FILARIAISIS AS A WORLD PROBLEM

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HISTORICAL. Filariasis is an important disabling disease, caused by a threadlike nematode. Two species are common in man, Wuchereria bancrofti (Cobbald 1877), Scour, 1921, and Brugia malayi (Brug, 1927), Buckley, 1958. The microfilariae of W. bancrofti were first seen by Demarquay in 1863, more than 100 years ago, in hydrocele fluid from a patient in Cuba. They were found by Wucherer, in Brazil, three years later in chylous urine, and by Lewis in 1872 in blood from a patient in India. Bancroft recovered the first adult filaria in 1876, in Brisbane, Australia.

Sir Patrick Manson, 1878-79, working in Amoy, first described nocturnal periodicity of microfilariae and pointed out that larval stages developed in the common night-biting mosquito of the area.

Elephantiasis in Polynesia was first accurately described by Wilson (1799) in Tahiti, and the first microfilariae from Polynesia were collected by Davis in Samoa in 1884, but only reported by Manson in 1896. Earlier in the same year, Thorpe, in Tonga, was the first to report the presence of microfilariae in the peripheral blood of man during daytime in Polynesia. Bahr (1912) in an extended study in Fiji, added much to the knowledge of subperiodic filariasis in the Pacific. The line of geographic demarcation in the Western Pacific between nocturnal periodic filariasis and the subperiodic type was well defined by Buxton in 1928.

Slowness in developing control programs for filariasis was caused by difficulties in devising suitable methods for mosquito control and in discovering satisfactory filaricides. The unexpected occurrence of filariasis cases among troops in the Pacific theatre during the Second World War stimulated renewed interest in research, a most important outgrowth of which was the discovery of diethylcarbamazine, by Hewitt et al. (1947), a filaricide harmless to man, which held promise for use in the control of filariasis.

The FILARIOIDEA. The main epidemiologic, clinical and morphologic characteristics of the etiologic agents of the Filarioidea are displayed in Charts 1 and 2. Filariasis, as indicated above, is caused by one of two genera belonging to this superfamily. They may cause either acute filariasis, e.g., lymphangitis with filarial fever or several types of chronic filariasis, such as elephantiasis, of arms, legs, breasts or genitalia; chyluria or hydrocele.

The photograph in Figure 1, taken in 1950 before control was begun, showing advanced elephantiasis in a man from Society Islands.

Fig. 1.—Advanced elephantiasis in man from Society Islands.
Society Islands, illustrates a type of Bancroftian filariasis that is disappearing through the application of control measures. Figure 2 shows a Malayan with normal legs, and another with elephantiasis of the legs. Usually elephantiasis associated with Malayan filariasis is less severe than that caused by Bancroftian filariasis.

**Distribution.** The world distribution of the two principal types of filarioideal diseases, i.e., filariasis and onchocerciasis, is seen in Figure 3. Surveys throughout the world show some filariasis areas of low endemicity, i.e., with microfilaria rates from 1 percent to 8 percent, some areas of high endemicity, with microfilaria rates of 25 percent or more, and others with intermediate rates.

The use of diethylcarbamazine and of DDT or other new insecticides developed during and soon after World War II, led to field investigations in many parts of the world to evaluate methods for their use in filariasis control programs.

**International Meetings.** The first international meeting was sponsored by the South Pacific Commission at the Institute of Medical Research, in Tahiti, where in 1951 some 30 workers met for a two weeks' conference. Soon after this, in 1955, the World Health Organization called the first Study Group on Filariasis to meet in Kuala Lumpur, Malaya, to observe the epoch-making discoveries that were taking place with reference to Malayan filariasis in Pahang. The WHO Secretariat called a Scientific Committee in 1959, and an Expert Committee in 1961, both of which met at WHO Headquarters in Geneva. This last committee summarized most of the available literature, in the form of guides rather than rules, which was published in 1962, (WHO Tech. Report Series No. 233).

In November, 1965, the first Inter-Regional Seminar on Filariasis was held in Manila under the auspices of the WHO. Twenty-five countries where filariasis occurs accepted invitations to attend, as follows:

**African Region:**
1. Madagascar
2. Mauritius

**Eastern Mediterranean Region:**
3. Sudan
4. United Arab Republic

**Southeast Asia Region:**
5. Ceylon
6. India
7. Thailand

**Western Pacific Area:**
8. American Samoa
9. Australia
10. British Solomon Islands
11. China (Taiwan)
12. Fiji
13. French Polynesia
14. Gilbert and Ellice Islands
15. Japan
16. Korea
17. Malaysia
18. Philippines
19. Ryukyu Islands
<table>
<thead>
<tr>
<th>Parasite</th>
<th>Periodicity</th>
<th>Vectors</th>
<th>Reservoirs</th>
<th>Clinical Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Wuchereria bancrofti</em></td>
<td>Nocturnal</td>
<td><em>Culex</em></td>
<td>Man</td>
<td>Acute lymphangitis, filarial fever</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Anopheles</em></td>
<td></td>
<td>Chronic lymphadentitis. Hydrocele elephantiasis</td>
</tr>
<tr>
<td></td>
<td>Diurnal in Polynesia</td>
<td><em>Aedes</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Brugia malayi</em></td>
<td>Nocturnal</td>
<td><em>Mansonia</em></td>
<td>Cats, dogs, Macaca, Slow loris</td>
<td>Same, but elephantiasis less severe</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Anopheles</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Loa loa</em></td>
<td>Diurnal</td>
<td><em>Chrysops</em></td>
<td>Probably monkeys</td>
<td>Migratory, Calabar swellings</td>
</tr>
<tr>
<td><em>Acanthocheilonema perstans</em></td>
<td>Modified Nocturnal</td>
<td><em>Culicoides</em></td>
<td>Monkeys</td>
<td>Pathogenicity? allergic dermatitis</td>
</tr>
<tr>
<td>A. streptocerca</td>
<td>None, found in skin</td>
<td><em>Culicoides</em></td>
<td>Probably monkeys</td>
<td>Cutaneous edema and elephantiasis</td>
</tr>
<tr>
<td><em>Mansonella ozzardi</em></td>
<td>None</td>
<td><em>Culicoides</em></td>
<td>Man</td>
<td>?Hydrocele and lymph gland enlargement</td>
</tr>
<tr>
<td><em>Onchocerca volvulus</em></td>
<td>None, found in skin</td>
<td><em>Simulium</em></td>
<td>Not proved</td>
<td>Nodular Ophthalmic</td>
</tr>
</tbody>
</table>

Chart 1.—Epidemiologic and clinical differences among filarial infections of man.

20. Singapore  
21. Tonga  
22. Territory of Papua and New Guinea  
23. Trust Territory of the Pacific Islands  
24. Viet Nam  
25. Western Samoa

Altogether, some 50 people attended the seminar.

**Comparison of Malaria and Filariasis Control.** A comparison of filariasis control with the early history of malaria control shows the first measures applied against malaria to be concerned with the control of mosquitoes. These involved multiple types of drainage, spraying with oil and paris green. Subsequently, numerous other insecticides were applied against both larvac and adults. Much of the success in malarial control came from the fact that most species of anopheline mosquitoes were domestic, and usually rested in houses or buildings. This made spraying practical for control against adults.

When eradication programs became the rule, malariologists were faced with the problem of resistance to insecticides. At this time, they added surveillance and drug control to their armamentarium, and now include such measures in their regular programs. In areas where identical species of anopheline mosquitoes transmit both malaria and filariasis, e.g., *Anopheles gambiae* in Africa and *Anopheles farauti* in New Guinea, combined control programs are being considered.
<table>
<thead>
<tr>
<th>Parasite</th>
<th>Adult Worm</th>
<th>Microfilaria</th>
<th>Sheath</th>
<th>Tail Nuclei</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length of Female</td>
<td>Location in Tissue</td>
<td>Time to Mature</td>
<td></td>
</tr>
<tr>
<td><strong>Wuchereria bancrofti</strong></td>
<td>Periodic, 70-100 mm.</td>
<td>Lymph nodes</td>
<td>About 12 months</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Sub-periodic 60-77 mm. ?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brugia malayi</strong></td>
<td>42-55 mm.</td>
<td>Lymph nodes</td>
<td>About 3 months or less</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Loa loa</strong></td>
<td>50-70 mm.</td>
<td>Subcutaneous tissue</td>
<td>Possibly 1 year</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Acanthocheilonema perstans</strong></td>
<td>70-80 mm.</td>
<td>Pleural, Peritoneal or Pericardial cavities</td>
<td>Not known</td>
<td>No</td>
</tr>
<tr>
<td><strong>A. streptocerca</strong></td>
<td>?</td>
<td>Connective tissue</td>
<td>Not known</td>
<td>No</td>
</tr>
<tr>
<td><strong>Mansonella ozzardi</strong></td>
<td>65-80 mm.</td>
<td>Body Cavities</td>
<td>Not known</td>
<td>No</td>
</tr>
<tr>
<td><strong>Onchocerca volvulus</strong></td>
<td>35-50 mm.</td>
<td>Subcutaneous nodules</td>
<td>About 12 months</td>
<td>No</td>
</tr>
</tbody>
</table>

**Chart 2.—** Differences among filarioidea of man.

In filariasis control, it is recommended that mass treatment with diethylcarbamazine be administered first, thus diminishing microfilaria rates and densities, which reduces potential transmission immediately. Mosquito control is begun simultaneously, or as soon after as possible.

Mosquito Control. Most mosquitoes which transmit malaria belong to the genus *Anopheles*, while most mosquitoes which transmit filariasis belong to one of the four genera, *Anopheles*, *Culex*, *Aedes* and *Mansoniah*. The bionomics and breeding places of the many species belonging to these four genera make mosquito control for filariasis a highly specialized and expensive problem, albeit one of great importance.

Drug Control. Although arsenical and antimonial drugs, when first used for filariasis, showed promise, difficulties have often occurred during their administration and reluctance has developed concerning their use in control or mass-treatment programs.

Diethylcarbamazine, a non-toxic drug, introduced by Hewitt *et al.* in 1947, gave much promise and has been tested extensively in many parts of the world.

The writer has been closely associated with two filariasis control programs in the South Pacific, in which diethylcarbamazine has been used, the first in French Polynesia and the second in American Samoa. The motion picture film, "The Control of Subperiodic Filariasis in Polynesia" illustrates the major aspects of the problem in this area. During this study, filariasis control was based primarily on a mass-treatment regimen with
a minimum of 12 doses of 6 mg per kg of body weight, i.e., a total of 72 mg per kg of body weight of diethylcarbamazine, to the whole population.

Three main systems of spacing the administration of the 12 doses of diethylcarbamazine have been used in the two programs: (1) once a day for six days then once a month for six months, (2) once a day for six days, rest six months, then repeat once a day for six days, and (3) once a month for 12 months. The first follow-up blood survey is recommended one year after the last treatment. Theoretically, each person who shows microfilariae in annual follow-up blood surveys begun one year after the close of diethylcarbamazine treatment is retreated with a standard regimen of diethylcarbamazine.

Sanitation procedures and clean-up of mosquito breeding places within and around each home in Tahiti for a radius of 100 yards was recommended on a volunteer basis and is supervised by an instruction and inspection team. In American Samoa, clean-up is performed on a village basis with weekly collection by trucks of garbage, cans, bottles, etc., that might serve as breeding places for mosquitoes.

Prior to control in Tahiti, as shown by Beye et al. (1952 and 1953), the microfilaria rates per rural district ranged from 25 percent to 43 percent, with an average rate of 32 percent. The average microfilaria count per 20 cm3 of blood per person in these districts was 32 and per carrier was 80, the latter with a range from a low of 41 to a high of 118.

Experimental areas receiving diethylcarbamazine and control areas with neither diethylcarbamazine nor mosquito control were compared as follows:

A. Microfilariae in blood surveys.

The results of blood surveys in experimental areas may be reported either by recording microfilaria rates and average counts in (1) the total population of the area, which furnishes an epidemiologic base line for clinical and blood surveys and for comparison with larval rates in mosquito surveys; or (2) only in those carriers who have received a complete regimen of a standard treatment. This selected group provides information concerning chemotherapeutic results. The following observations were apparent:

a. There was no reduction in microfilaria rate nor in microfilaria counts when no drug was administered.

b. Results reported by procedure (1), above, showed a decline in microfilaria rates to 2.5 percent by the first year after the close of treatment with average microfilaria counts per 20 cm3 of blood of less than one. In areas receiving no further treatment, the average rate had increased to 7.5 percent during the third year; however, with average microfilaria counts still less than one. In areas where recurrent positives, detected by annual follow-up blood surveys, were routinely treated with diethylcarbamazine, the follow-up microfilaria rates held at 3 percent or less, thus indicating that the results are dependent upon the thoroughness of the treatment. Procedure (2), above, for two groups of carriers, one with a pre-treatment average microfilaria count of 61 per 20 cm3 of blood who received twelve doses of diethylcarbamazine, totaling 72 mg per kg of body weight, and the other with a pre-treatment average count of 56, who received a total of 152 mg per kg in 26 doses, gave the following results three years after the treatment: The first showed a microfilaria rate of 24 percent with an average microfilaria count of 1.8, and the second showed a rate of 13 percent with an average microfilaria count of 0.2. It will be noted that the group receiving the greater amount of drug showed the lower microfilaria rate and count.

B. Infective stage larvae in mosquitoes.

The infective stage larval rate of Wuchereria bancrofti in naturally infected mosquitoes in two areas, when checked each three months for two years before control, was 3.1 percent with a low of 1.2 percent and a high of 8.7 percent. Three years after the first round of mass-treatment with diethylcarbamazine, the rate in these two areas was less than 0.5 percent.

C. Clinical manifestations.

The prevalence of elephantiasis and hydrocele in four rural villages in American
Samoan in 1962 is compared with reports by Dickson (1943) and Murray (1948), from surveys made when the U.S. Navy was in charge of medical and public health activities. There was little change in the rates from 1943 to 1962, a period of 19 years, during which control measures were not instituted.

In contrast, Laiqet et al. (1965) in Tahiti, where an island-wide filariasis control program was in progress during a 12-year period from 1953 to 1965, report appreciable reductions in both elephantiasis and hydrocele.

**Problems and Conclusions.** The success of a control program against filariasis is directly proportional to the thoroughness with which it is executed. Several important problems in the use of diethylcarbamazine as a chemotherapeutic control measure should be emphasized: (1) The number of people excused from mass-treatment campaigns for health reasons. (2) The number of people refusing to take the drug. (3) The speed with which the new microfilaria carriers who migrate to a given area are adequately treated. (4) The recurrent microfilaria positives, as compared with pre-treatment positives. The higher the pre-treatment density, the greater the likelihood of recurring microfilaremia. See Ciferri and Kessel (1965).

Reports listed in the References, together with current information, show that adequate administration of diethylcarbamazine will result in marked lowering of microfilaria rates and densities in man, infective-stage larval rates in mosquitoes, and in clinical filariasis rates, to the point where the disease is no longer the severe public health problem previously experienced. Even so, at least in areas of highest microfilaria densities, as found in Tahiti before filariasis control, eradication has not been reported.

In a few regions, notably those with lowest microfilaria rates and densities, as in certain areas of Japan and in the Austral Islands, interruption of transmission may have been attained. Where this can be confirmed, studies leading to filariasis eradication programs are indicated.

An additional important problem remains, as found in control of any infectious disease, i.e., improvement of currently used therapeutic agents and methods. Diethylcarbamazine, the safest and most generally used drug, may require several administrations to eliminate recurrence of microfilariae. With its continued use, one must practice perseverance by repeated administration.

To increase efficiency in present control measures and advance to successful eradication programs, attempts should be made (1) to improve drugs now in use and to discover more efficient ones, (2) to improve insecticides and methods of vector control, and (3) to enhance public health education.

**References**


Hawking, F. 1962. A review of progress in


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PUBLIC HEALTH ASPECTS OF PEST MOSQUITO CONTROL

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At the turn of the century a new era in vector control began with the first successful demonstrations for the control of mosquito-borne diseases: first, Watson's malaria control work in Malaya, then Gorgas' yellow fever epic in Havana, followed by the control of malaria in Panama by Gorgas and LePrince. In the more than 60 years that have elapsed since those historic projects, mosquito control has been employed on many occasions to check epidemics throughout the world.

When such a program is undertaken at the time of an epidemic, or in a situation where the disease is endemic, it is possible to obtain some measurement of the benefits through careful interpretation of morbidity data. But how does one evaluate the public health benefits of a control program in an area where there are no infectious diseases of mosquito origin?

It is unlikely that we will ever have a comprehensive answer to this question based on experimental procedure. We can perhaps profit, however, by organizing some of our subjective observations and conclusions.

Referring again to the Panama incident, the results were obtained mainly by an attack against the mosquito at the source, by drainage, filling, grading, and some use of oil larvicides. Residual insecticides and chemotherapeutic drugs had not yet become available. It is apparent, therefore, that the early Panama program was based upon nonspecific mosquito control. The old reports show that there were few mosquitoes of any kind left in the areas subjected to organized control, although both pest and vector species were abundant in the uncontrolled areas nearby. The people living within the Canal Zone were