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## A PRELIMINARY ACCOUNT OF THE FORMS OF *ANOPHELES LEUCOSPHYRUS* DÖNITZ (DIPTERA : CULICIDAE).

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### 1. INTRODUCTION.

ALTHOUGH *Anopheles (Myzomyia) leucosphyrus* has long been known or suspected as a vector of malaria in certain areas, especially in Borneo and Sumatra (Roper, 1914; Doorenbos, 1931; Stoker, 1934, etc.), it is only comparatively recently that its potential importance as a vector has become more widely recognized. This has been due mainly to the work of Clark and Choudhury in Assam (1941), of McArthur in British North Borneo (1947), and the experiences of the Armies in Burma, e.g. Covell (1944 : 411), Afridi and Arthur (1945). In all these instances trapping and dissection showed that *leucosphyrus* was a very efficient vector of malaria. Consequently it has become a matter of importance to clear up the systematics of this species.

*Anopheles leucosphyrus*, which is readily distinguished by the broad white band covering the tibio-tarsal joint of the hind leg, has a wide distribution in the Oriental region, ranging from south-west India eastward to the Philippines and Celebes. It appears to consist of at least six or seven distinct forms, four of which occur in the Malay Peninsula. The purpose of the present paper is to draw attention to this situation, and to provide notes on nomenclature and a tentative key for separating the adult females of these forms, pending the completion of a fuller account at a later date. Also to give some evidence which, though scanty at present, does seem to point to one among these forms as being that which has been found infected in the recent investigations quoted.

For descriptions of *leucosphyrus* and *leucosphyrus* var. *hackeri*, see Christophers (1933) and Gater (1934 and 1935).

### ACKNOWLEDGMENTS.

This account is based partly on the specimens in the collection of this Institute (I.M.R.)<sup>1</sup> and partly on examination of the specimens in the collections at the British Museum (Natural History) (Mr. H. Oldroyd) (B.M.), the Institute for Tropical Hygiene, Amsterdam (Professors N. H. Swellengrebel and S. L. Brug) (B.), and the London School of Hygiene and Tropical Medicine (Professor P. A. Buxton and Mr. H. S. Leeson) (L.S.H.T.M.). A few specimens were also seen in the Pasteur Institute, Paris (Professor E. Roubaud and Dr. J. Colas-Belcour) (P.), and in the collection of Dr. de Meijere at the Zoological Museum, Amsterdam (Dr. Kruseman) (A.). I wish to thank all these gentlemen, and the Keeper of Entomology at the British Museum, Mr. N. D. Riley, for their very kind help. My thanks are especially due to Professor Buxton, who has

<sup>1</sup> The letters in brackets following the name of each collection are the abbreviations used to indicate the location of the specimens seen, when giving their collection data.

gone out of his way to help me in my work on this and other species of *Anopheles*. I was greatly assisted by the grant of study leave and travelling expenses from the Malayan Government.

## 2. KEY TO THE ADULT FEMALES.

### Definitions.

Many of the characters employed in the key which follows are those used by King and Baisas (1936) in their important paper on the Philippine forms of

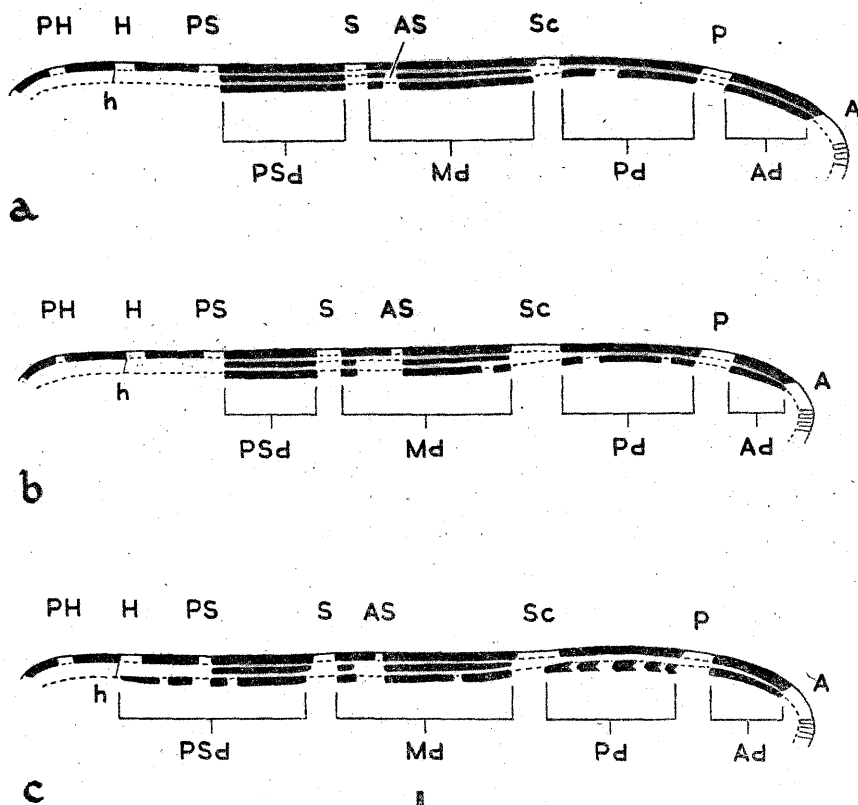


FIG. 1.—Diagrams to show typical distributions of light and dark marks on the costa, subcosta and vein 1 in: (a) *hackeri*, *elegans* and *riparis*; (b) *pujutensis*; (c) *leucosphyrus* s.s. Explanation of symbols: *h*, humeral cross-vein, pale areas; *A*, apical; *AS*, accessory sector; *H*, humeral; *P*, preapical; *PH*, prehumeral; *PS*, presector; *s*, sector; *Sc*, subcostal; dark marks; *Ad*, apical; *Pd*, preapical; *Md*, middle; *PSd*, presector. Nomenclature after Christophers, 1933, p. 18.

the *leucosphyrus* group; in particular the number of pale interruptions (hereafter called "divisions") in the presector and preapical dark marks on vein 1 (fig. 1), the presence or absence of a dark stripe on the ventral aspect of the apical pale band of the hind tibia (called the "hind tibial pale band"), and the presence or absence of a basal pale band on hind tarsus four. This last character appears to be only of minor or perhaps local value.

Provisional key to the adult females of the  
*Anopheles leucosphyrus* group.

1. Palps clearly shorter than the proboscis which is longer than the fore femur . . . . . \* 2  
Palps and proboscis subequal, the latter not longer than the fore femur . . . . . 4
2. Preapical and middle dark marks on vein 1 nearly always with more than one division each (fig. 1b). Fourth hind tarsus without basal pale band, costa often with accessory sector pale spot. Apical and preapical pale bands of palps broad, apical segment half or more than half white . . . . . var. *pujutensis*.  
Preapical and middle dark marks on vein 1 with only one division each (fig. 1a). Fourth hind tarsus often with basal pale band, costa without accessory sector pale spot. Apical and preapical pale bands of palps broad or narrow . . . . . 3
3. Apical and preapical pale bands of palps narrow, only tip of apical segment white. Palps much shorter than proboscis, shorter by more than length of last segment, usually by about length of last two . . . . . var. *hackeri*.  
Apical and preapical pale bands of palps broad, apical segment half or more than half white. Palps shorter than proboscis by not more than length of last segment, usually less . . . . . var. *elegans*.
4. Vein 1 with presector dark mark divided, usually extending basally into the presector pale area; preapical and middle dark marks usually with more than one division each (fig. 1c). No dark stripe on ventral aspect of hind tibial pale band. Hind tarsus four often with small basal pale band . . . . . *leucosphyrus* type form and var. *balabacensis*.  
Vein 1 with presector dark mark undivided, the same length as the corresponding marks on the costa and subcosta; preapical and middle dark marks with not more than one division each (fig. 1a). With a more or less well marked dark stripe on at least the proximal portion of hind tibial pale band. Hind tarsus four usually without basal pale band . . . . . 5.
5. Costa without prehumeral pale spot . . . . . *A. cristatus*.  
Costa generally with prehumeral pale spot . . . . . *A. leucosphyrus* var. *riparis*.

In general, males can be identified without much difficulty, chiefly by the number of divisions in the dark marks on vein 1.

### 3. NOTES ON THE FORMS.

Whilst it is probable that most of the forms discussed here will before long be regarded as good species, there are some, such as *elegans* and the form from Celebes (p. 45), the status of which is uncertain at present; see discussion on page 47. For this reason varietal rank has been preferred for the time being, whilst the non-committal term "form" is employed in discussion.

*Anopheles leucosphyrus* var. *pujutensis* Colless, 1948.<sup>2</sup>

*Adult*.—The adult females resemble those of *hackeri*, in having a proboscis considerably longer than the palps, and longer than the fore femur. They differ principally as shown in the following couplet:

<sup>2</sup> Colless, D. H., 1948, *Proc. Linn. Soc. N.S.W.* 73: 101. A timely meeting with Mr. Colless and examination of his specimens, some of which he has kindly presented to this Institute, has saved me from creating a synonym.

Apical and preapical pale bands of palps broad, especially the apical, so that apical segment of palps is half or more than half white. Preapical dark mark on vein 1 usually (17/20) with more than one division; middle dark mark on vein 1 usually (18/20) with more than one division; costa in about half the specimens (10/20) with an accessory sector pale spot (fig. 1*b*). Fourth hind tarsus without basal pale band. Ventral aspect of hind tibial pale band without, or with only a small dark stripe *pujutensis*.  
 Apical and preapical pale bands of palps narrow, especially the apical, so that only the extreme tip of apical segment is white. Preapical dark mark on vein 1 with only one division; middle dark mark on vein 1 with only one division, the accessory sector pale spot (20/20); no accessory sector pale spot on costa (20/20) (fig. 1*a*). Fourth hind tarsus in about half the specimens (12/20) with a small basal pale band. Ventral aspect of hind tibial pale band generally with a proximal dark stripe *hackeri*.

The tip of the palps broadly or minutely pale is the most reliable distinguishing character. The long proboscis and the wing characters will distinguish the males from the other forms and from *hackeri*.

*Larva*.—The larvae cannot at present be distinguished from those of *leucosphyrus* type form and var. *riparis*, but like these two, they are distinguished (at least in Malayan specimens) from the larvae of *hackeri* by the absence of the well-developed pigmented palmate hairs on the second abdominal segment, present in the latter. In addition, the inner submedian prothoracic hair of *pujutensis* is smaller and more slender and has fewer branches:

<i>pujutensis</i>	10-16, average 12	}	20 measured.
<i>hackeri</i>	17-28, ,, 22		

Types: C.S.I.R., Canberra, Australia; paratypes in Brit. Mus. (Nat. Hist.)  
 Specimens seen: BORNEO: North, Membakut, 1913, 3 ♀ (*R. Roper*) (1 ♀ in B.M., specimen noted by Edwards; 2 ♀ L.S.H.T.M.); East, Balik Papan, 3 ♀ (B.). SUMATRA: Deli, 4 ♀ (B.); Moeara Tebo, 1 ♀ (B.). MALAY PENINSULA: Various localities in Negeri Sembilan, Selangor and Perak, 50 ♀♂ (I.M.R.).

Paratypes have been placed in the British Museum, together with Malayan specimens with corresponding larval and pupal skins.

Up to now this form has generally been confused with var. *hackeri*. Edwards (1921), in his description of *hackeri*, notes an exceptional specimen of Roper's with broad apical pale bands on the palps, and, partly on account of this specimen, gives *hackeri* only varietal rank. This specimen, which I have examined, belongs to var. *pujutensis*.

Specimens of *pujutensis* have been seen from the Malay Peninsula, British and Dutch Borneo and Sumatra.

*Anopheles leucosphyrus* var. *hackeri* Edwards, 1921.

So far, specimens of this form have been seen only from the Malay Peninsula, which is the type locality, and from Pulau Laut, south-east Borneo. The few specimens of *leucosphyrus* from the Celebes which have been seen, and which included three females, were rather distinct, but are possibly more closely related to *hackeri* than to any of the other forms. The palps are exactly like those of *hackeri*, shorter than the proboscis, and with very narrow apical and

subapical pale bands, but the dark marks on vein 1 tend to have numerous pale interruptions, e.g. 3-6 in the preapical dark mark instead of only one as in typical *hackeri*. Also the dark stripe on the hind tibial pale band tends to be divided, taking the form of a short proximal stripe with a disconnected black spot distally.

The characters attributed to var. *hackeri* by King and Baisas (1936: 88) in their key are at variance with those of var. *hackeri* as understood here, and would seem to be more applicable to *pujutensis* and the Celebes form.

Type: ♀ in Brit. Mus. (Nat. Hist.).

Specimens seen: MALAY PENINSULA: Numerous specimens (B.M., L.S.H.T.M., I.M.R.). BORNEO: South-east coast, Pulau Laut, 9 ♀ (*Leopold*) (A.). CELEBES: Variant form: Aalo, Kaboena, Boeton, 1937, 2 ♀ (*Brug*) (B.); Lindoe Meer, 1000 m., 1937, 1 ♀ (*Arug* and *Tesch*) (B.); ♂♂ from both localities probably this form.

*Anopheles leucosphyrus* var. *elegans* James, 1903.

Nine females and two males of this form have been seen; six of the females and the two males were some of Cogill's original specimens from the type locality, Karwar, south India (Cogill, 1903), on which James' description is based (James in Theobald, 1903: 51). Of the remaining three females, one is from Travancore, south India, and two, rather damaged, but apparently of this form, are from Ceylon. The form appears to be close to *hackeri*, but differs as indicated in the key, and in other respects; in particular the relative lengths of the palps, proboscis and fore femur appear to distinguish it from *hackeri* (data to be published later).

Christophers (1933) describes a discontinuous distribution for *leucosphyrus* in the Indian area: on the west coast region of India, and then in Burma, Assam, Bengal and the Andaman Islands in the east. It may be that *elegans* is confined to this western area which would appear to include Ceylon.

Investigation reveals a rather complicated situation in regard to the name *elegans*. James sent one specimen with his manuscript description under the name *elegans*, and a drawing of a wing, to Theobald, who promptly published the description and the drawing, designating the single specimen as the type of *A. leucosphyrus* var. *elegans* James (Theobald, 1903: 51).

Christophers (1933), following Theobald, states that the type of *elegans* is in the British Museum. There is in fact no specimen labelled as type, but there is one of which the collection data agree with those given by Theobald (Karwar, April, 1902) and this is presumably Theobald's specimen. The other specimens are labelled September and October, 1902, which agrees with Cogill (1903) who states that he found only two larvae in April and the rest not until September, after the rains. Unfortunately, this single April specimen, though rather shrivelled, is apparently of the type form, having more than one division in the preapical dark mark and the presector one divided; it is not the same as the remainder of the specimens which are clearly those to which James' description applies.

James and Liston (1904) published the same description and figure as Theobald (together with additional figures and information), but stated that the figure in question (p. 83) represented a variant specimen. Their figure on plate 12 represents the normal type of wing, and agrees exactly with the

specimens seen, except that it shows a small dark mark on vein 1 proximal to the presector dark mark; there was only one specimen with a few scales in this position. In accordance with the figure their description states that "the first longitudinal vein shows seven dark-scaled areas of different sizes arranged as shown in the diagram." It would appear that there are normally six; the figure of the variant wing shows eight, and the wing of the April specimen has nine. The significance of this is that the figure of the normal type agrees with the specimens in showing a wing like that of var. *hackeri* with only one division in the preapical dark mark, whilst the figure of the variant wing shows more than one division in this mark, as in the type form of which the April specimen is an example (see key).

It may be mentioned, incidentally, that whilst James and Liston's figure of the normal wing accurately depicts a common distribution of pale fringe spots, in particular one at the termination of vein 5.2 and one between 5.2 and 6, they state in their description that there is a fringe spot at the end of each vein, and this is shown in the figure of the variant wing. I have not seen a fringe spot at the termination of vein 6 in any form in the *leucosphyrus* group.

Cogill (1903), who also describes his specimens, correctly mentions that the proboscis of the female is slightly longer than the palps.

It seems, therefore, that Theobald was in error in designating the April specimen as the type of var. *elegans* James, and it is clear that the description given by James and Liston, despite minor discrepancies, refers to the bulk of the specimens, collected by Cogill in September and October, 1902, eight of which I have seen.

Variety *elegans* was sunk as a synonym of *leucosphyrus* by James and Stanton (1912), but if, as seems probable, it is a distinct form, the name *elegans* should be revived.

Types: In Brit. Mus.

Specimens seen: INDIA, S.W.: Karwar, N. Kanara, 9.x.1902, 6 ♀, 2 ♂ (*H. Cogill*) (4 ♀, 2 ♂ in B.M., 2 ♀, L.S.H.T.M., in cavity slides); Travancore, 1934, 1 ♀ (Iyengar) (L.S.H.T.M.). CEYLON: Kapitigalla, 1921, 1922, 2 ♀ (*R. Senior-White*) (B.M.).

*A. leucosphyrus* Dönitz, 1901, and var. *balabacensis* Baisas, 1936.

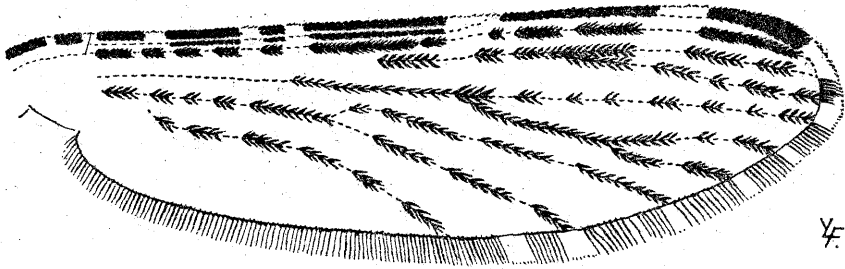
Dönitz described *leucosphyrus* from several specimens from Kajoe Tanam, Sumatra; he sent one specimen to Theobald which the latter (1901: 307) described. In the British Museum there is an old broken specimen labelled in pencil, possibly by Dönitz himself, "*A. leucosphyrus* Dö Sumatra. K.T.," which is presumably this specimen; K.T. probably standing for Kajoe Tanam. Fig. 2 is a sketch of one wing of this specimen which shows a pattern common for this form, the important point being that the presector dark mark is divided and there is more than one division in the preapical (see key). Dönitz (1902: pl. I, fig. 7) gives a photograph of a wing of *leucosphyrus* from Kajoe Tanam, which is reproduced slightly altered by Theobald (1903: 53). Dönitz's photograph shows the preapical dark mark with three divisions. The basal part of the wing is not in sharp focus so that one cannot say what is the condition of the presector dark mark.

It seems therefore that this specimen in the British Museum can be regarded

as a cotype. The abdomen is distended with dried blood, which suggests that it, and probably the whole series from Kajoe Tanam, may have been captured resting indoors after biting, which may be significant (see discussion on the vector form, p. 50).

The principal diagnostic features of this type form, so far as they are known at present, are indicated in the key. The number of divisions in the presector and preapical dark marks is variable, and sometimes on one wing there may be only one in the preapical. This tendency to reduction in the number of divisions in the preapical dark mark has been noticed in specimens from Assam. However, apart from the *hackeri*-like form from Celebes (p. 45) this type form appears to be the only one with a divided presector dark mark on vein 1.

King and Baisas (1936) and Russell and Baisas (1936: 38), provisionally treat the form from Luzon and Mindanao as belonging to the type form; this would seem to be correct as it had the principal characters of the type form, though lacking the basal pale band on hind tarsus four. King and Baisas



2

FIG. 2.—Sketch of the wing of a presumed cotype of *leucosphyrus* Dönitz in the British Museum.

note the reduced tarsal banding as compared to specimens from Borneo. But Baisas (1936) then separates specimens from Palawan as variety *balabacensis* Baisas, which differs from the Luzon specimens principally as follows:

- Hind tarsus four usually with a basal pale band, pale bands of fore tarsi usually complete beneath; costa often with an accessory sector pale spot. Larva with palmate hairs of abdominal II moderately well developed . . . . . var. *balabacensis*.  
 Hind tarsus four without basal pale band, pale bands of fore tarsi not complete beneath; costa less often with accessory sector pale spot.  
 Larva with palmate hairs of abdominal II rudimentary . . . form from Luzon.

But all these characters of *balabacensis*, except perhaps that of the larval palmate hairs, are also characters of the type form as represented by specimens from Sumatra and Borneo, and it is doubtful whether adults of *balabacensis* could, in general, be distinguished from those of the type form. The differences between the latter and the Luzon form are almost certainly examples of geographical variation. The closer resemblance between the type form from Sumatra and Borneo and var. *balabacensis*, than between the former and the

Luzon form, is only to be expected since Palawan is nearer the centre of the range of the type form than is Luzon, and has a fauna which is more closely allied to that of Borneo than that of the Philippines (Scrivenor *et al.*, 1943, pp. 141, 148, etc.).

In these groups of closely allied and morphologically very similar forms (sibling species of Mayr, 1942), it does not seem desirable to name what appear to be only geographical variations of one form, until we have distinguished the forms which occur side by side in the same region (sympatric species of Mayr). The comparative scarcity of well substantiated geographical races (subspecies) in *Anopheles* may be largely due to the fact that we have only recently begun to detect these closely similar forms (sibling species) which occur together in the same or widely overlapping regions. Until these are described we can hardly hope to make much progress in the study of geographic variation in *Anopheles*. In this connection see Bates (1940) on *A. maculipennis*, and comments on his paper by Mayr (1942).

It would seem best, therefore, for the time being to sink the name *balabacensis* as a synonym of *leucosphyrus* type form. When much more material, including the immature stages, has been examined, and the group is better understood, we shall most probably recognize the sympatric forms as full species, as has been done in the case of *A. maculipennis* (Bates, 1940) and the *punctulatus* complex (Rozeboom and Knight, 1946). The form from Luzon might then be found to be a subspecies (geographical race) of *leucosphyrus sensu stricto* (= type form) and could be named accordingly.

The "Spine IV long" pupal type of Crawford (1938) corresponds to the type form.

Specimens of the type form have been seen from Karwar (see p. 47), and Duars, Bengal, in India; Andamans, Assam, Burma, French Indo-China, Philippines (both Luzon and *balabacensis* forms), north and south Borneo, Sumatra and the Malay Peninsula.

Types of *leucosphyrus*: ? non-existent. Cotype: ♀ in Brit. Mus.

Types of var. *balabacensis*: ♂♀ in Bureau of Health, Manila, ? still extant.

Specimens seen: INDIA: 1930, 1 ♀ (*Christophers*) (L.S.H.T.M.); Karwar, iv. 1902, 1 ♀ (*H. Cogill*) (B.M.); Bengal, Jalpaiguri, 1907, 1 ♀ (*C. Wallich*) (B.M.), 1933, 1 ♀ (*B. M. Khan*) (L.S.H.T.M.). ANDAMAN ISLANDS: 1908, 1 ♀, 1 ♂ (*Ray White*) (B.M.). ASSAM (L.S.H.T.M.): Tura, 1934, 5 ♀ (Assam. Med. Res. Soc.); Juri, Sylhet, 1937, 5 ♀ (*Hamilton*); Lebac Cachar, 1934, 1 ♀ (*C. Frazer*). BURMA (L.S.H.T.M.): 1 ♀ (*T. T. Macan*); Kabaw Valley, 1944, 2 ♀, 1 ♂ (*T. T. Macan*). FRENCH INDO-CHINA: Laos, 1932, 1 ♀ (*C. Toumanoff*) (B.M.); Suzannab, 1 ♀, 2 ♂ (*Borel*) (P.). MALAY PENINSULA (I.M.R.): Selangor, Kuala Kubu, iv. 1941, 2 ♀, 3 ♂, Gombak, iii-iv. 1934, 3 ♀; Negeri Sembilan, Gemas, iii. 1946, 1 ♀. SUMATRA: K.T., 1 ♀ (? cotype) (B.M.); Deli, 15 ♀ (B.); Mandailing, 1 ♀ (B.). BORNEO: North, Membakut, 1913, 7 ♀ (*R. Roper*) (2 B.M., 5 L.S.H.T.M.); Sarawak, Bidi, 1906, 2 ♀ (*J. C. Moulton*) (B.M.), Quop, 1906, 1 ♀ (*J. C. Moulton*) (B.M.), Miri, 1927, 1 ♀ (*V. A. Stookes*) (L.S.H.T.M.); East, Balek Papan, 2 ♀, ♂♂ (B.); S.-East, Pulau Laut, 6 ♀ (*Leopold*) (A.). PHILIPPINES (B.M.): Los Banos, 1930, 1 ♀ (*P. F. Russell*); Balabac Island, 1934, 1 ♀, 1 ♂ (*P. F. Russell*); Palawan Island, Iwahig, 1934, 1 ♀ (*P. F. Russell*).

*Anopheles cristatus* King and Baisas, 1936.

This form, though similar to var. *riparis* in the adult stage, has distinctive larval characters; in particular the posterior clypeal hairs are large and strongly branched. There is only one adult specimen in the British Museum, but that is a very small insect and has much the shortest proboscis, relative to the fore femur, of any specimens measured.

Types: ♀♂ in U.S. Nat. Mus.

So far known only from the Philippines.

*Anopheles leucosphyrus*<sup>var</sup>/*riparis* King and Baisas, 1936.

The form of *leucosphyrus* which seems to be commonest in collections from Malaya, and which is Crawford's "Spine IV short" pupal type, is evidently the same as variety *riparis*. No Philippine material was available, but Malayan specimens agree in all important respects with the description of *riparis*. There are, however, minor differences, and as with the type form, it is evident that geographical variation occurs. For example, in the female of the Philippine *riparis*, the accessory sector pale spot usually extends onto the costa; the male is said to be the same. But in Malayan *riparis* there is rarely (1/20) any accessory sector pale spot on the costa in the female, though it is common in the male (7/10). There seems to be less speckling on tarsus 1 of the mid leg in Malayan *riparis* than in specimens from the Philippines, where this speckling is used as one character for distinguishing *riparis* from *cristatus*.

Types: ♀♂ in U.S. Nat. Mus.

So far specimens have been seen only from the Malay Peninsula. The type locality is Mindanao, Philippine Islands.

Specimens seen: MALAY PENINSULA: Various localities, numerous specimens (B.M., L.S.H.T.M., I.M.R.).

#### 4. EVIDENCE FOR SUSPECTING THE TYPE FORM TO BE A VECTOR OF MALARIA.

In 1941 Dr. J. McArthur, who was working at Tambunan in the interior of British North Borneo, and was in correspondence with this Institute, reported that he had found a high glands infection rate in *leucosphyrus*, and sent specimens (McArthur, 1947). These were examined by the writer, and this led to his study of the *leucosphyrus* group.

McArthur's specimens were all of the type form. At about the same time nearly 400 *leucosphyrus* were caught in a human bait mosquito net trap, operated for about 17 nights in all, at two places on the Malaya-Siam border, by No. 6 Anti-Malarial Unit (O.C., Captain Kuraisy, I.M.S.). On one night, whilst the trap was located in a new clearing in the jungle, 163 *leucosphyrus* were caught, many of them having fed on the men operating the trap. A few dissections were made, but the results were inconclusive. On another night when the writer was present, 22 were caught; all of these, and all other specimens seen by him were of the type form. The trapping of numbers of *leucosphyrus* in Malaya was a new and exciting event, but the Japanese invasion put a stop to any further investigations.

Recently, a few specimens from Assam and Burma in the collection of the London School of Hygiene and Tropical Medicine (details on p. 49) have been examined and all were found to be the type form. This is interesting because

Clark and Choudhury (1941) proved *leucosphyrus* to be a vector in upper Assam, and the British and American Forces (McArthur, 1947, editorial footnote, p. 558) found the same to be true in Burma. Macan, who collected the specimens from Burma referred to above, informs me in a letter that *leucosphyrus* was regarded as the principal vector of malaria during the wet season in the Kabaw Valley of Burma from which his specimens came.

The writer, whilst a prisoner of war, encountered *leucosphyrus* in Siam in June and July, 1943, during the wet season, in the Me Nam Kwe Noi Valley near the Burma border. Unfortunately, the exact form could not be determined and specimens were not kept, but the breeding places were like those usually chosen by the type form.

Roper (1914), in North Borneo, reported finding blood-fed *leucosphyrus* inside his patients' mosquito nets in the mornings. Ten of his specimens have been examined; seven were the type form, and three were var. *pujutensis*, but it is not known whether these ten were collected from the mosquito nets or not.

There is no point in labouring this somewhat flimsy evidence further, but so far as it goes, it suggests that it is the type form which has been found infected in the recent investigations quoted, and that this form bites man readily; it has not yet been shown that any of the other forms do so. What is required now is further trapping and dissection of *leucosphyrus*, taking care to identify the form to which each specimen belongs before dissection.

#### 5. BREEDING PLACES OF THE LARVAE.

Morphological differences between the larvae and pupae of these forms of *leucosphyrus* are only imperfectly known as yet, and for that reason, apart from a few remarks in the preceding pages, they are not discussed here. It is hoped to deal with them at a later date.

Differences in preferred larval breeding places are also largely undefined as yet, but one can say that it seems as if the larvae of the type form are often found in somewhat temporary breeding places, such as rain water in elephant tracks and wheel ruts, often in rather open jungle. Variety *riparis*, on the other hand, tends to frequent streams, being often found in still pools in the rocky beds of small streams in jungle, or under dense rubber. Variety *hackeri* seems to be found as usual under shade, but there almost solely in such places as in fallen split bamboos, pools on rotten logs, and on the coast, in collections of water in the bases of Nipah palms (*Nipah fruticans*). Variety *pujutensis* is occasionally found along with *hackeri*, but occurs more frequently in small pools and other such places, not unlike those commonly chosen by the type form. In collections from Selangor, Malaya, only *hackeri* and *pujutensis* have so far been found associated with the brackish water zone.

#### 6. SUMMARY.

1. Apart from earlier records (Covell, 1944) which did not attract much attention, *Anopheles leucosphyrus* has recently been proved a vector of malaria in Assam (Clark and Choudhury, 1941), Burma (Covell, 1944), and Borneo (McArthur, 1947), and it is therefore important to clarify the systematics of the species.

2. The species appears to consist of at least six or seven distinct forms, four of which are known to occur in the Malay Peninsula. A tentative key to the adult females of these forms is given.

3. Notes are given on the nomenclature, identification and known distribution of these forms, one of which is identified, by examination of a probable cotype in the British Museum, as the type form of Dönitz.

4. The question of geographical variation and closely allied species in *Anopheles* is briefly discussed (p. 49).

5. The two types of pupae of Malayan *leucosphyrus* described by Crawford (1938) are identified. The "Spine IV long" form produces adults of the type form, and the "Spine IV short" form those of var. *riparis*.

6. Evidence is given which, so far as it goes, points to the type form as the one which has been found infected recently.

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