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Control of Bancroftian Filariasis in the Pacific*

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Although the etiological agent and the vector of filariasis were recognized early in the history of tropical medicine, control programmes were slow in developing, mainly because efficient filaricides were not known. Following the discovery of diethylcarbamazine, however, control projects were inaugurated in many parts of the world, including a number among island populations of the Pacific, in ideal conditions for observation and assessment.

This paper reviews the answers to questionnaires sent to twelve areas in the Pacific where control projects have been undertaken. The most rapid and effective results appear to have been obtained in the Society Islands and Niue and Atiue, where mass treatment of the whole population with diethylcarbamazine was employed simultaneously with mosquito control. The authors conclude from the answers received that most control projects support the combined use of diethylcarbamazine and mosquito control, and that, where a control programme has brought the microfilaraemia rate down to 5% or less, the launching of an eradication programme should be considered.

The occurrence of bancroftian filariasis in the following three areas of the Pacific, as depicted in Fig. 1, is discussed in this paper.

1. The northwest, including Micronesia where the periodic nocturnal type occurs and transmission is mainly by members of the *Culex pipens* complex, mostly *C. quinquefasciatus (fatigans)*. Rozeboom & Cabrera (1956) consider that in the Philippines, *Aëdes poecilus* is the most important vector.

2. Melanesia, west of Buxton's Line, where the periodic nocturnal type occurs. In this region the genus *Anopheles* is the main vector, although the genera *Culex* and *Mansonia* are also incriminated. (See de Rook & van Dijk, 1959.)

3. Polynesia and that part of Melanesia, east of Buxton's Line, which includes Fiji, New Caledonia, and the Loyalty Islands, where continuous, diurnally sub-periodic [3] filariasis occurs. Here transmission is mainly by the genus *Aëdes*, the most widely distributed species being *Aëdes polynesiensis*. *C. quinquefasciatus* is generally considered to play a lesser role.

Questionnaires seeking information concerning the present status of filariasis control programmes in the Pacific were mailed to the areas where surveys or studies on filariasis are known to have been made. The following questions were asked:

1. Name of organization or institute in charge of programme.

2. Name and title of person co-operating in procuring this information.

3. Have control measures been instituted in your area? If so, please describe under:

(*a*) Chemotherapy (name drug, dosage, and schedule);

(*b*) Mosquito control (larval or adult); list procedures.

4. If you have used several schedules of a drug in chemotherapeutic control, which one do you consider to be the best?

5. If no control measures have been instituted, do you anticipate organizing a control programme? If so, what methods do you expect to use?

6. What is the lowest percentage of elephantiasis, or mircofilaraemia, and the lowest average number of microfilariae per 20 mm³ of blood in a population which you would consider significant before inaugurating a filariasis control programme?

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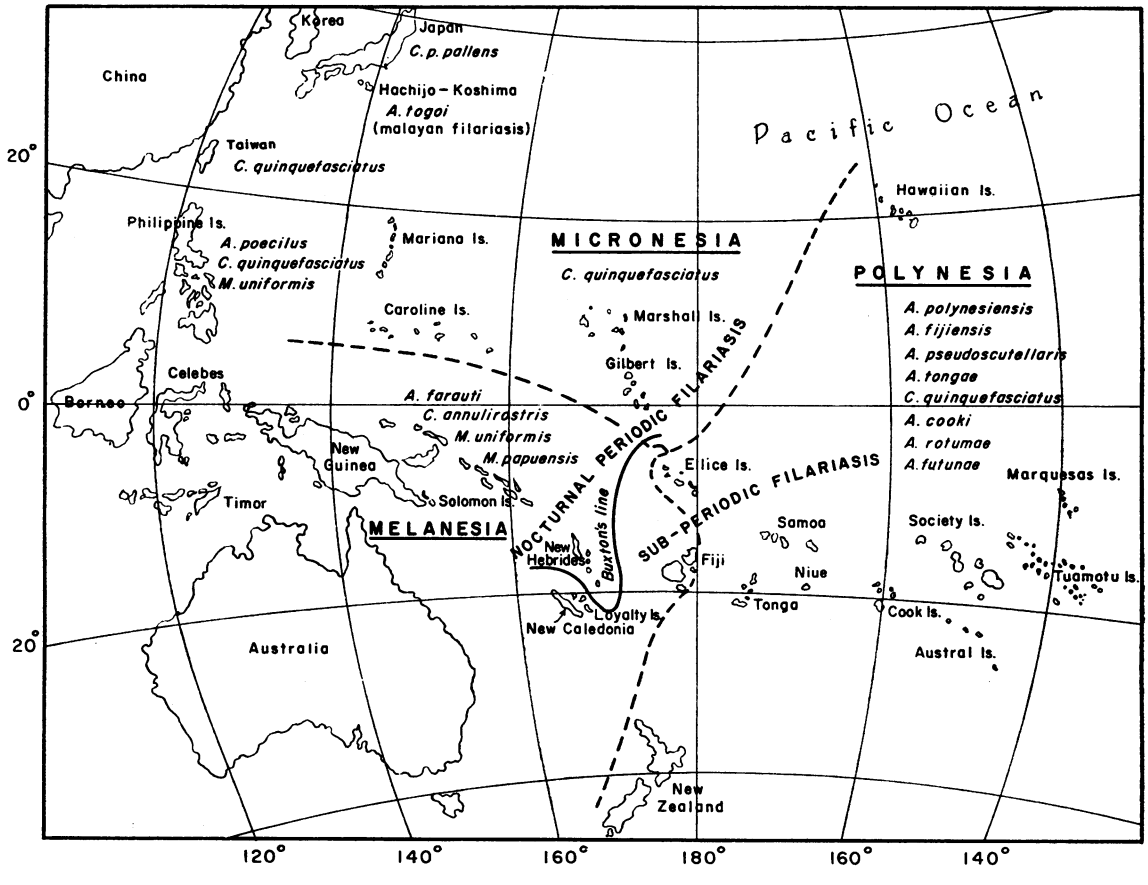
[3] Often designated as non-periodic filariasis.

FIG. 1
DISTRIBUTION AND VECTORS OF BANCROFTIAN FILARIASIS IN THE PACIFIC



7. Do you consider mosquito measures alone to be adequate in your area to (*a*) control filariasis, or (*b*) eradicate filariasis?

8. What procedures do you use to determine prevalence rates of mosquitos?

9. Do you employ a potential transmission index for filariasis in your programme? If so, please state the formula used.

Blank tables were supplied which, if completed, would make it possible to summarize information concerning clinical surveys, blood surveys, and mosquito surveys, both before and after any control programme that had been inaugurated.

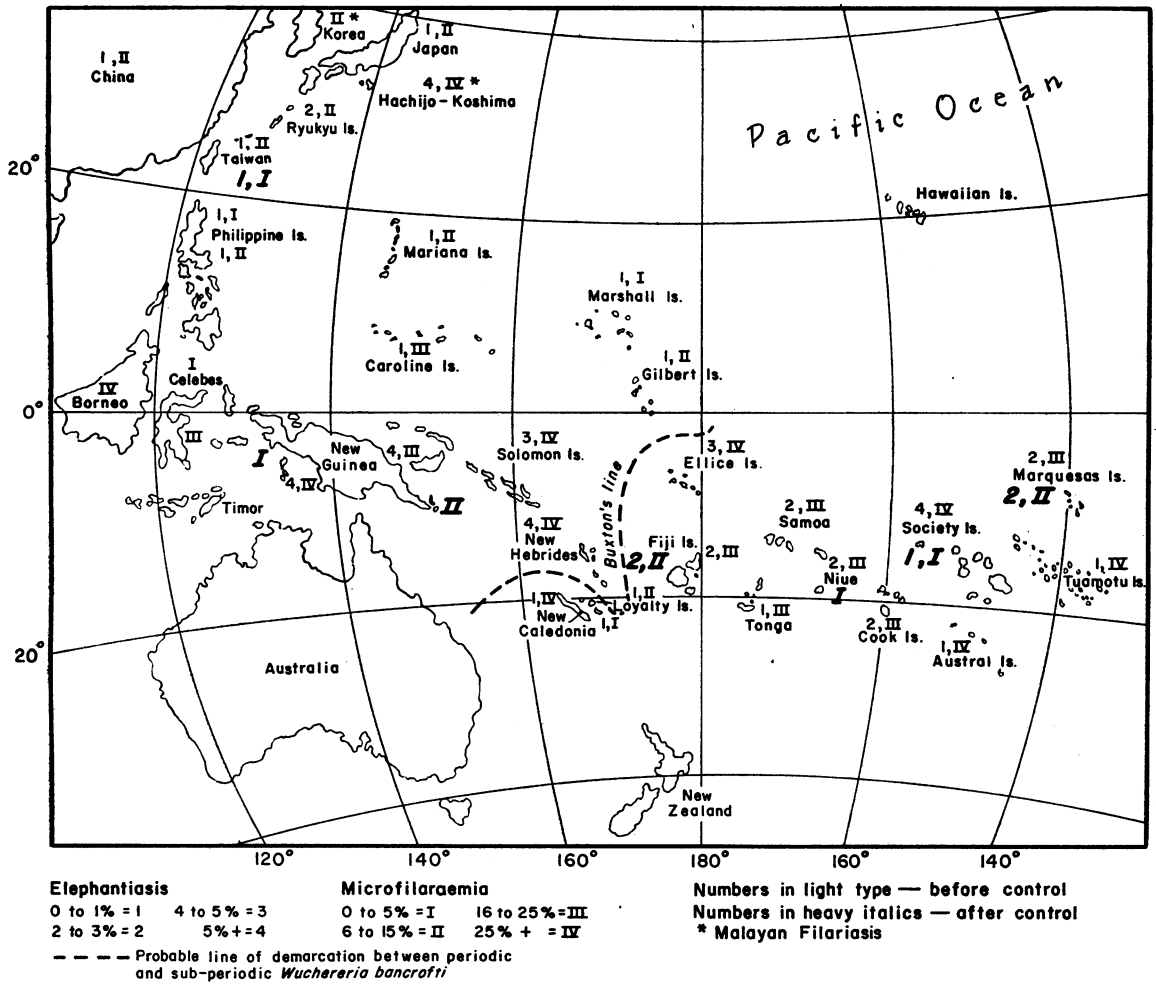
INFORMATION COLLECTED

Although twelve replies were received, all questions were not always answered nor tables completed. However, sufficient information was obtained either from the replies or from recently published reports to make the following review. The authors also have drawn extensively on data from the filariasis control programme in French Polynesia, with which they have both worked and are most familiar.

Many blood surveys for microfilariae have been performed in the Pacific area since the first report of the occurrence of continuous filariasis by Thorpe (1896). Prior to the close of the Second World War most of these were performed on specialized groups of the population such as adults only, military personnel, hospital patients, schoolchildren, etc., and were not representative of the population as a whole. When surveys were made on adult groups only, the rates were obviously higher than would have been expected for the whole population and

FIG. 2

PREVALENCE OF ELEPHANTIASIS AND MICROFILARAEMIA IN THE PACIFIC



these surveys cannot be compared with later surveys which record representative examinations by standard age-groups.

Prevalence of elephantiasis and microfilaraemia

Fig. 2 shows reports of elephantiasis and blood surveys made since the Second World War, the figures in light type representing the prevalence of elephantiasis and microfilaraemia prior to control, and the figures in heavy italics representing the prevalence of these same two categories following institution of control measures. (For a more detailed report before control of a few characteristic surveys by age-groups, see Table I in Kessel (1960).) In Fig. 2 the rates are displayed in four separate groups described in the legend at the bottom of the map.

Detailed information of clinical and blood surveys before and after control is recorded in Table 1, which lists six areas where control programmes have been instituted and the type of control, together with the results. Complete data for all of these categories in each area were not available, hence the several blank spaces. The amount of elephantiasis before control is shown for five of the areas reported, but only for Tahiti were post-control figures reported. As results of the blood surveys by age-groups after

TABLE 1

DETAILS OF BANCROFTIAN FILARIASIS FOR SIX AREAS OF THE PACIFIC WHERE DIETHYLCARBAMAZINE HAS BEEN ADMINISTERED

		Nocturnal periodic type						Continuous diurnal subperiodic type					
		Taiwan (Pescadores)		Netherlands New Guinea (Inanwatan)		Australian New Guinea (Maclay Coast)		Tahiti		Fiji (Rewa)		Niue [a]	
		Date	% pos.	Date	% pos.	Date	% pos.	Date	% pos.	Date	% pos.	Date	% pos.
Clinical survey													
Elephantiasis	Before treatment			1959	5.2	1959	9.7	1952	7.0	1956	2.4	1954	2.5
	After treatment							1959	2.2				
Hydrocele	Before treatment						18.7	1952	9.8				
	After treatment							1959	3.2				
Lymphangitis	Before treatment							1952	23.1				
	After treatment							1959	1.6				
Blood survey before treatment													
Age-group (years):													
0-9		1957	3.07	1959	6.0	1959	7.7	1952	11.4	1958	1.5	1954	
10-19			7.7		17.5		28.8		27.4		5.5		
20-29			10.35		23.2		45.0		45.7		12.5		
30-39			9.37		35.9		52.0		54.1		16.5		
40-49			10.45		40.5		61.8		55.0		20.0		
50 and over			10.72		42.2		70.8		57.0		29.3		
Total % pos.			7.78		21.0		35.1		37.9		12.2		22.1
Type of control programme		Diethylcarbamazine only		Diethylcarbamazine only		Diethylcarbamazine only		Diethylcarbamazine and mosquito control		Diethylcarbamazine only		Diethylcarbamazine and mosquito control	
Blood survey after treatment													
Total % pos. (and time after treatment)			3.06 (3 years)		1.3 (1 year)		9.5 (½ year)		5.9 (5 years [b])		2.7 (1 year)		2.8 (2 years)
Density of microfilariae per 20 mm³ in total population													
	Before treatment				67.0 [c]		55.0		35.0		4.0		
	After treatment				13.0 [c]		1.5		0.6		0.36		

[a] Data from Simpson (1957) and Iyengar (1958). [b] Over-all control was begun in 1954.

[c] For Netherlands New Guinea these figures represent the microfilarial density per 20 mm³ of blood per person positive.

TABLE 2

LARVAL PREVALENCE OF *WUCHERERIA BANCROFTI* IN MOSQUITOS BEFORE AND AFTER CONTROL WITH DIETHYLCARBAMAZINE

Area	Species of mosquito	Percentage of mosquitos infected before control		Percentage of mosquitos infected after control	
		All stages	Mature stage	All stages	Mature stage
Tahiti (11 districts)	*Aëdes polynesiensis*	8.5	3.5	1.6	0.5
Fiji (Rewa)	*Aëdes polynesiensis* and *Aëdes pseudoscutellaris*	4.6	0.66	0.12	0.0
American Samoa [a]	*Aëdes polynesiensis*	5.6			
Australian New Guinea (Maclay Coast)	*Anopheles farauti*	4.1		0.0	
	Anopheles koliensis	5.6		0.0	
Netherlands New Guinea (Inanwatan)	*Anopheles farauti*	27.6	1.5	In progress	In progress
	Culex annulirostris	24.7	0.6	In progress	In progress
	Culex quinquefasciatus	14.3	0.8	In progress	In progress
Taiwan (Pescadores Is.)	*Culex quinquefasciatus*	8.0	1.7	3.0	0.46
Philippines	*Aëdes poecilus*	11.9	1.1	In progress	In progress
	Culex quinquefasciatus	2.4	0.13	In progress	In progress

[a] Diethylcarbamazine not administered.

control were available for two of the areas only, the surveys by age-groups before control only are included in the table. The densities of microfilariae or number of microfilariae per 20 mm³ of blood in the total population are recorded from three areas and the percentage positive for one area. It will be noted that the prevalence of microfilaraemia had been markedly reduced after control in all areas at the time of the follow-up examination and also that the density of microfilariae per 20 mm³ of blood was significantly reduced in all four of the areas where this was recorded.

Tahiti is the only area in which prevalence of clinical manifestations both before and after institution of a control programme has been recorded. As reported by March et al. (1960), surveys in rural areas of Tahiti recording prevalence of elephantiasis, hydrocele, and lymphangitis collected by Beye et al. (1952, 1953) were compared with the figures collected in identical areas by the staff of the Institut de Recherches médicales de la Polynésie française in 1959. This was five years after general institution of a standardized diethylcarbamazine treatment and a mosquito control programme. The prevalence of elephantiasis had dropped from 7% to 2.2%,[1] hydrocele from 9.8% to 3.2% and lymphangitis from 23% to 1.6%.[2] No new cases of elephantiasis were apparent in areas where adequate control measures had been applied for two years or longer. The reduction in prevalence of elephantiasis may be assumed to have resulted from (*a*) an increased population in younger age-groups who showed no elephantiasis and (*b*) the natural deaths in the advanced age-groups, among whom most old-standing cases of elephantiasis existed.

Prevalence of larvae of Wuchereria bancrofti *in mosquitos*

Table 2 summarizes the prevalence of larvae of *Wuchereria bancrofti* in mosquitos caught in seven areas in the Pacific before any control measures were introduced and in six areas after control by administration of diethylcarbamazine. It will be observed that in four areas where follow-up examinations were reported marked reductions in percentages of

[1] 1960 = 1.3%.
[2] 1960 = 0.75%.

infected mosquitos were noticeable following administration of diethylcarbamazine to the general population. As one would expect, these parallel, in general, the reductions observed in microfilaraemia rates occurring in man following administration of diethylcarbamazine. Among the three areas without follow-up reports of mosquito dissections is American Samoa, where diethylcarbamazine had previously been administered in one limited experimental area by Otto et al. (1953) and later given by prescription to many selected cases.

Control measures employed

Of the twelve areas reporting, eleven employed diethylcarbamazine as a control measure; five using the drug alone and six using it in combination with mosquito control. Only one area was engaged in preliminary studies to determine whether mosquito control alone would be suitable for filariasis control.

The schedules recommended for administration of diethylcarbamazine varied from the original dosage of 2 mg/kg body-weight three times a day for one week to a dosage of 6 mg/kg body-weight once a day each month for 12 months. Some areas prefer the concentrated dosage schedule and others prefer the intermittent schedule. Adequate reasons were not always given, and it would appear that convenience of administration, depending upon both the convenience of the administrating staff and the habits of the people were the most important factors in selecting a dosage schedule. The data from Pacific areas reviewed in this report indicate that studies by Sasa (1961) from Japan provide the most extensive recent information on dosage since the earlier studies by Thooris et al. (1956) and Kessel (1957a). Sasa finds that a schedule of 6 mg of diethylcarbamazine per kg of body-weight daily for six days, followed by eight intermittent doses of the same amount either at weekly or monthly intervals, was administered most easily and produced the most effective reductions.

Answers to questions 6 and 7 of the questionnaire are sufficiently complete from eight areas to summarize in Table 3. Considerable variation in opinion is seen concerning the prevalence of elephantiasis and of microfilaraemia and also the density of microfilariae per 20 mm³ of blood that would be required to warrant the institution of a control programme. For elephantiasis this varies from " any amount " to 5%; for microfilaraemia from 0.5% to 30%; for density of microfilariae per 20 mm³ for the whole population the variation ranged from 1 to 80. It is noteworthy that eleven of the twelve replies agreed that mosquito control alone was not adequate for a successful filaria control scheme.

TABLE 3

SUMMARY OF ANSWERS FROM EIGHT AREAS TO QUESTIONS 6 AND 7 OF QUESTIONNAIRE

Area	Lowest rates to warrant establishing control			Is mosquito control alone adequate?
	Elephantiasis	Microfilaraemia	Density of microfilariae per 20 mm³	
1	5.0%	30%	80+	No
2	0.5%	5% of total		No
3	0.1%	1% meaningful, even if unaccompanied by elephantiasis		No
4		0.5%		No
5	Any amount	10%		No significant answer
6	Any amount	5%	1+	No
7	Any clinical symptoms	10%	1+	No
8	Any clinical symptoms	10%		No

Indices of significance in evaluating a control programme

Questions 8 and 9 were for the most part left unanswered. However Bonnet et al. (1956) and Kessel (1957a) reported indices obtained from blood surveys and mosquito surveys which it is thought might be advantageously reviewed for purposes of performing both preliminary surveys and follow-up surveys after inauguration of a control programme. A number of these are summarized in Table 4 and will show several interesting correlations. One may comment briefly on the table as follows:

(*a*) Parallel reductions were apparent in microfilaraemia rates, in density of microfilariae from blood surveys and in the percentage of mosquitos positive both for all stages of larvae and for mature larvae of *Wuchereria bancrofti*. The transmission index selected for the studies in Tahiti showed this same trend.

TABLE 4

INDICES BEFORE AND AFTER CONTROL FOR 11 DISTRICTS IN TAHITI WITH LONG-TERM SURVEYS

District	Blood				Mosquitos									
	% pos.		Density		% pos. for all-stage larvae		% pos. for mature larvae		Average No. mosquitos		% stations with pos. mosquitos		Transmission index	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Afaahiti	25	3	32	0.6	9.0	0.0	3.5	0.0	0.55	0.3	1.5	0.39		0.0
Faaa	24	5		0.7		3.5		1.0	0.1	0.23		4.5		7.5
Faaone	34	3		0.3	8+	0.0	4+	0.0	0.42	0.15		0.0		0.0
Hitiaa	44	4		0.7	5+	0.0	1.5	0.0	0.5	0.2		0.0		0.0
Mahaena	36	5		0.4		2.6	1	0.0	1.13	0.34		5.8		10.0
Mahina	35	4.5		0.6		2.4		1.4	2.0	0.29		5.5		6.8
Mataiea	38	6.5		1.1		1.7		0.4	0.53	0.09		1.5		2.1
Paea	30	7.1		1.0		4.0		1.8	0.30	0.15		5.7		5.6
Pueu	31	5.7		0.7		1.1		0.0	0.5	0.2		1.9		1.5
Vairao	31	7.5		0.9	13	2.0	7.6	0.1	0.41	0.2	25.8	2.0	100	2.0
Tautira	32	4.5		0.4		0.8		0.0	0.15	0.13		1.0		1.57

(*b*) For comparing changes in adult mosquito populations, either the average number of mosquitos caught per minute or the stations with infected mosquitos may be selected as providing significant information. Although in Tahiti the average number of mosquitos caught per minute was chosen for comparing prevalence of adults, there is some evidence that the percentage of stations with positive mosquitos is likewise a valuable index to use.

SOME SIGNIFICANT FACTORS IN THE CONDUCT OF A FILARIASIS CONTROL PROGRAMME

Modern methods of malaria eradication, now being employed in many countries throughout the world, recognize the value of joint procedures combining the use of the most effective method for control of the particular species of mosquito involved with the use of drugs against the parasite. Mosquito control measures usually precede the use of the drugs for plasmodia. In filariasis control it would appear that the best procedures reverse this order and that the chemotherapeutic control should be used first, thereby reducing microfilaraemia to a minimum as early in the programme as possible. This may be accompanied or followed as rapidly as possible by mosquito control or subsequent mosquito eradication.

In the control programme in Tahiti, which is based on the combined use of diethylcarbamazine and mosquito control, the evaluation of the programme has now been possible for a sufficient length of time to bring to light the following topics of special interest.

Recurrent infections

The first follow-up blood surveys after an adequate treatment of a population with diethylcarbamazine are usually gratifying in that the microfilaraemia rate and the density of microfilariae per 20 mm^3 show marked reductions. The degree of reduction will depend on the percentage of the population treated, the dosage of diethylcarbamazine used, and the thoroughness with which the diethylcarbamazine tablets were administered. It was previously reported by Kessel (1957a) that, in a group of carriers receiving a dosage of 2 mg/kg body-weight three times a day for seven days, the microfilaraemia rate had dropped to 6.6% at the close of the schedule. One year later this had increased to 50.6%. The corresponding microfilaria densities par 20 mm^3 were 90 before treatment, 1 at the end of treatment and 8 one year later.

Another group of 57 carriers in Tahiti with an average of 55 microfilaeria per 20 mm^3 of blood was treated with diethylcarbamazine in a dosage of 6 mg/

kg body-weight one day each month for a minimum of 12 months. One year after the completion of treatment all were found to be negative for microfilariae. Three years later they were retested, 40 mm^3 of blood from each being examined, and 6 (or 10.5%) were found to be positive, with an average microfilaria density of 1.5 per positive person.

Although those results show that 10.5% of the original positives treated in a mass diethylcarbamazine campaign may return to a light carrier state by the end of three years if given no subsequent diethylcarbamazine therapy, such findings do not indicate that the positives so resulting would increase transmission to a degree that would jeopardize a control project. Such recurrences, however, should not be disregarded but searched for by periodic blood surveys, and then re-treated. Rachou & Ferreira (1958) suggest, instead of periodic blood surveys and re-treatment of positives, repeating the administration of 6 mg of diethylcarbamazine per kg of body-weight to the whole population once every six months.

Procedures for collecting blood films in surveys

Beye et al. (1952), comparing the 20 mm^3 method and the Knott (1939) method for collecting blood for filariasis surveys, concluded that while the Knott method was somewhat more efficient, especially in light infections, it also was much more time-consuming and that for the type of control programme that was being established in Tahiti the 20 mm^3 method was satisfactory. Subsequent studies by Thooris et al. (1956) showed that by examination of one film of 20 mm^3 of blood the lighter infections were often being missed. When two or three films of 20 mm^3 each were examined, the chance of procuring positives was increased.

Symes (1960), Burnett (1960) and Burnett & Mataika (1961), employing Symes's modification of the Knott method, show that Symes's modified method is more efficient than either the original Knott method or the 20 mm^3 method, and Burnett proposes a correction factor of 9.5% where 20 mm^3 are used.

Although Symes's modification of the Knott method is more time-consuming than the 20 mm^3 method used in Tahiti, both methods were employed on a selected group of 40 individuals whose blood had been reported negative for 45 months following completion of the diethylcarbamazine mass treatment. By examining two 20 mm^3 films from each person (i.e., 40 mm^3) and using also Symes's modification of the Knott method, 33 of the 40 people so examined by both methods were negative, leaving seven who were positive by one or both of the two methods. Four were positive by Symes's modified method but negative by the 40 mm^3 method; one was positive by the 40 mm^3 procedure but negative by Symes's method; and two were positive by both methods.

Significance of new infections in early age-groups in evaluating a control programme

Kessel et al. (1959) pointed out the importance of evaluating the success of a programme by determining the infection rate in young age-groups who had grown up in an area following the inauguration of such a programme. At that time it was stated that the annual blood survey for 1957 in Tahiti, which followed control, showed 1001 children in the age-group 1-4 years, who had never received any diethylcarbamazine, to be negative for microfilariae, while 5.6% of this age-group had been positive in 1949, before control. During 1958, two children of this age-group were found to be positive. It is of interest that both lived in homes with positive parents who had refused to accept diethylcarbamazine.

Also in 1949, before control, 14.2% of 1452 children examined in the 0-9-year age-group were positive, with a corresponding density of 4.1 microfilariae per 20 mm^3; while, after control, in 1960, among 1070 of this same age-group, who had never received diethylcarbamazine, 0.9% were positive, with a microfilarial density of 0.03.

These low infection rates in the early age-group indicate that filariasis infection in the age-group 0-9 years has reached a low point of less than 1%. Such a figure may be assumed to be closely related to the transmission rate in this same group. This finding, together with the fact that few or no new cases of elephantiasis developed in the whole population during the same period, indicates that in the areas under thorough control transmission has reached a low level where clinical filariasis is no longer apparent as an important public health problem.

The question arises at this time whether one should be content to maintain the programme on a control basis only or whether an effort should be made to proceed to the eradication stage similar to that developed in eradication programmes against malaria.

Significant rates from selected indices in a control programme

In considering the various indices selected for evaluation of a control programme it is a problem to determine the exact point or reading of each index at which transmission may be taken to be so low that significant clinical filariasis ceases to occur. In the programme in Tahiti the following figures for six important indices were set as arbitrary points which should not be exceeded:

Microfilaraemia rate	5.0%
Density of microfilariae per 20 mm³ 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

Such low rates may not be essential to attain cessation of the development of significant clinical filariasis. It is considered, however, that rates below these points are within the safety limits, and if these are maintained, clinical filariasis should not exist as a public health problem.

Cultural and social factors which influence a control programme

Migrations of people. Changes in human populations, such as migrations of people from one area to another, have been shown to be significant in the increase or decrease of filaria rates. Kessel (1961) reviewed a number of the important ecological factors that are of interest in filariasis and particularly mentioned the early migrations of the Polynesians. Recent studies by Belkin (1961) concerning the relation of vectors of bancroftian filariasis to the origin of the disease in the Pacific are of special interest. Iyengar (1959) describes changes in New Caledonia, and Wu (1961) discusses a recent introduction of filariasis into Taiwan by migration of Chinese from the mainland of Asia.

A control programme may be definitely affected by the migrations of people into a treated area from a region in which a control programme has not been organized. For example, in Tahiti, where tourism has come to be emphasized in recent years, migrations of great numbers of Polynesians occurred from outer regions of French Polynesia, where filaria control had not been started. Until thoroughly treated, such people materially increased the prevalence in districts where they settled.

Urban and rural areas. A comparison of urban and rural populations in several areas where continuous filariasis occurs, e.g., Fiji, Tahiti, and Samoa, shows a reduction in filarial prevalence and also of *Aëdes polynesiensis* in the urban areas. In the cities, *Culex quinquefasciatus* and *Aëdes aegypti* commonly replace *Aëdes polynesiensis* and become the dominant mosquitos.

Use of diethylcarbamazine before mass treatment. Another item which should be mentioned is the lowering of microfilaraemia in a non-controlled area by the non-official distribution of diethylcarbamazine. At times, this drug has been extensively administered by physicians for therapeutic purposes —for instance, in American Samoa and the Society Islands—and at other times progressive individuals, learning of the benefit of diethylcarbamazine, have often procured the drug for their own personal use before a control programme has been instituted.

Significance of microfilaraemia rates and of microfilaria density in relation to elephantiasis

Kessel (1957b, Table III) pointed out that in surveys carried on in areas of continuous filariasis there was a closer correlation between density of microfilariae per 20 mm³ of blood and prevalence of elephantiasis than between microfilaraemia rates and elephantiasis rates.

This correlation is not always apparent in reports from areas where periodic nocturnal filariasis occurs—see, for instance, McFadzean (1954), Krishnaswami (1955) and Pipkin.[1] Reports in Table 1 of this paper from Netherlands New Guinea and Australian New Guinea, however, disclose a correlation similar to that found with continuous filariasis in Polynesia. It is hoped that further studies will be made in more widely separated areas where periodic nocturnal filariasis occurs and that these will provide additional information on this subject.

Possible resistance to diethylcarbamazine by Wuchereria bancrofti

In following a filariasis control programme in which diethylcarbamazine has been used as a

[1] Pipkin, A. C. (1953) Wuchereria bancrofti *in Micronesia* (unpublished paper presented at the 8th Pacific Science Congress, held at Quezon City, Philippines, November 1953).

chemotherapeutic agent, one should constantly be on the alert to determine whether resistance of the parasite is ever developed to this drug. When an area shows an increase in microfilariae over a previous survey, one wonders whether this is a result of resistance or of imperfect administration of the drug. In our studies in Tahiti careful checking has never shown that any resistance has developed. Rather, when increased prevalence rates have been observed in a given area, it has always been possible to explain the increase on the basis of one of the following: (*a*) an increase of positive immigrants to the area, (*b*) the occurrence of positive carriers who have refused to accept the drug, (*c*) new infections, or (*d*) recurrent infections. In our opinion this fourth group results from individuals who had either an early or a light infection at the time of the first follow-up examination or from individuals in whom treatment did not destroy the adult filariae but temporarily impaired their reproductive mechanism, which subsequently regenerated.

It has become a practice in the programme in Tahiti to give these groups special therapeutic attention by administering to them a concentrated dose of diethylcarbamazine—e.g., 6 mg/kg bodyweight once a day for 7-14 days—followed by monthly doses for a period of six months to one year. Under this regimen the prevalence rates for 1961 are showing a gratifying reduction, indicating that it is the thoroughness of diethylcarbamazine administration which is important and that resistance to the drug is not apparent.

SUMMARY AND 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), and by Pipkin,[1] 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 (1957b), 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 above and their general distribution shown. Their relationships to human populations and the parasite *Wuchereria* has been discussed by Belkin (1961, 1962).

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 diethylcarbamazine, on the customs and habits of the people.

Recurrent infections reported in this study indicate that diethylcarbamazine 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, sub-periodic filariasis, appear to outweigh the disadvantages and to warrant its continued use.

In some areas, mosquito control seems impracticable under present conditions and control by drug administration alone is recommended. Eleven of the twelve replies stated that mosquito control alone was inadequate for effective filariasis control. The twelfth reserved judgement.

[1] Pipkin, A. C. (1953) Wuchereria bancrofti *in Micronesia* (unpublished paper presented at the 8th Pacific Science Congress, held at Quezon City, Philippines, November 1953).

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 probable 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.

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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.

RÉSUMÉ

La découverte de la diéthylcarbamazine a ouvert la voie aux campagnes de lutte contre la filariose qui ont été mises en œuvre en différentes parties du monde. Il en a été ainsi notamment parmi les populations des îles du Pacifique qui offrent des conditions d'observation et de contrôle idéales. Afin de mettre à profit les divers projets pilotes réalisés, un questionnaire a été adressé à douze zones du Pacifique au sujet du déroulement des opérations et de leurs résultats. Le présent article analyse point par point les réponses à cette enquête.

En ce qui concerne les manifestations cliniques de l'affection, Tahiti est la seule zone qui permette de comparer la situation à cinq ans d'intervalle, avant et après traitement associant la diéthylcarbamazine à la lutte antimoustique. En fréquence globale, l'éléphantiasis a passé de 7% à 2,2%, l'hydrocèle de 9,8% à 3,2%, et la lymphangite de 23% à 1,6%. Partout où le traitement a été appliqué avec méthode pendant deux années consécutives, il n'a plus été observé de cas nouveaux d'éléphantiasis. Parallèlement, le taux d'infestation des moustiques a diminué dans de fortes proportions.

La posologie et l'administration de la diéthylcarbamazine ont obéi aux deux schémas suivants: *a*) 2mg/kg de poids corporel, 3 fois par jour, pendant 1 semaine; *b*) 6mg/kg de poids corporel, 1 fois par jour, chaque mois, pendant 12 mois. Eventuellement, cette dernière dose pourrait être prescrite à nouveau tous les six mois à l'ensemble de la population, afin d'atteindre les quelque 10,5% de sujets qui normalement redeviennent positifs en l'espace de trois années.

La microfilarémie est variable selon les régions considérées, sans que l'on puisse toutefois établir de corrélation certaine entre son importance et la fréquence de l'éléphantiasis. En revanche, lorsque le taux de filarémie ne dépasse plus 5%, il semble que l'on puisse envisager une campagne d'éradication. L'analyse de la série de projets pilotes a montré que la meilleure façon de procéder consiste alors à appliquer directement la chimiothérapie (elle réduit la filarémie au minimum) et à la faire suivre sans retard de l'éradication des moustiques. Bien entendu, ce dernier point soulève la question d'une résistance éventuelle des vecteurs: à Tahiti où elle a été vérifiée systématiquement, la résistance n'a jamais jusqu'à présent été constatée chez *Wuchereria bancrofti*.

Les auteurs rappellent qu'avant toute campagne de nombreux facteurs doivent être pris en considération, et notamment les mœurs et coutumes des habitants, la bionomie des insectes, etc. Les îles constituent un milieu favorable pour les études épidémiologiques; celles-ci ont montré qu'à Taïwan, Niue et Atiue, ainsi qu'aux Iles-sous-le-Vent, où le taux de microfilarémie est inférieur à 1%, il est désormais possible d'envisager la réalisation d'un programme d'éradication.

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