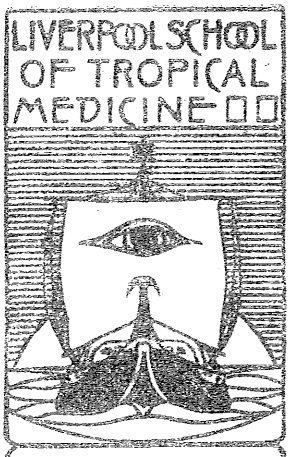

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BOTHA DE MEILLON, D.Sc., F.E.S.

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ON *ANOPHELES FUNESTUS* AND ITS ALLIES IN THE TRANSVAAL

BY

BOTHA DE MEILLON, D.Sc., F.E.S.

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(*Received for publication* 10 *January*, 1933)

The principle of 'species sanitation' depends for its success on the accurate identification of the insects concerned with the transmission of malaria. Unfortunately, in South Africa one of the main vectors of malaria, namely *A. funestus*, is a difficult insect to name with certainty both in adult and larval stages. Moreover, the recent discovery of another closely related form has complicated matters still further. It has therefore been thought advisable to publish these notes in an attempt to make the present position clear.

A. funestus belongs to the group *Myzomyia* of the subgenus *Myzomyia*, and its nearest allies are *A. marshalli* Theo., *A. longipalpis* Theo., *A. transvaalensis* Carter,* *A. rhodesiensis* Theo. and the recently discovered *A. funestus* var. *leesoni* Evans.† The author (1931) has already shown that in the larval stages *A. transvaalensis* and *A. marshalli* present no difficulty, as they are immediately distinguished by the branching of the anterior dorsal pleural hair of the mesothorax. *A. longipalpis* is known by the relatively small anterior abdominal plaques and by the fact that the posterior abdominal plaques, at least on the posterior segments, are three in number. The larva of *A. rhodesiensis* is our only *Myzomyia* with the inner clypeals barbed. The larva of *A. marshalli* further differs from all our *Myzomyia* larvae in having the saddle hair much branched (fig. 1, *a* and *b*).

* It may be necessary to rename this anopheline, and attention is directed to a forthcoming paper dealing further with the species.—Edd.

† Evans (1931) described this as *A. funestus* subspecies *leesoni*.—Edd.

A. funestus var. *leesoni* was described by Evans (1931) in November, 1931, from material collected in Rhodesia. At about the same time this form was discovered in Tzaneen, and the following is an extract from a report to the Director of the South African Institute for Medical Research, dated 20th December, 1931 : ' I have now confirmed the observation set out in the monthly report for November, namely, that there exists another mosquito formerly confused with *funestus* but really quite distinct from it. Originally separable in the larval stage only it has now been found that the adult males are also distinguishable ; the adult females remain inseparable. The absence of males from habitations indicates

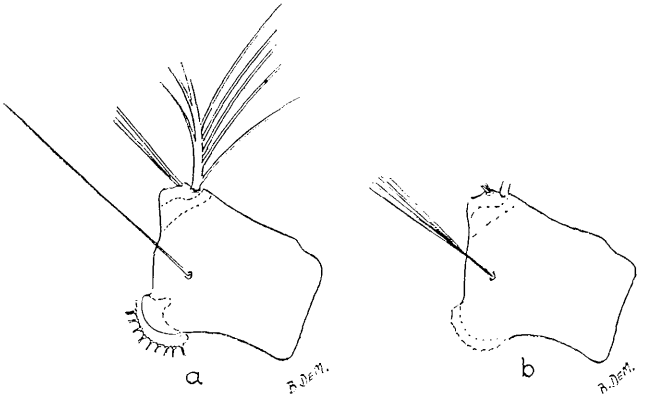


FIG. 1. *a.*—*A. funestus*, anal segment of larva showing lateral hair ; *b.*—*A. marshalli*, anal segment of larva showing lateral hair.

that this species does not enter houses. It was thought that this observation would clear up the whole problem of *funestus* with and without malaria, but it is now becoming evident that this is not the whole truth. Intensive collecting has shown that apparently true *funestus* larvae do occur in non-malarious areas. It is possible that a third species is involved but I am inclined to think that some ecological factor will be found to be the cause.'

In the larva of *A. funestus* var. *leesoni*, the long mesothoracic pleural hairs are both simple. It therefore falls into the same category as the larvae of *marshalli*, *longipalpis* and *funestus*. From these it is distinguished in the first place by the much branched inner occipital hair (fig. 2, *c*, *d* and *e*). From the larvae of *marshalli*

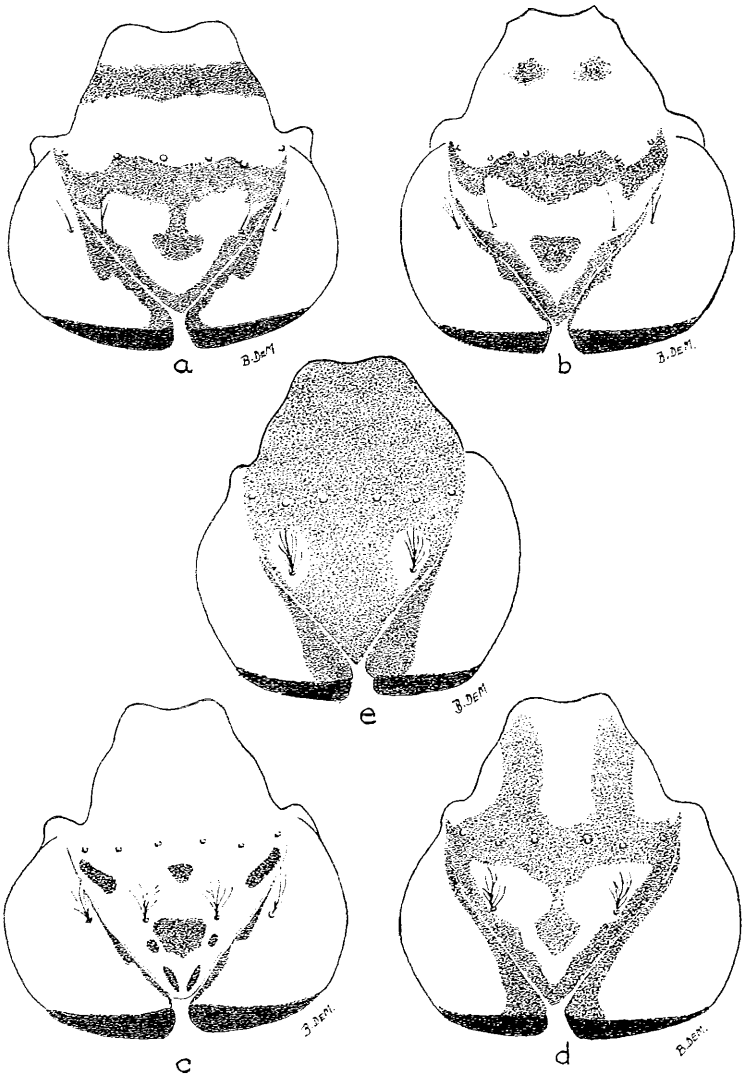


FIG. 2. *a.*—*A. funestus*, head of larva showing typical pigmentation; *b.*—*A. funestus*, head of larva showing atypical pigmentation; *c.*—*A. funestus* var. *leesoni*, head of larva showing atypical pigmentation; *d.*—*A. funestus* var. *leesoni*, head of larva showing typical pigmentation; *e.*—*A. funestus* **var.** *leesoni*, head of larva showing atypical pigmentation.

and *longipalpis* one can recognise it by the relatively larger anterior abdominal plaques. It differs from *funestus* in the following respects :—

1. Inner occipital with 7-8 branches. We have seen a *funestus* larva in which one inner occipital had four branches. Nothing approaching the condition seen in var. *leesoni*, however, has ever before been noted.
2. Anterior head pattern consisting of two longitudinal stripes (fig. 2, *d*) instead of a transverse band (fig. 2, *a*). We have seen *funestus* in which the transverse band is not complete. The band is then represented by two small darkened areas, but one can usually trace a tendency for these two to unite transversely (fig. 2, *b*). Occasionally the anterior portion of the clypeus is quite unpigmented. Sometimes, in the larva of *funestus* var. *leesoni*, the two longitudinal stripes are completely absent (fig. 2, *c*), and we have seen one larva of this variety in which the whole clypeus, with the exception of two small areas at the bases of the inner occipitals, was pigmented. (fig. 2, *e*).

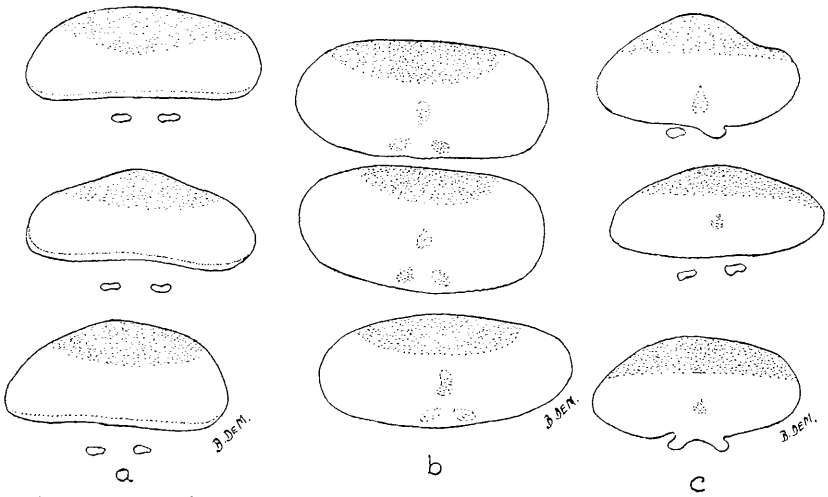


FIG. 3. *a.*—*A. funestus* var. *leesoni*, abdominal plaques V, VI and VII of the larva; *b.*—*A. funestus*, abdominal plaques V, VI and VII of the larva; with posterior plaques included in anterior plaques; *c.*—*A. funestus*, abdominal plaques V, VI and VII of the larva; with posterior plaques in the process of being included by the anterior plaques.

3. Two posterior plaques always present on some abdominal segments (fig. 3, *a*). Typical *funestus* has no posterior plaques (fig. 3, *b*). Sometimes, however, these are present

on the anterior abdominal segments and, rarely, on all segments. Usually, in *funestus*, posterior plaques can be distinguished in the young larva, or the process of their inclusion by the anterior plaques can be seen (fig. 3, *c*). When no posterior plaques are present in *funestus*, they can often, but not always, be seen as darkened areas lying in the anterior plaque (fig. 3, *b*). A scheme for separating these closely allied larvae is given as follows :—

1. Anterior dorsal mesopleural hair, feathered..... 2
   Anterior dorsal mesopleural hair, simple 3
2. Inner clypeals, simple ..... *transvaalensis*
   Inner clypeals, barbed ..... *rhodesiensis*
3. Anterior plaque of abdominal segment VII more or less half as deep as the segment itself. This plaque about as wide as the segment 4
   Anterior plaque of abdominal segment VII much shallower, about one-fifth as deep as the segment. Plaque much narrower than the segment 5
4. Inner occipital much branched. Anterior portion of the head with two longitudinal pigmented areas. Posterior plaques always present on some segments at least..... *funestus* var. *leesoni*
   Inner occipital simple, or with at most four branches. Anterior transverse pigmented band usually present on the head. Posterior plaques usually absent ; occasionally present on anterior segments, rarely on all segments..... *funestus*
5. Filaments of abdominal palmate hairs short. One posterior plaque present. Saddle hair much branched. Larva pale in colour ..... *marshalli*
   Filaments long. Three posterior plaques present on some segments at least. Larva very dark in colour..... *longipalpis*

The ventral surface of abdominal segments IV, V, VI, VII and VIII, but more especially segments VI and VII in the larva of *funestus*, is clothed with a large number of closely-set, sharp-pointed spines, with their apices directed towards the tail end of the larva (fig. 4). These possibly aid the larva in keeping a hold of the side

FIG. 4. *A. funestus*, spines from the ventral surface of abdominal segment VI of the larva. (× 600 approx.)

of the stream. It is a peculiar fact, however, that these spines are absent from the larva of *funestus* var. *leesoni*, although its breeding habits are very similar to those of *funestus*, and the two occur side by side in the same streams. Indeed, the larva of *A. theileri* is the only other stream breeder in which these spines are developed to any extent.

As pointed out by Evans in her original description, the pupae of *funestus* var. *leesoni* and *funestus* are easily separable. Some of the main differences are shown in figs. 5 and 6. It will be seen that bristle 'A' of segments V, VI and VII is relatively much longer in *funestus* var. *leesoni*; similarly, bristle 'B' is longer, and, furthermore, is simple in these segments, whereas in *funestus* it is bifid or triple.

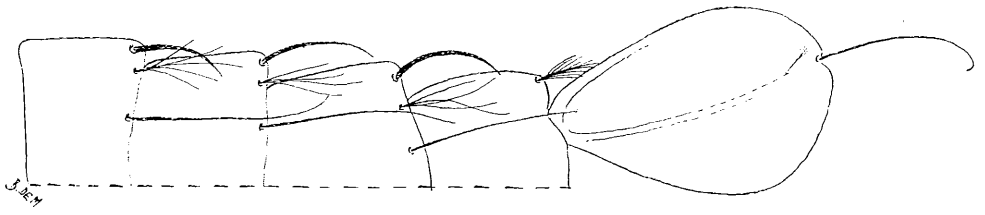


FIG. 5. *A. funestus* var. *leesoni*, portion of the pupa.

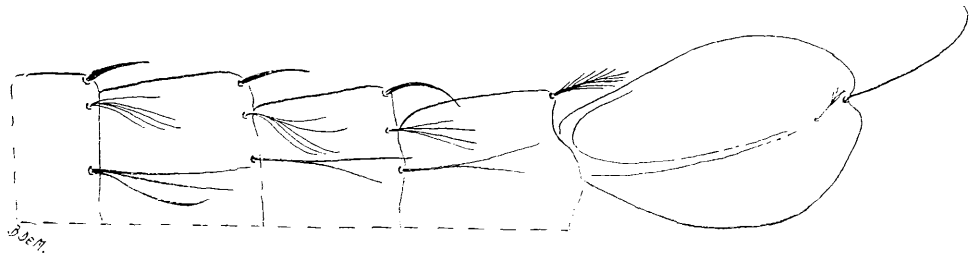


FIG. 6. *A. funestus*, portion of the pupa.

Breeding Places. *A. marshalli* and *A. transvaalensis* are typical seepage breeders in shaded water. They also occur to some extent along the edges of streams. *A. rhodesiensis* breeds usually in exposed pools and sometimes in rock pools. *A. funestus* and its variety occur side by side along the edges of shaded streams, less often in marshy ground where there is some movement of the water, and occasionally in seepages. It has repeatedly been pointed out that in South Africa *A. funestus* is not a marsh breeder. This has led to some

misunderstanding because of the various ways in which the term ' marsh ' can be interpreted. By ' marsh ' we mean a collection of surface water, usually in the form of a number of small pools which are overgrown with vegetation and in which there is no movement of water. Very often it happens that a marsh or swamp has a central stream of slow moving water, as occurs in the Northern Rhodesian ' dhambo.' In such a case, larvae of *funestus* will, of course, be found, and the breeding place is no longer a marsh or swamp according to our terminology.

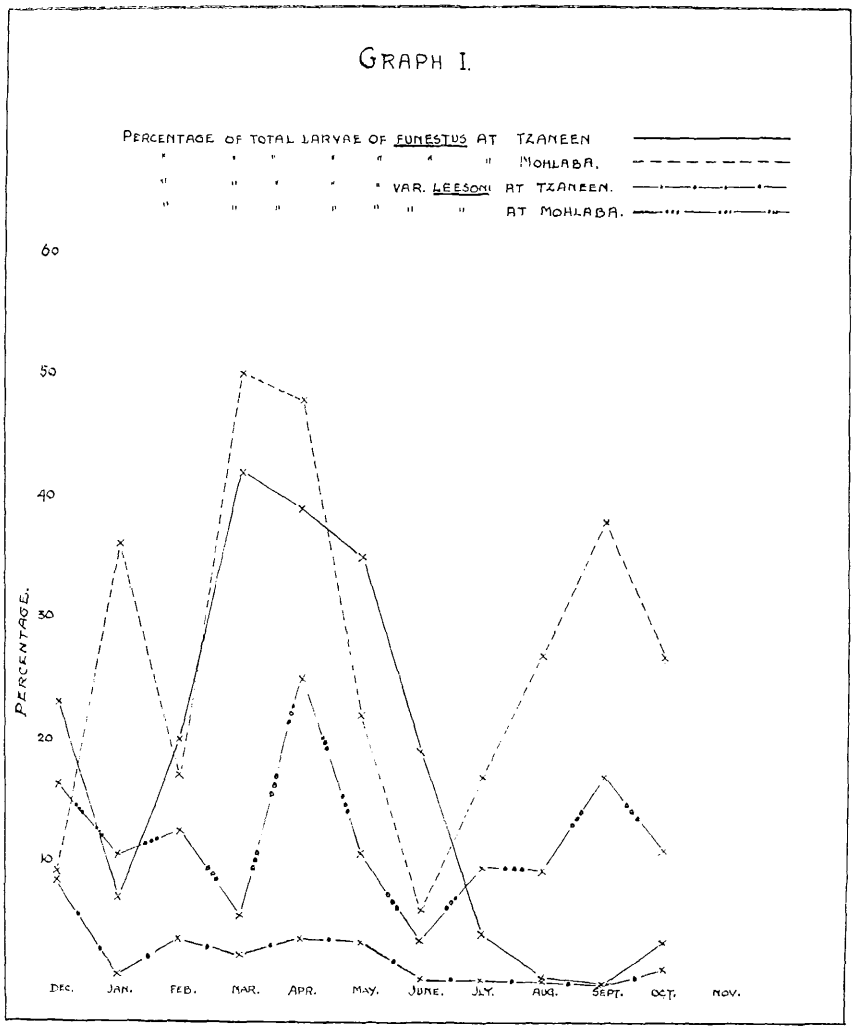
SEASONAL PREVALENCE OF *A. FUNESTUS* AND ITS VARIETY IN THE DRAKENSBERG FOOTHILLS

At Tzaneen, the larvae and adults of *funestus* and *funestus* var. *leesoni* both disappear in winter; whereas at Mohlaba, 12 miles distant, they breed all the year round. This is clearly shown by Graph I and Table I. Weekly collections of larvae in all types of breeding places were made at Tzaneen and Mohlaba and their environs during 11 months. Monthly totals were then made, and the percentage calculated of *funestus* and *funestus* var. *leesoni* of the total of all larvae.

It will be seen that *funestus* and its variety disappear from Tzaneen in September, whereas at Mohlaba the minimum is reached in June and breeding really never stops. At first sight, this extraordinary change of habit in two places only 12 miles distant appears to be incomprehensible. It has been found, however, that the climatic conditions of the two places are very different. This aspect of the problem will be elaborated in a later publication.

ADULTS. It is very commonly thought that ' species sanitation ' simply implies the correct identification of larvae, the identification and biology of the adult being neglected. This would be, of course, a perfectly correct procedure if biological behaviour could be measured by a morphological yardstick. It implies the principle that morphologically identical species—bearing in mind that there may be obscure structural differences of which we are unaware—always behave in the same way. That this is not so is, of course, well known in other countries. It is, therefore, possible that, by merely identifying larvae and proceeding with control in the shape of spraying or

drainage, a harmless race of anopheline may be destroyed. This is especially possible if the amount and origin of malaria in a particular community is not first estimated—a proceeding which is not the rule in South Africa. To sum up, therefore, morphologically identical



species may be divided into differing biological groups called ' races,' and, following the argument to its logical conclusion, ' race sanitation ' may be substituted for ' species sanitation.'

TABLE I. Tzaneen and Environs.

Month	*Funestus*	*Costalis*	*Funestus* var.	*Mauritianus*	*Maculipalpis*	*Rufipes*	*Pretoriensis*	*Longipalpis*	*Transvaalensis*	*Marshalli*	*Squamosus* var.	*Nili*	*Theileri*	*Natalensis*	*Squamosus*	*Rhodesiensis*	*Cinctus*	*Ardensis*	Total	% *Funestus* var. of total	% *Funestus* of total
Dec.	154	1	57	183	131	20	41	9	1	9	32	10	20	1	...	...	...	...	669	8·5	23
Jan.	10	...	1	13	89	...	6	...	16	9	...	...	...	...	...	...	...	...	144	·7	7
Feb.	72	...	12	36	152	14	5	1	4	4	34	2	19	...	...	...	...	...	355	3·6	20
Mar.	95	2	5	26	49	9	4	...	...	15	13	2	3	...	...	...	...	...	223	2·2	42
April	329	3	31	152	74	22	7	15	21	14	2	3	150	26	3	...	...	...	852	3·6	39
May	410	9	38	214	95	63	3	5	28	59	40	...	185	33	4	...	...	...	1176	3·2	35
June	195	...	1	345	55	41	...	2	32	96	74	...	100	22	32	1	3	8	1016	·09	19
July	32	...	1	266	31	50	...	1	21	83	158	...	8	136	7	3	...	...	797	·12	4
Aug.	4	...	1	200	11	3	...	...	47	99	193	...	31	99	8	...	...	...	696	·14	·6
Sept.	...	...	...	175	95	20	35	...	12	18	219	...	4	16	67	...	13	...	674	...	...
Oct.	17	...	6	85	98	38	94	1	16	14	64	...	10	2	23	...	...	...	468	1·3	3·6

Mohlaba and Environs.

Dec.	69	59	119	164	40	25	134	45	7	...	1	48	18	13	1	...	...	...	743	16	9
Jan.	38	...	11	19	7	2	23	3	...	...	...	5	6	1	...	...	1	...	104	10·5	36
Feb.	54	96	39	27	2	41	27	2	...	1	...	11	8	...	2	...	...	...	310	12·2	17
Mar.	55	2	6	7	...	14	...	...	5	9	...	5	3	...	2	...	...	2	110	5·4	50
April	195	9	101	16	...	6	4	1	1	3	...	9	24	35	...	...	...	1	405	25	48
May	113	79	54	96	3	2	26	21	2	1	4	...	90	13	11	...	...	...	515	10·48	22
June	46	319	28	87	...	5	18	150	3	40	...	...	61	18	34	...	...	1	810	3·45	6
July	114	6	65	100	...	2	42	46	25	41	...	...	74	57	109	...	3	...	684	9·5	17
Aug.	180	...	63	68	1	36	1	35	3	43	...	1	136	11	97	...	1	...	676	9·3	27
Sept.	228	...	104	120	...	11	16	...	...	...	...	...	75	9	40	...	...	...	603	17	38
Oct.	136	51	54	23	...	72	96	20	2	...	3	...	48	...	16	...	...	...	501	11	27

Recent researches in South Africa have clearly shown that differing biological behaviour within the same species is certainly to be reckoned with. It has already been pointed out that the prevalence of the larvae of *funestus* differs enormously in two localities. In one they are to be found all the year round, whereas in another they disappear during the winter. This is thought to be due to differing climatic conditions, so that the races, to distinguish them from purely physiological ones inhabiting similar climatic areas, may be called 'climato-races.' Now it has been found that at Mohlaba *funestus* adults enter human habitations much more readily than at Tzaneen. The actual figures show that 150 times more adults were caught per hut at Mohlaba than at Tzaneen over a period of 9 months. At the same time it must be remembered that at Mohlaba, owing to the large numbers present, only some adults were taken at each catch, whereas at Tzaneen a thorough examination was made of each hut, so that the figure is actually much bigger. It is therefore suggested that it will be found that the race of *funestus* which inhabits the Tzaneen area is largely zoophilic, whereas that of Mohlaba is largely homophilic.

Following from this it will at once be seen that it is essential, when contemplating anti-malaria control in a given area, to determine first of all the species present in human habitations. This brings us down to the identification of adult *funestus*. (It is assumed here that the vector of malaria is always a house-frequenter, and our experience so far has shown that the infectivity among non-house frequenting species is negligible in the parts of South Africa where detailed investigations have been made.)

The identification of adult *funestus* can be a very difficult and sometimes an impossible task. A scheme for separating it from other closely related forms has already been given by the author (1931), where it will be seen that the chief difficulty lies in the differentiation of *transvaalensis* and *funestus*. Further distinguishing features not given in the keys will be seen in the illustrations of the wings on pages 345 and 347 of the same publication. In *transvaalensis* the 4th, 5th and 6th veins are relatively paler, and this feature has been found to be of great use in separating some small specimens of *transvaalensis*. Further, in the latter species the base of the costa is broken by two pale spots, whereas in *funestus* there is at most one

pale spot, and often this is absent. When we come to distinguish *funestus* var. *leesoni* from *funestus*, however, a very serious difficulty arises, for it has been found that the females are inseparable. Close on 50 specimens of the variety have been bred in our laboratory from identified larvae, and in none of these has any feature been

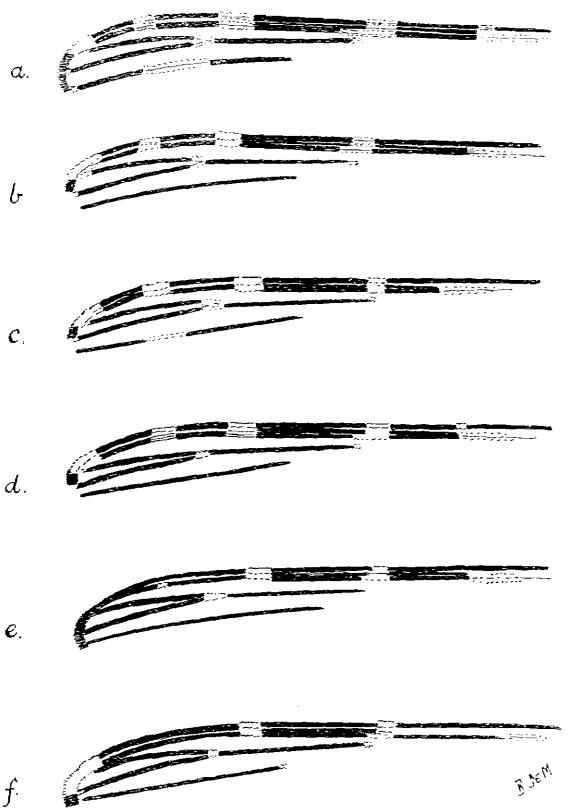
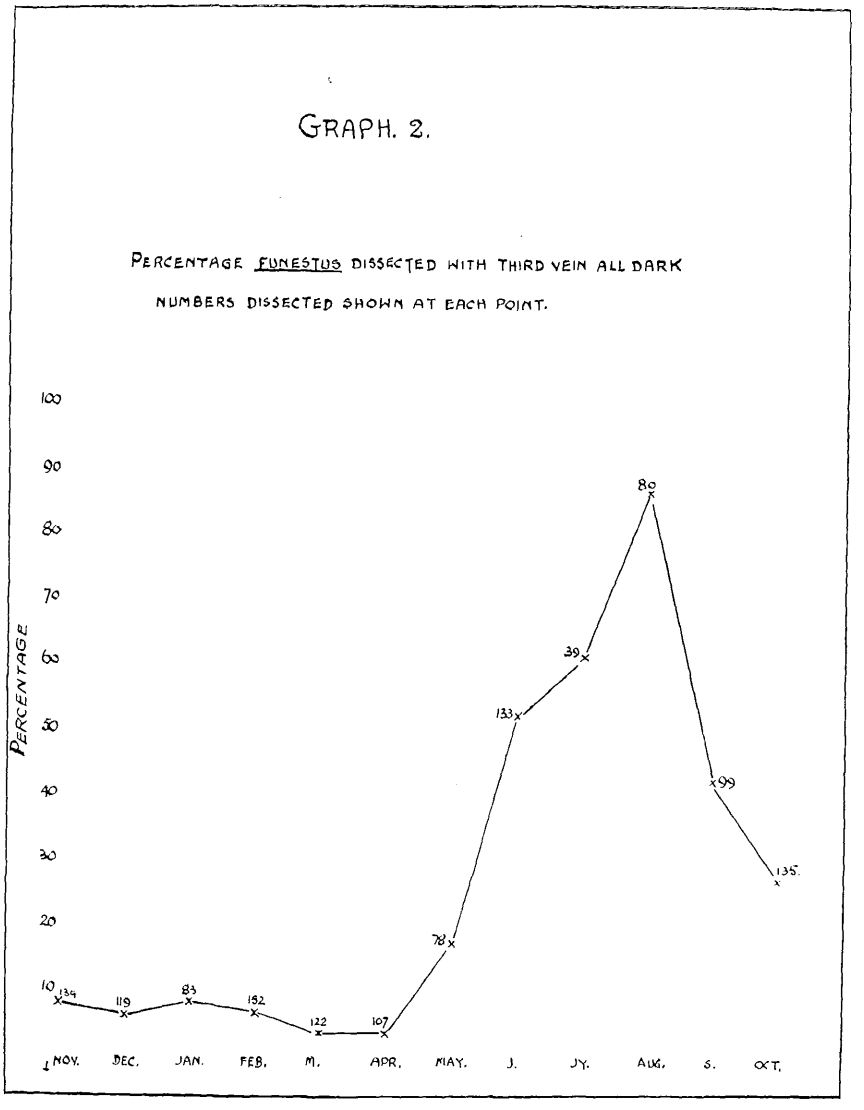


FIG. 7. *A. funestus*, costa, subcosta, first, second and third veins of the wing. *a.*—base of the costa broken, third vein pale in centre; *b.*—base of costa unbroken, third vein dark; *c.*—base of costa unbroken, third vein pale in centre; *d.*—base of costa broken, third vein dark; *e.*—base of costa unbroken, third vein all dark, apex of wing all dark, other pale spots reduced; *f.*—base of costa unbroken, third vein all dark, apex of wing largely pale.

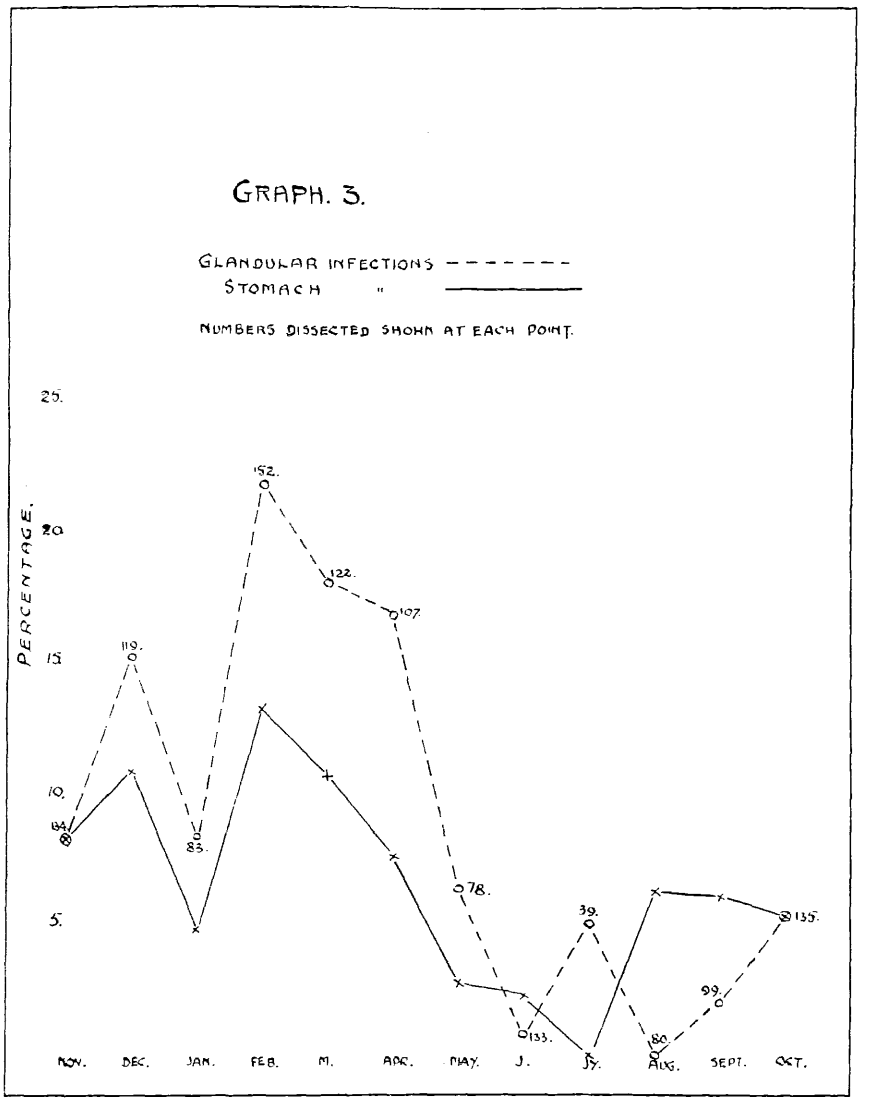
found to distinguish them from *funestus*. As a general rule, the pale markings on the wing of the variety are more restricted, but, as is well known from the work of Leeson (1930), the wing of *funestus* is very variable. That author mentions 9 types of wing variations, and we give here 6 others (fig. 7) not mentioned by him. It is of

interest to note that, whereas the form with the base of the costa broken apparently does not appear in Southern Rhodesia, it is quite common down here. In none of our specimens of *funestus* var. *leesoni*, however, is the base of the costa broken. Leeson has further



noted that the type of *funestus* with the third vein pale is the wet season form, and this we have been able to confirm. Graph II shows the percentage of specimens dissected during a year, with the third

vein totally dark. We have, however, been unable to find any evidence that this form is the hibernating one, as was suggested by Leeson. It is suggestive, nevertheless, that in the month of August, when the percentage of dark winged forms reached its maximum,



there were no glandular infections noted among 80 specimens. Graph III gives the infection rate among *funestus* adults caught in selected huts at Mohlaba.

A. funestus var. *leesoni* cannot definitely be said to show the same seasonal variation, although out of 50 females, 5 had the third vein all dark, and 4 of these occurred in May, a relatively dry month.

The males of *funestus* var. *leesoni* are easily distinguished from *funestus* by having 3 instead of 2 pale markings on the palp (fig. 8, *a* and *b*).

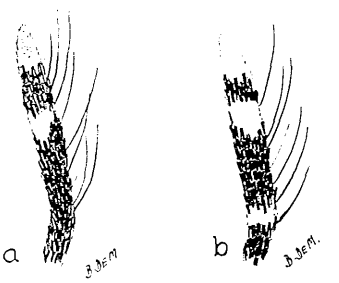


FIG. 8. *a*.—*A. funestus*, apex of male palp; *b*.—*A. funestus* var. *leesoni*, apex of male palp.

It will be clearly understood from the above that it is impossible to estimate directly the rôle played by *funestus* var. *leesoni* as a vector of malaria. We have, however, abundant indirect evidence that this variety does not enter human habitations to any extent. During the course of the year, 237 males of *funestus* have been taken in our catching stations, and only 1 male definitely belonging to the variety. Other evidence which shows that this variety is not homophilic is suggested by the following experiment. During April, 1932, *funestus* and its variety were breeding in enormous numbers in the Letaba River at Tzaneen. A tent was pitched on the bank of the river, and a native slept in it as bait on 7 nights. Each morning a catch of adults in the tent was made, as well as during the night or evening, when mosquitoes were noticed. The total catch was *funestus*, or *funestus* var. *leesoni*, 2 females; *funestus* var. *leesoni*, 1 male; *mauritianus*, 2 females; *theileri*, 3 females; *costalis* (*gambiae*),* 2 females. Compare this with a catch on the Letsitele River at Mohlaba, where, during a single night, 32 females of *funestus* typicus or var. and 12 males of *funestus* typicus entered the same tent, showing that the tent and its occupant were not distasteful to a homophilic strain.

* The name *costalis* is used in this Journal.—EDD.

GEOGRAPHICAL DISTRIBUTION OF *A. FUNESTUS* var. *LEESONI*

We have records of this species from the following places :— Nylstroom, Waterberg District, Transvaal; Louis Trichardt, Zoutbansberg District, Transvaal; Letaba District, Transvaal; N'Kwaleni Valley, Natal; Darnall, Natal.

I am greatly indebted to Dr. Annecke and his staff of the Department of Public Health, and to my assistant, Mr. Meeser, for the great help rendered in accumulating the data for this paper.

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References to authors in the text must be made in the following way :—'According to Smith (1900) the spleen is enlarged, but Robinson (1914) says the reverse.' The references should be collected in alphabetical order of authors' surnames at the end of the paper, and arranged in the following way :—

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SMITH, J. (1900). Enlargement of the spleen in malaria. *Jl. Pathometry*, **1**, 1.

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