and Tallantyre on mud-cores from Hockham Mere show clearly that this area was forest-covered for much of the post-glacial period. However, after the date of human occupation the area became deforested so that grass and herb pollen replaced that of trees. In addition, the appearance at this time of the pollen of plants such as *Plantago* and *Artemisia*, weeds of cultivation, suggests here, as elsewhere in Europe, that forest clearance was associated with human occupation. Similar evidence is available for Danish heaths, while deforestation of the heather moors in Yorkshire appears also to have taken place since the Bronze Age.

Apart from the debased condition of existing Breckland soils (which were described by Dr. A. S. Watt) there is, at present, no direct evidence of changes in soil conditions in this case; but results in the similar climate of eastern North America have given abundant evidence of the soil degeneration following deforestation, shown both by the lower nitrogen content which results and also in the greater soil erosion which has left its mark in the more inorganic character of recent lake sediments.

The study of lake sediments promises, indeed, to throw valuable light on post-glacial trends in soil conditions, for in many cases sediments of this type must be samples of the actual soil materials. The difficulty will be to allow for changes which take place in transit, or during and after deposition. Some evidence is already available from the English Lake District which poses the problems and suggests intriguing solutions.

In general, the post-glacial sediments in lakes like Windermere and Esthwaite Water appear to have been uniform in character during at least the first half of the post-glacial period or rather more. Later, and particularly during the past three thousand years, there are various types of change in the character of the sediments. If each of these changes were considered alone, several possible causes for each might be suggested, but if, as seems probable, all are connected one to the other, then all seem to run parallel to the onset and development of deforestation, and it remains for further inquiry to elucidate the connexions and to analyse the basal controlling influences.

Deforestation in the Lake District appears to have started in the second millennium B.C. Apparently it proceeded rapidly after the Norse occupations (say, from A.D. 1100 onwards) and reached a maximum in the sixteenth century. Following this, the lake muds corresponding in time show a minimum of organic matter which is attributed to soil erosion following deforestation. Parallel changes which apparently became intensified at this time include such features as a diminution in the electrical conductivity of the mud, and an increase in its acidity. The latter is particularly well shown in mud cores from the Esthwaite Fen, where it can be closely correlated with the diminishing base-saturation of the mud colloids.

The three features of the more recent mud-layers, decreased conductivity, decreased base-saturation and increased acidity, suggest that the soils from which the muds were derived may have suffered pronounced leaching in the course of time. The existence of rapid soil leaching under present-day climatic conditions was, of course, first demonstrated by Salisbury on various British dune systems and has since been shown elsewhere, especially by Hissink for Dutch 'polders'. The evidence from lake-muds apparently confirms the existence of this tendency in the past; it may also show that leaching proceeded at widely different rates at different times. If the present indications on this point are confirmed, leaching appears to have been extremely slow under the continuous forest-cover of the earlier half of the post-glacial period and to have been greatly accelerated as deforestation became more and more pronounced. There is, however, no evidence which serves to decide whether deforestation and soil deterioration in the Lake District were the results of 'natural' changes or of human action. The climatic deterioration known to have occurred just before the Christian era in north-west Europe may well have been a decisive factor in these changes, and it may be a matter of chance that its action should have coincided somewhat closely with the time of extending human settlements. Certainly one must be reluctant to ascribe the earliest deforestation of so many different parts of Britain to Neolithic man—until more is known of the numbers of individuals in each locality.

Any general conclusion which can be drawn from this type of work seems only to confirm the general impression reached by ecologists that many types of 'marginal' land can only be really productive under forest. Undoubtedly much of northern Britain at least should never have been deforested, and it seems that the simplest biological method of re-creating lost fertility in such areas may be by afforestation. Further, these areas are now invariably of low nitrogen status and it seems to follow that alternative forms of land-use, if any exist, should properly aim towards products chemically different from the bread and beef of our lowland agriculture. A sound policy should aim first at the redevelopment of a more stable and productive soil status, and only later at high yields.

# THE FIGHT AGAINST FILARIASIS IN THE PACIFIC

By SIR PHILIP MANSON-BAHR, C.M.G.

FILARIASIS remains the dominant scourge of the Pacific, especially in those islands mainly inhabited by Polynesians. These palm-covered coral-reefed atolls constitute what are popularly known as South Sea Islands and are made familiar to many in the film of the "Blue Lagoon" or by the vivid writings of Robert Louis Stevenson. There amidst fantastic and beautiful surroundings the filaria is rampant, finding conditions ideal for its propagation. Malaria, which in other parts of the tropics and indeed throughout Melanesia is the greatest bar to prosperity and progress, is here quite unknown. It is now more than seventy years since the transmission of the filaria (*Wuchereria bancrofti*) through the mosquito was proved by Sir Patrick Manson, and some forty years have elapsed since the Pacific filaria[1] was recognized as possibly a separate entity and its spread by a special distinct species of mosquito peculiar to the Pacific islands proved by me. Nevertheless, comparatively little had been done up to the present to transform these scientific facts into practice.

Filariasis and its maximal expression, elephantiasis, have existed in Polynesia for many centuries, and the disease appears to have been spread from one island to another by migrating Polynesians during the fifteenth century. In the Central Pacific the area dominated by filariasis is enormous: an area delimited by long. 170° E. to 130° W. and lat. 10° N. to 24° S. in a vast oblong some 3,500 miles in length and 2,200 in breadth containing well over a thousand islands and a population of about 370,000 Polynesians.

In 1912 I was able to show that the chief vector of the non-periodic filaria in the Fiji Islands was the prevalent black-and-white striped mosquito which had been described by Theobald as *Stegomyia scutellaris* from specimens sent to him by F. P. Jepson[2]. This species has had a chequered career as regards terminology, being renamed *A. variegatus* and now finally *Aedes scutellaris pseudoscutellaris* by F. W. Edwards. The ecology and bionomics of the species have been thoroughly studied since by O'Connor[3], by Buxton and Hopkins[4], by R. W. Paine[5], and by Byrd, St. Amant and Bromberg[6].

Now the surprising discovery has been made by E. N. Marks[7] that, in what was thought to be a homologous species, two morphologically similar identities exist and that a new species, *Aedes scutellaris polynesiensis*, has to be recognized as valid, distinguished from *Aedes s. pseudoscutellaris* by the shape of the lobe of the coxite of the male. *Polynesiensis* is the most important and widespread species in that area of the Pacific now under consideration. This entomological problem is further complicated by the presence of a third, closely similar and related species of *Aedes* in Fiji, *Aedes scutellaris horrescens*, the female of which is indistinguishable from *pseudoscutellaris*, which was described by F. W. Edwards in 1935[8]. This is a forest-frequenting form and breeds in tree holes of coconut palms, tree ferns and other forest trees. The main distinction lies in the larvæ, which are readily separable as being more hairy.

The recent researches in Fiji by P. Manson-Bahr and W. J. Muggleton carried out in 1950 have now been published[9], supporting the arguments originally proposed in 1912 that the Pacific filaria should be considered as a separate species, for which the name *Wuchereria pacifica* has been proposed. From the work of J. J. C. Buckley[10] on the adult worms collected from Samoa and Fiji, it appears that some morphological differences can be recognized. In *W. pacifica* the head is oval in outline; in *W. bancrofti* it is round. The tail of the female lacks the bulbous swelling seen in *W. bancrofti*, and the length of the adult specimens, both male and female, is considerably smaller. Added to this, the non-periodic habit in the blood of the microfilaria of *W. pacifica* is adapted to the biting habits of its insect intermediaries *A. polynesiensis* and *A. pseudoscutellaris*. The fact that it does not develop normally in *Culex fatigans* or in *Aedes ægypti* reinforces the argument of distinct specificity. In contrast, the nocturnal microfilariæ of *W. bancrofti* are adapted to the night biting habits of *C. fatigans* and *Anopheles punctulatus farauti*, mosquitoes which act as the optimum intermediaries in Melanesia.

The geographical distribution of these two forms of filaria appears to be quite distinct, and *W. pacifica* is to be found in those Pacific Islands east of 170° E. It has been further suggested by me[11] that wherever *W. bancrofti* occurs it is the result of a domiciliary infection acquired during the night hours. Therefore, women and children are infected almost as heavily as the males, whereas in *W. pacifica* it is contracted in the daytime in the bush and plantations away from habitations and therefore this form of filariasis should be regarded as a rural infection. Men are consequently more heavily infected than women owing to their occupations in the open air in gardens and plantations. That the site of the infecting bites may also be important is shown by the frequency of elephantiasis of the arms in the Pacific as compared with British Guiana, where *W. bancrofti* is common and elephantiasis of the legs the rule. Repressive measures have to be based on these premises. In the nocturnal form the infecting mosquitoes must be attacked inside dwellings; in the non-periodic form in the immediate surroundings of dwellings and in the bush. The former (the nocturnal form), as has been shown by Giglioli[12] in British Guiana, is comparatively easy to eradicate.

Little repressive work against filariasis had been undertaken prior to 1942 in Fiji. In that year D. W. Amos[13], a retired business man who was an amateur entomologist, undertook an educational survey of the mosquito pest within the town of Suva. In 1943, appointed senior mosquito inspector, he commenced to train Fijian assistants in anti-mosquito measures and this scheme has since developed into the Mosquito Control Service. By these means the Fijians themselves have been made responsible in their villages and townships for the conduct of the anti-filariasis campaign. At the Central Institute in Suva Amos, and since Amos's death in 1949, Isimeli Rakai, his chief assistant, have trained classes of selected Fijian youths in this work, which comprises the structure and identification of the adult and larval stages of Fijian mosquitoes, and many other allied subjects. Up to 1948, more than 45,000 blood examinations had been made and an overall microfilaria rate of 18 per cent established. A training manual on mosquito control[14] by D. W. Amos was published in 1944 and revised in 1947. A shorter edition in the Fijian language and embellished with original cartoons was produced by Isimeli M. Rakai[15] in 1950.

There is no doubt that the Mosquito Service has done, and is doing, great work for Fiji, and the results of this campaign are already apparent. This was evident during my visit to Fiji in 1950. In the field, the Mosquito Service teams have been most active in clearing up the surroundings of villages, in filling in tree holes, burning coconut shells and debris, cutting down jungle, burying refuse heaps and generally making the village Fijians 'mosquito conscious'.

Now the battle has been joined by American workers in Tahiti and the preliminary results of their work have been published.

The anti-filariasis campaign in the Pacific has also received a great stimulus by the creation of the South Pacific Commission in 1949 and of which the first conference assembled in Suva in May 1950; afterwards a select group met in Tahiti during August 21–September 1, 1950, and a summary of the proceedings has been issued[16]. This was composed of delegates from French Oceania, New Zealand, Australia, Fiji, New Caledonia, Cook Islands, Samoa, Hawaii, University of California and other American interests.

Filariasis work in Tahiti is being conducted at the Institut de Récherches Médicales de l'Oceanie Française, Papeete, Tahiti. In July 1951, an annotated bibliography on filariasis, elephantiasis and related aspects in the South Pacific area was issued[17] by E.

Massal, executive officer, and D. J. Kerrest, research officer, Health Department of the South Pacific Commission.

## Mosquito Control

In addition to the work in Fiji, medical officers in Samoa have been investigating methods of mosquito control in suppressing filariasis. In their paper, Jachowski and Otto[18] endeavoured to determine the maximum zone of infectivity in native villages by dissecting specimens of *Aedes pseudoscutellaris* (probably *A. polynesiensis*) at selected collecting stations situated at various measured distances from the living quarters. In doing so, they examined more than 2,300 specimens of *A. polynesiensis*. They were surprised to find that the highest incidence of filarial infection (in the thorax) was not in the immediate vicinity of the huts inhabited by the Samoans, as might well have been expected ; but the 'index of transmission' was very high in the bush and garden trails 175–275 yards from the centre of all the villages investigated. The age and sex distribution of microfilaræmia in Samoans, added to the habits of the villagers, and the well-ascertained biting habits of the mosquito vectors, which coincide with the visits of the gardeners to their plots, all support the conception of the non-domestic transmission of this filariasis. In some details their findings differ somewhat from similar researches by Byrd, St. Amant and Bromberg some few years earlier (1945), when they found the highest rate of mosquito infection at a range of 25 yards from the village centre.

The merits of mosquito control and drug suppression combined and contrasted have been employed on the grandest scale so far in Tahiti, where Beye[19] and his colleagues have now issued their preliminary report upon the suppressive measures they have initiated for the control of filariasis, covering the period November 1948–September 1950. Their schemes were carefully planned and the total area was divided into nine divisions, including the adjacent island of Maiao. They, too, employed collecting stations for adult mosquitoes in order to determine their densities. There were no less than three 'resting' and an equal number of 'biting' stations in each selected area, where recordings were made two to three weeks prior to the establishment of control measures.

Next, the microfilariæ-rate per 20 c.mm. of blood had to be determined for each area, both before and after treatment with 'Hetrazan'. In order to obtain reliable data upon which to base their conclusions, measures varied in different areas, keeping as a control one with a microfilaria-rate of 38·6. In other areas different methods of suppression were instituted, some with 'Hetrazan' prophylaxis, others with sanitation and DDT. The effect of the several methods on the percentage of persons with microfilariæ was estimated at six and twelve months after the measures were commenced, and thus it was ascertained that a noticeable drop occurred in each of the four areas where 'Hetrazan' was administered, whereas wherever anti-mosquito measures were instituted there was a drop in the numbers naturally infected to 0·6 per cent.

## 'Hetrazan' Prophylaxis

Clinical work on 'Hetrazan' in human filariasis was initiated by Santiago-Stevenson and others[20] on twenty-six persons harbouring *W. bancrofti* in Puerto Rico. When it was given by the mouth, in doses of 0·5–2·0 mgm. per kgm. body-weight three times daily, the number of microfilariæ was greatly reduced by the second day and in some 34·6 per cent they disappeared entirely. Afterwards, work was continued in British Guiana[21] and on the Island of S. Croix[22], and again substantial reductions of microfilariæ were obtained which persisted for three to twelve months.

The exact dosage of 'Hetrazan' and the length of the course necessary to banish microfilariæ from the blood has not even yet been finally determined. I found[23] in Fiji that, if the deep venous blood is examined, although no microfilariæ may be present in the peripheral circulation, they can usually be demonstrated. This leads to a consideration of the mode of action of 'Hetrazan'. Hawking, Sewell and Thurston[24] have shown that microfilariæ (*W. bancrofti*) in enclosed cavities, such as the pleura, or in a hydrocele sac, are not affected by 'Hetrazan' ; but that, after treatment, they congregate in the liver, where they are attacked and devoured by leucocytes. It appears probable that 'Hetrazan' modifies the microfilariæ in some manner so that the leucocytes are attracted to them as if by some opsonizing effect.

It would seem that a very considerable reduction in numbers results from comparatively small doses of 'Hetrazan', but that larger ones are more lasting. Halawani[25] in Egypt treated ambulant cases (*W. bancrofti*) with 'Hetrazan' in doses of 0·9–2 mgm. per kgm. three times daily. In Indian nocturnal filariasis (*W. bancrofti*), Raman and colleagues[26] gave 0·45–2·2 mgm. per kgm. similarly for twenty-one days with a similar result. In East Africa, Laurie and associates[27] have given 'Hetrazan citrate' in doses as high as 12 mgm. per kgm. every twelve hours for three days to banish microfilariæ from the blood. Nine moderately infected patients received a single dose of 20 mgm. per kgm., and it was found that microfilariæ were absent from the blood two years later ; but it is laid down that those patients with greater numbers of microfilariæ are definitely more difficult to sterilize than those with smaller numbers.

The most detailed account so far of the control of filariasis with 'Hetrazan' has been published by McGregor, Hawking and Dean Smith[28] at the Medical Research Council's Field Station in the Gambia. The dosage of 'Hetrazan citrate' was 25 mgm. per kgm. daily for five days. Of 154 infected persons who completed the prescribed course, 64 per cent had their blood free from microfilariæ so long as ten months later. In the remainder who did not respond so satisfactorily the parasitæmia was substantially reduced.

It is not surprising to learn that these large doses were not well tolerated and toxic effects appeared in one quarter. This form of medication soon became unpopular and it was only with great difficulty that the trial was completed.

In non-periodic Pacific filariasis, the microfilariæ are possibly more difficult to exterminate. In addition to the work of Beye and colleagues in Tahiti, Gaillard and Mille[29] gave small doses—2 mgm. per kgm. three times daily for seven days—and microfilariæ were banished in 87 per cent for about four months. It is still open to question whether one large loading dose is more effective in reducing microfilaræmia than a more prolonged course of smaller ones.

It would thus seem probable that the disproportion of the severer manifestations in the two forms of filariasis, nocturnal and non-periodic, discussed in this article reinforces the argument that, in the former (*W. bancrofti*) infections and in the latter (*W. pacifica*), we are dealing with separate entities which necessitate different methods of prophylaxis and possibly of treatment as well. (The statement made by McGregor and colleagues that out of 603 Gambians examined there were only six with signs of filarial disease and that the people regard it as altogether of minor importance must also be borne in mind.)

Owing to the uncertainty of the dosage and length of treatment with 'Hetrazan' in order to banish microfilariæ from the peripheral blood for a sufficient time to render mass application a practical proposition, added to the almost insuperable difficulties which arise in carrying through such a programme in Polynesians, there exists at present a prejudice against this form of causal prophylaxis. The minimal infective microfilarial concentration in the blood (after 'Hetrazan' treatment) for *A. pseudoscutellaris* and *A. polynesiensis* has yet to be determined. According to my observations[23] it is about four microfilariæ per 20 c.mm. of blood.

It appears probable that 'species sanitation' against the main vector, as had been practised in Fiji and Rarotonga, and now in Tahiti, promises to be the most effective measure in the ultimate eradication of Pacific filariasis, and that the actual carrying out of repressive measures should be left to specially trained teams of Polynesians.


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# OBITUARIES

## Dr. C. S. Hudson

The death occurred suddenly on December 27, 1952, of Dr. C. S. Hudson at the age of seventy-one, and carbohydrate chemists all over the world mourn the passing of one of their greatest leaders.

Claude Silbert Hudson was born in Atlanta, Georgia, and spent a happy boyhood in Mobile. He entered Princeton University in 1897 in order to study for the Presbyterian ministry. He became so interested in chemistry during his course for the B.S. degree that eventually he decided to become a scientist. After graduation (1901) he was elected into an endowed fellowship in experimental science at Princeton and began an investigation on the mutarotation of milk sugar, under W. F. Magie, then professor of physics. This first investigation, published in 1902 when he was twenty-one, marks the beginning of his brilliant series of more than two hundred and fifty publications on the carbohydrate group.

Hudson's first leanings were towards the physical side of chemistry, and he spent a profitable year with Nernst at Göttingen (1902–3). On returning to the United States he became a research assistant to A. A. Noyes in Boston, and then he held an instructorship in physics at Princeton (1904–5) and at Illinois University (1905–7); after holding several other posts he was appointed chemist to the Bureau of Chemistry at Washington, where he stayed until 1919. He then became a consultant chemist for four years, afterwards joining Frederick J. Bates at the National Bureau of Standards, where he carried out many notable researches up to 1929. In this year he was invited to the professorship of chemistry in the U.S. Public Health Service, where he remained until his retirement at the age of seventy. During his tenure of this latter post he was enabled to secure the assistance of a succession of brilliant young scientists who, inspired by his able leadership, have achieved world-wide distinction.

Among his many great works on carbohydrates, Hudson's contributions to preparative methods and to the relationship between rotatory power and structure stand out, while his famous 'lactone rule' was perhaps his greatest single personal contribution and was one of the most notable landmarks in carbohydrate chemistry. He was a brilliant experimentalist and his writings bear the stamp of a master mind. He infused his passion for the sugars into his many pupils, who bore him great respect and devotion.

In the late 1920's he engaged in a notable controversy with the late Sir Norman Haworth regarding the ring structure of certain of the sugars, and following his eventual acknowledgment of the correctness of Haworth's views the two began a friendship which both greatly treasured. The results of this friendship were seen in the founding of the "Advances in Carbohydrate Chemistry", to which Hudson as the senior editor particularly devoted the last few years of his life and from the guidance of which he will, indeed, be sadly missed. He was largely instrumental also for founding the "Starch Round Table", which provides an annual forum for discussions on this important foodstuff.

Many honours came to him, particularly from the American Chemical Society. He received the Borden Medal and Award (1941), the Nichols Medal of the