ON THE TRANSMISSION OF THE SUBTERTIAN MALARIA PARASITE (PLASMODIUM FALCIPARUM, WELCH, 1897) BY EGYPTIAN ANOPHELES.

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HAVING been unable in the past literature of malaria to find any records of the actual development of the subtertian parasite in the local species of Anopheles found in Egypt, I have thought it advisable, on account of the prevalence of this form of malaria in certain parts of Egypt, as well as of the prevention of its spread amongst the troops stationed there, to place a short research I carried out in the autumn of 1916 on record.

Five well-recognized species of Anopheles have been recorded (Gough, Bull. Ent. Res.) as occurring in Egypt; these are:

1. Anopheles (Cellia) pharoensis (Theobald).
2. Anopheles squamosus (Theobald).
3. Anopheles (Myzomyia) turkhudi (Liston).
4. Anopheles (Pyretophorus) palestinensis (Theobald).
5. Anopheles (Myzorhynchus) mauritianus (Grandpré).

Of these for our present purpose squamosus can be left out of count, as it has been recorded but once—by Theobald. The remaining four species, however, appear to be widely distributed in Egypt. On the Canal zone I have found pharoensis, turkhudi and mauritianus. In the Fayoum and Western Oases, pharoensis, turkhudi and palestinensis. In the Cairo district, pharoensis and turkhudi. With the exception of turkhudi, few direct transmission experiments with the subtertian parasite appear to have been performed with any of these species in India or any other country in which they occur.

I will now give a short account of previous evidence with reference to the spread of malaria by these species.

1. Anopheles (Cellia) pharoensis.—The transmission of the benign tertian parasite (Plasmodium vivax, Grassi and Feletti, 1890) has been followed out in this species by Newshead, Dutton and Todd, but no work in this direction appears to have been done on the subtertian parasite (P. falciparum) in this species.

2. Anopheles (Myzomyia) turkhudi.—This species comprises the following, all of which are synonymous, or are at the most geographical variations:

   Anopheles multicolor, Camboulin, 1902.
   Anopheles impunctus, Dönitz, Egypt, 1902.
   Pyretophorus chaudoyei, Billet, Algeria, 1903.
   Pyretophorus myzofacies, Theobald, India, 1907.
   Pyretophorus nigrofuscatus, Theobald, Algeria, 1907.
   Myzomyia azriki, Patton, Aden, 1905.
   Myzomyia hispaniola, Theobald, North Africa and Spain, 1903.

Zygotes of the subtertian parasite have been found by Stephens, Christophers, and James in the stomach of this insect in India, and it has been regarded as one of the carriers of this parasite in that country (James, Sci. Mem. Gov. India, 1902, No. 2, p. 79).

3. Anopheles (Pyretophorus) palestinensis, synonymous with Pyretophorus sergenti, Theobald, Algeria.—Under the latter name Ed. and Et. Sergent have
found sporozoites in this species and regard it as a common carrier in Algeria and Spain. It appears to be distributed in Algeria, Spain, Cyprus and Palestine, as well as in Egypt, where, however, its range is confined to the Western Oases—Kharga, Dakhla, Baharia and Siwa Oases. Though its distribution intimately corresponds with that of subtertian malaria in those localities no direct evidence against it ever appears to have been recorded in Egypt. This species is very closely allied to turkhudi, but differs in having the terminal segment of the palp tipped with white in place of black.

I found this species in January, 1917, breeding abundantly in the warm wells in the Dakhla Oasis (the water temperature varying from 80° F. to 120° F.). Adult insects were then abundant in camp; and although the temperature was as low as 1° C. (34° F.) they appeared to be capable of conveying the subtertian parasite to freshly arrived troops, a proportion of whom contracted the disease ten days after arriving in the Oasis. As it is generally stated (Hindle, p. 162) that the development of this parasite ceases below 18° C. (64° F.) the epidemiological evidence I have just recorded requires further elucidation.

(4). Anopheles (Myzorhynchus) mauritianus is a rare mosquito in the interior of Egypt and appears to breed according to my experience in brackish water. Owing to its comparative rarity in malarial districts it is doubtful whether it plays any part in the actual transmission of malaria in Egypt, and it is regarded by Ross, as it occurs in Mauritius, in this light.

During the months of October, November and December, 1916, an opportunity presented itself in Cairo of carrying out the transmission of the subtertian parasite in species of Anopheles which were, owing to the pools formed by the over-flowing of the Nile, most abundant at that time, namely: Anopheles (Cellia) pharoensis; Anopheles (Pyretophorus) turkhudi.

Large numbers of freshly-hatched insects were caught and subsequently fed on a Bulgarian patient from Salonika, whose blood, although he was not suffering from fever, contained large numbers of crescents. These were estimated by means of a Thoma-Zeiss counting apparatus at about 600 per cubic millimetre of blood. The exflagellation of these crescents readily took place from ten to fifteen minutes after blood had been drawn.

Owing to the active co-operation of the patient it was found possible to feed the infected Anopheles daily for twenty-two days from the commencement of the experiment on his blood, and a certain number of insects were dissected daily from the second day after feeding onwards. The insects were fed in gauze cages, and were subsequently placed in a damp atmosphere in a chamber kept constantly at a heat of about 25° C.

In order to keep the atmosphere sufficiently damp—and I wish to make clear it is a very essential point for the life of the mosquito—the cages were covered every night with damped Chardin filter paper. Out of the large number successfully fed thirty-six specimens of Anopheles (Cellia) pharoensis survived after the fourth day, and their stomachs were dissected and stained. In one specimen only out of these thirty-six were any developmental forms found. In this two large oocysts (measuring forty-five microns by thirty microns) containing sporozoites were found on the fifteenth day after the original feed of crescent-containing blood.

It would appear therefore that this species can occasionally act as a trans-
mitter of the subtertian parasite; but probably under natural conditions it is not a significant factor in this respect.

On the other hand only three specimens of Anopheles (Myzomyia) turkhudi survived after the third day, and only one to the tenth day after its first feed. On dissection the latter specimen showed an extensive development of pigmented oocysts in the stomach, no less than ninety-six being counted with a $\frac{1}{2}$ inch lens in a permanent specimen stained with Giemsa. They measured on an average twenty-four microns in diameter.

I have submitted specimens of Anopheles of each batch I experimented with to Mr. G. Storey, B.A., F.E.S., of the Entomological Section, Ministry of Agriculture, Egypt, and I am indebted to him for the confirmatory identification of the species.

CONCLUSIONS ON EXPERIMENTAL GROUNDS.

(1) Anopheles (Myzomyia) turkhudi is an efficient definitive host of the subtertian malaria parasite in Egypt.

(2) Anopheles (Cellia) pharoensis can act as an inefficient and occasional definitive host for the subtertian parasite. This fact is of interest in view of the prevalence of its congener Anopheles (Cellia) pulcherrima in Mesopotamia where it is regarded as a probable carrier.

REFERENCES.

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THE SUCCESSFUL CONSERVATIVE TREATMENT OF EARLY GAS GANGRENE IN LIMBS BY THE RESECTION OF INFECTED MUSCLES.

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Among the points brought forward by Colonel Cuthbert Wallace in an article on "Gas Gangrene," some months ago were the following:—

(1) It is rare to meet gas gangrene without muscle injury.

(2) It is chiefly a disease of muscles, and is rarely dangerous unless muscle is involved.