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FILARIAL INFECTIONS IN MOSQUITOES IN FIJI

BY

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An inquiry into the possibility of employing insecticides for the control of the non-periodic form of *Wuchereria bancrofti* infection in Fiji was promoted by the Secretary of State for the Colonies and the Government of Fiji, about a year ago.

In the course of preliminary studies an attempt is being made to assess the importance of the more prevalent species of mosquitoes in the carriage of this infection. For this purpose in selected areas a proportion of the adult mosquitoes captured in houses and in bush for studies on bionomics and populations, are dissected and examined for the presence of developing forms of filaria. At the same time females of the same species, bred from larvae in the laboratory are infected in the laboratory by feeding upon infected people.

The house catches are made both by hand, with sucking tubes, and by the use of an insecticidal " fog " from a generator. The " fog " produced rapidly in large volume, brings down to the ground-sheets at least a very great majority if not all the mosquitoes in a room or house, and so provides fairly reliable data on both the size and species content of mosquito populations at the time of fogging. This method is of course merely an improvement of the well-known " flitting " of rooms widely used in studies on malaria mosquitoes.

In the bush the mosquitoes are caught by hand with sucking tubes when coming to feed on a human bait, and also whilst resting in grass, and bush, on tree trunks and other harbourages of well-fed females.

Identification of *W. bancrofti* in dissected " wild " mosquitoes is not easy. The dog filaria, *Dirofilaria immitis*, is very common in dogs in Fiji. Its early developing forms in mosquitoes are readily identified by their position in Malphigian tubules. Its mature larvae, occurring as do those of *W. bancrofti*, in thorax, head and proboscis, differ from the latter essentially by having only one terminal papilla, *W. bancrofti* having three or four. These papillae are usually not easily seen. It is probable then, that some of the mature or nearly mature larvae recorded in dissections are those of *D. immitis*. But the number may not be large, since only some 2 per cent. of a sample of 402 mosquitoes from houses and surrounding bush, submitted to the precipitin test by Dr. B. WEITZ of the Lister Institute, contained dog blood, and only about 6 per cent. of 101 developing infections in wild mosquitoes (4 in *Culex* (*Culex*) *annulirostris*) were those of *D. immitis*, found in the Malphigian tubules. It may perhaps be assumed then, that at the most one or two of our recorded mature, or nearly mature infections in wild mosquitoes are those of *D. immitis* (Table I).

There is another slight difficulty in the interpretation of results. There may be other filaria in the local fauna of which nothing is known here. Filaria of cattle (? *Setaria labiata papillosa*) has been found in three of a total of 82 cows examined. No infection has been recorded in the relatively few fowls, cats, and rats so far examined. The results of the 402 precipitin tests mentioned were briefly : Man 81 per cent., horse 2.7 per cent., ox 2 per cent., dog 1 per cent., fowl 6 per cent. These do not suggest the presence in villages and the surrounding bush of a major unknown host. It is perhaps not unreasonable to assume, therefore, that the great majority of infections recorded in wild mosquitoes are those of *W. bancrofti.*

TABLE I. Filarial infection in " wild " mosquitoes caught in houses and bush in Fiji.

Species	Number examined	Number positive (all stages)	Number with mature or nearly mature infections.
Aedes (*Stegomyia*) *pseudoscutellaris* *Aedes* (*Stegomyia*) *polynesiensis*	828	23 (2.8%)	1 (0.12%)
Culex (*Culex*) *fatigans*	583	28 (4.8%)	2 (0.34%)
Culex (*Culex*) *annulirostris*	222	22 (10%)	3 (1.3%)
Aedes (*Finlaya*) *fijiensis*	314	68 (21.6%)	6 (1.9%)
Aedes (*Aedimorphus*) *vexans*	356	4 (1.1%)	1 (0.28%)
Aedes (*Stegomyia*) *aegypti*	46	7 (15%)	0
Mansonia (*Coquillettidia*) *crassipes*	16	1 (6%)	0
Culex (*Culex*) *sitiens*	5	0	

Laboratory infections are of course produced in the normal way by feeding laboratory bred female mosquitoes on infected people. Observations are made on the progress of the infection in the mosquitoes by dissection and microscopical examination of the fed specimens during 15 to 20 days following the feeding. Results of our first infections are shown in Table II. Lots 3, 5 and 6 were fed on the same infected person ; Lots 4, 7, 8 and 9 were fed upon another person, 4 and 7 together in the late evening, and 8 and 9 at 9 a.m. and 4 p.m. on successive days. Lot 2 fed upon a man from Rotuma Island with advanced elephantiasis in both legs and scrotum. His blood count of microfilaria was low.

Blood counts were made either of 1 c.c. of blood taken from the median cubital vein and treated by the Knott method, or of 20 c.mm. taken from the finger, or both. All blood slides for counts, except for the first were stained with Geisma for examination.

If the data recorded mean anything, they would appear to suggest that both *Culex* (*Culex*) *fatigans* and *Aedes* (*Finlaya*) *fijiensis*, as well as *Aedes* (*Stegomyia*) *pseudoscutellaris*, are efficient carriers of filariasis in Viti Levu, and that any schemes designed to control filariasis, should include measures for the control of these two species. An effort is now being made to assess separately the rôles of *A.* (*Stegomyia*) *pseudoscutellaris* and *A.* (*Stegomyia*) *polynesiensis* ; and *C.* (*Culex*) *annulirostris* and *A.* (*Aedimorphus*) *vexans* will receive early attention. Investigations of this kind will be continued here in Viti Levu and will be extended to other islands of the Fiji group until all common and important species have been dealt with.

TABLE II. Summary of laboratory infections of mosquitoes with non-periodic *W. bancrofti*, in Fiji. *All mosquitoes were fed upon infected male Fijians.*

Blood count.	No. of mosquitoes fed	No. died	No. infected (living)	First 3rd-st. larva seen on . . day	No. of mature infections
Culex fatigans					
1. 2867 in 1 c.c. V *	18	3	4	19	3 (in 8 mosquitoes dissected on days 19 and 20).
2. 525 in 1 c.c. V * / 22 in 20 c.mm.	67	0	12	15	5 (in 30 specimens dissected on days 15 to 20).
3. 5689 in 1 c.c. V * / 169 in 20 c.mm.	26	5	16	14	5 (in 14 dissected on days 14 to 20).
4. 133 in 20 c.mm. **	47	11	31	12	20 (in 26 dissected on days 15 and 16).
5. 5689 in 1 c.c. V * / 169 in 20 c.mm. **	36	5	23	15	10 (in 12 dissected on days 16 to 19).
A. fijiensis					
6. 5689 in 1 c.c. V * / 169 in 20 c.mm.	15	3	11	13	9 (in 10 dissected on days 14 to 17).
7. 133 in 20 c.mm. **	61	18	40	10	31 (in 37 dissected on days 14 and 15).
A. pseudoscutellaris (? and *A. polynesiensis*).					
8. 82 in 20 c.mm. ** / 102 in 20 c.mm. **	13	4	9	14	9 (in 9 dissected on day 14).
9. 77 in 20 c.mm. **	23 (1)	4	18	9 (dead) / 12 (living)	(1) 13 (in 17 dissected on days 13 and 14).

* Averages taken from 3 hourly counts over 24 hours.
** Count at time of feed.
(1) Five of these were definitely *A. pseudoscutellaris*.

Sir Philip MANSON-BAHR *comments on* Mr. C. B. SYMES' *communication, as follows :*

Mr. SYMES has undertaken to re-investigate the transmission of filariasis in Fiji before directing an insecticidal campaign there. In the short space of some four months he has accomplished an amazing amount of work. Although this question is being investigated by a number of organizations and research workers in the Pacific, Mr. SYMES' results have come as somewhat of a surprise and, if his implications are correct, a reorientation of the policy of the Medical Department in Fiji regarding suppressive measures is bound to ensue.

I am interested in this matter in view of my own original work on this very subject.

The first rather disturbing results are given in Table I. on filarial infections of wild-caught mosquitoes in houses and in the bush in Fiji. (Unfortunately no exact localities are

given). The total number of these insects dissected (2,370) is one of the largest yet recorded. There are no previous figures of this particular work being undertaken in Fiji, though there are some from Tahiti and Samoa. Dissecting mosquitoes is a time-consuming occupation and it must have taken many weeks to get through this big series. A considerable number of these wild-caught Fijian mosquitoes were found to be harbouring larval filariae. Little is known of the developmental stages of filariae in birds — which some of these may be ; but it is interesting to note that two species that may harbour these parasites, the red-vented bulbul (*Molpastes haemorrhous bengalensis*) and the Malayan dove (*Steptopelia chinensis tigrina*) have been introduced into Fiji during the last 30 years. Although HU (1931) has found marked variation in host-parasite relationship in *Dirofilaria immitis*, so widespread amongst dogs in Fiji, it was established some 10 years ago in Fiji that that vector there is *Aedes aegypti* solely.

The mosquito fauna of Fiji has changed somewhat in the last 45 years — when *Aedes vexans* and *A. fijiensis* did not present the same menace as these appear to do now. Indeed R. W. PAINE (1943) mentions that the former became prominent only in 1937.

The most exciting discovery is that 21.6 per cent. of wild-caught *A. fijiensis* contained developing filarial larvae, and 1.9 per cent. had 3rd-stage larvae in head and proboscis. These are the highest figures yet given. O'CONNOR (1923) in Savaii (Samoa) recorded one single specimen of wild-caught *A. kochi* (an allied sub-species) naturally infected out of 73 dissected.

BYRD and colleagues (1945), also in Samoa, out of 6,634 specimens found 2.9 per cent. of *Aedes scutellaris pseudoscutellaris* and 7.9 per cent. of *Culex fatigans* infected, though in the latter species the great majority of larval filariae died out when kept under laboratory conditions. In American Samoa again, JACHOWSKI and OTTO (1952) out of 1,700 *Aedes scutellaris polynesiensis* dissected found the percentage infected on the village green was 6.9, 5.2 in the houses, and 2.9 in the bush. In Tahiti GAILLARD and colleagues (1949) have recorded as high a figure for the first-named species as 50 per cent. In Melanesia BACKHOUSE and HEYDON (1950) found 12 of 52 wild-caught *Anopheles punctulatus* containing larval filariae of the nocturnal form.

In Table II are given the results of laboratory infections, and some 304 insects were used. As a standard method of gauging the intensity of microfilarial infection in the donor's blood. Knott's method was employed and the microfilariae in the sediment were counted. Surprisingly the figure of 5,689 microfilariae was recorded three times in six counts. The difficulty of making accurate counts with thousands of entangled microfilariae thus obtained need hardly be emphasized. I have already pointed out that in Fiji a free-living nematode of the genus *Aphenlenchoides* may find its way into the distilled water employed in this method, and so is apt to be mistaken for microfilariae in the sediment.

The figures obtained for artificial infection of *C. fatigans* are higher than those recorded by myself, BYRD and ST. AMANT and more recently by BACKHOUSE and WOODHILL. *A. fijiensis* proved so very efficient that 3rd-stage larvae were found in 52 per cent. This is most significant, for no one except BACKHOUSE and HEYDON (1950) has worked with its cogener *A. kochi* ; they found it an efficient vector of the nocturnal microfilariae in Rabaul as well as in Queensland. No one, except FENG (1934) and YAMADA (1927) in most exhaustive studies, has ever worked with *A. vexans* before, and they reported that in the nocturnal form of *W. bancrofti* it is a completely inefficient vector.

The above criticism has been written with a view of assisting Mr. Symes in his laborious

researches and to wish him every success, but I would like to emphasize a point which he acknowledges, that from the epidemiological point of view *A. s. pseudoscutellaris* and *A. polynesiensis* remain the most important vectors in Fiji. O'CONNOR for instance, found this latter species was the only mosquito in the Tokelau Islands where filariasis is rife. Insecticidal measures should therefore be taken against these two species.

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FOOTNOTE

As certain other species of mosquito are referred to by Mr. Symes it should be stated that in my original report *Aedes vexans* Meigen was termed *Culex nocturnus* ; *Aedes kochi* Donitz as *Finlaya poecila* Theobald ; and *Culex annulirostris* Skuse as *Culex jepsoni* Theobald.