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Can anopheline-transmitted filariasis be eradicated?

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Introduction

Human lymphatic filariasis can be caused by *Wuchereria bancrofti, Brugia malayi* or *B. timori* and transmitted by a number of culicine and anopheline vectors. No vector is specific to a particular parasite, *Anopheles* mosquitoes transmitting *B. malayi* just as easily as *W. bancrofti*, and similarly with *Culex* spp. Emphasis has normally been given to differentiating the varieties of lymphatic filariasis by species of causative parasite because of the clinical manifestations and distribution but, for control, it is the vector that is the key. This paper sets out the reasons for this difference emphasizing that the control of *Anopheles*-transmitted filariasis is a much more achievable goal than control of that borne by culicine vectors.

Limitation, facilitation and the pharyngeal armature

The host–parasite relationship was discussed by Pichon (1974) and Pichon *et al.* (1974). Two different patterns of infection occur: limitation, due to culicine transmitted filariasis, and facilitation (Brengues & Bain 1972), due to anopheline transmitted (see Figure 1). By studying Figure 1 it will be seen that as the number of ingestedmicrofilariaeincreases so the number of infective larvae (in the mosquito) also increases. If this was at the same rate then a straight line, constant ratio graph, would result (P). With both types of filariasis, mosquito mortality occurs if the number of ingested microfilariae is too great, giving an upper stable limit (E). Tracing back from this upper point (E), two different patterns occur. In culicine transmission (limitation) the number of ingested microfilariae is always greater than the constant ratio (P), so that even at very low microfilarial numbers parasite uptake by mosquitoes occurs. This however is in contrast to anopheline-transmitted filariasis (facilitation) where there is a lower critical point (C) below which the number of ingested microfilariae drops below the constant ratio. Infection cannot be sustained, the parasite population will decrease spontaneously, and the disease will invariably die out.

One biological explanation for this difference between anopheline and culicine mosquitoes is due to the action of the pharyngeal armature (Coluzzi & Trabucchi 1968; Bryan *et al.* 1974; McGreevy *et al.* 1978). The pharyngeal armature is well developed in anopheline mosquitoes so that microfilariae are damaged when they are ingested. If sufficient microfilariae are ingested then enough will escape damage to infect the mosquito, but at low levels of microfilariae this is unlikely. Bryan and Southgate (1988a) showed that the uptake of *W. bancrofti* was proportional to the microfilarial density (of the host) for *An. gambiae* and *An. arabiensis*, but the proportions of microfilariae damaged by the foregut (pharyngeal) armatures were not (Bryan & Southgate, 1988b). In three density groups of microfilaria carriers (low, medium and high) the proportion of microfilariae damaged was very comparable, 57.1–60.0% for *An. gambiae* and 33.3–50.6% for *An. arabiensis*, showing that at low densities there are very few undamaged microfilariae left to infect the mosquito. Bryan *et al.* (1990) repeated the experiment in East Africa where additional species of *Anopheles* mosquitoes were available and obtained comparable results for the proportion of microfilariae damaged.

Loss of microfilariae also occurs in fluid expelled from the anus of feeding *Anopheles* mosquitoes (Reid 1953; Kartman 1953; Jordan 1954; Wharton 1962; Brengues 1975) but not from *Culex* or *Aedes* species (Kartman 1953).

Critical density and threshold level

This lower point below which disease will die out in *Anopheles*-transmitted filariasis can be achieved either by reducing the density of parasites or the density of mosquitoes. Webber (1977, 1979) followed the natural decline of *W. bancrofti* in the Solomon Islands where the density of mosquitoes had been substantially reduced by a malaria control campaign using DDT residual house spraying. Webber and Southgate (1981) using human biting rate measurements showed that there was a critical number of bites that could be permitted without transmission of $0.66\,h^{-1}$ (equivalent to eight bites during the 12-h night-time period).

The paper by Zhang *et al.* (1991) (in this issue) sets out to measure the parasite threshold level of *B. malayi*, below which infection would invariably die out. They found that between 1.55 and 2.23% (prevalence) there was a threshold level, providing no individual had a higher density than 12 microfilariae $60\,mm^{-3}$ blood. Although eradication has not yet been achieved in their study villages, the progressive decline in the two below the threshold level gives every indication that this will occur. In another part of the same province (Shashi) eradication has been achieved from a prevalance rate of 11.37% in 1984.

Strategy for control

Filariasis control has mostly been aimed at culicine-transmitted disease using mass drug administration. A much easier infection to control would appear to be filariasis transmitted by anopheline mosquitoes. The important factor is the density of microfilariae in individuals, not trying to cure every low density carrier who still provides microfilariae for uptake by culicine mosquitoes. This means that a strategy of selective treatment of positive microfilaria carriers should be adequate.

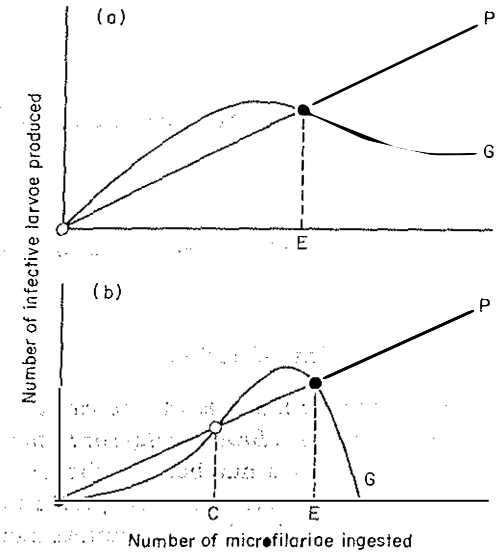

Figure 1. a, Limitation (Culicines) and b, facilitation (Anophelines). Modified from Pichon *et al.* (1974).

Selective treatment of positives is much easier to organize, it can be part of a routine health service, and does not require any special programme. Positives can be diagnosed by taking night blood films of fever cases, those with lymphangitis, or with any of the other clinical signs. Initially it is preferable to undertake a mass blood survey to diagnose all positive cases. The level to be aimed at can be taken from the results of Zhang *et al.* (1991). The criterion is the total available microfilariae, a composite value made up of the number of people infected and the density of individual microfilaraemia. It would seem that at least 1.6% of the population can remain with microfilariae providing no individual has a density of more than 12 microfilariae per $60\,mm^3$. While these are figures for *B. malayi*, it is likely that *W. bancrofti* will be very similar.

If infection is allowed to die out naturally once transmission has ceased, then it will take in excess of 8 years (Webber 1979). If a diagnosis and case treatment approach is used as in Shashi (mentioned above), then it will take 5 years to achieve eradication. The treatment regime used in China was 1 g diethylcarbamazine (DEC) once a month for three successive months in *B. malayi* infection and 0.6 g DEC daily for 7 days (repeated once or twice) in *W. bancrofti*.

Table 1. Areas where anophelese vectors are involved in the transmission of filariasis

Geographical area	Transmitting *W. bancrofti*	Transmitting *B. malayi*
Africa Madagascar	*An. gambiae, An. arabiensis* *An. funestus, An. melas, An. merus*	
India Bangladesh	*An. philippinensis*	*An. barbirostris*
China	*An. sinensis*	*An. antropophagus* *An. sinensis*
Korea		*An. sinensis*
Thailand (south)		*An. barbirostris*
Malaysia	*An. letifer, An. whartoni* *An. macualtus*	*An. donaldi,* *An. campestris*
Philippines	*An. mininus*	
Indonesia	*An. balabacensis (B. timori)*	*An. barbirostris*
Papua New Guinea Solomon Islands Vanuatu	*An. farauti, An punctulatus* *An. koliensis*	
Brazil, Guyana	*An. darlingi*	

From Sasa (1976) and other sources.

Prospects for filariasis eradication

The areas of the world where filariasis is transmitted by an anopheline vector are shown in Table 1. There is now sufficient evidence to give priority to these areas for filariasis control using selective treatment of all positives until their level of parasitaemia falls below the critical level. Providing the control programme is maintained for a sufficient length of time, the prospects for eradication are good. This has been achieved for *B. malayi* using this method, while *W. bancrofti* has been eradicated using vector control. It is hoped that selective treatment of positives can be implemented in a vigorous fashion in all those areas where filariasis is transmitted by an *Anopheles* vector.

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