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Gater, B.A.R. 1932
 Far East Assoc. Jap. Med.
 Juss. Soc. Congress (Siam 1930)
 2:132-143

69. ENTOMOLOGICAL INVESTIGATIONS IN RELATION TO TROPICAL TYPHUS IN MALAYA.

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The following is a summary of the entomological, or more strictly the zoological, investigations in relation to the disease known as "Tropical" or "Scrub" Typhus pursued while the writer was Entomologist to the Institute for Medical Research, Federated Malay States.

On serological grounds Fletcher, Lesslar and Lewthwaite (1929) recognized two forms of tropical typhus. The investigations here described relate to the rural form which agglutinates the so-called "K" strain of *Proteus* X 19 and those pursued in the field refer to an endemic area which has elsewhere been designated "Oil-palm Estate". In this area a number of cases occurred every month among Tamil workers in fields where oil-palms were planted, while those working in fields devoted to rubber escaped. The epidemiology has been discussed by Fletcher, Lesslar and Lewthwaite (*loc. cit.*) and Lewthwaite (1930) has recently summarized the existing knowledge. These workers suggested that the reservoir host might be rats of the *Rattus rattus* group and that the vector might be a larval thrombidiid mite. The zoological aspect was therefore studied along the following lines:—

1. LICE IN MALAYA.

Fletcher and Lesslar (1925) concluded that there was strong evidence that the body-louse (*Pediculus humanus corporis* de Geer) was not the vector. The writer examined a total of 472 Tamil hospital patients and labourers without being able to find a single body-louse. Head-lice (*Pediculus humanus capitis*) were present to the extent of 43 per cent. and pubic lice (*Phthirus pubis*) were found on between two and three per cent. At the same time, Dr. Enid Robertson, Lady Medical Inspector of Schools, kindly gave access to her records

of a louse survey of 6,459 school girls, 1,128 of whom were Indians, mostly Tamils. No body-lice were found but head-lice were present to the extent of 48 per cent.

2. EXAMINATION OF PATIENTS.

Patients admitted to hospital suffering from tropical typhus were minutely examined, with the aid of binocular magnifiers, for signs of arthropod attack. The dark skin of Tamils rendered observation difficult and since patients were admitted to hospital some days after the onset of the disease and therefore a considerable time after the beginning of the incubation period, neither signs of arthropod attack nor specimens still adhering to the skin could readily be expected. It was afterwards found that Tamils on "Oil-palm Estate" did not complain of irritation following the bites of thrombidiid mites nor could any signs of reaction be observed on the skin after their removal. The absence of any initial lesion, in contrast to Japanese river-fever, has been noted as typical of tropical typhus by Lewthwaite (1930).

3. THE FAUNA OF THE AREA.

This appeared to be typical of similar areas adjoining jungle, with some swamp and extensive tracts of secondary growth. On the Estate, two factors tended to influence the fauna in the oil-palm area. Among the palms (*Elaeis guineensis* Jacq.) a considerable quantity of undergrowth and tall grass (*Imperata cylindrica*) had been allowed to grow, competing in some places with a planted cover crop. This encouraged rats of the *Rattus rattus* group, always prevalent where oil-palms are planted, and allowed a number of wild rats and other small animals to overrun the estate from neighbouring jungle. Squirrels were also numerous.

The palms were young and in most cases only just coming into bearing. Lewthwaite (1930) has described a higher incidence of tropical typhus among those workers who come into close contact with the young palms when they are being prepared for harvest: a process which consists of cutting away the lower leaves and dead male and female flowers. Dead male flowers were examined on other oil-palm estates and found to contain large numbers of microlepidopterous larvæ. On this estate, however, the dead male flowers had remained

longer on the young palms than would be permitted on an estate in full bearing. The microlepidoptera had been replaced by mites and large numbers were obtained by the Berlese funnel method. It was impossible to identify this large number of mites in Malaya and efforts to enlist the services of a worker in Europe were unsuccessful. Reference collections were mounted, but none of the mites found in the male flowers was subsequently found attached to workers in the area; although a few were found wandering over their bodies. The presence of mites in the oil-palm material therefore appeared to be of little significance, but the favourable conditions of herbage for rats, small jungle animals and larval thrombidiid mites seemed to open up some possibilities.

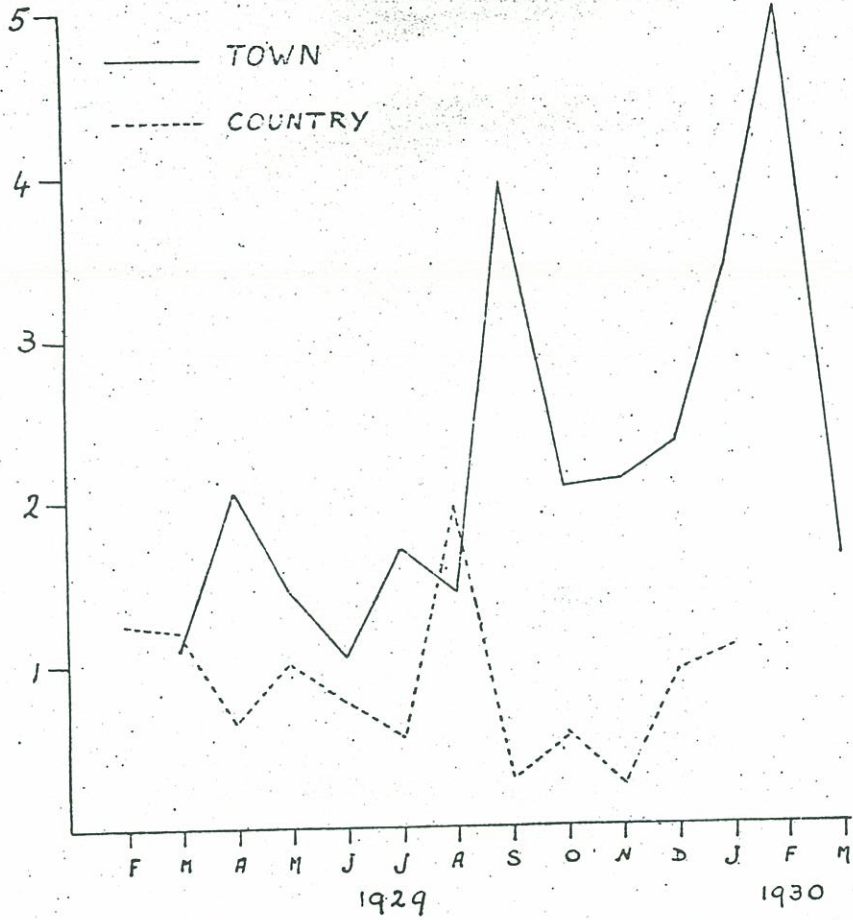
4. EXAMINATION OF LABOURERS.

Over a period of three months, 43 labourers were examined, as far as possible daily, directly they finished work among the palms. Owing to movements from one part of the estate to another and other reasons, it was not possible to accumulate daily records for each man; the average number of examinations was twelve but some attended throughout the period. In all, 538 examinations were made which resulted in 65 specimens of *Thrombicula akamushi* Brumpt, 17 specimens of *T. deliensis* Walch and five specimens of a species which for the present may be called *T. pseudoakamushi* Hatori, being removed. The species named were found 45 times, 14 times and 5 times respectively and with the exception of two larval ticks and head and pubic lice, were the only human parasites observed. Of the 43 labourers examined, 15 at one time or another carried *T. akamushi*, 6 *T. deliensis* and 5 *T. pseudoakamushi*.

During the investigation, two men contracted tropical typhus and one, who absconded, was reported to have done so. The latter is of little use as a record, but *T. akamushi* was found on him 11 days before he reported sick and absconded. The second man became ill 21 days after his first examination but had not attended regularly, missing twelve examinations. *T. akamushi* was found on him three days prior to the onset of the disease. The only complete record is the third case who was a regular attendant. A larval *Amblyomma* was found on him 15 days before he showed symptoms of having contracted the

FIGURE I.

X. CHEOPIS - MONTHLY INDEX



Rat- flea (*X. Cheopis*) index in a town and in the endemic area.

disease and *T. akamushi* was removed from him on the 14th, 13th, 11th, and 9th days before. The only other larval tick found was taken from a man who had previously recovered from an attack of tropical typhus. Lewthwaite (1930) places the incubation period at from 11 to 22 days.

Among those on whom *T. akamushi* was found, in addition to the three mentioned above, four were known to have recovered from previous attacks, three had been on the estate for periods of four to six years and may have contracted tropical typhus before investigations began and eight were not subsequently affected.

5. ECTOPARASITES OF RATS.

Including rodents and other small vertebrates such as mouse-deer, tree-shrews and birds, 1,152 animals were examined for ectoparasites. Of these, 743 were *Rattus rattus diardi* (Jentink) or *Rattus r. jalorensis* (Bonhote). Half of these, including nearly all the sub-species *jalorensis*, came from the endemic area and half came from the town of Kuala Lumpur, in Selangor, where the rural form of tropical typhus does not occur. Approximately thirty rats from each locality were thoroughly examined every month for a year, all ectoparasites being identified. It was found that the ectoparasites of the two sub-species differed only according to locality:

Of the numerous ectoparasites found, only five were found to attack man, while the status of two others, occurring only in small numbers, remained doubtful. Four of those found to attack man were larval thrombidiids. Fleas, all *Xenopsylla cheopis* Roths., were much more numerous on rats from the town than on those from the endemic area. On the latter the index never rose to more than two, while an index of four and five occurred on those from the town. The monthly indices are shown in Figure 1.

Only three thrombidiid mites known to attack man were found on the town rats, one specimen of each of three species being obtained. On the rural rats they were much more numerous; *T. deliensis* was found on 21.3 per cent., *T. pseudokamushi* on 7 per cent., *T. akamushi* on 1.8 per cent. and *T. acuscutellaris* Walch on 2 per cent. The last species, although collected from women by Dr. Enid Robertson in another district, was not found on any of the labourers on

FIGURE II.

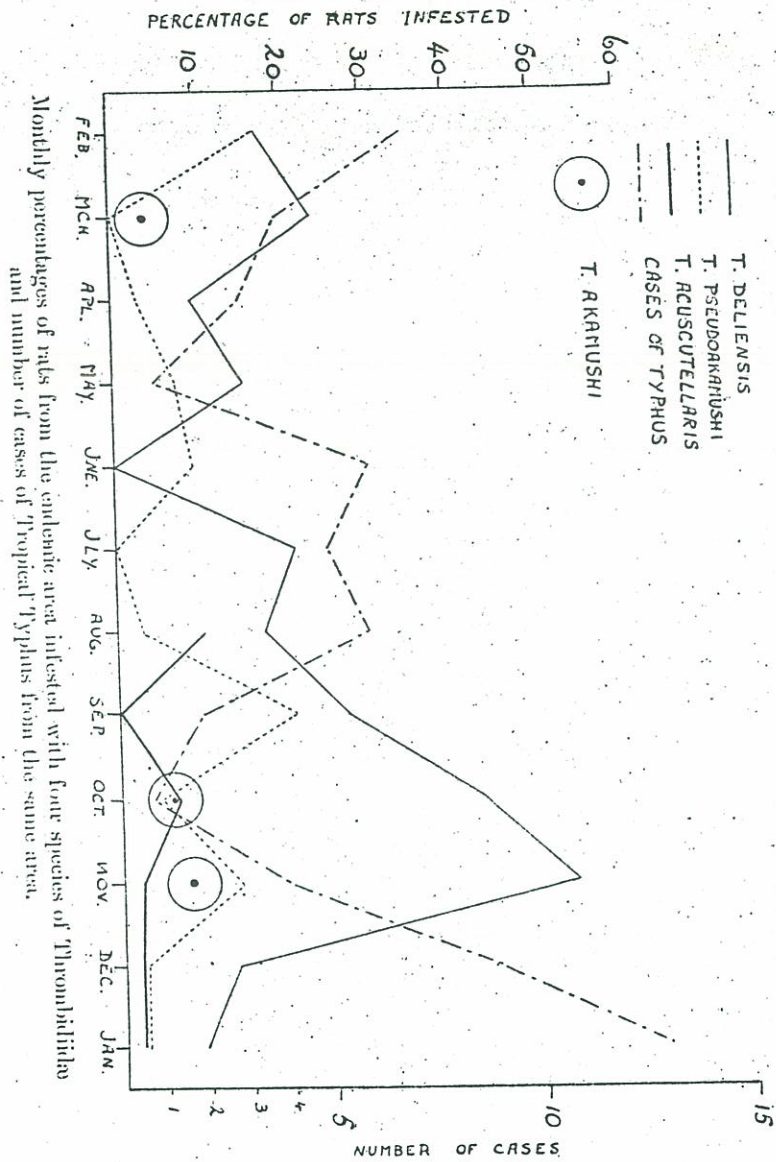
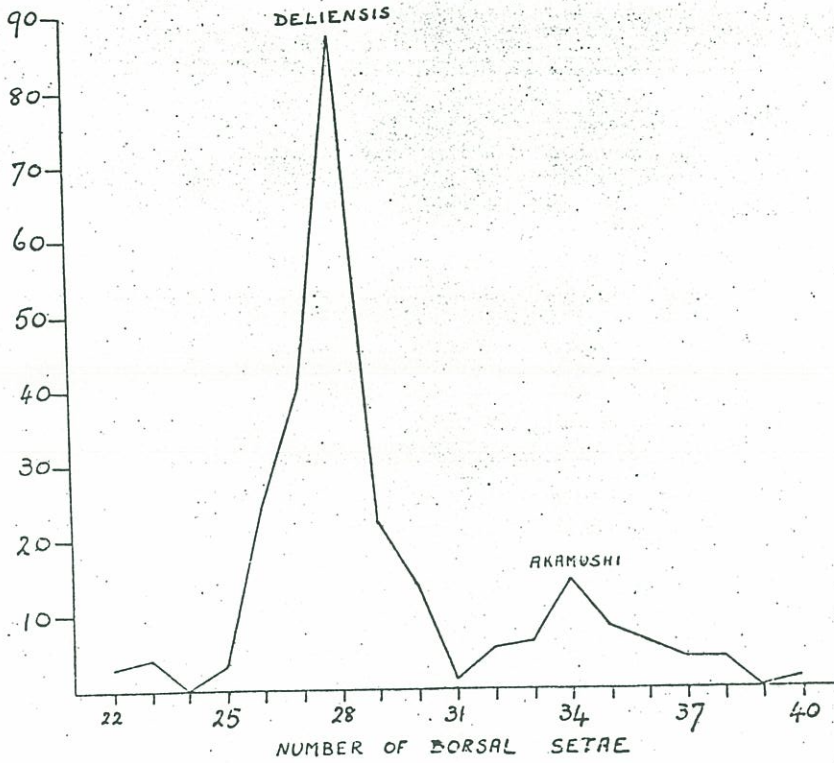


FIGURE III.



Curve showing variation in number of Dorsal Body Setae in *T. Deliensis* and *T. Akamushi*.

Ewing (1925) holds that variations in the number of dorsal setæ and small morphological differences such as are found in various setæ are of no specific value and considers that the species described by Nagayo and others (1921) are really variants of *T. akamushi*. In Malaya the writer has seen specimens which could be referred to the *akamushi-deliensis* group, with dorsal setæ varying in number from twenty-two to forty. In some cases it was extremely difficult to decide to which of the two species a specimen belonged, but on the average they separated into two groups, one with twenty-eight setæ (*deliensis*) and one with thirty-four setæ (*akamushi*). It appeared as if the forms graded into one another and that specific separation was not justifiable. An analysis of 202 specimens is shown in Figure III.

If the two species prove to be identical it is possible, in view of the great similarity between tropical typhus and Japanese river-fever established by Dr. L. Anigstein in his paper before this Congress, that both diseases are transmitted by the same vector and that the transmission of Japanese river-fever in Sumatra by *T. deliensis* requires little further proof. Owing to the curious host preferences exhibited by the two forms in Malaya, however, it will be as well to keep them as separate species until long series from this country and Sumatra have been examined.

ACKNOWLEDGEMENTS.

The writer is indebted to the Medical Officer and Management of the Estate for facilities in carrying out his investigations; to the Health Officer, Kuala Lumpur, for obtaining the town rats and to the Medical Officer, District Hospital, Kuala Lumpur, for granting facilities for the examination of patients; to Mr. C. Boden Kloss, Dr. H. E. Ewing and Sir Guy A. K. Marshall, C. M. G., F. R. S., for aid in identification and to his assistants, P. D. Rajamoney and A. Ganapathypillai, for help in all the investigations described.

7. SUMMARY AND CONCLUSIONS.

The results of examining 472 Tamils for lice, typhus patients in hospital, the fauna of an endemic area, 538 examinations of labourers in the same locality and 1,152 rodents and other animals for ectoparasites, are summarized. From the

results obtained it is considered that the following preliminary conclusions are permissible:—

1. Tropical typhus, in its rural or "K" form, appears to be associated with undergrowth, and the presence of larval thrombidiid mites as suggested by Fletcher and others.
2. Body-lice could not be found in the State of Selangor in Malaya but head-lice were prevalent and may under certain conditions occasionally act as vectors.
3. Mites in oil-palms appear to be of little significance and evidence of a vector directly associated with oil-palms was lacking.
4. Rat-fleas, being more numerous in a town, where rural tropical typhus does not occur, than in an endemic area, are unlikely to act as vectors.
5. If the rat is the reservoir, which according to Dr. Anigstein's results appears to be almost certain, the vector may be looked for in a parasite which attacks both rat and man. Apart from fleas, the only known parasites common to both hosts in Malaya are four species of Thrombidiidae.
6. *Thrombicula deliensis* is common on rats, widely distributed as regards hosts and localities and attacks man. *T. akumushi* was common on man but rare on rats and other animals.
7. It is suggested that *T. akumushi* and *T. deliensis* are merely forms of the same species and that the vector of tropical typhus may prove to be the same as for Japanese river-fever.

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DISCUSSION.

Dr. Anigstein emphasised the value of the author's investigations which have to be regarded as a pioneer work in the parasitology of British Malaya. The possibility of the identity of *Thrombicula deliensis* and *T. akamushi* is very significant because at the same time Dr. Anigstein's investigations have shown the very close relationship between tropical typhus and tsutsugamushi. If both diseases are transmitted by *T. deliensis*, then we have to explain the pathogenic action of the tsutsugamushi virus as regards the primary lesions as a result of a specific feature of this virus. Otherwise we have to admit that both diseases are transmitted by different vectors one of which has the property to produce the skin lesion.

Dr. Anigstein also mentioned the possibility of a direct transmission of tropical typhus from rat into man because of the very high concentration of the virus in the rat. This fact was shown by Dr. Anigstein in smears from the tunica vaginalis of infected rats caught in the endemic area. In some cases the enormous number of the micro-organisms gave the impression of a culture.

Phra Vaidya: Has any investigation been made as to a relation between bed bugs and typhus?

Prof. Gater replied: With reference to Dr. Phra Vaidya Vidhikarn's question about bed bugs, these insects occur in large numbers in towns and if they played any part in the transmission of tropical typhus one would expect the rural form to occur in towns, whereas it is only recorded from country districts. Dr. Anigstein's point about the initial lesion is a sound one and opens up a possible line of differentiation between the *akamushi* and *deliensis* forms. The reaction to the bites of infected larval thrombidiids appears to differ in Malaya. In some districts the bite is followed by extreme irritation and the formation of a small papule, but in the area examined the labourers did not complain of irritation, nor could any reaction be observed on the skin after the removal of mites. It may be that certain strains possess different powers of causing reaction in the skin.

If thrombidiid mites are to be incriminated it assumes that the virus of tropical typhus can be transmitted through the egg, since only the larvæ are parasitic. There is a strong possibility that direct transmission from rat to man occurs, since the Tamil labourer catches and eats rats, sometimes, it is said, raw, so that transmission may occur in handling them. In addition to the *Rattus rattus* rats, however, the many other such animals on which these mites are found may act as reservoirs.