prevalence among adults (aged over 20 years) with a clear male dominance. In a highly endemic area in Tonga, the use of the membrane filtration technique revealed that the microfilarial prevalence rate was essentially the same (about 70%) for all age groups studied (5 years and over), and that any difference in rates by sex was small (*9*). In Samoa, the employment of the NP method (1 ml blood) did not change the pattern of age-sex distribution from that obtained by the FP method (60 mm^3 blood).

The median microfilarial density calculated for 1979 was 18.6 per 60 mm^3 blood (males, 21.4; females, 14.2) or 6.2 per 20 mm^3 blood (males, 7.1; females, 4.7) when adjusted simply for the volume of blood examined. This value is roughly 1/3 to 1/4 of the pretreatment MfD-50 in 1964-65.

The MfD-50 was shown to have a close positive association with the mf prevalence rates in several villages. However, the relation between the MfD-50 value and the prevalence rate could not be established when the microfilarial density was analysed by age and sex. A relatively high MfD-50 value was observed in this study among young persons under 20 years old. This agrees with Barry et al. (*10*) and Fan et al. (*11*) who found the highest microfilarial density in the age group of 10–14 years and 1–10 years, respectively. The reasons for this are not clear.

The present study showed that there was a clear tendency for the mf-positive cases to be located in certain households. Mataika et al. (*12*), in Fiji, also reported that some houses did have more than their random share of infections, although the transmission was not intrafamilial. In Japan and the Ryukyu Islands, where filariasis was transmitted by culicine mosquitos, an intrafamilial transmission of filariasis has been reported (*13*).

Pichon et al. (*2*) proposed to apply the negative binomial distribution in analysing the distribution of microfilarial counts in a population. This model was tested and proved to be satisfactory as a more precise alternative to the log-normal distribution which had been recommended by WHO (*14*). Although the computation is complicated, the new method can be used to estimate the number of possible false negatives, an estimation which was also verified in the present study. The calculated number of false negatives was 9% of the estimated number of positives in the survey population when the NP method was employed and about 25% with the FP method.

Clinical manifestations of filariasis

There are few reports on clinical filariasis in Samoa. McCarthy & Fitzgerald (*15*) reported in 1955 that the prevalence rates for hydrocoele in males, and for elephantiasis in males and females in a Samoan village were 6.6%, 2.6% and 1.4%, respectively. Tin Maung Maung & Penaia[d] reported that the hydrocoele and elephantiasis rates in 1967–69 averaged 3.7% and 1.5%, respectively. The present study was conducted only among mf-positive cases by means of questioning, thus making the comparison with the past data difficult.

The present study showed that 15.1% of the mf-positive individuals suffered from some clinical manifestation, the most common being an attack of filarial fever (13.1%). As the total number of mf positives in the whole of Samoa is estimated at about 7200, the number of persons with some clinical manifestation would be 1087. The hydrocoele and elephantiasis rates were 1.7% and 0.9%, respectively.

Chyluria is a rare clinical condition in Samoa. Tin Maung Maung & Penaia[d] reported only four cases in 1967–76. Ciferri et al. (*16*) in American Samoa found one case among 1008 persons examined. In our study, two cases were confirmed by means of urine specimens.

The possibility that the cough and asthma in six of our patients might be of filarial origin may be challenged. Without having any previous report on pulmonary involvement in filariasis in Samoa, our study merely raises a speculation that some of these cases may represent tropical pulmonary eosinophilia.

The present study showed that clinical manifestations could be related to the dual factors of age and microfilarial count. Young people with a low microfilarial count were symptom-free, whereas older persons with a high count tended to show more signs and symptoms. Our study also suggested that new cases with clinical signs were still developing and that the incidence might now again be on the increase despite the generally accepted belief that clinical filariasis had been reduced drastically as a result of the two mass DEC-C campaigns. In Tahiti, March et al. (*17*) reported that, over a ten-year observation period, no new cases of elephantiasis or hydrocoele developed after the mass DEC-C treatment had

[d] See footnote *a* (page 870).

reduced the prevalence rate from 38% in 1949 to 6.5% in 1959.

Kessel (*18*) discussed the disabling effects of clinical filariasis under three headings—economic losses, deformity produced, and psychological injury—and indicated the significant personal and social disadvantages that may result from the disease. Economic losses from filariasis are of great interest to those engaged in filariasis control activities, especially when the cost of a treatment campaign has to be justified. The information obtained in our study has limited accuracy and was biased because we had many outpatients who might have been the more severe cases needing medical care. Nevertheless an attempt was made to estimate the annual economic losses from filarial fever attacks in Samoa. There are an estimated 7200 mf carriers in Samoa of whom 13%, or 936 persons, may be expected to suffer from attacks of filarial fever. Almost all of them are economically active people. If the estimated number of working days lost (27.1/person/year) is applied to all these cases, the total loss of working days in Samoa in 1979 was about 25 000 days. This is equivalent to the economic contribution of some 80 persons per year, and if the per capita GNP is estimated to be US$ 350, the total loss is about US$ 28 000.

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RÉSUMÉ

ÉPIDÉMIOLOGIE DE LA BANCROFTOSE SUBPÉRIODIQUE AU SAMOA 8 ANS APRÈS UN TRAITEMENT DE MASSE PAR LA DIÉTHYLCARBAMAZINE

Au Samoa, où la filariose subpériodique à *W. bancrofti* est endémique, deux campagnes de traitement de masse par la diéthylcarbamazine (citrate) ont été menées au niveau national en 1965–66 et en 1971. Elles se sont soldées par une chute du taux d'infestation microfilarienne, qui est passé de 19,1% en 1965 à 0,24% en 1972. En 1979, 8 ans après le dernier traitement de masse, on a effectué une étude sur la fréquence d'apparition des microfilaires chez 8385 habitants de 28 villages, à l'aide des techniques de filtration sur membrane nucléopore (avec 1 ml de sang) et de ponction au doigt (avec 60 mm^3 de sang). La première méthode a révélé un taux global d'infestation de 4,5% et la seconde de 3,8% (381 et 315 positifs respectivement, soit un écart de 21%). Le taux d'infestation microfilarienne était en moyenne 2,3 fois plus élevé chez les hommes que chez les femmes, et chez les hommes de 30 ans et plus, il s'élevait à pas moins de 20%. On s'est aperçu que les sujets positifs étaient concentrés dans certains ménages.

Pour l'ensemble du Samoa, la densité microfilarienne médiane (MfD_{50}) était de 18,6 pour 60 mm^3 de sang (hommes: 21,4; femmes: 14,2), soit environ $\frac{1}{3}$ à $\frac{1}{4}$ des valeurs observées en 1964–65, antérieurement au traitement. Si, dans chaque village, il existe une corrélation positive entre taux d'infestation et densité, on a noté chez les moins de 20 ans des densités relativement élevées même en présence d'un taux d'infestation pourtant faible.

Dans ce pays, la distribution de fréquence du nombre de microfilaires était plus proche d'une distribution binomiale négative que d'une distribution lognormale. Une fois effectué l'ajustement à la première loi, on a pu déterminer le nombre de faux négatifs, soit 9% du nombre estimatif de sujets positifs dans la population soumise à l'enquête par la méthode de filtration sur membrane nucléopore et environ 25% par la méthode de piqûre au doigt. La valeur de ces résultats a été confirmée par le fait que 17% des sujets trouvés positifs par la première méthode ont été jugés négatifs par la seconde.

Des études cliniques ont révélé que 15,1% des porteurs de microfilaires avaient présenté une manifestation clinique, la plus courante étant une poussée fébrile (13,1%). En moyenne, la durée de cette poussée était de 3 jours et demi et le nombre total de jours de fièvre par personne et par an, de 27,1. En 1979, on a estimé que la perte totale due à ces épisodes fébriles au Samoa représentait environ 25 000 jours de travail.

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