

"HUMAN FILARIASIS"

Being a thesis presented by GEORGE C. LOW, M.A., M.B., C.M.,
for the degree of M.D. Edinburgh University 1910.



CONTENTS.

Foreword	Page 1.
General Historical Summary	2.
Zoological position of the Filaridae ..	14.
Nomenclature and species of the blood filariae proper	17.
Filaria bancrofti:	
i. Geographical distribution.	18.
ii. Life history and biology.	25.
iii. Diseases caused by it.	86.
iv. Prophylaxis.	126.
Filaria loa:	
i. Geographical distribution.	141.
ii. Life history and biology.	141.
iii. Diseases caused by it.	165.
iv. Prophylaxis.	173.
Filaria demarquayi:	
i. Geographical distribution.	174.
ii. Life history and biology.	179.
Filaria perstans:	
i. History.	191.
ii. Geographical distribution.	192.
iii. Life history and biology.	197.
iv. Pathology.	213.

<i>Filaria magalhaesi</i>	..	..	..	Page 215.
Doubtful species.	..	..	..	220.
Bibliography	..	..	..	226.

FOREWORD.

Strictly speaking the term filariasis should mean the invasion of the animal host by any species of filaria, but in recent years at least it has gradually become more or less restricted to the description of those species which pour their embryonic or larval forms into the blood stream, that is to say the blood filariae proper. Such being the case the subject is considerably simplified, forms like the Filaria medinensis (the guinea worm), Filaria volvulus, Filaria conjunctivae, Filaria hominis oris, Filaria labialis, &c., being excluded.

In the present study it is intended therefore to use the term filariasis in this sense and to limit the discussion to species of filariae found only in the human subject, animal ones only being mentioned in so far as they throw any analogical light on problems occurring in the former. The life histories of some of the human blood filariae have now been cleared up very considerably but there are still many points of supreme interest remaining, amongst these being the question of doubtful species, the question of intermediate hosts, pathological points and so on.

Four good species certainly are to be found, viz.

Filaria bancrofti, Filaria loa, Filaria perstans and Filaria demarquayi, and it is with these that the paper will be chiefly concerned, indifferent ones such as Filaria magalhaesi, doubtful ones such as Filaria ozzardi, and spurious ones such as Filaria gigas and possibly Filaria philippinensis being briefly mentioned at the end. The habitat of the adult forms to be described as will be seen later varies, but they have all this common characteristic that their embryos inhabit the circulating blood and so the diagnosis of their presence can be easily accomplished by the simple procedure of examining the blood.

GENERAL HISTORICAL SUMMARY.

The history of filariasis is not a long one, only dating back to 1863 when Demarquay in Paris first discovered the embryos of Filaria bancrofti. Microscopically examining some fluid one day, removed by paracentesis from a lymphatic swelling of the scrotum in a young man from Havana, he was astonished to find several very minute cylindrical worms amidst the cellular structure and other debris. So struck was he by this phenomenon that he published the fact in the Medical Gazette of Paris⁽¹⁾ of the same year,

giving a very fair illustration of the parasites at the same time with his article. Strangely enough, his discovery attracted little or no attention, probably because it was an isolated case with little chance of getting similar or further ones in Paris, and in the course of a few years it appears to have been totally forgotten and lost sight of.

Wucherer in Bahia, in ignorance of this paper by Demarquay, rediscovered the embryos in cases of chyluria in 1866, and after collecting a series of twenty-seven such cases, in all of which he found similar parasites, published his results in the *Gazzetta Medica de Bahia* in 1865 and 1869.⁽²⁾ He believed the parasites had something to do with the pathological condition of chyluria in which he found them, a disease apparently common enough in the part of Brazil in which he practised, but further than that in the life history he did not get.

No further advance of any great importance was made in the subject till Lewis, in India in 1872,⁽³⁾ found what eventually turned out to be similar embryos in the blood of a patient suffering from diarrhoea and emaciation; these he named on account of their situation the *Filaria sanguinis hominis*, a nomenclature which was adopted by the helminthologists of the day and has kept its place in the literature

till quite recently, when owing to various circumstances it has had to be changed in order to fall in with present knowledge and ideas.

After Lewis's investigations, everyone working at the subject agreed that these small actively moving worms seen in the blood and urine (in chyluria cases) must be the young or embryonic forms of adults, situated somewhere or other in the body of the host, and different observers began a systematic search for them whenever suitable opportunities presented themselves.

Eventually the honour of their discovery fell to Bancroft in Brisbane Queensland,⁽⁴⁾ who, while opening a lymphatic abscess in the arm of a patient one day, in whose blood filarial embryos had been demonstrated, found a small worm, 3 to 4 inches long about the thickness of a human hair and most closely resembling a very fine piece of catgut. Later more of these parasites being found in similar cases, specimens were sent to Cobbold in England, one of the leading helminthologists of the time, for identification.⁽⁵⁾ The latter authority subjecting them to a close scrutiny found embryos in the uterus of a female specimen, corresponding exactly in shape and measurement to specimens taken from the blood of other cases, and so rightly came to the conclusion

that the young or embryonic forms found by Wucherer in cases of chyluria, and by Lewis in the blood were nothing more or less than the offspring of parent or mature worms which inhabited the lymphatic trunks of man. In honour of the discoverer Cobbold gave the name of Filaria bancrofti to these adult forms, and as shall be afterwards pointed out this name must hold.

In 1878 Manson in Amoy, China, ⁽⁶⁾ following up the study of Filaria bancrofti, made the very remarkable and far-reaching discovery that certain species of mosquitoes act as the intermediate hosts for the further development or metamorphosis of the embryonic filariae. He had been struck by the fact that the young forms in the blood showed no evidence of growing or in any way changing so gradually was led to the conclusion that in some way or other they must enter an intermediate host to allow of further development, analogies to this of course being common amongst other parasitic worms. Starting on this assumption then, he began to examine different suctorial insects, which were known to have fed on infected cases (e.g. cases with embryos circulating in the blood), and amongst these, mosquitoes formed the large majority, as they were very prevalent in the district. In all such insects examined he found that the filariae were ingested into the stomach with

the blood sucked up, but that in most of them they were slowly digested and eventually entirely disappeared, one exception to this rule however being the case of a small brown unstriped mosquito nocturnal in its habits. In the case of this insect the embryos, instead of dying and gradually disappearing, bored their way into the tissues of the host, chiefly the thoracic muscles, and there underwent a most remarkable development.

To follow these changes out accurately, Manson persuaded a Chinaman, who had filarial embryos in his blood, to sleep in a specially erected wooden framework covered with a mosquito netting, the door of which was left open for a short time each night to allow of mosquitoes entering to bite, and then in the mornings the gorged insects seen hanging on to the netting were carefully caught and put in stoppered bottles, being kept there till required for dissection.

Three species of mosquito were in the habit of visiting the house: two of the variety known as the "tiger", sooty in colour, with white bands on their legs, while the third was a small brown mosquito called by him Culex pipiens the common domestic or house mosquito of the tropics. The former two proved to be inefficient, but in the latter the embryos migrated to the thoracic muscles and there underwent

a metamorphosis, attaining in about eight days a relatively enormous size, $1/16$ th of an inch in length by $1/850$ th of an inch in breadth, and, further, now possessing a well developed alimentary canal and other structures.

Little was known about the life history of mosquitoes at that time, but as most of the insects died in 4 or 5 days Manson put forward the view that in nature, the mosquito, after laying its eggs on water, died there and disintegrated, thus freeing the young embryos which could presumably live in this medium until taken up by man, when they would by passing through the stomach gain some lymphatic trunk and there become the mature parasite again.

Confirmation of Manson's wonderful work on the metamorphosis of the young filariae in the mosquito soon appeared. Lewis⁽⁷⁾ in India, on beginning a systematic research into the subject being astonished to find that when care was taken, 14 per cent. of the mosquitoes taken at random round his house contained filarial embryos. He followed out the different changes undergone in the muscles of the insects, but did not describe forms later than the fourth or fifth day, most of his mosquitoes dying then.

Sonsino,⁽⁸⁾ in Egypt, in 1882 conducted a series

of similar experiments but failed to find such advanced forms as the other two observers.

For many years after this no further work on the life history of the filaria was produced, matters remaining pretty much in statu quo, but Grassi⁽⁹⁾ in Italy, in 1890, indirectly confirmed the insect phase of the filaria of man, by demonstrating that the embryos of Filaria recondita, a blood worm of dogs, undergoes a similar metamorphosis in fleas. Briefly the adults of the Filaria recondita live in the fatty tissues round the hilum of the dog's kidneys; from there the embryos find their way into the blood, and fleas, especially the Pulex serraticeps (now called the Gtenocephalus canis), feeding on such infected animals ingest them (the parasites) into their stomachs. The embryos pass from there through the stomach wall, embed themselves in fat cells, and undergo four stages of development, eventually becoming almost mature. Infection experiments by feeding dogs with such fleas give negative results.

In 1899, Bancroft⁽¹⁰⁾ (junr.), in Australia, worked out afresh the metamorphosis of the Filaria nocturna (Microfilaria bancrofti) in the common brown house mosquito of Australia (Culex ciliaris Linn.), and not only verified completely all the former work and previous discoveries, but at the same time

amplified them and suggested other important details. Before beginning his work he firstly made (probably the first ever made) a special study of the habits of mosquitoes, and soon found that the mosquito in order to be kept alive must be fed, juices of fruits, sugar, &c., being quite as suitable as blood, for this purpose. He then began his series of experiments by first rearing large numbers of young mosquitoes from eggs and larvae collected from water, and when these in course of time developed into adult insects, the females (the males do not bite) were fed on a girl with filariae in her blood. Serial dissections of such insects, made day by day, shewed the same changes as described originally by Manson, but the final metamorphosis was reached much later namely not until the sixteenth or seventeenth day. No great difficulty was experienced in keeping the mosquitoes alive provided they were fed on bananas and other fruits, and this of course permitted of study up to the eighteenth day and longer.

These results, especially in view of the fact that only reared mosquitoes were used, were interesting and corroborative of previous work, as already mentioned, but where Bancroft advanced and went further was in his experiments on dissecting mosquitoes with metamorphosed embryos in them, in

water, so as to allow the contained parasites to escape into that medium. Finding that these only lived three to four hours, he rightly concluded that this was not what happened in nature, that in fact water was injurious to them, and that if by chance they did get into it they perished. Having satisfied himself as to this then, some other explanation had to be adopted, so he proposed two alternative theories: (1) The accidental swallowing of mosquitoes; (2) A suggestion that the filariae might come out by piercing the oesophagus of the mosquito when it was sucking blood and so get into the system of man by the skin. The first of these was improbable, how near the truth the second was will be shown immediately.

Bancroft, at the same time as he was dissecting mosquitoes serially day by day in Australia, also made a collection of large numbers of infected insects in glycerin, in separate bottles, duly labelled as to the day they had fed and so forth, and sent these home to Manson in London.

Low⁽¹¹⁾ while working at the London School of Tropical Medicine in the spring of 1900 was given this material to work up by Manson, and after a prolonged investigation involving the cutting of hundreds of sections demonstrated conclusively the path by which

the metamorphosed filariae leave the mosquito. He found that when development reached its final stages in the thoracic muscles of the mosquito the embryos began to leave that site and many passed forward into the head of the insect. Later sections through the proboscis actually showed the young forms stretched out in that organ evidently waiting for the mosquito to bite in order that they might wriggle into the wound and so get back into man their definitive host. This discovery (the paper will be referred to again in detail later) was an exceedingly important one, especially so as regards the prophylaxis of the disease, because it disproved once and for all the water transmission theory and showed that filariasis was like malaria a directly inoculable disease. It also showed the value of Bancroft's observation on the young filariae dying in water and further proved completely his theory that the worm might get into the system of man through the skin.

Confirmation of Low's discovery was quickly to hand. Apparently working simultaneously at the same subject, in India, Capt. James⁽¹²⁾ of the Indian Medical Service, while dissecting fresh mosquitoes also found a completely metamorphosed filaria in the proboscis of one of these insects. His publication of the fact appeared later in the year as did also

12

further corroboration by Grassi, in Italy, ⁽¹³⁾ who, along with Noe, traced the embryos of F. immitis, one of the blood worms of the dog through the common Anopheles maculipennis. These authors found that the embryos of the dog filaria developed in the Malpighian tubes and not in the thoracic muscles of the mosquito, and in about 10 days became completely metamorphosed. They then left the tubes, passed into the adjacent tissues, migrated forwards to the head, and so into the proboscis. By direct infection experiments on healthy dogs, they found that the worms passed from the proboscis into the tissues of the dog and disappeared.

A third confirmation came from the Second Malaria Expedition of the Liverpool School of Tropical Medicine from the West Coast of Africa, ⁽¹⁴⁾ the members of that expedition wiring home that they had found an active filaria in the proboscis of an anopheles; they had been led to examine for this on hearing of Low's original discovery.

In 1901 Low ⁽¹⁵⁾ while in the West Indies worked out afresh the development of Filaria bancrofti in different species of mosquitoes, using insects bred from larvae and dissecting these after infection, daily. He had the advantage of knowing the mosquitoes used and demonstrated the metamorphosed forms in the proboscis in 11 days. (This paper will be referred

to in detail later).

In 1902 Vincent in Trinidad⁽¹⁶⁾ did similar work, his dates for forms appearing in the proboscis being the 16th to the 19th days.

Since that time though nothing further of a striking nature has been discovered, several observers have repeated the older work again.

Lebrede⁽¹⁷⁾ in 1905 worked out the metamorphosis in Culex pipiens, Ashburn and Craig,⁽¹⁸⁾ in the Philippines, studied the development of what they believed to be a different species of filaria to Filaria bancrofti in Culex fatigans, and Fülleborn⁽¹⁹⁾ has given some interesting papers on the subject generally, one in particular 'Researches on human filaria and their carriage by mosquitoes' being of special value.

Other papers dealing with subjects such as the unequal distribution of filariasis, the different species so far known, the pathological role of the parasites in disease, the prophylaxis, &c., will be more suitably dealt with later throughout the text when these subjects are under discussion. The above summary only gives the chief landmarks in the history of the gradual evolution of our knowledge of this important branch of helminthology.

ZOOLOGICAL POSITION OF THE FILARIDAE.

The filariae belong to the Vermes or worms; group Nemathelminthes; class Nematodes; natural order Filaridae; genus *Filaria*. The adult members of the order are threadlike or like fine catgut, of considerable length, the males usually being smaller than the females. The vulva in the female always lies in the front part of the body. In the male the tail is often spirally rolled, the genital orifice often shows two long spicules protruding from it and there are a variable number of papillae in front of or behind the anus; pre anal or post anal papillae.

Braun⁽²⁰⁾ in his well known work 'Die thierischen parasiten des menschen' 3rd edition gives 19 species of filariae as having been met with in man. His list is as follows:-

- | | | |
|------|-----------------------------|-------------|
| (1) | <i>Filaria medinensis</i> | (Velsch) |
| (2) | <i>Filaria immitis</i> | Leidy. |
| (3) | <i>Filaria bancrofti</i> | Cobbold. |
| (4) | <i>Filaria diurna</i> | Manson. |
| (5) | <i>Filaria perstans</i> | Manson. |
| (6) | <i>Filaria demarquayi</i> | Manson. |
| (7) | <i>Filaria ozzardi</i> | Manson. |
| (8) | <i>Filaria magalhaesi</i> | Blanchard. |
| (9) | <i>Filaria loa</i> | Guyot. |
| (10) | <i>Filaria oculi humani</i> | V. Nordann. |
| (11) | <i>Filaria conjunctivae</i> | Add. |

(12) <i>Filaria restiformis</i>	Leidy.
(13) <i>Filaria hominis oris</i>	Leidy.
(14) <i>Filaria labialis</i>	Pane.
(15) <i>Filaria equina</i>	(Abildg)
(16) <i>Filaria romanorum-orientalis.</i>	Sarc.
(17) <i>Filaria volvulus.</i>	Leuckart.
(18) <i>Filaria kilimarae.</i>	Kolb.
(19) <i>Filaria sp.</i>	

A glance at this table shows that it is merely a tabulated list, the arrangement and grouping being poor. No attempt evidently has been made to classify the groups, animal ones which can only occur as the rarest accident in man being included and given a prominent place, while doubtful species in other instances will have to be removed. Provisionally one may split up the different members into one or two well defined groups as follows:-

- I. *Filariæ* inhabiting the subcutaneous tissues, embryos escaping externally or at least not into the blood.

Filaria medinensis (the guinea worm)
(embryos escape into water).

Filaria volvulus. (Life history of embryos unknown).

- II. *Filariæ* inhabiting the subcutaneous tissues, lymphatics, or mesenteric tissues, embryos escaping into the blood and living

there. Probably always removed from that site by suctorial insects.

Filaria bancrofti.

Filaria loa.

Filaria perstans.

Filaria demarquayi.

III. Filariae of animals inhabiting various sites, embryos in blood or not. Rare and merely accidental in man.

Filaria immitis (Dog) (Doubtful if ever found in man).

Filaria equina (Horse)

Filaria conjunctivae (Horses and asses)

IV. Filariae of doubtful import, found once or twice only, life history and other details unknown.

Filaria magalhaesi. (Found once in heart of child)

Filaria oculi humani. Syn. *F. lentis*. (Found 3 times in a cataract, once in man, twice in women).

Filaria restiformis. (Found once in the urethra of a man in Virginia)

Filaria hominis oris. (Found once only)

Filaria labialis. (Found once only, in a pustule on lip).

Filaria romanorum orientalis. (Found in the blood of a Roumanian)

Filaria kilimarae. (Found in the abdomen of a native in German East Africa).

Filaria powelli. (An embryonic form found once in the blood of a native in Bombay).

NOMENCLATURE AND SPECIES OF THE BLOOD
FILARIAE PROPER.

As already stated in the foreword it is only with filariae, whose embryonic or larval forms are found circulating in the blood, that we are concerned with in this thesis, that is with group II. of the provisional classification just given. Much confusion has arisen in the nomenclature of this group, chiefly owing to the fact that the embryonic and adult forms have received different names in some instances, and also to the fact that embryos have been named before their parents have been discovered or vice versa parents before their embryos. Recently a very good suggestion has been made, namely to call embryonic forms microfilariae, this indicating their microscopic character as compared with the macroscopic characters of the adults. Using such a terminology and adhering to the rules of zoological nomenclature we may therefore amplify the classification of group II. as follows:-

<u>Adult form.</u>	<u>Embryonic or larval form.</u>
I. <i>Filaria bancrofti</i> .	<i>Microfilaria bancrofti</i> .
	Synonyms:
	<i>Filaria sanguinis hominis</i> .
	<i>Filaria nocturna</i> .
	<i>Microfilaria nocturna</i> .
	<i>Filaria philippinensis</i> ?
II. <i>Filaria loa</i> .	<i>Microfilaria loa</i> .
	Synonyms:
	<i>Filaria diurna</i> .
	<i>Microfilaria diurna</i> .
III. <i>Filaria demarquayi</i> .	<i>Microfilaria demarquayi</i> .
IV. <i>Filaria perstans</i> .	<i>Microfilaria perstans</i> .

V. <i>Filaria magalhaesi</i> .	Unknown.
Unknown.	<i>Microfilaria ozzardi</i> ?
	<i>Microfilaria philippinensis</i> ?
	<i>Microfilaria powelli</i> .

FILARIA BANCROFTI.

i. Geographical distribution.

The geographical distribution of Filaria bancrofti is tropical, and, to a much lesser degree sub-tropical. Its habitat may be taken as lying between the latitudes of 30° N. and 30° S., that is to say in the hottest parts of the earth where the

mean temperature is 70° Fahr. or higher. It may however spread outside these limits, but the probability is that in places like Charleston in North America, Carthagena in Spain, and Brisbane in Australia it has been introduced by the sea route from the tropics, and finding a sufficiently high temperature at part of the year for its development in the mosquito, has remained and become indigenous there. Its distribution between the parallels mentioned has only been worked out irregularly here and there, but as far as it has gone it shows that it is an unequal one and subject to considerable variations even within comparatively short distances. At a recent meeting of the Society of Tropical Medicine and Hygiene of London I read a paper entitled 'The unequal distribution of filariasis in the tropics'⁽²¹⁾, and there I pointed out, from statistics collected by myself in the West Indies, British Guiana, East Africa, Uganda, and other places, how prevalent the parasite might be in one place, how moderate in numbers in another place, and how scanty or even absent in a third.

The determination of the prevalence and general distribution of this form of filariasis must always be a difficult and tedious one because of the fact that large numbers of people may harbour the Filaria bancrofti and yet show absolutely no signs of any

disease caused by it at the time of examination. The only way left then to arrive at a correct conclusion of how many individuals in any given district are infected is to make exhaustive blood examinations---in this case at night---of the population generally.

A group of islands like the West Indies is a very suitable place to conduct such experimental work for the reasons, that they are isolated from each other, that many of the inhabitants have never been out of them, that the population is not excessive and that as a rule there is one main town with several villages or townlets at other parts of the island. My plan of procedure in the work was as follows. On arrival at an island I enquired from the local medical men if clinical manifestations of filariasis (elephantiasis, lymph scrotum, chyluria, filarial lymphangitis, &c.) were common; then after looking for them myself---but of course without specially selecting them for my statistics---I took the night blood from as many of the general population as I could get, obtaining these from the streets, hospitals, prisons and almshouses, and trying as far as possible to take indigenous natives. Elephantiasis cases, though looked upon as filarial and being used as an undoubted guide to the prevalence of the disease in any given place, were

always kept in separate lists because it is extremely rare to find embryos in such cases, the pathological lesions being the late results of an infection years before. Out of the numbers examined a note was always made of how many showed signs of filarial disease or were infected---namely, those with symptoms with or without embryos in the blood, and those without symptoms but with embryos in the blood.

The results generally came out as follows: where there was much clinical filarial disease, (elephantiasis, lymph scrotum, varicose groin glands, chyluria, lymphangitis, &c.) then the percentage of ordinary apparently healthy people with embryos in their blood was high, where there was little disease then the percentage was low. Testing some of the different islands and British Guiana on the mainland of South America⁰ in this way, all with the exception of the latter and Barbados resembling each other physically, and all with no exceptions teeming with the proper intermediate host for F. bancrofti---Culex fatigans---the inequality of distribution will be seen to be very marked falling in one of the islands Granada to practically nil.

The following are the detailed results in order of frequency:-

St. Kitts.---Blood of 143 cases examined by

38
 night; 47 infected = 32.8 per cent.: with symptoms 9, without 48. White people of the best class: 23 examined, 7 infected = 30.4 per cent.; with symptoms 3, without 4. Elephantiasis cases: 14 examined, embryos present in 3.

British Guiana.---Blood of 150 cases examined by night; 25 infected = 16.6 per cent.; with symptoms 5, without 20. Race characteristics: general population of hospital, negroes, coloured, Portuguese, and whites; 100 examined, 22 infected = 22 per cent.; with symptoms 5, without 17. Coolies (East Indians), 50 examined; 3 infected = 6 per cent.; with symptoms nil, without 3. Elephantiasis cases: 15 examined, embryos present in 1.

Barbados.---Blood of 600 cases examined by night; 76 infected = 12.66 per cent.; with symptoms 27, without 49. Race characteristics: Negroes 401 examined 44 infected, mulattos 160 examined 18 infected, whites 39 examined 14 infected. Elephantiasis cases: 10 examined, embryos present in the blood of none.

Trinidad.---Blood of 400 cases examined by night; 43 infected = 10.75 per cent.; with symptoms 19, without 24. Elephantiasis cases: 23 examined embryos present in none.

Dominica.---Blood of 144 cases examined by

night; 11 infected = 7.63 per cent.; with symptoms 2 without 9. Elephantiasis cases: 2 examined embryos present in neither.

St. Lucia.---Blood of 356 cases examined by night; 27 infected = 7.58 per cent. Elephantiasis cases: 5 examined, embryos present in none.

St. Vincent.---Blood of 100 cases examined by night; 6 infected = 6 per cent. Elephantiasis cases: 2 examined, embryos present in neither.

Grenada.---Blood of 174 cases examined by night: none infected = 0 per cent. I saw however one case suffering from varicose groin glands and elephantiasis, and as he had never been out of the island all his life, it shows that the infection though excessively scanty does and can exist.

Carriacou (A Grenadine).---Blood of 28 cases examined by night; 1 infected, but this individual was born and had lived in St. Kitts, only having been in Carriacou one year, so deleting him we get a percentage of 0 again.

Passing to other parts of the world I found in the Swahilis (coast natives) of Mombasa, British East Africa, 13 out of 50 cases examined infected that equalling 26 per cent. In Uganda far up in the interior it is practically non-existent amongst the indigenous tribes as I only found it, out of many

examinations, in one Waganda. In Nubians from the Nile it was present in 2 per cent. Amongst the Masai, the warlike tribe of the highlands of British East Africa, no clinical signs of filarial disease were present and one is justified in concluding from that, that it does not occur there. In Zanzibar, an island off the East Coast of Africa, there were plenty of cases with definite symptoms, elephantiasis, &c., and though unable to examine bloods there, it is evidently fairly prevalent, this assumption being borne out by the fact that bancrofti embryos were fairly common in the blood of natives of Zanzibar examined by myself in the Seamen's hospital in London. I have also met with the infection in the latter place quite commonly amongst Goanese, much less so amongst Punjabis and other natives of India, indicating that amongst them it is less frequent. Manson in his book on 'Tropical Diseases' ⁽²²⁾ gives further figures. He states 10 per cent. harbour the parasite in South China, that one third of the inhabitants of Cochin have it, that in the Friendly Islands Thorpe found it in 32 per cent., and that it is said to be abundant in Samoa, Madras, and West Africa. Sandwith ⁽²³⁾ states that Dr. Hayward out of 400 blood examinations of patients in the Kasr-el-Ainy hospital at Cairo found it in 15 per cent., and

other figures or statements as to its prevalence in different parts of the world are from time to time seen.

Enough has been said now to show that this form of filariasis is world wide in its distribution and that it is exceedingly prevalent in different tropical places. As it is frequently associated with pathological conditions, most of which are quite incurable, its importance as one of the tropical diseases cannot be overestimated, and this especially so when it is considered that it is a preventable disease.

ii. Life history and biology.

The life history of Filaria bancrofti may be divided into an intra corporeal or human phase and an extra corporeal or insect phase. The former of these is represented by the adult or fully mature worms in the lymphatics; the embryos, young, or larval forms circulating in the blood stream; and by the metamorphosed forms from the time they are introduced by the proboscis of the mosquito till they become mature adults. The latter is represented by the metamorphosis or development of the young forms (embryos), sucked out of the human blood, in the thoracic tissues of the mosquito.

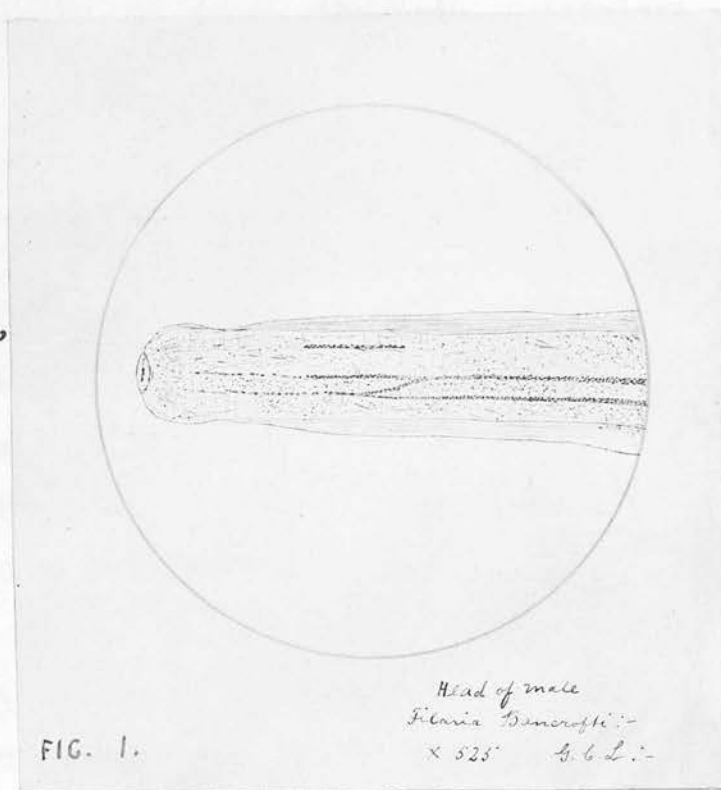
Intra corporeal or human stage. The adults

inhabit some part or other of the lymphatic system, the thoracic duct for example, the large abdominal or pelvic lymphatics, the lymphatics of the arms or legs or smaller ones elsewhere. Fine catgut best describes their appearance and of course they are macroscopic objects being quite visible to the naked eye. They are bisexual (males and females) the latter giving birth to living embryos (viviparous) and not depositing eggs. Unless one has had experience they are by no means easy to find at the autopsy even though one knows the cadaver was infected during life. I conducted a post-mortem in the West Indies once on a negro who had a small infection of embryos during life but though searching very carefully and examining the main lymphatic trunks, which as far as I could make out showed no signs of dilatation or disease, I could not find the adults. Vide (examinations for adult filaria perstans when infection is small later).

Adults however have been fairly often found and have been accurately described. Not having made any detailed study of this form, apart from a general study of the types in the museum of the London School of Tropical Medicine, and as it has been fully described in works of helminthology and tropical medicine, a synopsis of its anatomical features and measurements will be sufficient for here.

Measurements. Female. 3 to 4 inches long by $1/90$ to $1/125$ of an inch broad. (76 - 100 mm. by .288 to .211 mm.). Male $2\frac{1}{2}$ to 3 inches long, breadth less than above .1 mm., finer and smaller generally than female.

Structural Anatomy. Head club shaped. (Fig. 1.) Oral aperture simple, circular, no papillae. Head joined to body by a thin neck $\frac{1}{8}$ the thickness of latter (Fig. 2). Tail blunt, circular, not bulbous. Body cavity enclosed by a longitudinal layer of muscle fibres covered by a smooth cuticle with no



striae. Alimentary canal simple ending at anus which is situated near tip of tail (.225 mm. from tip).

Female. Vagina opens anteriorly 0.710 mm. behind head (Daniels), passing backwards the vagina

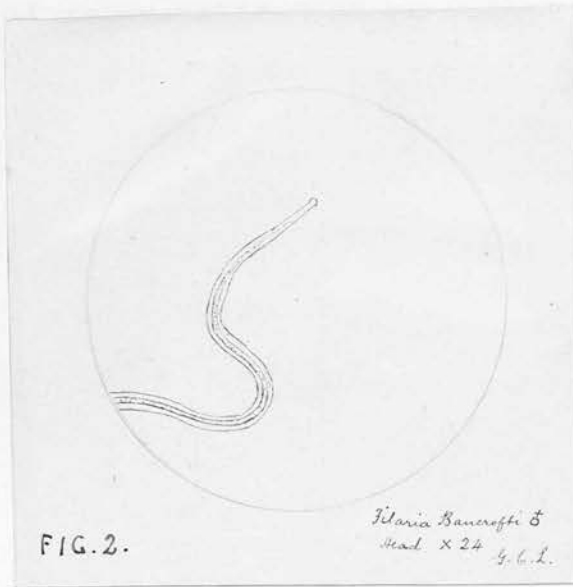


FIG. 2.

Filaria Bancrofti ♀
Head X 24 G.C.L.

leads to the double uterine tubes which in turn extend backwards completely filling the whole of the posterior part of the body. Posteriorly these tubes are seen to be packed with eggs containing embryos in all stages

of development, anteriorly the embryos have emerged and take the place of the eggs. When ready these escape via the vagina into the lymph and so eventually reach the blood stream of their host. The ova measure .050 of a mm. in length by .033 of a mm. in breadth.

Male. In the male the tail is curved, testicles take the place of the uterine tubes in the female, and from the anal orifice protrude two unequal spicules (0.2 and 0.6 mm. long according to Braun). Anal papillae are usually said to be present, Braun stating that there are three small pairs of pre anal ones and also post anal ones. Personally I have been unable to satisfy myself from the material examined that these papillae do exist, though from

analogy with the adults of some of the other species it is probable.

The embryos. The embryos are found in the circulating blood; they may also be demonstrated in the urine in cases of chyluria or in the lymph or chylous fluid aspirated from varicose groin glands. As seen alive and in a fresh condition they exactly resemble miniature snakes or little eels; but though actively wriggling about they do not progress over the slide or as it is termed they do not locomote. The reason of this would seem to be because of a loose bag or sheath in which they are enclosed.

Fig. 3. In order to properly study the different anatomical features of the embryos various technical details must be

carefully observed in preparing the

specimens. Technique

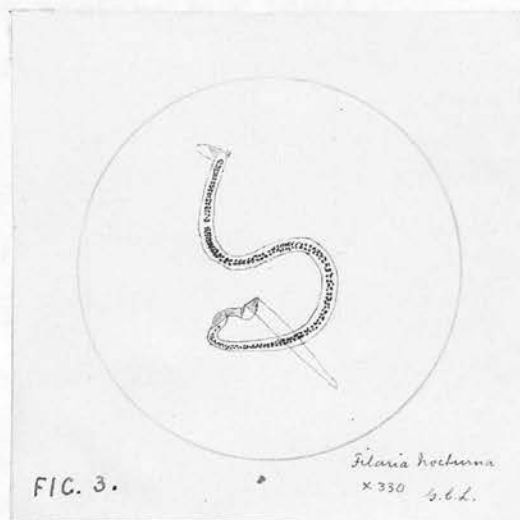
for the study of the anatomy of embryos in

the blood and other

fluids and for their

development in the

mosquito.



(1) Fresh specimens. A suitable case with a good infection of embryos having been found a large drop of blood is taken any time after 9 p.m. and

simply covered with an ordinary slip. Examine with low power of microscope ($\frac{1}{8}$ "). Embryos are easily seen coiling and uncoiling amongst the corpuscles. Ring with vaselin and examine next morning when movement will have slowed down considerably. High power objectives are required and ecdysis or escape of the embryo from its sheath can also be followed.

(2) Stained specimens (Manson's method). A totally different film to that required for malaria, spirochaetosis, or typanosomiasis is necessary; the parasites are microscopically large and they are not so numerous, so in ordinary films they might easily be missed. Manson to obviate this advised a large quantity of blood being taken and then got rid of the red corpuscles by washing out their haemoglobin in water; the white corpuscles and any filaria are left behind in the residue and adhere to the slide. A suitable case is bled then, 3, 4 or more large drops of blood are placed in the middle of a slide, spread out with a needle, and allowed to dry. The subsequent examination may be conducted at once or deferred for a day or even a month.

- (1) Place the film in water till all the haemoglobin comes out.
- (2) Dry in air or over lamp.
- (3) Fix in alcohol and ether equal parts 5 to 10 min.
- (4) Dry.

- (5) Stain with good well matured haematoxylin. (Ehrlich's, Delafield's or haemalum may be used).
- (6) Place in water 5 minutes.
- (7) Dry and mount in Canada balsam.

Nuclear column of the filariae, nuclei of the white corpuscles, &c., will be stained purple blue.

Without doubt the haematoxylin specimens are the best. I have tried many other stains, Romanowsky's included, but have never satisfied myself that they are so good.

Technique for the study of the development of the embryos in the mosquito.

(1) Fresh dissections. Suitably infected mosquitoes are serially dissected every day. All the apparatus required is some normal saline solution and a couple of needles. Separate proboscis from head, head from thorax, thorax from abdomen; and dissect these out in the saline on different slides. Cover with a cover glass, and examine first with low power then with high power under the microscope. The growth and development of the different anatomical points can easily be followed out by this method.

(2) Sections. The method I adopted for cutting sections of the mosquitoes sent by Bancroft to the London School of Tropical Medicine was based

on a technique devised by a Mr. Colquhoun and also on the celloidin methods I learnt in Vienna. The mosquitoes came in glycerine from Australia and I followed Mr. Colquhoun's plan of soaking them in 5% acetic acid to remove this. Later I found out that it is much better not to use glycerine at all but simply to drop the mosquito when alive into 60% alcohol. It struggles and inspires and this draws the alcohol into its tissues and thus ensures proper hardening. If the insect is allowed to die normally, the juices in its body quickly dry up and in a few hours it is so dry that it is useless attempting to cut sections of it later. Tabulated the procedure of hardening and sectioning is as follows.

- (1) Alcohol 60% 5 days. (The living insect to be dropped into this.)
- (2) Alcohol 95% 1 day.
- (3) Alcohol absolute 1 day.
- (4) Alcohol absolute and Ether = parts
1 day.
- (5) Thin celloidin 1 day.
- (6) Thick celloidin 1 day.

Next build up a platform of thick celloidin on a wooden block; as this solidifies lay mosquito horizontally on the top (taking care it remains horizontal and does not sink in the celloidin), cover with more celloidin, and drop into 60% alcohol.

Next day the sections may be cut the best microtome for use being the "Yung" Heidelberg. About 20 sections will be got off each mosquito and these must all be examined carefully. On leaving the knife of the microtome they are placed in 60% alcohol and may be stored in this for days or weeks till required for staining.

To stain:-

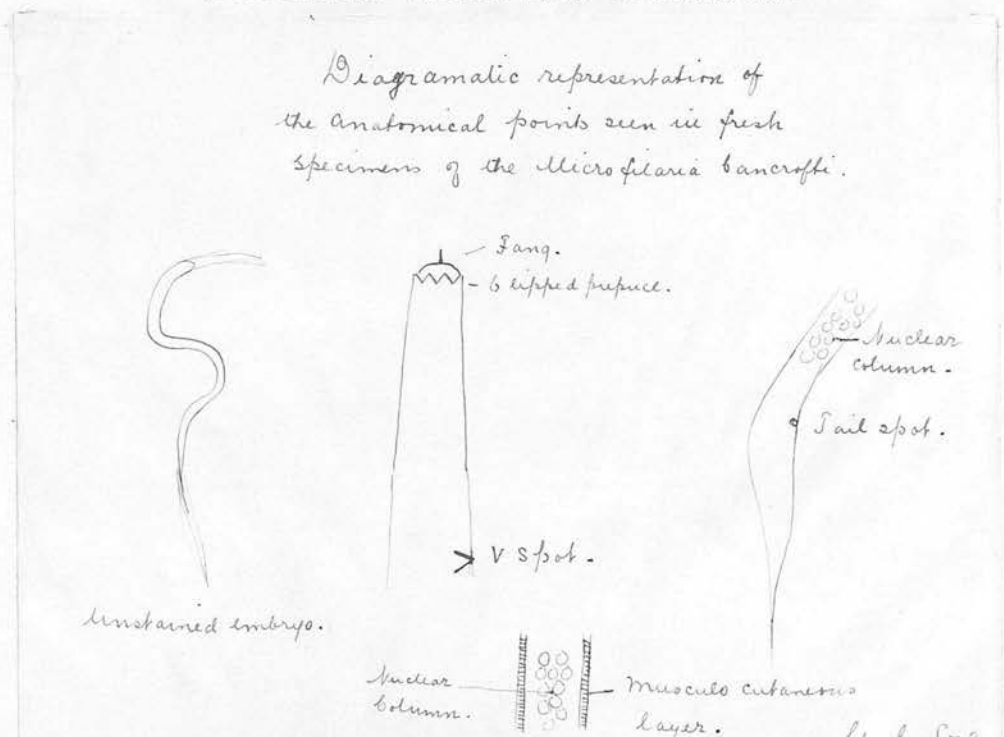
- (1) Pass the sections from the 60% alcohol into water.
- (2) Place in Mayer's haemalum 5 to 20 minutes e.g. overstain.
- (3) Decolourise in acid alcohol till on placing back in water the section is a moderate purple colour. (Only experience will tell the best colour.)
Acid alcohol = Concentrated HCl 1 + 70% alcohol 100 CC.
- (4) Alcohol 60% a few seconds.
- (5) Alcohol 95% ditto.
- (6) Carbol xylol till clear.
- (7) Blot firmly with filter paper.
- (8) Mount in Canada balsam.

The staining and dehydrating should be done in watch glasses, a section lifter being employed to lift the section from one to the other. When in carbol xylol the sections may be examined with a low power of the microscope and if no filariae are seen the subsequent mounting may be dispensed with, the sections being rejected. There must be no milkiness or opacity in the sections when taken out of the carbol

xylol to be placed on the slide, if there has been when first placed in it soon disappears. Wonderfully constant and beautiful results are got by this method as the micro photographs of my sections show.

Anatomy of the embryos. This must be studied in fresh and stained specimens as certain features are brought out by the former, certain by the latter. In fresh specimens the following points may be made out.

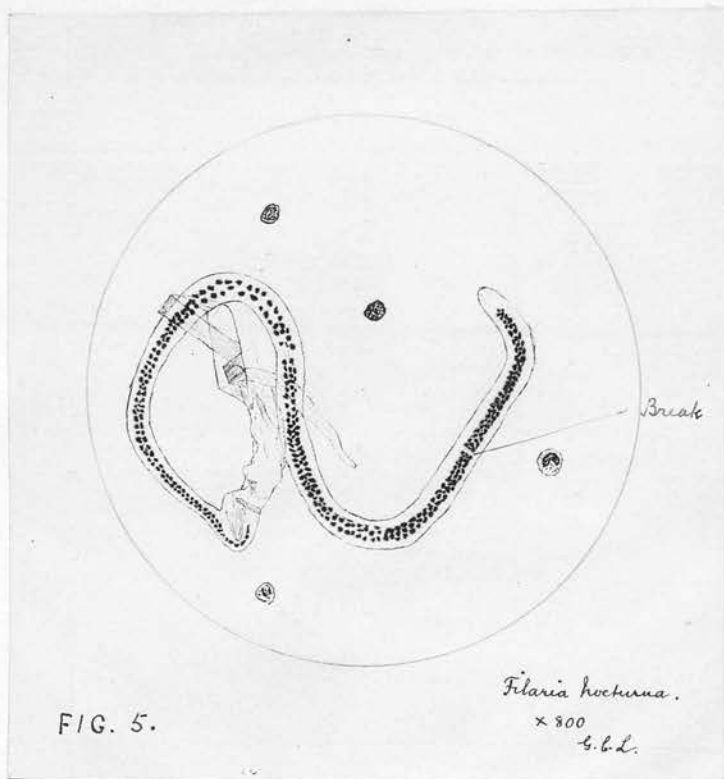
- (1) The sheath, a delicate transparent membrane which encloses the embryo, somewhat difficult to see unstained.
- (2) The cephalic armature, consisting of a 6 lipped prepuce and a small spine which may be seen alternately protruded and retracted.
- (3) The V spot, a structure exactly like a V.
- (4) The tail spot.
- (5) The central nuclear column of cells.
- (6) The musculo-cutaneous layer which shows a delicate transverse striation.

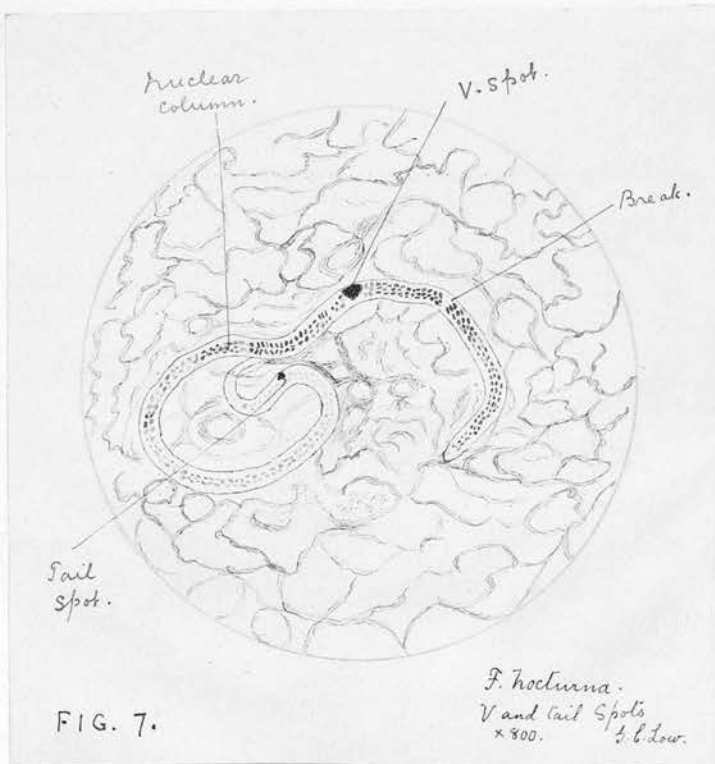
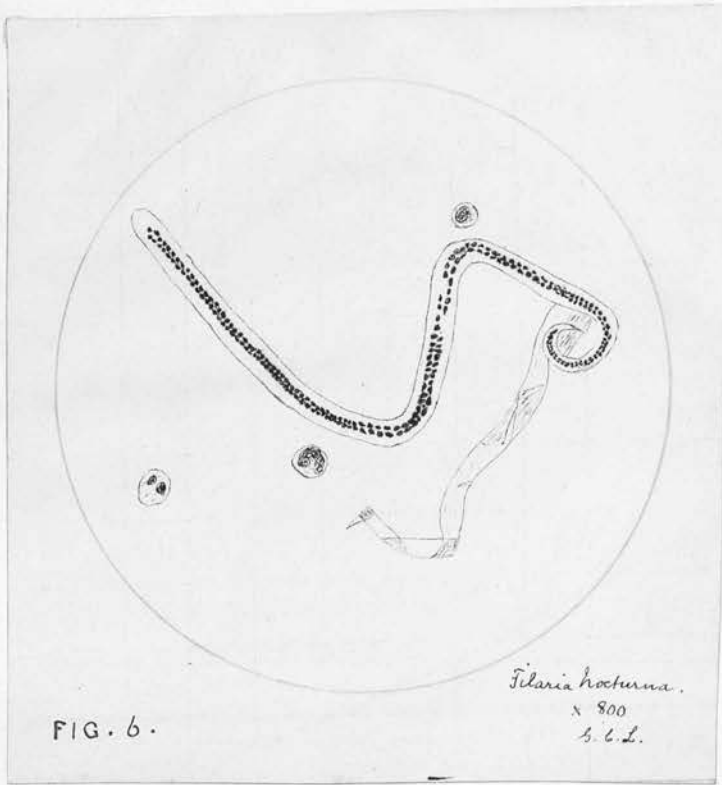


In stained specimens (haematoxylin) the following points may be made out.

- (1) The sheath, now very distinct, stained a faint purple.
- (2) The central nuclear column of cells, also very distinct, stained dark purple. Figs. 5 and 6.
- (3) The break in the continuity of the cells.

The V spot is not usually visible in ordinary haematoxylin stained specimens, to bring it out is difficult, weaker stains being better, but when one succeeds it is very definite, vide diagram 7.





At one time the break in the continuity of the cells was confused with the V spot but by making a series of careful measurements I was able to point out to Manson⁽²⁴⁾ in 1900 that they were different, the break being anterior to the V spot. Fig. 7. The following are the original measurements (hitherto unpublished) by which this conclusion was reached. Fig. 8. Table.

TABLE.

Break in ordinary stained specimens. 10 examined.

1.	.056	mm	from head.
2	.048	"	" "
3	.052	"	" "
4	.052	"	" "
5	.052	"	" "
6	.052	"	" "
7	.050	"	" "
8	.052	"	" "
9	.048	"	" "
10	.048	"	" "

Measurements in living specimens.

Breadth at V spot = 0.075 mm.
 Depth of V spot $1.5\mu = \frac{1}{5}$ of breadth
 V Spot from head = 0.090 mm -
 Tail spot = 0.50 mm from tip of tail. Long 1 μ or under.
 Total length of this individual worms = 3.17 mm -

FIG. 8.

Measurements of V. tail spot and break.
 as studied in 25 stained specimens -

V spot from head. Break from head. Tail spot p. tail.

1	.080. mm	Doubtful.	.048 mm
2	.080.	.050 mm.	nil
3	.075	.050 "	.040 "
4	.080	.050 "	nil
5	.074	.055 "	doubtful
6	.070	.047 "	.040 "
7	.080	.045 "	nil.
8	.080	.050 "	nil.
9	.080	.050 "	doubtful.
10	.080	Doubtful.	nil
11	.077	no break	.048 "
12	nil.	nil.	"
13	.080	.050 "	Doubtful
14	.075	.045 "	nil
15	nil	.050 "	nil
16	.085	.055 "	.040 "
17	.085	nil.	nil
18	nil	.055 "	nil
19	nil	.055 "	nil
20	.080	nil	nil
21	.075	nil.	nil
22	.080	.050 "	.040 "
23	.075	.050 "	nil
24	.077	.052 "	nil
25	.080	.047 "	nil
		.055 "	.040.

Exactly what some of these anatomical points mean is yet doubtful. As will be seen later some of the embryos of the other species of filariae have no sheath and such locomote easily and quickly amongst the blood corpuscles on the slide. Why this individual one should be muzzled, so to speak, is not clear, but this much is certain that the first thing it does on arriving in the stomach of the mosquito is to escape from its sheath; the fang no doubt then is used for piercing the muscular wall and by the passage so made the embryo passes through and makes its way to the muscles.

Various interpretations have been given to the peculiar V shaped structure (the V spot). It has been supposed that it represents the rudimentary opening of the vagina and its position would be right for this, but then it is met with in all embryos alike, and as some of these at least must be males this explanation cannot hold. Whatever it is, it disappears altogether as the metamorphosis of the embryo goes on in the mosquito, and our present knowledge of its function or nature is therefore only conjectural.

The same may be said of the break in the continuity of the cells; this being a constant feature evidently indicates something but what that may be we do not know. It is not the same structure

nor apparently in any way connected with the V spot as I have shown above; it lies nearer the head. The tail spot possibly represents the rudimentary anus, a structure which becomes very distinct as growth progresses in the mosquito. The nuclear column of cells are the primitive or embryonic matrix from which the cells of the musculo cutaneous layer of the adult are formed and also the cells of **the** rudimentary intestine (see later).

Measurements of the embryos. These are of special importance when used for comparison with other species. The embryos have often been measured by different people and their length is usually given as 1/90 of an inch, their breadth that of a red blood corpuscle 7.5 μ . In measuring any embryo, where possible only living or just killed specimens should be employed, as if dried and stained shrinkage must of course take place. The usual trouble is to get the parasite to uncoil and lie out straight, but this may be overcome to a certain extent by poisoning them with chloroform or ether (invert drop of blood on slide before applying cover slip over a watch glass of chloroform or ether, then drop on slip and examine. I have measured large numbers of embryos of Filaria bancrofti at different times and places and the following are my results. Living specimens.

Length. .280 to .320 mm. average .310 mm.

Breadth. .0073 to .0084 mm. average .0075 mm.
(7.5 μ).

V spot from head .090 mm.

Breadth at V spot .0075 mm. depth of V 1.5 μ
= 1/5 of breadth.

Tail spot .050 mm. from tip of tail.

Fang 1 μ or under.

Break in continuity of cells, which is only demonstrable in stained specimens, average .050 mm. from head e.g. anterior to V spot.

Type of embryo sheathed with sharp pointed tail.

Other points of interest in the intracorporeal or human cycle of the embryos.

Ecdysis or escape of the embryo from its sheath is really the first stage in the extra corporeal cycle of the parasite, but as it may be followed in ordinary fresh films under the microscope, in a similar manner to the flagellation of the crescent in malaria, it may be considered here and then referred to later. Ordinary fresh films, fairly thick, are the best to use and after being made they are kept over night at room temperature till next day. A careful examination of the edges of these, where the blood has become laked, may show embryos, and if so, one of these should be selected and with an oil immersion lens should be watched for half an hour or

longer. If fortunate, the embryo will be seen to butt or thrust its head forcibly up against the cephalic end of its sheath and after repeatedly doing this--- the laked condition of the blood appears to fix and steady the sheath---a rupture occurs and the head escapes. Still struggling violently the worm passes forward and gradually more and more of it comes out till at last it is free with its cast off membrane behind it. Its movements change immediately now; instead of being moored or fixed in one place it passes actively amongst the blood corpuscles (locomotes) and soon reaches the edge of the slide where with others it collects.

Periodicity. The term periodicity is applied to the peculiar habit of the microfilariae bancrofti in only appearing in the peripheral blood by night. Manson, as long ago as 1879, first discovered this peculiar phenomenon and showed that if the finger blood were examined every 3 hours for a period of 2 or 3 days what happened was as follows. The day blood will exhibit no filariae or only perhaps one odd one here and there, but as evening approaches embryos gradually begin to appear till at midnight they may be literally swarming. Again as morning reappears they (the embryos) as gradually disappear till by 9 a.m. they are gone and the blood is free.

It is useless therefore examining the population of districts or single individuals for this parasite by day, to ensure success the examinations should preferably be conducted as near midnight as possible. The first stragglers generally appear somewhere about 6 p.m. and then as the hours go on more and more arrive so that from 9 to 10 p.m. there are plenty present for making a diagnosis, and this will save one many a weary wait till the later hours. The disappearance is generally complete by 9 or 10 a.m., earlier hours such as 6 a.m. showing stragglers or a scanty invasion only. For complete charting of the periodicity in any given case similar measured quantities of blood must be taken every 3 hours (stained films are much more accurate than wet) suitably stained, the filariae carefully numbered and records kept. The night nurse, after suitable training, may by this method take the early morning ones.

What happens to the embryos when they leave the peripheral blood in the morning was first demonstrated by Manson in London in the case of a patient in Charing Cross Hospital the subject of lymph scrotum and varicose groin glands who committed suicide one morning---8.30 a.m.---by taking hydrocyanic acid. During life there had been a

heavy infection of embryos present nightly in the blood, so that death occurring at 8.30 a.m., an hour as has just been shown, when ~~its~~ ^{the} disappearance for the day is complete, these manifestly must have retired to their abode for the day. Blood was expressed from the different organs and large vessels, slides made, and any filariae found in these enumerated, the result indicating that the lungs and large thoracic vessels are the situations chiefly selected for the diurnal repose. The following is Manson's table giving the enumeration of filariae in a drop of blood expressed from the following organs.

Organ.	No. of Slides	Aggregate No. of filariae	Average per slide.
Liver.	3	2	2/3
Spleen.	3	3	1
Brachial venae comites.	4	111	28
Bone marrow.	1	0	0
Muscle of heart	3	365	122
Carotid artery	1	612	612
Lung.	10	6751	675

So far as I am aware no confirmation of this appeared---due probably to the difficulty of getting suitable autopsies---until I published the report of

the post-mortem notes of a Filarial Case in the Journal of Tropical Medicine in 1902.⁽²⁵⁾ The autopsy was obtained on a man---a negro---in Barbados who during life had a very few embryos in his peripheral blood by night. He had never suffered from any filarial symptoms, but was the subject of a sarcoma of the humerus which eventually caused his death, the latter event taking place one morning at 10 a.m.

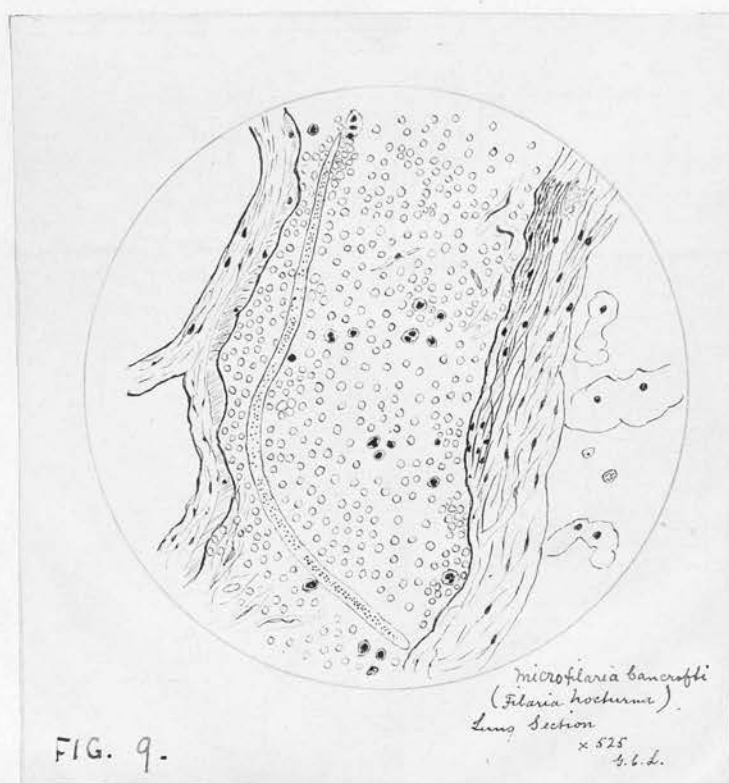
No adult worms were found, though a prolonged and careful search was made; the thoracic duct was healthy and free as were also the pelvic lymphatics, and there were no signs of any dilatation or varicosity in any other lymphatics. The fact of there being so few embryos in the peripheral blood pointed of course to only one or two adult worms and these of course may have been in any of the lymphatics of the limbs. Drops of blood were taken from the various organs in a similar manner to that adopted by Manson in London in his case and the results were as follows.

Organ.	No. of Slides	Aggregate No. of filariae	Average per slide.
Lung.	4	65	16.2
Liver.	4	0	0
Spleen.	4	0	0
Kidney.	4	0	0
Pancreas.	4	0	0
Heart muscle R. side	4	0	0
Heart muscle L. side	4	0	0
Inferior vena cava.	4	0	0
Aorta.	4	0	0

No embryos will be seen were found except in the blood from the lungs and this is in all probability their special seat of selection by day, other neighbouring vessels and organs being inhabited as well when the infection is a large one and the embryos very numerous.

Sections of the different viscera were also made in Manson's original case and the lung again easily came out first. The method by sections is not so accurate as that of the examination of stained films because it is very seldom that one gets the filariae

completely stretched out in the plane of the section. Again they appear much smaller than in an ordinary dehaemoglobinised film from the blood, the hardening of the tissues causing a certain degree of shrinkage. The following sketch and photographs, with the exception of the filaria in the washed out film, are from sections of material from Manson's case.



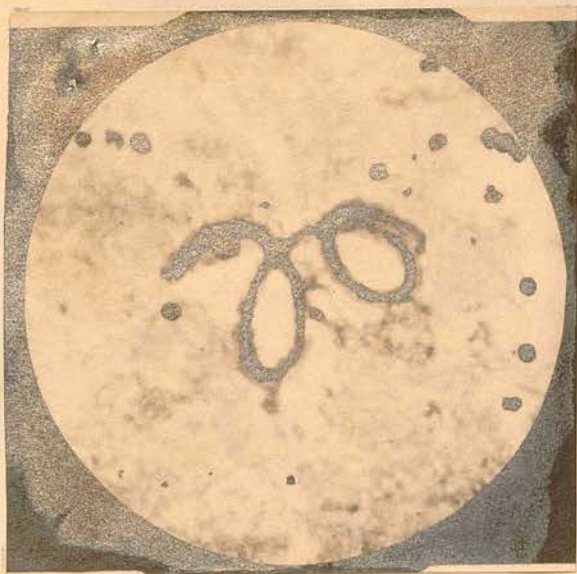


Fig. 10. *Microfilaria bancrofti* in dehaemoglobinised blood film $\times 375$.



Fig. 11. *Microfilaria bancrofti* in capillary of brain (section) $\times 160$.



Fig. 12. *Microfilaria bancrofti* in small vessel of lung (section) $\times 160$.

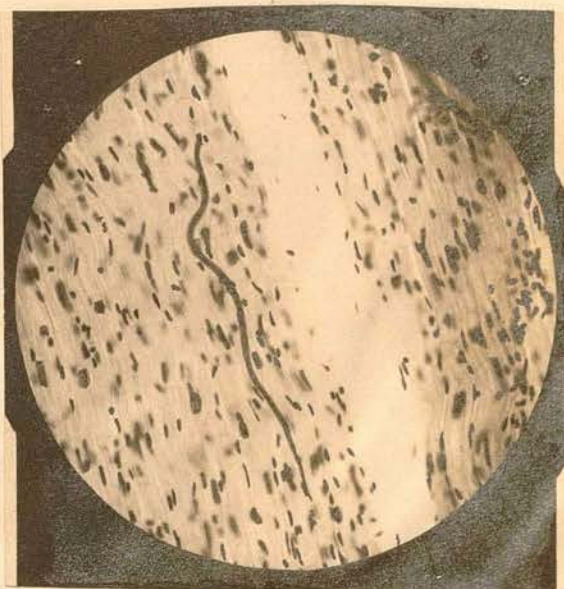


Fig. 13. *Microfilaria bancrofti* in capillary of heart muscle (section) $\times 160$.

Reversal or alternation of periodicity.

Mackenzie⁽²⁶⁾ while studying the question of periodicity in a filarial case in London found out a further peculiar fact, namely that if a filarial subject be made to sleep during the day and sit up and move about during the night then the embryos appear by day and disappear by night. This goes on constantly while such habits are kept up, but at once reverts to the old status when normal habits are restored. The periodicity can also be rendered irregular by making the individual sleep say for two or three hours, remain awake for the same period of time, and then sleep again, and so on.

Explanations of periodicity. Many explanations have been given from time to time of this peculiar feature in the life history of the embryos of Filaria bancrofti. Scheube⁽²⁷⁾ gives a summary of some of the more important in his book 'The diseases of warm climates' and a few may be mentioned here. Manson's original view was that the embryo filaria had adapted itself to the nocturnal habits of its intermediate host, but as I once pointed out this seems improbable because in the case of the embryos of the Filaria immitis, one of the dog filariae, there is no definite periodicity---embryos present in peripheral blood by day as well as night---and yet their intermediate host is Culex fatigans or in

Italy Anopheles maculipennis, both nocturnal feeders. Lancereaux⁽²⁸⁾ believed that light might exercise some influence. A patient shut up in a dark room all day still did not show embryos in his blood. Another idea is that the nightly circulation of the embryos in the blood is caused by the periodical daily deposit of them by the adult females and Scheube propounds a view that by the absolute rest of sleep favourable conditions are afforded to the embryos to pass along the lymphatics and so gain the circulation. This view is easily destroyed. Firstly one has to prove the contention put forward which would be difficult, and secondly one would have to presuppose that all these embryos would have to be destroyed---which they are not as we know they are found in the lungs by day---as otherwise on the following night there would be twice the number of the first and on the third night, three times the number and so on, a phenomenon which never appears.

The extraordinary thing is how constant the number of embryos remain night after night when accurately counted. Still there must be a death rate amongst them in the blood vessels somehow or somewhere as otherwise their numbers would go on increasing and clog the blood corpuscles. How and where this takes place is unknown; probably the leucocytes attack them and eat them.

According to V. Linstow⁽²⁹⁾ the nocturnal appearance of the embryos in the blood is connected with sleep, the cutaneous vessels according to him being dilated during sleep, contracted while awake. There is no proof of this so far as I am aware, and further as Manson has already pointed out the embryos begin to appear in the evenings long before the time of sleep and persist in the morning long after the person is awake. Myers⁽³⁰⁾ believes the blood contains more oxygen at night and that this is the factor that draws them there; against that one might suggest that they would get it fresher and more direct by staying in the lungs themselves. More recently Manson has suggested that the periodicity might be due to some physiological product of metabolism that forms during the waking hours and which during the day drives the embryos from the peripheral vessels into the inner organs. This is purely theoretical and has nothing special in its favour. The fact is we do not know what is the proper explanation of this extraordinary phenomenon.

From time to time, especially when one is examining large numbers of bloods for this parasite, one comes across embryos in day blood quite identical with the microfilaria bancrofti. Thorpe⁽³¹⁾ has had this experience in the Friendly Islands and I along

with others have from time to time met with it in different parts of the world.

An explanation of such a phenomenon is not altogether easy.

The young adults. A stage in the life history of the Filaria bancrofti about which nothing is known is that of the metamorphosed embryo on its return to the human host. As it is inoculated by the mosquito this young adult measures $\frac{1}{16}$ of an inch. It manifestly finds its way to the nearest lymphatic trunk and proceeds to grow, the sexes later become differentiated and then the stage of the ordinary adult is entered upon. How long it requires for this gigantic increase in size $\frac{1}{16}$ of an inch to 2 or 3 inches in length to take place is entirely unknown, by analogy it would probably be months, 5 or 6 say. The only possible way it seems that one could settle the question would be the noting how soon embryos appeared in a given individual after coming to reside in a filarial country. Still even this would be inaccurate as firstly he might not be infected for months or even years after arrival, and secondly he might be lucky enough not to become infected at all.

Analogical experiments on dogs have been done and are comparatively easy of accomplishment. Infected mosquitoes can be fed on young dogs (puppies) protected carefully against other mosquitoes and insects, and then can be killed from time to time and their hearts examined to see if adult worms are present there. (The adult filaria immitis lives in the right ventricle of the dog's heart.)

The description then of these young adults or metamorphosed forms concludes the intra corporeal or human stages of the Filaria bancrofti. Recapitulating those we have:-

- (1) The adults living in the lymphatics.
- (2) The embryos living in the blood.
- (3) The metamorphosed embryos, inoculated into the subcutaneous tissues, and as far as we know quickly passing to the lymphatics and also living there.

We pass next to the extra corporeal or mosquito phase of the parasite.

THE EXTRA CORPOREAL OR MOSQUITO STAGE OF
FILARIA BANCROFTI.

Naturally, every blood-sucking insect that imbibes the blood of a filarial patient at night must necessarily take up embryos into its stomach in large numbers. Though this is true yet the majority of such insects do not act as efficient hosts; i.e. they are incapable of allowing of the development of the filariae in their tissues; as the blood in their stomachs is digested so are the parasites and thus they entirely disappear. A second class may be termed partially efficient, in their case the embryos not only migrating from the blood contained in the stomach to the thoracic muscles, but even undergoing a slight development, which is, however, slow and ends in nothing, death and absorption eventually taking place. The next or third class are the completely efficient hosts, as in them the complete metamorphosis of the filariae can take place and eventually they are capable of re-infecting man. Several genera of mosquitoes as far as our present knowledge goes comes under this category.

Tabulating this then we have for Filaria bancrofti:

- (1) Non efficient hosts. Fleas, bugs,
Lice, many mosquitoes and
biting flies.
- (2) Partially efficient hosts.
Stegomyia calopus (fasciata).

(3) Efficient hosts. Culex fatigans
(chiefly), anophelines, &c.

(1) Little need be said of the non efficient hosts. Fleas, bugs, lice, ticks, biting flies other than mosquitoes, ---tsetse flies, stomoxys, tabanidae--- many genera and species of mosquito, midges, &c., are all perfectly harmless as regards carrying the embryonic forms of Filaria bancrofti. Some of these may, however, act in other instances, as for example one of the dog filariae F. recondita undergoes its metamorphosis in the dog flea (the ctenocephalus canis), Filaria perstans probably in a tick (the ornithodoros moubata), and so on.

(2) The second class, the partially efficient host, is a curious one. I have invented this name as best describing what occurs, for example, with the embryos of Filaria bancrofti in Stegomyia calopus (fasciata), and also with the embryos of Filaria demarquayi in the same mosquito (see description of the development of the Microfilaria bancrofti in different mosquitoes later).

(3) Efficient hosts. As has just been stated several genera of mosquitoes may act as efficient hosts for the parasite under discussion, the definition of an efficient host being one, in which the complete metamorphosis of the parasite takes place in the thoracic muscles, the forms, on the

completion of this, passing into the proboscis and lying there till---on the mosquito re-biting---they are inoculated back again into man.

Manson (Loc. cit.) found the small brown house mosquito of Amoy China, called by him Culex pipiens, but which in all probability was the common Culex fatigans, efficient; Bancroft,⁽³²⁾ junr., in Australia, found Culex ciliaris, the common house mosquito of these parts to be the same; James in Travancore⁽³³⁾ found Myzomyia rosii (Anopheles rosii); the second expedition of the Liverpool School of Tropical Medicine to the West Coast of Africa⁽³⁴⁾ Pyretophorus costalis (Anopheles costalis); Daniels⁽³⁵⁾ in Central Africa Mansonia africanus (Panoplites africanus); while working in the West Indies myself⁽³⁶⁾ I found Culex fatigans and Cellia argyrotarsis and Albipes (Anopheles argyrotarsis).

Of these, the embryos were not actually seen in the proboscis in two instances, namely by Daniels in Mansonia africana and by myself in Cellia argyrotarsis, but as almost completely mature forms were seen in the thoracic muscles it is quite likely that both these genera may act. It is thus evident that the embryos of Filaria bancrofti may develop either in Culex or in some of the Anophelines, but certainly for the West Indies the former is by far the commoner host and is the chief carrier, and this very likely applies

for other parts of the world as well.

Though my first work---namely that which eventuated in the discovery of the metamorphosed embryos in the proboscis of the mosquito---was done by sectioning preserved mosquitoes, I intend to give the later researches on living material done by myself in St. Lucia, West Indies, now,⁽³⁷⁾ returning later to the former. Manson and Bancroft had, as I have already shown in the historical summary, done this work up to a point, viz. to the metamorphosed forms in the muscle, but as they disputed about the times taken for the complete metamorphosis, it became necessary that a third party should revise the subject and show if possible where these differences of opinion arose. This I believe I have done.

On arrival then in St. Lucia the first thing to do was to study the different mosquitoes found in Castries, the main town, and very quickly it became evident that two genera or species were common. The first of these, a brown insect, nocturnal in its habits, and closely resembling the common Culex pipiens of England, was sent home by Dr. Gray, of Castries, to Mr. Theobald of the British Museum in London, and the latter identified it as Culex fatigans. The second, a smaller brownish black insect, with white banded legs, silver bands on the sides of the thorax, and on the dorsum of the

abdomen, we knew then as the Culex taeniatus. (This insect later was separated altogether from the genus Culex by Mr. Theobald and given generic rank as the genus Stegomyia, the individual species under discussion being known as the Stegomyia fasciata, a name which has held good up to quite recent times when it has had the specific part of the designation changed again, namely to calopus.)

The latter is very bloodthirsty, feeding by night or day whereas the former only feeds by night. A patient with numerous Filaria bancrofti embryos in his blood having been selected, I fed both these mosquitoes on him and followed out the developments that took place in them.

Technique.

Larvae collected from waterbutts, tubs, and similar situations were placed in tea cups in small wooden boxes, $1\frac{1}{2}$ ft. long, by 1 ft. broad, and 1 ft. high, each of the sides being covered with gauze to admit air. At one end a door, closed by a sleeve of gauze, was constructed, large enough for the hand and arm to be easily passed into the house. In a few days many of the larvae became transformed into insects. In the evenings, between 9 and 10 p.m., the patient simply placed his hand and arm in the box, and all the mosquitoes which bit him were then caught in ordinary test tubes, and transferred to a

separate box, where they were kept till required for dissection, the date of biting being carefully noted on a label stuck on the top of the box. Sometimes the Culex fatigans mosquitoes were averse to biting; I found, however, that matters might be facilitated if the patient---a negro---first soaked his hand in hot water, the increased flow of blood to the part probably attracting them.

No trouble was experienced in keeping the insects alive, bananas and brown sugar being used as food. A certain proportion of males were kept with the infected females, and many of the latter deposited their eggs in small glass vessels full of water kept for the purpose. This method of infecting mosquitoes is simpler than introducing them under the mosquito net of a patient's bed at night. None are lost, and the trouble of collecting and separating them is reduced to a minimum.

Anophelines may either be fed this way or from test tubes, over the mouth of which a piece of gauze has been stretched, they bite quite readily when applied by the latter method. Strangely enough Culex and Stegomyia will not bite when imprisoned in test tubes.

EXPERIMENTS ON STEGOMYIA CALOPUS.

On dissecting insects of this species twelve to

twenty hours after feeding, many actively-moving filaria embryos are seen amongst the muscles of the thorax (the technique for dissecting such infected mosquitoes and cutting sections of them has already been given); they have then no trace of the long sheath which encloses them while circulating in the human blood. Four and a half days after infection the embryos show some development; they are now longer and broader, and show with a high power some increase in the number of the cells of the body. A fine cuticle, ending in a sharp point some distance behind the tail, encloses them.

At seven and three-quarters days they have become distinctly sausage shaped; a mouth is now visible, and the body cells are becoming arranged to form the alimentary canal. Many show the usual hernial protrusion at the anus; all still have the fine cuticle. At dates later than this (eight and three-quarter days) some have changed from the sausage stage, becoming now elongated, and there is further increase in the cellular structure. Later than this, from nine days onwards, though seeing a more developed form with a fairly distinct alimentary canal, the growth of the embryo seems to come to a standstill. Instead of rapidly increasing as in efficient hosts they begin to degenerate, the cells of the body becoming granular, and the intestinal canal very

indistinct. At fourteen days nearly all have disappeared, only small imperfectly developed ones remaining. Some of these are, however, still alive and move feebly. At seventeen days only one out of ten insects show anything and the embryos seen are either dead or degenerating. At twenty days after infection no trace was to be seen of filariae in many mosquitoes dissected.

The conclusions, therefore, one must arrive at as regards Stegomyia calopus are that this insect is not an efficient host, i.e. as the embryos in the muscles never become completely metamorphosed and never reach the proboscis it cannot infect man. Why development should go so far and then suddenly stop is a very interesting problem, but one to which at present one can give no answer. I think the name I have given to an insect of this class, namely, a partially efficient host, is explanatory to a certain extent of what takes place. It is extraordinary how often one notes in books and periodicals, that ought to know better, the misstatement that this mosquito is a host and transmitter of filariasis. From what has just been said it is manifestly nothing of the sort. It is practically certain to my mind, that Manson's mosquito which he called the tiger in his original experiments, was the same as this (the Stegomyia calopus), but as far as I know he did not

notice this peculiar partial development in his specimens. Rees⁽³⁸⁾ hinted at the same thing at a meeting of the British Medical Association in 1900; and Vincent⁽³⁹⁾ in Trinidad confirmed my work in the following year.

EXPERIMENTS ON CULEX FATIGANS.

In marked contrast to the slow and imperfect development of the embryos of Filaria bancrofti in Stegomyia calopus is the extremely rapid rate of growth they exhibit in the thoracic muscles of Culex fatigans. In twelve to twenty hours after feeding large numbers have arrived in the muscles, and even in forty hours show a considerable amount of change. There is an increase in the number of the cells, and the fine cuticle can be seen tapering to a point posteriorly. By the end of four and a half days the sausage shape has been reached, the alimentary canal has begun to form, and the mouth and anus are visible. They even now are larger and stouter than the stage described in Stegomyia calopus at seven and three quarter days. Growth now goes on with great rapidity. At five and a half days they have lengthened out, and the anatomical structures are better marked.

At six and a half days they are still longer; mouth, anus, and alimentary canal are very distinct

and well formed.

At seven to seven and a half days the oesophageal bulb has appeared; most have lost the fine cuticle, and some show the commencement of the trilobed tail.

At eight and a half days they measure 0.88 mm. in length by 0.94 mm. in breadth; the large cells which originally formed the intestinal tube having at this date become transformed into fine small cells, and the whole appearance begins to resemble that seen in the final stages of development.

Nine and a half days forms show a still further increase in length.

At ten and a half days forms measuring 1.26 mm. (1/20 in.), to 1.3 mm. in length by 0.04 mm. in breadth, are seen.

Anatomically they present a mouth, an oesophagus, an oesophageal bulb, and a long alimentary canal ending at the anus, which is situated some little distance above the trilobed tail. Movement is now very active; though they do not change their positions on the slide they are constantly twisting and coiling themselves about in what has been called a purposeless manner, very much resembling the movements of the immature embryos when seen in a drop of blood.

By the following day (eleven and a half days) metamorphosis of some of the young filariae may be

complete and mature forms may be seen in the head, neck, and proboscis, and more rarely in the abdominal cavity. One is at once struck by the fact that the embryos vary considerably in length, and also that the thoracic muscles still show a number of very short filariae which have developed much more slowly; this corresponds to what one finds in sections. Measurements gave for the longest of the mature embryos 1.6 mm. (1/16 in.) while one dissected out of the proboscis only attained to 1.44 mm. (1/18 in.), and another in the muscle was as small as 1.26 mm. (1/20 in.). The breadth varied from 0.024 mm. to 0.032 mm. that is, they are finer or thinner than those seen at ten and a half days. None as large as 1/13 in., the limit given by Bancroft, were seen.

The origin of the question of the differences of time given for complete metamorphosis by Manson in 1879 and 1883, and by Bancroft in Australia in 1899, is interesting. The latter, it will be remembered, pointed out that Manson worked with mosquitoes not bred from larvae and therefore quite probably already infected.

This of course---granted the mosquito had been infected before---would introduce fallacious results, but other explanations also suggest themselves.

James in India (loc. cit.) working with Myzomyia rossii found that twelve to fourteen days

were required for the complete development and he put forward the view that climate and probably other factors have an important influence on the development of the parasites. This question of climate and temperature is, I think, without doubt the prime factor in the variability, feeding also probably playing a part however.

Manson's experiments were done in Amoy, Bancroft's in Queensland, James's on Anophelines in Travancore, whilst mine were conducted in St. Lucia, one of the West Indian Islands, in March, when the weather was moderately hot. Possibly had they been done later when the weather was even hotter the complete metamorphosis might have taken place as early as the eighth day, the time originally stated by Manson.

Against this, however, is the fact that Vincent conducted similar experiments the following year in Trinidad, in August one of the hot months, and in his experiments forms first appeared in the proboscis on the 16th day, a considerably later date. From this it is evident no definite time can be given, the occurrence of the phenomenon is a variable one.

TABLE giving the different dates on which metamorphosis has been observed to take place.

<u>Authority.</u>	<u>Place.</u>	<u>Dates.</u>
Manson.	Amoy China.	8th day.
Low.	St. Lucia, West Indies.	11½ days.
James.	Travancore, India.	12 to 14 days.
Bancroft.	Queensland.	18th day and later dates.
Vincent.	Trinidad, West Indies.	16 to 19 days.

FURTHER DETAILS OF THE METAMORPHOSIS.

On ingestion of the filariae into the mosquito's stomach the first thing to take place is the escape of the embryo from its sheath. Bancroft has denied this, suggesting that ecdysis is an artificial phenomenon. That it is not, is easily proved by sections where the empty sheaths can be seen lying in the blood of the stomach. Ecdysis or escape of the embryo from its sheath we have seen can be well studied in wet films that have been kept for some time (vide page. 40.), the film representing artificially what occurs naturally in the stomach.

Once out of the sheath, the embryo using the fang or spine at the end of its head, quickly bores through the wall of the stomach and passes amongst the fibres of the thoracic muscles.

To do so it has to pass through (1) a delicate cuticula, (2) a single layer of cubical epithelial cells, (3) an elastic lamina, and (4) the transverse and longitudinal layers of muscle, these layers forming the wall of the stomach. It is exceedingly likely that most pass through the anterior or thoracic part of the stomach, this part being entirely enclosed and surrounded by the different thoracic muscles. When accommodated in a properly efficient host growth is extremely rapid, this being due at first to an increase in breadth, the length remaining constant. Thus the appearance of a sausage is produced, a stage reached in C. fatigans about the fourth day of development. A dimple forms at the head end the rudimentary mouth and another one some distance from the tail, the anus, a hernial protrusion of the contents of the body often being noted here. The central column of cells of the embryo grow into larger cells and divide into two layers, a slit appears down the middle of these the rudimentary alimentary canal; as growth proceeds this becomes more defined and the cells dwindle in size till they appear only as a dark line the wall of the fully developed alimentary canal.

About the 7th day other important structural alterations take place; the breadth remaining more or less constant after the 5th day, the length

rapidly increases and the fine tapering piece of cuticle which was seen in the early stages disappears, its place being taken by a tail with three lobes---the trilobed tail. An oesophageal bulb also now appears and the anatomy of the metamorphosed embryo is practically complete.

SUMMARY.

From the minute embryo of the blood stream, a more or less structureless creature, the sojourn in the mosquito has resulted in then (1) an enormous increase in length from $1/80$ of an inch to $1/16$ in., (2) the formation of a simple unarmed mouth, (3) an oesophagus, (4) a well developed and defined alimentary canal, (5) an anus, (6) a non striated musculo-cutaneous layer.

THE STUDY OF THE DEVELOPMENT IN SECTIONS.

One or two other points may be gained by a study of properly stained and well cut sections of mosquitoes infected with filariae, the technique for which has already been given in detail. As the embryos lie in the muscle it is interesting to note for example that although degenerative changes appear to be produced in the muscles of the mosquito,

especially by the more advanced forms of the filariae, yet nothing of the nature of inflammatory change or of encystment as in the case of trichina infection of vertebrate muscle is ever observed. Sections also reveal the path of transit from the muscle to the proboscis, the young filariae after reaching their maximum stage of development in the muscle passing forwards into the loose cellular tissue of the prothorax, then on along the inferior aspect of the neck, and so to the head where they coil themselves up in the loose connective tissue immediately under the cephalic ganglion and salivary duct. From here the passage to the base of the labium the fleshy part of the proboscis is easy and this they enter passing along it towards its tip. It was in a section, which took the plane of the proboscis in, that I discovered the filaria in that organ, but even before that my suspicions had gradually been aroused by so many sections of old infected mosquitoes exhibiting metamorphosed embryos in the prothorax and head. It is further seen that the large dorsal mass of thoracic muscle is mostly selected for development though those working the limbs are also found at times to be occupied and in much rarer instances development has been noted going on in some of the abdominal muscles.

The embryos of Filaria bancrofti never develop

in the malpighian tubes, a site selected by the embryos of Filaria immitis of the dog.

Sections are necessary to study this development in the malpighian tubes, a development which is very similar to that of the bancrofti embryos in the muscle, the metamorphosed embryos finally passing forwards along the anterior or inferior aspect of the mosquito and so getting to the proboscis.

The following microphotographs of some of my original sections from the material sent by Bancroft to the London School of Tropical Medicine give a very clear picture of the different stages of the development.

The sections are in the Museum of the above school.

DIAGRAMS of the development of the microfilaria bancrofti in the tissues of the mosquito.

Microphotographs by Mr. Pringle of the author's sections.

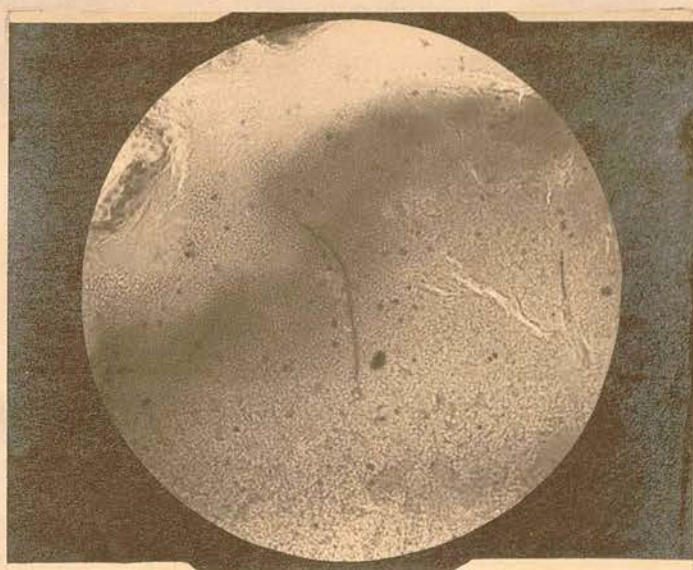


Fig. 14. Young embryo in the stomach of the mosquito 12 hours after feeding. x 160.

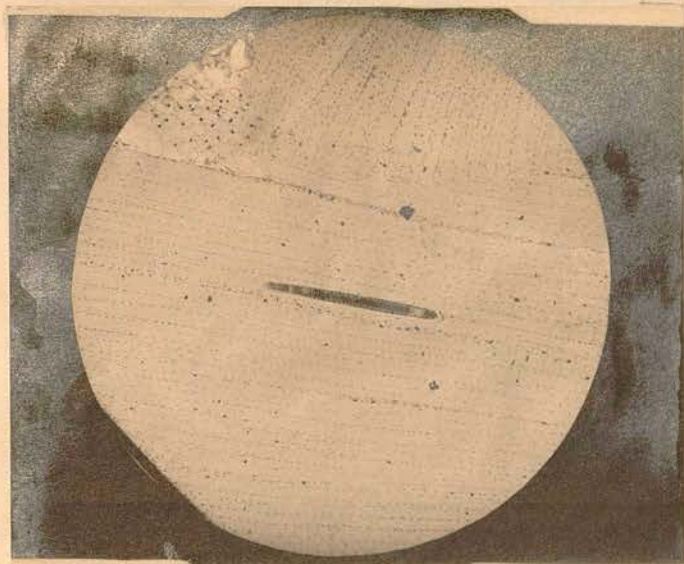


Fig. 15. Commencing development of the embryo in the thoracic muscle of the mosquito. $\times 80$.

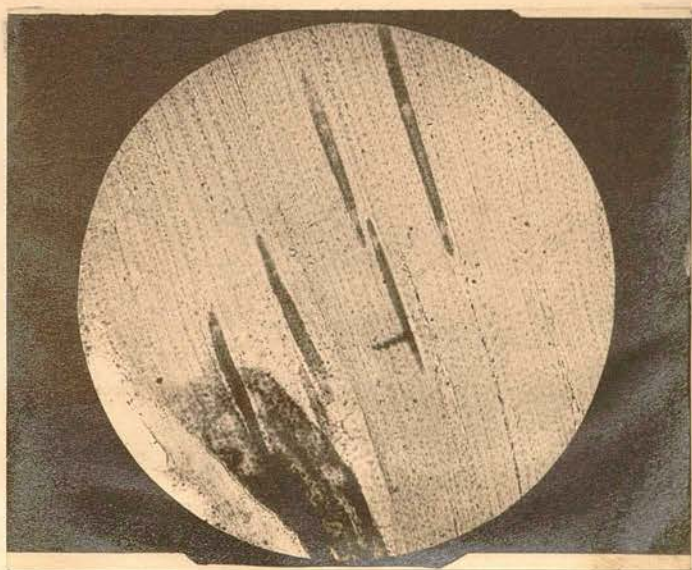


Fig. 16. Further development proceeding, increase of length, formation of alimentary canal, &c. $\times 80$.

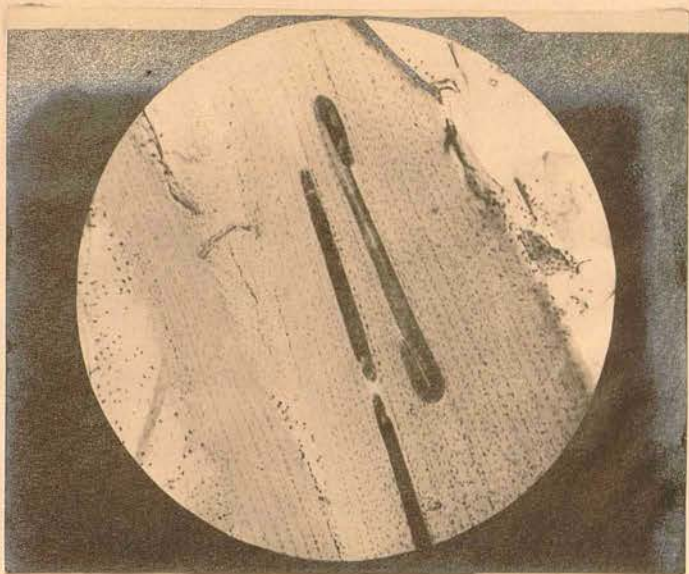


Fig. 17. Section of a filariated mosquito $11\frac{3}{4}$ days after feeding on an infected case. Note the great increase of size in the embryos, the one to the right is approaching maturity. $\times 80$.

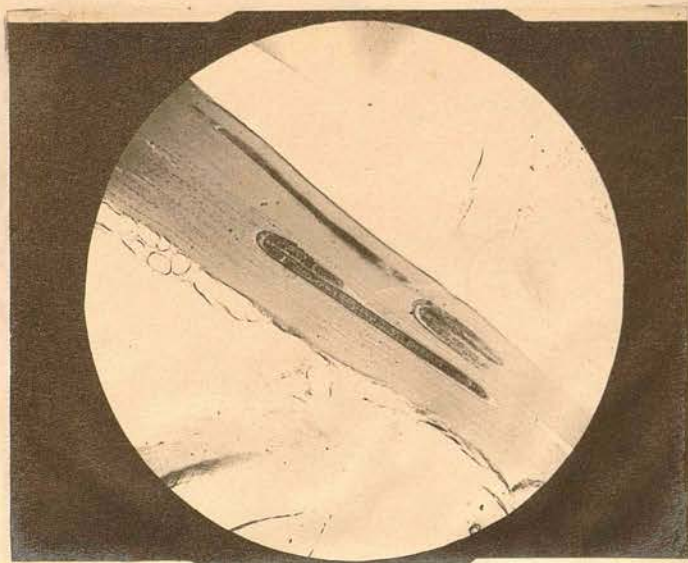


Fig. 18. Section of filariated mosquito $19\frac{1}{2}$ days after feeding on an infected case. Shows much the same stage of development as Fig. 17. $\times 80$.

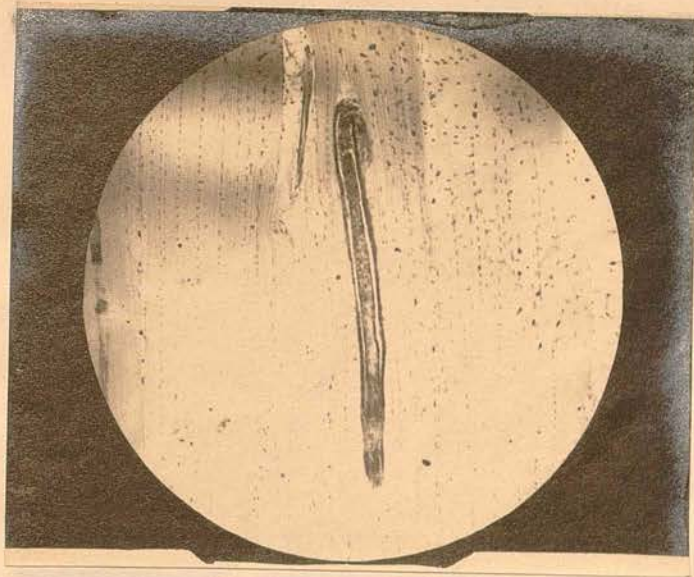


Fig. 19. Section of filariated mosquito 19 $\frac{1}{2}$ days after feeding on an infected case. Alimentary canal well seen in middle. Development almost complete. x 150.

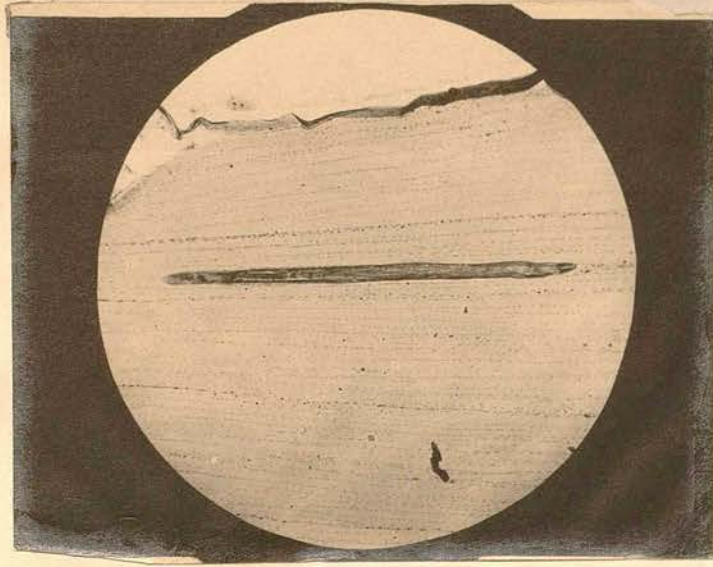


Fig. 20. Section of filariated mosquito 20 days after feeding on an infected case. The embryo has now undergone its complete metamorphosis and is ready to burst out of the muscle and so to escape into the head of the insect. x 75.

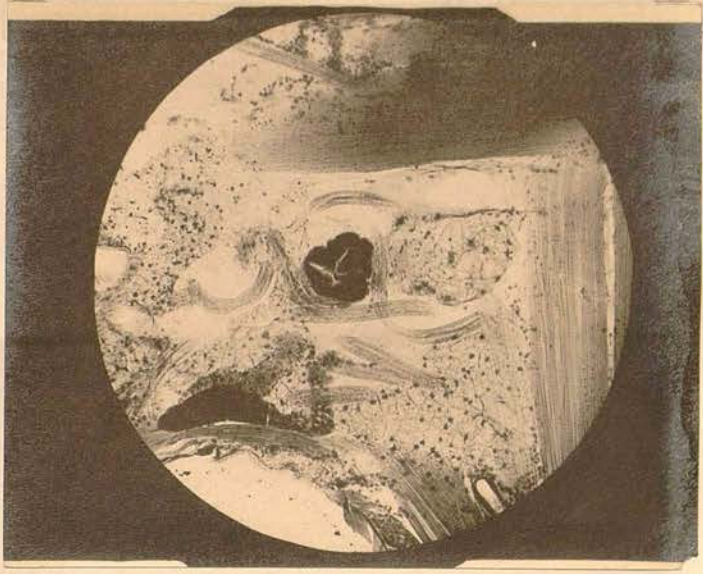


Fig. 21. Section of a filariated mosquito 43 days after feeding on an infected case. The metamorphosed embryos have left the thoracic muscles and portions of them may be seen in the prothorax above one of the lobes of the salivary gland. The upper dark mark in the section is a cross section of the elementary canal, the lower is one of the lobes of the salivary gland. x 80.

Fig. 22. Section of a filariated mosquito 43 days after feeding on an infected case. The metamorphosed embryos have left the thoracic muscles and portions of them may be seen in the prothorax above one of the lobes of the salivary gland. The upper dark mark in the section is a cross section of the elementary canal, the lower is one of the lobes of the salivary gland. x 80.

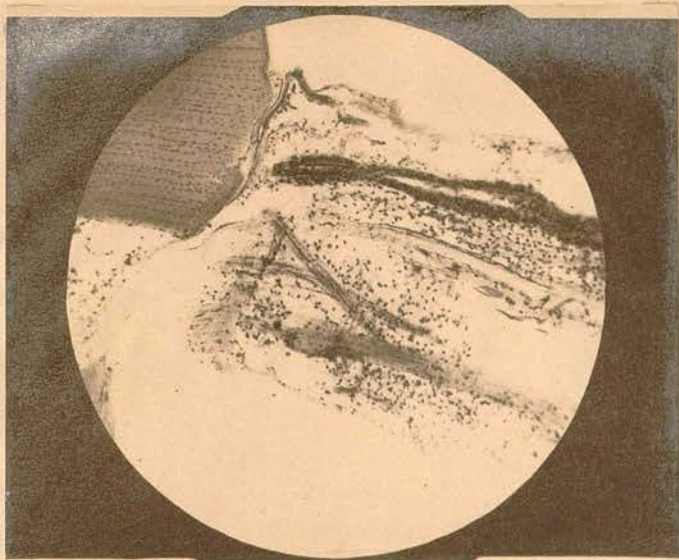


Fig. 22. Section of a filaridated mosquito 60 days after feeding on an infected case. Two metamorphosed embryos seen lying in the loose connective tissue of the anterior part of the abdomen. This is not usual. Dark appearance in upper part of section is the alimentary canal. x 75.

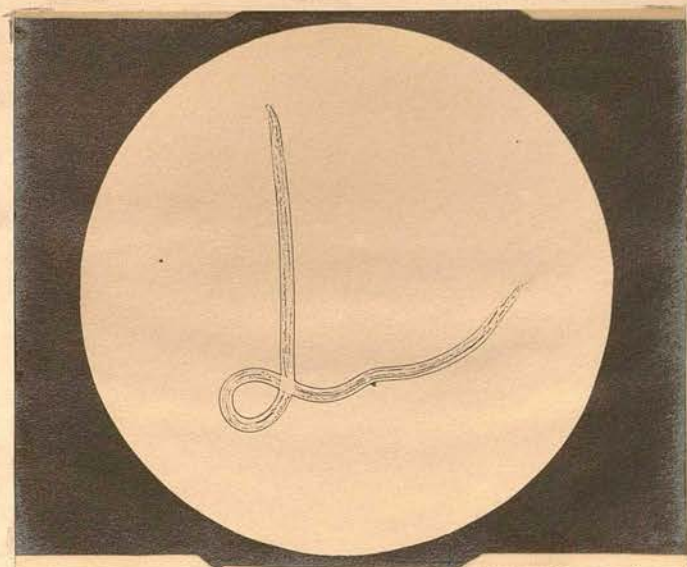


Fig. 23. Young filaria (completely metamorphosed form) dissected out of the proboscis of a mosquito---mounted in formalin solution. x 45. Such a specimen is just visible to the naked eye measuring 1/16 of an inch or thereabouts.

THE MECHANISM OF THE ESCAPE OF THE
FILARIA FROM THE PROBOSCIS.

There is no doubt that Dutton's⁽⁴⁰⁾ explanation of the way the filariae escape from the proboscis is the correct one. Originally I supposed that the filariae burst through the base of the labium and thus come to lie free amongst the stylets, but as the former authority in criticizing my work showed, some of my illustrations clearly represented them lying in the labium.

Grassi and Noe⁽⁴¹⁾ advanced the idea that, owing to the bending of the labium stuffed with filaria, when the mosquito pierces the skin with the stylets, a rupture of the integuments at the bend made in that organ near its centre is brought about, which allows of the escape of the filariae along its dorsal groove. This as Dutton says would be extraordinary and further has now been proved to be incorrect.

The weak spot in the chitinous exoskeleton of the labium is as Dutton pointed out a delicate loose membrane situated between the tip of the labium and labellar joints, and as this is also in close relation to the skin when the mosquito draws blood, it is easy to see how the embryo as it comes through gets into the wound.

Not long after this explanation was published Bancroft photographed the proboscis of a mosquito with

two embryos actually coming out at this spot and Fulleborn more recently has given a diagrammatic sketch of a mosquito biting showing the same thing. This may therefore be taken to be proved.

It is probable that the embryos lying in the proboscis can discriminate between the animal juices and those of fruits; failure to do so would of course end in the death of many. Certainly in some instances they can, because forms may still be found in the proboscis of insects 30 or 40 days after infection, and that even though they have been feeding daily on bananas and other fruit.

The specimens Bancroft sent to London are instances of this, and Vincent in Trinidad records the same thing.

On the other hand Grassi and Noe state that the embryos may pass into fruits. This seems doubtful however. The warmth of the skin, and of the blood passing up the proboscis, when the mosquito bites an animal, is, I believe, what influences them to escape, and without such a stimulus they are content to lie quiet in the proboscis and wait.

PERCENTAGE OF INFECTED MOSQUITOES IN

A FILARIAL DISTRICT.

This of course will depend entirely on the

proximity or otherwise of individuals with embryos in their blood to the mosquitoes.

I conducted some experimental work in this direction in the General Hospital of Barbados once, where at the time there were several patients with embryos of F. bancrofti in their blood.

These individuals had no outward signs of filarial disease, they were suffering from surgical or ordinary medical complaints simply, and one only found they were infected by routine night blood examination of the whole of the inmates of the hospital. I thought it would be interesting to note how many mosquitoes such a case might infect naturally, so I had a red curtain placed, similarly to a bronchitis tent, over the foot of the bed of one, who was a patient in a fair sized Ward No. 7.

Mosquitoes from all parts of the ward used to come to this curtain every morning to sleep and from it I collected at random a certain number every day for dissection.

In addition I also collected some from other wards and passages. Out of a series of 100 mosquitoes dissected (Culex fatigans), caught mostly on the curtain over the bed of the filarial case in Ward 7, I found 23 infected (23%). The dissections were always carefully and accurately performed,

proboscis, head, thorax, and abdomen all being dissected separately on different slides. It may be of interest to give the details of those found to be infected, the non-infected ones being omitted.

The first number is my book record figure, the second in brackets totals the number infected.

167. (1) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Stomach full of blood. A few young filariae present in the blood.
168. (2) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. No blood in stomach. Many almost completely mature forms in thoracic muscles, probably about 10 days old---all appear to be same age---none migrated yet.
171. (3) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. 2 young filariae in blood of stomach, none in muscles.
176. (4) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Stomach full of fresh blood, many filariae in it and also young ones in thoracic muscles.

177. (5) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. 7 young filariae in blood from stomach, 4 in thoracic muscles apparently all same age.
185. (6) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Stomach full of blood, several young forms in thoracic muscles, just migrated.
189. (7) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. No blood in stomach. Thorax full of embryos---early sausage stage---one poorly developed form in abdomen.
190. (8) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Fresh blood in stomach, many young embryos in this and also many in thoracic muscles. Fed evidently last night.
191. (9) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Fresh blood in stomach, one embryo there, none in thoracic muscles.

197. (10) Culex fatigans Hosp. Ward 7.
Curtain over bed. Case 165. Fresh blood
in stomach. Many young embryos there and
in thoracic muscles.
198. (11) Culex fatigans Telephone room
corridor outside Ward 7. Stomach full
of blood, many young embryos there, none
yet migrated to thorax.
206. (12) Culex fatigans Ward 7. Curtain
over bed. Case 165. No blood in stomach.
Many mature forms in thorax, numbers
migrated, several in head, one in
proboscis, movement typical of perfect
metamorphosis.
207. (13) Culex fatigans Ward 8. Sausage
forms in muscles of thorax, nothing in
fresh blood in stomach.
213. (14) Culex fatigans Ward 7. Curtain over
bed. Case 165. Stomach full of blood.
Many young embryos in this and also in
thoracic muscles.
215. (15) Culex fatigans Ward 13. Thorax
contains many embryos, just past the
sausage stage, evidently about 5 days
after feeding. Single infection. No
filarial case near where insect was caught.

217. (16) Culex fatigans Ward 7. From wall of ward. At other side of bed of case 165. 1 in blood of stomach, many young forms of same age in thoracic muscles.
220. (17) Culex fatigans Ward 7. Curtain over bed. Case 165. Nothing in stomach though full of blood, one young form in thoracic muscles.
222. (18) Culex fatigans Hosp. Ward 7. Curtain over bed. Case 165. No blood in stomach. An early pre-sausage stage in thoracic muscle.
227. (19) Culex fatigans Hosp. Ward 7. Curtain over bed. Case 165. Blood in stomach. 2 embryos in that, none in muscle.
232. (20) Culex fatigans Hosp. Ward 7. Curtain over bed. Case 165. Young embryos in blood of stomach and muscles same age.
234. (21) Culex fatigans Ward 7. Curtain over bed. Case 165. Many newly migrated embryos in thorax, some still in blood of stomach, single infection.

237. (22) Culex fatigans Hosp. Ward 7.

Curtain over bed. Case 165. No embryos in stomach, many in thoracic muscles, showing increase of breadth, &c. Apparently about 2 or 3 days old.

238. (23) Culex fatigans Ward 7. Not from

curtain. Stomach full of blood, many young embryos in thoracic muscles. Some still in blood of stomach. Apparently a single infection.

A case therefore with filarial embryos in his blood, in a house to which mosquitoes have access, is a danger not only to others but also to himself. Mosquito No. 206, if it had not been captured, would on the following evening either have bitten patient 165, and reinfected her, or someone else in the Ward infecting that individual for the first time. 165, I note on referring to my records for Barbados, was a young negress born in Demerara, 19 years of age, and admitted for colic. Possibly this had something to do with the filarial infection as ordinary blood films shewed as many as 50 embryos to the slide,---a heavy infection. Mosquito 157, a Culex fatigans bred from a larva, and fed on her one night, was dissected 40 hours after feeding. 20 active filariae were seen in the thoracic muscles already shewing increase of size.

3 dying were seen in the remains of the blood of the stomach.

The case on which I infected mosquitoes in St. Lucia---these experiments have been already described---was No. 378 St. Lucia series, a negro born in Antigua and who had lived in Castries a year. He was only a very moderate infection, 14 to the slide, and presented no symptoms of any filarial disease.

The danger of infected people in houses will be returned to when the prophylaxis of the disease is under discussion, that it is a real one is borne out by an experience narrated to me by Dr. Hutson of Barbados. He informed me, when we were talking about the escape of the filaria via the proboscis one day, that he was sure there was something in this, because in an office he knew all the young clerks employed there invariably developed symptoms of the disease. One of the partners in the business he knew to be infected. Manifestly, to my mind, the sequence of events here was something as follows. After dusk (6 p.m.), and later, every evening mosquitoes bit the infected partner; they remained somewhere or other about the building, probably sleeping behind desks or cupboards or somewhere about the ceiling. Eventually mature forms would appear in their proboscis, and on rebiting, probably, as likely as not, this time one

of the clerks the insect would transmit the infection to him. Next time it might bite the same or another and so on, the eventual chances of anyone employed there being very much in favour of becoming infected.

THE EFFECT OF THE DEVELOPMENT OF THE
FILARIAE ON THE MOSQUITO.

So far as we know a moderate infection of filariae does not seem to exert any prejudicial effect on the mosquito. Certainly the death rate amongst my experimentally infected ones was not considerable and those that did die shewed nothing special to account for their demise. Probably very severe infections might damage the host and cause serious trouble. The fact that the embryos lie in the muscle without causing inflammatory or cystic changes has already been alluded to.

III. DISEASES CAUSED BY FILARIA BANCROFTI.

A large number of pathological lesions, resulting in many peculiar clinical conditions, may be brought about by the presence of the adult Filaria bancrofti in the lymphatic system of man.

It is generally conceded now that certain of these conditions---sometimes known as the elephantoid diseases---are without doubt due to the filariae, but that as regards others, elephantiasis for example, the proof is not so certain.

From my own observations I am quite satisfied that the latter condition is a late result of the damage caused by the filariae at some previous date, and if one admits that lymphangitis is filarial (filarial lymphangitis) then I cannot see how---I shall explain the connection in detail later---one can deny that elephantiasis is not also due to the same cause.

The clinical signs of the lesions will be associated with the lymphatics in some way or other, the chief signs being dilatation or inflammation of the trunks and branches of this system.

TABULAR LIST OF FILARIAL DISEASES.

A.	B.
1. Filarial lymphangitis.	Elephantiasis
	of
2. Filarial abscess.	Legs, arms, scalp,
3. Dilated lymphatics in groin and axilla, also in the skin and subcutaneous tissues.	scrotum, penis, vulva, mamma and subcutaneous
4. Lymph scrotum.	tissues (pedunculated
5. Filarial orchitis.	elephantiasis).
6. Chyluria and associated conditions such as chylous ascites, chylous diarrhoea chylocele.	

(1) Filarial lymphangitis.

In all countries where filariasis is common one is at once struck with the large number of cases of attacks of lymphangitis that one is constantly seeing. The condition has been variously named, as for example lymphangitis, filarial lymphangitis, elephantoid fever (Fayrer), Fever and ague (Barbados), The rose (Barbados).

I studied this condition in some detail in Barbados, where, owing to the fact that there is no malaria present, one got the cases in a pure state without complications.

An attack of filarial lymphangitis comes on with great suddenness, an injury or blow, or even bathing

in the sea often being the predisposing factor. Very often ushered in by a rigor, the patient may quickly become delirious and raving and with this there may be vomiting. An examination of such a case will reveal a swelling of say a foot and leg, and in addition to this an erythematous blush spreading up the limb, the lymphatics often standing out distinctly and being very tender. The glands in the corresponding drainage area (femoral and groin ones in the case of a foot and leg) are also enlarged and painful.

The condition most closely resembles erysipelas and though due, primarily no doubt, to the filaria is evidently an inflammatory condition due to an organism, a streptococcus. It differs from erysipelas in not being infectious and in not spreading to other patients in the same ward, such cases being treated in the wards of the general hospitals with no untoward results.

After a few days' rest in bed, even without anything very definite in the way of treatment, the temperature falls rapidly, the swelling stops increasing, the redness and inflammation disappears, the lymphangitis subsides and the limb may return to normal or very nearly so. Once having suffered from such a condition, however, the usual thing is to have subsequent attacks, one, two or three even in a year, and then after each it can be noticed that a little

permanent thickening remains. Continue this a stage further and the thickening becomes more and more pronounced, so much so indeed that it gradually merges into or becomes identical with what we know as the early stages of proper elephantiasis. Such a history, as we shall see when we deal with the latter disease, is common, though at the same time, it seems as if in other instances, it (elephantiasis) may appear without such attacks.

Another point of great interest in the study of filarial lymphangitis is that after the attack the embryos disappear entirely from the peripheral blood; this indicating either a death of the parent worms, or a blocking of the lymphatics in the area in which they lie, the further progress of the embryos being thus arrested (see later under pathology).

Illustrative cases of Filarial lymphangitis with blood examinations and temperature charts.

(1) Farnell 7, coloured, m. Born Barbados.

History. First attack; no other illnesses.

Bitten on foot by brother, wound produced by this, however, trivial. Apparently taken ill February 2. 02, with pain and swelling of left thigh (same side as bite).

State on admission. Admitted February 5. 02.

Left thigh swollen red and tender, glands

in groin inflamed, palpable and tender.
 Temp. 101.8 F. Healed scar at site of bite,
 no sepsis there. No other wounds or
 abrasions. No implication of lower part of
 leg. "Fever and ague" (the local Barbadian
 name for filarial lymphangitis) diagnosed.
 Patient put in bed, lead lotion applied to
 thigh.

Progress. February 7. 02. Temperature down to
 normal, inflammation
 subsiding.

February 8. 02. Temperature normal,
 condition clearing up
 quickly.

February 11.02. All symptoms and
 physical signs
 completely gone.
 Attack mild therefore,
 discharged cured.

Blood examination.^x

Feb. 10. 02. 2 slides 0.

x

All blood examinations made at night of course.

Temperature Chart.

NAME.		RESIDENCE.		AGE.	SEX.	OCCUPATION															
(1). Farnell.		Barbados.		7	m.																
DISEASE. <i>Filarial lymphangitis -</i>																					
1902		DATES OF OBSERVATIONS																			
February		5	6	7	8	9	10	11	12												
Cent.	Fahr.	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM				
	.8																				
	.6																				
	.4																				
	.2																				
41	106																				
	.8																				
	.6																				
	.4																				
	.2																				
40	105																				
	.8																				
	.6																				
	.4																				
	.2																				
40	104																				
	.8																				
	.6																				
	.4																				
	.2																				
39	103																				
	.8																				
	.6																				
	.4																				
	.2																				
39	102																				
	.8																				
	.6																				
	.4																				
	.2																				
38	101																				
	.8																				
	.6																				
	.4																				
	.2																				
38	100																				
	.8																				
	.6																				
	.4																				
	.2																				
37	99																				
	.8																				
	.6																				
	.4																				
	.2																				
37	98																				
	.8																				
	.6																				
	.4																				
	.2																				
NORMAL	98																				
	.8																				
	.6																				
	.4																				
	.2																				
37	97																				

(2) Richard Small, 15, m. Born in Barbados, but has been in St. Lucia, Dominica, &c.

History. Has always been healthy, no previous illnesses. This said to be his first attack of lymphangitis. On night of February 17, 1902, apparently had a rigor. Right leg became swollen and was very tender. Condition persisting, boy was brought four days afterwards to Hospital and was admitted on the night of the 21st.

State on admission. From nurse: Redness of ankle and lower part of rg. leg, this spreading up to knee, very tender, no note as to the condition of the glands. All the symptoms disappeared rapidly on the application of antiseptic lotions. Seen first by myself on the 24th of February. Temperature then almost normal. Condition found: Right ankle, and lower part of right leg very markedly thickened, no inflammation now and no glands palpable in groins or femoral region. No other evidence of filarial disease elsewhere. The permanent thickening looks exactly like the early stage of elephantiasis and this has evidently been the most marked feature of the attack in this case.

Progress. Discharged Feb. 25th, 02. Permanent thickening remaining.

Blood examination.

Feb. 25. 02. 2 slides 0.

State on admission. Admitted February 18. 01.

Left leg swollen and red, redness chiefly below knee, ankle also involved, femoral glands enlarged and very tender, temperature 102. Filarial lymphangitis diagnosed. Put in bed, spirit lotion applied to leg. Temperature began to fall next day and swelling diminished. (Never had an attack like this before.)

Progress. October 21. 01. Swelling and redness completely gone, temperature normal, no pain. Slight enlargement of femoral glands still.

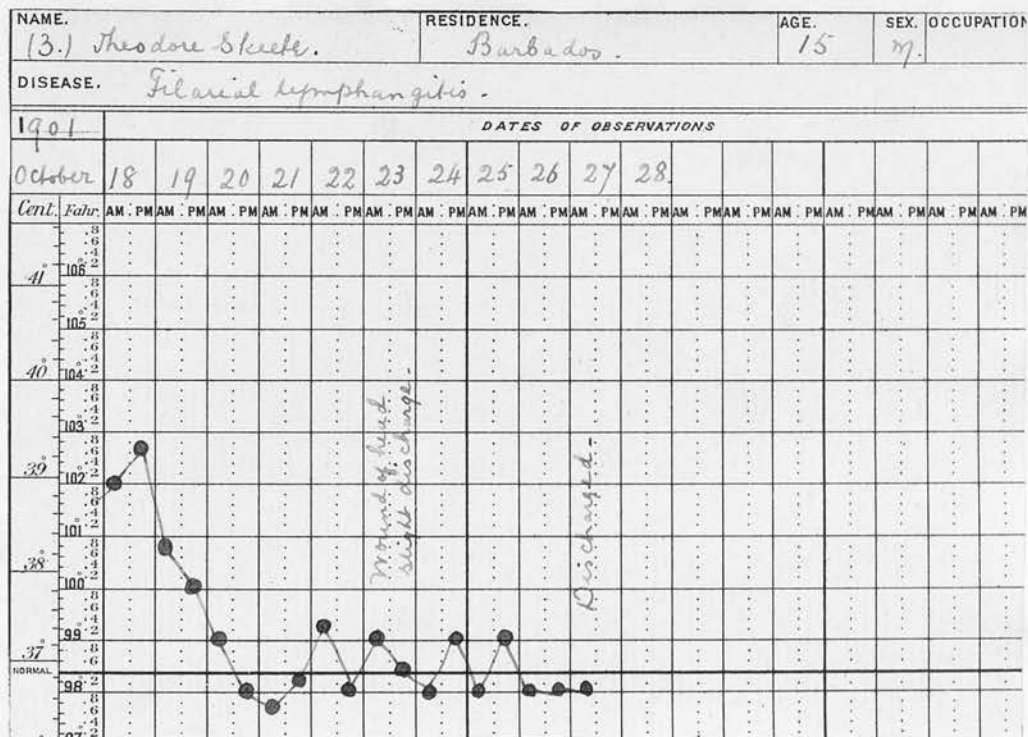
October 23rd, 01. Leg better. Some discharge from wound in head, this probably accounting for rise in temperature.

October 27th, 01. Wound on head almost better. Left ankle slightly larger than right, otherwise everything cleared up. Discharged to-day.

Blood examination.

Oct. 23. 01. 4 slides 0.

Temperature Chart.



(4) Ethel Payne, 21, f. Mulatto. Born and lived in Barbados.

History. Has had four previous attacks, last 2 weeks ago, old scars on legs, no other illnesses. On night of October 18th 01 felt shivery, right leg between ankle and knee began to swell and got red and very painful. Came to hospital.

State on admission. Admitted October 19. 01.

Right leg and ankle considerably swollen and red, also very painful, thigh practically free, calf chiefly affected. A

soft rather fluctuating gland at upper part of rg. thigh, some of the other femoral glands also inflamed and painful. Temp. 102° F. Given quinine grs. v t.i.d. and lotion applied to leg. Temperature fell rapidly following day and patient got quickly better. There was no history of injury or nothing definite to account for the attack.

Progress. October 21. 01. Examination of leg shows some slight thickening of right ankle and lower part of leg.

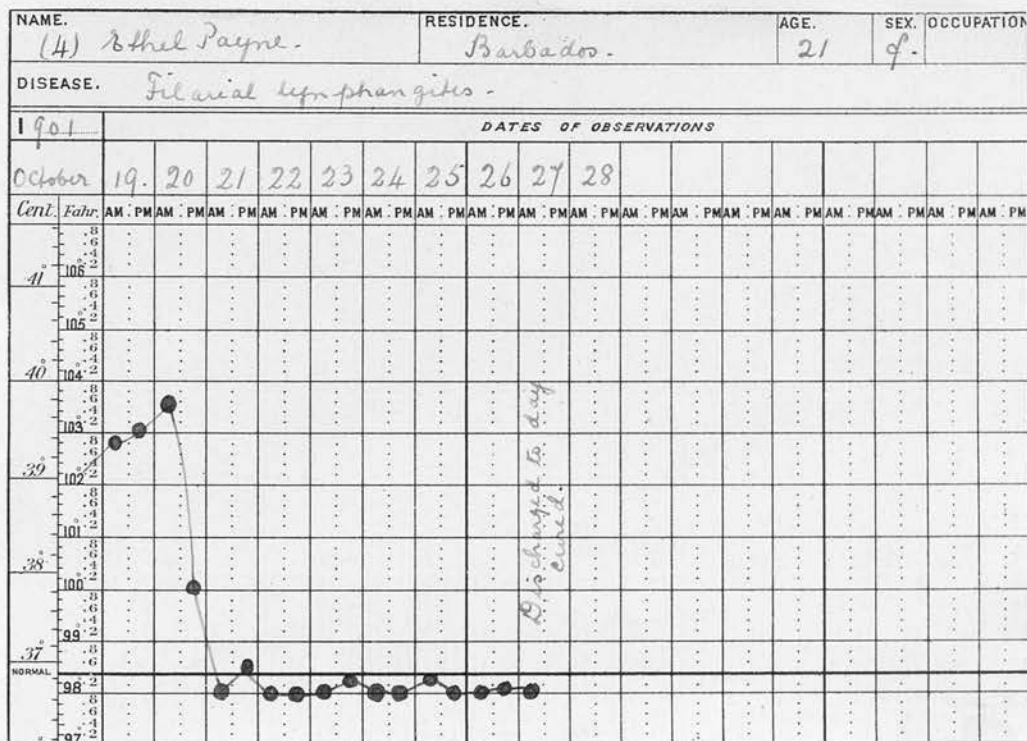
October 23. 01. Temperature normal, inflammation of leg gone.

October 27. 01. Discharged cured. All symptoms gone, no thickening now left.

Blood examination.

October 23. 01. 4 slides 0.

Temperature Chart.



(5) Sainthill f. 42 Mulatto. Born and bred in Barbados.

History. Had similar attacks, twice before.

Left foot began to swell and was painful October 10th 01. No apparent cause. Redness began to run up leg to middle of calf. Temperature rose rapidly, patient became delirious and raving on 11th.

State on admission. Admitted October 12. 01.

Raving and completely off her head. Left foot swollen, very tender, erythema running

up leg, lymphatics standing out red and very tender. Slight enlargement of glands in Scarpa's triangle.

Progress. Confined to bed, put on a milk diet, $2\frac{1}{2}$ grs. of quinine and phenacetin four hourly. Bichloride lotion to leg and foot.

October 13. 01. Temperature coming down.

October 14. 01. Delirium gone, temperature down to normal.

October 16. 01. Foot and lower part of leg still slightly swollen, redness gone. Temp. keeping down, delirium gone.

October 21. 01. Discharged. Slight permanent thickening of parts remaining.

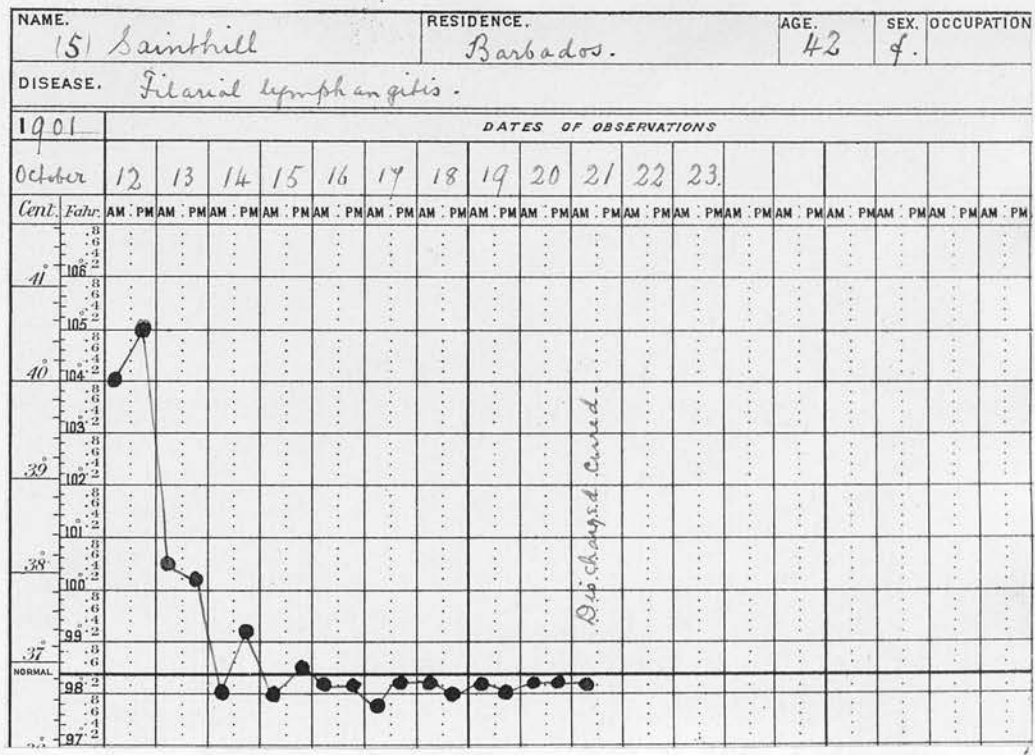
Filarial history. No varicose groin glands, no history of chyluria.

Blood examinations.

October 15. 01. 3 slides 0.

October 20. 01. 2 slides 0.

Temperature Chart.



(6) S. Lynch, 24, m. Negro. Barbados.

History. Very healthy up to present attack, never fever and ague before. Eight days before admission had fever and rigor with severe headache, no vomiting. Severe pain in left groin, stayed in bed feeling ill. As condition showed no signs of improvement sent to hospital.

State on admission. Admitted February 22. 02.

Rigor day of admission, severe pain in abdomen, no vomiting, nothing palpable in

groin, no swelling of leg.

Progress. Temperature continued to swing up and down till the 3rd of March when it fell to normal. It then rose again and ran a similar course till the 15th of March. On the 16th it began to rise again and on the 17th there was a severe rigor with a temperature of 104° F.

March 17. 02. Rigor as above, left calf began to swell to-day and was very painful, thigh followed, very severe pain in left groin, glands enlarged there, very tender and painful. Lymphatics of limb palpable, acutely inflamed. Pyrexia very high for 7 days, then began to fall, swelling of leg diminishing at the same time. Though the leg resolved there still was very severe pain in abdomen just above Poupart's ligament.

March 25. 02. Temperature now coming down, left leg and thigh still slightly swollen. Glands in groin large and palpable and a thickened mass of something felt passing into abdomen from this, extreme pain and tenderness at this place. No fluctuation to be made out and no signs of any abscess formation about limbs.

April 3. 02. Temperature keeps down, varying from 99 to 100. Patient feels quite well and gets up daily.

Condition of limbs. Left calf no swelling now, left thigh slightly thicker than right, still palpable glands in left groin, not now tender, feel hard in consistence. The mass extending into abdomen much less in size still slightly tender.

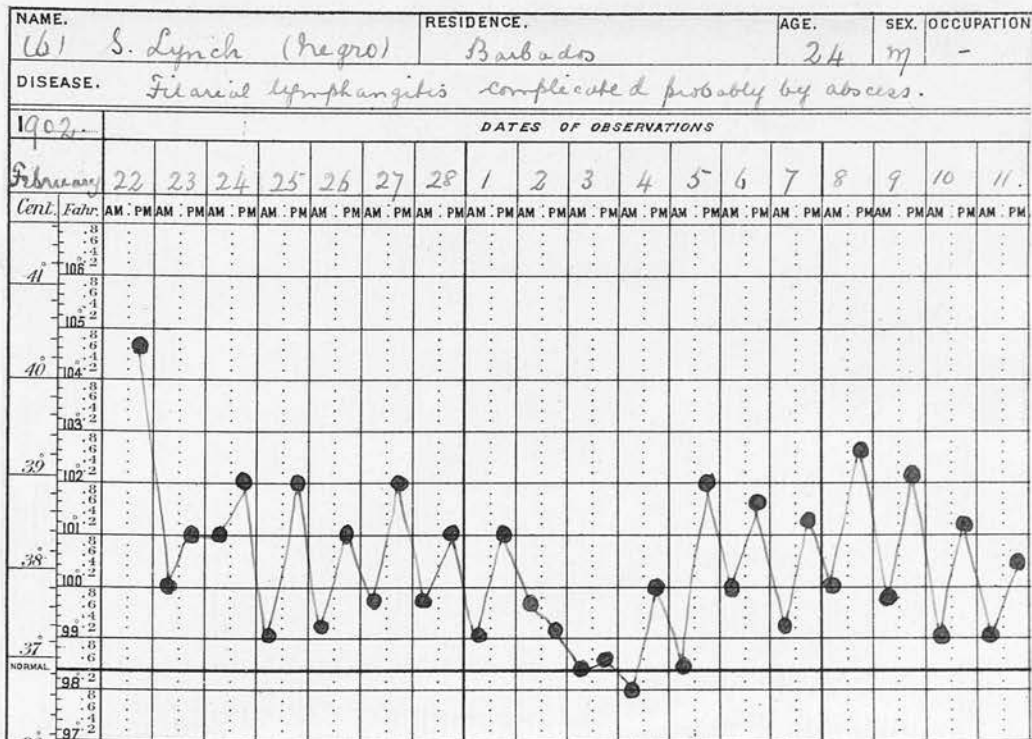
Left hospital a few days after this.

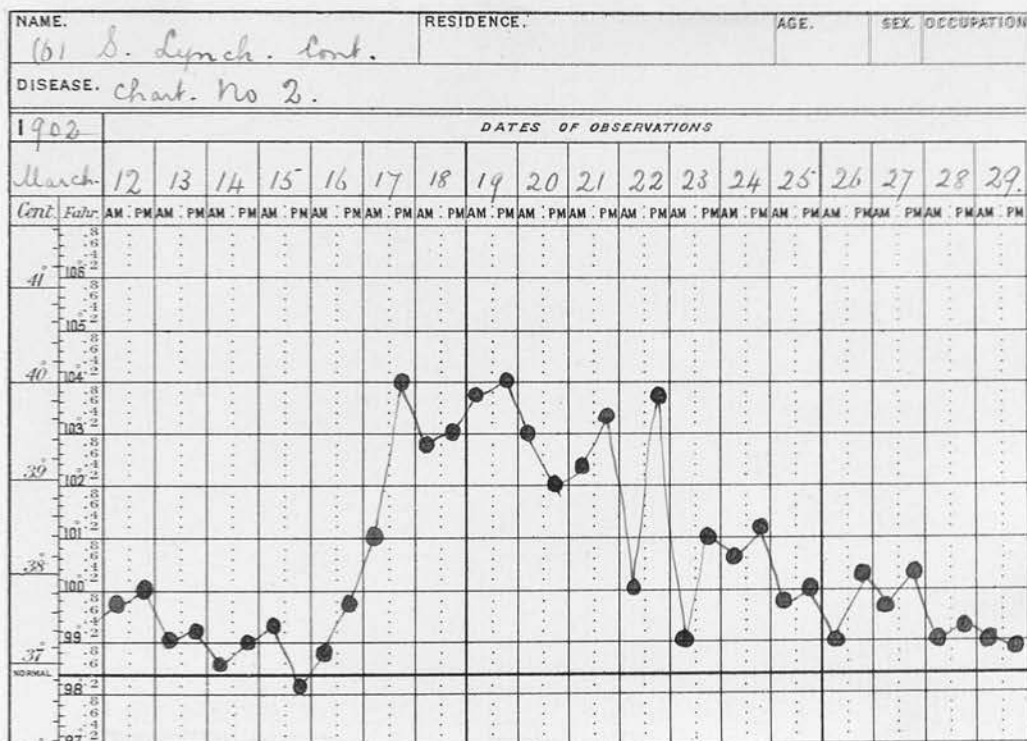
Blood examinations.

March 26. 02. 9 p.m. 2 slides 0.

April 3. 02. 0.

Temperature Charts.





Summary of case:- The patient presented a more or less typical picture of filarial lymphangitis, first evidently of the lymphatics in pelvis and abdomen, then during second attack of lymphatics of pelvis and leg.

There may have been some abscess formation in the abdomen, but if so it had evidently been shut off from the peritoneal cavity, and then either became absorbed or became quiescent. The thickened mass in and above groin was probably glandular and was very likely the seat of the worms.

Though the lower extremities are very frequently attacked by this form of lymphangitis, as the above cases show, yet it is by no means confined to them, the lymphatics in any part of the body being capable of being attacked. Thus we see a filarial lymphangitis of the arms, of the spermatic cord---a very distressing type---and of the abdomen. The last case (No. 6) exemplified this in combination with a limb.

Filarial lymphangitis of the pelvic and abdominal lymphatics, locally known as 'fever and ague of the abdomen' in Barbados, is a very deadly disease and may kill the individual very quickly. If complicated by abscess formation, a quite likely probability, the bursting of this into the general peritoneal cavity would lead to a general septic peritonitis.

(2) Filarial abscess.

In countries where filariasis is prevalent, there are always a large proportion of abscesses occurring to which none of the usual causes can be adduced. Though the filarial abscesses may be situated in any part of the body, the limbs are the most usual site, and on opening them, remains of the adult worms may be found---Bancroft senior, it will be remembered, first discovered the adults in a lymphatic abscess of the arm.

They may be deep seated or more superficial, they generally form somewhat slowly, are not specially painful, and quickly heal up on being evacuated. They are due in all probability to the death of the parent worms and the addition of a staphylococcus or other germ.

(3) Dilated lymphatics in groin &c.

Manson has given the name of varicose groin glands to this frequently seen condition of filariasis. The filariae causing obstruction somehow or other higher up, the lymphatics dilate and so form large, soft, semi-fluctuating swellings in the groins or in Scarpa's triangles. They may also be seen in the axilla. The little dilatations (varicosities) seen on the superficial lymphatics are of different origin in all probability; Maitland has excised some of these and found adult worms in them.

Often mistaken for herniae these dilated lymphatics have been operated on and the mistake only discovered when the escape of a milk like fluid has taken place.

Aspirating such a swelling with a needle one draws off the same fluid (chyle) and in it embryos of the Filaria bancrofti can often be demonstrated.

The following is an illustrative case of the condition I saw in Trinidad.

Case 199. Filaria book. Trinidad series.

November 8. 01. Varicose glands &c.

Emanuel de Freibas. Mulatto. Born in Antigua.

History. Five years ago noticed a soft swelling in left groin, after this had attacks of fever off and on. Worse after walking. Next a similar swelling appeared in rg. groin, soft and boggy.

State on examination. November 5. 01.

Got up all right in morning. About 12.30 (noon) felt pain in right popliteal space. Went on working till 4.30. Pain then became so bad and he felt so feverish and shivery that he stopped work and came to hospital. Glands in the groin during the course of the day became much larger and tender. Condition found. Large boggy swelling in rg. Scarpa's triangle, smaller glands above this. Localised tender lymphatic in right popliteal space, tissues around inflamed and swollen, no other swelling of rg. leg at any other part. Left leg, large varicose lymphatic below Poupart's ligament, one smaller one above this.

After being a day or two in hospital patient's temperature fell quickly to normal, the inflammation disappeared and the swelling of the lymphatics subsided to pretty much the same as he had had before the attack.

Blood examination + Microfilaria bancrofti

8 per slide.

(4) Lymph scrotum.

In this condition the scrotum becomes swollen and heavy, it is usually somewhat smooth to the feel and has a boggy or doughy resistance when palpated. Lymph or chyle may ooze out of it at times and its size varies greatly from time to time. It may be, and often is as a matter of fact, succeeded by the condition of elephantiasis.

Illustrative case.

Case 385. Filaria book. St. Lucia series.

John Floissac. Mulatto, 35. Born Castries, St. Lucia.

History. In youth visited Trinidad, Panama, and some of the other West Indian islands. Fourteen years ago noticed his scrotum began to swell. After this from time to time got attacks of fever, these being associated with marked swelling and bogginess of the scrotum.

State on examination. On February 16. 01, patient noticed what he described as milk coming from the scrotum, and called in Dr. Gray his medical attendant, with whom I saw the case. Condition: Lymph scrotum well marked. Hernia on left side, chylocele on right. Chyle exuding from one or two small fistulous openings on the right side not communicating with Tunica vaginalis. Seen after the attack had quieted down the scrotum had diminished

greatly in size and the chyle had ceased to flow the openings having closed up.

Examination of chyle escaping from scrotum
3 slides no filariae.

Blood examination + a very few microfilarae
present.

(5) Filarial orchitis.

Filarial orchitis is usually found coexisting with other manifestations of the disease, such as lymph scrotum, varicose glands, &c. The testicle becomes enlarged, swollen and hard and there may be lymph (lymphocele) or chyle (chylocele) in the tunica vaginalis. From time to time attacks of lymphangitis of the cord occur and with them vomiting delirium, and rigors are got just as in the similar attacks of the limbs. In a case I saw in Barbados the medical attendant had to give large doses of morphia to alleviate the distressing symptoms.

(6) Chyluria---or Haemato-chyluria.

In chyluria, owing to a rupture of some dilated lymphatic or lymphatics on the inner wall of the bladder, chyle is poured into the bladder and subsequently is passed with the urine, the latter, especially on being voided, resembling very closely the appearance of milk. The attacks are intermittent, long periods being passed with perfectly healthy

urine and no special symptoms. This of course indicates that the rupture of the dilated lymphatic must have healed for the time being or even perhaps permanently. A certain amount of blood is also passed giving the milk like chyle a slightly reddish tint. Filarial embryos may be present or absent in the urine, the same holding good for the blood (vide cases).

Illustrative cases.

(1) Case 542. *Filaria* book. Barbados series. June 1901.

Chyluria:-

Sarah Bennet, 34. Mulatto. Born Barbados.

History. When a girl was some years in Demerara. After that visited different parts of the Spanish Main as a stewardess in the Royal Mail. In January, 1900, noticed urine was like milk, no pain; after this went to England and all the symptoms disappeared. Later got married, and then the chyluria appeared again, becoming much worse after the birth of a child. For the last 6 months she has had it pretty constantly off and on.

State on examination. No signs of any other filarial manifestations, no varicose glands, never fever and ague. When urinating patient complains of an aching pain in lower part of abdomen and in groins. Urine typical, white like milk; on standing

a rose coloured clot appears.

Examination of urine. 3 times examined. No embryos.

Blood examination. 5 night blood slides at different times examined. No embryos found.

(2) Case 75. Filaria book. British Guiana series.

Haemato-Chyluria.

Sarah Brydon, f. 60. Born Liverpool.

History. 5 years ago received a blow on right side. A swelling appeared after this and had to be opened twice. Slight sinus now over lower part sternum to right. $1\frac{1}{2}$ years ago while in British Guiana noticed urine milky and red---this lasted 3 months then entirely disappeared. One month ago had a return, chyle with at times plenty blood colouring urine pure red. At present this prevails. Never fever and ague, never swelling of legs, no varicose glands, rupture once---both sides 30 years ago, now nothing---no glands.

Examination of urine. Not done.

Blood examination + many embryos present as many as 57 in one slide.

(3) Case 9. Filaria book. Barbados series B.

Chyluria.

John Atherley, 70 m. Negro.

History. Ten years ago first noticed urine

milky---this disappeared quickly. Since then the condition has come and gone up to present date.

(October 15. 01). Has had attacks 6 times a year on an average. Not much pain. Lately however attacks have been complicated with retention of urine.

Prostate enlarged. History of 4 attacks of fever and ague many years ago in rg. leg.

State on examination. Old man, now passing milky urine, passed it again twice on following days. Hard swelling behind right knee, no swelling of legs, no varicose glands.

Oct. 20th 01. No recurrence of chyluria. Urine now pure straw coloured, no albumin.

Oct. 21st 01. No recurrence.

Oct. 27th 01. Passed chylous urine this morning. No clots, a little difficulty in making it. No temperature.

Examination of urine. No embryos.

Blood examination Oct. 17. 01. 1 slide 0.

Oct. 23. 01. 4 slides 0.

Temperature Chart.

NAME.		RESIDENCE.		AGE.	SEX.	OCCUPATION									
John Asherly		Barbados.		70	m.	-									
DISEASE. Chyluria															
1901	DATES OF OBSERVATIONS														
October	15	16	17	18	19	20	21	22	23						
Cent.	Fahr.	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
41	106	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	105	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	104	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	103	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	102	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	101	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	99	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NORMAL	98	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	97	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Chylous ascites, chylous pleurisy, chylous diarrhoea and chylocele have also been described. I have not seen cases of the first three but their explanation is the same as for chyluria namely rupture of a dilated lymphatic and escape of chyle into the peritoneal cavity, pleura, or intestinal lumen. In the case of chylous pleurisy the leakage might come from the thoracic duct itself.

B. Elephantiasis.

This late sequel of filarial disease may attack any part of the body, the legs and scrotum being most commonly affected. The arms, scalp, penis, vulva, and mammae do not entirely escape however and pedunculated masses may even grow out from the groins.

Practically all authorities are agreed that elephantiasis follows repeated attacks of filarial lymphangitis (elephantoid fever or fever and ague). Manson ⁽⁴²⁾ for example states "the disease (elephantiasis) commences with a rapidly evolved lymphangitis, dermatitis, and cellulitis, accompanied by elephantoid fever. Occasionally though very rarely, enlargement may progress after one, two, or more initial inflammatory attacks, and without further recurrence of these."

Wilson ⁽⁴³⁾ in Fiji states "In all the cases of elephantiasis a clear and definite history of recurrent attacks of elephantoid fever was given" and again "Elephantoid fever is in my experience an essential condition in the production of true elephantiasis, and it occurs sooner or later in a large majority of cases of varicose groin glands. Daniels refers to cases of elephantiasis without any pain or febrile attacks, these I imagine to be very rare and may possibly correspond with the cases of elephantiasis occurring in non-filarial countries."

My experiences are similar; in the vast majority of cases the usual history is for the patient to have suffered previously with attacks of filarial lymphangitis, a little permanent thickening remaining after each, till a stage is reached when one calls the condition elephantiasis. There is no necessity to record such cases therefore, but those rarer ones, quoted by Daniels and Manson, where the disease goes on after a single attack, or after none at all, without pain, are of extreme interest. Wilson apparently never saw them in Fiji but I was more fortunate in the West Indies as I find I have records of 3 cases in all.

The histories of these are as follows.

(1) Case 2. Filaria book. Barbados series B. Elephantiasis left foot and leg.

Medford 22 f. Mulatto.

History. An attack of fever and ague at 13, left leg, no subsequent ones. When 20 instep began to swell, no special pain and no febrile attacks. Six months afterwards leg began to swell and case developed into an ordinary one of elephantiasis. Quite certain about only having the one attack of lymphangitis.

State on examination. Left leg and foot very big, typical elephantiasis. Dr. Brown operated, taking large slices of the tissue out. The result

was very satisfactory, there being quite a marked diminution of the swelling.

The interest of the case lies in there having been only one attack of lymphangitis.

Blood examination

Oct. 15. 01. 2 slides at
night 0.

(2) Case 12. Filaria book. Barbados series B.
Elephantiasis both legs.

Sarah Willock 70 f. Negress. Born in Demerara
residing in Barbados.

History. Never had 'fever and ague' (filarial lymphangitis). 37 years ago had twins, definitely noticed her legs swollen after this. The swelling always became worse when pregnant and after several pregnancies legs became definitely elephantoid. Swelling not associated with any special pain or inflammation. Absolutely certain about never having had 'fever and ague', never chyluria, never varicose groin lymphatics. Within the last few years swelling has diminished, no ulceration. Patient was admitted into hospital for double cataract and that was how she was seen. She made no complaint about her legs.

State on examination. Right side. Foot slightly elephantoid, well marked sulcus over ankle. Calf very large, thigh also swollen but not so much in proportion to calf. Left side. Foot normal,

calf thickened much less than right. Thigh not thickened, no glands, no other filarial symptoms
 Typical elephantiasis.

Blood examination (night)

Oct. 21. 01. 1 slide 0.

Oct. 23. 01. 3 slides 0.

Oct. 27. 01. No change in legs, no signs of any inflammation, no temperature.

(3) Case 13. *Filaria* book. Barbados series B.
 Elephantiasis rg. foot and leg.

Julia Toppin 30 f. Mulatto. Barbados.

History. No previous illnesses, never 'fever and ague'. Came into hospital complaining of weakness and swelling of rg. leg. Four months ago she felt she was not so strong as usual. Noticed instep swollen one day and this instead of going away gradually became more marked and leg became stiff. Foot then began to swell and also leg below knee. No pain, no inflammation, purely a painless swelling. With this she felt weak, and became tired easily.

State on examination. Early stage of elephantiasis, rg. foot and leg---sulcus over ankle nil, no ulceration or sign of any inflammation, considerable pigmentation dorsum of foot, no glands or other filarial signs.

Blood examination (night)

Oct. 21. 01. 1 slide 0.

Oct. 23. 01. 3 slides + 3 micro-
filaria bancrofti
found.

I have the notes of another case who developed elephantiasis of the scrotum without any history of previous attacks of fever and ague, but after that he did get them.

Case 3. *Filaria* book. Barbados series B.

Elephantiasis of scrotum.

James Potter 48 m. White.

History. In youth healthy, never suffered from 'fever and ague'. 24 years ago scrotum began to swell and gradually began to increase in size, attacks of lymphangitis then became frequent, often great pain in hip running down left leg.

In 1883 operated on, a portion of the scrotum being taken away. After this the condition remained quiescent with few attacks of lymphangitis till 1900 when it began to grow again rapidly, increasing greatly in size. Operated on again 10th October 1901. Growth almost completely removed. Lymphous blood stained discharge for following days. No other signs of filarial disease elsewhere.

Progress. Oct. 18. 01. Wound still open, some
of the stitches having given way.

Very little discharge.

Oct. 23. 01. Wound healing gradually,
temperature now normal.

Blood examinations (night)

Oct. 15. 01. 2 slides 0.

Oct. 23. 01. 3 slides 0.

PATHOLOGY OF THE DIFFERENT FILARIAL MANIFESTATIONS.

The pathology of filariasis cannot be said to have been well worked out, the real cause of this being the difficulty of getting suitable and frequent autopsies on such cases.

Scheube (loc. cit.) in the translation of his 'Diseases of warm countries' 1903 states that to his knowledge there are only reports of four autopsies in the literature. Of course far more autopsies than this number have been conducted on filarial cases---I know of several myself for example---but the fact still remains that few of these have been published, with the result that the literature of the subject remains exceedingly meagre.

Further the subject is by no means an easy one because of several things. (1) Many people, it has been shown in the statistics of the West Indian

islands, may exhibit embryos in their blood, thus clearly indicating that they are infected, and yet exhibit no symptoms of any disease. As to how long this immunity from attack may last, can only be accurately gauged by following up the histories of the cases in detail. Many certainly go on for years without suffering from any disease and if this is so then others may be still more fortunate and escape altogether. On the other hand many undoubtedly do eventually get pathological lesions as the following example shows. When in St. Vincent, West Indies, in October 1901, in my general examination of the population for filariasis I found filarial embryos in the blood of two of the nurses at the Colonial Hospital. In 1908, i.e. 7 years later, I happened to meet Dr. Branch in London one day and during our conversation he mentioned that both these females had developed elephantiasis. Again when in St. Vincent I saw a case of elephantiasis in an old negro with no embryo filariae in his blood; Dr. Newsome however told me that Dr. Manson had found embryos in the same individual's blood in 1894, 7 years before. (These were found in blood films sent by Dr. Newsome to Sir Patrick Manson in London.)

(2) After pathological lesions appear (Filarial lymphangitis for example) it is the common thing for embryos to disappear from the peripheral blood.

Though the explanation of this is not difficult, yet some people can never see how this should be, and therefore at once begin to doubt that the filaria had anything to do with causing the lesion.

(3) In the late sequels of the disease (elephantiasis) the same thing holds good (no embryos in blood) and further similar cases are sometimes found in places where there are no filariae, so the sceptic at once exclaims the filaria must therefore have nothing to do with elephantiasis. Such argument is of course based on an incomplete and faulty knowledge of the whole subject and cannot be taken seriously. The late lesions of filariasis may for explanatory purposes be likened to the late ones produced by the gonococcus. In a stricture of the urethra occurring years after a gonorrhoea one does not expect to find the gonococcus, the cause has long gone but the result remains. So it is with elephantiasis, occurring years after an infection with Filaria bancrofti, the cause---the filaria---has died, but the result, the damages produced to the lymphatics, remain. So again all strictures are not due to antecedent gonorrhoea, a small percentage, 5 per cent. say, may be due to trauma and other causes; just in the same way all cases of elephantiasis are not necessarily due to the filaria, a small percentage, 5 per cent. say, may be due to

prevertebral fibrosis or tumours pressing on the thoracic duct and so on. The proof of the pudding lies in the fact that where filariasis is rare elephantiasis is rare, where filariasis is absent elephantiasis is absent or at most represented by a spurious case from time to time due to some other cause than the filaria.

In the A class of the filarial diseases (elephantoid diseases) the few autopsies that have been done have shown either obstruction of the thoracic duct with dilatation below, or dilatation and varicosity of the duct with no definite obstruction. The changes evidently that may be caused by the adult filariae then are (1) dilatation or (2) by their death inflammation and consequent stenosis with blocking of the thoracic duct or other large lymphatics in which they lie.

In Ponficks case⁽⁴⁴⁾, a patient who had acquired chyluria 18 years before in Brazil, all the lymphatic vessels of the abdomen, and the trunk of the thoracic duct itself, were dilated to about the thickness of a finger. In Mackenzies⁽⁴⁵⁾ case the thoracic duct was obliterated at a certain spot in the thorax, the duct and receptaculum below this being much dilated as were also the lumbar, renal, and large pelvic lymphatics. At the autopsy of a case at the Seamen's Hospital, Greenwich, the thoracic duct was

considerably dilated in the thorax, while below the diaphragm it disappeared into a large hard tumour mass in front of the vertebral column. A similar sort of tumour seemed to occlude it near its opening into the subclavian vein.

In the Charing Cross Hospital case described by Young⁽⁴⁶⁾ extensive lesions were found. This patient had suffered from lymph scrotum and varicose groin glands during life and committed suicide by taking hydrocyanic acid. (This is the same case in which Manson demonstrated the site of the embryo filarie during the day.) The thoracic duct in the thorax was dilated and tortuous, in some places being as thick as a man's finger, in others about the normal size. Its opening into the vein seemed to be patent: there were no signs of the receptaculum chyli but the lacteal vessels were not prominent nor dilated. The spermatic cords contained large numbers of dilated and varicose lymphatic vessels; the inguinal canals were very large easily admitting the passage of three fingers; the femoral and superficial inguinal glands were enlarged and varicose; in front of the lumbar vertebrae was a mass of lymphatic glands and dilated lymphatics 1 foot long, 9 inches broad and 3 inches deep; the kidneys were covered by similar masses, and another large group of varicose lymphatics beginning in the pelvis,

between the bladder and rectum, was connected with the dilated lymphatics coming from the scrotum and formed the chief retroperitoneal mass.

Adult worms were found in a lymphatic vessel in the right groin, and also in both vasa deferentia 6 females on the right side, 6 females and one male on the left side.

The case, from this large number of adults and also from the enormous amount of embryos found in the blood, was evidently one of a very heavy infection.

It is quite clear that the lesions will vary considerably in different cases of this type, these being dependant largely on the number of adult worms present, the site in which they are lying, and the amount of stenosis and inflammatory change they have produced.

More difficult of explanation is the Pathology of cases of Filarial lymphangitis. It has already been noticed that the leg is a very common situation for this complaint and it is exceedingly likely that the parent worms in this instance are situated in the lymphatic vessels near the groin glands. Probably their death is responsible for the first step in the production of the lymphangitis, organisms of the streptococcus group supplying the second and later ones. Against this, however, is the fact that when once one has had an attack, relapses are very likely

to follow, and it is hardly fair to assume a death of worms for each of these each time. It may be that on account of the original death and inflammatory trouble some permanent blockage of the lymphatics results----this being borne out by the disappearance of embryos from the blood---and that subsequent attacks are purely streptococcal in their nature. Autopsies are about the only way by which one will ever be able to advance the subject, ^{but} as such cases rarely die at this stage there is not much hope even in this for the future.

As previously stated elephantiasis is usually the result of repeated attacks of Filarial lymphangitis, and the explanation of the one is necessarily therefore that of the other. Manson's original idea was that the adult worms when damaged aborted, eggs being voided instead of embryos, and the greater breadth of the former was responsible for a wholesale blockage of the glands and lymphatics of the part. It is difficult to prove this, quite as much as a matter of fact, as it is to say that the death of the worms without abortion starts primarily lymphangitis and elephantiasis. Post mortems may not help much when the elephantiasis is of long standing, the cause has long disappeared only the results remain. Apart from the usual pathological lesions of thickening, hypertrophy, and solid oedema, I have found nothing

to account satisfactorily for the condition of elephantiasis in four elephantiasis legs I have dissected.

Everyone is now perfectly satisfied that the filaria per se does not cause elephantiasis, organisms must also help and of these the streptococcus is the one most likely to assist. The absence of embryos from the blood in elephantiasis is easily explained by the pathological lesions found, the adults are long dead and there are no embryos therefore to find their way into the blood. In heavily infected countries it is quite feasible that such a case should get reinfected with filaria---the adults inhabiting some lymphatic in a different part of the body---and in that case embryos will again appear in the blood. I have noted this in several instances in St. Kitts.

One must leave the pathology of elephaniasis and some of the other filarial manifestations, therefore, admitting that the subject is by no means settled and that extended work is urgently required for the solution of the different problems presented.



Fig. 24. Section of lymph scrotum x 160.



Fig. 25. Section of elephantiasis skin and subcutaneous tissues x 45.

IV. PROPHYLAXIS OF FILARIAL INFECTIONS DUE
TO FILARIA BANCROFTI.

In discussing the diseases produced by the Filaria bancrofti nothing was said about treatment. As a matter of fact, apart from treating symptoms as they arise, little if anything can be done to mitigate the disease and anything in the way of a cure is not to be hoped for.

Of course in the case of an individual with elephantiasis of a foot and leg amputation will remove the growth, and if no recurrence takes place in the stump, a useful enough life is before the patient. The same may be said of elephantiasis of the scrotum, the removal of such a condition again often eventuating in a more or less normal life for the future, but on the whole there is no malady to which the motto 'Prevention is better than cure' better applies than to this.

Such being the case, all our efforts should therefore be directed to the prevention of infection by the Filaria bancrofti, and as the parasite has to pass through two cycles, one in man, the other in the mosquito, it is thus rendered more vulnerable to attack. So far there is little hope of attacking the worm when living in the human body, no drug being known that will kill it without harming the host, but if its intermediate host is removed, i.e. if a link of

the chain of its cycle is taken bodily away then further development is impossible and the life history of the parasite must come to an end. The prophylaxis will therefore be, as in malaria, a war against and a general destruction of mosquitoes, so that there will be no longer any suitable intermediate hosts left, but before this millenium is reached, a further step, and that a very useful one, will be the protection of individuals harbouring embryos in their blood, by mosquito nets, this procedure preventing any stray mosquitoes becoming infected and so harmful to the general population. The prevention of the disease--- and I say this after a large experience---is simple, not only theoretically but practically.

The dangerous class of case to the community at large is very often not the one that exhibits pathological symptoms, as in almost all cases of elephantiasis, and in many cases of filarial lymphangitis the embryos have gone from the peripheral blood, but the one that may exhibit no definite symptoms at all, though being infected and having abundant embryos circulating in his peripheral blood by night. The only way of determining who is, or who is not, dangerous, as has already been stated, is by making a census and night blood examination of the people living in the town or district. It is clear

that all such (cases with embryos in blood) may spread the disease to other people in the same house and vicinity---not directly of course, but by infecting the special species of mosquito which is efficient to allow of the development taking place in it. These infected mosquitoes live and frequent the house, biting fresh people every three days or so; and, eventually, when the parasites have arrived at maturity and are situated in the proboscis reinoculate the original person again, or inoculate fresh individuals.

Filarial prophylaxis may be conveniently divided then into (A) Personal prophylaxis and (B) General prophylaxis.

(A) Personal prophylaxis. As a means of personal prophylaxis everyone either visiting or residing in a tropical climate should always sleep under a properly applied mosquito net.

The visitor will not be bitten and so will escape the chance of suitably infected mosquitoes inoculating him with the filaria, while the resident, if he should happen to harbour embryos in his blood, will not infect mosquitoes, or conversely if he is free, will not be bitten and therefore will remain so.

It is astonishing how few of the residents of Barbados and some of the other West Indian islands use mosquito nets, this omission resulting in many of them

becoming infected with filariasis, and often suffering from one or other of the diseases produced by this parasite.

While in Barbados and St. Kitts I had the chance from time to time of questioning many of the better class white people who were infected and the general answer to my question "Do you sleep under a mosquito net?" was "No, they are too hot and stuffy and besides mosquitoes never bite me." The proof of course that they do bite them is that they are infected, and I remember in St. Kitts that in 5 instances, where mosquito nets were always properly and carefully used, in none of these was any infection found.

The non use of nets is really a matter of carelessness and lethargy, a disease which is so apt to appear in people permanently residing in these tropical parts, and this is aided by the fact that though nightly bitten by mosquitoes, very little irritation or mark is left on their skins, a gradual immunity to the effects of the bites evidently being obtained by prolonged residence in the climate.

Mosquitoes bite anyone, negro, coloured, or white; they seem to prefer newcomers but that perhaps is more apparent than real, owing to the marks and irritation they leave behind them on the skins of such people. I used a negro for infecting my mosquitoes experimentally,

there was no trouble about them biting him, and in the same way if one put up a faulty curtain over a negro, mulatto, or indigenous white, in a hospital, one can collect innumerable mosquitoes gorged with blood next morning. Granting then that mosquitoes are about, every one is liable to be bitten by them, and there is not the slightest doubt that a much more careful use of this easy means of personal prophylaxis for the wealthier classes, certainly in the West Indies and Fiji, and quite likely in other parts of the world, would not only help to diminish the disease but also would prevent much of the useless suffering undergone by so many of these people.

Such a method of prevention, though manifestly of great use to the individual, and clearly also of the greatest value in preventing to a large measure other tropical maladies such as yellow fever and malaria, is after all only palliative and is useless for the bulk of the native population who would never adopt it. It does not strike at the root of the evil; the real crux of the question must turn on the destruction of the intermediate host---the mosquito---without which the disease cannot go on. This leads us therefore naturally to---

B. General prophylaxis, (destruction of mosquitoes).

It has been shown previously that Filaria

bancrofti may be carried and transmitted by several kinds of mosquito, anophelines as well as culex, but though the former class may be harmful as far as country districts go, it is of little importance as regards the spread of the disease in towns as in the majority of these no anophelines exist. (Barbados is a good example of this, no anophelines in Bridgetown, the main town, nor as a matter of fact in the island either.)

Undoubtedly the commonest host for this filaria is the common house or domestic mosquito the Culex fatigans and the war of extermination must therefore be waged against it. Of course one does not suggest that anophelines should not be destroyed; their destruction however is more concerned with the prophylaxis of malaria, and if that is being energetically carried on by any individual colony or place then the chance of them acting as filaria carriers is also suitably dealt with.

Further, as the habits and breeding grounds of Stegomyia calopus (a non efficient host for F. bancrofti but the carrier of yellow fever) are identical in many instances with those of C. fatigans the means adopted for the destruction of the latter will equally apply to the former and we will thus kill two birds (Filarissis and Yellow fever) with one stone, a great saving of expense and labour.

Before one can start such a campaign, however, a general knowledge of the life history of these domestic mosquitoes (C. fatigans and S. calopus) is essential, so I shall here describe the conditions found in the West Indies, and my remarks on the prophylaxis must be understood to refer to these islands, though of course there is no reason why they should not, with slight modifications, apply to other parts of the world as well.

Description of Culex fatigans.

Culex fatigans, the common domestic mosquito of the West Indies and other parts of the tropics, is a small brownish-yellow insect, the males being harmless; i.e., not biting and being readily distinguished by their more slender build and feathery antennae. It is essentially a domestic or house mosquito, its whole life history being passed in or around the house in which it happens to be born. Nocturnal in its habits, it sleeps by day in the darkest part of the room it can find, but as soon as the shades of night descend, it becomes active once more and sallies forth for the evening meal. Just after the sun has set its presence near one can readily be detected by its humming or piping noise, and then after this preliminary notice the next thing that happens is that it gently lights on some exposed

part, inserts its proboscis (which feels like the prick of a needle) and sucks up (if not disturbed) its fill of blood. After this, gorged and heavy, it rises slowly, retires to some quiet spot to rest, remains more or less torpid for the next day or two till its meal is digested, and then is ready to start afresh.

The eggs in the ovaries now enlarge rapidly, making the abdomen look swollen and white and the impending mother seeks any artificial collection of water (tanks, water-barrels, wells, tubs, cisterns, gutters, broken bottles, or empty tins) usually found about the house or compound to deposit them on. In the species under consideration they are laid stuck together in boat or raft shaped masses, each egg in about two days giving rise to a small larva which escaping into the water swims about there, growing rapidly and feeding on the animalculae and other organisms found in that medium. The larvae breathe by a long tube at the posterior end of the body (the respiratory syphon) and the position of this structure compels them to hang head downwards or at an angle to the surface of the water so that the tip of the syphon may come into contact with the atmospheric air. Oxygen is essential to them and this explains how when we put kerosene or petroleum on the water (these substances form an impenetrable layer on the surface of the water) they no longer get this and die (are

drowned really) as a result.

Growth, provided there is plenty of food and the temperature is high, proceeds rapidly till in 12 to 15 days it is complete and then the larvae change into the next stage of their life history, namely the pupa or chrysalis. This is a resting stage; they cease to feed and the respiratory syphons or breathing tubes become altered in position now being found on the dorsum of the thorax. In two days or so the skin splits down the back of the pupa and the imago or perfect insect emerges. After resting for a minute or two on its cast of case to allow its wings to dry, it flies away and commences its life. The young females are quickly fertilised by the males, after that they (the females) suck blood, their eggs develop and so the cycle of their existence goes on.

The destruction of mosquitoes. (Culex fatigans and Stegomyia calopus.)

The easiest and most effective way of destroying these domestic mosquitoes, or as a matter of fact any mosquitoes, anophelines included, is to strike at their larval stage, i.e. the stage when they are living in the water. A certain amount of good may accrue in slaying adults, and that especially so if we know they are infected, but in the time we are accounting for 20 or 30 of them say we might by

upsetting a tub of water kill 5 or 600 larvae, therefore manifestly the latter method is the one to employ.

To diminish or to completely eradicate mosquitoes, then, from a house, by striking at their larval stage, several ways are open to us: Firstly, either to have no collections of water for them to breed in: secondly, if such collections are a necessity, to cover them in such a way that the insects cannot deposit their eggs on the water contained in them: thirdly, to render the water harmful to them so that if they do lay their eggs there, these, and the subsequent larvae they give rise to, will quickly be destroyed.

(1) The first method is undoubtedly the most efficacious and it is the one to aim at where practical. In several places, Barbados and St. Kitts for example, there are now first-rate and abundant water-supplies laid on by pipes, and as the water can be drawn in public places at stand pipes by the inhabitants there is no longer any reason for water-barrels, wells, tanks or other collections of water existing. Of course,---and this is a point on which too much stress can never be laid,---if the removal of stray collections of water is to be of any advantage to the public at large then the action must

become a general one, insisted on by laws passed by the respective governments. In 1900, in conjunction with Sir Frederick Hodgson, the then Governor of Barbados, I proposed such bye-laws for that place but the time was not yet ripe for such advanced views and the bill was thrown out by the local House of Parliament. More recently, however, the presence of yellow fever in that colony and some of the other West Indian islands has opened the eyes of the inhabitants to the dangers of breeding mosquitoes, and suitable bye-laws have now been passed and are being stringently enforced.

It is outside the province of this thesis to enumerate the splendid achievements of the Americans in Havana and Panama in stamping out yellow fever by the destruction of the Stegomyia calopus. Indirectly of course they affect filariasis as millions of C. fatigans must also have been destroyed, and the same holds good for malaria, vide Sir Rubert Boyce's recent book 'Mosquito or Man'. (47)

My own ideas as to the removal of all useless collections of water such as wells, broken gutters, drains, water-barrels, broken bottles, and kindred others, is that the householder should be compelled to do the work under the supervision of the Sanitary Inspector or his subordinate officers. I would have the Sanitary Inspector supreme in this work just as

he is in ordinary sanitation, and he could be controlled of course by the Medical Officer of Health for the place.

Common work such as finding larvae, emptying water butts, and cleaning drains, &c., is not the work of highly trained medical officers any longer; they shewed originally how to do it and explained how it affected the mosquito life, having done this less highly trained people can now take their place.

Properly carried out, the removal of all exposed waters outside any tropical house, will quickly render it proof against the attacks of the domestic mosquitoes, and if one's neighbour over the wall is doing the same then there should be few if any mosquitoes about.

(2) Having indicated how towns with proper water supplies should be treated, one must now pass to less favourably situated places where such conditions do not exist. The main difficulty will always be the storing of the drinking water, this usually being done in tanks of various kinds, in wells, or other receptacles.

Whichever method is adopted, tightly fitting covers, wooden or or metallic gauze, must be applied so as absolutely to prevent any mosquitoes getting access to lay their eggs in the water. That such a

procedure is quite feasible and not of superhuman difficulty was shown by the protecting of all the large water tanks in the military territory in St. Lucia, West Indies, an experiment which I had the good fortune to witness. The results obtained were excellent and larvae disappeared from them.

The chief trouble is, of course, to have the lid so tightly fitting that a small creature like a mosquito cannot enter and this, one admits, in many instances is difficult.

Another class of water that might come under this category, is tanks and other artificial collections that are often kept in gardens for watering the plants. In many instances these can be quite easily protected and so mosquitoes kept out, or if not they may be dealt with in another manner as follows:-

(3) Rendering the water harmful to mosquitoes is a method that has its uses. This is usually done by (A) putting one or other chemical substance in the water, which may act by keeping air from the larvae, or by directly poisoning them, or (B) by keeping fish in the water, these feeding on the larvae and eggs of the mosquito.

(A) Petroleum, kerosene, and similar substances have been used with considerable success. They act by forming an impenetrable layer on the surface of the water through which the mosquito cannot breathe,

death taking place as a result. They are specially useful for outdoor collections of water on a large scale, such as ponds, marshes, ditches, &c., but they are also good for drains, and other waters that are difficult to get at. Their use is only temporary, however, and their constant re-application is necessarily costly.

Poisonous chemical substances (Carbolic, Jeye's fluid, Lysol, &c.) are of very limited use, as they cannot be employed in waters where there are fish or other life nor in waters used for plants. They are good for privies, stable drains, water closet drains, and such like accumulations.

(B) Fish.

When in Barbados I found it was a common habit amongst the well-to-do people to keep tubs of water in their gardens for growing water-lilies in, and one gentleman told me that he always kept minnows in his and as a result never saw any larvae. He very kindly showed me his tubs and I found no larvae, while on procuring some of the latter from another source and introducing them beside the minnows they were at once seized and eaten. I found later that gold fish also eagerly feed on the same food and I completely eradicated all mosquito larvae from a large fountain in a garden by introducing four of this kind of fish.

The keeping of fish, therefore, affords us an easy and ready means for destroying mosquitoes in certain varieties of water which it would be difficult or inconvenient to absolutely do away with. Collections such as ornamental fountains, large tanks, tubs for growing water-plants in, may therefore be allowed provided minnows or gold fish are kept in them.

In addition to these three main measures indicated above, subsidiary ones will be found requisite for different places. Privies, catch-pits, and old wells abound in all West Indian towns and villages, affording countless breeding grounds for many mosquitoes. These are excessively insanitary and should be replaced by modern inventions or done away with.

From what has now been said it is clear that the destruction and consequent reduction of the filarial mosquito,---and with it of course the disease to which it gives rise,---is by no means a difficult task.

If domestic mosquitoes are found in any given house then it means they are breeding somewhere in the vicinity and all that is required is to find the collection of water and deal with it in one of the ways described above. General action on such lines must enormously reduce the number of mosquitoes and with their reduction the chances of so many getting infected in the future must be greatly curtailed.

It is not as if we were working in the dark; the

form of filariasis due to the Filaria bancrofti and the way it is spread is known from beginning to end; we further know that the dangers of such an infection may be great and if symptoms exhibit themselves the chance of cure is practically nil. All this being so, and knowing as we do how easy it is to cut the chain of the cycle and so bring the disease to an end, it is surely not too much to expect that the governments of the countries interested should attempt as far as it lies in their powers to free themselves from this loathsome and disgusting disease, one which is largely responsible for filling their almshouses and other charitable institutions, and which brings much useless suffering to many of those unfortunately affected by it.

Perhaps in the past the diseases produced by this filaria have been overshadowed by the importance of yellow fever and malaria, but now that the subject has been more prominently brought before the public, and after all as all three depend for their continuity on the mosquito, it is to be hoped that in the course of the next five years or so a distinct reduction in the number of cases of filariasis will have taken place, a reduction comparable with that seen in both the diseases mentioned.

FILARIA LOA.

i. Geographical distribution.

The geographical distribution of this filaria (F. loa) is, as far as our present knowledge goes, a very limited one, its habitat being a small part of the West Coast of Africa somewhere or other in the vicinity of the equator. It is best known probably round Calabar in Southern Nigeria, but has also been found in Lagos which has now been incorporated with Nigeria, in the German Cameroons and, in parts at least, of the French and Belgian Congos. I do not think it is known on the Gold Coast, and I have not heard of it further north in Sierra Leone or the Gambia. It does not exist in Uganda or British East Africa as I specially searched for it there and entirely failed to find it.

Doubtless if more extended observations were carried out as to its range, this would be found to be more extensive than at present depicted, but even then it apparently will never be a large one.

Outside of the West Coast of Africa no such parasites have ever been found as far as I am aware.

ii. Life history and biology.

The adults of this species have long been known. According to Braun,⁽⁴⁸⁾ Pigafetta first brought them

into notice in 1598, then Bajon saw them again in
Negros in Guiana (slaves from the West Coast) in 1768,
then Mongin in Mariborou in San Domingo in 1770, then
Guyot, a French ship's surgeon, on the West Coast of
Africa in 1778, the latter giving them the name
'Filaria loa' which has remained till this day.

There is no doubt that the fact of these worms
crossing the conjunctiva from time to time was what
led to their being recognised in such early times,
such a journey having so much of the supernatural and
novel about it as at once to attract attention.

Description of adults:-

From time to time I have examined adult Filaria
loa sent to me from Nigeria, but as I have nothing to
add to previous descriptions of them, I shall condense
my remarks and simply give a summary of the leading
points of their anatomy.

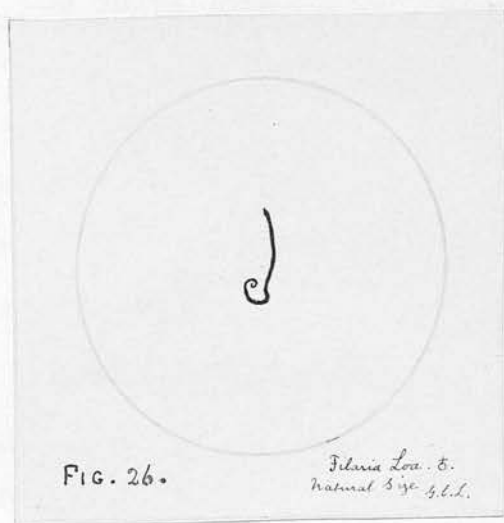


FIG. 26.

*Filaria Loa. ♂.
Natural Size 3/100.*

Both sexes are typically filarial, being filiform, cylindrical, of a white colour, and with a tapering away at the tail end. Both are broader than the corresponding adults of Filaria bancrofti but much shorter. They most closely resemble cat gut. Minute chitinous nodules or bosses are scattered over the cuticle and this feature at once tells them from the other human filariae.

The male measures 20 to 30 mm. long by 0.3 to 0.4 mm. broad, its chief diagnostic characteristic being its incurved tail; at the side of the sub terminal anus are 5 papillae on each side, three in front of the anus, two behind, all of these being of different sizes. Two slightly unequal spicules protrude from the anal orifice.

The female measures 30 to 40 mm. in length by 0.5 mm. broad, the anterior end is conical, the posterior end rounded, the vulva lies at the level of the first and second fourths of the body, a long vagina leads to the uterine apparatus which posteriorly contains eggs, anteriorly larvae or embryos.

These are enclosed in sheathes, have sharp pointed tails, and to all intents are identical with microfilaria diurna embryos.

Habitat of the adults.

The parasites live in the subcutaneous tissues and

deeper connective structures and can locomote from place to place with rapidity and ease. In so doing they may come near the eye and then may pass across the front of the orbit, being then quite visible under the conjunctiva. Unless fixed at once with forceps they quickly pass over and disappear, and then may leave this district and go off to somewhere else.

In other instances, however, apparently the same worm may stay for several days in the vicinity and may even be seen under the conjunctiva once or twice before its capture. Their numbers will vary in different cases depending on the primary infection and chances of reinfections; in one case dissected by Professor Wurtz in Paris dozens were removed, most of these being found in the connective tissues immediately under the skin. Breeding, when mature males and females are present, goes on and the embryos are thrown out into the tissues; from here they must escape from the host in some way or other and the most feasible explanation is that they are collected in the lymph and so carried to the blood, where they circulate, and then eventually are removed by some suitable intermediate host.

If we accept this explanation then we must admit the presence of embryos in the blood---not necessarily always---but certainly at times, and these embryos must of course be identical with ones taken from the uterus of the mature Filaria loa females.

The proof is almost sufficient now that the embryonic forms found in the blood by day in cases from Southern Nigeria and adjoining parts (Filaria diurna) answer this description and they are consequently now described as the young forms of Filaria loa.

Description of embryos.

Some three years ago I worked at the question of the identity of Filaria diurna with the young of Filaria loa and I am at present again investigating the subject afresh, especially with reference to the part the adults play in the production of disease. None of these observations have so far been published and though some of my latter researches are not complete yet I think it will be best to narrate them now so as to make the subject as exhaustive as possible.

(a) Embryos of Filaria loa.

Dr. Currie of Lagos very kindly sent me some mature forms of Filaria loa and two of these being mature females with the anterior part of their uterine apparatus packed with fully developed embryos, plenty of material was quickly available by simply rupturing the worms with a needle.

I measured large numbers of these and though a slight fallacy may have crept in, owing to shrinkage from the preserving material, yet the results must be looked upon as approximately correct. Out of 40

measured the average length came as 0.245 mm. with a breadth of .0075 mm. Full sized eggs were .0425 mm. long by .0330 mm. broad. Braun (loc. cit.) gives the following measurements. From 0.253 to 0.262 in length by .0047 to .0050 mm. in breadth. He does not state where his material came from nor who made the measurements, but manifestly though the length is pretty nearly correct the breadth is impossible, such a diameter being on a par with that of Filaria perstans, a very much smaller and finer worm.

The embryos as expressed from the uterus are sheathed, have sharp pointed tails, exhibit a break in the continuity of the cells, and show the usual nuclear column of cells.

In many of my specimens a line seemed to run from the cephalic end of the sheath to the extremity of the head, but whether this was an artifact or not I could not absolutely determine. I rather incline to the view that it is now.

The features of embryos expressed from the uterus of the female Filaria loa then are: Sheathed embryos, with sharp pointed tails, measuring (average) .245 of a mm. long by .0075 of a mm. broad.

(B.) Microfilaria diurna, (? microfilaria loa).

In 1891 Manson twice encountered in Negroes a blood filaria, according to him, with the same dimensions and anatomical characters as far as he

could make out of the Microfilaria bancrofti. It differed however from the latter in coming into the blood during the day and disappearing by night, this periodicity being thoroughly made out by prolonged observation in one of the cases. One of the cases came from Old Calabar, the other from the Congo, and one had had some years previously a Filaria loa in one of his eyes.

This combination of circumstances made Manson suspicious that he might be really dealing with the embryonic form of the sexually mature Filaria loa and he advanced this view merely as a conjecture. Since that time many more cases have been seen and studied and everything has gone in favour of Manson's original view being the correct one. There is not the slightest doubt about this at any rate, that there is a blood filaria found in Nigeria, the Congo, Lagos and adjoining territories---i.e. in exactly the same places where Filaria loa occurs---which has an entirely different periodicity to the embryos of Filaria bancrofti and which as I shall show presently also differs anatomically in certain important details from that parasite. (This point has not been previously noted by any observer as far as I am aware.)

Lately a good deal has been said about Filaria bancrofti embryos occurring in the blood during the day in Fiji, the Philippines and other places, Lynch⁽⁴⁹⁾,

Wilson⁽⁵⁰⁾, Brunwin⁽⁵¹⁾ having noted this for the former place, Ashburn and Craig⁽⁵²⁾ for the latter. Others have noted it in other places and I have seen such cases in British Guiana and the West Indies. Whether this means that these embryos represent different species or whether it only indicates some abnormality in the periodicity---which of course is very regular in some instances---is open to argument, but this much is certain that they have nothing to do with the Microfilaria diurna and it is absurd talking of them as such. The latter, as far as we know, has a regular diurnal periodicity, the cases from Fiji and elsewhere, just mentioned, show no periodicity, numbers of embryos occurring irregularly in the blood by night as well as by day, the normal sequence of events in the case of Filaria immitis of the dog.

Morphology of Microfilaria diurna: (embryos from peripheral blood). I have had many opportunities of examining such embryos both living and dead, and as I shall show immediately I am convinced that their measurements are different from those of the Microfilaria bancrofti. The case in which I chiefly studied them---it will be described with other cases in detail later---was that of a missionary, a Mrs. M. from the French Congo. She had had Filaria loa extracted from her on different occasions and her blood was teeming with a microfilaria which appeared

regularly by day and disappeared entirely by night.

These diurnal microfilariae measured---the measurements have been confirmed by myself several times on authentic examples of the same parasite--- from .210 mm. to .280 mm. in length (average .240 mm.) by .0070 mm. to .0075 mm. in breadth, the V spot being situated .060 to .073 mm. from the head (all measurements on living specimens), the break in the cells .042 mm. from the same point (stained specimens).

Comparison of the embryos of Microfilaria diurna with those of F. bancrofti and loa.

A comparison of these measurements with those of a series of Microfilaria bancrofti show at once a marked difference. Bancrofti embryos run from .280 mm. to .320 mm. in length, a fair average being .317 mm. with a breadth of .0075 mm. A very short Bancrofti might therefore just equal the longest diurna, but if we take the average then it is at once evident that the latter is a shorter worm altogether. On the other hand a comparison of the measurements of the Microfilaria diurna with embryos squeezed out of the uterus of Filaria loa show an identical measurement, e.g. an average length of .240 or .245 mm. with a similar breadth (.0075 mm).

As regards other anatomical points one must admit that these very closely resemble each other in all three. Diurna embryos have a long sheath, a cephalic

armature consisting of a fang and serrated prepuce, a V spot, a tail spot, a central column of cells, and a striated musculo-cutaneous layer. In specimens stained with haematoxylin the nuclear column of cells appears very distinctly, there is a break in the continuity of the cells anteriorly and the tail ends in a sharp point. Loa embryos have a similar anatomy, the only points I am uncertain about, being the cephalic armature, the V, and tail spots, as I have not had the opportunity of examining the worms alive---a necessity in making these out. Bancrofti embryos it will be remembered show the same points as those just described for diurna.

Summary:-

To summarise therefore. Microfilaria diurna is not the same as Microfilaria bancrofti, it is a shorter worm though it resembles it closely in other points. It is exactly similar to the Microfilaria loa corresponding absolutely in length and other points, and therefore unless we can presuppose different parental worms producing absolutely identical embryos we must conclude that the two are one and the proper name to adopt will be the Microfilaria loa.

Subsidiary evidence of the identity of the two is forthcoming in the identity of the geographical range, the only point that is not quite clear being the fact sometimes noticed of persons with undoubted Filaria loa

in their systems not having diurnal embryos in their peripheral blood. Such discrepancies might be explained away in many ways.

The adults might not be sexually mature and therefore would not be giving birth to embryos, or again it is possible that the females breed only at certain times of the year, or lastly one might only be infected with a few worms and these might all be males. Whatever the explanation, about an equally large percentage of cases have now been accumulated which have shown the double infection, and this percentage might quite easily be raised if cases were examined over long periods of time.

Periodicity of the *Microfilaria loa*:-

In the case of "Mrs. M." already mentioned, the microfilaria in the peripheral blood kept a very regular periodicity, swarming in the blood by day and disappearing by night. This, tested on several occasions was constant, and therefore it became of interest to see, if the habits of the patient as to sleeping and waking were changed, whether the periodicity would change, as Mackenzie and others had found it did in the case of *Microfilaria bancrofti*. The blood was carefully tested for a few days, then the experiment was started by the patient entirely changing all her habits, e.g. she stayed up and worked all night, sleeping all day from

9 a.m. to 9 p.m. Though a few embryos then appeared in the blood at nights all our attempts failed to check the usual periodicity and the maximum number of embryos occurred as usual at 12 midday or 3 p.m. Apart from this being of interest, the point would seem to be of diagnostic value in differentiating the embryos of this filaria from those of Bancrofti, as in the cases where periodicity is exhibited by the latter, it can very easily be inverted or broken by changing the habits of the patient.

Records of experiments.

Table I. Mrs. M. Case of Filaria loa with diurnal embryos in blood. Enumeration of these embryos in measured quantities of blood every three hours while patient was leading an ordinary life.

Date.	Hour	Number of embryos in 20 cmm. of blood	Remarks
Oct. 11.04	12 noon.	77	
-	3 p.m.	110	
-	6 p.m.	58	
-	9 p.m.	4	
-	12 mid.	0	Ordinary habits of life.
Oct. 12.04	3 a.m.	0	
-	6 a.m.	0	
-	9 a.m.	26	

[Table I. continued.]

Date.	Hour.	Number of embryos in 20 cmm. of blood.	Remarks.
Oct. 12.04	12 noon.	92	
-	3 p.m.	82	
-	6 p.m.	45	
-	9 p.m.	3	
-	12 mid.	0	
Oct. 13.04	3 a.m.	0	
-	6 a.m.	1	
-	9 a.m.	42	
-	12 noon.	75	

Table II. Mrs. M. Case of Filaria loa with diurnal embryos in blood. Enumeration of embryos in measured quantities of blood every three hours while patient's habits of life were totally altered, e.g. sitting up, working, and eating by night, sleeping by day. Stayed up and worked all night on the 13th and 14th of October, went to bed 7.30 a.m. on morning of 14th. Afterwards went to bed 9 a.m., got up 9 p.m.

Date.	Hour.	Number of embryos in 20 cmm. of blood.	Remarks.	
Oct. 14.04	12 noon.	126	Sleeping.	
-	3 p.m.	123		
-	6 p.m.	47		
-	9 p.m.	1		
-	12 mid.	0		
Oct. 15.04	3 a.m.	1	Up and about writing and sewing.	
-	6 a.m.	4		
-	9 a.m.	70		
-	12 noon.	101		
-	3 p.m.	65		
-	6 p.m.	32	In bed sleeping.	
-	9 p.m.	2		
-	12 mid.	1		
Oct. 16.04	3 a.m.	4		Up.
-	6 a.m.	9		
-	9 a.m.	20		
-	12 noon.	65		
-	3 p.m.	42		
-	6 p.m.	17	In bed sleeping.	
-	9 p.m.	1		
-	12 mid.	4		
Oct. 17.04	3 a.m.	10		Up.
-	6 a.m.	42		
-	9 a.m.	92		

[Table II. continued.]

Date.	Hour.	Number of embryos in 20 cmm. of blood.	Remarks.	
Oct. 17.04	12 noon.	110	In bed sleeping	
-	3 p.m.	105		
-	6 p.m.	31		
-	9 p.m.	4		
-	12 mid.	0		
Oct. 18.04	3 a.m.	10	Up.	
-	6 a.m.	25		
-	9 a.m.	113		
-	12 noon.	120		
-	3 p.m.	74		In bed.
-	6 p.m.	32		
-	9 p.m.	15		
-	12 mid.	9		
Oct. 19.04	3 a.m.	10			Up.
-	6 a.m.	18		
-	9 a.m.	68		
-	12 noon.	131	In bed.	
-	3 p.m.	85		
-	6 p.m.	30		
-	9 p.m.	7		
-	12 mid.	9		
Oct. 20.04	3 a.m.	8	Up.	
-	6 a.m.	35		
-	9 a.m.	62		

[Table II. continued.]

Date.	Hour.	Number of embryos in 20 cmm. of blood.	Remarks.
Oct. 20.04	12 noon.	130	
-	3 p.m.	70	

It will be noticed that some embryos did appear in the blood by night after the habits were changed, but the periodicity went on unchecked as a whole.

The following charts shew the results of the tables at a glance, the last two days of Table 2, October 19th and 20th, as they shew nothing further, being omitted.

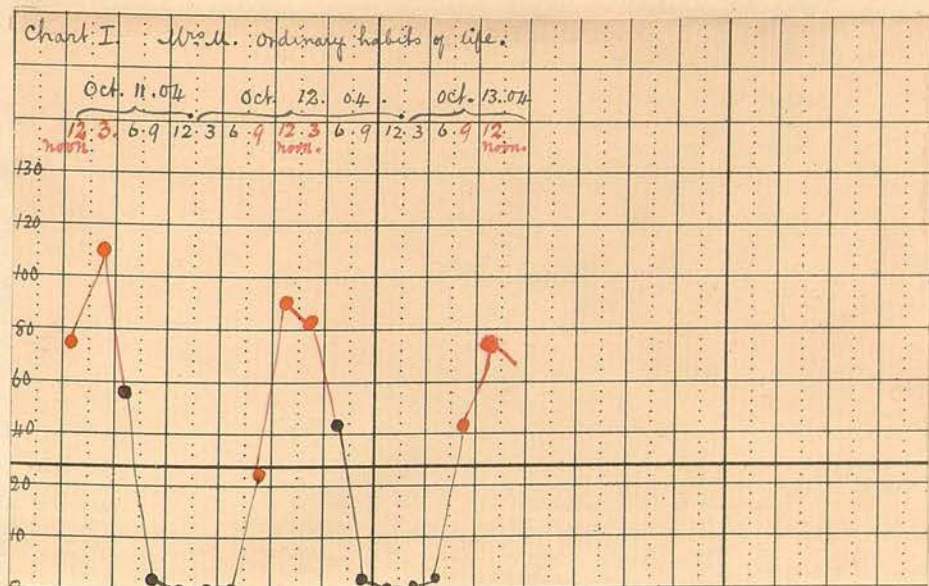


Chart I. Mrs. M. Ordinary habits of life.

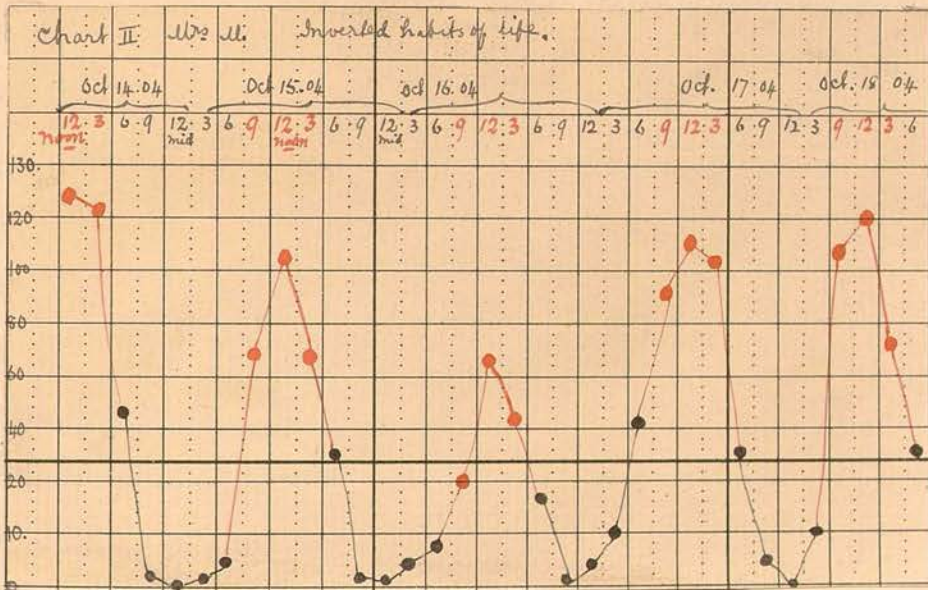


Chart II. Mrs. M. Inverted habits of life.

One case is perhaps not enough to generalise on so I hope in the future to get others who may be willing to submit themselves to the discomfort of being pricked every three hours, and to the worse discomfort of sitting up all night and sleeping all day for 5 or 6 days at least.

Diagrams of Microfilaria loa from the peripheral blood.

In studying a case with embryos of Filaria loa in the peripheral blood, when one is daily staining large numbers of specimens, one sooner or later comes

to agree with the idea, first I believe brought forward by Manson, that the embryos in dying take up a different position to the usually spirally coiled one adopted by the Microfilaria bancrofti. So striking is this, that without undue boasting, I now feel more or less confident, that in specimens stained by my own method, I can tell which of the two embryos I am dealing with. I admit this takes a considerable amount of practice, but still I am certain the difference exists. Two further points also brought out in stained specimens are: (1) that the tip of the tail in the Microfilaria loa is often bent onto the body (incurvated) and (2) that the V and tail spots are easier to bring out by staining than in the case of Microfilaria bancrofti.

The diurnal embryos from the blood of Mrs. M., for example, when stained by Delafield's haematoxylin for 10 minutes in the cold exhibited no stain in the nuclear column but shewed the V and tail spots deeply stained, while on the other hand embryos of Filaria bancrofti---from a case I happened to have at the same time---when stained in exactly the same way and for the same time showed no signs of either of these structures.

I believe this to be rather important but unfortunately I have not had a chance recently to

corroborate it.

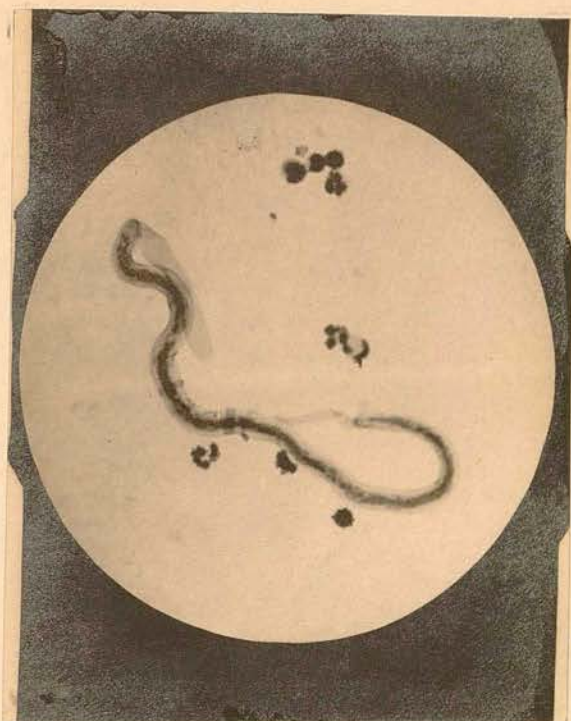


Fig. 27. Microfilaria loa (diurna) from peripheral blood, shewing characteristic attitude in which the worm dies on the slide. (Micro photograph.)

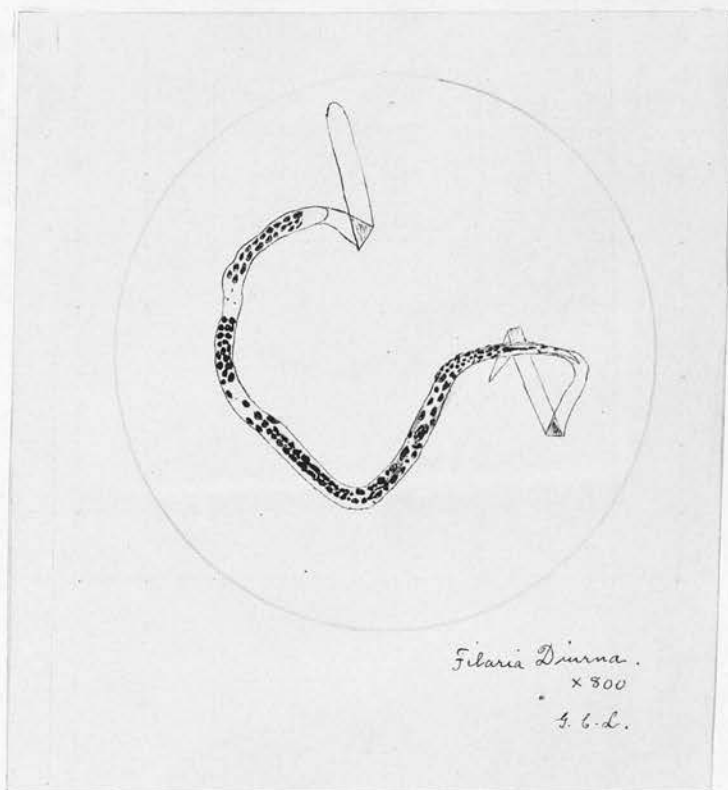


Fig. 28. Shews the same as Fig. 27. Sketch from another case by the Author.

Table shewing differences between the Micro-
filaria bancrofti and Microfilaria diurna, also points
of similarity between latter and the Microfilaria loa.

Microfilaria bancrofti Microfilaria diurna Microfilaria loa

Average length	.317 mm.	.240 mm.	.245 mm.
Average breadth	.0084 to .0073 mm.	.0075 to .0070 mm.	.0075 mm.
Break in cells from head.	.050 mm.	.042 mm.	-
V spot from head	.090 mm.	.060 mm	-
Eggs.	Average .050 by .033 mm.	-	.042 by .033 mm.
Character of curves in dried specimens on slides.	Spiral coils.	In wavy lines.	-
Appearance of tail in similar specimens.	Straight.	Incurvated.	-
Periodicity.	In blood at night (or in equal numbers in blood by day and night Fiji &c.)	In blood by day.	-
Periodicity when habits of sleeping and waking changed.	Inverted.	No change.	-

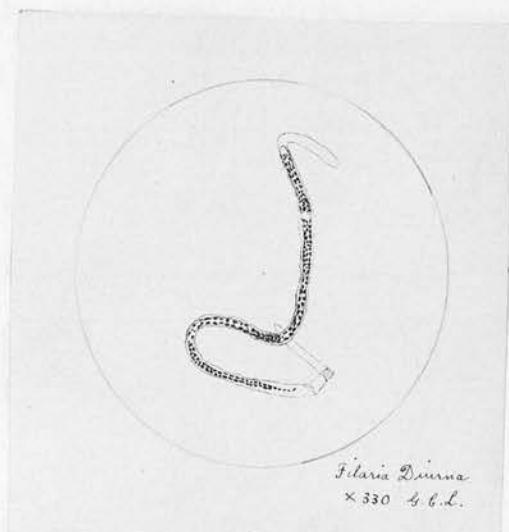


Fig. 29. Microfilaria loa (diurna)
showing sheath and break
in cells.

The intermediate host of Filaria loa.

Analogy leads one to suppose that an intermediate host must be necessary for the embryos of the Filaria loa to develop in, just as is the case with the embryos of the Filaria bancrofti and the Filaria immitis of the dog. It is difficult certainly to see how the embryos could escape from the peripheral blood without the aid of some suctorial insect to extract them, and in trying to come to any definite conclusion as to what that insect might be many things have to be taken into account.

Looking for a moment at the two filariæ just mentioned we find that the embryos of Filaria

bancrofti develop in the thoracic muscles of Culex fatigans, or of anophelines, the embryos of Filaria immitis in the malpighian tubes of anophelines or culex. Both these genera of mosquitoes are chiefly nocturnal in their habits and feed by night and the periodicity of the embryos of Bancrofti was supposed by Manson to be an adaptation to this characteristic of the host. That it is not so is at once seen by the fact that the embryos of the Filaria immitis occur in the blood of the dog by day as well as by night and also by the fact of the Fijian species of Bancrofti doing the same.

Still if a mosquito or other biting insect is to act as a host for the embryos of the Filaria loa, and if their diurnal periodicity is always as well marked as in the case just described, then the act of suction to be of any use must take place by day. This in no way invalidates some genus or species of mosquito as functioning of course, because many of these bite readily by day---the genus Stegomyia for example---but if a mosquito is the intermediate host then it will most probably be one with a more or less limited geographical range corresponding to that of the parasite, though even this does not necessarily follow.

I am not aware of any experiments having been

conducted to determine the point, but I think Manson has suggested that the Mangrove fly might act. I have enquired from men coming from Southern Nigeria about this fly and find that it is a local name loosely applied to several biting flies, chiefly of the genus Tabanus and such being the case I should think it had therefore nothing to do with the dissemination of the filaria in question.

It may be that an insect with a geographical distribution corresponding to the filaria is responsible and in working at the subject that would be the first point to determine.

Failing such a discovery all the different blood sucking insects will have to be studied in detail. Tabanidae,---as I have just said,---Stomoxys, and Glossina are all I think unlikely. Some day feeding mosquito might act, and the probability of ticks, ornithodoros moubata or otherwise, playing a part must not be overlooked.

iii. Diseases caused by the Filaria loa.

Living as it does in the subcutaneous and connective tissues the Filaria loa is not likely to produce anything very gross in the way of pathological lesions and this so far as we know is so. By its death one would have supposed, provided organisms were present, that like the Filaria bancrofti it might have given rise to abscess formation but this has never been recorded. In its movements about--- and these often are very active---it may give rise to a series of minor discomforts such as pricking, itching, or creeping sensations, perhaps more rarely to transient oedemas, and when it crosses the conjunctiva to irritation accompanied by lachrymation. So marked are these symptoms in certain cases that the patients know when a worm is coming near the surface.

Calabar swellings. It is now generally admitted that what were first described and named Calabar swellings by Dr. Thompstone of Southern Nigeria are lesions due to the Filaria loa. These swellings are common among negroes as well as whites in Calabar and the adjoining territories, in fact in areas where Filaria loa is common. The swellings may occur on any part of the body and Dr. Thompstone's description of them is as follows:- "The swellings are about the size of half a goose's egg, they are painless though somewhat hot, both objectively and subjectively, they

do not pit on pressure and they usually disappear in three days."

Such lesions have not been noticed in other parts of the world and the fact of their geographical range being so similar to that of Filaria loa is very suggestive of a casual connection. They are of little importance apart from the slight annoyance they cause and patients look upon them more in the light of a curiosity than of a pathological lesion. I have had several cases of the complaint lately and the histories and descriptions of the conditions given bear out Dr. Thompstone's original observations very closely. Most of my cases have shown no diurnal embryos in their blood, and this fact, which has also been noticed by others who have recorded such cases, has led some to the belief that there is no connection between the filaria and the swellings. On the whole my opinion is that there is and further study of such cases over prolonged periods may very likely furnish the further proofs we require to make definitely certain.

Histories of Cases.

(1) Mrs. M. 50 f. Missionary. (Case of Sir Patrick Manson's.)---This is the case on which the observations of the periodicity and other points were worked out, see previously.

History. Born at Rochester, U.S.A. Went to the

French Congo, 1879, as a missionary, then aged 25. Resided for one year on the coast, three years in the interior. During this period suffered several times from malaria. Returned to America for a year and a half, then back to the Congo for four years. After that lived, with intervals of leave spent in America, on the Congo till she left for England in 1897. In July of that year swellings appeared for the first time on her wrists and hands; these were from one inch to $1\frac{1}{2}$ inches in diameter, were hard, not painful, could not be indented by pressure and soon disappeared lasting from a few hours to 2 to 3 days only. (Compare Thompstone's description.) A similar one appeared on the right leg 3 inches above the ankle, and at intervals of a few weeks to several months others kept coming till December 1902. Shortly after the first appearance of the swellings a worm was removed from her eye by Dr. Du Boulay in Weymouth, (Dr. Du Boulay kindly sent me this worm and I indentified it as a Filaria loa) and after that 5 more were obtained at different times some in America. Since the removal of the last she has several times experienced the sensation of other worms moving under the skin, especially on the hands and round the eye.

Physical examination. An examination of the blood on September 8th, 1904, by myself shewed many

filarial embryos with a diurnal periodicity. Vide previous charts. The various systems shewed nothing abnormal, the different organs of the body being healthy. There was no glandular enlargement present; a few small scars were visible where incisions had been made for the removal of worms.

Subsequent History. On several occasions patient said she was certain a worm was coming to the surface; on two of these I cut down on the part but failed to find anything. No definite Calabar swellings appeared while she was under our observation.

Blood examinations + September 8, 1904,
October 11, 1904, and other
dates. Day blood always
swarming with embryos
(Microfilaria loa).

Summary of Case.

Calabar swellings, Filaria loa, and
Microfilaria with a diurnal
periodicity all present.

(2) Mr. S. A case of Dr. Rice's in Southern Nigeria.

Complaint. Calabar swellings.

Dr. Rice's notes:- (1) Patient's occupation, an Engineer. (2) Residence in Southern Nigeria about four years including periods of leave in England. (3) Consulted Dr. Rice in May, 1905, about localised swellings in various parts of his body, wrists, ankles,

buttocks, &c., accompanied by the most intense and acute urticaria. These attacks usually lasted a few hours; some were so acute as to cause the superficial layers of the skin to be piled up, layer on layer, forming a very red protuberance with a white patch in the middle. Examination of the blood shewed embryo filaria (day blood), a subsequent one on August the 22nd, 1905, shewed none. (4) In the beginning of August, 1905, patient developed an attack of blackwater fever and was sent home to England for this. (5) Dr. Rice's opinion was that patient has or has had a Filaria loa.

The patient unfortunately did not come to see me as directed but returned to Africa in the beginning of October, 1905. Dr. Rice then sent me films of his blood taken by day and in those I found Filaria diurna embryos.

Blood examination + November 22nd, 1905, over
20 Filaria diurna present in
one slide.

Summary of Case.

Calabar swellings, ? Filaria loa,
diurnal microfilaria present.

(3) Mr. K. A case of my own.

Complaint. Calabar swellings.

History. 15 years in Nigeria (southern) with the usual home leave. First period lived up the Niger.

Went to live in Calabar as headquarters in 1900. Apart from malaria no other illnesses. First noticed symptoms of Calabar swellings June, 1904. At that time had swellings of both arms, both hands, and right eye, local doctor thinking that latter was due to the bite of some insect. The swelling of arms affected the forearms chiefly and was more or less general. Since that time at home and abroad has suffered from small localised swellings on extensor aspect of lower part of forearms. Size about that of a pigeon's egg. Very fugitive in nature, lasting a couple of days or so. On November 22, 1905, I saw the patient and he was then suffering from an ordinary Calabar swelling on the extensor aspect of the right forearm. This swelling resembled in appearance a large ganglion; it was about the size of a pigeon's egg, was white in colour, did not feel hot, did not pit on pressure, was quite painless, and apart from the stiffness to the arm it produced did not give rise to any great inconvenience. Next day the swelling was much less and on the third day it had disappeared.

Blood examination. November 23rd, 1905. 12 noon.
0 no embryos present.

Summary of Case.

Calabar swellings. No proof of Filaria loa, no diurnal microfilaria present (one examination).

(4) Mr. B. A case of my own.

Complaint. Stomach trouble and Calabar swellings.

History. Fourteen years service on coast, all in Southern Nigeria. First noticed Calabar swellings last trip 1908-1909. These chiefly came on right arm then shifted to left. In May 1909 left testicle became swollen, red, and painful. Had not injured it and had never suffered from gonorrhoea. After rest and suspension swelling gradually went down and pain disappeared. Came to England July, 1909, and I saw him in October. Patient's own description of a swelling was as follows:- "The part affected becomes stiff and there is a feeling as if one could take one's arm up and squeeze something out of it, there is also a tingling somewhat itching feeling like the sting of a jelly fish. They last from a few days to a week and their size is that of a small hen's egg."

Five days before I saw him he had had one on the back of his right arm but though I made a careful examination there was no trace of it left.

Blood examinations. October 5.09.

Reds	5,000,000
Whites	6,800
Haemoglobin	100

Differential.

Polymorphonuclear	59%
Large Mononuclear	5%
Lymphocytes	26%
Eosinophile	9%
Transitional	1%
Mast Cells	0

Examination for Filaria diurna. 12 noon.
3 large films negative.

October 9.09. 11 a.m. 2 large films 0.

Examination of faeces no ova of any
sort present.

October 26.09. 11.30 a.m. 3 large films 0.

November 30.09. 12 noon. 3 large films 0.

Summary of Case.

Calabar swellings, no proof of
Filaria loa, no diurnal microfilaria
present.

I hope to be able to see this patient in a year's
time and will then follow up the blood examinations to
see if embryos will eventually appear.

(5) Mr. G.

No definite complaint.

History. Has been in Southern Nigeria for some
years. On March the 10th, 1908, while in England, his
upper eyelid on left side became swollen for no
definite reason. Next day swelling was gone. On his
return to Africa did not notice any further swellings
but has several times experienced a tickling feeling
on flexor aspect of right forearm. Saw patient in
England again in 1909 when he told me this. I do not
feel certain that this case can be considered one of
Calabar swellings. All one can say of it is that it
is suspicious and might perhaps be due to an infection

with one or two Filaria loa. The fact of the patient coming from Southern Nigeria adds of course to the suspicion.

Blood examinations (day blood films).

March 10.08. 0.

October 12.09. 0.

Summary of Case.

? Filaria loa infection.

iv. Prophylaxis.

Little if anything can be said of the prophylaxis of infections by Filaria loa until we know the complete life history of the parasite and the insect---if it be one---that acts as the intermediate host. Causing so little disturbance as it does, one would certainly find difficulties ahead of one in persuading the ordinary individual to take steps to prevent infection even if we did know that a fly or mosquito was the cause. All that can be said is that all insect bites should be avoided as much as possible not only to prevent infection from this parasite but also from the more deadly ones of malaria, sleeping sickness, and tick fever. The question of a tick as the spreader is one I think well worth working out.

FILARIA DEMARQUAYI.

i. Geographical distribution.

The geographical distribution of the Filaria demarquayi has only been partially worked out and much work still remains to complete it. So far, if we except the instance of New Guinea recorded by Sir Patrick Manson, it has only been recorded from the New World, from some of the West Indian Islands, and-- if the sharp tailed embryos of the aboriginal Indians of the forests of South America are the same---from the northern parts of the continent of South America.

The Microfilaria demarquayi i.e. the embryonic forms were first discovered by Sir Patrick Manson⁽⁵³⁾ in films of blood sent to him by Dr. Newsome of St. Vincent, West Indies, and by Dr. Galgey of St. Lucia. Later in blood films sent by Dr. Ozzard of British Guiana (aboriginal Indians) Sir Patrick discovered two different embryos, a sharp tailed one and a blunt tailed one, and these were provisionally named Filaria ozzardi until proof was forthcoming as to their identity or difference with known species. As I shall describe under Filaria perstans, this blunt tailed microfilaria is now supposed to be identical with the microfilariae of that parasite, the sharp tailed ones generally being talked of as identical with embryos of the Filaria demarquayi though this is not absolutely proved.

When I went to the West Indies in 1901 as the Craggs Research Scholar of the London School of Tropical Medicine, the mapping out of the distribution of the Filaria demarquayi was one of the pieces of work I resolved to investigate, so for that purpose I went first to St. Lucia, a known focus of the parasite. On my arrival there Dr. Galgey informed me that most of the cases that shewed the infection came from one part of the island, but I never expected to find the distribution so extremely localised as I subsequently did.

St. Lucia is a small island with mountains in the interior, this causing the townships and villages to be situated on the coast line, and I examined all these in detail with the exception of a small one (Dennery) on the North Coast.

The results shewed that the infection was limited to one village---Gros Islet by name---the other places being free. If one did find a case in any of the other parts of the island, the record of the individual in question shewed at once that he had either been born in Gros Islet or had lived there for some part or other of his life. The fact of the embryos of this parasite being found in the peripheral blood by day as well as by night rendered the examination of the people from the different villages

more easy, day visits on this account being as useful as night ones.

Statistics for the island of St. Lucia.

Villages.

Gros Islet. 62 people examined, 16 or 25.8% infected with the Microfilaria demarquayi.

Anse-la-Raye. 31 examined, 0 infected.

Vieux Fort. 30 examined, 0 infected.

Sonfriere. 78 examined, 2 infected. Both two policemen who had lived at Gros Islet however.

Dennerly. Not examined.

Town.

Castries. Out of hundreds of bloods examined in Castries one or two cases of infection with the Microfilaria demarquayi were seen. All these cases from Gros Islet however. The infection does not exist in Castries.

Passing next to St. Vincent, an island adjoining St. Lucia, I found much the same thing, one of the villages (Calliaqua) shewing many of its inhabitants infected with the Microfilaria demarquayi, while the others and the main town were always quite free. The following figures indicate this very clearly.

Statistics for the island of St. Vincent.

Villages.

Calliaqua	50 examined, 16 or 32% infected with the <u>Microfilaria</u> <u>demarquayi.</u>
Layou.	30 examined, 0 infected.
Barrouallie.	30 examined, 1 infected. (This individual had lived in other parts of the island including Calliaqua.)
Georgetown.	30 examined, 0 infected.
Chateaubelair.	30 examined, 0 infected.

Town.

Kingstown.	Out of hundreds of blood examined no infection found. The parasite does not exist in Kingstown.
------------	-------------------------------------------------------------------------------------------------------------

In addition to these two islands, where Manson had already indicated that the infection existed, I found the parasite in Dominica, Trinidad, and probably also in St. Kitts. In none of these places did I succeed in finding the exact focus of infection, owing to the villages being remote and difficult of access, nor did I see more than one case in each place, but as the individuals in Dominica and Trinidad had been born there and had never been out of the island that of course was sufficient to indicate that the filaria exists there indigenously.

Records of these cases.

Dominica. Leon Roudett, Mulatto, 48 m. Born and lived all his life in a village called Batalie. Many embryos of Microfilaria demarquayi in his blood. Had never been out of the island.

Trinidad. A young female in the Lunatic Asylum, Port-of-Spain. Born and had lived all her life, until removal to Asylum, in a village called Matalot on the north coast of the island. Plenty embryos of the Microfilaria demarquayi in her blood. Had never been out of the island.

St. Kitts. Case No. 78. Martin, a Portuguese born in Madeira. Came to St. Kitts when a youth and only once out of the island again, when he lived for a short time in Port-of-Spain, the rest of his life has been in Cayou, a village on the windward coast of St. Kitts. Plenty embryos of the Microfilaria demarquayi in his blood. This case affords strong presumptive evidence that the village of Cayou is an infected focus.

I found no trace of the Filaria demarquayi in Barbados, Grenada, and Carriacou one of the Grenadines.

In British Guiana, in the blood of the Aboriginal Indians, sharp tailed embryos identical with the Microfilaria demarquayi are common and are usually found in conjunction with blunt tailed ones.

(The statistical prevalence of these will be given under Filaria perstans.)

As far as the distribution of Filaria demarquayi goes for the West Indian islands then, it is seen that the parasite is never got in towns, its habitat being small villages on the coast, but here its distribution is most localised, some places being heavily infected while others---apparently exactly similar physically---are free. This will be returned to when the question of an intermediate host is discussed.

I have never met with it in any other parts of the world, Africa, &c.

ii. Life history and biology.

The adults. The adults of this species have only been rarely found, few people ever having taken the trouble to look for them. Dr. Galgey in St. Lucia found 4 or 5 at the autopsy of a case which he knew to be infected with the embryonic forms during life, and previously to that Dr. Daniels in British Guiana had found one or two adults of the British Guiana sharp tailed embryos, but outside of these two instances I do not know of anyone else ever having found them. Dr.

Galgey's specimens were sent home to the London School of Tropical Medicine and Dr. Daniels described and measured them. Still having his old British Guiana specimens by him he was able further to compare the two and ultimately came to the conclusion that there were some differences between them. His tables are as follows:-

DANIELS.

	<u>Filaria ozzardi</u>		<u>Filaria demarquayi</u>	
	♀	♂	♀	♂
Length.	81 mm.	38 mm.	80 mm.	unknown.
Greatest breadth.	.21 mm.	.19 mm.	.21 to .25 mm.	
Diameter of head.	.05 mm.	?	.1 to .09 mm.	
Distance of genital pore from head.	.71 mm.	-	.76 mm.	
Diameter at point of genital pore.	.12 mm.		.1	
Distance from tail of anus.	.23 mm.	-	.25 mm	
Cuticular thickening tip of tail.	None.		Cuticular thickening over tip knobby and irregular in outline.	

A cursory glance at this table shews that as regards measurements the two filaria are for all practical purposes identical, the only difference being the cuticular thickening at the tip of the tail. I know the specimens well and have often discussed them with Daniels and I admit that the St. Lucia ones have the thickening over the tail, but as the specimens from British Guiana are so very scanty in number it is just possible that further ones carefully examined and properly preserved might also shew the same. My personal opinion is that the two filariae (F. ozzardi sharp tailed and F. demarquayi) are identical but at the same time I am quite willing to let the matter remain sub-judice until more material (males and females) have been collected.

In general appearance these adults very closely resemble the adults of Filaria bancrofti being about the same length and thickness, and shewing up like cat gut. They are typically filarial, with an anatomy and other structural changes exactly on the same lines as in the type specimens of the genus.

Habitat. Their habitat is in the connective tissues of the mesentery, omentum, and in the peritoneal tissues behind the anterior abdominal wall. It is possible that they may inhabit other similar sites but so far these are the only places in which they have been found.

The embryos. The first thing that strikes one on looking at the embryos of Filaria demarquayi is their small size as compared with those of Filaria bancrofti, and the second that they are devoid of any sheath. These points are alone sufficient to distinguish them from F. bancrofti and Manson, who first saw them, knew at once that he had found a new species.

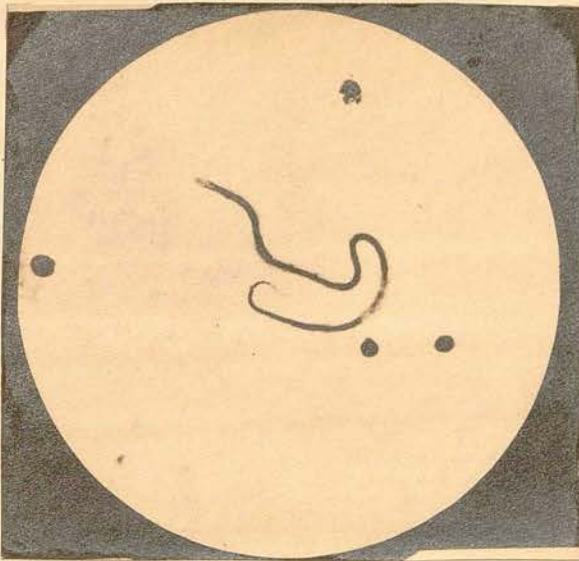


Fig. 30. Filaria demarquayi
x 375.

Note the small size,
absence of sheath and
sharp pointed tail.

Seen in fresh blood films their movements are exceedingly active and they do not remain fixed in one place, as in the case of the Microfilaria bancrofti, but freely wriggle about over the slide. (The term applied to this progressive movement is that they locomote.) After their movements have

ceased, either naturally or by poisoning them by various vapours they become stretched out and can be examined in detail.

I have measured⁽⁵⁴⁾ large numbers of them both in St. Lucia, St. Vincent, and British Guiana, and their average measurements come out .205 to .208 mm. long by .005 mm. broad; stained specimens often appear shorter owing to shrinkage and also shew more variability in length. There is no sheath; the nuclear column of cells completely fills the body cavity, this when stained shewing no clear space outside as in the case of the Microfilaria bancrofti. The cephalic armature consists of a rather poorly developed prepuce, not serrated as in the case of the Microfilaria bancrofti and much more difficult to see, and of a minute spine or fang which is alternately pushed out and retracted. A V spot exists .052 from the head, the angle being an obtuse one and on account of its generally small size is difficult to see unless the highest objectives are used. In some specimens I thought I could detect a tail spot but of this I was not absolutely certain.

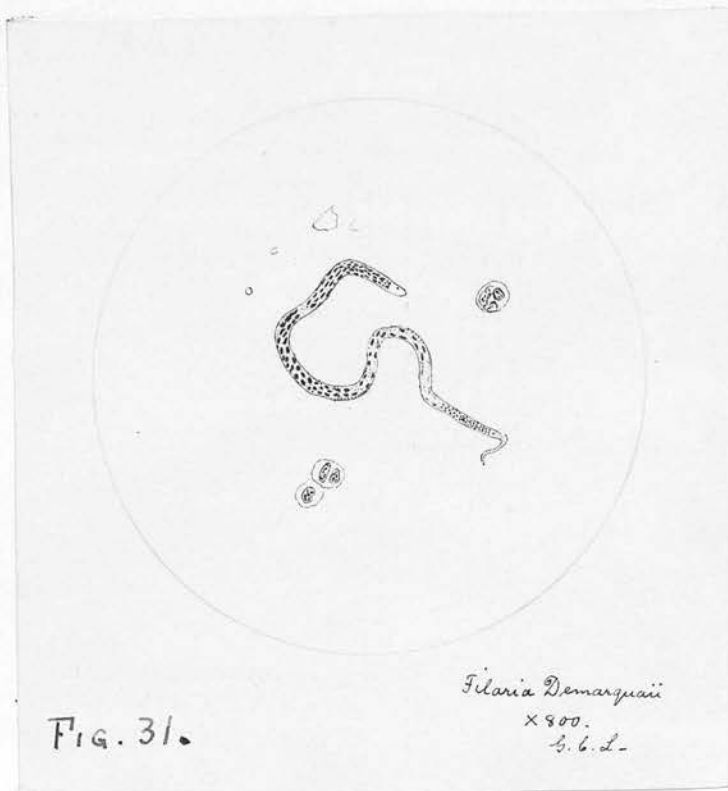
In stained specimens (Haematoxylin and Haemalum) a break in the continuity of the cells may be made out; this is situated in front of the V spot of which there is practically no sign in such specimens.

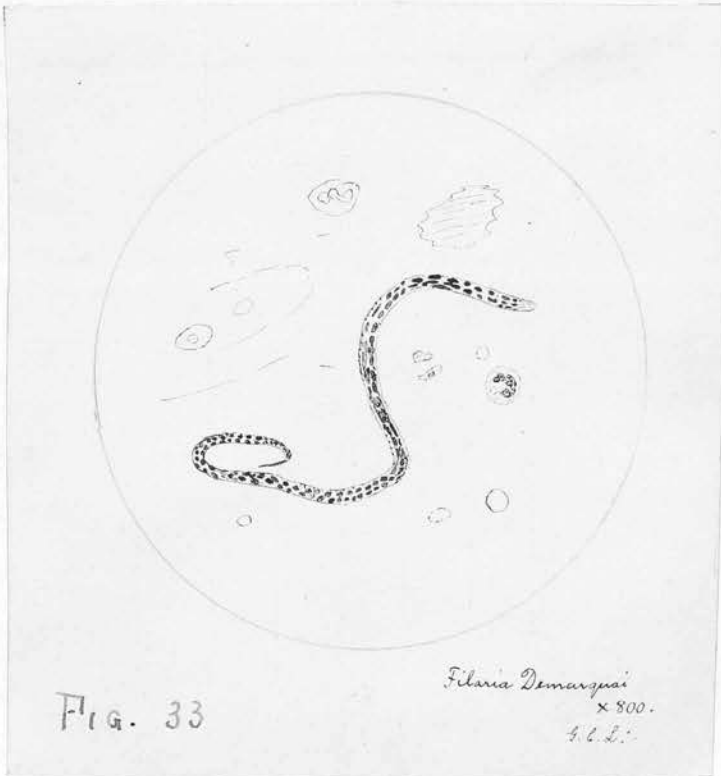
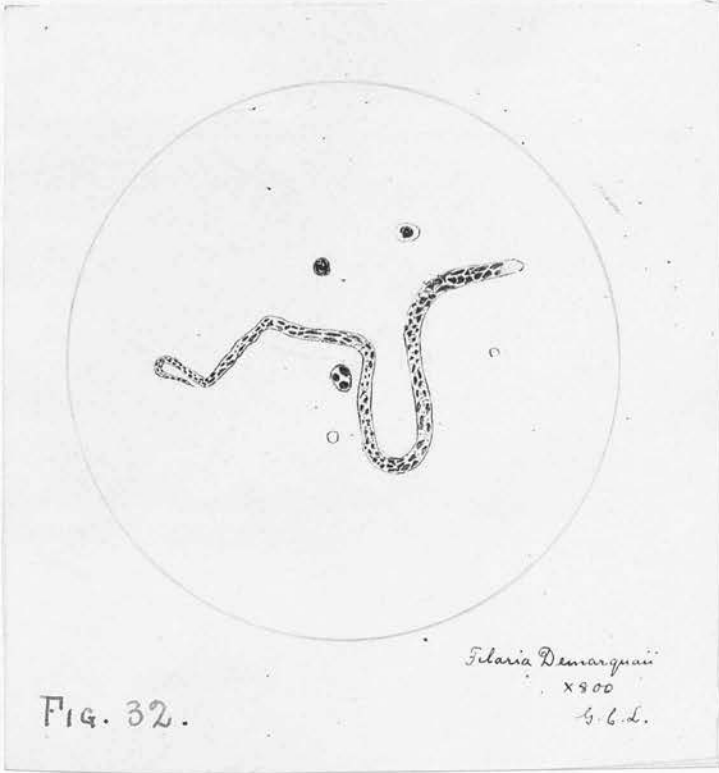
The embryos are present in the peripheral blood by day as well as by night, I did not however have the chance of determining whether they shewed any increase at any special time.

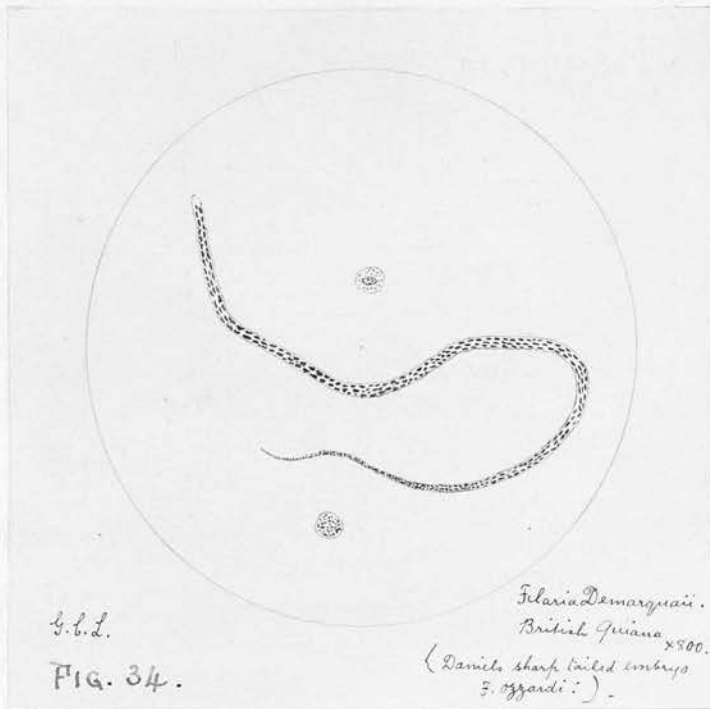
It has been suggested that the active movements of this embryo are due to the absence of a sheath. I should think this is very likely.

A comparison of the Microfilaria demarquayi from the islands with the sharp tailed embryos found in the aboriginal Indians of British Guiana shews that they are very similar to each other, in fact I do not think one would be very far wrong in saying they were identical.

DIAGRAMS.







The intermediate host: It is almost certain that there must be an intermediate host, probably an insect or a tick, in which the microfilariae can undergo their metamorphosis before their return to their final host. Analogy is all in favour of this, the intermediate hosts of many of the filariae being known. Filaria bancrofti for example in different mosquitoes, Filaria immitis in mosquitoes, Filaria recondita in the dog flea, &c. From the peculiar localised distribution of the parasite (vide statistics for St. Lucia and St. Vincent) it would appear that the intermediate host whatever it may be is not a wide spread one, and probably is one that finds something

special to its taste in the environments of the infected areas. Physically in the islands one village was very much like its neighbour, and though I specially examined Gros Islet and Callⁱ_Λiqua I never could detect or hear of any special biting creature at these places. Both villages were situated on the sea coast, with some swampy ground and plenty low bush behind them and Cellia argyrotarsis and its subspecies Cellia albipes abounded much in the same way as they did in other places. I did hear of one special mosquito at Call^Λ_Λiqua, the Haemagogus cyaneus (Williston), but I was never fortunate enough to catch any of them there, though I did capture a few at another part of the island where no F. demarquayi existed. I carried these with me to Kingstown to feed them on an infected case but unfortunately they died just before my arrival.

In British Guiana the predominant physical feature for the occurrence of this parasite is apparently the presence of forest and bush, e.g. uncleared land. Georgetown and the cultivated strip of land along the coast are entirely free, whereas on the Waini river further north, in the bush close to the sea, 9 out of 15 Warau Indians living there were found to be infected. In the forests inland the infection seems universal and the percentage is very high.

At one place in the forest, namely at Wismar 60 miles up the Demerara river, the forest had been entirely cleared to make room for a railway and other buildings in connection with the gold fields, so I examined the blood of 25 people, Creoles and others, who had been living there for periods of from two to ten years. In every instance the result was negative, while conversely 3 out of 5 full blooded negros living in the forests of the Pomeroon river were infected. Anyone living in infected parts of the interior is quite liable to the infection.

Both in the West Indies and in British Guiana I conducted many feeding experiments with different biting insects to try to determine the intermediate host but failed to do so.

While in St. Lucia using mosquitos bred from larvae I excluded Culex fatigans, Cellia argyrotarsis (Anopheles argyrotarsis old name) and Stegomyia fasciata as efficient hosts. One very striking observation was however made and that was that in a certain number of Stegomyia a sausage stage of development in the thoracic muscle was reached. Nothing came of this, but still it shews very clearly that if one could have found the proper intermediate host, a development similar to that of the embryos of F. bancrofti would have taken place. The appearance of the sausage stage was exactly similar

in miniature to that of F. bancrofti. Vincent in Trinidad also noted this, and I see quite recently that Fulleborn working with a case of Filaria demarquayi in Hamburg has seen similar stages in some of the mosquitoes he used.

In British Guiana I worked at an Indian settlement on the Pomeroon river in the interior where 71 per cent. of the Indians were infected with sharp or blunt tailed parasites. The blood sucking insects were caught after feeding in the evenings as it was impossible to rear all these from larvae. The commonest one was the Stethomyia nimbus---an anopheline---and of these over 30 were dissected, but with the exception of a few dead embryos in the semi-digested blood in the stomach of one nothing was found, this indicating that this mosquito was non-efficient. In a species of Taeniorhynchus similar results were obtained, in two instances dead and degenerated sharp and blunt tailed embryos being seen in the semi-digested stomach blood, but none were seen in any of the other tissues. Many of the other rarer mosquitoes that frequented the huts were also dissected, the results being uniformly negative. Twelve fleas (Pulex irritans) and many chiggers (Sarcopsylla penetrans) were also examined but nothing was noted in them either.

I am sorry now that I did not examine ticks as I

believe it possible that they may be the proper intermediary. They were very abundant certainly in many parts of the forest, one's arms often being covered with them when one came in after a journey. I did not note Argas persicus (Argas miniatus) but that is not to be wondered at as I did not specially look for it.

I certainly consider that this branch of insect should be worked at by anyone again taking up the somewhat difficult subject.

Pathology. The parental and embryonic forms of Filaria demarquayi, as far as I am aware, give rise to no pathological effects or clinical symptoms, the diagnosis only being made by an examination of the blood.

I did one post-mortem examination on an Indian, with a few sharp tailed embryos in his blood, in the Colonial Hospital in Georgetown, British Guiana, but failed to find the adults though I searched for many hours.

Prophylaxis. Nothing need be said about this. Avoidance of the villages where the parasite is found is all that is required, but even if one did become infected it apparently would not matter. Until the intermediate host is known we must remain entirely in the dark.

FILARIA PERSTANS.

i. History.

The embryonic or larval forms of Filaria perstans were first discovered by Manson⁽⁵⁵⁾ in 1891 in the blood of a West African negro suffering from sleeping sickness, under the care of Dr. Stephen Mackenzie in the London Hospital.

Later the same authority found them in films of blood sent from Old Calabar and the Congo, and in 1897 described small sharp and blunt-tailed filarial embryos in specimens of blood sent by Dr. Ozzard from British Guiana which he provisionally named F. ozzardi (see also description of Filaria demarquayi).

Daniels⁽⁵⁶⁾ soon confirmed (1897) the presence of these two species in the blood of the Aboriginal Indians of the forests of Guiana shewing how common they really were, and in the following year he discovered the parental forms of the blunt-tailed variety.

Adult forms of the African blunt-tailed embryo called by Manson Filaria perstans were next found at the autopsy of one of the negroes who died of sleeping sickness in Charing Cross Hospital, and he (Manson) after a comparison of those with the British Guiana forms came to the conclusion that they were identical, thus shewing that the blunt-tailed micro-

filaria of South America and Africa were the same species.

ii. Geographical distribution and prevalence.

South America. Filaria perstans, as Daniels and Ozzard first pointed out, is very common amongst the Aboriginal Indians (Caribs, Arawaks, Waraus, &c.) of the interior of British Guiana though not being found in Georgetown and the coast adjoining. While studying filariasis in the West Indies I soon confirmed this⁽⁵⁷⁾ by journeying through different parts of the primeval forests of that country and examining the blood of large numbers of the said Indians.

In all I examined 163 pure blooded Indians of different breeds in different parts of the dense tropical forests of the interior and found that no fewer than 94 or 57.6 per cent. exhibited this parasite in their blood, 56 of these being pure infections, the other 38 being a mixed infection, the blunt-tailed parasites here being associated with sharp-tailed embryos (Microfilaria demarquayi ? ozzardi). In 11 instances Microfilaria demarquayi were found alone. As regards the different districts there was little to choose between them, the infection being equally prevalent on the Demerara, the Waini, the Pomeroon and the Barima rivers

I also found as Daniels had done before that Georgetown and New Amsterdam with the cultivated strip of coast between them was free, though to the north

on the Venezuelan boundary where the forests come down to the sea the infection again shewed its presence.

There is not the slightest doubt that the same parasite Filaria perstans if looked for, would be found in Dutch, and French Guiana, Brazil and in parts of Venezuela where the tropical forests are dense and its distribution as far as South America is concerned is without doubt a much more extensive one than we at present know of.

As regards the West Indian islands I did not however meet with it there, Trinidad, Grenada, Carriacou, St. Vincent, Barbados, St. Lucia, Dominica, and St. Kitts all being carefully examined.

Africa. Manson has shown that Filaria perstans is common on the Congo, Old Calabar, and other parts of the West Coast of Africa, 30 out of 54 individuals showing it in blood slides sent to him by Professor Firket from the Congo, and 35 out of 61 in slides sent from Banza Mankeka. Dr. St. George Gray has sent me bloods slides from the hinterland of Sierra Leone also shewing the same parasite, and Dr. Rice recently informed me that he had found it in 50 per cent. of the people of Ibadan in the hinterland of Lagos. The Liverpool School of Tropical Medicine and others--- Broden at Leopoldville on the Upper Congo for example---have also found it widely distributed in other parts of equatorial Africa.

On the East Coast of Africa I did not personally find it in the towns of Zanzibar, or Mombasa; nor amongst the Masai, a warlike race inhabiting the highlands of British East Africa; nor amongst the Kavirondo who dwell along the North East shore of the Victoria Nyanza.

In Uganda, on the other hand, as Moffat, Hodges, and Cook had shown, it was extremely prevalent in many areas of that large province. At the time I visited that district I was a member of the Royal Society's Commission on Sleeping Sickness and as at that time Filaria perstans was supposed probably to be the cause of that disease I had ample opportunities of following up its prevalence in the different parts of the country.

The following table gives an idea of how prevalent the parasite was.

No.	Race.	District.	Percentage with <u>Filaria perstans</u> .	Remarks.
1.	Wagandas	Entebbe.	51%	General examination.
2.	Wagandas	Sese islands.	86%	
3.	Wagandas	Bulemezi	62%	
4.	Wagandas	Kago.	62%	
5.	Wagandas	Mugema	50%	
6.	Wagandas	Buddu	20%	

No.	Race.	District.	Percentage with <u>Filaria perstans</u> .	Remarks.
7.	Wagandas	Ndeje.	14.2%	
8.	Wagandas	South Buddu.	30%	
9.	Wagandas	Gimbo Chagwe.	100%	
10.	Wagandas.	Bugaia.	2%	
11.	Waganda children.	Entebbe.	14.2%	
12.	Ankoles.	Ankole.	7.8%	
13.	Wanyoros.	Unyoro.	74%	
14.	Nubians.	Nile districts	6%	
15.	Alurs.	Wadelai.	8.4%	
16.	Swahilis.	Coast.	2%	Acquired in Uganda.
17.	Kavirondos	Kisumu.	0%	
18.	Wagandas	Entebbe.	42.2%	
19.	Europeans	Entebbe.	0%	

As a rule 100 bloods were examined of each section so the figures are fairly accurate.

In British Central Africa on Lake Nyassa it is evidently not common, as Dr. Daniels told me that he only found it in one case there, though he made fairly extensive examinations.

Physical features of the country where Filaria

perstans is found.

So far Filaria perstans has only been found in or near the equatorial belt, where the temperature is always high and the atmosphere saturated with moisture, examples of this type of place being the Tropical forests of South America, the steamy forests of the Congo and Uganda where tropical forests alternate with enormous swamps and open ground. In Kavirondo as already mentioned, the forest disappears and the land is covered with scrub and short grass, and here the parasite entirely disappears, nor is it found on the grassy plains of the highlands of British East Africa. Towns and areas where the forest has been cut down and cultivation has taken its place, as on the coast line of British Guiana, are also exempt from it.

iii. Life history and biology.

The adults. Having had the opportunity of getting numerous specimens of the adults of Filaria perstans at the many autopsies I performed on sleeping sickness ^{cases} in Uganda, I have made a careful study of these forms, especially noting the male worm which up to that time had been very imperfectly described and about which many points were still sub-judice.

The following remarks therefore are based on one's own personal observations.

The parental or adult forms of Filaria perstans were first discovered by Daniels⁽⁵⁸⁾ in British Guiana in 1898.

They resemble to the naked eye fine white coiled threads, the males being shorter and finer than the females, and therefore correspondingly more difficult to find. Comparing them with the adults of Filaria bancrofti and Filaria demarquayi it is at once seen that they are smaller and much finer than the above mentioned parasites. They however present typical filarial features and without going into a more minute and searching examination would at once be classed in that genus.

In both sexes the head is club-shaped, a narrower neck joining this to the body which tapers somewhat as it approaches the tail. The latter organ has the cuticle over it distinctly thickened, the

thickening taking the form of two triangular appendages (Fig. 35) and this is a point of considerable diagnostic importance.

A well-marked musculo-cutaneous non-striated layer encloses the body cavity in which the viscera and generative organs are placed. The alimentary canal begins with a simple circular mouth, without papillae, and extends almost throughout the entire length of the worm, ending on the concavity of the curve formed by the tail. (Diagrams.)

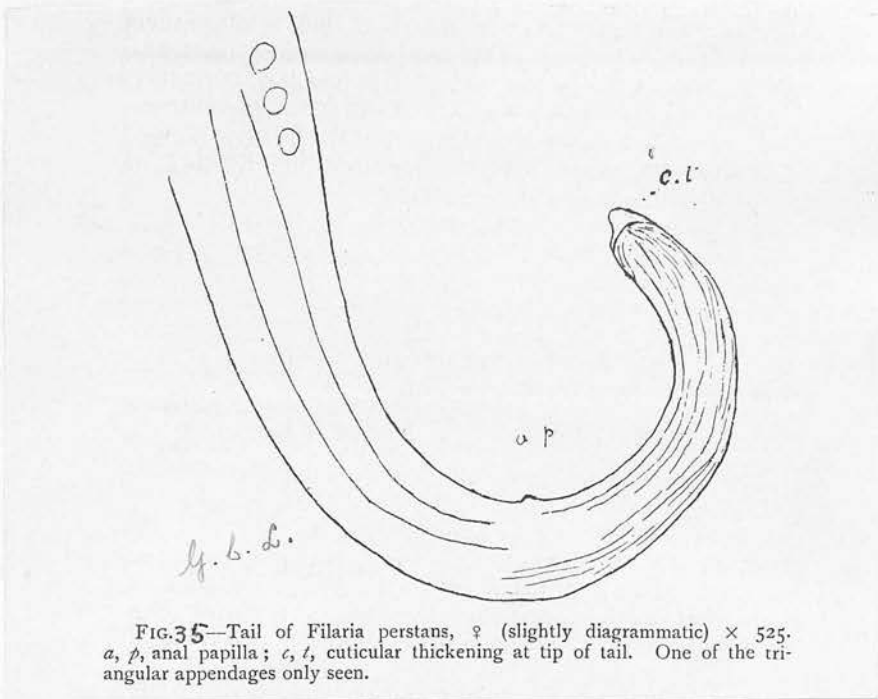
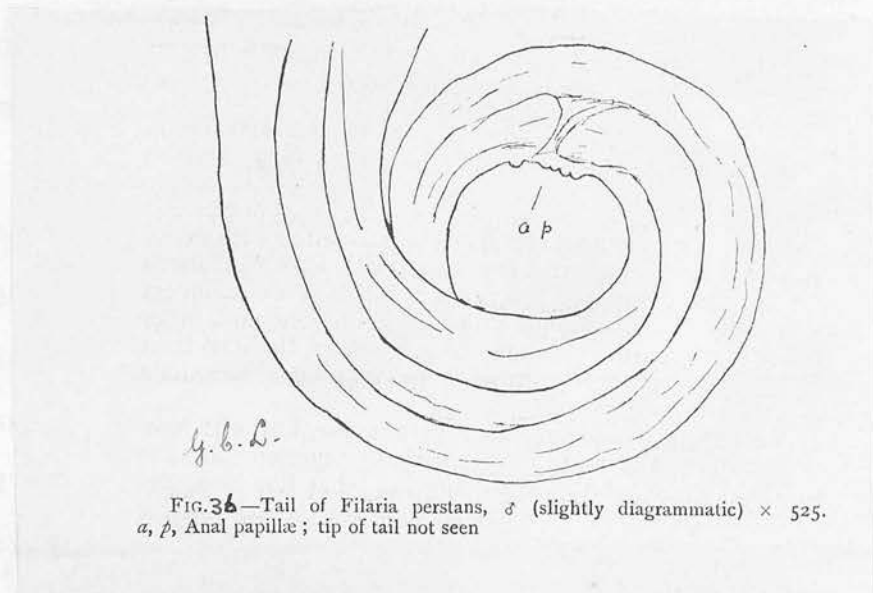


FIG. 35—Tail of *Filaria perstans*, ♀ (slightly diagrammatic) × 525. *a, p.*, anal papilla; *c, t.*, cuticular thickening at tip of tail. One of the triangular appendages only seen.



In the female as shewn in Fig. 35 the anus opens at the apex of a slight bulge or papilla on the cuticle; in the male it opens at the general level of the body but has four pairs of papillae placed in front of it (pre-anal papillae) and one pair behind it (post-anal papillae) Fig. 36. Two unequal spicules may sometimes be seen protruding from the orifice.

In the female the two uterine tubes almost completely fill up the body cavity of the female, these being packed with eggs posteriorly and with embryos anteriorly, the latter which are blunt-tailed and non-sheathed eventually escaping into the vagina, which opens externally some distance behind the head.

Habitat of the adults.

The adults inhabit the connective tissues of the mesentery especially towards its base, this evidently being their seat of selection as I have failed to find them in any of the other tissues of the body. They may be found readily enough after a little practice, especially if one has plenty of time to expend on the research. The best method I found was to remove the whole of the mesentery from the intestines and the tissues at its base en bloc, and then to place them in 2 per cent formalin.

At one's leisure this has then to be dissected piecemeal and one can just pick the worms out with the naked eye, a lens being really unnecessary. I found two ordinary dissecting needles were the best thing to do this with. The parasites when found may be placed in 2 per cent. formalin and after measuring they should be mounted for permanent specimens---with or without staining---in glycerine jelly.

After a time one found, that if embryos were in very small numbers in the peripheral blood, it was useless looking for adults as they would be exceedingly scanty. On the other hand where embryos were numerous then one could always rely on finding one, two, or more adults in the mesenteric tissues.

Measurements of adults. I measured some of the adults found in Uganda and found on the whole that they

were generally much shorter than those measured by Dr. Daniels in British Guiana, the usual length given by him being 70 mm. The following table gives my measurements for an adult female and male.

TABLE.

Measurements of an adult female and male Filarie perstans from Uganda.

	♀	♂
Length.	50 mm.	34 mm.
Greatest thickness.	0.160 mm.	0.104 mm.
Diameter of head.	0.080 mm.	0.064 mm.
Diameter of neck.	0.072 mm.	0.054 mm.
Distance from head of vaginal orifice.	1.22 mm.	
Distance of commencement of uterus from head.	1.60 mm.	
Distance of end of uterus from tail.	0.600 mm.	
Distance of anus from tail.	0.160 mm.	0.120 mm.
Anal papillae.	None.	Four pairs of pre-anal papillae, one pair of posterior.
Termination of tail.	Cuticle thickened to form two triangular appendages.	Cuticle thickened to form two triangular appendages.

The embryos. The embryos of Filaria perstans (the Microfilaria perstans) closely resemble in size and shape the young or larval forms of Filaria demarquayi the essential difference lying in the shape of the tail. In the former (perstans) it is blunt or truncated (Fig. 37) while in the latter it is finely pointed.

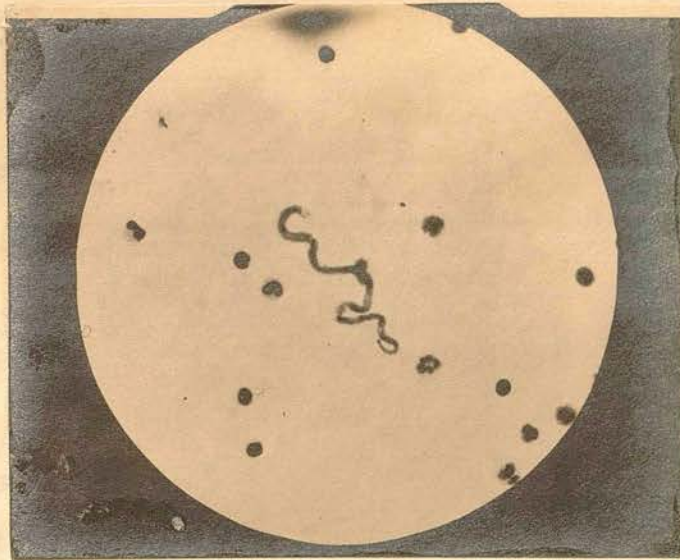


Fig. 37. Filaria perstans x 375. The blunt tail is not very clearly brought out in photograph. It is better seen in the drawings Fig. 38, &c.

The average length of the Uganda Microfilaria perstans I found to be .203 to .205 mm. long by .0042 mm. broad. They are devoid of any sheath and locomote very actively over the slide on which one is examining them. They shew no periodicity, their

numbers in the peripheral blood varying from time to time, but being equally numerous by day as well as by night. Having some cases in the Sleeping Sickness Hospital in Entebbe I took the opportunity of examining their blood every four hours (excepting the 2 a.m. one) to see what happened and the results bear out what has just been said. In determining the number of filarial embryos in the blood at any given time, it is of course of the utmost importance that the same quantity of blood should be taken each time and the technique I employed for this was as follows. A pipette graduated to 5 cmm. was used---any quantity such as 10 or 20 cmm. would do as well---and this quantity of blood, after being sucked up, was blown out on to a slide, spread out and allowed to dry.

Afterwards I washed the haemoglobin out by placing the slide for a minute or so in water, and after drying fixed the film by immersion in alcohol and ether for 5 minutes.

Next I stained with fuchsin or haematoxylin and the number of filariae present could then be accurately counted.

The following table shews the absence of periodicity in the embryos of Filaria perstans.

Date and Hour.	Case I. Number of <u>Micro- filaria</u> <u>perstans</u> in 5 cmm of blood	Case II. Number of <u>Micro- filaria</u> <u>perstans</u> in 5 cmm of blood	Case III Number of <u>Micro- filaria</u> <u>perstans</u> in 5 cmm of blood	Case IV Number of <u>Micro- filaria</u> <u>perstans</u> in 5 cmm of blood
ept. 8, 1902, 10 a.m.	16	12	10	15
" " 2 p.m.	8	17	10	17
" " 6 p.m.	19	8	13	19
" " 10 p.m.	10	6	10	10
ept. 9, " 6 a.m.	10	4	18	10
" " 10 a.m.	14	15	8	14
" " 2 p.m.	10	10	10	10
" " 6 p.m.	7	8	11	7
" " 10 p.m.	5	10	11	9
ept. 10, " 6 a.m.	11	10	9	15
" " 10 a.m.	10	10	10	10

Having determined this absence of periodicity the next point of interest that suggested itself was did the embryos occur in equal numbers in the blood all over the body, e.g. in the blood of the large vessels of the thorax as in the peripheral blood. Chances to solve this question soon presented themselves as numbers of sleeping sickness cases were dying daily and in the blood of most of these abundant Microfilaria perstans were present.

I selected two of these, and at their autopsies sucked up 5 cmm. of blood in a pipette from each of the different viscera and large vessels, also at the same time making smears from the different glands. These were all examined by the method just described. The results quite paid for the trouble of the exhaustive examination, as I found that the blood of the inner organs is the seat of special selection of the embryos of this parasite, the peripheral blood only shewing a small fraction of the numbers present there. This peculiar feature is not uncommon among the filaridae as I found the same thing in the filaria of the Barbados blackbird (Quiscalus crassirostris). Examining the peripheral blood of one of these birds one day I noted one filaria, whereas on immediately killing it and examining its heart blood I found them in very large numbers.

The following table shews at a glance the results from which these conclusions were reached.

Organ	Number of embryos	Number of parasites
Heart blood	1000	1000
Peripheral blood	10	10
Small intestine	100	100
Large intestine	100	100
Stomach	100	100
Liver	100	100
Spleen	100	100
Testis	100	100
Prostate	100	100
Bladder	100	100
Uterus	100	100
Vagina	100	100
Rectum	100	100
Anal	100	100
External	100	100
Total	1000	1000

Enumeration of Microfilaria perstans in 5 cmm.
of Blood from the Different Internal Organs
and in Lymph.

CASE I.

Died 6 p.m., September 30th, 1902. Number of Microfilaria perstans in 5 c.mm. of blood on that day---
8 a.m., 0; 4 p.m., 4. Necropsy, 6 a.m., September 31st, 1902.

Organ.	No. of slides.	No. of <u>Microfilaria perstans</u> in 5 c.mm. of blood.
Heart, L. vent. ...	1	19
" R. vent. ...	1	14
Lung, R. ...	1	14
" L. ...	1	17
Liver ...	1	1
Spleen ...	1	0
Pancreas ...	1	2
Kidney, R. ...	1	0
" L. ...	1	0
Aorta ...	1	30
Superior vena cava ...	1	16
R. common carotid ...	1	4
R. internal jugular vein ...	1	10
L. saphenous vein ...	1	7
Sup. longitudinal sinus ...	1	7
Subdural vein ...	1	8
Brain, capillary motor area ...	1	1
R. middle cerebral ...	1	0
Smears not measured ...	---	---
Lateral ventricle fluid ...	1	0
Mesenteric gland, A. ...	2	0
" " B. ...	2	0
" " C. ...	2	0
Cervical gland ...	1	0
Femoral gland ...	1	0

CASE II.

Died 3 p.m., September 16th, 1902. Number of Microfilaria perstans in 5 c.mm. of blood on that day---
2 p.m., 7. Necropsy, 4 p.m., September 16th, 1902.

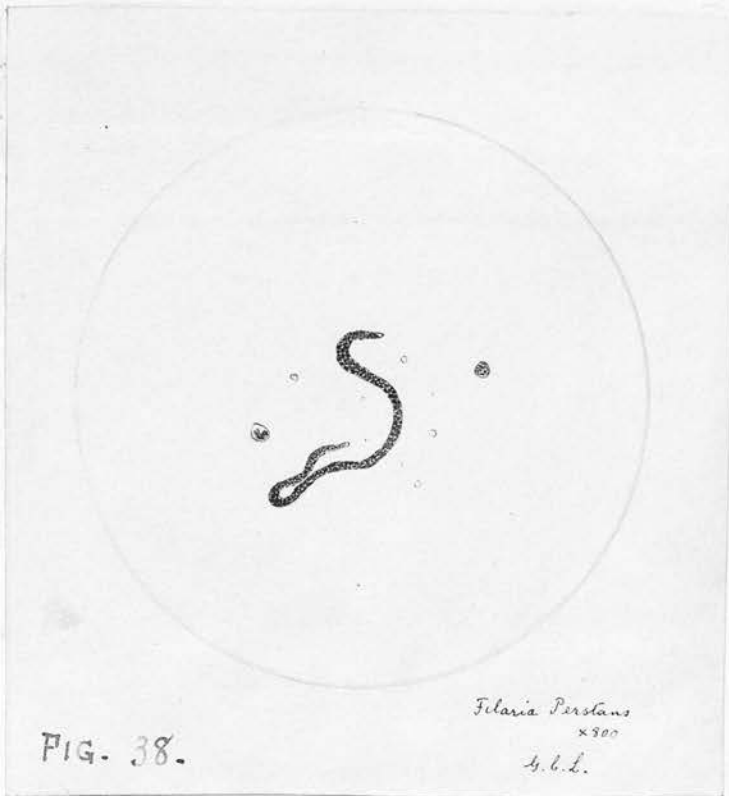
Organ.	No. of slides.	No. of <u>Microfilaria perstans</u> in 5 c.mm. of blood.
Heart, L. vent. ...	1	11
" R. vent. ...	1	24
Lung, R. ...	1	10
" L. ...	1	15
Liver ...	1	0
Spleen ...	1	0
Pancreas ...	1	1
Kidney, R. ...	1	8
" L. ...	1	2
Aorta ...	1	10
Superior vena cava ...	1	10
R. common carotid ...	1	24
R. internal jugular ...	1	7
L. saphenous vein ...	1	10
Sup. longitudinal sinus ...	1	4
Subdural vein ...	1	2
Brain, capillary motor area ...	1	8
Capillary at base of brain ...	1	1
Smears not measured ...	---	---
R. lateral ventricle fluid ...	1	0
Femoral gland ...	1	0
Neck gland ...	1	0
Mesenteric gland ...	1	0

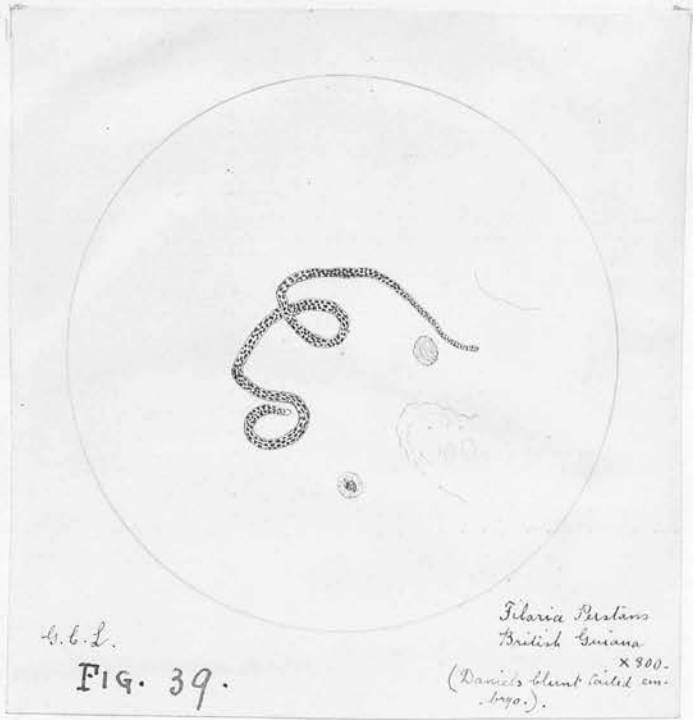
Further points of anatomy.

A cephalic armature can be seen in fresh specimens; it consists of a non serrated prepuce difficult to make out and a little fang or spine. A V spot with the angle

more obtuse than that seen in the Microfilaria bancrofti is present but it is difficult to say if a tail spot is or is not. In stained specimens the nuclear column is seen to fill the entire body cavity and a break in the continuity of the central column of cells can usually be made out. The tip of the tail, as has already been noted ends in a blunt or truncated manner.

DIAGRAMS.





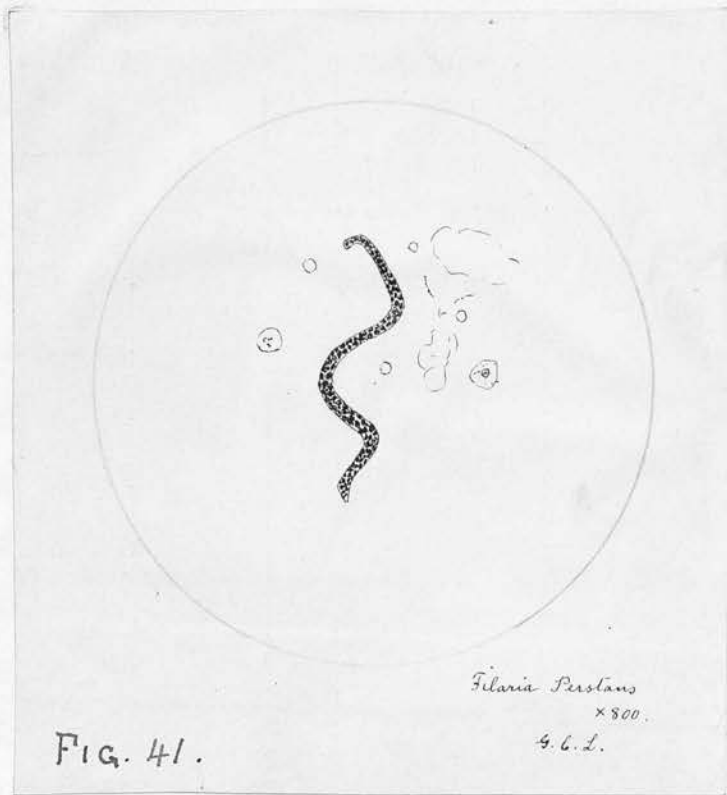
G. L. L.
FIG. 39.

Filaria Perstans
British Guiana
x 800.
(Daniels' blunt tailed em.
1890.)



FIG 40.

Filaria Perstans
x 800.
G. L. L.



The intermediate host.

Just as in the case of Filaria demarquayi I failed to find an intermediate host for Filaria perstans. Analogy again leads me to suppose that one must be necessary, but though I found two sausage shapes in one mosquito, Taeniorhynchus fuscopennatus (Theobald), which had fed on an infected case nothing else happened. The observation however, just as in the similar one of the sausage stages of Demarquayi in the thoracic muscles of Stegomyia calopus

(fasciata), is important, because it again indicates that if the suitable host could be found a development on similar lines to that of Filaria bancrofti in Culex fatigans would occur.

Of other mosquitoes and insects I experimented on large numbers all of which however gave negative results. These were as follows:- Stethomyia nimbus, of the subfamily of the Anopheline^s, Anopheles argyrotarsis (Cellia argyrotarsis), Culex fatigans, Culex atratus, Janthinosoma musica, Culex viridus, Culex luteolateralis, Culex quasigelidus, Pyretophorus costalis, Myzomyia funestus, Panoplites africanus vel uniformis, Uranotænia cæruleocephala, Pulex irritans, Pulex penetrans (chigger), Pediculus capitis, and Pediculus vestimentorum.

The peculiar distribution of the parasite and its association with dense tropical forests suggests some insect with a similar distribution. Some time after I did this work Feldman in German East Africa⁽⁵⁹⁾ wrote a paper in which he incriminated a tick the Ornithodoros moubata as the host but his work was of such a nature as to leave one's mind open to doubt. Still, later on Wellman in Angola conducted a long series of experiments on this tick, rearing them from the egg, and feeding them on infected cases, and he concluded that a development of the filaria did take place in them.⁽⁶⁰⁾ (controls never shewed similar

bodies). He wrote me several times when doing this work for advice as how to proceed, and eventually sent me some of his specimens, but unfortunately these were mostly all broken in coming through the post and nothing very definite could be made of them. Ticks have such a hard chitinous exoskeleton that sectioning them is very difficult so this means of getting definite proof is not of much use.

On the whole after carefully reading Dr. Wellman's paper, and his letters to me on the subject when doing the work, I am inclined to think that the Ornithodoros moubata the bug-like tick that infests the cracks and crevices of mud huts and similar situations in Tropical Africa is in all probability the intermediate host of Filaria perstans. Whether this be so or not it is of course incumbent that the work should be confirmed by some expert and the matter definitely settled.

If a tick eventually turns out to be the intermediate host of Filaria perstans then it requires no very great stretch of imagination to suppose that a similar insect will also be found to spread Filaria demarquayi. I have often thought of this lately, and it is just possible that in this suggestion an explanation of the localised distribution of the latter parasite in the West Indian Islands may be found.

iv. Pathology.

Filaria perstans was at one time supposed to be the cause of sleeping sickness and the connection did certainly seem a fairly intimate one, but I was able to disprove this, ⁽⁶¹⁾ firstly by pointing out that in British Guiana where there are abundant F. perstans there is no sleeping sickness, and secondly by pointing out that in Kavirondo, Africa, where there were no F. perstans sleeping sickness was rife. Other points brought out at the autopsies of sleeping sickness cases also tended to disprove the theory, and the soundness of these conclusions was amply verified by Castellani's subsequent discovery of the trypanosome as the cause of this disease.

Filaria perstans apparently gives rise to no pathological symptoms, the position of the worms in the connective tissues of the mesentery apparently causing no harm. Differential leucocyte counts on a series of 8 cases showed that 5 had no eosinophilia, even though one of these also had bilhazial disease--- a very common complaint in Uganda. The other three--- two being children, one a young adult---showed an eosinophile percentage of 15, 16, and 19 respectively; but as their faeces exhibited the ova of ankylostomata, trichocephalus, and ascaris lumbricoides, it is difficult to decide to which of these the condition was due.

As the parasite is then to all intents and purposes harmless there is little use in laying stress on any prophylaxis as regards it.

Till we know the proper intermediate host we are helpless and can only conjecture as to how the parasite passes from one individual to another.

If the Ornithodoros moubata does eventually turn out to be the host then the prophylaxis will be comparatively easy, namely the avoidance of life in native huts and old disused buildings to which natives have access. As better houses are built for Europeans, bricks and mortar will take the place of cow dung and mud and the tick will not get a chance to get in to establish itself. In moving about the country it is always advisable to sleep in one's own tent, but if one should by chance be compelled to inhabit a cow dung rest house or native hut then one should never sleep on the floor but in one's camp bed under a mosquito curtain. The importance of avoiding these tick bites lies more of course in the avoidance of tick fever than of infection with Filaria perstans but what is good for the one, will, if the tick is the host of the filaria, prove equally good for the other.

FILARIA MAGALHÃESI.

This name has been given to an adult form of a filaria found by Dr. de Saboia in a clot in the left ventricle of the heart of a child in Rio de Janeiro. The worms---both males and females were present---were sent to Dr. Magalhães who described and measured them. If Dr. Magalhães name was not a well known one for scientific accuracy and ability one would have been dubious that a mistake had been made somewhere, but in view of the statement just made the only conclusion to be reached, from the measurements of these worms, is that they represent an entirely new species of human filaria.

The female measured 155 mm. in length by .71 mm. in breadth, the male 83 mm. in length by .4 mm. in breadth, figures that at once indicate that they are entirely different to the Filaria bancrofti. Though that is so the general anatomy resembles somewhat that of the last named parasite. The tail is blunt and circular in both sexes, the male shews four pairs of pre-anal papillae, four pairs of post-anal papillae and two unequal spicules protruding from the anal orifice, the female, the double uterine tube and vagina situated anteriorly. The cuticle, however, was said to have fine transverse striae and if this is so then that would constitute a further difference

between the two species. Manifestly then these adult filaria are different to anything so far described in man (1) as regards their situation and (2) as regards their measurements.

I have often thought it possible that the worms might really have come from the connective tissues, or even from the thoracic duct, behind the heart, but against such an idea is the definite statement that they were in a clot in the left ventricle of the heart, a statement about which there could hardly be any doubt.

Of course there is nothing extraordinary about the site in which the parasites were found, as the Filaria immitis, a parasite of the dog, normally inhabits the right ventricle of the heart of that animal. The parasites were not a stray example of immitis occurring in man, however, as that worm measures 25 to 30 cm. in the female, 12 to 18 cm. in the male, enormous lengths as compared with the species under discussion.

There is no record of the Filaria magalhãesi ever having been found again either in Rio or in any other part of the globe, and therefore all one can do is to wait to see if anyone will be fortunate ^{enough} to re-discover it.

The blood of the child in which it was found had not been examined during life or after death so it is

impossible to say if embryos were or were not present in the blood, and also what the shape, measurements, and other anatomical points of these might be.

I have never heard of any examinations of night or day bloods being made in Rio, which is unfortunate, because if the parasite is common a solution to the mystery might soon be forthcoming. Even if this did not come about the prevalence or otherwise of F. bancrofti in that town would be interesting.

Brothel	20-30	150	210
Diameter of head	.005	.005	.005
Diameter of body	.005	.005	.005
Distance from head (1) of ventral surface	.010	.010	.010
(2) of dorsal surface	.010	.010	.010
Distance from tail of anal orifice	.005	.005	.005
Coloration of shell	Irregular not bilobed	Elliptical bilobed covered by callosities papillae-like & irregularly arranged	Bilobed callosities not prominent

TABLE of the measurements of the adult
female human filaris.

(Daniels, Magalhães and Low)

	DANIELS.		
	<u>F. bancrofti</u>	<u>F. perstans</u>	<u>F. ozzardi</u>
	mm.	mm.	mm.
Length	85-90	70-80	81
Greatest thickness	.20-.26	.120	.210
Diameter of head	.055	.070	.050
Diameter of neck	.049	.054	.039
Distance from head (1) of vaginal orifice	.710	.600	.710
(2) of ovarian opening	.920	?	.850
Distance from tail of anal orifice	.225	.145	.230
Termination of tail	Blunt circular not bulbous.	Slightly bulbous covered by thickened cuticle prolonged into 2 triangular appendages	Bulbous cuticle not thickened.

	DANIELS.	MAGALHAESI.	LOW.
	<u>F. demarquayi</u>	<u>F. magalhaesi</u>	<u>F. perstans</u> (Uganda)
	mm.	mm.	mm.
Length	80	155	50
Greatest thickness	.21-.25	.715	.160
Diameter of head	.09	.331	.080
Diameter of neck	---	.285	.072
Distance from head (1) of vaginal orifice	.76	2.560	1.22
(2) of ovarian opening	---	---	1.60
Distance from tail of anal orifice	.250	.132	.160
Termination of tail	Bulbous cubicular thickening over tip.	Ends in a blunt point simple.	Cuticle thickened to form 2 triangular appendages.

Filaria loa 30-40 mm. long by .5 mm. broad. One measured by myself gave 35 mm. for the length with a breadth of just under .5 mm.

DOUBTFUL SPECIES.

Filaria ozzardi. The question of the specific distinction of the Filaria ozzardi has already been discussed. It has been shewn that the blunt tailed microfilaria are the Microfilaria perstans, and that in all probability the sharp tailed ones are the Microfilaria demarquayi, though this latter statement may just perhaps be open to a little doubt. The name Filaria ozzardi must therefore disappear unless the latter supposition should prove correct, when it (the name) would have to be retained for the sharp tailed embryos of the Aboriginal Indians of British Guiana and other parts of South America.

Filaria philippinensis. Recently Ashburn and Craig⁽⁶²⁾ in the Philippine islands have described what they believe to be a new embryonic form of human filaria, basing this belief on the facts of (1) differences in morphology, (2) the presence of progressive motion, while their parasite was still contained within its sheath, and (3) an absence of periodicity.

Though quite granting that there may be different species of embryonic filaria included under the name of Filaria bancrofti I had⁽⁶³⁾ ---in opening a discussion on this subject at the Society of Tropical Medicine and Hygiene, March 19, 1909---to criticise

the work of these authors somewhat severely shewing that they had not produced enough scientific proof to uphold their contentions. Dr. Craig replied to these remarks in the Journal of Tropical Medicine⁽⁶⁴⁾ and I answered his note in the same journal a few weeks later.⁽⁶⁵⁾

The so called Microfilaria philippinensis when analysed critically is seen to measure exactly the same as the Microfilaria bancrofti; still further it undergoes---according to Ashburn and Craig---an exactly similar and identical metamorphosis in Culex fatigans, and its anatomy is also, as far as one can judge, identical with that of the latter parasite, or at least any differences that do exist might quite easily be produced by a different technique in staining. The presence of progressive motion while the parasite is still contained within its sheath is interesting, but sometimes it is by no means easy to be certain, when looking at fresh specimens, whether the filaria is or is not out of its sheath. I have already shewn, that in Fiji and other parts of the world, microfilariae to all intents and purposes identical with Microfilaria bancrofti are to be found in the blood by day as well as by night---that is to say exhibit no periodicity---but as to whether we are justified in labelling them as a new species on account of this peculiarity is quite another thing.

This irregular periodicity was evidently what made Ashburn and Craig jump to the conclusion that they had found a new species of embryonic filaria, but, considering the many points of similarity between it and the Microfilaria bancrofti, I hold they should have suspended judgment till adults had been found, carefully measured, and otherwise compared with F. bancrofti.

It is exceedingly probable, I should say, that if the embryonic forms are identical that the adults will also be so, but at any rate---if eventually they are found to be not---it will be time enough then to give them specific rank.

A study of Ashburn's and Craig's three cases shews that the infection was an exceedingly scanty one, averaging only about one microfilaria in 2 smears, and this indicates that there were few adults and these in all probability young ones just beginning to breed. I note also that two other Americans, who have been working at filariasis in the Philippines since the authors left, have not confirmed the finding of this new species, but have pointed out that Filaria bancrofti is quite prevalent.

For the present then the name Filaria philippinensis to my mind must rank as a synonym of Filaria bancrofti.

Filaria gigas. Prout⁽⁶⁶⁾ believed that he had found a new microfilaria in the blood of a native of Sierra Leone which on account of its large size he provisionally named Filaria gigas. I saw these specimens at the London School of Tropical Medicine and was very dubious as to their real nature, as they had been treated by acids and were very much overstained. Prout however published the observation and the word crept into the literature. Later Dr. St. George Gray of Sierre Leone tried to find these parasites again in the same district from which the original case came. He could not find proper filariae but discovered similar looking bodies in blood slides which had been left exposed in a native hut, a subsequent exposure of slides smeared with a little egg albumin also giving the same appearances. He concluded therefore that these came from the air and eventually proved that they were hairs of a fly.

After seeing his specimens I wrote a short note proposing that the name F. gigas should be deleted from the literature, and this I notice has since been done.

Filaria powelli. This name has been applied to a worm found in the blood of a native policeman in Bombay by Dr. Powell. I saw the specimen in London through the kindness of its owner and I noticed at once that it did not resemble any of the human blood

filariae. Personally I should be very doubtful if it was the embryo of a filaria at all; it looked much *more* like the embryo of some other nematode which had been passing through the circulation by chance, in a similar manner to that in which the young ankylostomes must do in their passage from the skin to the lungs. This hypothesis has something to support it as I believe the patient's blood was often examined again but always with negative results.

In some books, I notice, this worm is said to have had a sheath, it certainly did not have one in the sense of the sheath of the Microfilaria bancrofti and as far as I can remember it I would have called it sheathless.

Its significance is very doubtful and it has never been found again as far as I am aware.

Filaria ? Dr. Nuttall of Cambridge recently sent me a blood slide he had received from Dr. Greig I.M.S. to see if I could recognise a filaria, said to be in it.

I saw the parasite certainly but could not say definitely what it was. I do not think it was an ordinary blood filaria; it was very small and required the highest powers ($\frac{1}{12}$ " oil immersion) to properly make it out. It had no sheath and appeared to have a blunt tail.

Its significance like that of Powell's is

doubtful, and I never heard if any more were found in the individual's blood again, nor in fact of any further details concerning it.

It is possible that as time goes on other species of blood filariae will be found, it being very unlikely that we have only the five definite ones described. There are still parts of the world, New Guinea, Borneo, and Java for example, where little blood work has been done and when this eventually is accomplished no doubt the results will be fruitful of new and interesting species.

The question also of the possibility of there being different species included under the name of Filaria bancrofti I have just mentioned; this is a point of some importance, and it would probably repay anyone, who can afford the time, to take the matter up and definitely settle whether this is so or not.



(1) Journal of the Royal Society of Medicine, London, 1927, p. 100.
(2) British Medical Journal, London, 1927, p. 100.
(3) British Medical Journal, London, 1927, p. 100.
(4) British Medical Journal, London, 1927, p. 100.
(5) British Medical Journal, London, 1927, p. 100.
(6) British Medical Journal, London, 1927, p. 100.
(7) British Medical Journal, London, 1927, p. 100.
(8) British Medical Journal, London, 1927, p. 100.
(9) British Medical Journal, London, 1927, p. 100.
(10) British Medical Journal, London, 1927, p. 100.

BIBLIOGRAPHY.

- (1) Gazette Médicale de Paris, 1863, chap. xviii., pp. 9, 665.
- (2) Gazzétta Medica de Bahia, Dec. 5th, 1868, and Sept. 30th, 1869; und Leuckart's Parasiten, Band II., pp. 9, 646.
- (3) Eighth, Tenth, and Fourteenth Annual Reports of the Sanitary Commissioner with the Government of India. Calcutta.
- (4) Lancet, July 14th, 1877, and Cobbold, Parasites, 1879.
- (5) Lancet, October 7th, 1877.
- (6) Lancet, May 12th, 1878.
Proc. Linn. Soc., March 7th, 1878.
Medical Times and Gazette, London, 1878.
Transactions, Linn. Soc. of London, 2nd Series; Zoology, vol. ii., Part X., p. 367.
- (7) Proc. Asiatic Soc., Bengal, March, 1878, pp. 9, 89; and Fourteenth Annual Report of the San. Com. with Government of India, 1878.
- (8) Medical Times and Gazette, May 27th, 1882, p. 554.
- (9) Centralbl. für Bakter. und Parasiten, Band II., No. 8, 1890; also John Hopkins, Hospital Reports, vol. viii., 1892 (Nuttall).
- (10) Journal of Tropical Medicine, London. November 15th, 1899, page 91.
Australian Medical Gazette, March 20, 1899.
- (11) British Medical Journal, June 16th, 1900.
- (12) British Medical Journal, September 1, 1900, p. 533.
- (13) British Medical Journal (Translation) November 3rd, 1900.
- (14) British Medical Journal, August 18, 1900, p. 443; ditto September 8, 1900, p. 682.
Memoirs III. and IV. of the Liverpool School of Tropical Medicine.
Report of Malarial Expedition to Nigeria.

- (15) British Medical Journal, June 1, 1901, p. 1336.
- (16) British Medical Journal, Jan. 25, 1902, p. 189.
- (17) Journal of Infectious Diseases, Suppl., No. 1,
p. 332.
- (18) Philippine Journal of Science, Vol. II., p. 1.
- (19) "Filarien" Separat-abdruck aus Real-Encyclopädie
der gesamten Heilkunde. 4 Aufl. und
Archiv f. Schiffs- und Tropenhygiene, 1908.
Beiheft g. Band XII. und derselbe t. XI.,
No. 20.
- (20) Die thierischen parasiten des menschen. Braun
dritte, vermehrte und verbesserte auflage.
Würzburg 1903.
- (21) Lancet, Feb. 1, 1908, p. 279.
Transactions of the Society of Tropical Medicine
and Hygiene, 1907-1908, Vol. I., p. 84.
- (22) Tropical Diseases. Manson. Cassell & Co.,
London.
- (23) Trans. Soc. of Trop. Med. and Hygiene, Vol. I.,
p. 102.
- (24) Tropical Diseases. Manson. 1903 edition, p. 552.
- (25) Journal of Tropical Medicine, April 15, 1902,
p. 118.
- (26) Lancet, 1881, Aug. 27, p. 398.
Transactions of the Path. Society of London,
1882.
Ibid., 1883, XXXIII, p. 394.
- (27) Scheube. The diseases of warm countries.
Translation. 2nd edition. Bate, Sons &
Danielson, 1903, p. 405.
- (28) Gaz. des hôp, 1888, No. 68.
Bulletin de l'Acad. de médecine, 1888, No. 36.
- (29) Centrablatt für Bakteriologie u Parasitenkrankheit,
1892, XII., p. 88.
- (30) China Imperial Maritime Customs Med. Reports,
1881, XXI., p. 1.
Ibid. 1886, XXXII.
Lancet, 1881, December 10th, p. 1015.
Brit. Med. Jour. 1882, Jan. 14th, p. 51.

- (31) Brit. Med. Jour. 1896, Oct. 3rd, p. 922.
- (32) Journal of Tropical Medicine, Nov. 1899, p. 91.
- (33) Brit. Med. Jour. Sept. 1, 1900, p. 535.
- (34) Brit. Med. Jour. "Malaria Expedition to
Nigeria", Jan. 12th, 1901, p. 97, and
Brit. Med. Jour. Sept. 7th, 1901, p. 612.
- (35) Jour. of Trop. Medicine, London, June 15th,
1901, p. 193.
- (36) British Medical Journal, June 1st, 1901, p. 1336.
- (37) Ibid.
- (38) British Medical Journal, Sept. 1, 1900.
- (39) British Medical Journal, Jan. 25, 1902, p. 189.
- (40) British Medical Journal, Sept. 7, 1901, p. 612.
- (41) British Medical Journal, Nov. 23, 1900, p. 1307.
- (42) Tropical Diseases, p. 585.
- (43) Elephantiasis and filariasis in Fiji. (Wilson)
Locally published at the Polynesian Gazette
office, Levuka, Fiji, as a pamphlet.
- (44) Deutsche Med. Woch., 1881, p. 624.
- (45) Trans. of the Pathological Society of London,
1883, XXXIII., p. 394.
- (46) British Medical Journal, 1879, April 24, p. 1037.
- (47) Mosquito or man? Boyce, 1909.
- (48) Die thierischen parasiten des menschen, 1903,
p. 272.
- (49) Lancet, January 7th, 1905.
- (50) Elephantiasis and Filariasis in Fiji (loc. cit.)
- (51) Journal of Tropical Medicine and Hygiene, Dec.
15, 1909, p. 365.
- (52) American Journal of Medical Science, Sept. 1906.
Philippine Journal of Science, Vol. II., No. 1,
March 1907.

- (53) British Medical Journal, 1897, II., p. 1837.
 - (54) British Medical Journal, Jan. 25, 1902, p. 196.
 - (55) Lancet, 1891. 1. 4.
 - (56) British Guiana Medical Annual, 1897, IX., 28.
 - (57) British Medical Journal, Jan. 25, 1902, p. 196.
British Medical Journal, March 28, 1903, 1.722.
 - (58) British Medical Journal, April 26th, 1898, 1.1011.
 - (59) Arch. f. Schiffs- u Tropenhyg., 1904, VIII., 285.
 - (60) British Medical Journal, July 20th, 1907.
 - (61) Royal Society. Reports of the Sleeping Sickness
Commission, No. II., November 1903.
 - (62) American Journal of Medical Sciences, Sept. 1906,
and Philippine Journal of Science, Vol. II.,
No. 1, March 1907.
 - (63) Transactions of the Society of Tropical Medicine
and Hygiene, March 19, 1909.
 - (64) Journal of Tropical Medicine and Hygiene, August
16, 1909.
 - (65) Journal of Tropical Medicine and Hygiene, Sept.
1909.
 - (66) British Medical Journal, Sept. 20th, 1902.
-