MAP 1

DISTRIBUTION OF FILARIAL INFECTION (based on examination of thick blood smears)
Areas with filarial infection
After Megaw & Gupta 1927.
revised Acton & Rao 1931.

MAP OF INDIA
(SHOWING PROVINCES AND DISTRICTS).
INTRODUCTION.

Most of the more important diseases that are to be found in Assam have been very thoroughly investigated, and the part they play and their distribution have been well assessed. Notable examples have been Kala-Azar, Malaria, Cholera, Hookworm disease, Yaws, and, of late Nutritional diseases, the Anaemias and Tropical Ulcer. A disease which has received very scant attention, and the degree and distribution of which has not been studied is Filariasis.

Filariasis itself in India as elsewhere has become more complex on account of the comparatively recent recognition of \textit{Mf. malayi}, Brug. It is probable that when its recognition and differentiation from \textit{Mf. bancrofti} becomes better established it will be found to have a much wider incidence than at present supposed.

It is proposed in this paper to discuss the incidence of filarial infection in general in the province of Assam, and in particular the occurrence of \textit{Mf. malayi} Brug; the mosquitoes which play the part of
vector of *M. malayi* and the biological factors which operate in the case of these vectors. The results of the author's own investigation are given, and the discussion is based mainly on these findings.

ASSAM. - Geography, physiography, climatology and population.

The administered area of Assam is nearly 70,000 square miles, as large as England & Wales and a third of Scotland. The population is a little over 9 millions. It is situated in north east India bordered on the West by Bengal, in the South by Tripura State and the Chittagong Hill Tracts, on the East by the Lushai Hills, Manipur State and Naga Hills contiguous with Burma, on the North by Bhutan, and the lower eastern end of the Himalaya range. Except on the West, then, where it borders Bengal, it is surrounded by hills and mountains. It is divided into two valleys, separated by the North Cachar Hills, and the Khasia & Jaintia Hills running practically East and West, the upper being the Assam or Brahmaputra Valley, and the lower the Surma Valley. In the Assam Valley the main river is the great Brahmaputra winding from the north east corner along the northern part of the Valley to the north western corner where it abruptly turns South and then South East through Eastern Bengal to empty into the Bay of Bengal, in a delta on which stands the port of
Chittagong. The plains districts of the Surma Valley are two, Cachar in the East, Sylhet in the West bordering East Bengal; the main river is the Barak or Surma rising in Manipur State, pursuing a very tortuous course from East to West through Cachar and Sylhet, finally emptying into the Brahmaputra in East Bengal. In both valleys there are innumerable smaller rivers, in the hilly districts swift and moderately straight, in the plains slow and tortuous except at flood time. The plains occupying the central part of each Valley, are very low-lying - from about 300 ft. above sea level in the upper part of the Assam Valley to 70 ft. in the Surma Valley at rice-land level. They form an alluvial tract of clay, sand and vegetable matter, and are freely cultivated for rice. In the Upper Valley there are large stretches of low flat plateau on which tea is cultivated, but the Surma Valley is more broken up by isolated hillocks and small plateaus on which the tea is grown. In both valleys swamps and stagnant water areas abound.

The annual rainfall in the Upper Valley varies from 80 inches in certain districts to 125 inches in others. In Lakhimpur it is 120 inches. In the Surma Valley it averages 130 inches, Sylhet being a little more than Cachar. Minor floods are common with occasional major floods in both valleys. The range of temperature is from 80° to 95°F. or higher
in the hot weather and rains, and 45° to 60°F. in the cold weather, and the higher range continues roughly from April to October. The humidity in the plains of both valleys is from 70 to 100 per cent for about 7 months of the year. Finally, Cachar and Sylhet are about 180 miles distant from the sea (Chittagong), Tezpur 300, and Dibrugarh in Lakhimpur is 400 miles distant (Map 2).

PRESENT VIEWS ON THE INCIDENCE OF FILARIASIS IN ASSAM.

It is generally agreed filarial infection seldom to any degree occurs above 2000 ft., so that the hilly area of Assam is ruled out of consideration. But the plains, apart from their low-lying situation, fulfill the requirements generally postulated for the occurrence of the infection: those are a range of temp. between 75° and 90°F., and a humidity of over 60 per cent, for 6 or 7 months of the year, the appropriate carrier mosquitoes, and the infective human reservoirs. At the same time, in India, endemic areas are generally found either along the sea coast or in the neighbourhood of rivers. In this respect the plains of Assam are very similar to Bengal, especially East Bengal, except that Assam has got no sea-board although on the other hand it has got a very large system of rivers. Bengal as a whole is one of the most
MAP OF ASSAM
SCALE 50 MILES TO ONE INCH
heavily infected provinces of India, but East Bengal lying adjacent to Assam, mainly the Sylhet district of Assam, has an infection rate of less than 5% (Rao 1937). Rao explains this as being due to the efficient drainage by the river system of East Bengal preventing water-logging. There appears to be a general impression outside the province that Assam has also got a fairly intensive filarial infection and Megaw & Gupta (1927) and later Acton & Rao (1931) in their map of India showing filarial distribution and intensity, mark Assam as considerably infected. Rao also in a recent very useful summary of the distribution of filarial infection in India (1937) says that infection is present in most districts; that districts lying on the banks of the Brahmaputra show a fair amount of infection; and that low-lying areas such as Sylhet, Tezpur and Jorhat on the banks of the Brahmaputra show heavier infection than others in Assam. On page 8, however, he says that Assam like the Central Provinces is a slightly endemic area.

On the other hand, the opinion held by most medical men in the province is that filarial infection must be very slight or absent in most districts. On account of the few cases of filarial disease encountered and from their experience they consider that the few cases of infection or disease known never lead to endemic spread but rather die out. Such a keen observer as Dr. G. C. Ramsay, the Principal of the Ross
Institute in India, who has travelled extensively in Assam and visited practically all tea estates advising on malaria control measures, and has seen considerable numbers of the estate population at spleen examination musters, was of the opinion that the incidence of filarial infection must be very slight to judge by the numbers exhibiting clinical signs, and that in most districts it appeared to be absent except for an occasional isolated case generally imported with the condition. He could refer to only one apparently endemic area and that was in Lakhimpur in the extreme north east of the Province (personal communication).

In this part of Cachar the writer has seen in a period of 10 years 4 cases of infection with what was diagnosed as *Mf.bancrofti*. These cases ultimately ceased to show any microfilaria in the blood, and at the same time there was no evidence that they had started endemic spread. This was also the experience of his predecessor Dr. G.C. Ramsay. Other Medical Officers in the Surma Valley have remarked on the failure of the disease to take a hold in the low-lying plains districts of the Valley, and when this opinion was taken with special reference to Sylhet which is adjacent to Bengal, it became particularly interesting.
FILARIAL INFECTION IN SOUTH EAST CACHAR.

In the writer's medical practice, then, filarial infection was practically non-existent, until a few years ago supervision extended to a further group of estates, separated from the original group by a fairly large river, the Barak. Part of that area (map) was found to have numerous cases of elephantiasis amongst its population, of which rumours had previously been heard. It was obviously an endemic area of filariasis. It was puzzling to understand how the filariasis occurred in such active form in this restricted area, and not elsewhere. Certainly the terrain was low-lying and swampy but not more so than innumerable other places of habitation throughout the district, further, the disease was of a very mild type, namely moderate elephantiasis of the extremities, generally the lower, and usually involving only one limb. A single case of mild elephantiasis of one arm was detected. It was found that genital elephantiasis, hydrocele, or chyluria, did not occur. Numerous cases of lymphangitis occurred. These features - the strictly local (but nevertheless fairly rapid) spread, and the mildness of the physical signs roused suspicions that the infection might be *Mf. malayi*. At that time, Dr. J. J. C. Buckley from the London School of Hygiene & Tropical Medicine arrived to study helminthological
problems in the district and at the writer's request examined the night bloods of the infected, and identified the microfilaria as Mf. malayi Brug. The infection rate in one set of lines was found to be over 30%. Anopheles hyrcanus var nigerrimus (Wied.) was incriminated, although it was suspected that species of mansonioides would also be vectors. At that time however, the study of culicines had not been undertaken at the writer's laboratory.

Later, the writer himself investigated the area thoroughly with the following results:

**TABLE I.**

Infection and Disease rates in the populations of Naidal, Rabipur, Alicherra, Tilkah T.E., Bhubonber and Powda Busty, in South East Cachar.

<table>
<thead>
<tr>
<th></th>
<th>Total Number</th>
<th>Number with Mf. examined in blood</th>
<th>Microfilaria rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NAIDAL.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>9</td>
<td>1</td>
<td>11.11</td>
</tr>
<tr>
<td>No physical signs</td>
<td>106</td>
<td>34</td>
<td>32.07</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>35</td>
<td>30.43</td>
</tr>
<tr>
<td><strong>RABIPUR.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>2</td>
<td>1</td>
<td>50.0</td>
</tr>
<tr>
<td>No physical signs</td>
<td>43</td>
<td>7</td>
<td>16.27</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>8</td>
<td>17.77</td>
</tr>
<tr>
<td><strong>ALICHERRA.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>16</td>
<td>3</td>
<td>16.75</td>
</tr>
<tr>
<td>No physical signs</td>
<td>380</td>
<td>43</td>
<td>11.31</td>
</tr>
<tr>
<td>Total</td>
<td>396</td>
<td>46</td>
<td>11.61</td>
</tr>
<tr>
<td>Location</td>
<td>Elephantiasis, etc.</td>
<td>Number with Mf. in Blood</td>
<td>Microfilaria Rate</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>TILKAH T.E.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>20</td>
<td>7.35</td>
</tr>
<tr>
<td></td>
<td>No physical signs.</td>
<td>272</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>281</td>
<td>20</td>
</tr>
<tr>
<td>BUBONBER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17</td>
<td>7.23</td>
</tr>
<tr>
<td></td>
<td>No physical signs.</td>
<td>235</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>239</td>
<td>17</td>
</tr>
<tr>
<td>POWDA BUSTY.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>27</td>
<td>5.34</td>
</tr>
<tr>
<td></td>
<td>No physical signs.</td>
<td>505</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>508</td>
<td>27</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>5</td>
<td>11.62</td>
</tr>
<tr>
<td></td>
<td>No physical signs.</td>
<td>1541</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1584</td>
<td>153</td>
</tr>
</tbody>
</table>
### Table II

<table>
<thead>
<tr>
<th>Types of Filarial Disease</th>
<th>Ali-Cherra</th>
<th>Naidol-Tilkah</th>
<th>Bhubon-Ber</th>
<th>Powda-Busty</th>
<th>Pur.</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephantiasis of one leg</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>&quot; &quot; both legs</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>&quot; &quot; &quot; and one arm.</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Filarial lymphangitis</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>43</td>
</tr>
</tbody>
</table>

\[ \text{Disease rate} = \frac{43}{1584} \times 100 = 2.7\% \]

#### Filarial Endemicity Rate

- Number with signs of filarial disease \( \ldots \) 43
- " " no signs but with microfilaria in blood \( \ldots \) 191
- Total number examined \( \ldots \) 1584

\[ \text{Filarial endemicity rate} = \frac{1584}{191} \times 100 = 12\% \]
1. Microfilaria malayi, Brug (Sheath not shown.)
2. " bancrofti, Cobbold " " "

Stained Giemsa
MICROFILARIA MALAYI BRUG.

Description and Distribution as at present known.

A brief description of **Mf. malayi** Brug 1927 and its differentiation from **Mf. bancrofti** Cobbold 1877, with a note on its world distribution as far as it is at present known may be conveniently interposed here.

The microfilaria is on the whole rather shorter than **Mf. bancrofti** but its length varies considerably. It has been variously stated as 165 to 263 μ, 187 to 265 μ (Brug 1927), 220 to 260 μ (Manson Bahr 1935), and 145 to 185 μ (Rao 1936). **Mf. bancrofti** on the other hand is 260 to 300 μ. The difference in breadth is insignificant. The cephalic space, that is, the anterior extremity devoid of nuclei, is about twice as long as the breadth of the head in **Mf. malayi** and only equal to the breadth of the head in **Mf. bancrofti**. The nuclei are large, coarse, overlapping and hardly countable in **Mf. malayi**; whereas in **Mf. bancrofti** they are neatly arranged, smaller, distinct, and countable. The anal pore is more anteriorly placed in **Mf. malayi**, at about 1/5 of the length from the tip of the tail. It makes a clear indentation in the nuclear column and is oval and deep, and very noticeable, whereas in **Mf. bancrofti** it is faintly marked, situated to the side of the nuclear column without breaking it, and difficult to see. The tail is more tapering in **Mf. malayi**, and in the majority of specimens one, two
or three, but generally two, nuclei are seen, particularly one at the extremity, and one at the thicker (proximal) part of what is described as tail. They generally stain much more deeply than the other nuclei, are conspicuous, and stain well with Giemsa. They appear elongated in correspondence with the length of the microfilaria. In *Mf.bancrofti*, of course, the tail portion is devoid of nuclei. Transverse striation of the cuticle in *Mf.malayi* is not so obvious as in *Mf.bancrofti*, but this is not a reliable feature. In thick films the disposition of the curves in *Mf.malayi* are irregular, coarse, with superimposed secondary waves in contradistinction to the long, smooth and graceful curves of *Mf.bancrofti*. On the whole, especially with Giemsa staining, *Mf.malayi* presents an appearance of being coarse, blurred, and dark staining, compared to the longer, apparently thinner on account of greater length, brighter staining and etched appearance presented by *Mf.bancrofti* and if the two are seen together in the same film or, better, in the same field of the film, the contrast is striking, and causes surprise that these differences remained so long undetected.

Both microfilariae are sheathed and have a nocturnal periodicity. Graphs of periodicity (Fig.12) of *Mf.malayi* in the Cachar endemic area are shown; it is interesting to note that Yen and Chang (1935) found
CASE No. 1

CASE No. 2

CASE No. 3

CASE No. 4

CASE No. 5

CASE No. 6

CASE No. 7

CASE No. 8

CASE No. 9

CASE No. 10

Fig. 12

By courtesy of Dr. J. J. C. Buckley.
the peak concentration of larvae in the blood rather later than these demonstrate.

*Mf. malayi* was first studied in Sumatra in 1926 by Lichtenstein (Lichtenstein 1927) who thought he was dealing with *Mf. bancrofti* on account of the sheath and periodicity. He became uncertain when he found that *culex fatigans* Wied. could practically not be infected, and was in further doubt when he found that the clinical signs of the disease were only elephantiasis of the extremities even in heavily infected areas with an infection rate of 30-50%. Therefore Brug took up the study of the microfilariae from these cases and deciding it was a new species called it *Mf. malayi*. It was found to occur in Sumatra, Java, the Celebes, New Guinea, and other islands of the Malay Archipelago (Brug 1928; Monchtar 1929; Van Gulik 1929; de Rook 1930; van Slee 1930; Jurgens 1932; Rodenwaldt 1931, 1934; Schpee 1935; Vander Heijde 1937). At first it was thought not to spread farther east than the lesser Sunda Islands and the Molucca Islands, but it has since been found to be common in China especially in Chekiang Province. Feng (1933, 1934, 1935); Yen & Chang (1935). It has been found in Malaya in Province Wellesley North (Strachan & Morris, 1934), and in the States of Selangor, Perak and Pahang (Hodgkin & Buckley, 1936). It has now
been found by H.F. Carter in Ceylon where it appears to be the main form of filariasis (Manson-Bahr 1935).

In India the first to discover *Mf. malayi* was Korke (1929) which he reported as the "atypical variety of bancrofti" in the sea-coast district of Balasore in Orissa. This "atypical variety" would appear to be the same as was reported by him from Muzaffarpur in Bihar 2 years previously (1927). He would not agree that it was a new species, but argued that as atypical forms, they might be adaptations of the type species *Mf. bancrofti* to the culicine carriers in the area.

Iyengar (1932) next reported *Mf. malayi* from an endemic area with the heavy infection rate of 27.4 per cent in North Travancore in the south west of India, and Rao (1936) found, during a survey in 1933, *Mf. malayi* to be the sole microfilaria associated with endemic filariasis in Patnagarh in Orissa, a small rural town about 500 ft. above sea level.

The most recent discovery of it in India has now been that found in the endemic focus in south east Cachar, identified by Buckley in 1934, as reported by the writer in his Presidential address to the Assam Branch British Medical Association in 1936 (Fraser 1936), this being the first discovery of *Mf. malayi* in the province of Assam.
A point which raises a major difficulty in referring to this filarial infection, and the particular disease signs associated with it, is the fact that the parental forms of the worm have not yet been found, and so the generic name *Filaria* is not strictly admissible. This fact excuses those who feel diffidence in applying names to apparently new forms of microfilaria.

**MOSQUITO FAUNA IN THE CACHAR EPIDEMIC AREA, AND VECTORS OF MF. MALAYI.**

The author continued the investigation of the original endemic area in Cachar, and attention was first directed to the more thorough identification of the vectors. *A. hyrcanus* having previously been satisfactorily proved to be a carrier in the area and other likely anopheles such as *A. barbirostris* shown to be insusceptible to infection by Dr. Buckley, attention was turned to the culicines. The first collection of identified specimens of the common culicines of the area with the numbers of each caught showing roughly the order of their frequency of occurrence was as follows:

- *Mansonia (Mansonioiides) uniformis* Theo. 93 ♀♀
- " " *indiana* Edw. 44 ♀♀
- *Aedes (Aedimorphus) vexans* Meigen. 42 ♀♀
Culex (Culex) fuscocephalus Theo. 31 ♀
" " bitaeniorhynchus Giles. 10 ♀
" " tritaeniorhynchus Giles. 3 ♀
" " fuscitarsus Barraud. 1 ♀
" " cornutus Edwards. 1 ♀

Subsequent collections showed also:--
Mansonionia (Mansonioides) annulifera Theo.
Culex (Culex) vishnui Theo.
Mansonionia (Coquillittidia) crassipes Van der Wulp.

The procedure adopted for discovering mosquitoes which were likely to be adequate as well as natural carriers was to take a heavily infected human host, place him in, or immediately in front of his house, in the evening, and capture alive all the mosquitoes which fed on him after they had been allowed to have a sufficient blood meal.

Experimental infection in the laboratory does not take account of the natural feeding habits of the insect, and "natural" infection rates of mosquitoes based on dissections of random collections from human habitations frequently involve more labour than can be afforded, and the procedure causes resentment and opposition. The method adopted in this case is a useful compromise and largely eliminates the objections of the other two methods. The captured
mosquitoes, then, were taken to the laboratory and dissected some time after ten days. The results were as follows:

**TABLE III.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Number dissected</th>
<th>Number positive</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Mansonia</em> (Mansonioides)</td>
<td>44</td>
<td>34</td>
<td>77.27</td>
</tr>
<tr>
<td>&quot; <em>uniformis</em></td>
<td>75</td>
<td>58</td>
<td>77.33</td>
</tr>
<tr>
<td>&quot; <em>indiana</em></td>
<td>14</td>
<td>9</td>
<td>64.28</td>
</tr>
<tr>
<td><em>Culex (Culex)</em></td>
<td>87</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&quot; <em>vishnui</em></td>
<td>25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>245</td>
<td>101</td>
<td></td>
</tr>
</tbody>
</table>

This agrees with the almost universal incrimination of three species of *Mansonioides* as being important if not the main carriers of *Mf. malayi* - in this case apparently in company with *A. hyrcanus* var *nigerrimus*. The work of identifying the various culicine fauna of the locality and the infectivity investigations were carried in 1935 and 1936.

**THE BIOLOGY OF THE MANSONIOIDES SUBGENUS.**

Iyengar (1933, 1935, 1937), particularly, has drawn attention to the fact that the species of *Mansonioides* lay their eggs on the under surface of the leaves of the water plant *Pistia stratiotes*, and that the larvae and pupae attach themselves to the roots of *Pistia* by means of horn-like and strongly
chitinised structures at the tip of the modified breathing syphons; these piercing structures penetrate the root tissue, and by this means the larvae obtain their oxygen needs from the air cavities of the root. The larvae and pupae remain stationary there and do not come to the surface for air in those stages. In nature, according to Iyengar, eggs are found on the leaves of *Pistia* only, and the presence of *Pistia* is an essential factor for oviposition of *Mansonioides*, furthermore *Pistia* is the only plant to which the larvae will attach themselves, and when *Pistia* is removed from a breeding place, the larvae also disappear from the breeding place although other water plants may be present in the pond. Rodenwaldt (1934) also mentions the correlation of the plant *Pistia stratiotes* with vectors of *Mf. malayi*.

**PLANT HOSTS OF MANSONIOIDES IN CACHAR.**

In the endemic area in Cachar under discussion *Pistia stratiotes* does occur in patches of moderate quantity, and it occurs quite widely throughout the swamps, stagnant-water areas, and tanks of Cachar plains generally. At the same time, at one spot in the area where infection was considerable, there was no *Pistia* within one to two miles. *Mansonioides* larvae were found breeding on their plant host *pistia* where it occurred, but it also was found as abundantly if not more so on the root of other aquatic
plants, namely water hyacinth *Eichhornia Crassipes*, and "Dol" grass which is the local (Bengali) name for a coarse aquatic grass, whose botanical name would appear to be *Sacciolepis interrupta* Stapf, (syn. *Panicum interruptum* Willd), according to the authorities of the Royal Botanical Garden, Calcutta. (personal communication). This grass forms a weed partly aquatic and partly amphibious, growing in swamps, water logged areas and moist low lying lands. These three plants all have a similar type of root although that of *Pistia* appears the finest, and "Dol" grass the coarsest. It is possible that there are other plants serving the same purpose. The larvae found in large numbers on these two plants and identified were *M.annulifera* and *M.uniformis* or *indiana*, the last two being indistinguishable in their larval stage. *M.uniformis* adults also were hatched out in large numbers. Other adults hatched out from these larvae were *M.annulifera*, and *M.longipalpis*. Species of *Coquillettidia*, - the other subgenus of *Mansonii*, were also found numerously in the larval stage, on both hyacinth and "Dol" grass; these likewise have the syphonal valves modified for piercing the tissues of aquatic plants.

In other parts of Cachar, it has been possible to find with ease the species of *Mansonicoides* developing in the manner described on the three water
plants, water hyacinth, "Dol" grass and pistia, and it should here be pointed out that these three plants are found growing profusely throughout the plains of the Surma Valley in low lying water-logged areas, and that Mansonioides species are amongst the most abundant culicine mosquitoes encountered. Two more observations are necessary, before leaving the subject of the mosquito fauna in Cachar, - one is the fact that A. hyrcanus var. nigerrimus while of course not having the same life history as Mansonioides selects the same type of breeding place as happens to be suitable for Mansonioides, i.e., swamps, and undrainable watery areas in low lying country and also tanks and borrow-pits. The other is the failure to find Culex fatigans in this part of Cachar. The writer has been on the look-out for this mosquito continuously for almost a year, and has had numerous catchers and surveyors searching for the larva or adult in or around all the likely breeding places and adjacent habitations over a wide area in his district but without success. Furthermore there is apparently no actual record of its presence in the districts of Cachar and Sylhet. This is remarkable considering that it is described as the common house mosquito of the tropics and supposed to be well-nigh universal. The possible significance of these observations will be discussed later.
LAKHIMPUR.

It was decided in 1937 to investigate the area in Lakhimpur in the north-east part of the Assam Valley, where a focus of endemic filariasis was suspected to exist. This was located on the south side of the small, tortuous and slow flowing Dibru river, which flows from East to West and empties at right angles into the Brahmaputra. It involved a tea estate and the surrounding villages, 16 miles east of Dibrugarh town. On reference to the Medical Officer of the Tea Estates in that area it was definitely established that tea estates to a certain extent, and the villages in the vicinity to a greater extent, were affected with a gross degree of elephantiasis and other forms of filarial disease. The area was about 350 ft. above sea-level, and was intersected with slow-flowing, almost semi-stagnant streams and drains, and was dotted about with swamps, tanks and undrained collections of water. The origin of the disease is obscure, it not being clear whether it started in the estate or adjacent villages as they are situated so close together. It is believed to have existed there for the last 50 or 60 years. It was soon found on examination of the night bloods of the inhabitants that both Mf. bancrofti and Mf. malayi were present, one predominating more in one set of lines or village, and the other in another set of lines or village, with both infections occurring
ALIJAN SOUTH. T.E. (DISTRICT LAKHIMPUR)

WITH TIANLINE & NEPHAPHOO BUSTY

RAISED LAND
ROADS
WATERY PLACES
POOLS & SMALL COLLECTION OF WATER
BUNGALOWS
HUMANHABITATION

CULEX FATTIGANS

MAP 5
side by side in each locality and similarly a fair number of dual infections in individuals.

Tables are given of the incidence of each infection in the various sets of lines and villages, both individually and collectively for the whole area, also giving the incidence of filarial disease infection rate, and the endemicity rate. It will be seen that though genital elephantiasis and the more severe forms of the disease are not marked, nevertheless the frequency of elephantiasis is more pronounced.

**TABLE IV.**

Infection and disease and endemicity rates in the populations of Christian Line Pathar, Nephaphoo Busty (Assamese), Nephaphoo Busty (Coolies), Tukra Line, Old Line and Ganjam Line.

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Bancrofti</th>
<th>Malayi</th>
<th>Mixed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHRISTIAN LINE PATHAR examined.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>12</td>
<td>2</td>
<td>16.66</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>No physical signs.</td>
<td>140</td>
<td>14</td>
<td>10.0</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.71</td>
<td>1.42</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21.14</td>
<td>27.14</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>16</td>
<td>10.52</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.13</td>
<td>1.81</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26.97</td>
<td>27.14</td>
<td></td>
</tr>
</tbody>
</table>

<p>| NEPHAPHOO BUSTY (ASSAMESE) |          |           |        |       |       |
| Elephantiasis, etc.       | 6        | -         | -      | 1     | 1     |
| No physical signs.         | 60       | 2         | 3.33   | 4     | 5     |
| Total                     | 66       | 2         | 3.03   | 5     | 7.57  |
|                          |          |           | 4.54   | 10    | 15.15 |</p>
<table>
<thead>
<tr>
<th>NEPHAPHOO BUSTY (COOLIES)</th>
<th>Number examined</th>
<th>POSITIVE</th>
<th>Bancrofti.</th>
<th>Malayi</th>
<th>Mixed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephantiasis, etc.</td>
<td>8</td>
<td>1</td>
<td>12.5</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>No physical signs.</td>
<td>44</td>
<td>2</td>
<td>4.54</td>
<td>5</td>
<td>11.36</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.27</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>3</td>
<td>5.76</td>
<td>5</td>
<td>1.92</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TUJRA LINE.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No physical signs.</td>
<td>46</td>
<td>6</td>
<td>13.04</td>
<td>3</td>
<td>6.52</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.98</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>6</td>
<td>12.0</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GANJAM LINE.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No physical signs.</td>
<td>65</td>
<td>8</td>
<td>12.3</td>
<td>4</td>
<td>5.63</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21.53</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>8</td>
<td>11.22</td>
<td>4</td>
<td>2.81</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRAND TOTAL.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephantiasis, etc.</td>
<td>44</td>
<td>4</td>
<td>9.09</td>
<td>2</td>
<td>4.54</td>
<td>6</td>
</tr>
<tr>
<td>No physical signs.</td>
<td>468</td>
<td>43</td>
<td>9.18</td>
<td>43</td>
<td>9.18</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.2</td>
<td>107</td>
</tr>
<tr>
<td>Total</td>
<td>512</td>
<td>47</td>
<td>9.17</td>
<td>45</td>
<td>8.78</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.92</td>
<td>107</td>
</tr>
</tbody>
</table>
### TABLE V.

<table>
<thead>
<tr>
<th>Types of Filarial Disease</th>
<th>Christian (Nephaphoo)</th>
<th>Tukra (Old)</th>
<th>Ganjam</th>
<th>Total Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathar, MBSE)</td>
<td>7 3 5 2 4 26</td>
<td>59.09</td>
<td>2 5 2 2 14</td>
<td>31.81</td>
</tr>
<tr>
<td>Elephantiasis of one leg</td>
<td>2 3 3 2 2 14</td>
<td>4.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; both legs</td>
<td>1 - - 1 - 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; and one arm.</td>
<td>1 - - - 1 - 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; of scrotum</td>
<td>1 - - - - 1</td>
<td>2.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; and one leg.</td>
<td>1 - - - - 1</td>
<td>2.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12 6 8 4 8 6 44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both the scrotum cases came from Dooomka district (Bihar recruiting depot.) with elephantiasis about 15 years ago. No microfilaria found in their blood.

**Disease rate** = 8.6%

### Filarial Endemicity Rate

- Number with signs of filarial disease .. 44 145
- " no signs but with microfilaria in blood .. 101

Total number examined ... 512

**Filarial endemicity rate** = 28.3%

The mosquito factor was then studied and Table VI gives the identification of a large number of culicine mosquitoes captured in human dwellings, not in cow-sheds, before infectivity experiments were undertaken. Particular attention was being paid to culicines.
### TABLE VI.

Culicine mosquitoes caught in Lakhimpur, Assam Valley, showing relative frequency.

<table>
<thead>
<tr>
<th>Name of species</th>
<th>Number caught</th>
<th>Percentage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Mansonia</em> (Mansonioides) uniformis</td>
<td>402</td>
<td>31.16</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; indiana</td>
<td>382</td>
<td>29.61</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; annulifera</td>
<td>90</td>
<td>6.97</td>
<td>All were caught from human habitations, not from cow-sheds.</td>
</tr>
<tr>
<td><em>Culex</em> (Culex) fatigans</td>
<td>108</td>
<td>8.37</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; vishnui</td>
<td>308</td>
<td>23.87</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1290</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Infection of mosquitoes was then taken up with a view to finding the vectors. The particular method described for Cachar was used. It should be pointed out that as the writer's particular interest was *Mf.malayi*, only cases of pure *malayi* infections were used for feeding purposes, hence results refer only to this microfilaria. These are shown in Table VII.

### TABLE VII (See over).
## TABLE VII.

Mosquitoes dissected at Balijan T.E. (Assam).

<table>
<thead>
<tr>
<th>Name of species.</th>
<th>Number dissected</th>
<th>Number positive</th>
<th>Percentage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mansonia (Mansonioides) uniformis</td>
<td>32</td>
<td>27</td>
<td>84.37</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; indiana</td>
<td>28</td>
<td>27</td>
<td>96.42</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; annulifera</td>
<td>10</td>
<td>10</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Culex (Culex) fatigans</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; vishnui</td>
<td>46</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>A.philippinensis</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>&quot; hyrcanus var niggerimus</td>
<td>9</td>
<td>7</td>
<td>77.77</td>
<td></td>
</tr>
<tr>
<td>&quot; vagus</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>152</strong></td>
<td><strong>71</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Nearly all mosquitoes which have proved susceptible to *Mf. malayi* infection were dissected within 14 days and showed mature or nearly mature development of the filaria larvae at that time. Examples of earlier mature development up to the stage of labium involvement for the Lakhimpur endemic area were as follows:--

---

TABLE VIII (See over).
### TABLE VIII.

Mosquitoes dissected at Balijan T.E. (Assam), about 10 days after feeding.

<table>
<thead>
<tr>
<th></th>
<th>Labium stage of infection.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M.indiana.</strong></td>
<td></td>
</tr>
<tr>
<td>4 after 10 days</td>
<td>4 after 10 days</td>
</tr>
<tr>
<td>3 &quot; 9 &quot;</td>
<td>4 &quot; 9 &quot;</td>
</tr>
<tr>
<td>1 &quot; 11 &quot;</td>
<td>2 &quot; 11 &quot;</td>
</tr>
<tr>
<td><strong>Total 8</strong></td>
<td><strong>Total 10</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M.annulifera.</strong></td>
<td></td>
</tr>
<tr>
<td>2 after 10 days</td>
<td>3 after 9 days</td>
</tr>
<tr>
<td>1 &quot; 9 &quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Total 3</strong></td>
<td><strong>Total 3</strong></td>
</tr>
</tbody>
</table>

The three species of *Mansonioides* play their part in the dissemination of filarial infection associated with *MF. malayi* in the human being, but *M.uniformis* and *M.indiana* are probably more important on account of their numerical superiority; *M.annulifera* is a potent intermediate host, but it does not appear to occur with nearly such great frequency as the other two. This is comparable to what was found in Cachar.
THE OCCURRENCE OF PLANT HOSTS OF THE \textit{Mansonioides} SPECIES IN THE LAKHIMPUR ENDEMIC AREA.

\textit{Pistia} was found in a few places in a sluggish semi-obstructed waterway, and in a few swampy and stagnant water areas in the vicinity. The obstructed waterway was full of "Dol" grass however, and this grass grew luxuriantly in this type of terrain on all sides. Water hyacinth however, was absent from the area under investigation. (See map 5.).

THE INCIDENCE OF \textit{Culex fatigans}.

\textit{Culex fatigans} adults were found in fair numbers in the human habitations of this area, as may be seen from Table VI. At the same time numerous breeding places with larvae of \textit{C.fatigans} were found in pools associated with stand pipes in the lines, in odd barrels and receptacles, and in borrow pits, and such excavations containing water. These are marked "F" on Map 5. It was planned to carry out more extensive investigations in Lakhimpur particularly confirming the fact which is at present assumed, that \textit{C.fatigans} is the carrier of bancroftian infection, in conformity with its role elsewhere in India, and also a more extensive infectivity survey of the mosquito fauna. It was also desired to explore the extent of this endemic area of filariasis of the two types, but further efforts had to be abandoned owing to opposition by the inhabitants, especially the Assamese.
villagers, and other difficulties. The coolie or villager in Cachar is generally much more amenable and co-operative than his Assam brother. Enough information however, has been collected to show that an endemic area exists in Lakhimpur, that it involves infection with *Mf. bancrofti* and *Mf. malayi* almost equally, that the infection rate for the combined types is very high, and might be classed as hyper-endemic.

**QUESTIONNAIRE ON Filariasis in Assam, and the Conclusions from Replies Thereto.**

In view of the fact that Assam had been credited with having a fair degree of filarial infection, (Megaw & Gupta; Acton & Rao; Rao; *loc. cit.*), a questionnaire was sent to all Civil Surgeons of districts, and nearly all Medical Officers of Tea Estates in the Province. Replies were received from all the former except one and as this concerned a hill tract it did not matter; two Medical Officers of Estates did not reply. The questionnaire was as follows :-

(1) Taking elephantiasis and other evidence of filarial disease as an indication, is there any filariasis in -

(1) Tea Estates under your jurisdiction.

(2) Villages in your area - to the best of your knowledge.

If so,

(2) To what degree does it occur - sporadic & rare cases, numerous and fairly general, or a restricted endemic focus?
(3) In your opinion, were these cases imported with filariasis?

If imported - can you give approximate date?

(4) Have you any idea from where it was imported?

(Filariasis *malayi* commonly comes from Patnagarh, Muzaffarpur, Balasore, and other parts of Bihar & Orissa).

(5) Is filariasis increasing noticeably?

(6) What is the nature of the filarial disease seen?

Moderate elephantiasis of the lower extremity, especially if only of one leg; very occasionally mild swelling of arm, would seem to indicate *Mf. malayi* when this mild degree is common to a number of persons in the same area; gross elephantiasis of various parts including scrotum, hydrocele, and chyluria are more associated with *F. bancrofti*.

The replies received indicated on the whole that cases occurred very rarely and that endemic conditions did not exist, except in the two areas previously regarded as endemic and now described here. Cachar and Sylhet replies including that of the Civil Surgeon, Sylhet, were emphatic in stating that cases of filarial disease were extremely seldom seen. Similarly, replies representing Jorhat and Tezpur indicated only the odd cases of filarial disease. On one large central group of gardens representing 20,000 labour population in Jorhat district, Sibsagar, not more than 12 cases of elephantiasis were known to exist, over a long period. There is however, one garden near Dhansirimukh on the Brahmaputra where eleven cases of elephantiasis were known; there was no increase of
cases apparent within many years but nevertheless this might prove a minor endemic focus. The information given by the Civil Surgeon, Lakhimpur, regarding records of hospital admissions to Dibrugarh Civil Hospital in the last years is interesting.

"Taking hydrocele, elephantiasis and unexplained chronic oedema as evidence of Filariasis we had in the last 3 years -

Cases of Hydrocele (Definitely imported .. 115 (Probably " .. 13 128

" of Elephantiasis (Definitely imported) .. 9

Case of unexplained chronic oedema. .. 1

138

It is probable that many of these hydrocele cases were due to \textit{F.bancrofti}, and the evidence in view of what has been proved in the vicinity of the Dibru river which is only 16 miles distant from Dibrugarh, suggests that Lakhimpur contains to a greater or less degree the only real endemic focus in Assam. The Medical Officer in that area is of the opinion that the endemic conditions radiate to a distance amongst the villages, beyond the field investigated and described here. In other parts of Lakhimpur however, the Medical Officers are definite in their views that filarial disease does not occur, except the occasional sporadic case.

It is, of course, realised that infection may exist without clinical signs and symptoms, but where this is at all extensive as in an endemic area there should be a noticeable degree of gross disease. Solitary
cases of elephantiasis are everywhere met amongst uninfected population. It is well-known that a great number of those brought the conditions with them as immigrants, many years ago, but these are not regarded as being of any epidemiological significance. Degree of filarial disease, then, is regarded as a sufficiently useful primary indication of the endemicity of the disease in any area, and no centre can be endemic for long without this gross evidence.

DISCUSSION.

Taking the results of the questionnaire first of all, then, it would seem that with the exception of the two endemic areas described, of which the extent of the Lakhimpur one is not fully known, filarial infection is not endemic in Assam. Occasional, usually burnt out cases of elephantiasis and gross filarial disease occur sporadically throughout the province, but these do not appear to spread the infection. This is in marked contrast to the neighbouring provinces of Bengal, Bihar and Orissa, which are heavily infected provinces. It is the more surprising when it is considered that these three provinces pour vast numbers of emigrants into Assam; Bengal sending cultivators, fishermen and forest workers admittedly mainly from East Bengal where the infection is much lower than the west side, and Bihar
and Orissa providing by far the greatest number of tea garden coolie labourers for the estates. As has been shown, the atmospheric conditions would appear optimum in the plains of Assam for the propagation of the disease and likewise the physiographical ones, and therefore it seems difficult to believe that in the last 5 or 6 decades or more, sufficient human carriers of the disease have not been imported from the neighbouring provinces to spread the disease extensively. So far as is at present known the main type is due to *F. bancrofti* of which the chief efficient intermediate host in India is *C. fatigans*, and in a large part of Cachar it has been shown that this mosquito is not found and if it occurs must be very scarce. If this holds good to any great extent it would account for the absence of bancroftian filariasis without further consideration, but more extensive surveys are required before this point can be ascertained. It is believed however, that its absence accounts for the failure of bancroftian filariasis to take a hold in Cachar and Sylhet. On the other hand where it has been found in Lakhimpur, there also was endemic *F. bancrofti* infection.

*Mf. malayi.*

Iyengar (loc. cit.) has pointed out the significance of *Pistia stratiotes*, an aquatic plant, in sub-serving the part of plant host to the metamorphic stages of *Mansonioides* species, which are
successful carriers of *Mf. malayi*. At the same time he (1937), and Sweet and Pillai (1937) show how under the Government of Travancore an endemic area of *Mf. malayi* infection was controlled successfully over 25 miles by "species sanitation", directed against *Mansonioides* by biological measures. These biological measures were the destruction of *Pistia stratiotes* over the area mentioned. This was carried on for 3 or 4 years, with absence of infection in the young children of the biologically controlled area in contrast to an unchanged rate in the young children of the neighbouring uncontrolled area. Iyengar stated that in N. Travancore only *Pistia* acted as host for *Mansonioides*; it was indispensable and its removal involved the death and disappearance of *Mansonioides* larvae although other aquatic plants were still left in the pond. He also commended this control work to other areas with similar conditions. In this he is justified, but the writer has found in Assam that *Pistia* is by no means the only, or even the most important, water plant acting as an essential host to *Mansonioides*; two others which are known are water hyacinth and "dol" grass, a kind of sedge with similar roots, common and abundant. Compared to these two, particularly the latter, *Pistia* is only fairly common, and in the case of one infected area, does not exist within a radius of over a mile. *Pistia* then is not the whole story and it would be unfortunate
to give the impression that it is everywhere the only problem in this connection. In some low lying parts in Assam, water hyacinth is not always found, but "dol" grass is very widespread in its occurrence. The removal of these three water weeds then (and there may be others) is required as a biological means of species control of *Mansonioides*, which actually is rather a forbidding proposition akin to the formidable one of clearing water hyacinth from waterways for traffic and other purposes. (See Plate 5.).

While on the subject of "Dol" grass it is interesting to note that only a few years ago the writer was concerned to preserve it as a biological measure in the control of malaria. The object was to get sufficient denseness of the grass above the surface of the water to cover it, and provide shade to discourage the breeding of *A. minimus*.

The control of the spread of *Mf. malayi* in Assam is difficult; *Mansonioides* are very common rural mosquitoes, with their type of breeding place in abundance nearly everywhere in the plains. At the same time there is *A. hyrcanus var nigerrimus* to be considered. It breeds very largely, though not altogether, in the same type of place as *Mansonioides*; it does not however feed freely on human blood but largely on animal blood, nevertheless it would require control, and biological measures adopted for eradication of *Mansonioides* will not simultaneously suffice for
A. hyrcanus, as it does not depend on the plant factor; oil or paris green would therefore be required which, under the circumstances, would not be feasible.

To limit the spread of the infection is the most that can be done, and it should be possible to confine it to its existing area. In Cachar it is spreading readily from the original central area, amongst the small villages and lines, helped by inter-marriage, but it appears so far to be restricted by the Barak river. This river, within a bend of which it is confined, with a high range of hills behind, acts as a natural barrier in the matter of communication and intercourse with places farther afield.

An obvious precaution is that Estates elsewhere should not accept transfer of coolies from the endemic area, either for labour, or in the course of marriage agreements, without having the night-blood of the individual examined. At the same time, Estates in the endemic area should make it known at the time of any transfer of the possible risk of introducing this infection from their area. If more attention had been paid to this infection at the medical inspections at the recruiting depots in the recruiting districts, especially Bihar and Orissa, Filariasis might have been kept out of Assam. It has always been the practice to examine recruits for other infectious diseases before passing them for migration. At the
same time Estates should make a point of themselves examining new arrivals for the presence of microfilaria, especially as so many have a good medical organisation. It is nearly certain that in the Cachar endemic area the disease was originally introduced by one or more coolies recruited from Doomka recruiting district in Bihar about 25 years ago. The people of the area point to one coolie woman with filariasis, still living in Naidal village, the central and most highly infected village, who is regarded as having introduced the disease.

The question of preventive precautions in the case of immigration into villages is more difficult, and is a matter for the Public Health authorities. Such immigrants are generally from Bengal, and of the cultivator class, and of late years such settlers have been very numerous. On the evidence so far available, the form of filariasis such people might introduce from Bengal, would be bancroftian, which, as the writer believes, does not readily become established.

It is interesting to speculate where \textit{Mf.malayi} infection in the human being originally arose. It occurs in Bihar and Orissa - was it introduced there by returned labour from Malaya, and disseminated to Assam therefrom? Thére would seem to be a possible connection between the Ceylon and Travancore infections through labour movements.
If these assumptions could be accepted it would appear as if *Mf. malayi* infection was comparatively new in India, but until the occurrence of the two infections throughout India is re-examined in the light of our fresh knowledge, that is difficult to say.

Then again was *Mf. malayi* introduced from China to Malaya and the Malay Archipelago?

The whole question opens up an interesting field of speculation and inquiry.

**SUMMARY AND CONCLUSIONS.**

It is concluded that Filariasis is less common in the province of Assam than has been maintained by previous writers.

There are nevertheless two well-marked epidemic foci - one in Cachar district in the Surma Valley, and one in Lakhimpur district in the Assam Valley.

In both these areas *Mf. malayi* infections were discovered, solely in the Cachar focus, and mixed with *Mf. bancrofti* in the Lakhimpur district.

The mosquito vectors of *Mf. malayi* in both cases were *M. (Mansonioiides) uniformis* Theo., *M. (Mansonioiides) indiana* Edw., *M. (Mansonioiides) annulifera* Theo., and *A. hyrcanus var nigerrimus* (Wied).

The plant hosts of the *Mansonioiides* species in Assam have been shown to be *Pistia stratiotes,*
Eichhornia crassipes (water hyacinth), and Sacciolepis interrupta staff ("Dol") grass.

These last two constitute new observations.

It is considered that "species sanitation" directed against the Mansonioides species by the removal of these aquatic plants is impracticable, and A. hyrcanus presents an additional difficulty.

A search for almost a year in an area of 400 square miles around the Cachar focus failed to reveal the presence of Culex fatigans. If this is general it would account for the apparent rarity of bancroftian Filariasis in the Surma Valley, and possibly, in a large part of the Assam Valley.

Culex fatigans, on the other hand, was found breeding freely in the endemic area of mixed infection in the Assam Valley.

Autopsy on three cases of malayi Filariasis in Cachar failed to reveal the parent worms.

The source and origin of Mf. malayi Filariasis and the route by which it has spread is discussed.
List of references to filariasis, especially concerning *Mf. malayi* Brug, with concentrated abstracts of each.


   *M. malayi* described as different from *M. bancrofti*. Scattered nuclei in tail and forward position of anal pore distinguishing characters.


   Detailed description of *M. malayi*. Distribution of filariasis in D. E. Indies tabulated. Outline of problems waiting to be solved in light of new discovery of *M. malayi* as a separate species.


   12.3% of 1051 cases positive for *M. malayi* in Benkoelen (Sumatra). Nocturnal habit of *Mf.* observed. No symptoms. *Aedes aegypti* found negative experimentally.


   People of villages below 2,300 ft. in Ketaun (West Sumatra) are slightly infected with *M. malayi*. None found infected above this altitude. 2015 people examined. Blood taken at 10 p.m.

M. bancrofti common in Dutch New Guinea. M. malayi only in carriers imported from elsewhere.


24.7% of 1024 infected with M. malayi (and a few M. bancrofti) in Mamedjoe (W. coast Celebes). Periodicity of M. malayi exclusively nocturnal (15.1 at night to 1 during day). (Clinical symptoms said to be same as M. bancrofti).


Taeniorhynchus (Mansonicoides) annulipes and T. (M.) annulatus experimental vectors of F. malayi. 93% and 83% respectively. Natural infection 1.2% and 1.9%. Probably T. (M.) uniformis and annuliferus will prove to be vectors also.


Repitition of previous papers. Periodicity of M. malayi 1 to 15 and 1 to 20; noon to night numbers, compared with 1 to 100 for M. bancrofti. Periodicity was reversed in a night worker. Atypical form described by Korke said to be identical with M. malayi.

15. Iyengar, M.O.T., 1932 - "Filariasis in North Travancore".
   Filarial infection resembling M. malayi. Did not develop in A. fatigans but readily did so in Mansonia annulifera. Natural infection 26% of 900.

   In Mamoedjoe (West coast of Celebes) F. malayi is principally carried by A. barbirostris. Experimental infection 83%, natural infection 8.9%. Human infection 37%. A. barbirostris scarce compared with T. annulipes. Aedes failed to be infected.

   Mainly on epidemiology of F. bancrofti and F. malayi in E. Indies.

   C. fatigans is the only mosquito found naturally infected with filaria larva in Amoy. Low incidence of human filariasis due to scarcity of A. hyrcanus v. sinensis which is a better carrier.


    M. malayi and elephantiasis cruris common in Serajoe (Java). 41% and 3.2% respectively in some villages. Taeniorhynchus annuliferus, T. uniformis, F. indianus and A. hyrcanus said to be chief vectors.

21. Idem 1933 - "Zur Morphologie van Microfilaria malayi".

23. Feng, L., 1934 - "Intermediate hosts of Microfilaria malayi in Chekiang, China".

   M. malayi transmitted by A. hyrcanus v. sinensis in Chekiang.
   Larva reaches infectivity in 6 days in July & August. Also develops in M. (Mansonoides) uniformis but in small numbers.
   Culex pipiens, Aedes albopictus and Armigeres obturans negative.

24. Rodenwaldt, E., 1934 - "Filaria malayi under ihre Uebertrager".
   Med. Welt, 8 (39), 1369-1371.

   Mentions correlation of plant Pistia stratiotes with vectors of M. malayi.


   Elephantiasis and filariasis common in Province Wellesley North (Malaya). Microfilaria said to have a slight nocturnal periodicity
   Identified as M. malayi.

26. Rodenwaldt, E., 1934 - "Filaria malayi im Delta des Serajoe. II".

   Eggs of Mansonia spp. (carriers of M. malayi) are laid on the under side of leaves of the aquatic plant Pistia stratiotes.
   Infection rate of mosquitoes caught on human beings (stage of infection not stated). Mansonia annuliferus 73.6% of 91
   M. uniformis 66.6% of 12, M. indiana 71.4% of 7, and A. hyrcanus 88.9% of 18.

27. Idem 1934 - "Filaria malayi im Delta des Serajoe. III."

   Suggests that F. malayi might be controlled by eradicating Pistia from swamps. Injection of antigen made from Dirofilaria immitis
   into elephantiasis cases without microfilariae in their blood and persons with M. malayi in their blood gave equally strong reactions
   in each group.

28. Iyengar, M.O.T., 1935 - "Biology of Indian mosquito larvae that attach themselves to the roots of water plants."


*M. malayi* recorded in large territory on the Indragiri R. (Sumatra) 18% of 5,000 persons infected.


Feng's experiments show *A. hyrcanus v. sinensis* most important carrier (probably) of *M. malayi* in Huchow area, but *Mansonia uniformis* may also participate.


36. Iyengar, M.O.T., 1936 - "Entry of Filaria larvae into the body cavity of the mosquito."
Parasitology, 28 (2), 190-194.

Mf. of bancrofti and malayi penetrate gut wall of C.fatigans and Mansonia annuliferus near or in proventriculus and escape into perivisceral cavity of thorax. Penetration occurs within two hours, in some cases 20 minutes.

37. Feng, L.C., 1936 - "The development of Microfilaria malayi in A.hyrcanus var. sinensis Wied."

Development in mosquito described in detail. Cellular changes in each stage. Correlation of structures in microfilaria and infective larva.


Filariasis in Patnagarh entirely due to F.malayi. Mansonia (Mansonioides) annuliferus the commonest mosquito, found to be principal carrier. 23 of 110 natural infection.


2.5% of coolies in Banka tin mines have M.malayi. No obvious pathological effect and no detriment to work.


Points out that distribution of filariasis is not well known in India, though known to be widespread. Differential distribution of bancrofti and malayi not well known.

In Kalawara (Celebes) F. malayi is carried chiefly by A. barbirostris which rarely attacks man elsewhere in the Archipelago. Experimental infection 99% (6.5 - 8.5 days). Natural infection 8.1%.

PLATE 1 - Naidal village. Heavily infected lines showing typical breeding areas for Mansonioides & A. hyrcanus in the vicinity.
Plate 2

Pistia stratiotes
PLATE 3 - Tank with Pistia.
Water hyacinth
Eichhornia Crassipes
PLATE 5 - Swamp with water hyacinth and "Dol" grass.
"DOL" grass
Sacciolepis interrupta starf (Syn. Panicum interruptum willd.)
PLATE 7 - Swamy area with "Dol" grass.
Egg cluster of Mansonioites on leaf of aquatic plant water hyacinth (as seen under low power magnification).
Mansonioides uniformis (Theo)
Mansonioides uniformis (Theo)
(Larva)
Fig. 4

Mansonioides indiana (Edw)
Mansonioides indiana (Edw)
(Larva)
Fig. 6

Mansonioides anulifera (Theo)
Mansonioides annulifera (Theo)
(Larva)
Fig. 8

*Anopheles hyrcanus var nigerrimus* (Wied)
Anopheles hyrcanus var nigerrimus (Wied)
(Larva)
Culex fatigans (Wied.)
*Culex fatigans* (Wied)
(Larva)