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ASSISTED BY F. W. EDWARDS, M.A., Sc.D.

DIPTERA.

VOL. IV.

Family CULICIDÆ.

Tribe ANOPHELINI.

BY

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AUTHOR'S PREFACE AND ACKNOWLEDGMENTS.

THE present work is an attempt to give an up-to-date account, likely to be useful for reference to those working on the subject, of the species and varieties of Anophelini so far recorded from the Indian area.

In such a task the author has found it necessary in certain directions to incorporate very largely the work of others, and some acknowledgments in this respect are necessary.

The account of larval characters and the descriptions of the larvæ here given are entirely based on the very complete work of Puri, especially his Memoir. I am also greatly indebted to this author for much kind personal help. The Key for the Identification of the Larvæ of Indian Species, after Puri, given in Part II., is taken, with the author's and Government's permission, from 'Health Bulletin,' no. 16, 1930*.

Pupal characters are to a large extent taken in an abbreviated form from Senevet, but the classification in part, and some new descriptions, are my own. The pupal characters of the Indian species have as yet been very inadequately worked out, and those given here must be regarded as very brief and provisional.

Data on the distribution of the species in India, and on the relation of different species to malaria transmission, have been taken from the two very full memoirs dealing respectively

* For details of various publications mentioned, see Bibliography at end of volume.

with these subjects and subsequent publications by Covell. Covell's very useful summary by districts of the distribution of the species in India, given here as an Appendix, has been taken, with the author's and Government's permission, from 'Health Bulletin,' no. 17, 1931.

Full use has been made of the papers by Sinton and Covell and Barraud and Covell on pharyngeal structure, and I am also indebted to these authors for kind permission to use their preparations. Further studies have, however, been made by me since the publication of their works, and much now given under this head is new.

Much of the systematic work has been taken, brought up to date, from my Catalogue of 1924. The synoptic table for adults, given in Part II., is based on the table published by the Malaria Survey of India in 'Health Bulletin,' no. 10, in the compilation of which I took part.

Finally, I am greatly indebted to Dr. F. W. Edwards for very kindly allowing me to use his MSS., before publication, of the section on Anophelini in his recent comprehensive work on the classification and systematics of the Culicidæ, published in 'Genera Insectorum.' So far as possible, use made of this has been acknowledged in the text, but its early consultation has given me many facilities which I can only acknowledge here.

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London,
August 1933.

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LIST OF IMPORTANT RECENT SYNONYMS OF INDIAN SPECIES.

Synonym.	Present Correct Name.
A. fuliginosus Giles.	*A. annularis* Van der Wulp.
A. listoni Liston.	*A. fluviatilis* James.
A. ludlowi var. *sundaicus* Rodenw.	*A. sundaicus* Rodenw.
A. maculipalpis var. *indiensis* Theo.	*A. splendidus* Koidzumi.
A. plumbeus var. *barianensis* James.	*A. barianensis* James.
A. rhodesiensis Theo. (Eastern).	*A. dthali* Patton.
A. rossii Giles.	*A. subpictus* Grassi.
A. sinensis Wied. (Oriental).	*A. hyrcanus* var. *nigerrimus* Giles.

ABBREVIATIONS USED IN KEYS AND DESCRIPTIONS

(in the order usually employed in the descriptions).

Adult.

t	Torus (of antenna).
fs	Flagellar segments (of antenna).
rbs	Rudimentary basal segment (of palp).
apn	Anterior pronotal lobes (prothoracic lobes).
ap	Anterior promontory of mesonotum.
af.....	Anterior forked cell.
pf	Posterior ditto.

Larva.

oc.....	Outer clypeal hair.
ic	Inner ditto.
pc	Posterior ditto.
is	Inner shoulder hair (inner submedian prothoracic).
ms	Middle ditto.
da	Dorsal anterior pleural hair of (1) pro-, (2) meso-, or (3) metathorax, respectively.
va	Ventral anterior ditto.
dp	Dorsal posterior ditto.
vp	Ventral posterior ditto.
spc.....	Spiracular chitinisation.
mps	Median plate of scoop.
ps	Postspiracular hair.
osc	Outer submedian caudal.
isc	Inner ditto.
1-3	Thoracic segments.
I-VIII	Abdominal segments.

Order DIPTERA.

Family CULICIDÆ.

Tribe ANOPHELINI.

PART I.—GENERAL.

I. INTRODUCTION.

MOSQUITOES of the tribe Anophelini are commonly spoken of as the Malarial Mosquito, Anopheline mosquitoes, Anophelines, or "Anopheles." They resemble in their chief characters other mosquitoes, but are generally to be recognized at once by their spotted wings and their characteristic attitude when at rest on walls or other objects *.

According to entomological definition, the Anophelini are distinguished from other mosquitoes by the long female palpi, which are about the same length as the proboscis. In the male the palpi have the last two segments swollen and somewhat flattened, forming a characteristically shaped club not unlike the head of a golf-club, which appearance, together with the spotted wings and attitude, usually suffices to distinguish the males of Anophelini from those of other mosquitoes †.

---

* Actually many species possess entirely unspotted wings. The commoner species in the tropics, however, mostly have spotted wings, though sometimes in dark species the pale spots are very small, and scarcely distinguishable without a lens.

Some Tipulidæ (small crane-flies) and Chaoborinæ (proboscis-less mosquitoes) may show a similar resting attitude, but no other Culicidæ. Some Anophelini, on the other hand, have a somewhat *Culex*-like attitude, though a typical hunch-back (*Mansonia*-like) attitude is practically confined to the rare and aberrant South American genus *Chagasia*.

† For details of characters of the tribe, see description of parts given in Section III. of this part of the volume.

During life the palpi of the female (except when the insect is feeding) are held closely approximated to the proboscis, so that the

The attitude of Anophelini when resting is very characteristic and is often referred to. Both in Culicini and Anophelini the fore and mid-legs are usually placed with the sharply flexed tibio-femoral joint directed upwards and the last tarsal segment or so only resting on the supporting surface, so as to give, with the first two pairs of legs, four *points d'appui*, more or less corresponding to the corners of a square; these legs form four approximately equal arches, supporting at a central point the weight of the body. In *Culex* the body is so slung as to be horizontal, the coxæ of all the legs being equally distant from the supporting surface, whereas in Anophelini the body is strongly tilted downwards at the head-end, each pair of coxæ from before backwards being progressively further away from the supporting surface. Taken in conjunction with the shape of the body, this causes the abdomen to point markedly away from the surface and the whole body to form with this an angle which may even approach 90° (fig. 1). The hind legs as a rule take little or no part in supporting the body, though they are often placed so as to touch the supporting surface, and even at times are used to give support. As also in some Culicini, these legs are very commonly held in the air, often high above the abdomen *.

The exact angle made by the insect's body with the supporting surface varies considerably not only with the species, but also according to whether the insect is resting on a vertical or horizontal surface or suspended from the latter, and, also, whether the insect is in a fed or gravid condition or not, or is fresh and lively or weak. A more or less *Culex*-like attitude is seen among Indian species in *A. aitkeni* and in

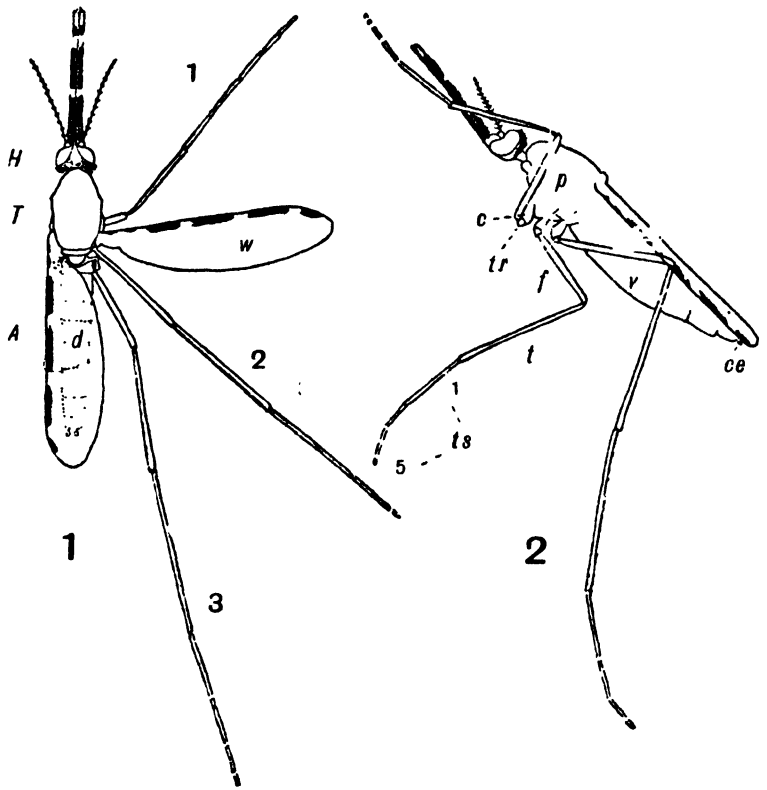
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two palps and the proboscis give the effect of a single organ. In the living condition all that an examination under a lens may show, especially when the palps are thin and delicate, is that, in Anophelini, the finger-like or bud-like palpi seen at the base of the proboscis in culicine mosquitoes are not to be made out. When the insect is dead, and the tissues somewhat dried, the palpi separate, and these organs, with the proboscis, may give a trident-like effect (fig. 2).

* In the female anopheline the tip of the labium and the palpi are brought so close to the object rested upon that they are almost in contact with it. The tips of the tibiæ of the fore legs, which, both in Anophelini and Culicini, reach to a level slightly below the head, are in Culicini so situated as to lie behind the head, whereas in Anophelini they are in front of the head, and in side view usually cross the line of the proboscis or are entirely in front of this. The mid-femora and tibiæ, which in *Culex*, in lateral view, cross the line of the abdomen, are usually, in Anophelini, entirely below this structure. Accentuating the distinction in attitude is the fact that the tarsus in Anophelini is usually relatively longer than in most Culicini, and the insect is, therefore, raised higher.

A. culiciformis and *A. sintoni*. In *A. culicifacies* the body is held rather close to the surface, and in fed or gravid females may have a very *Culex*-like appearance; but, though the angle formed is small, the anopheline attitude is generally quite

Fig. 1.



General structure and resting attitude of living insect:—1. Dorsal view of unfed ♀, showing position of wings folded and expanded. 2. Lateral view of an anopheline (*A. annularis*) resting on a vertical surface. The specimen is engorged to some degree.

A, Abdomen.
c, Coxa of fore leg.
ce, Cercus.
d, Dorsum of abdomen (tergites).
f, Femur.
H, Head.
p, Pleura.
T, Thorax.
t, Tibia.
tr, Trochanter of fore leg.
ts, Tarsus (segments 1–5) of mid-leg.
w, Wing.
v, Venter of abdomen (sternites).
1–3, Fore, mid, and hind leg respectively.

distinct in the unfed female, especially when suspended. The majority of species form angles with the surface on which they rest of from 30 to 45°. In *A. hyrcanus* and *A. barbirostris* the angle is very exaggerated, and approaches almost a right angle.

Equally characteristic of the tribe is the straight configuration of the body, the head and proboscis being nearly in the same line as the rest of the body. As a consequence, the angle formed by the under surface of the head with the prosternal region of the thorax is much larger in anopheline than in culicine mosquitoes (120° as against 90° or less). The attachment of the abdomen, further, is such that its axis forms about a right angle with a line joining the middle coxa with the middle of the dorsum of the thorax, whereas in culicine mosquitoes the angle is much smaller, in some cases less than 45°. Even when the attitude is somewhat *Culex*-like, *e. g.*, in *A. culicifacies*, the straight configuration of the body still largely holds good.

The spotting of the wings * is very characteristic of Anophelini, though not entirely confined to this tribe of Culicidæ, whilst many species of the tribe do not show it. The common European species *A. maculipennis* has wings spotted with small dark spots due to aggregations of scales on the wing-field ; but the more usual and typical form of spotting, and that which is seen in the majority of species, is due to pale spots on the costa and wing-veins caused by the veins being alternately clothed with dark and pale scales. The effect is to give rise to linear dark or pale spots, these appearing either as pale spots on a dark ground or *vice versa*, though about an equal amount of pale and dark is common.

Other features characteristic of the adult insect are noted under the Key to Genera and Subgenera and in the systematic part of the work. The most important are the bar-shaped scutellum, with the scutellar hairs forming an unbroken row †, the single large claw on the fore legs in the male, and the absence of a regular imbricated vestiture of scales on the abdomen, as is universal in Culicini. Though numerous scales may be present in some Anophelini on the dorsum, the sternites are always in large part bare.

So far as is known, the median acinus of the salivary gland in Anophelini is saccular, thus differing from *Culex*, where it is tubular, with a narrow duct. The female carries a single

* For a study of the wing-spotting in *Anopheles*, see Christophers, Ann. Trop. Med. and Par. vii, p. 45, 1913.

† The rare genus *Chagasia* is, however, exceptional in these respects (see Key to Genera in Part III.).

spermatheca, three being the usual number in Culicini, though a single spermatheca may be present in some forms.

The larvæ of Anophelini * are distinguished from the larvæ of other mosquitoes by the absence of a supporting tube (siphon) to the spiracular apparatus †, by their horizontal attitude when at rest or moving at the surface of the water, and by the fact that, when supported at the surface, their bodies are actually in contact with the surface-film by means of their abdominal float-hairs, which cause little dimples in the surface. A further character of the larva is the ability to rotate the head through 180° to allow of feeding at the surface. They are also peculiar in possessing eversible organs on the thorax (eversible organs of Nuttall and Shipley), and the large hairs are for the most part pinnately branched in one plane. The larvæ of Anophelini are found in nature almost exclusively in natural waters and, unlike many Culicini, are rarely found in pots and other domestic collections of water ‡.

The egg is also characteristic, being usually boat-shaped, with a demarcated upper surface and laterally situated floats §.

The total number of species known in the world is about 170, of which 42 species, with 10 varieties representing local forms or subspecies, have been recorded from the Indian area.

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For an elementary and semi-popular account of the characters and bionomics of Anophelini and their relation to disease, etc., see Daughlish, 'The Anopheline Mosquito,' John Murray, 1911; Edwards, 'Mosquitoes and their Relation to Disease,' Brit. Mus. (Nat. Hist.), Econ. Ser. no. 4, ed. 4, 1931 (price 4*d.*); Edwards and James, 'British Mosquitoes and their Control,' Brit. Mus. (Nat. Hist.), Econ. Ser. no. 4*a*, 1925 (price 6*d.*); Crawford and Chalam, 'Mosquito Reduction and Malaria Prevention,' 1926, Oxford Univ. Press (price 3 rupees), Covell, in Ghosh, 'A Treatise on Hygiene and Public Health,' 7th ed. 1930, Calcutta, Sci. Publ. Co. A very excellent little book, giving much information, is Hegh's 'Les Moustiques,' Brussels, 1921.

Complete monographs on Anophelini of a modern character do not exist, but the following are monographic studies dealing with

---

* For characters of the larva, see Section III. ("Characters used in Identification and Classification").

† The whole of the respiratory apparatus of *Anopheles* is represented by the parts at the tip of the siphon in Culicini.

‡ A common and important Indian species, *A. stephensi*, however, is noted for its power of breeding in cisterns and other artificial breeding places. Most species are rarely, if ever, found in artificial receptacles unless these give breeding places in some degree approaching natural collections of water. A number of species of Anophelini breed entirely in holes in trees; no fewer than four species in the Indian area adopt this special habit.

§ For further description, see Section III.

Anophelini of various countries or regions (commonly along with other mosquitoes) :—

Palæarctic Region.—Edwards, "A Revision of the Mosquitoes of the Palæarctic Region," Bull. Ent. Res. xii, p. 267, 1921; Martini, in Lindner, 'Die Fliegen der Palæarktischen Region,' Lf. 38, 40, 46 and 53 (index); also Lang, 'A Handbook of British Mosquitoes,' 1920.

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Egypt.—Kirkpatrick, 'The Mosquitoes of Egypt,' Cairo, 1925.

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India.—James and Liston, 'Anoph. Mosq. of India,' 2nd ed., 1911. Also Synopses, etc., published by the Malaria Survey of India, in Govt. India Publ. H. Bulletins (see list of important recent works at beginning of Bibliography in this volume.)

Dutch East Indies.—Swellengrebel, "Die Anoph. v. Ned. Oost Indie," 1921, Kolon. Inst. Amsterdam, Meded. xv; Swellengrebel and Rodenwaldt, *ibid.*, Gustav Fischer, Jena, 1932.

Philippines.—Recent papers by W. V. King (see full Bibliography at end of this volume).

Japan.—Yamada, Sci. Repts. Govt. Inst. Inf. Dis. iii, p. 215, 1924; iv, p. 447, 1925.

Australia.—Edwards, Bull. Ent. Res. xiv, p. 351, 1924.

America.—Howard, Dyar, and Knab, 'Mosq. N. and C. America,' iv, 1917, and ii, 1912 (plates); Dyar, 'The Mosq. of the Americas,' 1928; Costa Lima, 'Trat. de Parasit.' ii, p. 648, 1930; also papers by Root, Shannon, and Davis (see Bibliography).

For catalogues of world species, etc., see Christophers, Ind. Med. Res. Mem. no. 3, 1924; Covell, *ib.* no. 7, 1927; Edwards, 'Gen. Insect,' Fasc. 194, 1932.

For internal structure, see Christophers, Repts. Mal. Comm. Roy. Soc. ser. 4, 1901; Nuttall and Shipley, Journ. of Hyg. i, pp. 45–77, 269–276, 451–484; ii, pp. 58–84, 166–215; Thomson, Proc. Boston Soc. of Nat. Hist. xxxii, 145–202, 1905; Imms, Journ. of Hyg. vii, pp. 291–318, 1907; *id.*, Parasit. i, pp. 103–132, 1908 (larva); Hurst, Trans. and Ann. Rept. Manchester Microsc. Soc. 1890 (pupa); Roy, Ind. Journ. Med. Res. xiv, p. 995, 1927 (œsoph., divert., and sal. glands). See also under "Mouth-parts," "Thorax," "Wing," and "Hypopygium."

II. CLASSIFICATION.

The classification adopted in this volume * is, as regards the genera and subgenera, that given by Edwards in his most recent work, which appears most satisfactorily to display what is known up to date of the affinities of the main groups and of the aberrant forms of Anophelini. Of the three genera recognized, the genus *Anopheles*, which alone occurs in the Indian area, includes the great majority of species

* In the main the classification is that given by me in 1915 and 1924, since extended by Edwards in the work referred to. For the classification as it affects species recorded from India, see the Systematic Index. For a fuller statement, see Part III. (Systematic) of this work.

in the tribe. Structural differences such as can be used satisfactorily for classification have for the most part been brought to light only comparatively recently. The classification of Theobald and others on scale-structure has shown itself, in the course of time, inadequate and misleading, chiefly because it is evident that scale-structure in the tribe has progressed on somewhat parallel lines in a number of distinct phylogenetic stems. This classification has now been abandoned for others of a more satisfactory character.

Classification by Male Genitalic Characters.—After separation of the genera *Chagasia* and *Bironella* on the male tarsal claws, etc., the most satisfactory primary subdivisions appear to be those given by the male genitalic characters, *i. e.*, on the number and arrangement of the parabasal spines. Such subdivisions are generally agreed to be most conveniently treated as subgenera. They are not only consistent with the general structure and ornamentation of the adult (Christophers, 1913, 1915, 1924), but also accord closely with subdivisions based on the recent work on pharyngeal characters by Sinton and Covell (1927) and Barraud and Covell (1928, 1929) and those based on the pleural hairs and other characters of the larva as recently shown by Puri (1929, 1931).

The characters and arrangement of the parabasal spines on which these subgenera are founded are sufficiently indicated in the Keys to Genera and Subgenera in Part III. The great majority of species fall under one or other of the subgenera *Anopheles*, *Nyssorhynchus*, and *Myzomyia*, only the first and last of which occur in the Indian area.

Classification by Pharyngeal and Larval Characters.—Subdivisions based on pharyngeal and larval characters follow in the main those made on genitalic characters, and serve to strengthen the subgenera; but, whilst in no instance contradictory *, they sometimes give greater or less emphasis to particular subgenera and groups than do the genitalic characters. This is especially noticeable with the subgenus *Nyssorhynchus* and group *Neomyzomyia* of subgenus *Myzomyia*.

On the whole the genitalic characters appear the most suitable for the primary definition of the *subgenera* owing to their certainty and preciseness. The pharyngeal and larval characters, besides supporting the subgeneric divisions, have a special value in establishing the *groups*.

The accompanying schema illustrates the general relationship of the classifications based on general adult characters, pharyngeal characters, and the pleural hairs of the larva :—

* The only real anomaly in the classification based on genitalia is the remarkable character of the hypopygium in *A. parangensis*, which is not specially peculiar in any other feature of its organization.

Classification of Anophelini.

Genus or Subgenus.	Group.	Adult characters (general).	Parabasal spines (♂.)	Pharyngeal armature (♀.)	Long pleural hairs (larva).
Genus *Chagasia*	....	Distinct.	Peculiar.	Absent.	Extra hair.
Genus *Bironella*	....	Distinct.	Peculiar.		All simple.
Genus *Anopheles* :—					
Subgen. *Stethomyia* ..	....	Distinct.	One.		
Subgen. *Anopheles* ..	*Anopheles.*	Less than four main costal spots.	Two.		
	Arribalzagia.				
	Christya.				
Subgen. *Nysso-rhynchus.*	*Nyssorhynchus.*	Four main costal spots.	One basal, two on coxite.	Single row, recurved.	
	Myzorhynchella.				
	Kerteszia.				
Subgen. *Myzomyia* ..	*Neomyzomyia.*		Four to five in one group.	Single row.	
	Pseudomyzomyia.			Double row.	Some at least feathered.
	Paramyzomyia.				
	Myzomyia.				
	Neocellia.				
	Cellia.				

Classification by Pupal Characters.—The pupal characters of a considerable number of species have been described by Senevet. As a general rule division into *Anopheles* and *Myzomyia* is indicated by the paddle-hair (short and straight in *Anopheles*; long and hooked in *Myzomyia*). *Nyssorhynchus* and also group *Neomyzomyia* * are akin to *Anopheles* in this and some other respects. The following is Senevet's provisional table for the genera and subgenera † :—

Spine VIII without lateral branches.	
Hair C transformed into spine	Genus CHAGASIA.
Hair C not so	Subgen. NYSSO-[RHYNCHUS.
Spine VIII with several lateral branches.	
Paddle-hair short and straight	Subgen. ANOPHELES ‡.
Paddle-hair long and hooked	Subgen. MYZOMYIA.

The groups of subgen. *Anopheles* and, especially, of subgen. *Myzomyia* seem, however, also to some extent to be indicated. The following, in the main at least, holds good for the latter subgenus :—

Paddle-hair short and straight	*Neomyzomyia.*
Paddle-hair long and hooked.	
Spines IV–VII long, IV as long as or only somewhat shorter than V and sharp.	*Myzomyia.* / *Paramyzomyia.*
Spines V–VII only long, IV abruptly reduced and usually blunt.	*Neocellia.* / *Pseudomyzomyia.*

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* Senevet describes only *A. smithi* and *A. punctulatus*, but descriptions of several more species in the group given here also show these characters.

† Tree-hole breeding species, as with the larvæ, may form exceptions.

‡ Including *Stethomyia* and group *Neomyzomyia*.

III. CHARACTERS USED IN IDENTIFICATION AND CLASSIFICATION.

Adult Characters *.

The nomenclature used for parts of the body is shown in fig. 1. The different parts are considered more in detail below.

Head.

The nomenclature of the head-structures is indicated in fig. 2. The *head-scales*, which cover the occiput and most of the vertex between the eyes, are of a single type, being erect, narrowly fan-shaped, truncated, and often slightly

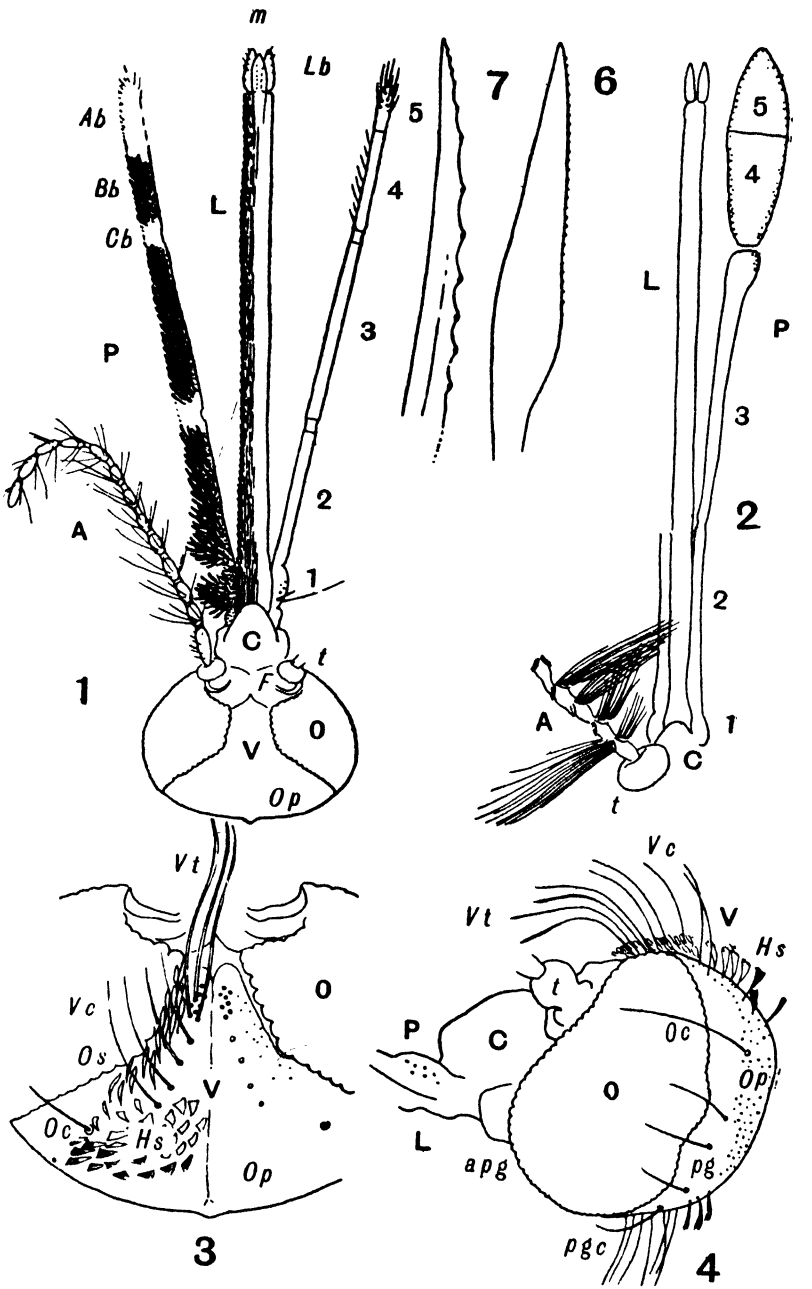
* Among general characters of the adult which should, perhaps, be mentioned are size and colour. *Anopheles* of the group *Myzomyia* are as a rule distinctly small. The outstandingly large Indian species is *A. gigas*, specimens of which may almost equal the giant African species *A. implexus*. The index used for designating size in this volume is the length of the wing; this is about 3 mm. for small species, 4–4·5 mm. for moderate-sized species, and 5–6 mm. for very large species.

Coloration in the group varies from a lightish grey or fawn to shades of brown practically amounting to black, and, though subject to some variation in the same species, is often very helpful in identification. Sometimes specimens may show more pigmentation than is usual with the species, with an increase in the extent of dark markings on wing, tarsi, palps, etc., and often with bridging of costal spots and other anomalies of wing-ornamentation (*melanism*). A contrary effect is seen where the dark markings are abnormally restricted and spots normally present obliterated, or pigmentation may be defective in a capricious manner or almost entirely absent (*hypomelanism*). An extreme condition of hypomelanism gives rise to the *immaculatus* form referred to under *A. vagus*, but an almost similar condition has been observed in *A. stephensi* and *A. pallidus*.

Nomenclature of parts of the head:—1. Head of ♀, showing palpi, antennæ, etc., the palp of the side shown denuded of scales. 2. Ditto of ♂. 3. Head, showing arrangement of scales and hairs on vertex. 4. Lateral view of head. 6. Tip of mandible. 7. Tip of maxilla.

A, Antenna.
Ab, Apical pale band.
apg, Anterior portion of postgena.
Bb, Intervening dark area between apical and subapical pale bands.
C, Clypeus.
Cb, Subapical pale band.
F, Frons.
Hs, Head-scales.
L, Labium.
Lb, Labella.
m, Tip of mouth-parts lying in labial sheath.
O, Compound eye.
Oc, Ocular chætæ.
Op, Occiput.
Os, Ocular scales.
P, Palp.
pg, Postgena.
pgc, Postgenal chætæ.
t, Torus.
V, Vertex.
Vc, Vertical chætæ.
Vt, Vertical tuft.
1–5, Segments of palpi (♂ and ♀).

Fig. 2.



(For explanation of figure, see opposite page.)

notched, giving them a forked appearance under a low power. They usually have about 12–15 striations, which extend nearly to the base of the scale. The scales vary somewhat in shape, etc., on different parts of the head, and only outstanding peculiarities are given in the descriptions in this volume. Almost always the head-scales are dark at the sides and back of the head, and become pale or white over the front of the vertex, forming a conspicuous white patch of varying extent in this situation (*pale vertical spot*).

Anteriorly between the eyes is a somewhat triangular area (*interocular vertex*), passing forward to about the base of the antennæ. The head-scales are usually continued on to this as overlapping fusiform scales, which make a conspicuous line of scaling along the inner margin of the eyes (*ocular scales*). Internal to the ocular scales on each side is a line of setæ, often milk-white (*vertical setæ*). The vertical setæ in front commonly terminate in a cluster of elongate setiform pale or white scales, usually more or less curled at the ends, which pass forwards over the clypeus. The long setiform scales, with the other vertical setæ and the ocular scales, together form the so-called *frontal tuft* characteristic of most anophelines.

Around the margin of the eyes are the dark *ocular chætæ*, and distinct from these ventrally below the eyes a close-set line of hairs, often giving the effect of a beard—the *postgenal hairs*.

Antennæ.

These consist of a globular basal segmen (*torus* *) and a beaded series of flagellar segments (13 in the ♀, 14 in the ♂), which form the antenna proper. In the male the torus is very large and the antenna markedly plumose, due to whorls of long hairs arising from paired plates on the segments. In the female the torus is smaller and the hairs are shorter, arising in a ring from the bases of the segments.

In the male the antenna, including the torus, is devoid of scales in all Indian species, except on the first flagellar segment, where some scales are often present, usually dark. In the female the torus may be bare or, in many species, may carry a few minute scales, often difficult to see. Scales are commonly present on the first or second flagellar segment or, in some species, on a number of flagellar segments in the female.

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* True second segment, the first being a narrow basal ring, only to be made out, as a rule, in cleared and mounted preparations. The torus is also called the pedicle, and the ring-piece at its base the scape.

Clypeus.

This is usually bare, but a tuft of scales is carried on the lateral aspect of the clypeus in *A. hyrcanus* (and the African species *A. mauritianus*), and may be a useful diagnostic feature in distinguishing, for example, between *A. hyrcanus* and *A. separatus*.

Female Palpi.

The normal arrangement of the segments is shown in fig. 2 (p. 11). The basal (first) segment is small and vestigial, and fused with the succeeding long segment. The relation of the length of segment 5 to that of 4 gives the *palpal index*, which varies from 0·3 to 0·7.

Scales are present on all the surfaces except the inner, which is bare of scales along the whole length of the organ; chætæ, or stiff hairs, are usually pr sent on the apical segment and in a line along the ventro-internal border of other segments. The scales may be appressed over the whole organ, when the palpi appear long and *thin*; or commonly the basal portion, or greater part, of the first long segment has erect scales, those over the rest of the organ being more appressed; or the whole organ may be covered with erect scales, giving it a *shaggy* appearance.

Ornamentation of the palpi is mainly in the form of pale scales forming bands of various width at the apex and at joints 3–4 and 2–3. When the apical segment is short it is usually completely involved in the apical pale band, the palpi showing three bands, including the apical. When the apical segment is long it frequently carries a dark band, and the palpi show four pale bands. In species normally showing three bands it is not uncommon for individuals to show a variation in the presence of a dark band on the apical segment and a resultant 4-banded palp. This is unusual, however, except where the apical segment is long (*e. g.* in *A. superpictus*).

In addition to bands, there may be patches of pale scaling on the dorsum of some of the segments, especially segment 3 (*speckling* of the palps). Specimens may sometimes show a more diffuse paling along the length of the segment which is often not of specific character, and may be referred to as *frosting*.

Male Palpi.

These are composed of five segments, including a vestigial basal segment, as in the female, but with segments 2 and 3 separated by an incomplete joint only. Segments 4 and 5 are expanded and somewhat flattened, usually with thickening

also, of the apex of segment 3. The junction of 4 and 5 is commonly more like a suture than a joint, but in some species the two are much more clearly articulated and the segments somewhat constricted at the junction.

Except where the scales at the extreme base, or at some other points, may be erect, the organ is covered on its outer aspect with appressed scales which give it its ornamentation. Long hairs arise from the swollen apical end of segment 3, and a line of hairs, which may be a single or several rows thick, is usually continued along both borders of segments 4 and 5 or may be wholly or partly lacking on the latter (*marginal hairs*).

The types of ornamentation can be seen from the descriptions of species. Care should be taken in examining this organ in the dried specimen, as it is often twisted, and misleading appearances may be seen should the unornamented lower (inner) surface of the club be uppermost.

Labium or Proboscis.

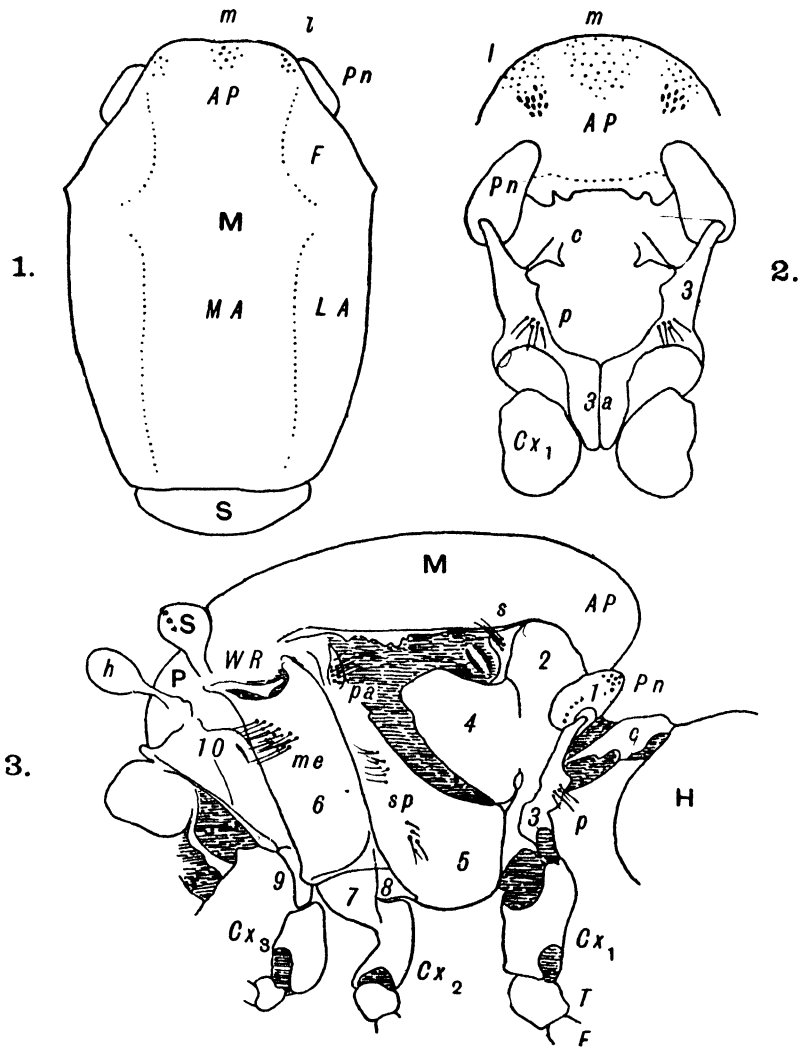
The labium is generally uniformly dark, except the labella, which are usually of a lighter colour. In a few species the apical half or so is light or golden, or there may be a diffuse pale patch beneath or at the sides towards the apex (*tache*). These effects are often only clearly visible in certain lights.

LA, Lateral area of mesonotum.
M, Mesonotum.
m, Site of median scale-tuft on anterior promontory.
MA, Median area of mesonotum.
me, Upper mesepimeral hairs.
P, Postscutellum (postnotum).
p, Propleural hairs.
Pn, Anterior pronotal lobe.
pa, Prealar hairs.
S, Scutellum.
s, Spiracular hairs.
sp, Upper and lower sternopleural group of hairs.
T, Trochanters.
WR, Base of wing.

Parts of pleuræ (membranous areas shaded):—

1. Anterior pronotum (anterior pronotal lobe).
2. Postpronotum, shown continued as narrow proepimeron to coxal articulation.
3. Propleuron (episternum).
3*a*. Basisternum of prothorax.
4. Postspiracular area (mesothoracic anepisternum).
5. Sternopleuron of mesothorax.
6. Mesepimeron.
7. Meron.
8. Trochantin.
9. Sternopleuron of metathorax.
10. Metathorax.

Fig. 3.



Nomenclature of parts of thorax:—1. Dorsal view of mesonotum. 2. Anterior view of prothorax and mesonotum after removal of head. 3. Lateral view of thorax.

AP, Anterior promontory of mesonotum.
c, Cervical sclerite.
Cx_1–Cx_3, Coxæ of fore, mid-, and hind legs.
F, Fossa of mesonotum.
F (lower figure), Femur.
H, Head.
h, Halter.
l, Site of lateral scale-tuft on anterior promontory.

Mandibles and Maxillæ *.

Normally contained within the sheath-like labium are the fine chitinous mandibles and maxillæ, along with the stylet-like labrum and hypopharynx. The mandible is expanded at its termination into a triangular plate, one edge of which carries very fine teeth, usually, in Indian species, about 25–30. The maxillæ have curved, sword-like ends, usually with about 13–15 teeth, larger than those of the mandible, which become progressively smaller and more minute towards the end of the organ. Examination of practically all the Indian species has shown but few differences in species or variation from the characters given above, and reference to these organs is usually, for brevity, omitted from the descriptions.

For detailed description of the *pharynx*, see under "Pharyngeal Characters" (p. 24).

Thorax †.

The general characters and nomenclature of the parts of the anopheline thorax are given in fig. 3 (p. 15).

The *anterior pronotal lobes* (prothoracic lobes) commonly carry chætæ only, but may be furnished, in addition, with a tuft of erect scales (*prothoracic* or *pronotal tuft*). On the narrow chitinous propleuræ, lying on either side of the membranous area below the neck, are the *propleural hairs*. These may form a cluster of four or five or more, be reduced to two or one, or be entirely absent; they are of considerable systematic importance.

The mesonotum may be bare and shiny, with only large chætæ, but more usually the surface is to a certain extent tomentose, giving different effects, depending on the direction of the light-incidence. Frequently darker longitudinal lines are seen, especially on the denuded notum, but such appearances usually vary with the light-incidence, and reference to them is omitted in the descriptions. In a few species *eye-spots* are present. Most usually there is a vestiture either of numerous small hairs, of hair-like scales, or of true

* For information about the mouth-parts, see Nuttall and Shipley, Journ. of Hyg. i, p. 461. A very detailed account of the mouth-parts in *Culex* is given by Dimmock, 'Anat. of the Mouth-parts of some Diptera,' Thesis (Boston, 1881). For an account of the maxillary teeth in connection with zoophilism and the method of counting these, see Roubaud, Ann. Inst. Past. xlii, p. 561, 1928.

† For structure of the thorax, see Baini Prashad, Ind. Journ. Med. Res. v, pp. 614 & 641, 1918; Edwards, Bull. Ent. Res. xii, p. 266, 1921; Freeborn, Insec. Insc. Mens. xii, p. 37, 1924; *id.* 'Mosq. of California,' p. 339, 1926; Kirkpatrick, 'Mosq. of Egypt,' p. 13, 1925. Also a very thorough account of the Nematocerous thorax, with numerous figures of different forms, including the mosquito thorax—Crampton, Annals Ent. Soc. Amer. xvii, p. 49, 1925.

scales. Very commonly there is a somewhat lighter coloured *median area*, which in species with scales is usually more closely scaled, contrasting with the darker *fossæ* and *lateral borders* of the mesonotum, which are frequently devoid of scales or relatively so.

On the anterior promontory there is usually present a number of pale erect scales behind the head (*median scale-tuft*). More laterally, at the angles of the promontory, there may also be scale-tufts (*lateral scale-tufts*). In the latter situation the scales are usually white above, and there are commonly conspicuous, often battledore-shaped, black scales below these on the anterior face of the promontory.

The pilotaxy * of the thorax is shown in fig. 3. The propleural hairs have already been referred to. Of the other pleural chætæ, the *spiracular* are commonly from 0–5 in number ; the *prealar* form a conspicuous tuft in some species, but are minute and difficult to make out in others ; the *sternopleural* are usually divided into two groups, an upper and a lower, and consist of small as well as larger hairs ; the *upper mesepimeral* are usually 15 or more in number and conspicuous. The lower mesepimeral on the epimeral plate separated from the upper group are usually absent, but are present in *A. barbirostris* and some other species. The postnotal (on the plate behind the anterior pronotal lobes) and the postspiracular (on the chitinisation behind the anterior spiracle) appear to be absent throughout the tribe. These hairs, with the exception of the propleural hairs, do not appear to be of very great systematic importance and, as their exact number appears to vary in the same species, only outstanding characters, if such exist, are usually given in the descriptions. Scales are not infrequently present on the sternopleuron or mesepimeron, and their presence or absence may help in the differentiation of certain forms.

Wing.

The nomenclature of parts of the wing and of the venation as employed in this volume are shown in fig. 4 †. In the descriptions, for brevity the longitudinal veins and their

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* For pilotaxy of the anopheline thorax, see Christophers, Ind. Journ. Med. Res. iii, p. 362, 1915 ; Edwards, Bull. Ent. Res. xii, p. 266, 1921.; Rodenwaldt, Tijds. v. Entom. lxiv, p. 147, 1921 ; Freeborn, 'Mosq. of California,' p. 339, 1926.

† For a full account of the wing-venation, with a discussion of the Comstock and Needham nomenclature as applied to the mosquito, see Christophers and Barraud, Ind. Journ. Med. Res. xi, p. 1103, 1924 ; see also Nuttall and Shipley, Journ. of Hyg. i, p. 475, 1901 ; Tillyard, Proc. Linn. Soc. N.S.W. xliv, pp. 533–718, 1919 ; Tillyard, 'Insects of Australia and New Zealand,' p. 338, 1926.

Venation and spotting of wing and nomenclature used:—**1.** Venation. **2.** Usual situation of spots on wing (*Myzomyia*) and nomenclature used. **3.** Arrangement of scales on veins. Right, vein viewed from above; left, as a vein would appear in vertical section.

1.
A, Apex of wing.
a, Alula.
af, Anterior forked cell.
B, Base of wing.
b, Bifurcation.
C, Costa.
cv 2–3, Cross-vein between vein 2 and vein 3; other cross-veins similarly, except humeral.
h, Humeral cross-vein.
pf, Posterior forked cell.
r, Remigium (or stem-vein).
F, Fringe.
Sc, Subcosta.
s, Squama.
1, First longitudinal (Radius, R_1 of Comstock and Needham).
2, Second longitudinal (R_{2+3} of Comstock and Needham).
2·1, Anterior branch, second longitudinal (R_2).
2·2, Posterior branch, second longitudinal (R_3).
3, Third longitudinal (R_{4+5}).
4, Fourth longitudinal (Media, M).
4·1, Anterior branch, fourth longitudinal (M_1).
4·2, Posterior branch, fourth longitudinal (M_2).
5, Main fifth longitudinal (Cu).
5·1, Branch of fifth longitudinal (Cu_1 or M_4).
6, Sixth longitudinal (Anal, A).

2.
A, Apical pale area.
As, Accessory sector pale area.
bs, Border-scales.
f, Fringe-spot.
H, Humeral pale interruption.
h, Humeral dark accessory spot.
P, Preapical pale area.
Ps, Presector pale area.
ph, Prehumeral dark accessory spot; may be divided into *inner* and *outer* by the prehumeral pale interruption.
S, Sector, pale area.
Sc, Subcostal pale area.

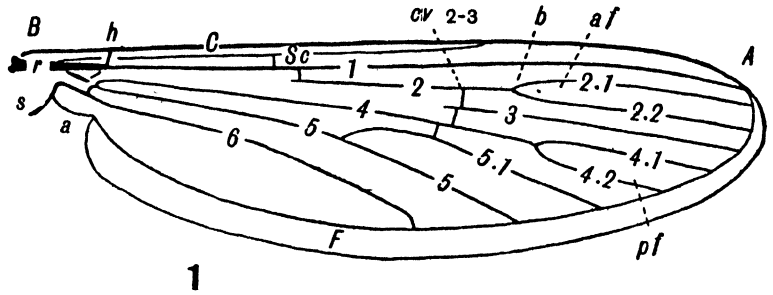
Between *A* and *P* is the *apical dark spot*; between *P* and *Sc* is the *preapical dark spot*; between *Sc* and *S* is the *middle dark spot*; between *S* and *Ps* is the *presector dark spot*.

a indicates the region of short pale spots due to the cross-veins; *b* is a bifurcation site; *c* is an example of a pale interruption dividing the dark length of branches of the forked cell into two spots on each branch.

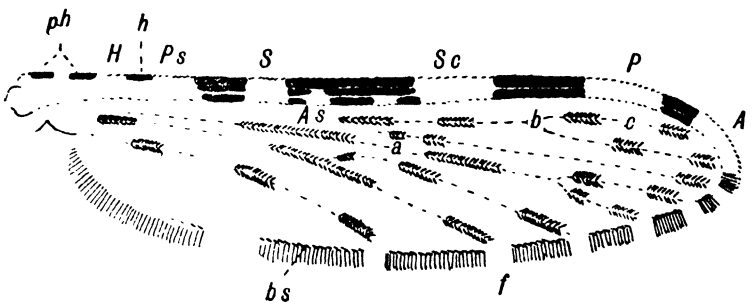
Dark spots on the stem and branches of veins may usually be sufficiently designated by the terms apical and basal, or, in some cases, also middle, *e. g.*, basal dark spot 2.1.

3.
l, Lateral squame.
m, Median squame.
p, Plume-scale (on under surface).
s Squame-scale (on upper surface of wing).
v, Vein (in section).

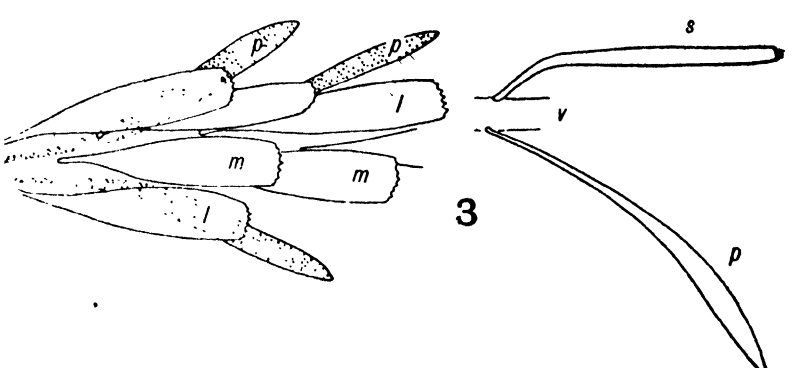
Fig. 4.



1



2



3

(For explanation of figure, see opposite page.)

branches are indicated by numbers, *e. g.*, 2, 2.1, 2.2 indicate respectively the stem, the anterior, and the posterior branch of the second longitudinal vein *.

The nomenclature of these veins on the Comstock and Needham generalized system is still, in the case of some of the branches, uncertain. The interpretation (following Nuttall and Shipley and Christophers and Barraud) is given below, but Tillyard (1919, 1926) considers 5.1 to be the fourth branch of the media, and the vestigial unscaled vein below 6 (usually unnamed or disregarded by other writers) to be the second branch of the cubitus :—

Nomenclature used in this volume.	*Comstock and Needham.*
Costa.	Costa.
Subcosta.	Subcosta.
First longitudinal, 1.	Radial, R_1.
Second longitudinal, 2, 2.1, 2.2.	R_{2+3}, R_2, R_3.
Third longitudinal, 3.	R_{4+5}.
Fourth longitudinal, 4, 4.1, 4.2.	Median, M, M_1, M_2.
Fifth longitudinal, 5, 5.1, 5.2.	Cubital, Cu, Cu_1, Cu_2.
Sixth longitudinal, 6.	Anal (An).
Cross-veins, 2–3, 3–4, 4–5.	Cross-veins, base of R_{4+5}, r–m, m–cu.

The length of the wing, measured from the origin of the costa to the level of the apex, is ordinarily, in Anophelini, about $2\frac{1}{2}$ times the length of the thorax measured from the anterior promontory to the back of the scutellum, but is proportionately more (up to three times or slightly over) in large-winged species such as *A. hyrcanus*. The greatest width, excluding the fringe, is usually slightly over $\frac{1}{4}$ the length ; the wing in the male is slightly narrower, about $\frac{1}{5}$ the length. The subcosta joins the costa slightly under $\frac{2}{3}$ the length of the wing from the base (0·62–0·65 of the wing-length). The anterior forked cell in the female usually measures $\frac{1}{4}$ or slightly more of the length of the wing ; its base in all Indian species, except *A. moghulensis*, is slightly nearer the base of the wing than that of the posterior cell. The relative lengths of the two forked cells, measured along

* This nomenclature, which is in common use among workers on the Culicidæ, has probably followed that given by Theobald (vol. i, p. 18). Theobald appears to have followed Skuse (Proc. Linn. Soc. N.S. Wales, iii, p. 1763, pl. 40, 1889), his figure being a copy of that given by Skuse, who seems to have been the first to adapt to the wing of the mosquito the system of nomenclature in common use among students of the Diptera in the latter half of the nineteenth century. Among students of the Culicidæ many of the cell-names and other unnecessary detail have gradually dropped out of use ; all that is now necessary is given in the accompanying figure.

the posterior branch in each case, is the *forked cell index* (usually about 1.5, but reaching 2 in some species where the anterior forked cell is very long). The length of the anterior forked cell in relation to its petiole (from the bifurcation to the cross-vein) is often very variable in the same species, but may be used to give a general indication of the length of the cell. The forked cells are usually slightly shorter in the male.

Scaling of the Wing.

The general arrangement of scales on the wing-veins in the Anophelini is shown in fig. 4 (p. 19), which shows the arrangement of scales on a convex vein as seen from above. The costa (up to the subcostal junction) and veins 1, 3, 5, and 6 are *direct* or *convex* veins, and the subcosta and veins 2 and 4 *reverse* or *concave* veins. On the upper surface of direct veins and the lower surface of reverse veins * the scales are normally somewhat bat-shaped, often truncated, and with parallel striations; they have short, bent stalks and lie flat and parallel to the vein (*squame scales*). Those in the middle of the vein (*median squames*), are usually shorter and often narrower than those projecting laterally over the wing-membrane (*lateral squames*). On the lower surface of direct veins and on the upper surface of reverse veins the scales are longer, usually narrower and more pointed, with less numerous and less markedly parallel striations; their stalks are not sharply bent and the scales project at an angle from the vein (*plume scales*). As the apex of the wing is approached, the scales tend to elongate and to lose their distinctive characters, and the same applies to the greater part of the wing in some species.

The broadest scales, as a rule, are on the inner third of the costa, subcosta, and vein 1. They are also about equally broad on the base of the stem of vein 5, but are distinctly narrower and usually less truncated on the remaining veins. The number of striations shown by the scales on the inner third of the costa, subcosta, or vein 1 is the *maximum striation* for the species.

On the wing-border posteriorly are the special *fringe scales*, and at their bases are small, obliquely set scales (*border scales*), which may be dark, or light, or absent more or less extensively towards the base of the wing, according to the species.

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* Christophers, Ind. Journ. Med. Res. x, p. 1011, 1923; Christ. and Barraud, *loc cit.* xi, p. 1106, 1924. See also, on the subject of convex and concave veins, Tillyard, Proc. Linn. Soc. N.S.W. xliv, pp. 539 *et seq.*, 1919.

Ornamentation of the Wing

The ornamentation of the wing is almost entirely due to scaling, and consists usually of alternate areas of dark and pale scales on the veins. For clearness the dark areas are here referred to as "spots" and the pale areas as "areas," usually with the prefix dark or pale, as the case may be, to aid the memory. The names used for spots and areas on the costa are shown in fig. 4 (p. 19). These names are not difficult to remember, and greatly simplify reference and description. The spots on the wing-field in subgenus *Myzomyia* are also very regular and are, to a certain extent, referred to specifically. The spots in subgenus *Anopheles* are more individual, and have for the present been referred to in whatever seemed the simplest manner.

Ornamentation at the base of the costa is highly important, the nomenclature here used being shown in the figure.

Ornamentation of the apex and fringe are also extremely important. At the junction of vein 1 with the costa at the apex of the wing is the *apical pale costal spot*, always very clearly identifiable. Beyond this point is the scale-thickened wing-margin, merging into the fringe and referred to as the *wing-apex*; this is commonly ornamented by pale areas, at least at some of the vein-junctions. On the fringe at vein-junctions, and sometimes in other positions, pale *fringe-spots* may be present. In subgenus *Anopheles* the appearance of fringe-spots tends to be rather capricious. In subgenus *Myzomyia* fringe-spots, if present at all, usually occur at all veins to 5.2, and in many species also at 6.

In the male the wing often has rather more extensive pale areas and often the dark areas are less dark, so that the markings may appear less definite; in certain cases points given as diagnostic in the female are not intended to apply to the male.

Legs.

The parts of the leg are shown in fig. 1 (p. 3). The coxæ may be devoid of scales; more usually the anterior pair at least carry some scales, which may be in conspicuous tufts. All the remaining segments, except sometimes the hind or middle trochanters, are clothed with small appressed scales, the coloration of which brings about such ornamentation as may be present.

The femora are sometimes pale towards their articulation with the trochanters, the distance to which the paleness extends being given usually in terms of the breadth of the femur. They may be pale beneath or show other characters, often of some importance in identification. In a number of species the femora of the front legs may be swollen in their basal half. Both femora and tibiæ are often more or less

extensively pale at their tips, a condition often referred to as *knee-spots*. In some species the femora and tibiæ, and sometimes some of the tarsal segments, are ornamented with defined patches or irregular rings of pale scaling (*speckling*). This is to be distinguished from an indefinite mottling sometimes seen.

The chief ornamentation of the legs is usually in connection with the tarsal segments. They may be uniformly dark, or they may be marked with white or pale bands at the joints (*banded tarsi*); bands may be *apical* only (*i. e.*, at the tips of the segments, leaving the bases dark) or *apical and basal* (*i. e.*, spreading across the joints).

A common condition is for the terminal one or more segments of the hind legs to be *completely white*. Commonly the last three segments are completely white, with some portion of the preceding segment. Where a single segment only, or sometimes two, is completely white there are nearly always broad white bands at the tarsal joints above this. It is important, in using the synoptic tables, to recognize that the number of white segments referred to are counted only to the first dark band. In a few cases the whole of the last segment is not white, but only the apical half or so (among Indian species *A. kochi*, *A. tessellatus*, and *A. leucosphyrus*); for this reason such species are sometimes placed in two positions in the synoptic table to prevent error.

Male Ungues.

In the male the mid- and hind legs carry a pair each of small simple hooks or claws, as do each of the legs in the female. But the fore legs are provided with a single large claw, having a spur about half-way along its length and a smaller process arising from the swollen base (*male ungues*). Except in *Chagasia* and *Bironella*, these structures seem to vary little, if at all, in the different species, but in *A. culiciformis* the small process at the base is absent.

Abdomen.

The abdomen consists of eight visible segments. The first segment usually forms a somewhat transverse bar dorsally carrying long, outstanding hairs. The abdomen is usually spoken of as having a dorsal surface or *dorsum* (tergites) and a ventral surface or *venter* (sternites). The 8th segment in the male is rotated with the hypopygium, so that when rotation has taken place the apparent tergite is the sternite, and *vice versa*. Beyond the 8th segment in the male is the *male hypopygium*, of which the two large appendages, *coxites*, are the prominent feature. In the female the two small *cerci* are all that can be seen externally of the female *hypopygium*. The structures

beyond the 8th segment in both sexes are often termed the male or female genitalia or *terminalia* (described in detail under "Hypopygial Characters," p. 29).

The characters of the abdomen used in systematic work are chiefly connected with the scaling. The entire abdomen, with or without the coxites or cerci, may be completely devoid of scales. Frequently scales are present on the tergites of the last, or last few, segments; less commonly they are present on all the segments except the first. Besides the ordinary scaling, the tergites may show outstanding scales at the posterior lateral angles and, if numerous, these may form tufts (*lateral tufts*), which in Indian species are, however, always associated with heavy general scaling of the tergites. The sternites are usually free from scales, except commonly on the last segment or two. When present, scale-tufts are medianly situated towards the apex of the segment, *ventral tufts*; a tuft on the 7th segment only in the female is present in some species. Scattered scales over the venter occur in some species, and their presence is sometimes useful in differentiating certain closely related species.

Pharyngeal Characters *.

The parts of the pharynx of the female as given by Sinton and Covell (1927), with a slight modification in the nomenclature, are given in fig. 5 (p. 27).

The table on the following page shows the general characters of the pharynx, so far as known, in the different genera and subgenera of Anophelini †.

The most important characters are in connection with the *pharyngeal armature*. This, when present, is carried on the posterior edge of the chitinised floor of the pharynx, which forms a ridge facing posteriorly at the junction of the pharynx and œsophageal pump and is here called the *pharyngeal bar*. The armature consists of teeth (*pharyngeal teeth*), which are commonly of two kinds, called by Sinton and Covell, from their general resemblance to the structures of

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* For a description of the internal anatomy of the head, including the stomodæal structures, see Dimmock, 'Anat. of the Mouth-parts and Sucking App. of some Diptera,' Thesis, (Leipzig, 1881); Thompson, Proc. Boston Soc. Nat. Hist. xxxii, p. 148, 1905. Christophers, Ind. Med. Res. Mem. no. 4, p. 191, 1926, on the head of *Phlebotomus*, and Jobling, Bull. Ent. Res. xviii. p. 227, 1928, on the head of *Culicoides*, may also be usefully consulted. For detailed studies on the pharynx, see Sinton and Covell, Ind. Journ. Med. Res. xv, p. 301, 1927; Barraud and Covell, Ind. Journ. Med. Res. xv, p. 671, 1928; Trans. 7th Cong. F.E.A.T.M. iii, p. 98, 1929; Manalang, Phil. Journ. Sci. xxxviii, p. 431, 1929; Christophers and Puri, Ind. Journ. Med. Res. xviii, p. 1139. 1931.

† For the most part as given by Sinton and Covell, *loc. cit.*

PHARYNGEAL CHARACTERS OF ANOPHELINI.

	Genus *Bironella*.	Subgenus *Anopheles*.	Subgenus *Nyssorhynchus*.	Subgenus *Myzomyia*.
Dorsal papillæ	12.	8–10.	6–8.	6.
Pigmented area	Elongate, with circular posterior portion constricted off by neck.	Median band.	Hour-glass-shaped.	Variable; conical or hour-glass-shaped, broadly expanded.
Posterior hard palate	Like inverted egg-cup.	Shaped like truncated cone.	Tongue-shaped, with constriction near tip; cobble-stone effect.	More or less rectangular in some cases, with slight constriction about the middle.
Lateral flanges	Poorly developed.	Poorly developed except in *Arribalzagia*.	Well developed.	Well developed and large; in group *Myzomyia* with several teeth.
Pharyngeal armature	None.	None.	Single series of large teeth, separated by intervals and directed backwards.	Directed forwards; usually double row of teeth in rods and cones.

the retina (*cones* and *rods*); or only a single type of tooth may be present, which has then more or less the character of cones.

On the membrane posterior to the pharyngeal bar are commonly several rows of small, overlapping, flap-like ridges, usually carrying spines on their free edges (*post-armature ridges*; bucco-pharyngeal ridges of Sinton and Covell). The most anterior of these commonly lie close behind the pharyngeal teeth, alternating in their arrangement with these.

The Pharyngeal Armature.

The characters of the armature are best appreciated by regarding the teeth as springing from the sharply bevelled-off edge of the ventral plate, where it ends to form the pharyngeal bar. This, somewhat like a chisel-edge, is projected into the lumen of the canal, where the pharynx ends at the membranous junction between itself and the œsophageal pump. It is directed upwards and backwards owing to the orientation of the pharynx (fig. 5, 6), the part corresponding to the unbevelled cutting-edge of the chisel being uppermost.

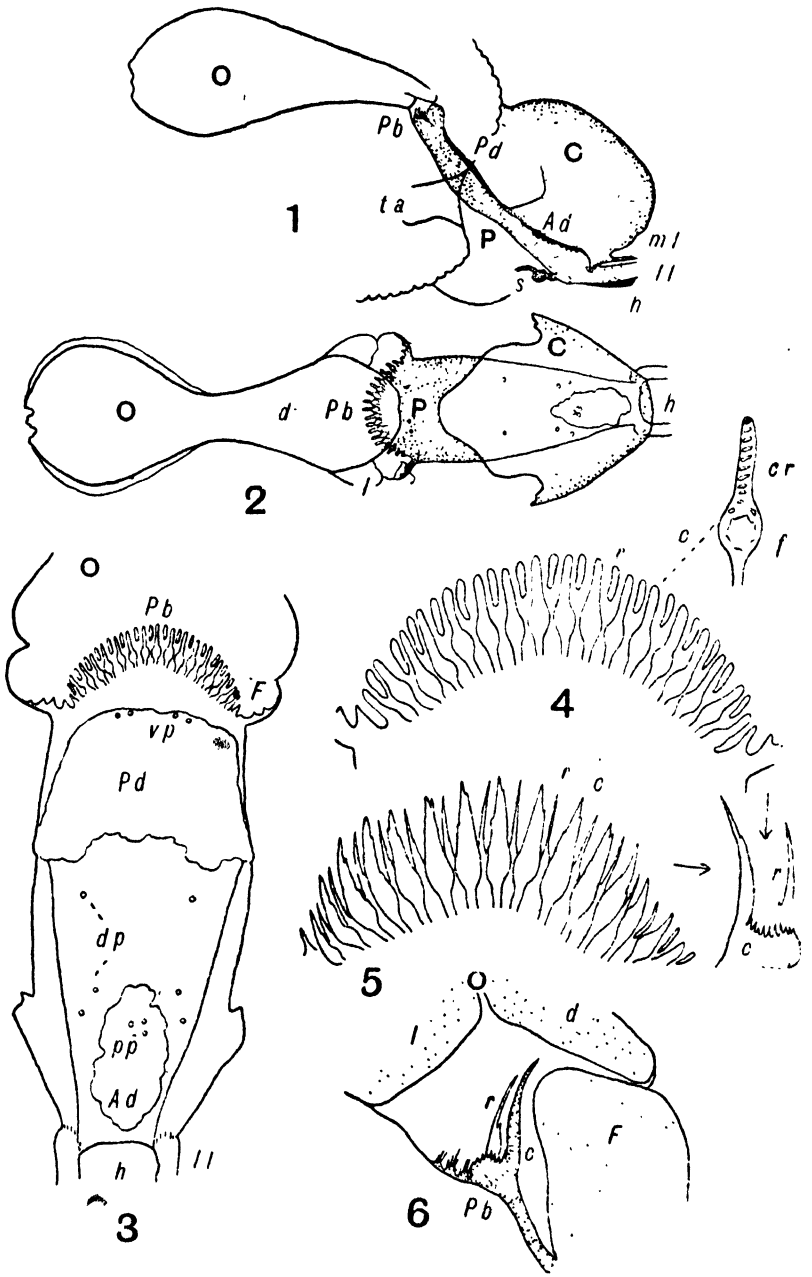
On the bevel the rods and cones, when both are present, are set alternately as shown in the figure, the cones anterior to the rods, but sending backwards an extension from their bases between these.

The cones consist of a basal portion (*pediment*), and a terminal *filament*. The filament is usually somewhat tapering, flat and strap-like, or thicker and more thorn-like. They may carry spicular processes (*spicules*), at their edges or arising from the anterior or posterior surface, and the termination may be simple, or nearly so, or fimbriated (fig. 6, p. 28).

General pharyngeal structure:—1. Lateral view of parts. 2. Dorsal view of parts as seen when dissected out. 3. Dorsal view of pharynx, with nomenclature of parts. 4. Enlarged representation of pharyngeal bar (view when rods and cones are seen in direction of vertical arrow). 5. Appearance given by the same preparation tilted at a different angle (view in direction of horizontal arrow). 6. Lateral view of junction of pharynx with œsophageal pump.

Ad, Anterior hard palate.
C, Clypeus.
c, Cone.
d, Dorsal plate of œsophageal pump.
dp, Dorsal papillæ.
F, Lateral flange.
f, Filament of cone, foreshortened and out of focus.
h, Hypopharynx.
l, End of ventro-lateral plate of œsophageal pump.
ll, Lateral piece of labrum.
ml, Median portion of labrum.
O, Œsophageal pump.
P, Pharynx.
Pb, Pharyngeal bar.
Pd, Posterior hard palate.
pp. Palatal papillæ.
r, Rod.
s, Salivary pump.
ta, Tubular apodeme of head.
vp, Ventral papillæ.

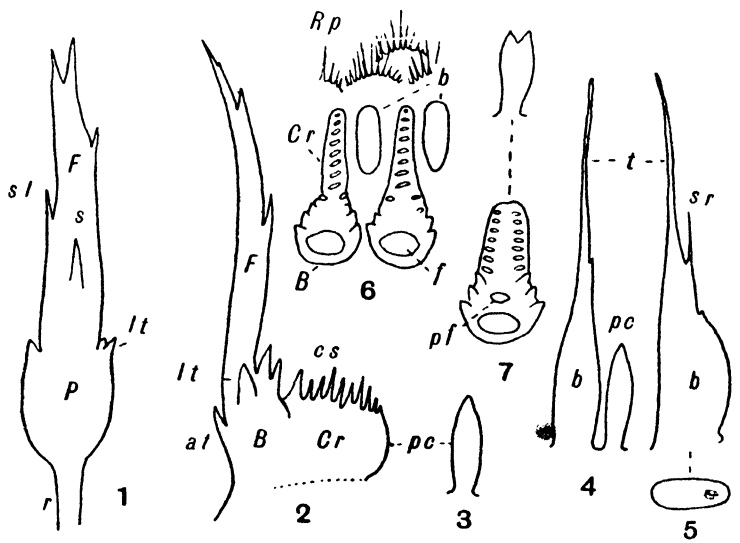
Fig. 5.



(For explanation of figure, see opposite page.)

The pediment is usually broad and more or less bulbous in its anterior portion (*bulb*), and narrower and often rudder-like in its posterior portion or *crest*. The bulb, from which the filament arises, may be continued without any special indication into the base of the filament, but is more commonly marked off by one or more tooth-like or spicular processes at the sides (*lateral spines*). The crest carries along its summit a row, or sometimes a double row, of spines (*crest spines*). The crest usually ends posteriorly in some more or less characteristic manner with a smooth posterior edge. Viewed from behind, this edge may show characteristic appearances, being conical, narrow, broad, or bifid.

Fig. 6.



Details of pharyngeal armature:—1. Anterior view of cone. 2. Lateral view, ditto. 3. Posterior view of crest. 4. Anterior or posterior view of rod; on the right of it is shown *in situ* the posterior border of a crest. 5. Lateral view of a rod. 6. View of two cones and two rods foreshortened, as commonly seen; behind the bases of the rods are shown a few post-armature ridges. 7. A similar view of a double-crested cone (*Neocellia*) and appearance of posterior view of crest in this group.

at, Anterior spine.
B, Bulb of pediment.
b, Basal portion of rod.
Cr, Crest portion of pediment.
cs, Crest spines; seen foreshortened at *Cr* in **6**.
F, Filament of cone.
f, Filament foreshortened and out of focus.
lt, Lateral teeth.
P, Pediment.
pc, Posterior border of crest.
pf, Spine behind base of filament.
Rp, Pharyngeal ridges.
r, Root.
s, Spine on anterior or posterior aspect of filament.
sl, Lateral spicules on filament.
sr, Spicules arising from rod.
t, Terminal portion of rod.

The rods arise from circular, oval or elliptical origins between the pediments (crests) of the cones; they have tapering or bulbous bases, often more or less melon-seed-shaped, and usually have simple, rod-like, tapering terminations, often with accessory spicules or processes (fig. 6, p. 28).

The cones, by their bulbs, arise, as it were, from the actual cutting-edge of the chisel. In some cases they are supported by extra buttress-like ridges arising from the flat dorsal surface of the ventral plate (*roots*). The rods arise near the flatter edge of the bevel, which is commonly scalloped, the swollen base of a rod corresponding to the convexity of a scallop. These scallops may be extended in finger-shaped processes, and the rods are then carried on these.

Examination for Pharyngeal Characters.

Owing to the entirely different appearances seen with different orientation of the pharyngeal bar, very incorrect conclusions may be drawn unless examination is carried out with the actual nature of the structures in mind. Fig. 5, **4** & **5**, shows two appearances seen in the same preparation somewhat differently oriented. In **5** the filaments of the cones happen to be lying flat, in **4** the filaments are directed, as they very commonly are, towards the observer, and what appear to be the filaments are really top-views of the crests of the pediments. From the characters of isolated teeth given in this volume it will generally not be difficult to interpret the various appearances seen and to ascertain the group-characters.

The pharyngeal characters of practically all the Indian species have been dealt with by Sinton and Covell (1927) and Barraud and Covell (1928, 1929), and, to save repetition, only other works dealing with certain of the species are quoted under the descriptions. The above authors may be consulted in all cases.

Hypopygial Characters.

Male.—The general character and nomenclature of the male hypopygium in Anophelini are shown in fig. 7 * (p. 31).

The *proctiger* (anal lobe) is mainly membranous, with an ill-

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* For an account of the male hypopygium in Anophelini, see Christophers, Ind. Journ. Med. Res. iii, p. 371, 1915, and Freeborn, Amer. Journ. Hyg. iv. p. 188, 1924. See also Edwards, Ann. Trop. Med. and Par. xiv, p. 23, 1920; Christ., Ind. Journ. Med. Res. x, p. 533, 1922 (development); Christ. and Barraud, Ind. Journ. Med. Res. x, p. 827, 1923; Root, Amer. Journ. Hyg. iii, p. 264, 1923, and iv, p. 456, 1924; Freeborn, 'Mosq. of California,' p. 343, 1926; King, Phil. Journ. Sci. xlvii, p. 305, 1932.

defined chitinisation (*ventro-lateral chitinisation* or *paraproct*)*. The 9th sternite is narrow and crescentic and is linked to the tergite by a very narrow ribbon of chitin, which lies round the base of the coxite externally. The 9th tergite is also narrow, forming a ribbon-shaped band dorsally at the base of the proctiger; at the lateral angles of the proctiger it is somewhat expanded, and in certain species is prolonged into a freely projecting spinous or knobbed process (*processes of 9th tergite*).

The *coxite* (side-piece) is conically cylindrical in shape, not unlike a stumpy human thigh, convex externally but somewhat hollowed out at its base internally. The *style* (clasper) is very long and arcuate, with a small, terminal, spur-like appendage.

The *parabasal spines* in subgenus *Anopheles* are two in number †, arising more or less distinctly from eminences, the inner spine shorter and stouter than the outer, both often recurved at the end. In subgenus *Myzomyia* there are usually five somewhat smaller thickened hairs rising directly from the surface of the coxite. These are arranged as shown in fig. 27, 14, four arising close together with the arrangement shown, and the fifth, a longer hair, at a little distance down the coxite. Hairs 1–4 are directed inwards, recurved at the ends and usually somewhat flattened, hair no. 1 being the shortest and hair no. 4 the longest. Hair no. 5 has more resemblance to an ordinary hair. One stout *internal spine* (or often two) on the inner edge of the coxite at a variable distance up this is usually present in subgenus *Anopheles*, but rarely in *Myzomyia*.

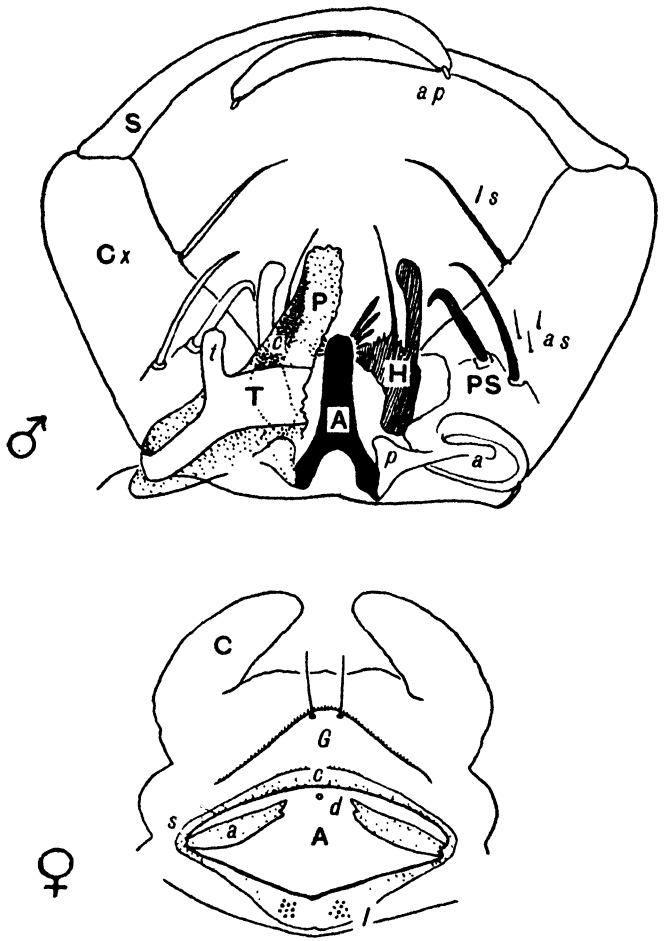
Lying on the inner aspect of the coxite at its base, on either side, is the lobe-shaped *harpago*. In subgenus *Anopheles* the crest of the harpago may be somewhat irregularly divided into lobes, each carrying stout or sword-like spines, or the spines on the outer (dorsal) lobe are more or less fused into a club. In subgenus *Myzomyia* the harpago is conical or rounded, carrying a club-shaped process dorsally, and usually at its summit one largish hair (*apical hair*), with one or more smaller hairs (*accessory hairs*), according to the species.

Between the two harpagos is the *phallosome* (œdeagus, mesosome). In all Indian species this is narrow and columnar, with a laterally expanded base. Though appearing straight when viewed from in front or behind, it is often seen, on a sideways view, to be much curved, a fact that has to be allowed

* These carry a ventrally directed chitinised process in *A. nimbus* (subgenus *Stethomyia*).

† Exceptions are found in the Palæarctic *A. algeriensis*, the Australian *A. stigmaticus* and *A. atratipes*, and the African *A. implexus*, which have only one parabasal spine, and in the European *A. claviger* (*bifurcatus*), which has three, the outer spine being duplicated.

Fig. 7.



♂ and ♀ terminalia:—Upper figure : true dorsal view of ♂ hypopygium, right half of proctiger and 9th tergite, shown as removed. Lower figure : ventral view of ♀ hypopygium.

♂.

A, Phallosome (œdeagus or mesosome).
a, Apodeme of coxite.
ap, Appendage of style.
as, Accessory spines.
c, Ventro-lateral chitinisation.
Cx, Coxite.
H, Harpago.
Is, Internal spine.
P, Proctiger.
p, Chitinisation of penis-cavity.
PS, Parabasal spines.
S, Style.
T, 9th tergite.
t, Process of 9th tergite.

♀.

A, Atrium.
a, Atrial plate.
C, Cercus.
c, Anterior part of postgenital plate (cowl).
d, Opening of spermathecal duct.
G, Postgenital plate.
I, Insula.
s, Sigma (peri-atrial chitinisation).

for in making measurements *. At the apex of the phallosome are usually, on either side, from three to seven or more leaflets. In some species these are absent. Of the leaflets, the first on each side is usually the largest, and the others diminish in size backwards. The larger leaflets, at least usually, are flat, more or less fusiform, blade-like or claw-shaped when properly displayed, and have usually a serrated thinner edge, the serrations being larger in some species. Seen edgeways, the same leaflets appear rod-like. To study the leaflets it is usually necessary to mount the phallosome separately and ensure proper flattening of the structures †. Besides leaflets of the usual shape, there may be several or numerous small spicules in addition.

Female.—The structure and nomenclature of the female hypopygium is shown in fig. 7 ‡. In Anophelini the post-genital plate is of conical form and, so far as is known, throughout the tribe carries two apical, rather closely set hairs. The atrial plates are well marked. Lying along the lower part of the opening posterior to the 8th sternite is a narrow transverse chitinisation, sometimes almost membranous, the *insular plate* carrying on either side the *insula*. The insula consists of two small islets, of from 9–15 hairs each, on either side of the middle line. Very few distinctive differences occur, though it is possible in some cases the number of insula hairs may be a specific character.

As there is practically nothing specific, so far as yet ascertained, about the female genitalic characters, these are omitted from the descriptions.

Pupal Characters. (Fig. 8.)

The external structure of the pupa in Anophelini has been especially studied by Senevet, whose nomenclature is here followed. The characters that have been made use of in description are: the respiratory trumpets; the paddle; the abdominal (and metathoracic) chætotaxy.

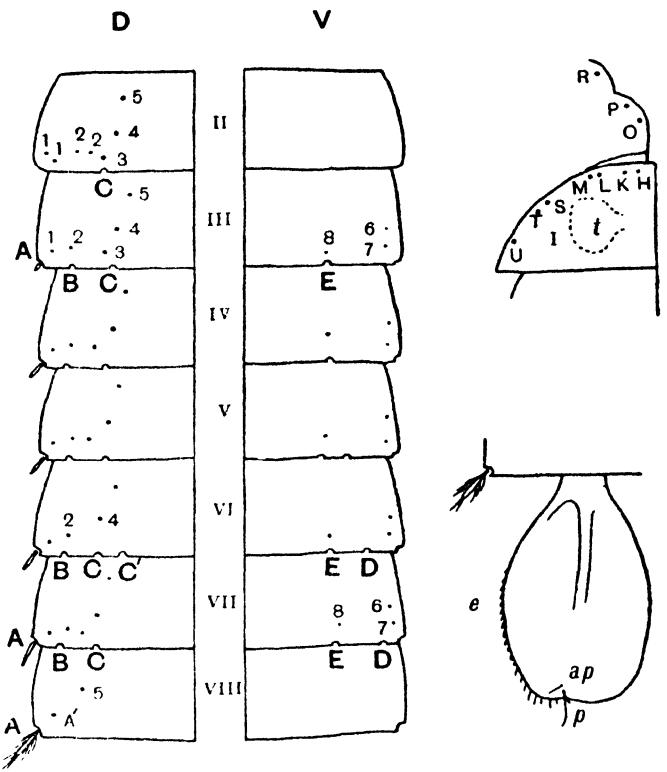
Respiratory Trumpets.—The respiratory trumpets in Anophelini are short, more or less sessile, truncated at the end, and with a very wide opening. Though the trumpets show differences in shape and appearance, no very definite description of these has so far been attempted, except for certain American and African species.

* When measurements are given in the descriptions they refer to the linear length of the organ dissected out and lying flat or on its side (preferable), the distance being taken from the level of the apex, excluding the leaflets, to that of the furthest extension of the basal expansions.

† See section on "Technique."

‡ For an account of the female genital organs, see Macfie and Ingram, Ann. Trop. Med. and Par. xvi, p. 157, 1922; Christophers, Ind. Journ. Med. Res. x, p. 698, 1923; Davis, Amer. Journ. Hyg. vi, p. 1, 1926.

Fig. 8.



Hairs of abdomen and paddle of pupa (After Senevet, with some modification.)

D, Dorsum.

A, Spine.
A', Accessory hair of spine.
B, *C*, *C'*, Large dorsal hairs.
D, *E*, Large ventral hairs.
1–5, Small dorsal hairs (hairs I–V of Senevet).
6–8, Small ventral hairs (hairs VI–VIII of Senevet).

V, Venter.

H–U, Hairs of metathorax and abdominal segment I, as given by Senevet.
t, Dendritic tuft of abdominal segment I.
e, External border of paddle.
p, Paddle-hair.
ap, Accessory paddle-hair.

Paddle.—The paddle in Anophelini is more or less oval in shape, with a median longitudinal midrib which may, or may not, extend to the margin of the paddle. At the apex of the paddle is a short, usually more or less hooked *paddle-hair*, and a little above the origin of the paddle-hair on the paddle is a smaller hair (*accessory paddle-hair*). On the external border may be present a series of denticles or teeth. Both the external and posterior border may carry small hairs on some, or all, of their extent.

The position of the accessory paddle-hair is characteristic of the Anophelini; in the genus *Culex* it is also present, but placed beside the paddle-hair, while in other Culicini it appears to be absent. The paddle-hair in subgenera *Anopheles* and *Nyssorhynchus* and group *Neomyzomyia* of subgenus *Myzomyia* appears generally to be short and more or less straight; in other groups of *Myzomyia* it is generally longer and hooked or curled.

Chætotaxy.—At the lateral posterior angle of each of the abdominal segments III–VII is a stout simple *spine* (hair *A*). On segment VIII is a similarly situated spine with branches (*spine of VIIIth segment*). The other hairs present on the abdomen are shown in the figure.

The presence of spines on the posterior corners of segments III–VII and of a branched spine on segment VIII is characteristic of Anophelini. In pupæ of other Culicini there is usually present a hair only, which does not arise quite at the angle, and is usually branched. The characters of the spine and the size and degree of branching of the different hairs on the various segments afford specific characters.

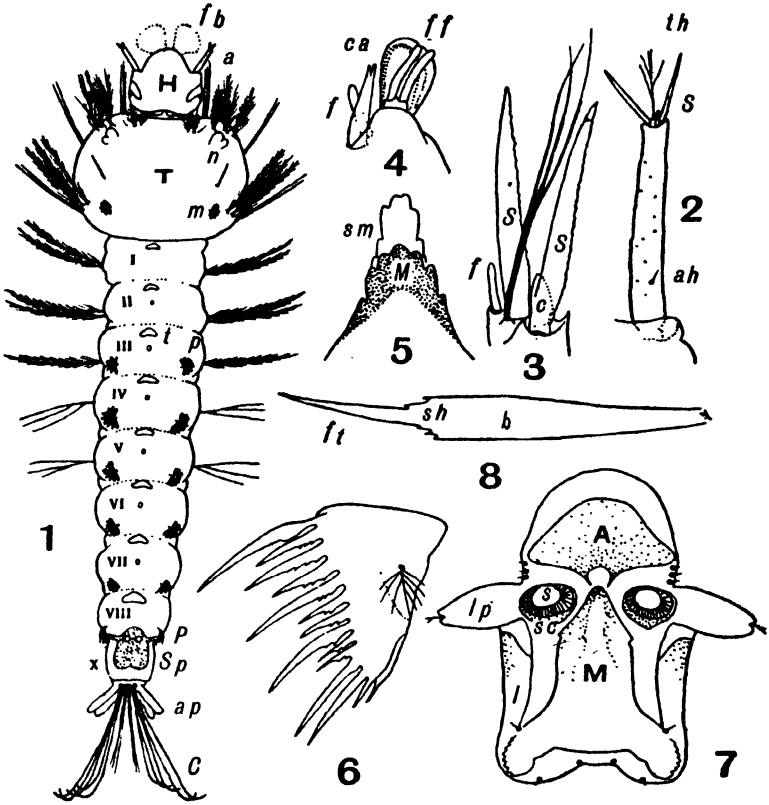
Spine *A* is generally long and pointed in *Myzomyia* but is frequently short, massive, and blunt in subgenus *Anopheles*. Hair *C* on segments V–VII is usually simple in *Myzomyia*, bifurcate or branched in subgenus *Anopheles*. For details regarding the other hairs Senevet should be consulted. There is considerable variation in the number of branches shown by the smaller hairs, and these are not, therefore, dealt with in the descriptions unless they show outstanding characters.

Bibliography.

Senevet, Trans. 2e Congr. du Paludisme, i, p. 69; *id.*, Arch. Inst. Past. Algérie, viii, pp. 297–382, 1930, and ix, pp. 17–112, 1931.

See also Ingram and Macfie, Bull. Ent. Res. viii, p. 73, 1917; Macfie and Ingram, *ib.* xiii, p. 409, 1923; Martini, Zool. Jahrb. Abt. f. Syst. xlvi, p. 531, 1923; Theodor, Bull. Ent. Res. xiv, p. 342, 1924; Buxton, *ib.* p. 310, 1924; Edwards, *ib.* xvii, p. 124, 1924; Kirkpatrick, 'Mosq. of Egypt,' p. 33, 1925; Root, Amer. Journ. Hyg. vi, p. 698, 1926, and vii, p. 470, 1927; de Meillon, Bull. Ent. Res. xix, p. 401, 1929.

Fig. 9.



Larval characters:—1. Dorsal view of larva. 2. Antenna. 3. Structures at apex of antenna (after Puri). 4. Structures at tip of maxillary palp (after Puri). 5. Mentum and submentum. 6. Pecten. 7. Spiracular apparatus, dorsal view. 8. Leaflet of palmate hair.

1. *a*, Antenna.
   ap, Anal papillæ.
   C, Caudal hairs.
   fb, Feeding-brushes.
   H, Head.
   m, Hair no. 1 of metathorax (palmate hair).
   n, Notched organ of Nuttall and Shipley.
   P, Pecten (or comb).
   p, Abdominal segment, palmate hairs.
   Sp, Spiracular apparatus.
   T, Thorax.
   t, Tergal plates of abdominal segments.
   I–X, Abdominal segments.
2. *ah*, Antennal hair.
   S, Sabre.
   th, Terminal hair.
3. *c*, Papilla.
   f, Spine.
   S, Sabres.
4. *ca*, Cone-shaped appendage (bifid).
   f, Finger.
   ff, Paired finger-shaped appendages.
5. *M*, Mentum.
   sm, Submentum.
6. The hair shown is no. 6 (comb-hair or pecten-hair).
7. *A*, Fan-shaped plate.
   l, Lateral plate of scoop.
   lp, Lateral papilla.
   M, Median plate of scoop.
   S, Spiracle.
   sc, Spiracular chitinisation.
8. *b*, Basal portion of leaflet.
   ft, Filament.
   sh, Shoulder-serrations.

Larval Characters *.

The general nomenclature of the parts of the larva is shown in figs. 9 and 10. Further details regarding the larval structures are given below. The notation employed for the hairs is that of Puri, 1925; differences from other authors, where they exist, will be found in the explanation of the figures.

Instars.

The characters given in synoptic tables of larval characters are those relating to the fourth or last instar.

Larvæ of the first instar are minute, measuring about 1 mm. and very dark in colour. Those of the second and third instars have a similar appearance but are larger. The third ecdysis leading to the fourth instar occurs when the larva has grown to about half the length it will be when fully grown. Immediately after an ecdysis the head is quite pale and almost transparent; later it becomes darker, and in the first three instars may be uniformly black.

In the first instar the hairs of the head, including the frontal hairs, are for the most part simple and unbranched. On the dorsal aspect of the head is the *egg-breaker* †. The palmate hairs consist of a single leaflet only. The comb consists of two parts—the *primary comb*, which has about 6–10 teeth, the longest in the middle, and anterior and ventral to this a comb-like arrangement of teeth, the *secondary comb*. The ventral fan is not developed as such, being represented by a cluster of appressed spines on the ventral aspect of the last segment, which, as shown by Lang ‡, may show specific differences.

In the second and third instars there is an increasing degree of branching of the frontal and other hairs, and the palmate hairs show more leaflets. The comb is comparable in shape with that of the last instar, but shows fewer and less differentiated teeth. The maxillary palp is devoid of a subapical hair in the second instar, but this is present in the third (*Lang*, p. 53). The dark collar on the posterior margin of the head grows in width in the earlier instars with the age of the larva, and may measure as much as one-third of the length of the head: it remains of its original width in the last instar. In the second and third instars the head is proportionately narrower than in the last instar.

* For a very full and complete account of larval characters, see Puri, Ind. Med. Res. Mem. no. 21, 1931.

† See Edwards, Ann. Mag. Nat. Hist. ser. 9, iii, p. 372, 1919; Tanzer and Osterwald, Arch. f. Schiffs. xxiii, Beih. 2, 1919; Bresslau, Biol. Zent. xl, p. 349, 1920.

‡ Lang, 'Handb. Brit. Mosq.' p. 50, 1920. (A very good account of instars.)

Colour and Pattern.

The head commonly shows a pattern due to *pigmented spots* connected with muscle attachments on the dorsum of the head; they may be variously developed in different species and joined up or enveloped in *pigment-clouds*. The three anterior spots just behind the frontal hairs are commonly linked up by cloud, forming a transverse bar across the middle of the head; the three median spots may be linked up to form a longitudinal median band; or the posterior spots may form a large triangular patch; there is also generally pigmentation along the V-shaped epicranial suture. The pattern is only of importance in certain cases where it may show specific differences in nearly related forms. All species breeding in certain situations (tree-holes, swamps, and wells) usually have almost completely dark heads.

Markings of various kinds may be present on the thorax and abdomen; silvery spots often form a V on the thorax and spots or lines on the abdominal segments. The colour of the larva is also largely characteristic for the species. As with the head-pattern, space will not permit of these characters being described unless there is some peculiarity, and for particulars of such Puri should be consulted.

The Head.

The various structures of the head are shown in fig. 10, **1**, **2**,

The *clypeal hairs* arise on the front of the frons-clypeus. They are here termed *inner*, *outer*, and *posterior*; for brevity the lettering *ic*, *oc*, and *pc* will be used respectively for these hairs in the descriptions. In subgenus *Anopheles* the bases of the inner hairs are close together, often nearly touching; in *Myzomyia* they are wide apart, usually twice, or more than twice, the distance between the bases of the inner and outer hair of the same side. The preclypeal hairs arising from the preclypeus in front of the inner hairs should not be mistaken for these; there is an inner pair, rather long and slender in some species; the outer are minute, flattened, often truncated projections.

The *frontal hairs* are three on each side; when long, feathered, and reaching forwards to the level of about the bases of the inner clypeal hairs, they are referred to in the descriptions as normal. They are reduced and usually simple or with a few branches in tree-hole breeding species and in *A. turkhudi*. The *sutural* (8) and *trans-sutural* (9) are usually about as long as the posterior clypeal; the former are simple in most species, but may be branched and even feathered, the latter may be

simple or feathered. The *subantennal* hair (basal hair) is usually a little shorter than the antenna, stout and feathered (normal); it is modified in tree-hole breeding species and in *A. turkhudi*.

The *antenna* carries at some point on its shaft the *antennal hair*. In subgenus *Anopheles* this normally arises from the inner surface and is usually branched even if small; in subgenus *Myzomyia* it is a small, simple hair arising from the dorso-external surface. Tree-hole breeders (subgenus *Anopheles*) are anomalous in respect to this hair, and in them it may not only be simple, but also arise from the external surface. At the distal extremity of the antenna are a number

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9. Trans-sutural (outer occipital of Root).
10. Terminal hair of antenna.
11. Antennal hair (shaft-hair).
12. Subantennal (basal).
13. Postmandibular (sub-basal).
14. Orbital (dorsal eye-hair of Martini).
15. Infra-orbital (ventral eye-hair of Martini).
16. Hair on maxillary palp.
17. Hair on basal piece of maxilla.
18. Postmaxillary hair.
19. Hair on maxillary plate.
20. Submental hair.

PROTHORAX.

0. Dorsal submedian (not given by Martini or Root).
1. Inner submedian prothoracic } Shoulder hairs.
2. Middle ,, ,, }
3. Outer ,, ,, }
4–7. Lateral prothoracic hairs (no. 6 simple).
8. Ventral hair of lateral series.
9–12. Pleural hairs.
13. Ventral submedian.
14. Subcervical.

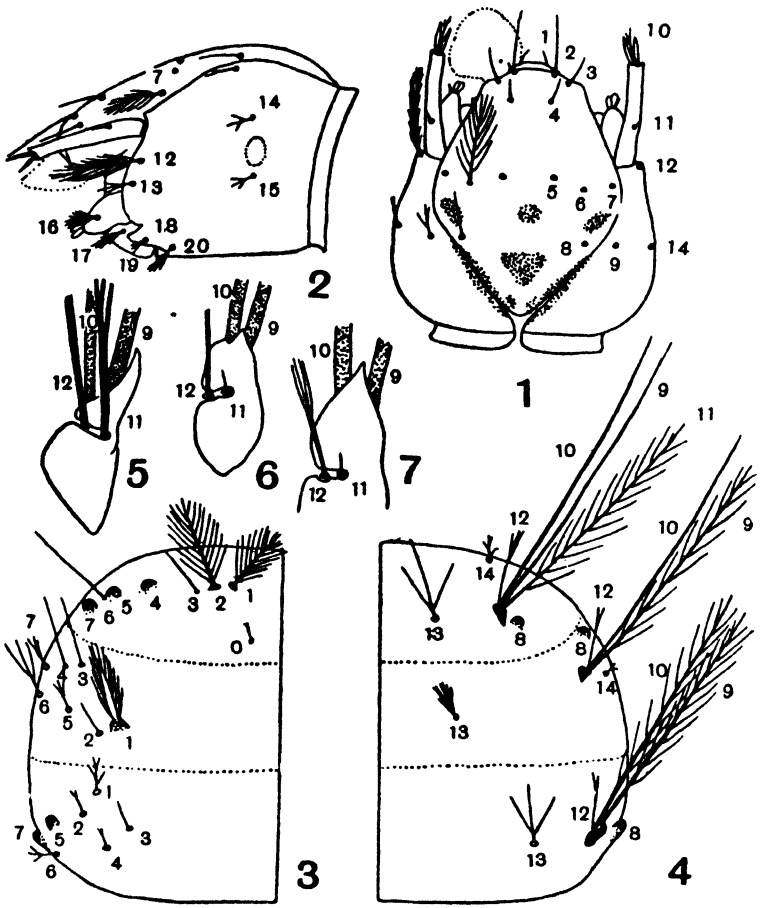
MESOTHORAX.

1. Large dorsal hair (representing palmate hair).
2–7. Small dorso-lateral hairs.
8. Large lateral hair (no. 9 of Martini).
9–12. Pleural hairs (nos. 10–13 of Martini and Root).
13. Submedian hair (no. 14 of Martini and Root).
14. Small lateral hair (no. 8 of Martini, 9 of Root).

METATHORAX.

1. Representing palmate hair (no. 4 of Martini and Root).
2. Small dorso-lateral ,, (no. 3 ,, ,,).
3. ,, ,, ,, (no. 2 ,, ,,).
4. ,, ,, ,, (no. 1 ,, ,,).
5. Large lateral hair.
6. Small hair posterior to 7 and 8.
7–8. Large lateral hairs.
9–12. Pleural hairs.
13. Submedian ventral.

Fig. 10.



Hairs of larval head and thorax (after Puri):—1. Head, dorsal view. 2. Head, lateral view. 3. Thorax, dorsal view of left half. 4. Thorax, ventral view of left half. 5–7. Bases of pleural hairs of pro-, meso-, and metathorax respectively.

(The hair-numbers are those used by Puri; unless otherwise stated, Martini's and Root's numbers do not differ.)

HEAD.

1. Inner preclypeal.
2. Inner clypeal (inner anterior of Puri).
3. Outer clypeal (outer „ „).
4. Posterior clypeal.
5. Inner frontal.
6. Middle frontal.
7. Outer frontal.
8. Sutural (inner occipital of Root).

of structures as shown in fig. 9, 3. The *papilla* is longer than the *spine* in all tree-hole breeding species and in some others (*aitkeni, insulæflorum, lindesayi, umbrosus, turkhudi, multicolor*). According to Puri the longer papilla is the more primitive ; it is especially long in the first instar larva.

The *mouth-brushes* (cephalic fans) show but little variation throughout the Anophelini, except in *A. turkhudi*, where they are peculiar and directed more outwards. The *mandibles* are of complicated structure, but show few features of systematic importance ; they are peculiar in *A. turkhudi*. The *maxillæ* consist of a quadrangular plate forming the greater part of the maxilla and an externally situated conical appendage (*maxillary palp*). At the apex of the palp are the structures shown in the figure. The three leaflet-like appendages are peculiar to the Anophelini and connected with their method of feeding at the surface-film, with which these structures are in contact. The relative length of the *cone* and the *finger* may vary in different species. The cone is usually single, but is bifid in the group *Pseudomyzomyia*. The *mentum* lies in the middle line about the middle of the head ventrally ; it carries a single apical and from 3–5 lateral teeth on each side, the arrangement and character of which are important. Ventral to the mentum is the somewhat similar *submentum*, with the apical tooth usually double (except, among Indian species, in *A. ramsayi* and *A. maculipalpis*, where it is single).

Thorax.

The division of the thorax into pro-, meso- and metathorax is only indefinitely indicated externally, but the limits of these parts will be sufficiently clear from the figure (fig. 10, 3, 4). Towards the front of the thorax on either side are the retractile transparent notched organs of Nuttall and Shipley. The long, branched, lateral hairs, of which the bases only are shown, vary very little in different species and are of little systematic importance. The various hairs of the thorax are shown in the figure ; the most important for taxonomic purposes are hairs nos. 1–3 of the prothorax (*submedian prothoracic* or shoulder hairs) and the *pleural* hairs.

The *submedian prothoracic* (shoulder hairs) comprise an *inner*, *middle*, and *outer* hair on each side. The middle hair is usually much the largest, twice or more the length of the inner ; it is stout and feathered and arises from a chitinised tubercle. The inner hair may be feathered or have a few branches only, or sometimes even be simple ; it may arise

from a thickened base, which may, however, be poorly developed or fused with that of the middle hair. The outer hair is short and simple, except in *A. annandalei*, where it is bifid or branched; it arises without a thickened base or from the base of the middle hair.

Hair no. 1 on the prothorax is the inner shoulder hair *. On the mesothorax it is a conspicuous large, stout hair arising from a thickened tubercle towards the middle of the dorsum on each side. On the metathorax it may exist as an ordinary hair, but is commonly formed into a modified or fairly well developed *palmate hair*, the test of which is whether the branches arise together and are flattened; it resembles, but is never so well developed as, the palmate hairs on the abdominal segments II–VII, and the leaflets are without a filament.

Pleural Hairs.

These form one of the most important characters in Puri's classification of the Anophelini on larval structures. Each segment of the thorax carries on the ventro-lateral surface of each side a group of four *pleural hairs*, arising from a common chitinised base; they cannot be mistaken, owing to the common origin of the hairs from characteristic tubercles which carry a chitinised projection (fig. 10, **5, 6, 7**).

The four hairs are arranged in each segment as an *anterior* and a *posterior* pair, each composed of a *dorsal* and a *ventral* hair. Of these, the anterior pairs are long, while the posterior pairs are short or vestigial, except on the prothorax, where the ventral hair is also long. There are, therefore, present on the thorax on each side, three pro-, two meso- and two metathoracic *long pleural hairs*. The posterior dorsal on the prothorax may in some cases also be long, giving four longish hairs on the prothorax, but this is never more than one-half or two-thirds the length of the others. The various conditions of these hairs, whether simple or feathered, form combinations that, with a few exceptions, are characteristic of the different genera, subgenera, and groups.

In *Bironella* and in the subgenera *Anopheles* and *Nyssorhynchus* all the long pleural hairs are simple in the great majority of cases. In subgenus *Myzomyia* they are simple in group *Neomyzomyia*, but some at least are feathered in all the remaining groups. The arrangement of the long pleural hairs in the different groups of *Myzomyia* are given in tabular form on the following page for ready reference.

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* Sometimes transformed into a palmate hair in *Chagasia* and *Nyssorhynchus* (Puri, p. 35).

Table showing Characters of Long Pleural Hairs in Groups of Subgenus Myzomyia.

	Neomyzomyia.	*Myzomyia.*	*Pseudo-myzomyia.*	*Paramyzomyia (A. turkhudi).*	*Paramyzomyia (A. multicolor).*	*Neocellia.*
Prothoracic dorsal anterior	0	F	F	F	F	F
,, ventral ,, ...	0	0	0	0	0	0
,, dorsal posterior	0	0	0	0	0	0
Mesothoracic dorsal anterior	0	0	0 or f	F	f	F
,, ventral ,, ...	0	0	0	F	0	0
Metathoracic dorsal anterior	0	F	F	F	F	F
,, ventral ,, ...	0	0	f	F	F	F

0 = Simple.
F = Feathered.
f = With some branches not amounting to feathering.

A more detailed description of the pleural hairs, including the character of the shorter hairs and basal chitinous tubercle, will be found under Characterization of Subgenera and Groups and under the descriptions of species.

The Abdomen.

Abdominal segments I–VII are of simple construction. Segment VIII posteriorly is slightly modified, its posterior tergal plate forming the fan-shaped plate of the spiracular apparatus. Segment IX is much reduced and modified, being

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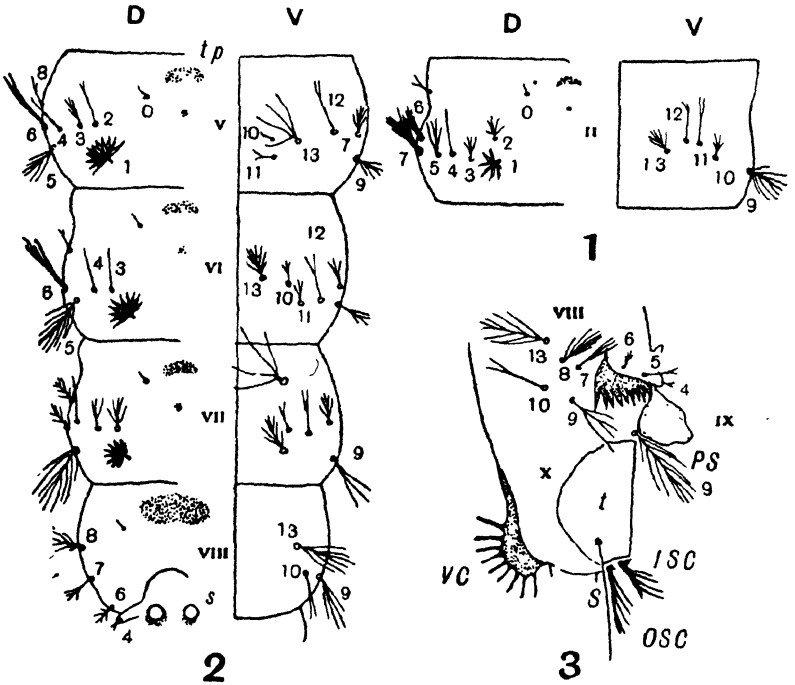
SEGMENT IX.

1–4. Hairs of scoop (hairs *a–d* of Martini) (not shown in figure).
6. Hair on ventral aspect of scoop (hair *e* of Martini) (not shown in figure).
8. Hair on ventral aspect of scoop (hair *f* of Martini) (not showr in figure).
9. Postspiracular hair (hair *g* of Martini) (*PS*).

SEGMENT X.

ISC, Inner submedian caudal (tail-hairs of Martini).
OSC, Outer ,, ,, (dorsal hairs of Root).
S, Lateral hair (saddle-hair).
VC, Ventral caudal (rudder-hairs of Martini, ventral fan of Root).
s, Spiracle.
t, Tergal plate of anal lobe.
tp, Tergal plates of abdominal segments.

Fig. 11.



Hairs of abdomen of larva (after Puri) :—1. Abdominal segment II, dorsal (D) and ventral view (V), showing hairs. 2. Abdominal segments V–VIII, dorsal and ventral view, showing hairs. 3. Lateral view of segments VIII–X, and anal lobe, showing hairs.

ABDOMINAL SEGMENTS I–VII.

0. Submedian dorsal.
1. Palmate hair.
2. Prepalmate (posterior to palmate hair on segment VI).
3–4. Small dorso-lateral hairs.
5. Dorso-lateral posterior.
6–7. Lateral hairs.
8. Stigmatic hair.
9. Ventro-lateral posterior.
10–12. Ventro-lateral small hairs.
13. Submedian ventral.

SEGMENT VIII.

0. Submedian dorsal.
1–3. Fossate hairs (not shown in figure).
4. Hair at tip of lateral papilla.
5. Hair at base of lateral papilla.
6. Pecten hair (hair *h* of Martini).
7. Subpecten hair (hair 6 of Martini).
8. Small lateral hair (hair 7 of Martini).
9. Ventro-lateral posterior.
10. Small ventro-lateral hair (hair 11 of Martini).
13. Submedian ventral.

represented in parts of the spiracular apparatus. Segment X forms an appendage-like mass (*anal lobe*), which carries the *caudal hairs* and four *anal papillæ*, the latter arising round the margins of the anus ; it is strictly a composite segment, including elements of segment XI.

Near the anterior border of each segment is an oval chitinous plate, which may be small or large (*anterior tergal plate*) ; about the middle of each segment is another very small rounded plate (*posterior tergal plate*). In group *Myzomyia* most species show, also, a little behind the posterior tergal plate, a pair of small, dark, oval plates, lying one on each side of the middle line (*paired oval plates*). The anterior tergal plates are very large in the species *funestus*, *fluviatilis*, *minimus*, and related forms, and may include the paired oval plates.

The structures about the spiracles are shown in fig. 9, **7**, and fig. 11, **3**. Along the posterior borders of the spiracles is a crescentic chitinisation, which may be poorly or well developed (*spiracular chitinisation*). When the anterior border of the *median plate* is broad it may approach or touch the spiracular chitinisations. On each side of the *scoop*, or posterior projection of the spiracular parts, is a comb-like structure, *pecten* (or comb) *, which carries long and shorter spinous projections, all of which are usually finely serrated on their basal half, only exceptions to this being noted in the descriptions.

The hairs of the abdominal segments are shown in fig. 11, **2**. The most important hairs are no. 1 (palmate or float hairs) and nos. 6–7 (lateral hairs).

On segments I and II *hair no.* 1 may be an ordinary small branched hair or developed as a *palmate hair* ; it is considered a palmate hair when the branches arise all together in a whorl and are flattened. On segments III–VII the hair is generally transformed into a well-marked palmate hair with from 12–24 *leaflets*. In subgenus *Myzomyia* the leaflets consist of a basal portion (*blade*) and a terminal *filament*, usually with a number of more or less closely-set serrations at the point of origin of the filament (*shoulder serrations*). In subgenera *Anopheles* and *Nyssorhynchus* the leaflets are usually lanceolate in shape, or the differentiation of the filament is imperfect, the serrations being spread out more or less along the apical portion of the leaflet.

The *lateral hairs* on segments I and II form two stout, feathered hairs, a dorsal (6) and a ventral (7) ; in most species the dorsal hair is also present as a stout, feathered hair on segment III (normal arrangement). In some species hair no. 6

* The term "pecten" is preferable, as this structure is homologous with the pecten, and not with the comb of culicine larvæ.

on segment III is not stout, has few branches, or is short. On segments IV–V hair 6 is very long and somewhat slender, splitting near its base or about its middle into 2–10 branches, approaching in appearance a feathered hair where the number of branches is large. On segment VI it is very long and somewhat slender in *Myzomyia*, some *Nyssorhynchus* and tree-hole breeding *Anopheles*, but short otherwise in this last subgenus ; it may be simple or branched and is feathered in *A. annandalei*. On segment VII no. 6 is very short and branched.

The *postspiracular* hair (hair no. 9 of segment IX) in the great majority of species has 3–8 branches ; it is simple in *barianensis*, *sergenti*, and *annandalei* (sometimes bifid in the last), and short in *culiciformis* and *sintoni*. The saddle-hair is practically always long and simple ; it is modified in *aitkeni*, *sintoni*, and *majidi*.

Arising from chitinised plates above the anus are the *inner* and *outer submedian caudal hairs*. The ends of the branches of the latter are usually curved to form hooks (*tail-hooks*) ; some branches of the inner may in some species also form delicate hooks. Ventral to the anus are the rudder-like *ventral caudal hairs*.

The ventral surface of the thorax and abdomen bear minute setæ, more marked on the posterior than on the anterior segments. These are especially conspicuous in some species, notably *A. annandalei* and *A. majidi*.

The salient points regarding the larvæ of Indian species are given in the descriptions, and information will also be found in the key in Part II., but for full details the very full descriptions given in Puri's Memoir must be consulted.

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Less recent or complete works on larval characters are :—Nuttall and Shipley, Journ. of Hyg. i, p. 51, 1901 ; Christ. and Steph., Repts. Roy. Soc. ser. 6, p. 11 ; ser. 7, p. 3, 1902 ; James and Liston, p. 35, 1904 ; p. 31, 1911 ; Stanton, Journ. Lond. Sch. Trop. Med. ii, p. 3, 1913 ; Bull. Ent. Res. vi, p. 159, 1915 ; Strickland, ' A Short Key, etc. ' 1915 ; Mangkoewinoto, Geneesk. Tijds. lviii, p. 462, 1918 ; *id.*, Meded. Burg. Ned. Indie, 1919, D. 2, p. 41 ; Swelleng., Geneesk. Tijds. lviii, p. 1010, 1918 ; Swell. and Swell., Meded. Burg. Ned. Indie, 1919, D. 6, p. 1 ; Lang, ' Handb. Brit. Mosq.' p. 14, 1920 ; Root, Amer. Journ. Hyg. ii, p. 379, 1922 ; Strickl. and Chowd., 'Anop. Larv. India, Ceylon, and

* A complete key to Indian anopheline larvæ, with structures, illustrated.

† This memoir gives a complete account of structure, with descriptions and keys for larvæ of Indian species.

Malaya,' 1927. See also (*instars*) Stanton, Bull. Ent. Res. iii, p. 387, 1912; Lang, *loc. cit.* p. 50; Puri, *loc. cit.* 1931; (*thoracic appendages*) Iyengar, Ind. Journ. Med. Res. xvi, p. 281, 1928; Puri, *loc. cit.* 1931; (*tail-hooks*) Lamborn, Bull. Ent. Res. xii, p. 91, 1921; Iyengar, Ind. Journ. Med. Res. ix, p. 630, 1922; (*spiracular apparatus*) Alessandrini, Rivist. de Malariol. N.S. v, Fasc. 1, p. 35, 1926; Montschadsky, Zool. Jahrb. Abt. f. Syst. lviii, p. 541, 1930; (*internal structure*) Imms, Journ. of Hyg. vii, p. 291, 1907; Parasit. i, p. 103, 1908. See also bibliographies under species (larva) in body of work.

CHARACTERS OF THE EGG. (See figs. 14 & 15, pp. 92 & 93.)

With rare exceptions the egg of the Anophelini is boat-shaped, with pointed ends, a flattish deck or upper surface, and a more convex lower surface; the end of the egg corresponding to the head of the larva is somewhat broader and blunter than the other. Surrounding the whole, or parts, of the upper surface is the frill; at the sides of the egg are the floats.

The *upper surface* * is usually unornamented, but may show small, pale, punctate spots over the whole or portions of its extent and rarely may show polygonal markings. In those species in which the frill does not entirely surround the upper surface it usually marks off a portion at either end (*anterior* and *posterior demarcated areas*), somewhat horse-shoe-shaped, whilst the *median area*, bordered by the floats, is roughly quadrangular in outline. At both extremities at the extreme points are a number of small, usually black, tubercles (*bosses*).

The *lower surface* in subgenus *Anopheles* is usually ornamented with a pale polygonal network †; in subgenus *Myzomyia* it is granular or may show pale punctæ. At the anterior extremity of the lower surface, just below the point of the egg, is the *micropilar area*. This is usually seen as a small, dark, papular area with a central depression, the *micropile*; it may show a delicate, pale, scalloped line surrounding it.

The *frill* may be broad or narrow; it is usually striated in the whole or part of its extent. Where it is not continued past the floats it may end by merging gradually into these or terminate more abruptly, in which case it usually ends in a small projecting *tag*.

The *floats* show a number of corrugations (*float-ridges*), and at either end there is commonly a more or less distinct terminal cell (*float-termination*), which may be large and rounded or small, and giving the float a pointed extremity.

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* As the upper surface corresponds to the ventral aspect of the contained larva, it is better to term this the upper surface rather than the dorsal surface, as given in Christophers and Barraud, 1931.

† This network is absent in *A. claviger* (*bifurcatus*) and *A. plumbeus*.

The majority of Oriental species have the egg conforming to one of two main types—the whale-back and the life-boat-shaped egg; some of the latter type have narrow high decks fore and aft, and may be described as galleon-shaped. The whale-back form has a narrow straight upper surface which is well separated from the floats, so that between the floats and the margin of the deck there intervenes a portion of the lower surface. The variations in egg-characters will be seen from the table given in Part II.

For minute structure and development of the egg from the follicle, see Christophers and Nicholson. The orientation of the egg and contained larva is dealt with by Bresslau. The flat side (upper surface) corresponds to the flatter side of the *Culex* egg and is *ventral*. The convexity (lower surface) is dorsal. The larva lies with the head towards the large end of the egg, with its ventral surface corresponding to the flat upper surface. The egg-breaker lies opposite the convexity of the egg towards the anterior end. The caudal hairs are directed forwards along the sides of the egg, and the balancer-hairs forwards and upwards towards the anterior end of the egg.

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IV. GEOGRAPHICAL DISTRIBUTION.

As no general account of the distribution of the Anophelini in a zoogeographical sense is usually given by authors writing on this group, some remarks on this subject may be useful.

The recognized zoogeographical regions of the world are shown in the map on p. 50 (fig. 12) *. These regions are mainly based on the study of the mammalian faunas, but it is generally recognized that other classes of animals, such as insects, usually show very similar, if not identical, faunal boundaries. Each of the regions is characterized by whole

* For information regarding these regions, consult Wallace, 'The Geog. Dist. of Animals,' London, 1876; Heilprin, 'The Dist. of Animals,' London, 1907; Beddard, 'Zoogeography,' Cambridge, 1895; Lydekker, 'Geog. Hist. of Mammals,' Cambridge, 1896; Déperét, 'Les Transformations du Monde Animal,' Paris, 1919; Trouessart, 'La Distribution Geographique des Animaux,' Paris, 1921; also 'Atlas of Zoogeography,' Bartholomew & Co., 1911; Sclater, 'The Geog. of Mammals,' Kegan Paul, French, Trübner & Co., 1899.

congeries of forms constituting that particular fauna, each constituent class of animals having its own representative types characteristic of such fauna.

Some of these types have a wide distribution and, probably, represent recently, or even now, actively spreading dominant forms. Others probably represent species or groups that are disappearing, and, though formerly more widespread, now occurring in small residual areas ; such a type of distribution has been termed by Tillyard * *palæogenic*. When forms extend very widely over the earth, owing to special adaptability or other causes, they are spoken of as *peregrine* forms.

The Anophelini conform very strictly in their distribution to the recognized regions as given on the map. They have no species of peregrine type comparable with *Aëdes ægypti* and *Culex fatigans* in the Culicini, though *A. gambiæ* has recently been recorded well outside its proper area of distribution, and must be regarded as at least an unusually actively dispersing form. Otherwise widely distributed species show almost always a remarkable adherence to the regional boundaries, and the distribution of subdivisions such as the subgenera indicate a remarkable similarity between the circumstances that have apparently affected the Anophelini and those responsible for mammalian distribution.

The genera *Chagasia* and *Bironella*, with few species and a restricted area of distribution, appear to be palæogenic forms representing relics of once more widely distributed types. The distribution of subgenus *Stethomyia* and group *Christya* of *Anopheles* also appears to be palæogenic, there being only two or three species confined to South and Central America and one confined to Central Africa respectively. Subgenus *Anopheles* is world-wide in distribution or almost so, but in South and Central America is represented solely by the peculiar group *Arribalzagia*, or forms nearly related to this, the group being confined to this region. Similar evidence of special localized occurrence is given by subgenus *Nyssorhynchus*, which is also entirely peculiar to South and Central America (Neotropical). Subgenus *Myzomyia*, on the other hand, is confined to the Old World †, and group *Neomyzomia* of this subgenus is predominant in the Australian Region, though it is also distributed throughout the Oriental Region and, as shown recently, is represented by a number of species in the Ethiopian Region. A very striking fact is that whilst the Old World tropical and subtropical areas have a mixed *Anopheles* and *Myzomyia* fauna, the considerable anopheline fauna of North America is purely *Anopheles*, no *Myzomyia* form being known.

* Tillyard, ' The Biology of Dragonflies,' Cambridge, 1917.

† Except for the recent introduction of *A. gambiæ* into Brazil.

The Zoogeographical Regions as displayed by Anophelini.

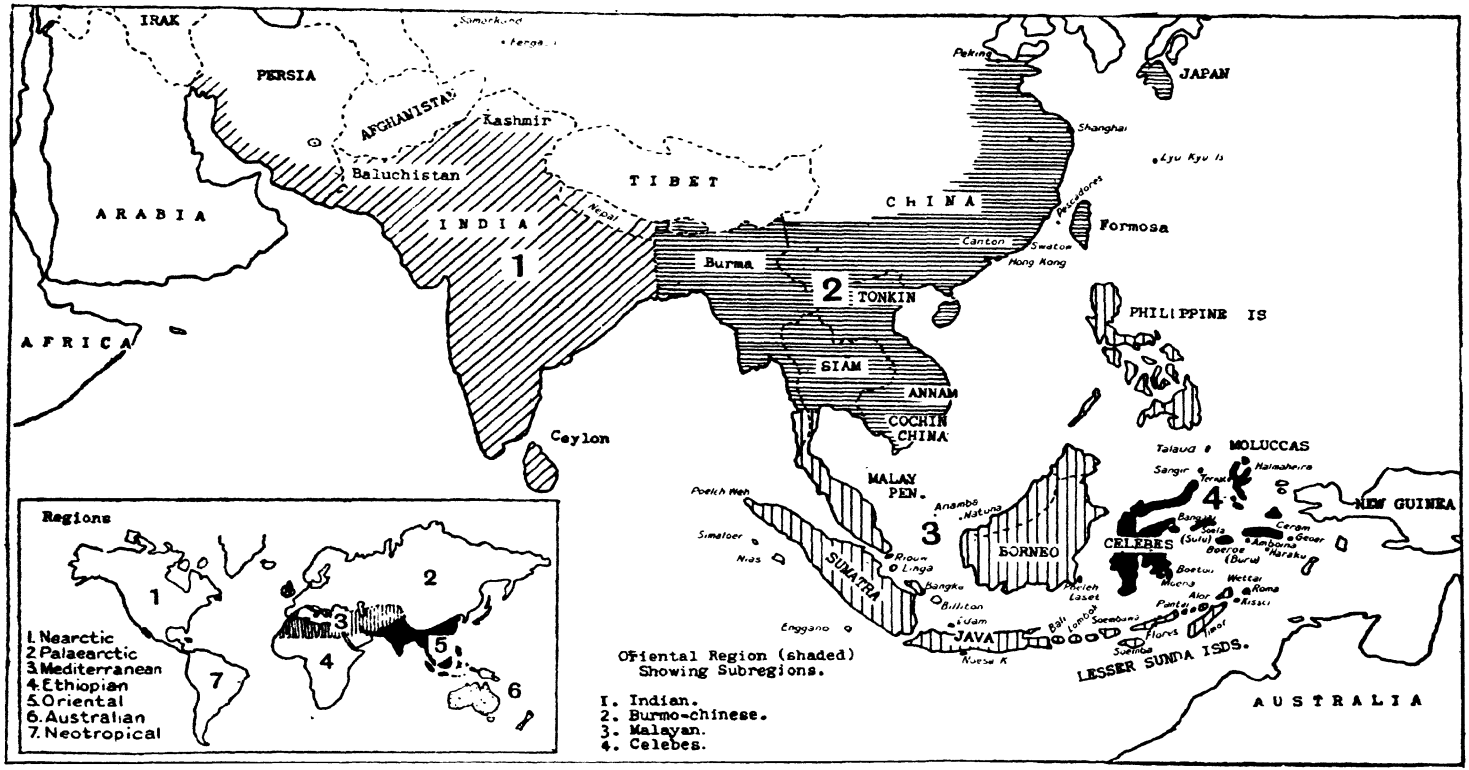
The completeness of the individuality of the Neotropical Region in respect to anopheline fauna is remarkable. Not only are the genus *Chagasia*, subgenus *Stethomyia*, subgenus *Nyssorhynchus* and group *Arribalzagia* of subgenus *Anopheles* entirely special to it, but no other forms than these exist within its limits except a few rather transitional forms recently placed by Edwards in group *Cycloleppteron* of *Anopheles*, which have strong *Arribalzagia* affinities.

The Australian Region, which appears, from its mammalian fauna, to show evidence of great isolation, does not show, in respect to Anophelini, such extreme evidence of isolation as does the Neotropical Region. Such isolation as there is appears to be of a more recent type, and is evidenced by the preponderance of the *Neomyzomyia* group, which on larval and pharyngeal characters seems to be a more primitive stem than the other groups of *Myzomyia*.

The anopheline fauna of the Nearctic Region is composed solely of group *Anopheles*. Only on its southern boundary do one or two common South American forms occur.

The Palæarctic Region over a large part of its extent shows only the well known species *A. maculipennis*, *A. claviger* (*bifurcatus*), and *A. plumbeus*, all typical of group *Anopheles*. Other species of this group occur to the east in Japan and North China, and no other forms occur to the south until, fairly far north, the unmistakable Oriental fauna is encountered. Proceeding south, in the western parts of the region a large addition in species occurs when the so-called Transitional or Mediterranean Subregion is entered. So distinct is this part of the Palæarctic Region in respect to the distribution of Anophelini that it would appear to merit, as regards Anophelini at least, the status of a region. The anopheline fauna of the Mediterranean Subregion, which we shall have frequently to refer to in connection with Western Indian species, shows some evidence of two components—a North African and a Turko-Iranian. These two types remain fairly distinct north and south of the existing Mediterranean, but east of this sea they tend to intermingle, and elements of both are found in Western India.

The Ethiopian Region is characterized by a large number of species of Anophelini. There are, however, relatively few representatives of subgenus *Anopheles*, and no tree-hole breeding anophelines, such as are so conspicuous a part of this subgenus in the Oriental Region, are known. Group *Myzomyia* is especially dominant, with a very large number of species.



Map of Oriental Region, showing subregions. Inset: Main zoogeographical regions of the world.

A certain number of *Neomyzomyia* occur. *Neocellia* is represented by two species, *A. maculipalpis* and *A. pretoriensis*. So far as is known, there is no species common to the Ethiopian and Oriental Regions *, a few Indian species, which were formerly thought to be the same as those of Africa, having now been shown to be distinct.

The Indian area forms a part of the Oriental Region, and the character of the fauna of this region is, therefore, of special importance in the study of Indian faunas. It has a large, composite anopheline fauna. Group *Anopheles* is well represented, and includes a considerable number of species living at high altitudes and of species breeding in holes in trees. Subgenus *Myzomyia* is represented by all the groups except *Cellia*. *Paramyzomyia* (*A. turkhudi*) occurs, however, only in the west, and is probably indicative of Mediterranean influence. *Pseudomyzomyia* is strongly represented by some of the most prevalent of all species. *Neocellia*, of which there are a large number of species, is a predominant group and almost peculiar to the region †. Group *Myzomyia* is rather poorly represented compared with the number of species of this group in the Ethiopian Region, the Oriental Region being richer in species of this group to the west, where it is reinforced by several forms belonging to what is referred to later as the Indian element in the fauna.

The boundaries of the Oriental Region as given by Wallace extend from the Indus along the Himalayas and through the mountains of South China to include South and East China as far north as Shanghai, and including Formosa, the Philippines, and the Malay Archipelago as far as a line passing east of Bali and west of Celebes. He recognizes four subregions: (1) Indian, including the greater part of India; (2) Ceylonese, including India south of Mysore and Ceylon; (3) Indo-Chinese, including Burma and South China, with an extension westwards along the Himalayas; and (4) Malayan, including the Malay Peninsula from Tenasserim, with the remainder of the area as already outlined. Sclater's boundaries and subdivisions are generally similar, but he includes country west of the Indus in the Indian subregion, with an extension through Baluchistan to the head of the Persian Gulf, and does not recognize a separate Ceylonese subregion. Celebes is placed in the Oriental instead of in the Australian Region, but as a separate subregion.

* *A. dthali* is, perhaps, to be regarded as an exception; its distribution is essentially eastern Mediterranean, but it extends southwards along the dry east coast of Africa as far as Somaliland, as well as eastwards into Baluchistan.

† Outlying species are the two referred to in the Ethiopian Region and the superficially very distinct Mediterranean *A. superpictus*.

Sclater's boundaries and subdivisions appear most in accord with distribution of Anophelini, but the Oriental area as given above should be extended to include China as far north as Pekin; South Japan; the Lesser Sunda Islands as far as the most eastern island, Roma; and to some extent the Moluccas.

As regards subregions, the Indian area under review lies mainly in the Indian and Burmo-Chinese * Subregions of Sclater. Only Tenasserim (in which few collections have been made) comes within the third or Malayan Subregion. The distinction, however, as regards Anophelini, between the Indian and the Burmo-Chinese Subregions, is not very marked, though in one or two cases some indication of their distinctness is given (*e. g.* the distribution of type-form *A. jeyporiensis* and of var. *candidiensis*). Blanford includes from the base of the Himalayas to Cape Comorin, with the exception of the Malabar coast and with the addition of North Ceylon, in his "Indian" area, and recognizes a Malabar or Ceylonese area which includes the Malabar coast and the neighbouring hills as far north as the Tapti River and southern Ceylon. Here again it is difficult to recognize any distinct difference in the anopheline faunas of the two areas.

Anopheline Fauna of the Indian Area.

On the whole the fauna of the Indian area appears to change somewhat gradually from east to west, and this change is clearly largely correlated with rainfall. A large part of the Indian Subregion of Sclater differs from country more to the south and west in showing, as one proceeds west, a progressive reduction in rainfall amounting eventually to actual desert conditions. In addition, new elements appear, as one proceeds further and further west, which modify to some extent the Oriental type of the fauna. Out of a total of 42 species and 10 varieties of these, 22 species and 2 varieties are widely distributed Oriental species extending into the Indian area, and one can only regard them as Oriental forms without any special reference to any of the subregions of the area discussed above. Two further species and four varieties of these may be termed of Oriental Alpine type, being forms which are found at high altitudes in a number of widely separated parts of the Oriental Region. Many of these species, however, have a distribution which does not extend to the western border of India, and some extend only a short distance, being recorded only from the more eastern or, sometimes, the more eastern

* Practically identical with Wallace's Indo-Chinese Subregion.

and southern portions of the Peninsula. There is thus a falling off in Oriental species from east to west, but this falling off is less marked as regards the still heavily forested area of heavy precipitation in Malabar and Ceylon, thus in part giving rise to the differences which might lead to these being considered as in some degree special. This falling off is made good by the appearance of a number of species which have an Indian distribution and are not eastern Oriental forms, and finally there appear species which are definitely transgressive from the Mediterranean area (see "Tabular Statement of Species," p. 56).

The Oriental Element.

No species having a wide Oriental distribution east of the Indian area has been recorded west of approximately the N.W. Frontier of India; only a small proportion, as will be seen from the table, extend so far. The western limit of the majority of these widespread Oriental species is such as to include Burma, Assam, Bengal, Bihar and Orissa, Madras, Ceylon, Bombay, and usually the Central Provinces—in other words the south and east of the area. The limit is very commonly an oblique line bisecting the Indian Peninsula and running in a south-west to north-east direction from about the Gulf of Cambay to the Himalayas.

Some species have not been recorded from the Central Provinces nor even from Northern Madras, and in this case there may be an apparently discontinuous distribution, the species occurring in Assam, Burma, and Bengal and in South or South-West India, but not in the intervening area. Such apparent distribution may, however, as more collecting is done, be shown to belong to the first type.

One or two species have only been recorded in the eastern parts of the area, and do not, apparently, extend into the Indian Peninsula.

These types of distribution are probably largely determined by the physiographical and meteorological features. Forest- and shade-loving species are likely to be restricted to the heavily forested and uncleared tracts, and thus show a continuous or discontinuous distribution in the east and south and in the area of heavy precipitation on the west coast. Forms less dependent on uncleared forest extend as a rule to about the limit noted above, when conditions for rice-field breeders etc. become much less favourable owing to a lower rainfall and more highly desiccated or desert regions. The Oriental element is then reduced to a relatively few species which still find suitable conditions, such as the foothill species and the monsoon species *A. subpictus*. Most of the typically Oriental species tend to become scarce even before

the limits of their actual distribution are reached. The hill species, on the other hand, tend to pass far to the west, the conditions along the foothills of the Himalayas, and even the drier hills of the North-West Province and Baluchistan, being relatively favourable to them. For such species the north-western limits extend at least as far as the Hindu Kush (Chitral).

Alpine Oriental species occur in the highlands, usually at altitudes of from 3000–8000 feet, especially in the south of the peninsula, in the Himalayas, and in the ranges of Assam and Burma. They may show on this account markedly discontinuous distribution, and they occur in the form of local varieties, usually a South Indian and a Himalayan form, whilst in the case of *A. gigas* there is also a distinct form in the east and one in Ceylon. In the north-west *A. gigas* var. *simlensis* has been recorded from hill-stations as far west as Rawalpindi, and *A. lindesayi* from various localities as far as Chitral and to the south in the ranges of the N.W. Frontier Province and Baluchistan. In the east *A. gigas* var. *baileyi* is recorded from Tibet and Central China.

Rightly included in the Oriental fauna are certain species and varieties which are forms of, or closely resemble, Oriental forms, but have a distribution more or less restricted to the Indian area. Among such is *A. pallidus* * which is particularly common in the Central Indian area. *A. theobaldi* is very close to *A. maculatus* and can only be regarded as Oriental in type, though its area of chief prevalence is also Central India. *A. majidi* is also a species which is best regarded as part of the Oriental element in the fauna, though it is not recorded east of India. *A. varuna* may possibly be considered in this category.

Further, there are certain forms with very localized distributions that may be regarded as indigenous species, and so also rightly considered as a part of the underlying Oriental element. *A. culiciformis* and *A. sintoni* are recorded only from the Malabar forest area, and appear to be highly indigenous forms peculiar to Malabar. *A. annandalei* is recorded from Eastern Bengal and Assam and also Ceylon. *A. barianensis* resembles the Palæarctic *A. plumbeus*, but is quite distinct; it has a distribution limited to the North-West Himalayas. It might be considered as exhibiting Palæarctic influence, but is better regarded as an indigenous (Oriental) species. All the above are tree-hole breeders.

If the various types of species referred to above are all included in the Oriental element, then 32 species and 10 varieties in the Indian list come under this category.

* This species has been recently recorded from Java.

The Indian Element.

Among species with an Indian distribution some have already been dealt with as more or less local developments in the Oriental element, or as indigenous Indian forms which should, in the absence of reasons to the contrary, be regarded as local developments of the Oriental element.

There remain certain species which do not conform in their type of distribution to the general Oriental plan and, from the nature of some of the species at least, may be regarded as to some degree a foreign element. It is characteristic of these species that they extend usually far beyond the western frontier and are found in Arabia, Turkestan, etc. It seems certain that their centre of prevalence is more westerly than that of the ordinary Oriental form, and they are here referred to as Indian. *A. culicifacies* is an extremely common species throughout the whole of India, Burma, and Ceylon, but is unknown further east, except from Siam. It has been recorded from Arabia (Muscat and Aden). *A. fluviatilis*, which occurs, along with *A. minimus*, in the more eastern areas, is found without the latter species up to the extreme north-west limit of India and in Turkestan. A variety or closely related species (*A. arabicus*) is recorded from Muscat. *A. moghulensis* has a distribution very similar to *A. fluviatilis* except that it does not extend so far east and is not recorded from Arabia; it is a distinctly western form not found in the east and south. *A. stephensi* is unknown in the Malay States, French Indo-China, Siam, Dutch East Indies or China. It occurs in India from Burma to the North-West Frontier, and in Mesopotamia to the borders of the Arabian Desert (Kerbela). *A. turkhudi* has a fairly wide distribution over the north-west of India and Baluchistan. It appears to be the species described by Patton from the Aden Hinterland as *A. azriki*, and is closely related to the Mediterranean species *A. hispaniola* and *A. italicus*, also to *A. flaviceps* of the Sudan and *A. multicolor* of the Saharan area.

The Mediterranean Element.

A. pulcherrimus has a distribution somewhat transitional between that of most of the Mediterranean species in the Indian area and that of the species that have been referred to as constituting the Indian element. It has a fairly wide distribution in India, extending as far east as the western United Provinces, and occurs in Sind, but it cannot be considered other than eastern Mediterranean, since it occurs widely in Turkestan, Mesopotamia, and the Caucasus.

A. superpictus has a more extended distribution than the last-mentioned species in the Mediterranean area, but a less

extended one in India. This species is a hill and mountain species and is distributed in the main accordingly ; *A. pulcherrimus* is specially associated with the large alluvial basins (Indus, Oxus, Tigris) which lie about the great Persian and Afghanistan plateau. Both species represent the Turko-Iranian type of distribution.

A. sergenti and *A. multicolor* are also Mediterranean species occurring in the Indian area ; they represent the North African type of distribution.

Tabular Statement of Species and Varieties of the Anopheline Fauna of the Indian Area, grouped according to considerations of geographical distribution.

A. ORIENTAL ELEMENT.

1. With a wide distribution in the Oriental Region to the east and extending into the Indian area.

   a. With a wide distribution in India, extending to the North-West Frontier or nearly so.

   A. barbirostris. — *A. maculatus.*
   A. annularis. — *A. splendidus.*
   A. hyrcanus var. *nigerrimus.* — *A. subpictus.*

   b. With a more restricted distribution, but extending into the peninsula and recorded east and south.

   A. aconitus. — *A. minimus.*
   A. aitkeni. — *A. philippinensis.*
   A. insulæflorum. — *A. pseudobarbirostris.*
   A. jamesi. — *A. tessellatus.*
   A. karwari. — *A. vagus.*
   A. leucosphyrus.

   c. Recorded in the east only (Burma, Assam, Bengal).

   A. aitkeni var. *bengalensis.* — *A. kochi.*
   A. hyrcanus var. *sinensis.* — *A. sundaicus.*
   A. jeyporiensis var. *candidiensis.* — *A. umbrosus.*

2. Species or varieties with an Indian distribution only, but nearly related to Eastern Oriental species.

   A. annandalei and var. *interruptus.* — *A. pallidus.*
   A. jeyporiensis. — *A. ramsayi.*
   A. maculatus var. *willmori.* — *A. theobaldi.*
   A. majidi. — *A. varuna.*
   — *A. barbirostris* var. *ahomi.*

3. Indigenous species with localized distribution in area.

   A. barianensis. — *A. sintoni.*
   A. culiciformis.

4. Oriental Alpine species.

   A. lindesayi and var. *nilgiricus.* — *A. gigas* and varieties.

B. INDIAN ELEMENT : species with a western Oriental type of distribution.

   A. culicifacies. — *A. stephensi.*
   A. fluviatilis. — *A. turkhudi.*
   A. moghulensis.

C. MEDITERRANEAN ELEMENT : species with a Mediterranean distribution recorded from the Indian area.

   A. dthali. — *A. sergenti.*
   A. multicolor. — *A. superpictus.*
   A. pulcherrimus.

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See also Bibliography, list D, at end of volume, and references given in sections on distribution under each species. The latter, if not in list C (Systematic), will be found briefly specified in list D (Distribution). For distribution in India the three works by Covell, quoted above, give a complete summary up to date, and for the numerous references to Indian records of localities Covell's bibliography, which is too lengthy for insertion in this volume, should be consulted.

V. PHYLOGENY.

No Anophelini occur among the known fossil forms of mosquitoes. No direct evidence on phylogeny therefore exists, but some indication of the evolutionary history of the tribe appears to be given by studies on its classification and distribution.

The hypopygial characters show only certain stems, none of which appear to meet in intermediate forms. Evolution in the stems appears to have been in the general direction of increased scaling and ornamentation, development of pharyngeal armature, an increase in the number of long pleural hairs in the larva that are feathered, and a change from a lanceolate palmate leaflet to one with a shoulder and a terminal filament. Along with these progressive changes are others of a retrogressive nature, such as reduction in the number of the propleural hairs of the adult and loss of the branched antennal hair of the larva.

Subgenus *Anopheles* appears to be the oldest of the predominant subgenera, not only on the above criteria, but by reason of its world-wide distribution and the greater diversity and distinctness of its forms; almost every species of the subgenus appears to be as distinctive as are the groups in subgenus *Myzomyia*, if not more so.

Nyssorhynchus appears to be a Neotropical development from some pre-*Anopheles* form, whilst group *Arribalzagia* appears to be a highly specialized development of subgenus *Anopheles*.

Myzomyia shows every evidence of being a new and actively disseminating branch, as is suggested by its complete absence from the New World. Had it been once disseminated throughout North America it is unlikely that it would have been eliminated from the whole continent so completely as to leave

not a single species in this area, though there is no actual proof that this did not occur. The apparent affinity between the group *Neomyzomyia* and subgenus *Nyssorhynchus* suggests an intermediate ancestor, though not necessarily one in the south, *i. e.*, such affinity does not prove or suggest a land-connection between Australia and South America, as the common ancestor may have been derived from the north and later eliminated.

From the affinities and geographical distribution of the different groups and the known history, based on fossil remains, of the mammals, forming components of the same faunal systems as these mosquitoes, it seems not unreasonable to hazard at least a suggestion of the probable history of the tribe.

The date of isolation of South America, judging by the history of mammals, would be from the middle of the Eocene, when connections between North and South America were severed, until the end of the Pliocene (*Zittel*). The anopheline fauna, therefore, arose from elements which pre-dated this period, and there were already subgenus *Anopheles*-like forms, as well as some earlier type from which *Nyssorhynchus* arose.

At some unknown period a similar special development took place, resulting in an early form (*Neomyzomyia*) of subgenus *Myzomyia*. This form appears to have once been distributed throughout the Oriental, Ethiopian, and Australian Regions, and to have later undergone some regression, eventually remaining in greatest strength in the Australian Region.

Edwards, in reviewing the fossil remains of mosquitoes, notes that probably all the main divisions of the family existed in Mid-Tertiary times much as they do to-day, and with almost identical characters, and considers that, though no fossil *Anopheles* have been found, there can be no doubt from its morphology that this is also an old genus, probably older than any culicine form. This receives support from the above.

Nevertheless, there is some evidence suggesting that some features in the distribution of the Anophelini are of relatively late period, *i. e.*, at least as late as the Pliocene. If we regard *Neocellia* as having a history comparable with that of the mammalian element of the fauna of which it now forms a part in the Oriental Region, its most probable origin would be from the Miocene fauna (Malayan fauna of Suess), which once extended over Europe and North Africa, and those few species found in Africa would be still more fragmentary remains of this fauna. Similarly, group *Myzomyia*, regarded as the equivalent of the existing mammalian African fauna

would be derived from a Pliocene fauna which once spread over the Mediterranean and far into the east (*Hipparion* or Siwalik fauna). Some of the distributional features must at least be relatively recent, since large tracts in the Middle East, now with an abundant anopheline fauna, were widely submerged in the Miocene. There seems little doubt, however, of the antiquity of the early stems.

Bibliography.

For an account of the geological history of faunas and information on fossil forms of Culicidæ, see Suess, 'Face of the Earth,' iv, p. 647, 1909; Zittel, 'Text-book of Palæontology,' iii, p. 290, 1925; Edwards, Quart. Journ. Geol. Soc. lxxix, p. 153, 1923; Christophers, Ind. Journ. Med. Res. vii, p. 715, 1920, and xvii, p. 528, 1929.

VI. BIONOMICS AND RELATION TO DISEASE.

Metamorphosis and Early Stages.

Only a very brief reference is possible in a volume of this nature to the very large amount of work that has been done in relation to the bionomics of Anophelini, and the part they play in the epidemiology of malaria *.

The eggs are laid either singly and directly upon water, or heaped up on the bank or some floating object. When first laid, the eggs are white, but they darken rapidly, and in a few hours become a deep black. Premature or unfertilized eggs may remain white and do not hatch. When laid directly on water, or when the heaped-up eggs are placed on water, they form patterns, due to the action of surface tension and the shape of the egg. Where the egg is broad and oval, with prominent floats, they tend to come together in sets of three eggs, with their poles approximated, forming triangles or larger groups of stars or six-rayed hexagons. Where the egg is longer and straighter, or where it has a very broad frill or lacks floats, many, or all, the eggs become arranged side by side, forming straight or curved ribbon-like groups. When floating free the eggs tend to accumulate at the edge of the vessel or bank, and are drawn up on the meniscus with the narrow end upwards and the broader end, due to its greater weight, downwards.

Hatching under normal conditions in the tropics usually occurs in about 48 hours, but may be delayed. Eggs up to about 12 hours after deposition are susceptible to desiccation,

* A bibliography on this enormous subject would be impracticable in a work of the present size and scope; for references to work in India consult the bibliography given by Covell in his Memoir on distribution. Actual references in the text under the different species are, however given in section E of the Bibliography.

and do not hatch if dried and later placed on water. After development has proceeded for 24 hours or more, even though they are wrinkled, eggs hatch, usually after some delay, when placed on water, if the period of desiccation has not exceeded about 48 hours. Eggs kept moist but not on water do not hatch, but remain viable for periods up to 10–16 days, and hatch almost at once on being placed on water. Cold delays hatching, and below certain temperatures (about 60° F. in some species) the eggs do not hatch unless the temperature is raised. Eggs may be kept at low temperatures (in ice), in some cases for long periods, without affecting their ultimate hatching.

The larva escapes by a spiral cut or break, forming a cap at the thick end of the egg, probably produced by the action of the egg-breaker and rotation of the head. The break is mainly on the lower surface, and the cap is left attached mainly by a portion of the deck. Larvæ, when hatched on wet blotting-paper or a floating leaf, etc., crawl, especially downwards, to reach the water.

The whole period of metamorphosis from oviposition to emergence of the adult usually lasts under favourable conditions in the tropics from about 13–19 days, but may be as short as 9–10 days in exceptional cases, or longer, with certain species, under unfavourable conditions or low temperature. The larval period may, under favourable conditions, be 8–9 days, or extended to a month or more under low temperatures or unfavourable conditions in regard to food. In species breeding in tree-holes the time may be very variable; Hacker records larvæ of *A. asiaticus* as living up to 163 days without pupating, though eventually emerging as adults. The first three instars last about 2 days each, the last instar being about twice as long.

The larva usually lies at rest at the surface, with the caudal end against some object, and the body directed at right angles to this, the position being largely maintained by physical forces. When disturbed, the larva either swims backwards in a series of wriggling, zigzag, or scuttling movements of the body, allows itself to sink, or swims rapidly downwards, tail first, to the bottom or to a considerable depth if in deep water. Young larvæ are usually less readily alarmed than older larvæ, which may be extremely alert, and sink, even as the result of tremors of approaching footsteps in some cases. Larvæ when disturbed may remain inert, and apparently dead, at the bottom, or hanging by their tail-hooks to the sides of a tank or vegetation up to 20 minutes or more, but usually they return after a minute or so to the surface and immediately swim to shelter. In running water they may attach themselves by their caudal tail-hooks to

maintain their position. They may sometimes remain beneath the surface attached to confervæ on stones or to vegetation, apparently respiring in this position.

Feeding takes place usually whenever at rest and undisturbed at the surface. The head is rotated to bring the ventral surface uppermost, and contact is made with the surface film by the maxillæ and submentum. The brushes are then worked rapidly and rhythmically, setting up a shallow surface current under the surface film directed to the head of the larva from in front. The current impinges against the closed mandibles and is shot out from the outer surface at right angles on each side of the head. As the current passes through the mouth it is combed by the maxillæ, which are in constant vibratile movement. After accumulation of a certain amount of solid matter in the mouth this is passed in a bolus into the œsophagus. Particles as small as bacteria are removed from the stream.

The food of larvæ is of a miscellaneous character, consisting of formed and unformed organic matter. With this is usually included a considerable amount of small spicules of silica and particles of other mineral matter. The formed material consists of unicellular algæ, flagellates, ciliates, and other floating vegetable and animal life. The nature of the brown amorphous unformed material that forms a considerable proportion of the food is not known. Larvæ may be reared on pure cultures of *Euglena*, yeast, etc. Where the water is especially shallow, larvæ of some species may browse at the bottom on organic particulate matter.

Change into the pupal stage occurs suddenly in full-grown larvæ after a short period, during which these cease to feed and rest at the surface, usually hanging down a little from the surface film in the attitude of an *A. turkhudi* larva. The pupal stage usually lasts in the tropics for 36–48 hours. Lamborn has never observed prolongation of this stage as of the larval period. At low temperatures, and especially with large species, the period may be longer (8 days in *A. gigas* in cool weather in the hills). The pupa, more frequently than the larva, may remain anchored to stones, etc., beneath the surface; they also tend to secrete themselves amongst vegetation and under rocky ledges, etc.

Emergence of the adult usually occurs in the tropics in the evening or at night before 11 P.M., but in cold climates emergence is usually at some time during the day. The proportion of the two sexes emerging is always about equal, with a slight preponderance of females. Sex has been supposed to depend to some extent on the food-supply of the larva, but this is almost certainly not so, as the sex is already detectable in very young larvæ.

Breeding Places.

The sites where larvæ are found breeding in nature are known as breeding places. The nature of the water forming breeding places is of a very varied character, but the collections are either small in extent, *e. g.*, pools, puddles, tree-holes, or have shelter provided by vegetation, *e. g.*, swamps, river-margins, rice-fields, etc. Only few species are sometimes found in foul or much polluted water. A certain number of species have the power of breeding in brackish water and some (*A. sundaicus, A. multicolor*) have an actual preference or normally breed in such water.

Different species may show predilection for certain types of breeding place (*selective breeding*). This predilection is not always according to the actual type of breeding place, but depends upon some requirement that may be present in several types. To ascertain what the actual requirements are, the physico-chemical characters of the water of breeding places have been much studied. With the same object the extent to which different species are found breeding together has been investigated (*association*). Similarly there exist many œcological studies of breeding places dealing with favourable and unfavourable vegetation, etc.

Selective breeding and association do not appear to be directly related in any degree to the physico-chemical characters such as hydrogen-ion concentration, dissolved oxygen, albuminoid nitrogen and absorbed oxygen, etc., though they may show an indirect relationship. Gater and Rajahmoney have analyzed breeding places in the Federated Malay States under the categories of swamps, ponds, rice-fields, streams, drains, seepages, wells, pools, sumps, artificial containers, hoof-marks, cut and bored bamboos, and miscellaneous. A better classification to bring out selective breeding habits of species would be one where such categories are subordinated to general œcological conditions and, in particular, one taking note of the surroundings. To classify breeding places logically is, however, very difficult, and no really satisfactory classification or method of setting these out has yet been given. The commonest breeding places of Indian species are given below, with the chief species found breeding in each general type. For more detailed information the note on habits under the species name in the systematic part of this volume should be consulted.

Indian breeding places differ from those that are prominent in Gater and Rajahmoney's series, notably in the relatively small importance of the heavy jungle and sea-coast type and the much greater frequency and variety of the seepage, rock and sand group and breeding places on alluvium. This is obviously due to the many large sandy and rocky river

beds and mountain torrents and nullahs without much vegetation in India, and to the very extensive alluvial plains of India, with the ubiquitous excavations about the villages and the great development of irrigation in the north-west associated with semi-desert conditions.

Chief Types of Breeding Places in Indian Area, with Species of Anopheles *most commonly found therein.*

A. Forest and deep jungle.

a. Pools, drains, streams, and backwaters.
A. aitkeni, leucosphyrus, umbrosus.

b. Tree-holes, collections in roots of trees, and cut stumps.
A. culiciformis, sintoni, annandalei.

B. Open vegetation or grass-covered stagnant waters.
A. barbirostris, hyrcanus, annularis, jamesi, philippinensis.

a. Swamps, drying rivers, bhils, khals, jheels.

b. Lakes, reservoirs, tanks, ponds, moats, large open wells.

c. Deep stagnant drains and ditches, stagnant river margins, stagnant weedy pools in river beds.

d. Grassy pools, *Casuarina* pits.

C. Rice-fields, fallow rice-land.
A. hyrcanus, pallidus, annularis, splendidus, jeyporiensis.

D. Open, slowly running water, river margins, streams with grassy edges, jhoras, flowing drains, and drainage channels.
A. minimus, maculatus, jeyporiensis.

E. Canals, irrigation channels, irrigation pools, leaks, and overflows.
A. culicifacies, subpictus.

F. Water in connection with rocks, sand, and seepage.
A. maculatus, stephensi, fluviatilis, splendidus, karwari, culicifacies, moghulensis.

a. Pools in rocky river, stream, and torrent beds, pools in sandy river beds and nullahs, leaks below reservoirs.

b. Seepages, water in cuttings, swampy and marshy land, springs, spring-fed pools and trickles.

G. Water collections on earth and alluvium.
A. subpictus, vagus, stephensi, culicifacies.

a. Collections of rain-water, water-filled excavations, borrow-pits, brick-fields, buffalo wallows, roadside pools, quarries.

b. Collections in ditches, drains, waste water.

c. Puddles, hoof-marks, cart-ruts, water-filled furrows, leaks from pipes or taps.

H. Artificial collections.
A. stephensi, subpictus, vagus.

a. Cement reservoirs, cisterns, fountains, collections of water used in buildings, flooded cellars.

b. Collections in barrels, tubs, pots, machinery, roof-gutters.

c. Wells, house-wells, irrigation wells.

Habits and Behaviour of the Adult.

Adults of many species are to be found in cattle-sheds and unoccupied disused rooms, where they are to be captured, often in large numbers, resting on the cobwebs, on and among thatch where it is dirty and sooty, among dung-cakes, in grain receptacles resting on chaff, sheltered behind stored agricultural implements, and suchlike situations. They are usually less numerous in occupied rooms, as the type of shelter is less suitable, and they are liable to be driven out in the early morning by smoke.

Males are not attracted, when seeking shelter to the same extent as the females, by the presence of man or animals, and tend to shelter elsewhere; they are also liable to die off more rapidly, at least in the drier climates. Probably, for these reasons, catches of adults in houses and cow-sheds usually show a great preponderance of females.

Such species as are found resting in houses and cattle-sheds, and very often breeding not very far from habitations, are frequently referred to as "domestic" species; those found almost entirely in forest or jungle, which attack man (when they do so) only in their own native haunts, are commonly called "wild" species. Some species are intermediate in character and enter houses to feed, but leave before the morning, and shelter during the day in the jungle or undergrowth.

A large proportion of the species in the tribe have been observed to feed on human or animal blood in nature or experimentally, or to have been caught engorged with blood. Almost all the Indian species have been so incriminated; even wild species frequently attempt to feed in the shade of the forest or near their breeding places. Domestic species usually feed by night or at dusk, but may do so, especially in warm weather, during the day.

Certain species are more especially associated with cattle; others show a relatively greater tendency to be found in houses (*house-frequenting species*). The term *zoophilism* has been given to a condition much studied in Europe, where different races of *A. maculipennis* are recognized, some showing a marked preference for cattle-blood as against human blood. This was at one time believed to be the result of selective breeding, where large numbers of cattle are permanently stabled under certain conditions, but is now recognized as due to the occurrence of varieties of *A. maculipennis* differing in regard to their associative habits with man and cattle respectively. Protection may be brought about through the presence of cattle, which attract *Anopheles* and reduce the number feeding on man (*deviation of Anopheles*). Whether

cattle protect, or to what degree they do so, in Indian conditions is uncertain.

Anopheles do not remain every night in the shed or room in which they have rested during the day, but appear almost nightly to change their resting place, so that the anopheline population of any particular room or shed is perpetually changing, and infected *Anopheles* are as likely to be found in a cow-shed as in a human dwelling (*nightly turnover*).

The distance traversed by Anophelini from their breeding places in search of food may be considerable, but usually does not exceed about a quarter of a mile. In open country distances of several kilometres have been recorded as traversed under some circumstances. There appear to be authentic instances where *Anopheles* have appeared on ships at a distance of some miles from shore. Some species appear to be stronger fliers than others. Besides active dispersal in this way, Anophelini are frequently carried considerable distances by trains, steamers or vehicles (*passive dispersal* or *conveyance*).

In captivity in the tropics Anophelini do not appear to mate very readily, but fertilization occurs usually if freshly hatched males and females are left together and the latter allowed a blood meal; better results, according to MacGregor, are obtained if suitable food (raisins or glucose solution) be given also to the males. Fertilization of the female appears to occur in nature under Indian conditions on the first or second night after emergence, as all females caught in houses or sheds, except those evidently newly hatched, show spermatozoa in the spermatheca. Swarming of males has been described in Europe, West Africa, Egypt, and the Philippines ("*rossii*"), but not, so far, in the Indian area, though it probably occurs. Fertilization probably occurs, apart from swarming in the open, in houses or sheds.

In the case of domestic species in the tropics, blood is taken very early—as a rule by the second night at least—and the ovaries begin a rapid development, which may be completed in some five days. An even shorter time is required for subsequent batches of eggs owing to the second follicle undergoing preparatory development before the eggs of the previous follicle are laid.

When the ovaries are approaching maturation the female ceases to feed and digests all the blood in the gut. On reaching this stage they leave the village to seek suitable places for oviposition. Following successful oviposition, they may return again to the same or some other source of blood-supply. Oviposition under artificial conditions usually occurs some time during the night. The female

fixes the anterior legs upon the sides of the vessel or other support and lowers the body, with the wings folded, horizontally towards the water, all the tarsi being flat on the water. Each egg is extruded abruptly upwards from the extremity of the abdomen. After remaining some seconds in this position the egg falls and another egg is extruded eggs are laid at a rate of about 6–10 per minute. Somewhat less than 100 are commonly laid, but the number may exceed 100 or, in some species, may amount to several hundreds.

Terrain, Season, and other Influences.

Type of country has a considerable effect in regard to the species encountered. India being very largely cleared of primeval forest, and lacking over most of the area the mangrove and *Nipa*-palm swamps of countries further east, species breeding in these conditions do not assume the same importance. The broad alluvial plains tend to show chiefly the common domestic and rice-field breeding species. The low hill tracts of the peninsular area have a somewhat different selection of species, whilst the high plateaus of the south and the Himalayas show a special alpine anopheline fauna not usually found below about 5,000 feet.

Seasonal prevalence in the southern areas is usually more or less constant throughout the year, depending on local conditions and rain. Over a large part of the Peninsula where conditions are less humid prevalence is greater during and following the S.W. Monsoon in July to September. In the north, and especially in the north-west, there is a reduction or virtual disappearance of adults, due to lowered temperature in the cold weather season. The latitude south of which, in the Indian area, lowered temperature ceases to play an important part in this respect appears to be about 27° N. Even in the north-west, however, some species continue to be found in small numbers in the cold season in the adult stage. True hibernation of adults has been recorded only in the case of *A. superpictus* in the Quetta area. The development of larvæ is much delayed, and some species pass the cold weather mainly in this stage (*wintering of larva*). Actual *hibernation* of larvæ in or under ice is not recorded in India, but Davys, at Quetta, records larvæ, obtained by warming frozen mud, which were believed to have come from eggs.

Altitude as such, up to several thousand feet, does not usually affect the occurrence of species beyond somewhat changing the physical character of breeding places. Most species of the Indian plains have been recorded up to considerable altitudes, but not as a rule above 5,000 or

6,000 feet. Hill-species may occur up to 8,000 feet or more, whilst the alpine form *A. gigas* has been recorded from the borders of Tibet at 11,000 feet, where Dr. Strickland observed it attempting to feed.

Relation to Malaria.

The data regarding the part played in malaria transmission by the species on the Indian list will be found fully set out in Covell's memoir and subsequent paper, from which sources all information on infectivity given in this volume has been taken. The following list shows the position regarding malaria-carrying species in the Indian area. Further particulars will be found under the different species in the systematic part of this work.

1. Important carriers wherever found :—

A. culicifacies. *A. fluviatilis.*
A. stephensi. *A. sundaicus.*
A. minimus.

2. Less important but proved carriers in some areas :—

A. varuna. *A. philippinensis.*

3. Species that are important carriers in other countries but of too limited distribution to be important in India.

A. superpictus. *A. multicolor.*

4. Species that have been found infected in nature or experimentally within or without the area, but which are probably not of importance as carriers :—

a. Found infected in nature in Indian area :—

A. maculatus. *A. maculipalpis.*
A. maculatus var. *willmori.* *A. pallidus.*
A. fuliginosus. *A. ramsayi.*
A. pulcherrimus. *A. vagus.*

b. Infected experimentally only in Indian area :—

A. theobaldi. *A. subpictus.*
A. turkhudi.

c. Found infected in nature outside Indian area only :—

A. hyrcanus. *A. umbrosus.*
A. barbirostris. *A. tessellatus.*
A. karwari. *A. aconitus.*
A. leucosphyrus. *A. kochi.*
A. sergenti.

The extremely common species *A. subpictus* and *A. vagus* appear to have little or no relation to the incidence of malaria.

VII. TECHNIQUE.

Collection.

Anophelini are very commonly obtained by rearing from the larva. It is well to collect especially pupæ and full-grown larvæ, as these give larger and finer specimens as a rule than are obtained by breeding out from younger larvæ in the laboratory.

In a small accessible breeding place, stir up the water to make it muddy and to wash out larvæ from shelter; the larvæ will be observed moving on the surface in their characteristic manner, and can be removed with a spoon. A cup held in the left hand is useful to collect a number of larvæ, which, after the excess of water has been poured off, are transferred to tubes. Tubes (corked specimen tubes, $3'' \times 1''$) are conveniently carried in a small wooden box tied up in a handkerchief, so that it can be carried about readily. Larvæ can be transported long distances in such tubes with moderate precautions; larger vessels usually lead to the larvæ being killed by the shaking. Larvæ are often collected by "dipping" with a white-bottomed dish or saucepan, which can be attached to a stick; or a muslin net is pushed through water in likely spots and inverted into a dish of water. Such methods are usually only necessary where the breeding place is less accessible. Eggs may be collected in some circumstances by covering the hand with a muslin bag and sweeping through the water in likely spots, or pouring water through the muslin and examining with a lens *.

Anophelini are also commonly captured as adults whilst resting during the day (see section on "Bionomics"). They are usually found on the upper parts of the room or on the ceiling. When occurring, as they often do, among thatch, they are difficult to find until disturbed, when they may be caught on the wing with a small hand-net, or their position on settling noted for capture. When seen, capture by placing a test tube *slowly* over them. Various mechanical devices for facilitating capture of numbers of specimens have been employed, but for the entomologist the use of tubes, preferably one per mosquito, is probably the most satisfactory.

Wild species are to be caught in the jungle by sitting quietly and capturing any specimens which settle in an attempt to feed. At night *Anopheles* may often be found sitting near an illuminated patch of wall or captured on an illuminated sheet, etc.

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* A method recently employed by Barber in Macedonia (Hackett, private communication).

Males are best obtained by rearing, as they are not so frequently found in houses and do not feed on animals; sometimes they may be taken in the open with a net while "swarming."

Rearing.

In the laboratory larvæ and pupæ collected in the field should be emptied out into dishes and the pupæ removed with a spoon or pipette to jars covered with mosquito-netting. Only a small depth of water is necessary in the jar, and some grass clipped with scissors into short lengths helps to distribute the pupæ and to give foothold to the emerging mosquitoes; or pupæ may be placed with some chopped grass in dishes, and allowed to hatch out in small nets, which latter may be made by binding together some squares of wire to make a frame, and covering with a bag of mosquito-netting, the mouth of the bag forming a sleeve (fig. 13, 1). The larvæ should be placed in open dishes, preferably in a good light or direct sunlight, until they pupate; if small, they should be dealt with as described below.

Anophelines to be bred out from the egg or from very early larval stages thrive best in uncovered large petri dishes (12″). These are filled with water, a small wad from a stock of *Spirogyra* added, and a small grass-tuft with roots placed in the middle.

To obtain eggs, select some fully gravid females and transfer each to a small lamp-glass, of which the upper end is tied over with netting and the lower end placed over a small cylindrical dish nearly fitting the bottom of the lamp-glass, and containing water in which is floating a paraffin-coated cork ring (fig. 13). The cork ring should be of such a size that it is held by the meniscus; this greatly facilitates examination of the eggs *in situ* under the microscope. A piece of paper or cardboard placed in the lamp-glass gives foothold to the mosquito *. The eggs can be transferred *en bloc* to a large petri dish as described above for breeding out.

Killing and Mounting.

After hatching, anophelines should be left as long as possible to harden before killing and mounting; if left overnight,

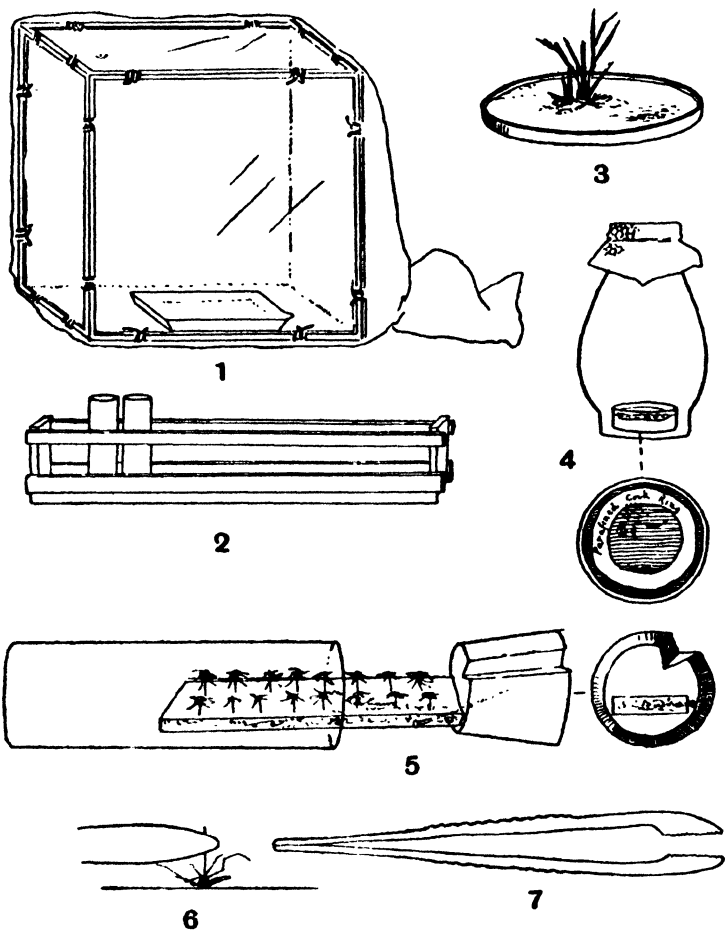
* Or use a wide-mouthed stoppered bottle with a hollow flat-topped stopper. A piece of card is thrust in the inverted bottle and the stopper filled with water in which a paraffined cork ring is floated.

Several females are said by Perry to lay more readily than one (private communication). Shute has found that a fully gravid female may be induced to lay by the following method:—Place in a thin test-tube and sharply tap the tube against the base of the thumb about eight times, stunning the insect; gently remove a wing, and transfer insect to water as above.

however, especially in a tube or jar, they badly rub the tips of their wings.

When hatched in a jar, the mosquitoes are removed by placing another jar upside-down over the breeding-out jar, slipping out the netting cover, and allowing any mosquitoes there may be to fly into the upper jar; facing towards the

Fig. 13.



1. Frame formed of wire squares, bound together, covered with mosquito net bag, for breeding-out mosquitoes. 2. Rack for holding specimen tubes for isolating larvæ, etc. 3. Large petri dish as used for breeding from the egg or young larva. 4. Lamp-glass prepared for obtaining eggs; below is shown the small glass vessel with paraffined cork ring. 5. Prepared mosquito tube, showing position of cork strip, etc. 6. Method of holding pin when pinning mosquito. 7. Mosquito forceps used in the Malaria Survey of India.

light facilitates this. Two pieces of cardboard are then inserted between the jars, the upper jar removed with the upper sheet of cardboard, and the lower, temporarily protected by the lower sheet, again tied over with netting. When the mosquitoes are to be killed, the cardboard on the upper jar is replaced with a piece of cardboard having a hole plugged with wool, on which chloroform is dropped.

If hatched into a net, the mosquitoes are first collected in test tubes and either killed in these or transferred for killing to a jar. To transfer, use a cardboard sheet over the jar, with a hole plugged with wool, insert the tubes, and shake or allow the mosquito to fly out, or a hole may be made in netting tied over the jar.

To kill, pour a few drops on the wool plug of a test tube, or a fairly large quantity in the case of a jar. An excess of chloroform may distort and stiffen the legs and wings and make mounting less easy. The anophelines should die so that, when turned out, they lie with legs and wings extended. It is a good plan, as a routine after mounting, to replace the specimens for a time in a jar containing chloroform-vapour to ensure death. All glass vessels used should be free from dust.

Turn out the dead mosquitoes on to a piece of paper or Bristol-board. If it is not already in this position, turn an insect on its back and insert a fine pin (Taylor's no. 3 double-pointed nickel *) in the middle point between the coxæ where these all lie close together ventrally. The pin is best held strictly at right angles in a blunt-nosed forceps †, and inserted as nearly as possible vertically downwards until it just meets the Bristol-board; there is no advantage in pushing the pin in further. Retaining hold of the pin with the forceps, and using the other point, set the specimen in its place on the labelled cork strip of a mosquito tube, previously papered as described below, if necessary giving a touch to the wings so as to spread them. Care should be taken in the original pinning, chiefly because, if the pin is well placed, a good subsequent display of the insect follows automatically.

For collecting in the field, "prepared mosquito tubes" should always be used. These are made from corked specimen tubes, 3″ × 1″, with good selected corks. The cork has a small

* Nickel pins should be used if obtainable, as silvered pins corrode in time and spoil the specimen. In place of nickel pins stainless steel pins may be used (no. 1 stainless steel points, obtainable from W. H. Janson & Son, 48 Great Russell Street, London, W. 1).

† Preferable to the ordinary entomological forceps for mosquito work is a blunt-nosed straight forceps usually known in India as "mosquito forceps" (fig. 13, 7).

wedge cut out at one side to prevent the tube, when corked, being completely sealed, a condition which greatly favours mould. On the cork is pinned, as shown in fig. 13, a strip, 3″×$\frac{3}{4}$″, of papered cork * ; this should be pinned on the bottom a little towards one side of the cork. It should be held whilst being pinned slightly slanting outwards, so that it lies, when inserted, close to the glass. A single pin is used, pushed in by the flat end of a pencil, and gives ample support if properly inserted ; two pins make it difficult to remove the strip later when required. In order to guard against curling of the cork strip (with consequent damage to the mosquitoes by pressure against the sides of the tube), it may be desirable to insert a strong pin at right angles to the cork at the end of the strip, this pin being cut to the length of the internal diameter of the tube. A tube should hold ten or more mosquitoes. After mounting the mosquitoes, a little plug of wool is loosely inserted into the wedge-shaped cut in the cork and, if in a damp climate, a drop of pure liquid carbolic is placed on the wool. The tube is finally wrapped in a piece of wool, 5″×4″, secured by a twist of the thumb and first finger round the tube.

In the laboratory the cork strips are removed from the tubes and pinned in the collection. When finally examined, any specimens desired are removed and transferred to other cork strips or, if to be mounted singly, to small individual strips of papered cork, $\frac{7}{8}$″×$\frac{1}{4}$″, transfixed at one end by a pin (Taylor's no. 16 silvered). Celluloid is sometimes used for mounting, but is in several ways less convenient for working purposes than papered cork. The size given for the small strips is that found by experience necessary to give protection from the fingers, etc., when handling without a redundant quantity of mount.

A cabinet should always be used where possible. The corked surface of each drawer should be wiped over with pure creosote (ex beechwood) and allowed to remain, with occasional opening of the drawer, until the creosote no longer gives a cloud on the glass. Some crushed naphthaline should be placed in the dust-trap space provided around the drawer. If celluloid has been used for mounting, naphthaline alone may be used as a preservative, for celluloid becomes badly discoloured and curls up in creosote vapour.

To examine a mounted anopheline, place a convenient-sized piece of papered cork on the stage of a binocular dis-

* To paper cork, paste thin white paper on both sides and allow to dry under a board with a weight ; the cork is cut to the measurements required with a sharp thin knife. The cork sheet should be of a good thickness, say $\frac{1}{4}$″.

secting microscope and have handy a spare cork (the cork of a specimen tube serves excellently). Transfer the specimen to be examined on its mount to the cork sheet and use the cork when the parts to be examined are not easily displayed otherwise. Suitable powers for examining are 52 mm. focus (low) and 25 mm. focus (high) with a no. 3 eyepiece. Scales may sometimes be examined at a higher magnification under the ordinary microscope; they are usually better seen in potash preparations of the parts mounted and stained.

Examination and Preservation of Larvæ and Pupæ.

For whole larvæ, mount, fixed or living, from water in Gater's fluid *. To preserve larvæ, fix in Bles's fluid (formalin 7; glacial acetic 3; 70 per cent. alcohol 90; use within a few days) and after 24 hours transfer to 75 per cent. alcohol. To kill larvæ with the palmate hairs displayed, cover the dish containing them with filter-paper wetted with formalin and leave undisturbed for a time; when dead, mix a little formalin with the water and leave larvæ still floating at the surface to harden somewhat. Place the specimens in small tubes and keep as described below for larval skins.

For systematic work it is usual to employ the cast skin of the fourth instar larva, of which the pupal skin and the adult have also been preserved. Isolate a number of full-grown larvæ in specimen tubes in a rack †. As each pupates, remove the larval skin by means of a needle or strip of Bristol-board to a small tube of 75 per cent. alcohol. Later add the corresponding pupal skin with the necessary label and mount the adult. For labelling, sheets of consecutive numbers obtainable from dealers may be used. The small tubes containing the larval and pupal skin (specimen tubes, $2'' \times \frac{1}{4}''$) are completely filled with the alcohol, and a cork, made with

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* Puri gives the following modification of Gater's adaptation of Berlese's fluid as the most satisfactory :—

Water	10 c.c.
Gum acacia (picked)	8 g.
Chloral hydrate	70 g.
Glycerine	5 c.c.
Acid acetic (glacial)	3 c.c.

The ingredients are dissolved in a water bath (at about 80° C.) in the order named, and the fluid passed through three or four thicknesses of clean muslin. Larvæ are mounted directly from water and the preparation ringed, when set, in 6 to 24 hours.

† A rack to hold a number of specimen tubes as shown in the figure is useful for this and other purposes.

a cork-borer from pith, wetted with alcohol and pressed in; the tubes are then stored in 75 per cent. alcohol in Kilner jars.

Larval skins should be mounted in chloral gum (De Faure's fluid) *. The skin is washed in two changes of water treated with 10 per cent. potash for about an hour, and washed again in three changes of water. With a pair of fine needles † work through the skin along the mid-line ventrally, make a cut at each shoulder, remove any particles of dirt with a fine brush (no. 0), and spread out the skin on the slide for mounting. If passed through alcohols to 70 per cent. and the skin, spread out on the slide and just about to dry, treated with a drop of 90 per cent. alcohol, it becomes flattened and adheres to the slide; if carefully separated and mounted as a section excellent flattened preparations displaying the hairs are obtained.

For pupæ the abdominal segments should be separated from the head and thorax and mounted on the flat; the remaining portion is readily opened out sideways, and also mounted on the flat.

Examination and Preservation of Eggs.

Eggs can be examined floating as laid within the paraffined cork ring or, after removal, on a strip of blotting paper placed on a slide and kept moist by adding a drop or two of water from time to time with a pipette. When the floats (in sunk or preserved eggs) are filled with fluid and do not show, they may be displayed by letting the eggs dry a little on the damp blotting-paper. A good light for examining eggs is a beam from a point-o'-light lamp passed through ground glass to diffract the light.

Eggs can be preserved by removing them on a strip of blotting-paper from the water and placing the strip in a specimen tube, the cork of which has been shut down on a piece of filter-paper wet with formalin.

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* Puri notes that Langeron (1921, p. 492) has given the formula of this mounting medium under "Gomme au chloral," and that Imms (1929) has recently described it as "De Faure's fluid." Its composition is as follows:—

Gum arabic (picked)	30 g.
Chloral hydrate	50 g.
Glycerine	20 g.
Distilled water	50 c.c.
Chloral hydrate of cocaine	0·5 g.

Filter after mixing these ingredients. Chloral hydrate of cocaine is not necessary when dealing with larval moults or fixed specimens.

† For remarks on needles, see footnote (*) on p. 76.

Dissection and Preparation of Parts.

Chætotaxy and General Structure.—Drop the mounted specimen * on its pin for 15 minutes to half an hour into 90 per cent. alcohol and transfer to 10 per cent. caustic potash overnight (or longer if temperature is very low). Remove to distilled water and allow to remain, with at least one change of water for 12 hours or more †. Transfer to water in a glass cell to which 1–4 drops of a saturated solution of fuchsin in water has been added ; leave overnight. Or stain more rapidly in a drop of the strong stain. Pass through alcohols (30, 50, 70, 90) to absolute and leave in this until the desired amount of stain has been taken out. Transfer to amyl alcohol (or carbol xylol=xylol 4, absolute phenol 1) and thence to xylol. Transfer to slide ‡, add some drops of Canada balsam, arrange parts, and allow balsam to harden somewhat ; mount, after adding a drop of fresh balsam, under a cover-glass supported by strips cut from a thin glass slide §. The chætotaxy and a great many other details can be studied. Rather faintly stained specimens are, perhaps, the best. The mesonotum and prothorax may advantageously be dissected off and mounted separately, the former showing the scales well and the latter the propleural hairs. Oil of cloves may be used where the part is to be studied carefully under the

* This refers to the dry specimen. Fresh specimens may be used, but are sometimes not so well acted upon by the potash. Placing first in 90 per cent. alcohol does away with the difficulty sometimes encountered where the specimen (possibly due to traces of creosote or naphthaline) is not readily wetted in the potash.

† Presence of alkali prevents proper staining by fuchsin.

‡ A narrow section-lifter or strip of Bristol-board is useful for this purpose.

§ The following simpler method of preparation of balsam mounts of adult mosquitoes is used by Dr. F. W. Edwards :—Place the dry specimen (either whole on its pin, as noted above, or the tip of the abdomen, if only the hypopygium is to be examined) into a small quantity of 10–15 per cent. caustic potash in a small tube. Place the tube in an outer vessel containing water, and just bring to the boil. Pour out the potash, with the specimen, into a watch-glass. Transfer specimen at once (with needles or Bristol-board as described) to a second watch-glass containing *glacial* acetic acid, to which has been added 1–2 drops of Ziehl's carbolic fuchsin. After 5–10 minutes (more or less, up to some hours, according to depth of stain required) transfer to a third watch-glass containing clove-oil. Mount in xylol balsam as described above. The whole of these operations can be completed in 15 minutes.

Instead of glass slides, small strips of celluloid, about ·5″×·2″, can be used (with or without a tiny glass coverslip) for mounting dissections, the advantage of this method being that the mount can be transfixed on the same pin carrying the remainder of the dry specimen. In either case it is most important to arrange the parts very carefully in the least possible quantity of rather thin balsam, and to allow this to harden before covering with more balsam.

microscope in the unmounted condition, as currents are not set up as is the case with xylol.

Head-parts.—Detach a female head and proceed, as in the last section, to xylol. Transfer to slide and add a drop of Canada balsam. The balsam should be of the correct consistency—if too thin it spreads rapidly away from the specimen; if too thick it does not spread at all. Fixing the nape with one needle *, use the other to break through the connections at the base of the frons-clypeus, separating the bases of the antennæ from this structure. Drag off the frons-clypeus and the parts that come with it (including the pharynx and, usually, the œsophageal pump, if not accidentally detached). Detach in one piece, with a little gentle dissection, the labium and the two attached palps, and display these on the flat. With the two needles work so as to cut through the eyes and to detach the front portion of the vertex with the bases of the antennæ, so as to display the interocular space. Cut through the labrum and other parts near the frons-clypeus and remove the frons-clypeus (with the pharynx) to a fresh drop of balsam on another slide. Arrange the parts, including the maxillæ and mandibles, on original slide, allow to harden †, and mount, with fresh drop, under cover. Such a preparation gives material for study of the palps, the interocular space, the head-scales, mandibles, and maxillæ, etc.

On the second slide detach, if still adhering, the œsophageal pump and, placing one needle in the hollow of the frons-clypeus, work to cut through the chitin at the side of the latter structure, which links this to the pharynx. Arrange the pharynx on the flat and place preparation aside to harden somewhat before mounting. This serves to show the general characters of the pharynx and the number of armature teeth, etc.

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* The most suitable needles for dissection, and especially for the dissection of the pharynx and hypopygium, are no. 16 sharps (obtainable in quantities of about a gross specially made to order by Kirby, Beard & Co., 7 Watling Street, E.C. 4; or no. 14 may be obtained ready made). These are broken off to about $\frac{3}{4}''$ and sunk up to $\frac{1}{4}''$ or less of the point in handles made from some soft wood (a match-stalk will do), which, after inserting the needle, is sharpened like a pencil towards the needle-point. The needle is then sharpened on a small hypodermic-needle hone (corundum). For this the end of the holder should be suitably marked, so that the needle can be ground in two fixed planes to a sharp-pointed lancet-like end. After use with Gater's fluid the point of the needle should be washed, dried, and dipped in balsam to prevent corrosion and rust. For very fine dissection the finest of steel entomological pins (if obtainable, German Minuten-Stiften, no. 000) may be used, mounted in match-stalks; it is sometimes an advantage to bend over the point of one pin, to make a small hook.

† Otherwise pieces tend to be carried away by currents in the balsam when mounted.

Pharyngeal Armature.—Proceed as above, but with the pharynx isolated in balsam on the slide cut off the posterior end carrying the armature. Remove the small bit left of the posterior hard palate (which tends otherwise to obscure the armature) and the lateral flanges, leaving as much as possible of the pharyngeal bar and its teeth. With the needles spread out the balsam away from the object examined until the piece of armature is left lying quite flat in a thin layer of balsam. Allow to harden and mount. Focus through different levels to determine the characters of the cones and rods. Separate preparations showing the dorsal and ventral aspects uppermost are desirable.

For isolated pharyngeal teeth proceed as above but, holding the pharynx with one needle, remove the posterior hard palate and jab repeatedly at the fringe of armature teeth until some are seen detached and floating in the balsam. It is necessary to have the balsam exactly of the right consistency and to keep the parts, whilst under manipulation, in the centre of the balsam area *, which should be spread out to the best working thickness by working out with a needle the edge of the balsam-drop. Allow to harden, remove any thickened rim of balsam, if present, and mount with sufficient balsam to run rapidly over the cover-glass area †. Look for isolated rods or cones with a low power, and turn on the carefully centred high power with a low eyepiece and increase eyepiece magnification as required. When found, rotate the rod or cone by pressing against the edge of the cover-glass to obtain different views. The preparation should be deeply stained.

Wing.—Detach wing under a binocular and allow to drop into xylol. Remove with a small spoon to slide with excess of xylol. If right side up, drain off xylol and mount; if not right side up, return to xylol pot and repeat. The trouble otherwise is the retention of large air-bubbles in the hollow of the wing.

Male Ungues.—Proceed as for Canada balsam preparation, staining lightly. Mount both tarsi, inner and outer surface respectively, uppermost. Arrange claw on flat by drawing away, and so thinning down the balsam in its neighbourhood, with the needle. Allow to harden; mount.

Male Hypopygium.—Place the mosquito for half an hour in a covered jar with some damp wool. Under a binocular snip off the last few segments of the abdomen and allow to fall into 90 per cent. alcohol; transfer, after 15 minutes, to 10 per

* To prevent the minute particles being carried away by currents in the balsam.

† All these points are important, for various reasons.

cent. potash. Proceed as under "Chætotaxy and General Structure," or mount direct from water in chloral-gum *.

For balsam preparations of the whole hypopygium, detach the hypopygium on the slide in balsam from the remaining portion of abdomen and, inserting needles within the ninth ring at the sides of the anal lobe, tear off, complete if possible, the ninth segment with the anal lobe; arrange these parts for examination. Arrange the coxites dorsal aspect uppermost and pull apart the styles. Mount, protected by slips of cover-glass on either side.

For balsam preparations of the separate parts proceed as above, but detach the phallosome and the two harpagines. Thin down the balsam by spreading this out with a needle until the parts are seen to be suitably oriented in a thin layer of balsam; allow to harden and mount.

For leaflets (also for good preparations of the harpago and parts generally) dissect from water in Gater's fluid. Separate off, as described, the ninth ring and, placing a needle on each coxite, pull gently apart. This usually splits the phallosome into two lengthways, a half being left attached to each coxite. Detach in turn the two halves of the phallosome from the coxites and transfer each on the needle to a fresh drop of Gater; cover. Examine under a moderate power and press with a forceps or stout needle on the cover-glass over the portion of phallosome until it is seen that the leaflets have been suitably spread out. On the original slide detach the harpagines and arrange the parabasal spines, etc. It is not necessary to stain the preparation.

Female Hypopygium.—As for the male hypopygium; then remove the tergites, leaving the 8th sternite attached. Nick sigma at sides and display preparation in thinned-down layer of Canada balsam, or dissect in chloral-gum.

Dissection for Malarial Oocysts and Sporozoites.

After capture, keep mosquitoes in original test tubes, after damping the plugs (or place in suitable lamp-jar or cage), until they have fully digested any blood they may contain (usually about 48 hours in the tropics) †. This can be seen by the entire disappearance of the black area of digesting blood ventrally on the abdomen. Kill or stun the mosquito by a blow of the test tube on the hand or with a little chloroform vapour, and place mosquito on saline in a covered watch-glass. To dissect, remove wings and legs and place body on drop of saline on slide under a dissecting microscope.

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* For composition of chloral-gum, see technique for larva.

† The glands can be dissected at once, but even a trace of blood makes dissection for oocysts difficult.

Turn mosquito on its side and cut through the thorax rather far back, replacing in the saline whichever portion is not being immediately dissected.

Glands.—Place a stout, suitably-mounted needle *, held in the left hand, in cut part of thorax to hold this and, with the other needle placed across the neck, pull away the head with the glands. Without letting go with the right-hand needle, cut down and sever the glands from the head. See, under low power, that the glands have been obtained and, if so, remove any excess tissue and cover. If not, try for these in the tissue of the thorax near the torn-off neck. Crush and examine under $\frac{1}{6}$ and $\frac{1}{12}$ for sporozoites.

Mid-gut.—Place the portion of thorax with abdomen on drop of saline. Fix thorax with one needle and, turning the abdomen ventral side uppermost, nick on either side so as partially to separate the last two segments or so. Placing the needle on these partially separated segments, drag them slowly away from the rest of the abdomen and observe the intestine and white Malpighian tubules, followed by the transparent mid-gut, leaving the abdomen. When the mid-gut entirely slips free, and before it shrinks together, cut away the intestine and tubules, clear up debris, and mount, if necessary with a clean drop of saline. A fair quantity of saline should be used and the gut flattened by removing excess fluid, if necessary with filter-paper, until it appears as a transparent flattened sac. Examine under $\frac{1}{6}$ and $\frac{1}{12}$ for oocysts in the tracheal layer.

In all cases it is important to arrange the background, when dissecting, to show up the parts suitably. Usually an opal plate or white mirror gives the best differentiation.

Outfit used for collecting *Anopheles* †
(adults, larval skins, and eggs).

1 oz. double-pointed pins ‡.
72 specimen tubes, corked, 3 " x 1 " (prepared for mounting) ‡.
72 ,, ,, ,, (unprepared).
3 sheets cork composition, papered both sides ‡ (for extra tubes).

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* The needles for this purpose should be stout, nos. 6 or 7, embedded to half an inch or less from the point to give rigidity. A special spear-pointed needle has been designed by Shute, and is obtainable from Messrs. Baird and Tatlock, 14 Cross Street, Hatton Garden, E.C. 1.

† This outfit was used by the author on collecting expeditions in India and in the Canary Is. If much collecting is to be done the quantities indicated should be increased, extra photo dishes, tubes, frames and nets being especially advisable.

‡ See pp. 71, 72.

1 packet domestic pins (for making extra tubes).
6 small enamel photographic dishes, 8″×6″ (or smaller).
2 wire frames, consisting each of 6 wire squares, 12″ sides, to be tied together to make frame.
2 bags of mosquito netting to fit over frames, leaving enough to form longish sleeve.
3 jars, say 5″ tall by 4″ wide, with rim for breeding-out special pupæ (one always required for taking off adults for chloroforming). Or use some of next item.
6 wide-mouthed bottles with flat hollow stopper, about 8 oz. cap. Simplest for obtaining eggs if lamp-glasses, etc., not available; can also be used for jars to breed out.
100 small specimen tubes, 2″×¼″, without corks.
100 pith corks, cut with cork-borer for same. These are wetted in the spirit before inserting after the tube has been filled to the top. The corks should, when dry, be larger than the tube-opening, and are readily compressed as they are pushed in with the forceps.
3 Kilner jars, filled with 70 per cent. alcohol.
2 lb. extra alcohol.
6 wooden racks, as figured, to hold row of specimen tubes when obtaining larval skins.
6 tin spoons, desert-spoon size, for collecting, etc.
2 enamel cups.
2 small wooden boxes to hold 8 tubes when collecting.
2 handkerchiefs or dusters for carrying outfit.
1 small net for capturing adults, in jungle or houses, on the wing, and for occasional use in water; or a stouter net may be taken for latter purpose.
2 forceps, blunt-nosed pattern, for mounting.
1 scissors, for cutting strips, etc.
1 sharp, thin scalpel, for cutting corks and cork sheet, etc.
6 pieces Bristol-board, 5″×3″; used for turning out adults on when pinning; also in strips for removing skins from tubes, etc.
1 lb. wool; used in packing, to save space.
2 yards muslin or mosquito netting.
2 hanks tape.
1 lb. chloroform.
1 oz. carbolic acid, liquid.
2 oz. formalin, for preserving eggs (eggs on blotting-paper placed in good corked tube, and a drop of formalin on a small piece of blotting-paper added before sealing).
1 packet filter-paper, 3″, for above purpose.
1 box to hold above, conveniently partitioned; sketch gives the pattern used in India, but it could probably be more specially adapted to collecting-outfit.

PART II.—KEYS.

KEYS FOR SPECIES OF *ANOPHELES* RECORDED FROM THE INDIAN AREA*.

A. Adults.

1.	Wings entirely without pale markings....	2.
	Wings with pale markings	4.
2.	Hind femur with distinct white knee-spots at distal end	*barianensis*, p. 117. [*pinjaurensis*, p. 110.
	Hind femur not so	3. [*florum*, p. 111;
3.	Head-scales very narrow, rod-like †	*aitkeni*, p. 103; *insulæ*- [*sintoni*, p. 116.
	Head-scales of ordinary type ‡	*culiciformis*, p. 111;
4.	Tip of hind tarsus not white §	5.
	Tip of hind tarsus white	26.
5.	Less than four dark areas on costa, involving both the costa and vein 1	6.
	At least four dark areas on costa of this character	11.
6.	Hind femur with outstanding tuft of black and white scales at its distal end.....	*annandalei*, p. 139.
	Hind femur not so	7.
7.	Hind femur with a broad white band	*lindesayi*, p. 123.
	Hind femur not so	8.
8.	Inner quarter of costa pale	*gigas*, p. 130.
	Inner quarter of costa mainly dark, though there may be scattered pale scales	9.
9.	Palpi with distinct pale markings; clypeus with a tuft of black scales at side ‖ ...	*hyrcanus*, p. 145.
	Palpi without distinct pale markings.....	10.
10.	Female with tuft of scales on ventral aspect of seventh abdominal segment; inner third or quarter of costa with scattered pale scales ‖	*barbirostris*, p. 155.
	Female without such a tuft; inner third of costa without scattered pale scales ‖.	*umbrosus*, p. 162.
11.	Tarsus of front legs with broad pale bands ¶	12.
	Tarsus of front legs unbanded or with only very narrow bands	15.
12.	Femora and tibiæ not speckled.....	13.
	Femora and tibiæ speckled	14.

* For varieties, see under respective species name in Part III.

† These three species only to be distinguished with certainty on larval or male genitalic characters.

‡ These two species only to be distinguished with certainty on larval or male genitalic characters.

§ In *A. leucosphyrus* only the extreme tip is white, and in *A. kochi* and *A. tessellatus* only half of the terminal segment is white.

‖ For distinctions from closely related species not yet recorded from the Indian area, see under species name in Part III.

¶ If *A. leucosphyrus* or *A. tessellatus* have not been detected as having the tips of the tarsus white, they will come into this group, and may be recognized by having more than three dark spots on vein 6.

13. Palpi of female with the dark preapical area equal to, or nearly equal to, the pale apical band * ..... *subpictus*, p. 231.
Palpi of the female with the dark preapical area half, or less than half, the length of the pale apical band * ..... *vagus*, p. 241.
14. With two broad apical bands and one narrow, more basal, band on female palpi; thorax with broad scales ..... *stephensi*, p. 273.
With apical band only broad; thorax not covered with broad scales ..... *sundaicus*, p. 245.
15. Thorax with obvious scales ..... 16.
Thorax with hairs or hair-like scales only. 19.
16. Tip of female palpi dark; fossa in both sexes covered with scales. N.W.F. only. *multicolor*, p. 257.
Tip of female palpi pale; fossa not covered with scales ..... 17.
17. Tarsi with narrow but distinct white apical bands..... 18.
Tarsal bands absent or indistinct, and not white. N.W.F. only ..... *superpictus*, p. 264.
18. A line of overlapping broad white scales at side of thorax in front of level of wing-roots †..... *moghulensis*, p. 270.
Without such a line of scales; scaling confined to median area of dorsum of thorax *jeyporiensis*, p. 220.
19. Spotting of wing confined to costa and vein 1 only; head-scales narrow, rod-like. N.W.F. only ..... *dthali*, p. 188.
Wing-field with the usual pale spots; head-scales of ordinary type ..... 20.
20. Female palpi with pale tip; male palpi with distinct pale tip, or at least without dark hairs at tip, and without extensive pale area on shaft 21
Female palpi with dark tip; male palpi with indistinctly pale tip and dark hairs; an extensive pale area on shaft. *turkhudi*, p. 252.
21. Female palpi with the two apical pale bands as broad as, or broader than, intervening dark area ..... 22.
Female palpi with subapical pale band narrow, intervening dark area much broader ..... 24.
22. Fringe-spot present at vein 6; apical half of proboscis pale ‡ ..... *aconitus*, p. 216.
No fringe-spots at vein 6; proboscis dark, or apical half pale in certain lights only. 23.
23. Basal third of costa uninterruptedly dark, without trace of pale interruption—even a pale scale or two; outer half of proboscis faintly or more markedly pale in certain lights ‡ ..... *varuna*, p. 214.

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* It is at present impossible to distinguish the males of these species with certainty; see remarks on identification under name of species in Part III.

† For further points of distinction, see Part III.

‡ For guidance in identification of these forms, see note on identification under *A. fluviatilis* in Part III.

Basal third of costa with a pale interruption, however small; proboscis with apical half dark, except sometimes with a small pale area ventrally * ..... *minimus*, p. 209.

24. Fringe-spots well marked at all veins but 6; some erect pale scales on front of thorax; vein 1 at base of wing internal to inner dark costal spot pale . 25.

Fringe-spots at one or two veins only, except rarely; no pale scales, or very few, on front of thorax. Vein 1 at base of wing internal to inner dark costal spot with dark spot ..... *culicifacies*, p. 197.

25. Third vein usually extensively pale; thorax with median area markedly paler than dark sides; frontal tuft conspicuous ..... *fluviatilis*, p. 203.

Third vein all dark, or with only a pale spot; thorax uniformly coloured; frontal tuft poorly developed. N.W.F. only ..... *sergenti*, p. 193.

26. Tarsi with only one segment, or less, white; commonly with broad white bands above this ..... 27.

Tarsi with a continuous white area, embracing at least the two terminal segments ..... 32.

27. Femora and tibiæ not speckled..... 28.

Femora and tibiæ speckled ..... 29.

28. Female palpi with two broad apical bands and one narrow band near these, in addition to usual more basal band †... *karwari*, p. 288.

Female palpi with two broad apical bands and usual more basal narrow band only † ..... *majidi*, p. 226.

29. Sixth vein with not more than three dark spots ..... 30.

Sixth vein with more than three dark spots. 31.

30. Abdomen with row of conspicuous black scale-tufts on ventral surface, clearly visible, on lateral view, to naked eye; female palpi with four broad pale bands. *kochi*, p. 172.

Abdomen not so; female palpi with usual three bands, with or without speckling. *maculatus*, p. 278.

31. Tibio-tarsal joint of hind leg with broad conspicuous white band ..... *leucosphyrus*, p. 177.

Tibio-tarsal joint of hind leg without such a band ..... *tessellatus*, p. 182.

32. Femora and tibiæ not speckled..... 33.

Femora and tibiæ speckled ..... 35.

33. 3¾ segments continuously white; abdomen heavily clothed with broad scales, which form projecting tufts on all segments ..... *pulcherrimus*, p. 311.

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* For guidance in identification of these forms, see note on identification under *A. fluviatilis* in Part III.

† For differentiation of males, see under species in Part III.

	3½ or less segments continuously white; abdomen with at most rather narrow scales not forming tufts, except on last few segments	34.
34.	Vein 5 mainly dark, or with at least a dark spot about the middle near origin of branch	*annularis*, p. 300.
	Vein 5, except at base and apex, continuously pale *	[*philippinensis*, p. 307. *pallidus*, p. 309;
35.	Hind tarsi with two segments only completely white	*theobaldi*, p. 287.
	Hind tarsi with three segments completely white	36.
36.	Female palpi with two broad apical pale bands and conspicuous speckling; male palpi with shaft banded and spotted with white	*splendidus*, p. 296.
	Female palpi with one broad apical band and two narrow bands without speckling; male palpi with shaft dark	37.
37.	Dorsum of last two abdominal segments clothed with golden hairs and scales; inner quarter and outer third of costa chiefly pale	*jamesi*, p. 291.
	Dorsum of last two abdominal segments not so; inner quarter and outer third of costa chiefly dark	*ramsayi*, p. 294.

B. Full-grown Larvæ. (After Puri) †.

(*For contractions used, see* p. xi)

1.	*ic* more or less approximated; distance between their bases never more than that between bases of *ic* and *oc* of one side ‡; antennal hair usually branched. (Subgen. *Anopheles*.)	2.
	ic well separated; distance between their bases about twice, or more than twice, that between bases of *ic* and *oc* of one side §; antennal hair simple ‖ (Subgen. *Myzomyia*.)	14.

* For differentiation of these two very similar forms, see under species in Part III.

† Slightly modified, with author's and Government's permission, from Health Bulletin, no. 16, Govt. of India, Central Publication Branch, Calcutta, 1930. Larvæ of all Indian anophelines have been described except those of *pinjaurensis*.

‡ In *aitkeni* these distances are about equal, but the presence of a branched antennal hair arising from the *dorso-internal* surface of the antenna at once indicates that the species belongs to this subdivision.

§ In very rare cases these distances may be equal; in such specimens the presence of the minute *simple* antennal hair arising from the *dorso-external* surface of the antenna, *together with* the long feathered frontal hairs, will show that the specimens come under this subdivision.

‖ In very exceptional specimens this hair may be bifid or trifid. In such cases its origin from the *dorso-external* surface of the antenna at once distinguishes it from the similar hair of the subgenus *Anopheles*, in which it is always internal in origin when branched.

2. **Antennal hair simple on dorso-external surface of antenna; most frontal hairs short and simple; lateral hair on I–VI long (tree-hole breeders)** ..... 3.

Antennal hair branched, arising from internal surface of antenna; frontal hairs always long and branched; long lateral hair on I–V ..... 7.

3. *oc* branched; *innermost pair of frontal hairs fairly long but simple, outer pair short, with 3–5 br.; subantennal hair very long and with only a few br*; body-integument covered with innumerable conspicuous minute recurved setæ; *outermost hair of the prothoracic submedian group often bifid; fairly well-developed palmate hair on metathorax; lateral hairs on IV–VI, long, stout, and feathered* ..... 4.

oc simple; body-integument not covered with conspicuous setæ ..... 5.

4. Both the long pleural hairs on each side of meso- and metathorax simple .... *annandalei.*

One long pleural hair on each side of meso- and metathorax sparsely barbed ..... *annandalei* var. *interruptus.*

5. Bases of *ic* not close together; subantennal hair minute; *all frontal hairs very short and simple*; hair above and below lateral hair on each abdominal segment transformed into a stout tripartie spine; thoracic palmate hair not differentiated; *lateral hair on III stout and feathered, on IV–VI long and split into 2–5 br.* ..... *barianensis.*

Bases of *ic* close together, nearly touching each other; subantennal hair long and stout; hairs dorsal and ventral to lateral hair not transformed into stout tripartite spines; thoracic palmate hair fairly well developed ..... 6.

6. Frontal hairs simple or with one or two branches; lateral hair on III–VI long, with a few very fine short, barb-like branches, subantennal hair club-shaped; innermost hair on ventral surface of prothorax not spine-like..... *culiciformis.*

Frontal hairs short but feathered, each having 5–7 br.; lateral hairs on III–VI with long branches (or split); subantennal hair splitting distally into a number of branches; innermost hair on ventral surface of prothorax spine-like, 4- to 7-partite..... *sintoni.*

7. *oc* simple, bifid, or with a few short primary branches..... 8.

oc many-branched, forming a tuft ..... 11.

8. *ic* split about their middle into 2–5 br.; bases not close together..... 9.

ic simple; bases nearly touching..... 10.

9. *ic* split into two a little above the base...	*aitkeni.*
ic split about their middle into 3–5.....	*aitkeni* var. *bengalensis.*
10. Fairly well-developed palmate hairs on thorax and I–VII; *lateral hair on III finer and with fewer branches than those on I and II*; all clypeal hairs simple, anterior rather stout, *oc* about ½ length of *ic*; filaments of abdominal palmate hairs very poorly differentiated.....	*insulæflorum.*
Palmate hairs present on thorax and II–VII; *lateral hair on III like that on I and II*; all clypeal hairs simple; *oc* about half length of *ic*; filaments of abdominal palmate hairs well differentiated and fairly long.....	[*nilgiricus.* *lindesayi* and its var.
Palmate hairs present on III–VII; thoracic palmate hair not differentiated; *oc* and *pc* may be branched	13.
Palmate hairs not differentiated on thorax nor on any abdominal segment; *oc* splits into 5–11 and *pc* into 2 or 3	*umbrosus.*
11. *is* with branches arising near base	12.
is simple or with distal end split into 2 or 3	[*mus.* *hyrcanus* var. *nigerrimus.*
12. *ic* completely simple	*barbirostris.*
ic frayed	*barbirostris* var. *ahomi.*
13. *oc* branched (2–6), *pc* simple	*gigas.*
oc simple, *pc* usually with 2–5 br.	*gigas* var. *simlensis.*
14. Anterior tergal plates on III–VII very large, with a convex posterior border extending to about middle of segment and enclosing the small rounded posterior tergal plate; *palmate hairs well developed on metathorax and on I–VII*..	15.
Anterior tergal plates on abdominal segments III–VII not exceptionally large, having a concave posterior border, behind which lies the rounded posterior tergal plate	17.
15. All clypeal hairs simple	16.
oc and *ic* with short scattered branches, *pc* branched from base	*aconitus.*
16. A pair of minute hairs arising from tergal plate on II–VIII.....	*varuna.*
The pair of minute hairs not arising from tergal plate, but lying a little posterior to the plate on each side	*minimus*; *fluviatilis.*
17. *ic* and *oc* simple or with short inconspicuous lateral fraying	18.
ic and *oc* with lateral branches or conspicuous fraying	30.
18. Fairly well-developed palmate hairs on I–VII; both long pleural hairs on mesothorax simple (one of them may be bifid), except in one species (*sergenti*), in which palmate hair on I is, however, obviously well developed	19.

Fairly well-developed palmate hairs on II–VII; one long pleural hair on mesothorax pectinate, the other simple. 25.

Fairly well-developed palmate hairs on III–VII; both long meso- and metathoracic pleural hairs on each side simple ..... 29.

Fairly well-developed palmate hairs only on IV–VI and comparatively very small; both long mesothoracic pleural hairs feathered; *pc* about as long as *ic*; *frontal hairs stout, with only* 2–6 *br.*; *lateral hairs on III–VI stout, feathered*.. *turkhudi*.

19. All thoracic pleural hairs simple; filaments of abdominal palmate hairs blunt; *ic faintly frayed and about four times the length of oc*; *metathoracic palmate hair fairly well developed* ..... *kochi*.

Some of the thoracic pleural hairs pectinate; filaments of abdominal palmate hairs sharp-pointed ..... 20.

20. Palmate hair not differentiated on thorax; root of *is* inconspicuous; both long metathoracic pleural hairs pectinate; all long prothoracic pleural hairs simple, or one of them may be split into 2 or 3 ..... 21.

Palmate hair on thorax more or less differentiated; base of *is* more or less conspicuous and brownish; one long metathoracic pleural hair pectinate, the other simple; one long prothoracic pleural hair feathered ..... 22.

21. *oc* and *pc* about ½ (or less) as long as *ic*; *pc* internal and close to *ic* ..... *vagus*.

oc and *pc* not so ..... *subpictus*; *sundaicus*.

22. Root of *is* somewhat poorly developed; one long mesothoracic pleural hair pectinate, other simple; *palmate hair on metathorax well developed*; *filament of abdominal palmate hair more than half length of leaflet* ..... *sergenti*.

Root of *is* thickened and conspicuous; long mesothoracic pleural hairs both simple ..... 23.

23. *ic* exceptionally long (about half length of fronto-clypeus); filaments of abdominal palmate hairs about ¼ the length of blades of leaflets; *palmate hair on metathorax large and very well developed*; *distal end of abdominal palmate hair leaflets light-coloured*; *fairly conspicuous minute setæ on ventral surface of posterior abdominal segments*.. *majidi*.

ic normally long (much less than half length of fronto-clypeus); filaments of abdominal palmate hairs about half, or more than half, as long as blades of leaflets ..... 24.

24.	*pc* about half length of *oc*; branches of *isc*, slender, their ends straight	*culicifacies.*
	pc about as long as *oc*; branches of *isc* like those of *osc* and their ends curved to form hooks	*dthali.*
25.	Filaments of abdominal palmate hairs about $\frac{2}{3}$ or as long as blades of leaflets; thoracic palmate hair fairly well developed (except in *A. multicolor*) ...	26.
	Filaments half, or less than half, as long as the blades; thoracic palmate hair usually not differentiated	28.
26.	*ic* and *oc* rather slender; *pc* longer than *oc*; hair representing the palmate hair of I with 5–7 br.; palmate hair of II smaller than those on the segments following	27.
	ic and *oc* rather stout; *pc* a little shorter than *oc*; innermost hair on I has 9–11 br.; palmate hair on II as large as on segments following	*moghulensis.*
27.	*ic* and *oc* faintly frayed; a single isolated dark spot in middle of fronto-clypeus; cone-shaped piece at tip of maxillary palp simple and a little longer than finger-shaped pieces; palmate hair on metathorax fairly well developed...	*superpictus.*
	ic and *oc* simple (completely); a pair of black spots in front of median spot present around bases of frontal hairs; cone-shaped piece at tip of maxillary palp split into two and about as long as finger-shaped pieces; palmate hair on metathorax not differentiated.....	*multicolor.*
28.	*oc* always simple, *ic* usually so *; second hair dorsal to lateral hair on I with 3–5 br.; palmate hair never differentiated on metathorax; usually a pale larva	*stephensi.*
	ic and *oc* finely frayed; second hair dorsal to lateral hair on I with 6–8 br.; palmate hair may be slightly differentiated on metathorax; greyish larva, usually breeding in seepage areas in sub-montane regions	[and its var. *willmori.* *theobaldi*; *maculatus*
29.	*is* with only 2–4 br. and arising from an inconspicuous root; a poorly developed palmate hair on metathorax	*tessellatus.*
	is with numerous branches, root large and dark brown; palmate hair on metathorax not differentiated.....	*leucosphyrus.*
30.	*oc* with long branches, often about as long as hair itself	31.
	oc with short lateral branches, never more than about $\frac{1}{3}$ length of hair	35.

* Some *stephensi* larvæ may show slight fraying of *ic*, an uncommon character; but the very obvious fraying of both *ic* and *oc* in *A. maculatus*, from the same locality, at once differentiates these two species.

31. *oc* with a large number of branches, forming a broom-like tuft ..... 32.
oc splitting distally into 4–12 only; *fairly well-developed palmate hair on metathorax and I–VII; filament about as long as blade of leaflets* ..... *pulcherrimus.*

32. Inner sutural (or occipital) hair simple or bifid near tip ..... 33.
Inner sutural hair split near base into 2–8 ..... 34.

33. Palmate hair on I well developed; larva usually dark grey, often with two or three silvery spots on dorsum; *filaments of abdominal palmate hairs half, or more than half, as long as blades of leaflets; well-developed palmate hair on metathorax.* *annularis.*
Palmate hair on I not differentiated; larva usually pale, dirty yellow, without conspicuous spots; filaments and thoracic palmate hair as in *annularis*.. *jamesi.*

34. *pc* with 2–5 br.; filaments of abdominal palmate hairs about half as long as blades of leaflets, or more ..... *pallidus.*
pc with 7–10 br.; filaments about ¼ as long as blades of leaflets ..... *philippinensis.*

35. *oc* pinnate, with a large number of branches arising practically the whole of their length; one long pleural hair on metathorax simple; well-developed palmate hairs on metathorax *and on I–VII*; *distal end of leaflets light in colour; anterior tergal plates rather large.* *jeyporiensis.*
oc with only a few short, scattered branches; both long pleural hairs on metathorax feathered; metathoracic palmate hair not differentiated—if present it is very poorly developed; anterior tergal plates small ..... 36.

36. *oc* exceptionally long (about half as long as fronto-clypeus); shortest pleural hair on prothorax stout, feathered, and with a somewhat truncated end; palmate hair on II very poorly developed. *ramsayi.*
oc normally long (much shorter than half length of clypeal plate); shortest pleural hair in prothoracic group normal, with 2–4 br.; fairly well-developed palmate hairs on II–VII ..... 37.

37. *oc* often split into two, and with 3–7 short, conspicuous, lateral branches; inner sutural hair split into 2–4; filament of abdominal palmate hairs very broad at base, with a blunt end, and about ⅓ length of blade of leaflet; *palmate hair on metathorax not differentiated*.... *splendidus.*
oc with a few fine lateral branches; inner sutural hair simple; filament not very broad, but may be blunt or sharp-pointed ..... 38.

38. Lateral hair on V and VI with 6–10 long branches (more like a pectinate hair); innermost hair on ventral surface of III with 7–9 br.; filament of palmate hair blunt; palmate hair on metathorax never differentiated, hair corresponding to it like a short pectinate hair, with 4–9 lateral br. ..... *karwari.*

Lateral hair on V and VI splitting near its base into 3–5 br.; innermost hair on ventral surface of III with 3 or 4 br. only; filament of palmate hairs usually sharp-pointed; palmate hair on metathorax usually not differentiated, and hair corresponding to it splits into 2–6 br. (in some specimens the branches are slightly flattened) ..... [and its var. *willmori.* *theobaldi*; *maculatus*

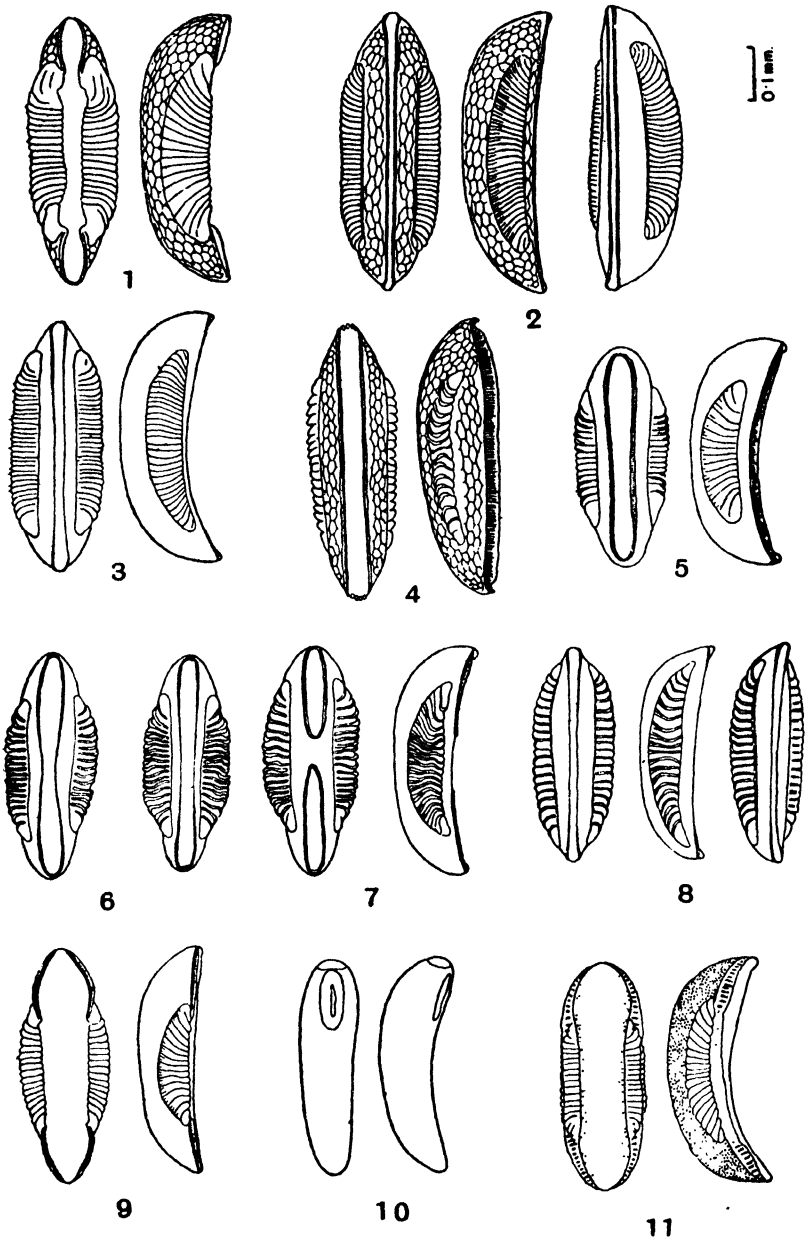
C. Eggs.

1. Lower surface with pale polygonal markings ..... 2.
   Lower surface not so ornamented ..... 6.
2. Floats absent; upper surface of egg rhomboidal in shape ..... *barianensis.*
   Floats present; upper surface of egg not so. 3.
3. Floats touching margin of upper surface . 4.
   Floats not touching margin of upper surface ..... 5.
4. Floats sharply tapering to points at the ends; both portions of frill together not above ⅛ length of egg ..... *annandalei.*
   Floats ending in large, rounded, float-termination; both portions of frill together exceeding ⅛ length of egg ..... *lindesayi.*
5. Upper surface distinctly narrower than portion of lower surface between this and float; frill narrow; float-ridges 30 or more, narrow, regular ..... [*rimus*; *barbirostris*, *hyrcanus* var. *niger-*
   Upper surface about same width as portion of lower surface between this and float; frill, seen laterally, about half breadth of upper surface; float-ridges not exceeding 20, broad, with sharp serrated contour ..... *tessellatus*; *kochi.*
6. Floats absent ..... 7.
   Floats present ..... 9.
7. Frill rudimentary, seen as small, oval tache on egg ..... *turkhudi,*
   Frill well developed ..... 8.
8. Frill present only at ends of egg..... *multicolor.*
   Frill continuous round margin of upper surface ..... *superpictus*; *dthali.*
9. Floats separated from margin of upper surface ..... 10.
   Floats touching margin of upper surface (or separated only by a very small interval) ..... 12.

10. Frill well developed in middle portion of egg; about ⅓ depth of egg seen laterally	*culicifacies.*
Frill either discontinuous in middle or very narrow, distinctly less in middle of egg than ⅓ depth of egg	11.
11. Terminations of floats not approaching extremities of egg within ⅛ of egg-length or more; float-ridges, seen from above, markedly longer than broad	*fluviatilis*; *minimus.*
Terminations of floats approaching extremities of egg by $\frac{1}{12}$ of egg-length or less; float-ridges, seen from above, almost as broad as long	*aconitus.*
12. Frill continued along whole margin of upper surface and passing above floats	13.
Frill interrupted in middle of egg where floats are present	16.
13. Frill striated through whole extent	14.
Frill striated in terminal portions only	15.
14. Frill ¼ width of egg-body; float-ridges 30–40	*subpictus.*
Frill distinctly less than ¼ width of egg-body; float-ridges 20–30	*vagus.*
15. Upper surface with punctæ confined to margins; float-ridges about 20; egg rather deep and somewhat concave above	*sundaicus.*
Upper surface with punctæ in the form of white spots covering whole extent; float-ridges about 16; egg very flat and shallow, with flat upper surface	*pulcherrimus.*
16. Upper surface as wide as egg-body; no portion of lower surface seen when egg is viewed from above	17.
Upper surface not so; at least some lower surface visible towards ends of egg when viewed from above	18.
17. Frill merging gradually at float-junction	*annularis*; *pallidus.*
Frill with more or less evident tags at junction with float	*jeyporiensis.*
18. Anterior demarcated portion of upper surface twice, or nearly twice, as long as posterior; floats extending distinctly nearer to narrow end of egg	19.
Anterior demarcated portion of upper surface only slightly longer than posterior; floats extending to about an equal distance from either end of the egg	22.

NOTE.—The eggs of the following species have not been observed:—*culiciformis, gigas, insulæflorum, leucosphyrus, majidi, pinjaurensis, pseudobarbirostris, sintoni, theobaldi, umbrosus*, and *varuna*. The eggs of *aitkeni* and *philippinensis* are insufficiently known for inclusion in the above table.

Fig. 14.

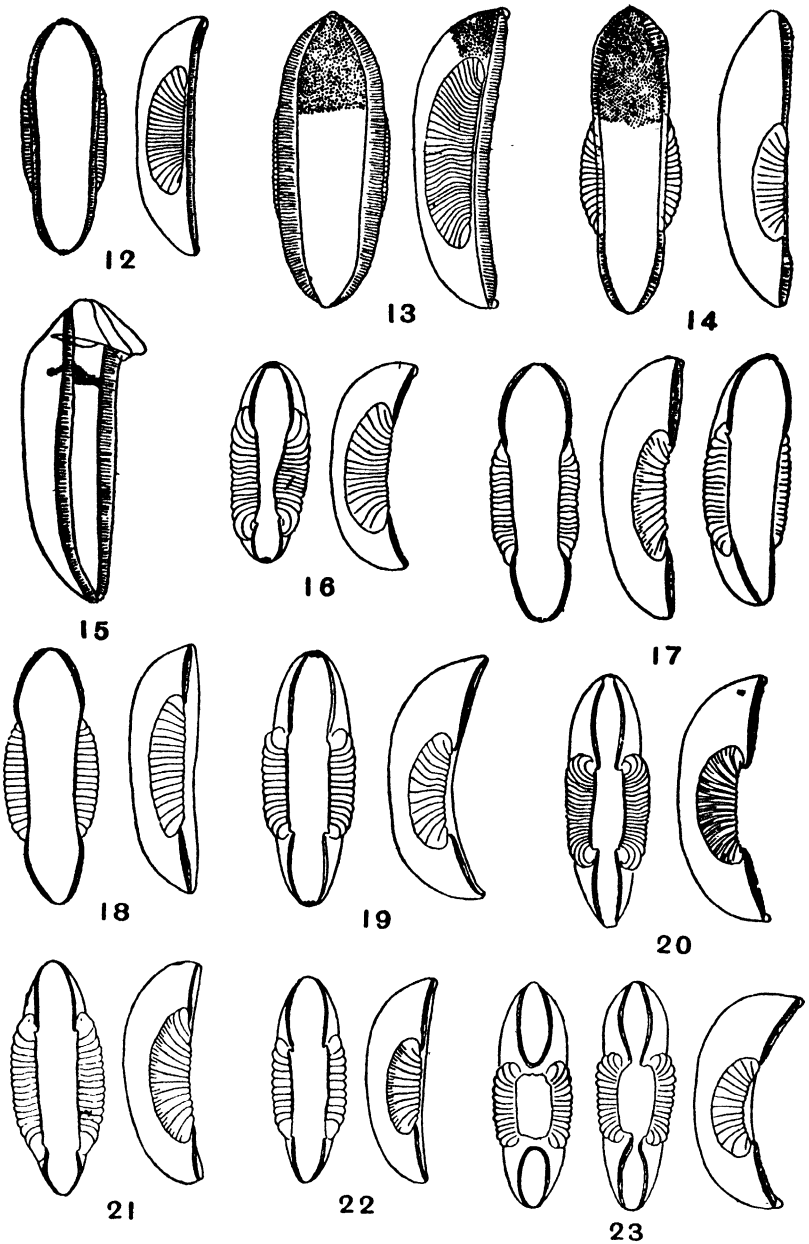


Eggs of Indian Anophelini.

1. *A. lindesayi*. 2. *A. hyrcanus* var. *nigerrimus*. 3. *A. barbirostris*. 4. *A. tessellatus*. 5. *A. culicifacies*. 6. *A. fluviatilis*. 7. Ditto, form with double deck. 8. *A. aconitus*. 9. *A. jeyporiensis*. 10. *A. turkhudi*. 11. *A. sundaicus*. (After Christophers and Barraud.)

(All eggs drawn to scale in upper right-hand corner.)

Fig. 15.



Eggs of Indian Anophelini (*continued*).

12. *A. vagus*. **13.** *A. subpictus*. **14.** *A. pulcherrimus*. **15.** *A. superpictus* (egg-shell). **16.** *A. moghulensis*. **17.** *A. annularis* (*fuliginosus*). **18.** *A. pallidus*. **19.** *A. stephensi*. **20.** *A. splendidus*. **21.** *A. jamesi*. **22.** *A. ramsayi*. **23.** *A. maculatus*. (After Christophers and Barraud.)

(All on same scale as fig. 14.)

19. Floats about half the egg-length; float-ridges about 12 ..... *ramsayi.*
Floats distinctly more than half egg-length; float-ridges over 16 ..... 20.

20. Middle portion of upper surface at least equal to the anterior and posterior demarcated portions taken together; floats occupying somewhat less than ¾ lateral aspect of egg in middle portions; frill somewhat narrower ..... *jamesi.*
Middle portion of upper surface less than anterior and posterior demarcated areas taken together; floats very broad, occupying ¾ the lateral aspect of the egg in middle portion; frill somewhat broader..... *moghulensis.*

21. Anterior demarcated area obviously shorter than the middle area, say ⅔ of this; egg flattened, not galleon-shaped ..... *sergenti.*
Anterior demarcated area about as long as middle area; egg galleon-shaped .. 22.

22. Floats not markedly concave above ..... 23. [var. *willmori.*
Floats markedly concave above ..... *maculatus* and its

23. Float-ridges about 14; frill less than $\frac{1}{10}$ depth of egg; floats only slightly more than ½ the egg-length..... *stephensi*; *karwari.*
Float-ridges about 22; frill about $\frac{1}{10}$ depth of egg; floats distinctly longer than ½ the egg-length..... *splendidus.*

PART III.—SYSTEMATIC.

Tribe ANOPHELINI.

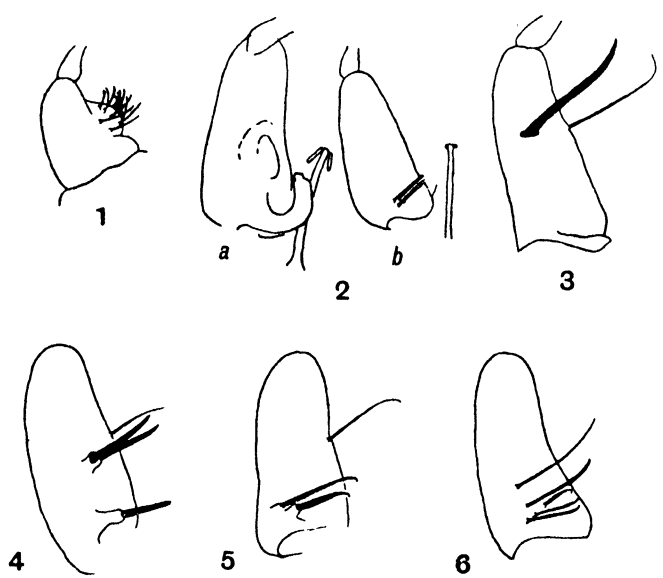
Edwards, Bull. Ent. Res. iii, p. 2, 1912.

Subfamily *Anophelina* Theo., 1901, Mono. Cul. i, p. 97.
Subfamily *Anophelinæ* Felt, 1904, New York State Mus. Bull. lxxix, Entom. xxii, p. 264.
Section *Anophelina* Marshall, 1911, Bull. Ent. Res. ii, p. 241.
Section *Epialurgi* Alcock, 1911, Ann. & Mag. Nat. Hist. (8) viii, p. 241.
Section *Anophelini* Brunetti, 1914, Rec. Ind. Mus. x, pt. i, p. 32.

Characters (see Part I).

The points in which the rare genera *Chagasia* and *Bironella* differ from the more usual anopheline characters are tabulated below (see Key to Genera).

Fig. 16.



Showing chief hypopygial characters of the genera and subgenera.

1. *Chagasia*. 2. *Bironella*: (a) *gracilis*; (b) *travestitus*. 3. *Stethomyia* (*nimba*). 4. *Nyssorhynchus*. 5. *Anopheles*. 6. *Myzomyia*.

Key to Genera.

1. Male with two large claws on each fore and mid-leg; scutellum (♂♀) somewhat trilobed, with a set of bristles on each lobe separated by intervals; larva with lateral border of scoop bearing fringe of hairs * .
   Three species only known, all from South and Central America ..... CHAGASIA.
   Male with a single large claw on fore legs only; scutellum (♂♀) with an evenly rounded border and uninterrupted line of bristles; larva without a fringe of hair on lateral borders of scoop ..... 2.
2. Claw of fore legs of ♂ without median or basal spur; claw-bearing segment shorter than preceding segment and without spiny enlargement at base; vein 5.1 beyond cross-vein concave †.
   Five species and one variety known, all from New Guinea or adjacent islands.
   The species *B. gracilis* Theo., *B. papuæ* Swell., *B. soesiloi* Strick. & Chowd., *B. de rooki* Soesilo & v. Sloot., and *B. papuæ* var. *brugi* Soes. & v. Sloot., with ♂ palpi almost as long as proboscis, anterior forked cell short or unclosed, and ♀ palpi ⅓ to ¼ length of proboscis, are placed by Edwards, 1931, in subgenus *Bironella*; and *B. travestitus* Brug, with ♂ and ♀ palpi alike less than ¼ length of proboscis and anterior forked cell only slightly shorter than petiole, in subgenus *Brugella* ..... BIRONELLA.
   Claw of fore legs of ♂ with median and basal spur (except in *A. culiciformis*, where there is no basal spur), claw-bearing segment longer than preceding, and with a spiny enlargement at base; vein 5.1 not concave beyond cross-vein.
   About 200 species, distributed throughout the world ..... ANOPHELES.

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* For further information, see Root, Amer. Journ. Hyg. vii, p. 470, 1927; Dyar, 'Mosq. Amer.' p. 431, 1928; Edwards, Bull. Ent. Res. vi, p. 124, 1926; 'Gen. Insect.' p. 31, 1932.

† For further information, see Brug and de Rook, Bull. Soc. Path. Exot. xv, p. 305, 1922; Brug, Geneesk. Tijds. lxviii, p. 921, 1928; de Rook and Soesilo, Geneesk. Tijds. lxx, p. 479, 1930, and Meded. Volks. xix, p. 213, 1930; Edwards, Bull. Ent. Res. xxi, p. 287, 1930; *id.*, 'Gen. Insect.' p. 32, 1932; Soesilo and v. Slooten, Meded. Volks. xx, p. 125, 1931. For characters of the subgenera, see Edwards 1932, *loc. cit.*

Genus **ANOPHELES** Meig.

Meigen, Syst. Beschr. i, p. 10, 1818 (*Anopheles* Hgg.).

For synonomy of names formerly accorded generic rank, see under respective subgenera and groups or series.

Type-species, *A. claviger* Meig. (*bifurcatus* Meig., nec Linn.)*.

Characters.

A description of the characters of the genus is given in Part I.: see "Introduction" and "Characters used in Identification and Classification."

Key to Subgenera.

1. Coxite of ♂ hypopygium with a single very large, stout, parabasal spine, nearly as long as coxite, arising near base or higher up coxite, without basal tubercle (fig. 16, 3). Mesonotum of adult with a median milky line. Larva with spiracles very far apart and opening on prominent papillæ; a process ending in four hairs arising from lateral papillæ †.
   Three species only known, from South and Central America ..... STETHOMYIA.
2. Coxite with two parabasal spines, at least the inner arising from a lobe or tubercle; inner stouter and shorter than outer; if only one spine present this has the characters of the inner spine, and there are no additional spines higher up on inner aspect of coxite (fig. 16, 5.) For further characters, see under the subgenus.
   About 80 species, distributed throughout Old and New World..... ANOPHELES.

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* Lang ('Handb. Brit. Mosq.' p. 73, 1920), following Coquillett (Proc. U.S. Nat. Mus. xxxvii, p. 107, 1910), gives *Culex bifurcatus* L., designated by Curtis ('Brit. Entom.' p. 210, 1828) as the type, but as Linnæus's name *bifurcatus* was originally applied to the male of *Culex pipiens*, and not to an *Anopheles*, the type is correctly given as above. Edwards ('Gen. Insect.' p. 35, 1932) quotes as the type *A. maculipennis* Mg., the second of the two species originally included in the genus, but this is an error. Fortunately this makes no practical difference, as both species belong to the same group.

† For further information, see Theo., 'Mono. Cul.' iii, p. 62, 1903; Peryassu, 'Cul. Braz.' p. 88, and p. 266 (*Rhynchomyia*), 1908; Bonne and Bonne-Wepster, 'Mosq. of Surinam,' p. 502, 1925; Dyar, 'Mosq. Amer.' p. 99 (*Goeldia*), and p. 446, 1928; Costa Lima, 'Trat. de Parasit.' p. 648, 1930; Edwards, Bull. Ent. Res. xxi, p. 288, 1930; 'Gen. Insect.' Fasc. cxciv, p. 35, 1932; Shannon and Davis, Ann. Entom. Soc. Amer. xxiii, p. 473, 1930 (detailed account of larva, pupa, and adult).

3. Coxite with one large spine at base and two twin spines higher up on inner face of coxite, all arising from basal eminences; a thickened internal spine may also be present (fig 16, 4). Adult with general ornamentation much as in subgenus *Myzomyia*; the wing with four main dark costal spots, but with the apical pale spot not at junction of vein 1 and costa, but basal to this. Pharyngeal armature with a single row of recurved teeth, separated by intervals. Larva with branched hair on antenna; inner clypeal hairs close together or moderately so; long pleural hairs branched or simple; leaflets of palmate hairs lanceolate, without terminal filament; inner shoulder-hair sometimes converted into a palmate hair *.

   About 17 species, confined to South and Central America ..... NYSSORHYNCHUS.

4. Coxite with four or five parabasal spines, arising close together in a cluster, the more basal ones with recurved tips, the one more apically situated longer, resembling an ordinary hair (fig. 16, 6). For further characters, see under the subgenus.

   About 80 species, distributed through the tropical and subtropical Old World .. MYZOMYIA.

Subgenus *ANOPHELES* Meig., *s.str.*

Christophers, 1915, Ind. Journ. Med. Res. iii, p. 383.

Type-species as for genus *Anopheles*.

ADULT.—Coxite with two parabasal spines, the inner at least arising from a more or less distinct prominence, the inner spine shorter and usually somewhat stouter than the outer. In a few cases only one spine is present, which then has the characters of the inner spine †.

Pharyngeal bar without an armature of teeth.

The propleural hairs usually form a conspicuous cluster of four to five or more. Ornamentation of the wings is on a different plan to that in subgenus *Myzomyia*; the wing is often entirely without pale spots; if pale spots are present,

* For further information, see Christ. 1915, p. 383; Evans, Ann. Trop. Med. and Par. xv, p. 447, 1921; Root, Amer. Journ. Hyg. iii, p. 266, 1923; iv, p. 460, 1924; and vi, p. 684, 1926; Costa Lima, Suppl. Mem. Inst. Osw. Cruz, 1928, no. 3, p. 91; *id.*, 'Trat. de Parasit.' ii, p. 600, 1930; Shannon and Davis, Ann. Entom. Soc. Amer. xxiii, p. 487, 1930; Edwards, 'Gen. Insect.' p. 43, 1932.

† The Old World species of this subgenus that show a single parabasal spine are *A. algeriensis* Theo., *A. stigmaticus* Skuse, *A. atratipes* Skuse, and *A. implexa* Theo.

the costa usually shows less than four main dark costal areas; bifurcation of veins 2 and 4, and the position of the cross-vein junctions, are commonly dark, not pale, as in *Myzomyia*; the pale areas on the fringe are much more capriciously developed. In addition, subgenus *Anopheles* shows some, or all, of the following characters in the wing-markings, none of which are usually seen in *Myzomyia*:—Aggregations of somewhat enlarged dark scales, especially at the bifurcations and cross-veins; presence of inflated or unduly large scales on the subcosta, stem of vein 4, or elsewhere; presence of mixed dark and pale scales on the veins in certain areas, in place of the discrete defined spots commonly seen in *Myzomyia*; pale markings on the upper surface lacking on the lower surface of the wing.

PUPA.—With spines V–VII usually short and blunt; paddle-hair usually short and straight.

LARVA.—Antennal hair (with rare exceptions) branched and arising from inner aspect of shaft; *ic* arising close together, their bases often nearly touching; palmate hair-leaflets lanceolate or with poorly differentiated filament, notches spread along distal portion of leaflet; long pleural hairs usually all simple.

Key to Groups.

1. Abdomen without lateral scale-tufts. Costa without kink, or with a very slight one, at subcostal junction. Outer parabasal spine, when present, stout. About 53 species, distributed throughout the world. Type-species as for genus *Anopheles* ..	Group *Anopheles*.
2. Abdomen with lateral tufts of broad scales. Costa with a well-marked kink near junction of subcosta with costa. Outer parabasal spine long and thin * About seven species, confined to South and Central America. Type-species, *A. maculipes* Theo.....	Group *Arribalzagia*.
3. Abdomen with long lateral tufts of greatly elongated scales. Costa without kink or with a very slight one. Outer parabasal spine absent †. A single species, confined to tropical Africa. Type-species, *A. implexa* Theo.	Group *Christya*.

* For further information, see Root, Amer. Journ. Hyg. iii, p. 246, 1923, and iv, p. 456, 1924; Costa Lima, Suppl. Mem. Osw. Cruz, no. 12, p. 280, 1929; Edwards, 'Gen. Insect.' p. 37, 1932.

† For further information, see Edwards, Bull. Ent. Res. xvii, p. 122, 1926.

Group *Anopheles*.

Root, 1922, Amer. Journ. Hyg. ii. p. 387.

Characters substantially as given under the subgenus, except in so far that characters special to the groups *Arribalzagia* and *Christya* are to be excluded.

Adult.—The wing-ornamentation shows in varying degree the characters given under subgenus *Anopheles*, as distinct from those shown by subgenus *Myzomyia*. Leg-ornamentation is moderate in degree and, except for the femoral ornamentation in some species, the legs are usually unicolorous or merely with some degree of tarsal banding, rarely white at the tips of the hind tarsus *.

Pharynx very similar throughout the group: a general description will suffice. Lateral flanges extended but narrow; ventral flange poorly developed and divided; pharyngeal bar ill defined, more or less concave, without armature; pharyngeal ridges minute, scarcely perceptible, in one or several rows, but few in number and widely separated. Dorsal papillæ 8–12 in number; commonly the second pair (counting from behind) the largest, followed by 2–4 small papillæ on each side of anterior hard palate; the actual number of these small papillæ subject to variation, and not infrequently one side has one less than the other, the number given in the descriptions being that which appears to be usual with the species. Posterior hard palate shaped like a truncated cone; pigmented area usually linear and median.

Hypopygium as described under subgenus *Anopheles*. Inner spine usually stout and recurved at tip; outer usually $\frac{1}{3}$ to $\frac{1}{2}$ as long again as inner and commonly also recurved at tip, but longer and straighter in series *Myzorhynchus*. Harpago usually more or less bilobed or trilobed, with sword-like and simple spines, the sword-like or flattened spines on outer or dorsal lobe usually not fused into a club, except in group *Myzorhynchus*. Phallosome often small and of simple construction, without leaflets; in other species large and well developed. Well-marked processes often developed from ninth tergite, especially in *A. gigas* and in the *Myzorhynchus* series.

Larva.—Arrangement of pleural hairs is substantially similar in the group, except for the dorsal posterior prothoracic (*dp* 1), which is slender and simple in some forms but split into stout spine-like branches in others (see Key to Series). The following schema gives the usual characters of the pleural hairs

* White hind tarsi are seen in the African species *A. mauritianus* and, as an extreme degree of individual variation, in *A. hyrcanus* var. *nigerrimus*.

in the group, with a note regarding any special feature shown by individual species. This schema should be consulted along with the descriptions.

	1 (prothoracic).	2 (mesothoracic).	3 (metathoracic).
da (dorsal anterior).	Long, simple *.	Long, simple †.	Long, simple ‡.
va (ventral anterior.	Long, simple §.	Long, simple ‖.	Long, simple ‖.
dp (dorsal posterior).	Short, slender, and simple ¶, or Stout, with 3–6 ** spine-like br.	Extremely short, simple.	Extremely short or minute, simple.
vp (ventral posterior).	Long, simple.	Variable in length ††, but always much shorter than the anterior hairs.	Very short ‡‡, most commonly with 2–4 br.

Classification.

Though the group includes a wide diversity of forms (no less than nine of the genera that have been created in the past on scale-characters, etc., are included in this group), classification is difficult owing to the occurrence of transitional species. Owing to this difficulty, systems of classification tend to range between recognition of very few divisions, each including many relatively distinct forms, and the making of more numerous groups each containing a very few species. Probably, in view of the facts, the last is the most natural and, eventually, useful classification, especially as new species are constantly being added, making some originally very small groups more extensive.

For the present I have followed Edwards in recognizing four series.

* With 5–7 br. in *culiciformis*; split about middle into 2–4 br. in *aitkeni*; finely barbed in *annandalei* var. *interruptus*.

† With 2–3 stiff barb-like br. in *culiciformis*; finely barbed in *annandalei* var. *interruptus*.

‡ With 2–3 br. in *aitkeni* var. *bengalensis*; 2–3 stiff barbed-like br. in *culiciformis*; finely barbed in *annandalei* var. *interruptus*.

§ About half as long only as the dorsal hair and slender in *annandalei*.

‖ Barbed in *sintoni*.

¶ Sometimes bifid in *aitkeni* and *insulæflorum*; split into 2–4 br. in *sintoni* and *gigas*.

** 5–6 br. in *umbrosus*; 3–4 in *hyrcanus* var. *nigerrimus* and *barbirostris*.

†† One-fourth length of anterior hairs in *gigas* and *umbrosus*; split into 2–4 br. in *annandalei*.

‡‡ Simple in *barianensis*; simple, sometimes bifid, in *insulæflorum*; bifurcate in *umbrosus*, *hyrcanus*, and *barbirostris*.

Key to Series.

(a) *Anopheles* series.—Front femora slender or only indistinctly swollen at base; scales of female palpi appressed or only slightly roughened towards base.

(b) *Lophoscelomyia* series.—Front femora somewhat swollen at base; female palpi rather thick; hind femur with conspicuous ornamentation of a large white scale-tuft at tip, preceded by an area of outstanding black scales.

(c) *Myzorhynchus* series.—Front femora markedly swollen at base; female palpi shaggy.

(d) *Cycloleppteron* series.—Resembling *Myzorhynchus* in general, but with differences in ornamentation. New World *.

(*a*) Series **Anopheles.**

Edwards, 1932, Gen. Insect.

Cœlodiazesis Dyar & Knab, Journ. N.Y. Entom. Soc. xiv, p. 177 1906. Type, *A. barberi* Coq.

Neostethopheles James, Rec. Ind. Mus. iv, p. 98, 1910. Type, *A. aitkenii* James.

Patagiamyia James, *ib.* iv, p. 98, 1910. Type, *A. gigas* Giles.

Proterorhynchus Brethes, Bol. Inst. Ent. y Pat. Veg. i, p. 10, 1912. Type, *A. pseudopunctipennis* Theo.

Cyclophorus Eysell, Arch. f. Schiffs. xvi, p. 422, 1912. Type, *A. nigripes* Staeger.

Memnemyia Strickland, Ind. Journ. Med. Res. iii, p. 204, 1915. Type, *A. brevipalpis* Roper.

Type-species as for genus *Anopheles*.

The following species and varieties are recorded from the Indian area :—

Without a pronotal scale-tuft (wings unspotted).

Interocular vertex narrow, sulcus-like (*Culex* attitude).

A. aitkeni James.
A. aitkeni var. *bengalensis* Puri.
A. insulæflorum Swell. & Swell.
A. pinjaurensis Barraud.
A. culiciformis Cogill.
A. sintoni Puri.

Interocular vertex broader, triangular (anopheline attitude).

A. barianensis James.

With a pronotal scale-tuft (wings with some pale spots).

A. lindesayi Giles.
A. lindesayi var. *nilgiricus* Christ.
A. gigas Giles.
A. gigas var. *simlensis* James.
A. gigas var. *baileyi* Edw.

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* Edwards, 'Gen. Insect.' 1932, places in *Cycloleppteron* the following New World species :—*A. amazonicus*, *A. annulipalpis*, *A. grabhamii*, *A. mattogrossensis*, *A. peryassui*, and *A. vestitipennis*. As Puri (1931, p. 53) notes that *dpl* in *A. grabhamii* is slender and simple, it is possible that *Cycloleppteron* may be distinguished on this point.

1. **Anopheles aitkeni** James, 1903 *. (Fig. 17.)

James, in Theobald, Mono. Cul. iii, p. 22, 1903 (*A. aitkenii*). TYPE-LOC. : Karwar, Bombay (near Goa Frontier). TYPE: ♀ described; ♀ type in Brit. Mus.

SYNONYMS :

fragilis Theo., 1903, Entomologist, xxxvi, p. 257 (*Stethomyia fragilis*). TYPE-LOC. : Kuala Lumpur, F.M.S. TYPE : described from 2♂♂ ; type in Brit. Mus. SYN. : by Stanton, Journ. Lond. Sch. T. Med. ii, p. 4, Dec. 1912.

pallidus Ludlow, 1905, Canad. Entom. xxxvii, p. 129 (*Stethomyia pallida*). TYPE-LOC. : Camp Stotsenberg, Pampanga, Luzon, P.I. TYPE : described from 1 ♀; type in U.S. Nat. Mus. (see Dyar, Insec. Insc. Menst. xiii, p. 85, 1925). SYN. : (probably) by Alcock, Journ. Lond. Sch. T. Med. ii, p. 159, 1913, and by Christ., Ind. Journ. Med. Res. iii, p. 461, 1916.

treacherii Leicester, 1908, Culic. Malaya, p. 19 (*A. treacherii*). TYPE-LOC. : Fed. Malay States. TYPE : ♂ and ♀ described ; specimens, probably types, in Brit. Mus. SYN. : by James and Stanton, Trans. 3rd Congr. F.E.A.T.M. p. 515, 1912, and Paludism, no. 5, p. 59, 1912.

RECOGNIZED VARIETY :

bengalensis Puri, 1930 ; see under *A. aitkeni* var. *bengalensis*.

A. aitkeni (type-form), var. *bengalensis*, and *A. insulæflorum* are distinguished mainly, or entirely, on larval characters, especially the form of *ic* †. The larval characters of the types of *A. fragilis* and *A. treacherii* (Malay) and of *A. pallidus* (Philippines) being unknown, these forms cannot at present be placed with certainty under any of the known types, and, are, therefore, still given as synonyms of the species (type-form), though it is probable that the two former, at least, may be identical with var. *bengalensis*, which appears to be the most common Malayan form.

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* SYSTEMATIC : Swell. 1921 *a*, p. 132 ; Puri 1930 *a*, p. 955. See also (*aitkeni*) James 1903, p. 22 ; Cogill 1903, p. 332 ; James and Liston 1904, p. 119 ; 1911, p. 59 ; Theo. 1908, p. 287 ; 1910 *a*, p. 13 ; James and Stanton 1912, p. 59 ; Strickland 1913 *b*, p. 203 ; Stanton 1914 *b*, p. 515 ; Christ. 1916 *a*, p. 461 ; 1924 *c*, p. 18 ; Mangk. 1918, p. 494 ; 1919, p. 76 ; Carter 1925, p. 67 ; Borel 1929, p. 25. (*fragilis*) Theo. 1907, p. 60 ; 1910 *a*, p. 36. (*pallidus*) Ludlow 1914 *a*, p. 43 ; Theo. 1907, p. 61 ; 1910 *a*, p. 36 ; Alcock, 1913 *b*, p. 159. See also under "Synonyms," "Hypopygium," and "Larva."

† The inner clypeal hairs in *A. aitkeni*-like larvæ may be :—

(*a*) Simple (outer hairs also simple) (fig. 17, **13**) ; *A. insulæflorum*—figured also as for *A. aitkeni* by Strickland, 1915, and Strickland and Chowdhury, 1926, but with branched outer hairs; possibly *A. insulæflorum*, as these authors do not mention this species.

(*b*) Split into two about ¼ their length from base, and without lateral branches or fraying (fig. 17, **14**); *A. aitkeni* (type-form) as given by Puri, 1930 ; type 3 of Swell. 1919—mentioned also by Mankoewinoto (West Java) ; only form described by South Indian authors (Cogill, 1903; James and Liston, 1904; Carter, 1925 (Ceylon); Puri, 1930).

(*c*) Split into 3–5 about ½ length of hair from base (fig. 17, **15**) ; var. *bengalensis* as given by Puri ; type 1 of Swell.—described also by Mangkoew. and by Stanton (Malay) ; type 2 of Swell., with three branches, may be this form.

(*d*) Single, but with short lateral branches or fraying on middle third (outer hairs simple) (fig. 17, **17**) ; type 5 of Swell.—described also by Stanton, 1915, for Malay ; this author, 1912, describes a form with the lower ½ frayed, possibly the same.

(*e*) Split into two as in (*b*), but with lateral branching or fraying , type 4 of Swell.—described also by Strickland (Malay).

Only (*a*), (*b*), and (*c*) are described from the Indian area.

A. aitkenii var. *papuæ* Swell. & Swell. 1920=*Bironella papuæ*. *A. aitkenii* var. *palmata* Rodenwaldt, Geneesk. Tijds. lxvi, p. 789, 1926 (and Meded. Volks. Ned. Indie, 1927, D. 3, p. 518), type-loc., West Java, and recorded from Borneo, has the inner clypeal hairs simple, like *insulæflorum*, the inner shoulder hair in the form of a delicate palmate hair, and large tergal plates, as in the *minimus* group. It is probably a distinct species, as practically suggested by Rodenwaldt; and also by Strickland and Chowdhury, 1931; it is not recorded from the Indian area

ADULT ♀.—A small to moderate-sized fragile brown anopheline (length of wing 2·5–3·5 mm., some large specimens reaching 4 mm.); attitude, *Culex*-like.

Head: vertex abruptly narrowed at eyes to form narrow sulcus-like space. Head-scales sparsely scattered, narrow, linear, rod-like, with bifurcated extremity; striations extending at most half-way down the scale. Two conspicuous, forwardly-projecting chætæ arising close together in middle line just posterior to sulcus, and in their neighbourhood one or two small narrow white scales. In sulcus between eyes a single row on each side of 5–7 small white scales, the series terminating anteriorly at two further conspicuous chætæ arising close together in sulcus. *Antennæ*, including *t*, entirely devoid of scales. *Palpi* very thin, delicate, straight, last two segments somewhat swollen, giving distinct club-like effect; apical segment short; index 0·41; thinly clothed with appressed scales, bare on inner aspects, some scales present on *rbs*; devoid of pale markings.

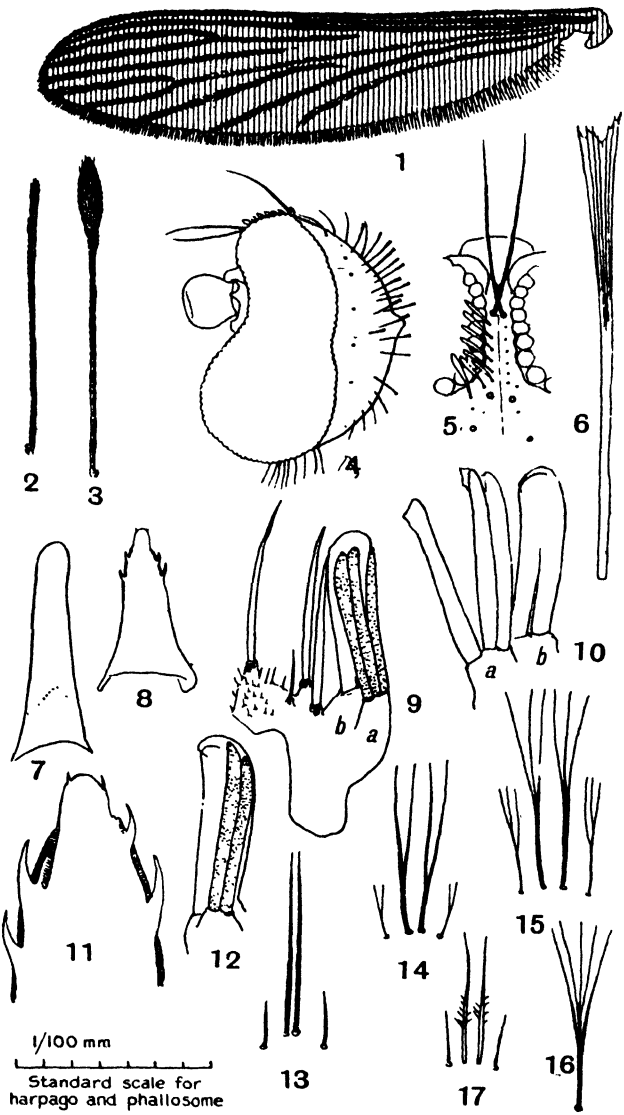
Pharynx as for group; dorsal papillæ 8.

Thorax rather short, rounded; *apn* with dark chætæ only; propleural hairs 1–2. Mesonotum uniformly coloured, dull brown or sometimes rather reddish; the bare spaces conspicuous and with slightly different texture; bare, except for lines of larger chætæ and some smaller hairs; entirely devoid of all scales. Pleuræ palish, devoid of scales; spiracular hairs absent; prealar reduced to one or two; upper mesepimeral about nine.

Wing with the *af* unusually long, almost ⅓ of wing-length, more than twice its petiole and half as long again as *pf*; bifurcation much nearer wing-base than that of *pf*; index about 1·8. Scaling of wing marked and defined but narrow; max. str. 7. Border scales extending nearly to base. Membrane somewhat dark.

Legs long and thin. Front femora not swollen in basal half. Femora unicolorous, dark to base above and usually beneath, but sometimes faintly pale in this situation for some distance. Tibiæ unicolorous, dark, showing pale at extreme base (joint only), and on front leg sometimes with a small triangular pale patch at apex externally. Tarsi uniformly dark. Dark scaling of legs somewhat shiny, and in certain lights may give a faint metallic appearance.

Fig. 17.



A. aitkeni; also *A. insulæflorum* (**8**, **11**, **13**).

1. Wing of ♀. **2** & **3.** ♀ and ♂ palps, same scale as **1**. **4.** Side-view of head, showing scales and vertical chætæ. **5.** Vertex. **6.** Head-scale. **7.** Phallosome, standard scale. **8.** Ditto, *A. insulæflorum*. **9.** Harpago of type-form: (*a*) external portion of dorsal lobe; (*b*) internal portion of same, standard scale. **10.** Dorsal lobe, slightly crushed. **11.** Phallosome, *A. insulæflorum*, apical portion, enlarged. **12.** Dorsal lobe of harpago, var. *bengalensis*. **13.** Clypeal hairs of larva, *A. insulæflorum*. **14.** Ditto, *A. aitkeni*, type-form. **15.** Ditto, var. *bengalensis*. **16.** Ditto, inner clypeal hair, with five branches. **17.** Clypeal hairs of type 5 of Swellengrebel.

(**13–16** after Puri, **17** after Swellengrebel.)

Coxæ pale, entirely devoid of scales. *Trochanters* mostly pale, devoid of scales.

Abdomen usually dark, with darkish hairs; devoid of scales even on cerci.

ADULT ♂.—In general as in ♀. *Palpi* narrowly and fusiformly clubbed; marginal hairs poorly developed, inconspicuous; dark, entirely devoid of pale markings. *Labium* very long and thin. *Ungues* with a basal spur. *Abdomen*, including coxites, entirely devoid of scales.

Hypopygium * : parabasal spines 2, about equally thick, markedly recurved at ends, inner somewhat shorter than outer, but otherwise very similar; a well-developed internal spine near apex of coxite. Harpago crest-like; dorsally a stout, strongly chitinised lobe partly, divided into two (ventral lobe of Christ. 1915, p. 384), the more dorsal part (ventral lobe of Puri 1930, p. 954), carrying three sword-like spines, the more ventral and internal portion with two spines, with their terminations expanded and often only clearly visible as two at their base, all these five spines forming a rather club-like aggregation; ventrally is a more membranous portion of the harpago, also more or less differentiated into two parts, the outer carrying two stout spines, the inner a single spine. Phallosome small, papilliform, with rounded end, without leaflets or any terminal thickening or spinous processes. Ninth tergite ribbon-like, without processes.

PUPA.—Undescribed. A reference to poorly developed hooks of the paddle-hair is given by Lamborn 1921, p. 96.

LARVA †.—*Clypeal hairs*: *ic* arising rather far apart (for subgenus *Anopheles*), about as far apart as distance between *ic* and *oc* of same side, split into two branches (bifurcate) about ¼ their length from base, smooth and without any lateral branches or fraying; *oc* short, only about ¼ length of *ic*, split into 2–5 br. towards termination; *pc* very short, 3–7 br. *Frontal hairs* normal, but reaching only to *pc*. *Subantennal hair* feathered, with a cluster of short branches at distal end. *Antennæ* wtih stout spines on shaft; antennal hair branched (6–8), arising on inner aspect about ⅛ length of antenna from base, a little longer

* HYPOPYGIUM: Christ. 1915, p. 384; Swell. 1921 *b*, p. 40. and 1921 *a*, p. 133; Puri 1930 *a*, p. 955.

† LARVA: Swell. and Swell. 1919 *a*, p. 25; Puri 1930 *a*, p. 955; Puri 1931, p. 95. See also Cogill 1903, p. 332; James and List. 1904, p. 119; 1911, p. 59; Stanton 1912 *b*, p. 4; 1915, p. 163; Strickland 1915 *c*, p. 7; Mangk. 1918, p. 494; 1919, p. 76; Lamborn 1921, p. 95 (tail-hooks); Swell. 1921 *a*, p. 134; Buxton 1923 *b*, p. 76 (comp. with *algeriensis*); Carter 1925, p. 79; Senior White 1925, p. 216; Stanton 1926, p. 42; Strick. and Chowd. 1927 *b*, p. 26; Puri 1928 *b*, p. 521; Borel 1929, p. 25.

than antenna is broad. *Mentum* with four teeth on each side of median tooth, first very small, an additional small tooth sometimes present basal to fourth tooth.

Shoulder hairs: inner without conspicuous chitinised root, 10–15 br.; middle, 14–17 br.; outer arising independently. *Pleural hairs* as given for subgroup *Anopheles*, but *da*1 split about middle into 2–3 br., and *dp*1 sometimes bifid. *Hair no.* 1 on metathorax developed as palmate hair with undifferentiated filaments.

Palmate hairs: well developed on III–VII; on I branched (8–11), but branches not flattened into leaflets; hair no. 1 developed as palmate hair on II, but less fully developed than on other segments, and filament not differentiated. Leaflets more or less uniformly coloured, fairly broad, with indentations at shoulder very variable, sometimes giving almost the appearance of a lanceolate leaflet, at other times with the filament well defined.

Lateral hairs long, stout, feathered on I–III, that on III resembling the others; long, with about 3–6 br. on V; very short on VI (8–10 br.) and on VII (4–7 br.). *Tergal plates* fairly small. Spiracular chitinisation fairly pronounced, widely separated from median plate. *Pecten* with about ten long and three short spinous projections, most of them serrated on basal half. *ps* fairly long, with about 8 br. *Saddle-hair* long, split into 4–6 br. at $\frac{2}{3}$ its length from base (the only Indian species showing this character). *osc* with 6–7 long br. forming sharply defined hooks; *isc* and *ventral hairs* with some also forming rudimentary hooks.

Egg.—Undescribed. Some notes taken from a dissected gravid specimen give the egg of the whale-back type, with long, narrow, upper surface surrounded by a narrow frill; the floats long, extending over $\frac{3}{4}$ of the egg-length, and (?) silvery polygonal markings on the under surface.

Identification.—The unspotted wings and characteristic head-scales distinguish *A. aitkeni* from all other Indian species except *A. insulæflorum*, *A. pinjaurensis*, and the variety *bengalensis*.

The following are points of distinction between the four very similar forms mentioned above :—

1.	Phallosome very long, tubular, and expanded at end	*pinjaurensis*.
	Phallosome shorter, not expanded at end .	2.
2.	Phallosome with some fine spinous projections laterally towards apex. Larva with *ic* simple, arising close together, with developed palmate hair on I; lateral hair III only half as stout as I and II, and carrying only 5–8 br. Outer part of dorsal lobe of harpago usually with three spines .	*insulæflorum*.

Phallosome without any spicular projections. Larva with *ic* bifurcate or branched, without developed palmate hair on I; lateral hair III as on previous segments..	3.	
3. Larva with *ic* bifurcate at about ¼ from base; outer part of dorsal lobe of harpago usually with three spines		*aitkeni.*
Larva with *ic* split into 3–5 br. about ½ from base; outer part of dorsal lobe of harpago usually with two spines		*aitkeni* var. *bengalensis.*

The Mediterranean species *A. algeriensis* (occurring in Turkestan) resembles *A. aitkeni* in general appearance, but the anterior forked cell is much less than half as long again as the posterior and the head-scaling differs in detail; there is only one parabasal spine; for larval differences, see Buxton, Bull. Ent. Res. xiv, p. 76, 1923.

DISTRIBUTION.—Widely distributed in the Oriental Region. Recorded from NEW GUINEA; MOLUCCAS (Ceram, Amboina); SULA; CELEBES; SANGIR; PHILIPPINE Is.; FORMOSA; LESSER SUNDA ISLANDS (Alor, Timor); JAVA (with Noesa Kambangan); SUMATRA (with Nias, Riouw, Linga, Enggano Islands); NATUNA ISLANDS; BORNEO; TONKIN; COCHIN-CHINA; MALAY PENINSULA; CEYLON; INDIA.

Records from the more eastern areas may require confirmation. Formosa is given by Brug, 1926 *c* *. Records for the most part do not enable the form to be stated. Apart from India, the type-form as defined by Puri has been definitely described only from Java (or with a general reference to the Dutch East Indies).

In India *A. aitkeni* has been recorded, according to Covell, from many localities over the east and south, including UPPER BURMA; ANDAMANS; ASSAM; BENGAL; CHOTA NAGPUR; MADRAS; MYSORE; BOMBAY PRES., as far north as Savantvadi State. It has not so far been recorded in any form from the Central Provinces, Bihar, the United Provinces or any part of India north and west of these.

The type-form in India has been recorded from Karwar (*Cogill*, 1903; *Puri*, 1930 *a*, from Bombay Presidency), Nilgiri Hills, and Coorg; also from Ceylon (*Carter*, 1925).

BIONOMICS.—*A. aitkeni* is a wild and shy species, not frequenting houses or cattle-sheds, though it may rarely be taken, more or less incidentally, in such situations (*Watson*, 1921; *Christ.*, 1925; *Ramsay*). It has been fed experimentally on human blood (*Barber*, 1918). I have observed it in numbers in the shade of jungle in the Nilgiris attempting to

* See also Koidzumi, Trans. 6th Congr. F.E.A.T.M. p. 27, 1927.

feed on man, and it is recorded as feeding on a bull (*Senior White*, 1921). It is doubtful if it takes a very active part as a blood-sucker.

Its breeding places are especially in connection with small streams, seepage springs, pools, etc., in forest and jungle; it has been observed breeding in tea-drains shaded by tea (*Ramsay, Strickland*, and *Chowdhury*, 1928). At Coonoor it is recorded by Rao (Coonoor) in swamps, marsh, channels, rivers, rock-pools, wells. (See also *Adhikari*; *Feegrade*, 1927 (Lashio); *Horne*; *Iyengar*, 1930; *MacCombie Young*, 1928; *Shortt*).

It occurs at Shillong, especially towards the end of the cold season (*McCombie Young*). It occurs commonly in the hills at considerable altitudes, but also at lower levels; it is very abundant in the Nilgiris at 6,000 feet.

RELATION TO DISEASE.—There is no evidence regarding its playing any part in malaria transmission.

1 *a*. **Anopheles aitkeni** var. **bengalensis** Puri, 1930 *.

Puri, Ind. Journ. Med. Res. xvii, p. 953, 1930 (*A. aitkeni* var. *bengalensis*). TYPE LOC.: Marianbarie, Bengal Terai, India. TYPE: ♂ and ♀ reared from isolated larvæ in Brit. Mus.; paratypes in Indian Mus. and collection of Malaria Survey of India.

ADULT.—Does not appreciably differ from *A. aitkeni* except in having usually two in place of three spines on external part of dorsal lobe of harpago.

LARVA.—The following distinctions from the type-form are additional to those already given :—Frontal hairs (median) reaching to base of *ic*; inner sutural and outer sutural not quite so branched; *da* 3 with 2–3 branches instead of simple. For still other small differences, see Puri, 1931.

DISTRIBUTION.—This form (as indicated by larval characters) has been recorded from MALAY PENINSULA; JAVA; COCHIN-CHINA; HONG KONG †; INDIA. It is probably a common, if not the usual, form in which *A. aitkeni* occurs to the east of the Indian area.

Recorded in the Indian area by Puri, 1930 *a*, from Marianbarie and Sukna, both in the Darjeeling Dist., Bengal. According to Puri most records from Bengal and Assam are probably this variety. It is not recorded by Puri from South and West India, nor are larvæ having its characters described

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* Stanton 1915, p. 163; 1926, p. 42; Swell. and Swell. 1919 *a*, p. 25; Mangk. 1919, p. 76; Borel 1929, p. 27; Puri 1930 *a*, p. 956. The variety should, perhaps, be known as var. *fragilis* Theo.

† Dr. R. B. Jackson 1932 (British Museum collection).

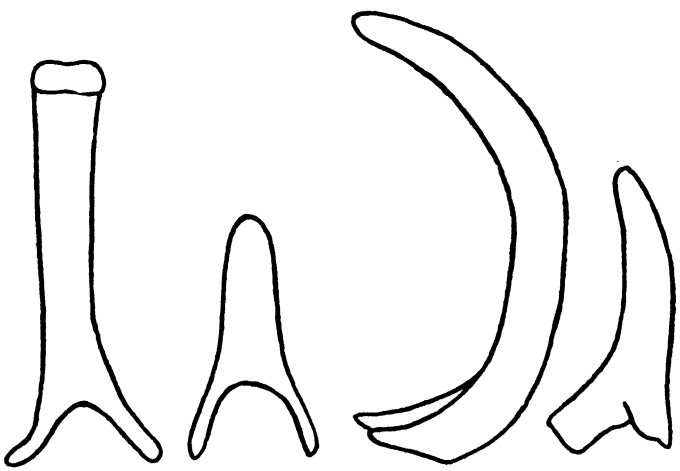
by any author from either South and West India or Ceylon. The breeding places, according to Puri, are similar to those of the type.

2. **Anopheles pinjaurensis** Barraud, 1932. (Fig. 18.)

Barraud, Rec. Mal. Surv. iii, p. 353, Dec. 1932 (*A. aitkeni* var. *pinjaurensis*). TYPE-LOC.: Pinjaur, near Kalka, Ambala District, Punjab. TYPE: ♂ (unique) in collection of Mal. Surv. India at Kasauli.

ADULT.—Very similar, except in the characters of the phallosome, to others of the *aitkeni* series. It is given as a variety of *A. aitkeni* by Barraud, but the very distinct phallosome is sufficient to show that it is a distinct species.

Fig. 18.



A. pinjaurensis.

Anterior and lateral views of phallosome contrasted with that of *A. aitkeni* (shorter figures). (After Barraud.)

Hypopygium: harpago very similar to that of *aitkeni* var. *bengalensis*; inner part of dorsal lobe with two spines, as in that variety. Phallosome very long and large, expanded at opening, with thickened rim and entirely devoid of leaflets or processes.

LARVA.—Unknown.

A single specimen only known, recently collected at Pinjaur, about a thousand miles from the nearest recorded locality for any of the other *aitkeni*-like species or varieties.

3. **Anopheles insulæflorum** Swell. & Swell., 1920 *.

Swell. and Swell., Meded. Burg. Ned. Ind. 1919, D. 9, Addend., p. 2 (following p. 118) (*Stethomyia aitkeni* var. *insulæflorum*). TYPE-LOC.: Noesa Kambangan (Isle of Flowers) S. Java. TYPE: location unknown.

ADULT.—Indistinguishable, except on the points already given, from *A. aitkeni*. The male is readily distinguishable by the spicular processes on the phallosome.

LARVA.—Besides differences already given, the following are noted by Puri:—Median frontal hair reaching a little beyond bases of *ic*; *is* and *ms* with a smaller number of branches, simple or bifid instead of showing 2–4 br., as in *A. aitkeni*; leaflets of palmate hairs more lanceolate; saddle-hair often simple.

DISTRIBUTION.—Except for the original type-locality and the Indian records, this species is mostly recorded from the Eastern Oriental Region. Recorded from NEW GUINEA; MOLUCCAS (Amboina, Ambon, Ceram, Haraku, Sanana); LESSER SUNDA ISLANDS (Alor); JAVA (Noesa Kambangan); CEYLON; INDIA.

Recorded in India by Puri, 1930 *a*, from Yellapur, N. Kanara Dist., Bombay Pres., and from Marianbarie and Sukna, Darjeeling Dist., Bengal, and in Ceylon by Carter, 1925. Puri's reference to Cogill in regard to record from Karwar is incorrect.

The breeding places, according to Puri, are similar to those of *A. aitkeni*.

4. **Anopheles culiciformis** Cogill, 1903 †. (Fig. 19.)

Cogill, Journ. Bombay Nat. Hist. Soc. xv, p. 333, Oct. 1903 (*A. culiciformis*). TYPE-LOC.: Karwar, N. Kanara Dist., Bombay Pres., India. TYPE: several co-types, ♂ and ♀, in Brit. Mus. (*vide* Edwards, Bull. Ent. Res. xiii, p. 90, 1922). Also described from same locality, under same name, by James and Liston, 1904, 'Anop. Mosq. India,' ed. 1, p. 122.

The two species *A. culiciformis* and *A. sintoni* occur together under similar conditions in some areas on the West Coast and are practically indistinguishable in the adult stage except for the very distinct male genitalia. Cogill's description of the basal antennal hair and balancer hair III of the larva, according to Puri, indicate *A. culiciformis* as now understood, whilst this author found only *A. culiciformis* in the locality investigated by Cogill. There is, therefore, every reason to consider the species here called *A. culiciformis* as the one described by Cogill.

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* SYSTEMATIC (incl. larva): Swell. and Swell. 1919 *a*, p. 23 (unclassified larva no. 1), and 1920, Addend. p. 2; 1919 *b*, p. 34; 1920 *b*, p. 81; Swell. 1921 *a*, p. 136; Christ. 1924 *c*, p. 19; Carter 1925, p. 67; Puri 1930 *a*, p. 954; 1931, p. 101.

HYPOPYGIUM: Swell. 1921 *b*, p. 135; Puri 1930 *a*. p. 954.

† For references, see next page.

ADULT ♀*.—A moderate-sized unornamented dark anopheline (length of wing 2·7–3·8 mm.); attitude, *Culex*-like.

Head with the vertex abruptly narrowed at eyes to form sulcus-like groove; eye-margin at side of head about middle with an angular indentation. Head-scales over occiput of normal expanded type, with 12–15 striations extending nearly to base; entirely without usual pale spot on vertex. Ocular and vertical chætæ forming continuous line of dark chætæ extending from postgenæ to sulcus; 4–5 darkish chætæ arising on each side of sulcus, intermixed with some lightish scales projecting forward to form imperfect frontal tuft; a few small lightish scales may extend on to vertex behind sulcus, but otherwise this area largely bare, head-scales ceasing abruptly. *Antennæ* with numerous large dark scales on first flagellar segment; one or two sometimes on torus. *Palpi* of moderate thickness, tapering at ends or blunt, but not clubbed; often a little shorter than proboscis; palpal index 0·6 or more, scaling somewhat erect over whole organ, giving rather shaggy effect; scales present on rudimentary basal segment; entirely dark.

Pharynx as for the group; dorsal papillæ 8 in number.

Thorax rather short, rounded. *apn* with dark chætæ only; propleural hairs 1–2. Mesonotum uniformly coloured, showing indistinct lines; dull brown or blackish in colour; bare except for lines of rather stout dark chætæ; no scales, even on anterior promontory. Scutellum with the chætæ dark and stout; some smaller chætæ and rather numerous dark scales usually present. Pleuræ dark grey, devoid of scales; spiracular hairs present (1–2); prealar 1; upper mesepimeral 1–6.

Wing with *af* somewhat variable; its length, compared with *pf*, often as long as in *A. aitkeni*, or nearly so; base much nearer base of wing than that of *pf*; its length, however, only somewhat longer than its petiole; index 2. Scaling of the wing moderately broad; max. str. 7–9; plume-scales noticeably broad, giving an effect of broader and more profuse scaling than in *A. aitkeni*. Membrane faintly stained, especially towards anterior margin. Wing entirely devoid of pale markings.

Legs uniformly dark, without knee-spots or tarsal banding. Femora dark to extreme base above and beneath, except on hind legs, which may be somewhat paler beneath for their basal quarter. Tibiæ uniformly dark, sometimes with a very

* SYSTEMATIC: Cogill 1903, p. 333; James and Liston 1904, p. 122; 1911, p. 61; Christ. and Khazan Chand 1916, p. 638; Edwards 1922, p. 90; Christ. 1924 *c*, pp. 20, 81; Puri 1929 *b*, p. 398. See also Theo. 1907, p. 62; 1910 *a*, pp. 36, 88; James 1910, p. 98; Alcock 1913 *b*, p. 159; Christ. 1916 *a*, p. 463. See also under "Hypopygium" and "Larva."

few pale scales at extreme apex or a very small pale triangular spot. Coxæ pale, devoid of scales. Trochanters with some scales on fore and mid-legs.

Abdomen dark, with dark hairs; devoid of scales, even on cerci.

ADULT ♂.—In general as in ♀. *Antennæ* with dark scales on first flagellar segment. *Palpi* narrowly and fusiformly clubbed; marginal hairs absent or inconspicuous; dark, entirely without pale markings. *Ungues* lacking the minute spur at base. *Abdomen*, including coxites, entirely devoid of scales.

Hypopygium *: parabasal spines 2; both unusually large and stout, arising from a very distinct lobe-like prominence; inner somewhat shorter and stouter than outer; both sharply and finely recurved at tip, outer often bifid at extremity. A well-developed internal spine near apex of coxite. Harpagones fused to form a continuous ridge ventrally; the usually prominent dorsal lobe scarcely to be distinguished; whole harpago as shown in figure, with an ascending row of large, straight and curved, sword-like chætæ. Phallosome very large, at least half length of coxite; carrying on each side 5–7 very long, stiff, curved leaflets (see fig. 19, **6**). Ninth tergite without processes.

PUPA.—Very briefly described by Christophers and Khazan Chand, 1916, p. 644. Paddles orbicular, with a well-marked fringe; short terminal hair not much longer than fringe-hairs. A small lateral spine on II–VII and a plumose spine on VIII. On V–VII long, simple hairs arising dorso-laterally, nearly twice length of segment, and projecting at right angles to body.

LARVA †.—*Clypeal hairs*: *ic* arising close together, their bases touching, long, simple, slender; *oc* simple, slender, about ½ length of *ic*; *pc* simple, slender, about same length. *Frontal* hairs greatly reduced, appearing only as small hairs with one or two branches; *inner* and *outer suturals* short, simple or sometimes bifid in former case. *Subantennal hair* forming expanded plate, with numerous fine hairs arising round edge (fig. 19, **10**). *Antennæ* smooth, dark, narrow; hair rising from dorso-external surface, simple, about as long as antenna is broad, situated ⅓–⅕ length of antenna from base; terminal hair simple; sabres less than ¼ length of antenna; cone 3–4 times length of finger and nearly as long

* HYPOPYGIUM: Christ. and Khazan Chand 1916, p. 641; Puri 1929 *b*, p. 399.

† LARVA: Cogill 1903, p. 333; James and Liston 1904, p. 122; 1911, p. 61; Christ. and Khazan Chand 1916, p. 638; Edwards 1922, p. 90; Puri 1928 *b*, p. 521; 1929 *a*, p. 398; Iyengar 1930 *a*, p. 771; Puri 1931, p. 87.

as sabres. *Mandible* with the two hairs on external surface minute. *Mentum* with four teeth on each side, three dark, adequal; a fourth, lighter coloured and smaller, at end of row.

Shoulder hairs: *is* short, 7–10 br., without conspicuous base; *ms* 2–3 times size of *is*, 12–16 br.; outer short, simple, arising from basal tubercle of middle hair. *Pleural hairs* as for subgroup, except that *da*1 has 5–8 short branches (an unusual feature in subgenus *Anopheles*); *da*2 and *da*3 also with some stiff barb-like branches; chitinous tubercles very small, as also the processes rising from these. *Hair no.* 1 on metathorax developed as palmate hair.

Palmate hairs well developed on II–VII; leaflets long, lanceolate, filament poorly developed, serrations shallow and scattered along border. *Lateral hairs* long, stout, feathered on I and II; single and only half as stout on III, with some very short, scattered, barb-like branches; lateral hairs on IV–VI similar; on IV with 1–3 short br.; on V 5–6; on VI 5–11; on VII very short, simple, or split near base into 2–4 br. *Tergal plates* of moderate size. *Pecten* with 14–17 long and 11–14 short teeth, which alternate, all with well-marked serrations; distal ends of long projections slightly flattened and with 3–4 deep serrations, ends of short projections curved upwards; pecten-hair with 4–6 br. *ps* very short, bifid or tripartite at tip. Saddle-hair long, simple. *osc* with a number of short branches rising from its ventral surface and only two or three long dorsal ones, with ends only very slightly hooked.

Lateral and ventral surfaces of larva with minute setæ longer than in most species.

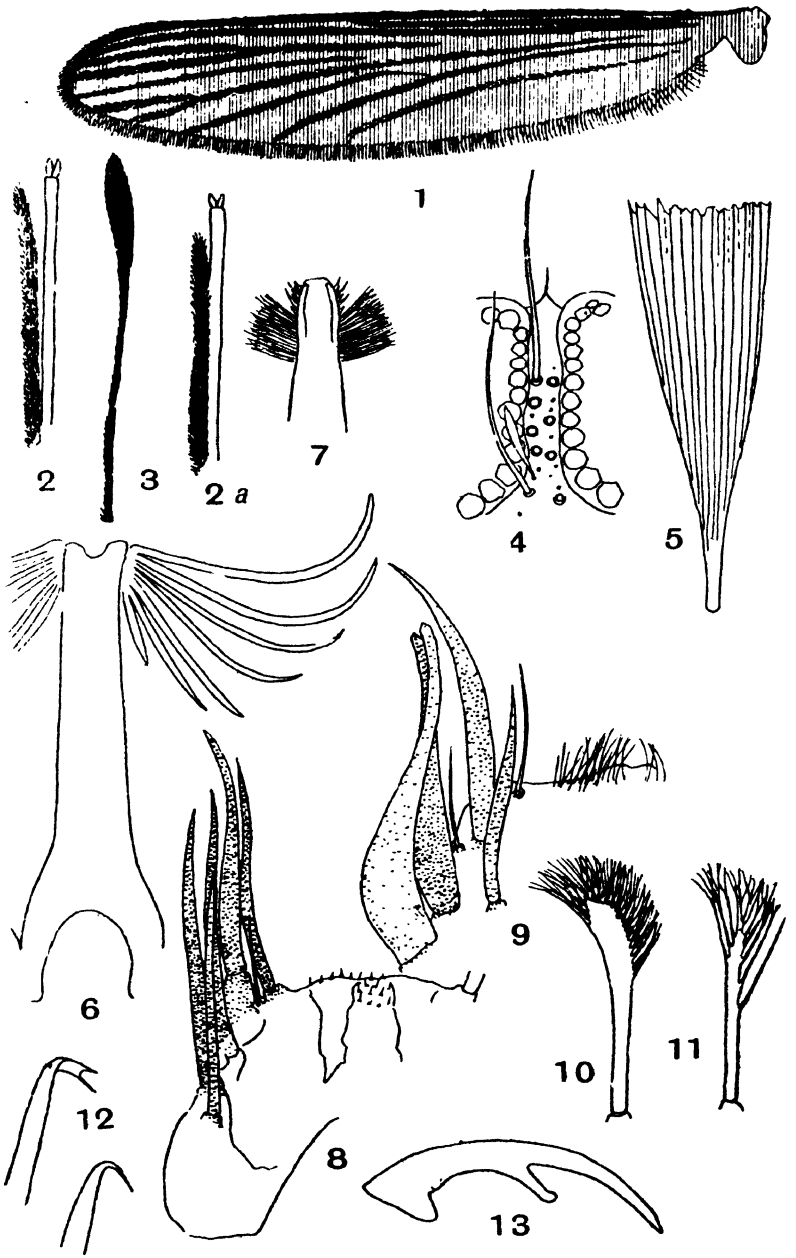
Egg.—Unknown.

Identification.—Distinguished from *A. aitkeni* and *A. insulæflorum* by the thicker, more shaggy palps and normal head-scales; also by its less fragile appearance and darker coloration. From *A. barianensis* it is readily distinguished by the absence of the white scaling on the vertex and white frontal tuft, as also by the absence of the conspicuous white scaling on the front of the mesonotum and the white banding of the apices of the hind femora and tibiæ.

From *A. sintoni* it is distinguished with certainty only by the larval and male genitalic characters (see under *A. sintoni*); the shorter palpi in the female and the presence

1. Wing of ♀. 2 & 3. ♀ and ♂ palp: 2 *a*. ♀ palp, *A. sintoni*. 4. Vertex. 5. Head-scale. 6. Phallosome, standard scale. 7. Apical portion of phallosome, *A. sintoni*, same scale. 8. Harpago, standard scale. 9. Ditto, *A. sintoni*. 10. Subantennal hair (after Puri). 11. Ditto, *A. sintoni* (after Puri). 12. Tips of inner and outer parabasal spines (outer on left). 13. Front tarsal claw of ♂.

Fig. 19.



A. culiciformis ; also *A. sintoni* (**2 a, 7, 9, 11**).

(For explanation of figure, see opposite page.)

of some hair-like inconspicuous scales on the median area of the mesonotum in *A. sintoni* may be used as a general guide to distinguish the two species.

DISTRIBUTION.—Not recorded outside the Indian area, and in India only from the West Coast, from Savantwadi State to Malabar. The following records are given by Covell:—SAVANTWADI STATE; GOA; N. KANARA DIST. (Karwar, Kadra); MALABAR DIST. (Pudapadi, Calicut). Specimens from all these localities are in the Malaria Survey collection. The record from Nilgiris, included in Covell's 1931 summary, is too doubtful to include (vide *Covell*, 1927).

BIONOMICS.—A forest species found breeding in holes in trees and by Cogill in jungle-pools. There is no record of its having been taken in houses or of biting man.

RELATION TO DISEASE.—There is no evidence regarding any rôle in malaria transmission or power to transmit (*Christ.* and *Khazan Chand*, 1916).

5. **Anopheles sintoni** Puri, 1929 *. (Fig. 19.)

Puri, Ind. Journ. Med. Res. xvii, p. 401, 1929 (*A. sintoni*). TYPE-LOC.: Calicut, Malabar Dist., S. India. TYPE: ♂ and ♀ types in Brit Mus.; paratypes in Indian Mus. and Malaria Survey of India collection.

ADULT.—Very closely resembles *A. culiciformis*, except in male genitalic characters, which are very distinct. Among external points of difference, Puri, 1929, gives the following:—Female palpi usually shorter than the proboscis by nearly a quarter the length of this organ; among the large setæ on median area of scutum are a number of short, golden, lanceolate scales with about three striations; large setæ on scutum lighter in colour, especially on lateral area.

Hypopygium: parabasal spines 2; as in *A. culiciformis*, but larger; other characters of coxite as in *A. culiciformis*. Harpagones fused in middle line as in *A. culiciformis*, but with differences in the spines and with numerous non-papillate hairs arising from the median area. Phallosome about half length of coxite, distal end narrowed and carrying laterally two beard-like hairy expansions, apical to which are a number of short processes (contrast the very characteristic phallosome of *culiciformis*).

LARVA.—Resembles *A. culiciformis*, but differs in a number of characters. Frontal hairs very short, but feathered; subantennal hair not formed into a plate, but with branches only. Mentum with four teeth on each side of median tooth, all equal in size and equally dark. On the thorax hair

* Puri 1929 *b*, p. 402; 1930 *b*, p. 43; 1931, p. 92.

no. 13 is stout and spinous instead of slender and inconspicuous, as in *A. culiciformis*. Pleural hairs: *da*1 simple, not branched as in *A. culiciformis*; *dp*1 split into 2–4; *va*2 barbed. Palmate hairs on II about equal to those on succeeding segments, not smaller as in *A. culiciformis*; leaflets longer and more fusiform. The lateral hairs on I and II normal, but on III–VI long and stout, with long conspicuous branches. Spiracular apparatus as in *A. culiciformis*; *ps* very short, with 3–4 br. Saddle-hair split at $\frac{2}{3}$ its length from base into 2–3 br. Distal ends of large teeth on pecten not split into teeth, but entire and blade-like. For other differences, see Puri, 1931.

DISTRIBUTION *.—Not recorded outside the Indian area. Recorded in India by Puri, *loc. cit.*, from Pudapadi and Calicut, MALABAR DIST., MADRAS PRESIDENCY.

BIONOMICS.—Found breeding in tree-holes in the forest in company with *A. culiciformis*.

RELATION TO DISEASE.—Nothing is known of its habits otherwise or powers of transmitting malaria (*Puri*, loc. cit.).

6. **Anopheles barianensis** James, 1911 †. (Fig. 20.)

James, in James and Liston, Anop. Mosq. of India, ed. 2, p. 76, 1911 (*A. barianensis*). TYPE-LOC.: Barian, near Murree, Western Himalayas, India. TYPE: ♀ described; type in Brit. Mus.

SYNONYM:

? *intermedius* Schingarew, 1928, Russ. Journ. Trop. Med. vi, p. 49 (*A. intermedius*); Martini, Flieg. Pal. Reg. p. 169, 1930 (*A. nigripes, intermedius*). TYPE-LOC.: Turkestan (?). SYN. by Edwards, Gen. Insect. p. 39, 1932.

Given by Christophers, 1916, as synonymous with *A. plumbeus*, but shown later by Edwards, 1921, to differ in some respects. Known in India for some time as *A. plumbeus* var. *barianensis*, but it is clear from the larval characters as given by Puri that it is a distinct species

ADULT ♀.—A medium-sized to large dark anopheline (length of wing 3·2–4·4 mm.); attitude anopheline-like.

Head with interocular vertex triangular. Scales over occiput of normal character, forming a pronounced pale vertical spot; vertical chætæ pale, few in number; ocular scales forming dense white area; anterior portion of interocular space with very numerous elongate white scales; frontal tuft very conspicuous and milk-white. *Antennæ* with some small scales on *t*; dark scales on first *fs*. *Palpi* about same length as proboscis, thin, cylindrical and smooth;

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* Puri 1929 *b*, p. 402; Covell 1931 *a*, p. 29; 1931 *b*, p. 14.

† James and Liston 1911, p. 76; Christ. 1916 *b*, p. 489; 1916 *a*, p. 475; Edwards 1921 *b*, p. 272; Christ. 1924 *c*, pp. 20, 81. See also "Hypopygium," "Pupa," "Larva," "Egg."

apical segment somewhat swollen, giving slight clubbed effect; palpal index 0·56; scaling appressed over greater part of organ and present on *rbs*; entirely devoid of pale markings.

Pharynx as for the group: dorsal papillæ 12 in number.

Thorax of usual proportions. *apn* with dark chætæ only; propleural hairs 2–4. *Mesonotum* with median area silvery grey, with frosted appearance in certain lights; fossæ and lateral areas dark; on median area narrow white scales extend about half-way to level of wing-roots; no lateral scale-tufts on anterior promontory; lateral areas bare except for chætæ; chatæ and hairs pale in median area, dark on lateral areas or lighter towards margin. Scutellum with dark hairs laterally and paler in median portion. Pleuræ darkish, sometimes with one or two dark scales; spiracular hairs present (3); prealar 5–6; upper and lower sternopleural forming continuous line of about 20 hairs; upper mesepimeral with about 6 large and 10 smaller hairs.

Wings: *af* about ¼ length of wing; its base only slightly nearer wing-base than that of *pf*; length of cell about half as long again as petiole; index 1·6. Scaling rather profuse, the scales rather long, with tendency to have pointed ends; laterals well developed and nearly meeting those of other veins in region of *af*; max. str. 10–11. Wing entirely devoid of pale markings.

Legs: femora not swollen in basal half, dark nearly to base above but somewhat paler in basal half beneath, the apices with a conspicuous white band about as long as femur is broad; tibiæ dark, with white ring at termination somewhat narrower than that on femur; tarsi entirely dark. Coxæ noticeably pale, with dark hairs on first pair; devoid of scales. Trochanters all with hairs and scales.

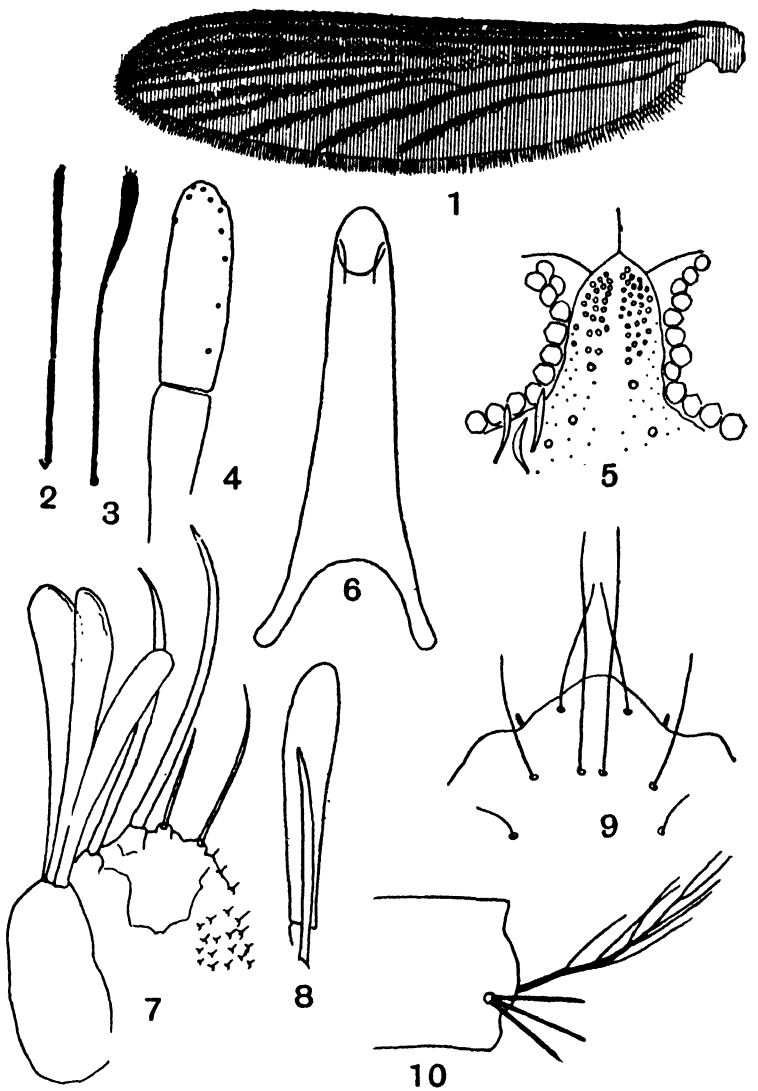
Abdomen dark, with dull grey hairs; devoid of scales, even on cerci.

ADULT ♂.—In general as in ♀. *Antennæ* with some dark scales on first flagellar segment. *Palpi* somewhat diffusely clubbed, apical segment rather rounded at end, preapical narrow towards base; marginal hair series imperfectly developed, only about seven inconspicuous hairs along ventral edge of apical segment and one or two on preapical segment. *Ungues* with a basal spur. *Abdomen* with a few dark scales on coxite.

Hypopygium *: parabasal spines 2; inner a little shorter than outer; both recurved at apex. A large internal spine about ⅔ down coxite, recurved at apex. Harpagones with three flattened spines on the chitinised dorsal lobe, the

* HYPOPYGIUM: Christ. 1915, p. 385; 1916 *b*, p. 492.

Fig. 20.



A. barianensis.

1. Wing of ♀. **2** & **3.** ♀ and ♂ palp, same scale. **4.** Apical segment of ♂ palp. **5.** Vertex. **6.** Phallosome, standard scale. **7.** Harpago, same scale. **8.** Dorsal lobe as it may appear if not fully displayed. **9.** Clypeal hairs of larva (after Puri). **10.** Third abdominal segment, to show spine-like character of hair 5 (hair 9 is very similar) (after Puri).

narrower of these often appearing as a narrow sharp spine when seen on edge, others not always distinguishable as two unless suitably flattened ; two large sharp spines on crest ventral to the first-mentioned ; a smaller spine, usually with a still smaller additional spine, on internal portion (fig. 20, 7). Phallosome simple, papilliform, with rounded end. Ninth tergite with edge of triangular area blunt, everted.

Pupa *.—According to Senevet resembles closely *A. plumbeus*, differing only in a few minor particulars. The following is taken from Senevet's description for *A. plumbeus* :—

Paddle : external border with some minute spines in posterior half, which are larger passing backwards, and are replaced in posterior ¼ by hairs. Paddle-hair short, thick, chitinised ; accessory hair of equal length but hair-like ; a dark chitinised ring round base of paddle.

Spine : (*VIII*) *without branches or with minute, scarcely visible hairs, bifurcate at end* (simple in *barianensis*), accessory hair half length of spine ; (IV–VII) short and pointed, ¼ length of segment ; (III) a little shorter and stumpier ; (II) absent.

Hair B : (VI–VII) thick and pointed, half length of segment ; (II–V) hair-like, somewhat shorter.

Hair C : (VII) minute, bifurcate ; (VI) duplicated (bifurcate in *barianensis*) ; (II–V) small, simple.

Other hairs on segments II–VII are few, small, simple, or bifurcate.

Larva *.—Full-grown larva dark grey ; head more or less uniformly very dark.

Preclypeal hairs long, simple. *Clypeal hairs* all simple, slender (see fig. 20, 9). *Frontal hairs* reduced, simple, minute. All other hairs of head simple. *Subantennal hair* very small, simple, and inconspicuous. *Antenna* smooth, dark ; hair arising from dorso-external surface a little below middle of antenna short, simple, less than width of antenna in length ; terminal hair simple or 2-3 br. ; sabres short ; cone very long, being half length of sabres and twice length of finger. *Mandible* without usual row of setæ on dorso-external surface. *Maxilla* with palp covered with fine setæ ; cone very short and dark. *Mentum* with an even row of five teeth on either side of median tooth, the last small.

Shoulder hairs : *is* short, without basal tubercle ; *ms* with large basal tubercle, stout ; outer short, simple. *Pleural hairs* as given in subgroup, but *dp*3 very minute and *vp*3

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* Pupa : Christ. 1916 *b*, p. 495 ; Senevet 1930, p. 345 ; 1931, p. 82.

† Larva : Christ. 1916 *b*, p. 493 ; Edwards 1921 *b*, p. 272 ; Puri 1928 *b*, p. 521 ; Iyengar 1930 *a*, p. 771 ; Puri 1931, p. 83.

simple. *Hair no.* 1 on metathorax not developed as palmate hair.

Palmate hairs well developed on II–VII, the hair representing these on I simple or with 2–3 br. Leaflets uniformly coloured, lanceolate, with a few ill-defined indentations on distal portion. All hairs of abdomen comparatively thickened and spine-like, noticeably no. 5, lying just dorsal to lateral hair, and no. 9, lying ventral and posterior to this hair, which are developed into characteristic very stout triradiate spines. *Lateral hairs* on I–VI long and stout, on I–III feathered; on VII very short. *Tergal plates* fairly small, except that on anal segment, which is very large, its edges nearly meeting in ventral line. Spiracular chitinisation slight. *Pecten* with 12–14 long and 4–5 short spines, all serrated in their basal portions; pecten-hair short. *ps* long, simple. *osc* with 6–8 branches, nearly all very long, with hooked ends. The minute setæ on the ventral surface are poorly developed.

The larva of *A. plumbeus* differs notably from that of *A. barianensis* in that hairs nos. 5 and 9 on the abdominal segments are not developed into the stout, dark brown tripartite spines so characteristic of the latter species; *oc* branched; lateral hairs on IV–VI much more feathered.

Egg *.—Somewhat lozenge-shaped, broad in middle, pointed towards each end; completely surrounded by a broad striated frill about $\frac{1}{5}$ total width of egg; frill of a distinct thickness, with rounded edge. Upper surface not so convex as lower. Lower surface with some silvery polygonal markings.

Identification.—The unspotted wings and conspicuous frontal tuft and femoral knee-spots at once distinguish this from any other Indian species.

From the European *A. plumbeus* it is distinguished in the adult by the much greater development of white at the apices of the femora and more extended white scaling on the mesothorax. The genitalic characters are very similar. For differences in the larval and pupal characters, see under these respective sections.

From *A. claviger* (*bifurcatus*), which occurs in East and Central Asia, it is distinguished at once by its darker colour and more vivid, almost silvery ash-grey median area of the thorax; also on genitalic characters. The somewhat similar North African *A. marteri* has a pale tache at the end of the wing.

Distribution.—Not certainly recorded outside the Indian area, but probably occurs in Turkestan (if *A. intermedius*

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* Egg: Christ. 1916 *b*, p. 492; Christ. and Barraud 1931, p. 172.

is correctly quoted as a synonym). In the Indian area apparently restricted to the North-West Himalayas at altitudes of 5,000–8,000 feet. Recorded in Covell and Christophers, 1931, from Barian, Murree, Simla, Kasauli, Kangra Dist. (Naggar and Sil Madhani), and Kashmir (Dal Lake, Srinagar).

Bionomics.—The habits are described by Christophers, 1916. Specimens of *A. barianensis* are commonly captured at dusk attempting to feed. In parts of Simla, where this species is common, it freely attacks man in the evenings in verandahs, houses, etc., but is chiefly found in the day resting inside hollow trees in the neighbourhood, many in such situations being gorged with blood, probably, to a large extent, of human origin. The species feeds readily under artificial conditions.

The larvæ are found only in collections of water in tree-holes, the water having the usual deep brown coloration seen in such situations. At Simla such breeding places were chiefly in oaks. Under artificial conditions the larvæ greedily attack and gorge themselves on fragments of crushed insects thrown on to the water, and their behaviour suggests that this may be in nature an important element in their food-supply. According to Puri, 1931, larvæ show great individual variation in the time taken for growth, larvæ of various instars being present even when these have been hatched from the same batch of eggs. Like other tree-hole larvæ (*A. annandalei*, *A. culiciformis*), they are very readily reared provided food of the nature indicated above is given; they appear much less affected by the usually adverse environment accompanying artificial breeding than are most anophelines.

According to Kalmykoff (quoted by Schingarew), larvæ of *A. intermedius* were found in a temporary artificial ground-pool in a wooded ravine, the pool being shaded and with a thick layer of dead leaves on the bottom.

Relation to Disease.—The species does not appear to be associated with any prevalence of malaria in the conditions under which it is found in nature. There is no experimental evidence regarding its powers of transmitting the disease.

7. **Anopheles lindesayi** Giles, 1900 *. (Fig. 21.)

Giles, Handb. ed. 1, p. 166, 1900 (*A. lindesaii*) †. TYPE-LOC.: Bakloh, Western Himalayas, India. TYPE: ♀ in Brit. Mus.

SYNONYM:

maculata Theo., 1910, Rec. Ind. Mus. iv, p. 1 (*A. lindesayi* var. *maculata*). TYPE-LOC.: Kurseong, Darjeeling Dist., Eastern Himalayas, India. TYPE: described from 1 ♀; type in Indian Mus., Calcutta. SYN. (of type-form) by Christ., Ind. Med. Res. Mem. no. 3, p. 24, 1924.

RECOGNIZED VARIETIES:

japonicus Yamada, Eiseig. Densenb. Zass. xiii, p. 689, 1918 (in Japanese): see Yamada, Sci. Repts. Govt. Inst. Inf. Dis. iii, p. 222, 1924 (*A. japonicus*). TYPE-LOC.: Kanayama, Hokkaido (♀♀) and Mt. Myogi (3,000 feet) (♂), Japan. TYPE: 3 ♀♀, 1 ♂. Not recorded from the Indian area.

pleccau Koidzumi, Daiw. Kenk. Hokoku, viii, pp. 17, 28, 34, 1920 (in Japanese): see Yamada, 1924, p. 219; see also Koidzumi, Trans. 5th Congr. F.E.A.T.M. p. 97, 1924 (*A. pleccau*). TYPE-LOC.: Musha (3,700 feet), Formosa. TYPE: paratype in Brit. Mus. Not recorded from the Indian area.

nilgiricus Christ.: see under *A. lindesayi* var. *nilgiricus*.

cameronensis Edwards, Bull. Ent. Res. xx, p. 323, 1929 (*A. lindesayi* var. *cameronensis*). TYPE-LOC.: Cameron Highlands (5,000 feet), Malay Peninsula. TYPE: type ♀ and allotype ♂ in Brit. Mus. Not recorded from the Indian area.

benguetensis King, Phil. Journ. Sci. xlvi, p. 753, 1931 (*A. lindesayi* var. *benguetensis*). TYPE-LOC.: Baguio, Benguet, P.I. TYPE: ♀ reared from larva. Not recorded from the India area.

ADULT ♀.—A large dark anopheline (length of wing 3·8–5 mm.; some very large specimens may have the wing 6 mm. and rival *A. gigas* in size.

Head with vertex not specially narrowed between eyes. Scales over occiput of normal character; a rather small white vertical area continued forwards in median line as a band of rather broad white fusiform scales; vertical chætæ white, about ten on each side, forming single line, the anterior somewhat thickened at ends. *Antennæ* with *t* bare; a few dark scales on first *fs*. *Palpi* about as long as proboscis; long, thin, and smooth, terminal portion often appearing slightly thickened; apical segment long, index 0·66. Scaling rather broad, black, appressed over greater part of organ; scales present on *rbs*; the organs entirely devoid of pale markings.

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* SYSTEMATIC: James and Liston 1911, p. 62; Christ. 1924 *a*, p. 11; Yamada 1924, p. 222; Christ. 1931, p. 321; King, 1931, p. 754. See also Giles 1901 *b*, p. 160; 1902, p. 323; Theo. 1901 *a*, p. 203; 1902, p. 381; 1907, p. 40; 1910 *a*, p. 14; 1910 *b*, p. 1; Blanchard 1905, p. 169; James and Liston 1904, p. 117; Christ. 1916 *a*, p. 470; 1924 *c*, pp. 24, 83; 1926, p. 876. See also pp. 124–127, footnotes. For non-Indian varieties see references given under "Varieties" and Christ., 1931, p. 321.

† See King 1931, p. 754, who notes Blanchard's correction to *A. lindesayi*.

Pharynx as for group; dorsal papillæ 8.

Thorax of usual shape. *apn* with a dense tuft of erect scales: propleural hairs 3–6. *Mesonotum* with median area markedly lighter than fossæ and lateral areas; erect pale scales on middle of *ap* and continued back on mesonotum a short distance; a few dull scales on lateral portions of promontory; median area mainly covered with rather pale chætæ and small pale hairs; fossæ and lateral areas bare except for chætæ. Scutellum with dark chætæ laterally and light chætæ in middle area. *Pleuræ* darkish, with a pale horizontal line, devoid of scales; spiracular bristles absent; prealar about 5; sternopleural with 2 in upper group and 3 in lower; upper mesepimeral 8 or more.

Wings with *af* somewhat over $\frac{1}{4}$ length of wing; base only slightly nearer base of wing than that of *pf*, about half as long again as its petiole; index 1·7. Scaling rather profuse and compact; squames and lateral scales somewhat broadly fusiform; max. str. 9–10, somewhat larger scales present at cross-veins (inner end of veins 2 and 3) and sometimes at bifurcations, giving the wing a variable degree of dark primitive spotting. Markings as shown in fig. 21, **1** (see also "Variation").

Legs: fore femora slightly swollen in basal half. Fore and mid-femora dark nearly to base above and beneath, also at apices except for some indefinitely pale scales about joint which give appearance of imperfect knee-spots. Hind femora (fig. 21, **4**) with a broad white band occupying about $\frac{1}{5}$ before distal $\frac{1}{5}$ of femur, also white beneath for about its inner $\frac{1}{3}$; apex with a few pale scales about the joint. Tibiæ dark, without any definite apical paling. Tarsi entirely dark. Coxæ palish, without scales. Trochanters pale, the first only with scales.

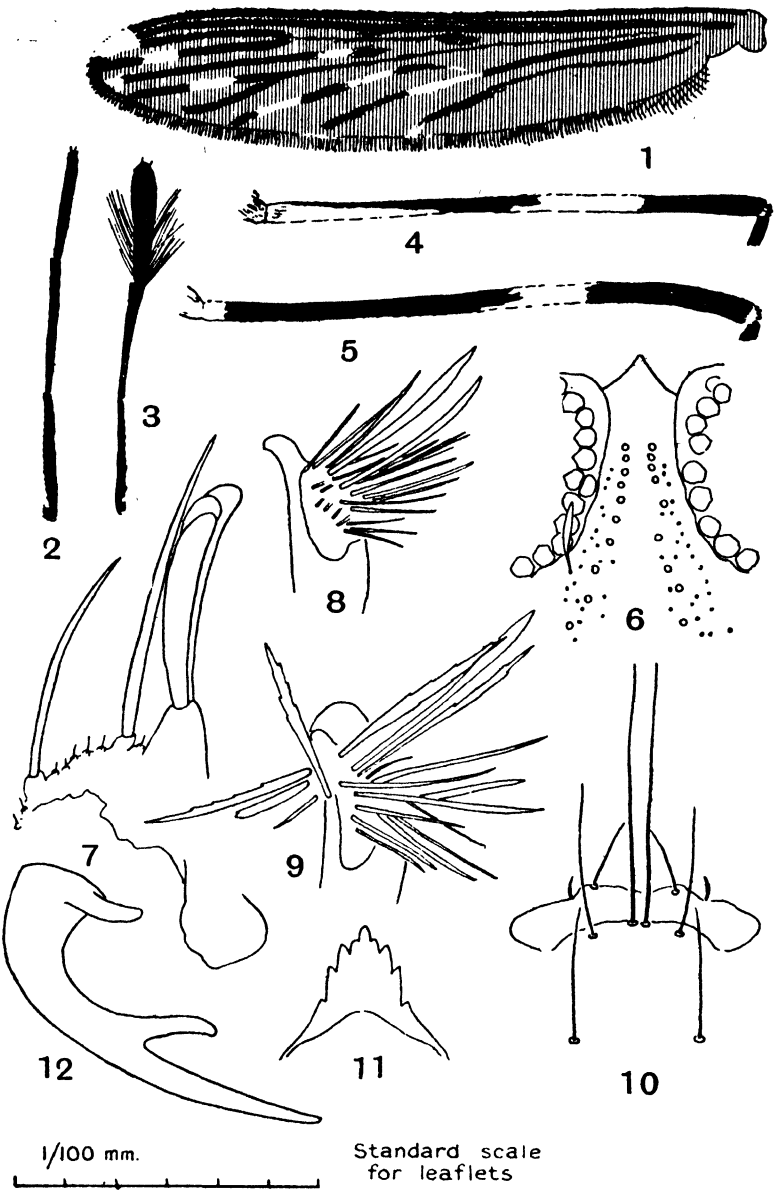
Abdomen dark, with lightish hairs; devoid of scales, even on cerci.

ADULT ♂.—In general as in ♀. *Antennæ* with some dark scales on first *fs*. *Palpi* about as long as proboscis, clubbed; apical segment as long as penultimate; marginal hairs on apical segment few and inconspicuous, on penultimate segment forming complete series, two to three deep, on both margins of ventral aspect of segment; apical hairs of segment 3 forming a dense tuft; hairs fine, numerous, rather silky; palp entirely without pale markings. *Ungues* with spur. *Abdomen* entirely devoid of scales, even on coxites.

Hypopygium *: parabasal spines 2; inner a little shorter, but about same thickness as outer, bent at tip; outer straight,

* HYPOPYGIUM: Christ. 1915, p. 388; King 1931, p. 754 (*benguetensis*).

Fig. 21.



A. lindesayi.

1. Wing of ♀. **2** & **3.** ♀ and ♂ palp, same scale. **4.** Hind femur, type-form. **5.** Ditto, var. *nilgiricus*. **6.** Vertex. **7.** Harpago, standard scale. **8.** Leaflets of one side of phallosome, type-form ; standard scale for leaflets, *i. e.*, half again that for harpago and full phallosome. **9.** Leaflets, var. *nilgiricus*, same scale. **10.** Clypeal hairs of larva (after Puri). **11.** Mentum (after Puri). **12.** Fore tarsal claw of ♂.

not bent nor hooked at tip. One, or sometimes two, well-developed internal spines about middle of coxite. Harpagones: dorsal lobe with three flattened chætæ; a large single spine on crest; a shorter, thinner spine on inner lobe (see fig. 21, 7). Phallosome rather narrow and long, carrying a large number of very fine needle-like leaflets, with a few, somewhat flatter and broader, arising in several rows from the membrane and numbering on each side 18–20 or more. Ninth tergite with a blunt triangular expansion.

Pupa *.—*Paddle*: index 1·66; external border with small spines towards base, rapidly becoming hairs which, on the posterior and *internal border*, form a complete fringe, hairs reaching $\frac{1}{10}$ length of paddle; paddle-hair about $\frac{1}{5}$ length paddle, slightly curved; acc. hair $\frac{2}{3}$ length paddle-hair, simple.

Spine: (VIII) with 3–4 lateral branches and dividing apically into two; acc. hair as long as spine, simple; (V–VII) curved, pointed, about half length of segment; (II–III) minute, unchitinised.

Hair B: (III–VII) as long, or almost as long, as segment, with 3–4 br. on segs. VI–VII, 3 br. on III–V.

Hair C: (VII) as long as segment, 3 br.; (IV–VI) as long as segment, 2 br.; (III) as long as segment, 3–4 br.

Hair 5 simple on seg. VII (simple IV–V, doubtful other segments).

Larva †.—Head with a broad median black area extending from posterior end of the frons-clypeus to beyond bases of frontal hairs, always very characteristic.

Clypeal hairs all slender, simple, the *pc* sometimes bifid; *ic* with bases nearly touching. *Frontal hairs* not reaching bases of *ic*. *Subantennal hair* normal. *Antenna* darker in distal half, with rather large spines on basal half; hair arising $\frac{1}{7}$–$\frac{1}{8}$ from base, a little longer than width of antenna, branched (6–9); terminal hair long and split about middle into 3–4 br.; cone $\frac{1}{3}$ length sabres and twice length finger. *Mentum* with a row of four teeth on either side of median tooth, first and last smaller than the other two, which are adequal and sharp-pointed.

Shoulder hairs: inner without conspicuous tubercle, short, with about 10 br.; middle stouter and about twice as long as inner, with about 12 br.; outer short, simple, arising independently. *Pleural hairs* as given for subgroup. Hair

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* Pupa: Senevet 1931, p. 93 (as *A. gigas* var. *simlensis*: see Senevet 1932.

† Larva: Puri 1931, p. 103. See also Steph. and Christ. 1902 *a*, p. 14; James 1902, p. 43; James and Liston 1904, p. 117; 1911, p. 62; Strickland 1925, p. 561; Puri 1928 *b*, p. 521.

no. 1 on metathorax forming well-developed palmate hair, with 15–22 lanceolate leaflets.

Palmate hairs well developed on II–VII ; hair no. 1 on I very short, splitting about middle into 3–4 br. Leaflets uniformly dark brown, filament differentiated but broad at base, indentations at base shallow and extending along edge. *Lateral hairs* on I–III long, stout, feathered ; on IV very long, slender, splitting near base into 3 br. ; on VI–VII very short, 3–6 br. *Tergal plates* fairly small. *spc* well developed, nearly touching anterior portion of *mps*, which is fairly broad. *Pecten* with 9–13 large, 6–8 short processes, all slender. *ps* long, dividing near base into 4–5 br. *osc* with 6–7 long br., the ends of which form hooks ; some ends of *isc* also slightly curved.

Egg *.—Upper surface narrow ; with an anterior and posterior demarcated area of about equal length, each about $\frac{1}{6}$ of egg-length. Lower surface with a polygonal network. Floats very long and broad, occupying about middle $\frac{2}{3}$ of egg-length, touching margin of upper surface throughout their whole length ; float-terminations very large, flat, rounded ; float-ridges about 20. Frill narrow, ending usually in short tag at float-junction.

Variation.—There is a considerable amount of variation in the pale spots at the ends of certain veins in the type-form. Most usually there is a pale spot at the end of 3, 4.2, 5.2 and 6, but any of these may be missing, though practically never all, and 4.2 rarely ; in addition, there may be pale spots at either or both 2.2 and 4.1. White bases to the fore and mid-femur are usually not conspicuous, as they are in the southern forms, but in well-marked specimens they may be quite vivid.

The following table gives the chief characters of the described varieties of *A. lindesayi* :—

1. All vein-terminations dark except 2.1 and 6	2.
At least one other vein-termination with pale spot	3.
2. Hind femur with a pale ring at base equal to $\frac{2}{3}$ the distal white band ; remigium with dark scales	*cameronensis.*
Hind femur with the pale ring about equal to the diameter of the femur in length ; remigium with yellow scales	*nilgiricus.*
3. Hind femur with ventral aspect pale for $\frac{1}{4}$ of its extent at base	4.
Hind femur with $\frac{1}{8}$ or less pale ventrally at base	5.

* Egg : Gill 1912 *b*, p. 3 ; Christ. and Barraud 1931, p. 172.

4. Hind femur with a line of dark scales on the dorsum extending to, or nearly to, the trochanter ..... type-form *.
   A broader area of white at base of hind femur dorsally ..... *pleccau.*
5. Hind femur dark above nearly to trochanter; usually pale for about $\frac{1}{6}$ of its length ventrally at base ..... *japonicus.*
   Hind femur usually pale for once or twice its diameter at base dorsally; usually about the same amount ventrally or up to $\frac{1}{6}$ its length ..... *benguetensis.*

IDENTIFICATION.—The characteristic markings of the hind femora, without the presence of outstanding scales, at once distinguishes this species †. For identification of the type and variety, see table given in section on "Variation" and under *A. lindesayi* var. *nilgiricus.*

DISTRIBUTION.—*A. lindesayi* has been recorded from a number of localities at high altitudes in different parts of the Oriental Region and also at lower altitudes in Japan and North China, always in one of the varietal forms already mentioned. The type-form is not recorded out of the Indian area.

In the Indian region the type-form is restricted to the northern areas, being recorded from numerous localities along the Himalayas, in the hills of the N.W.F. PROVINCE and BALUCHISTAN and the Khasi and Jaintia Hills, ASSAM (*Covell* and *Christophers*, 1931).

BIONOMICS.—*A. lindesayi* is a montane species most prevalent at altitudes of 4,000 feet or over and recorded at 8,940 feet elevation (*Gill*, 1920). It is a wild species not specially frequenting houses, but found several times in houses at about 3,500 feet (*Strickland* and *Chowdhury*, 1927), and also not infrequently taken in the village houses about Kasauli; it is stated to enter houses freely in search of food (*Gill*, 1923). It feeds readily in nature and experimentally on human blood, and was found feeding freely throughout the day in a small wood at an altitude of 7,500 feet at Shillong (*Shortt*, 1924), and biting freely at dusk near its breeding place by Gill, 1912, who also (1923) fed this species experimentally.

Breeding occurs especially in small clear pools in the rocky beds of mountain torrents, but also in miscellaneous breeding places such as pools and ditches connected with gardens

* Var. *maculata*, described by Theobald, is a specimen showing the dark spots on the wing-field due to scale-aggregation (primitive spotting) rather prominently, as is common in well-developed examples of the typical form.

† The closely allied *A. wellingtonianus* (of Malaya) is similarly coloured, but is distinguished by the black scales at the tip of the hind femur being suberect, forming a tuft; see also *A. asiaticus* and *A. annandalei.*

or cultivation in the hills. Larvæ are still to be found in reduced numbers throughout the cold season. The adult insect has been found resting among rocks and boulders near breeding places (*Gill*, 1923).

RELATION TO DISEASE.—Gill (1923) infected one out of four dissected with the parasites of B.T. malaria (oocysts). There is no evidence of its actual implication in malaria transmission in nature.

7 *a*. **Anopheles lindesayi** var. **nilgiricus** Christ., 1924*.

Christophers, Ind. Journ. Med. Res. xii, p. 13, 1924 (*A. lindesayi* var. *nilgiricus*). TYPE-LOC.: Nilgiri Hills, South India. TYPE: ♂ and ♀ in Brit. Mus.

ADULT.—Differs from type-form as follows:—Hind femora dark at base except for a conspicuous milk-white ring at extreme base about as long as femur is wide; similar rings on other femora. Distal white band on hind femur less extensive, about $\frac{1}{7}$ in place of $\frac{1}{5}$ of the femur-length measured on its dorsal part; femur more swollen distally. None of the wing-veins show any white spots at their terminations except 2.1 (which enters the apical spot) and 6; vein 3 generally more extensively pale; knee-spots more pronounced; there is a slight difference in the Nilgiri form being somewhat more golden, as against a silvery tint in the northern form, and the southern form is distinctly larger.

Hypopygium: leaflets of phallosome distinctly stouter, less needle-like, some of them serrated. Harpago not distinguishable from that of the type.

LARVA.—Differs from type-form in the following respects:—Given by Puri as larger (6·8 mm.). Head-spots distinct and separate, not forming continuous median dark area. *ic* relatively longer, spines on antenna more numerous; antennal hair rises nearer base ($\frac{1}{9}$—$\frac{1}{12}$ length); terminal hair usually simple. *is* with 13–15 br., not scattered, but closely set. Lateral hair of III with fine, short, barb-like branches, much shorter and finer than in type-form. Pecten with 9–11 long and 9–13 short br.

DISTRIBUTION.—Occurs at considerable altitudes (6,000–8,000 feet) in the Nilgiri and other plateaus in the extreme south of the Peninsula. It has not been recorded from Ceylon (vide *Covell* and *Christ.*, 1931).

BIONOMICS.—The breeding places are similar to those of the type-form (*Puri*, 1931).

RELATION TO DISEASE.—There are no observations on its power of transmitting malaria experimentally, or evidence that it may act as a carrier in nature.

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* Christ. 1924 *a*, p. 11; Puri 1931, p. 107.

8. **Anopheles gigas** Giles, 1901 *. (Fig. 22.)

Giles, Entom. Month. Mag. ser. 2, p. 196, 1901 (*A. gigas*). TYPE-LOC.: Coonoor, Nilgiri Hills (6,000 feet), S. India. TYPE: 1 ♂ and 2 ♀♀ cotypes in Brit. Mus.

RECOGNIZED VARIETIES:

formosus Ludlow, 1909, Canad. Entom. xli, p. 22 (*A. formosus*). TYPE-LOC.: Camp John Hay, Benguet, Luzon, P.I. TYPE. ♀ described; type ♀ in U.S. Nat. Mus. (*vide* Dyar and Shannon, 1925, p. 86). Not recorded from Indian area.

simlensis James, 1911: see under *A. gigas* var. *simlensis*.

refutans Alcock, 1913: see under *A. gigas* var. *refutans*.

baileyi Edwards, 1929: see under *A. gigas* var. *baileyi*.

An unnamed variety is also recorded from Sumatra and described by Swelleng., 1920 (?), p. 16; 1921, p. 129; for larva, see Swell. and Swell., 1919 *a*, p. 24 (unclassified larva no. II).

ADULT ♀.—Very large, with light-coloured, conspicuously spotted wings (length of wing 5–6 mm.); attitude anopheline.

Head with scales of normal type, with a rather narrow creamy vertical spot; vertical chætæ pale, ending in front in a large cluster of chætæ and elongated scales, which, with the ocular scales, form a conspicuous frontal tuft. *Antennæ* with some small dark scales on *t* and darkish and paler scales on first, usually also on second, *fs*. *Palpi* with index 0·56. Rather thin, but scaling somewhat erect, especially toward base, giving a rough effect: dark, unbanded, or with a few pale scales at some or all of the joints; apex dark.

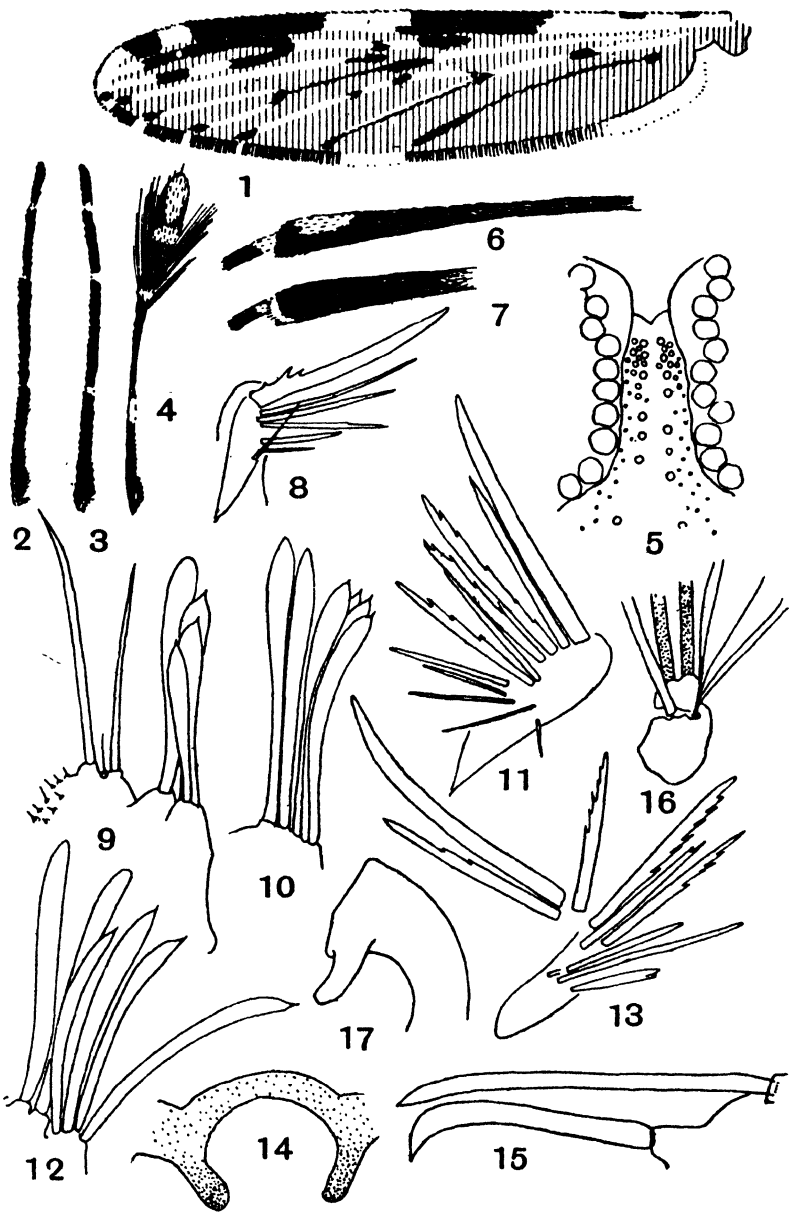
Pharynx as for the group: dorsal papillæ 10.

Thorax: *apn* with dense tufts of dark truncated scales; propleural hairs about 12, stout and long. Mesonotum with median area pale, fossæ and lateral areas brown; median area with numerous light chætæ and light yellowish scale-like hairs, latter becoming a conspicuous tuft of narrow, erect

* SYSTEMATIC: James and Liston 1911, p. 64; Christ. 1924 *a*, p. 12; 1931, p. 317. See also Giles 1901 *a*, p. 196; 1902, p. 316; Theo. 1901 *b*, p. 308; 1902, p. 374; Blanchard 1905, p. 184; Christ. 1924 *c*, pp. 25, 84; Yamada 1924, p. 240; Edwards 1926, p. 23 (distinct from *edwardsi*). See also references on pp. 133–4 (footnotes).

1. Wing of ♀, var. *simlensis*. 2. ♀ palp, type-form, usual appearance. 3. Ditto, var. *simlensis*, same scale as wing. 4. ♂ palp, var. *simlensis*. 5. Vertex, var. *simlensis*. 6. Apical portion of hind femur, var. *simlensis*. 7. Ditto, type-form. 8. Leaflets of one side of phallosome of type-form, standard scale for leaflets. 9. Harpago of type-form, $\frac{1}{10}$ standard scale. 10. Dorsal lobe of harpago, var. *simlensis*. 11. Leaflets of phallosome, var. *simlensis*, standard scale for leaflets. 12. Dorsal lobe of harpago, var. *simlensis*, standard scale for leaflets. 13. Leaflets, var. *baileyi*. 14. Processes of 9th tergite, var. *simlensis*. 15. Parabasal spines, var. *simlensis*. 16. Pleural hairs of prothorax (after Puri). 17. Base of front tarsal claw of ♂.

Fig. 22.



A. gigas.

(For explanation of the figure, see opposite page.)

scales on median area of *ap*; flat, dark scales present on anterior face of promontory laterally; lateral areas with numerous pale chætæ; fossæ with some scattered pale hairs. Scutellum with large and smaller hairs conspicuously light coloured. Pleuræ darkish, with horizontal pale bands in the usual positions; devoid of scales; spiracular hairs about 10, forming rather dense tuft; prealar hairs about 15; upper mesepimeral 20 or more; upper and lower groups of sterno-pleural about 4 and 7 respectively, or may be more.

Wings with *af* about ¼ of wing-length; petiole about half length of cell; index about 1·6; boldly ornamented, as shown in fig. 22, 1, for the variety, but differing in certain details, notably in absence of pale interruption on costa and vein 1 towards apex, so that there is a continuous, or nearly continuous, dark area between apical and subcostal pale areas; also a pale spot on outer half of vein 6; inner accessory spot continues to extreme base of costa. Apical pale spot extends to just before 2.2; fringe dark from 2.2 inclusive, with pale fringe-spots at 3, 4.1, 4.2 and 5.1, as well as a large spot (present in all the forms) between 5 and 6. Scaling rather compact and defined; scales rather broad, fusiform or clavate, max. str. 9–10. Halteres dead black, contrasting with the pallid base.

Legs with front femora distinctly swollen in basal half. Femora of all the legs dark brown, often somewhat mottled, with a pale band at extreme base not exceeding width of femur in length and not strikingly white; apices narrowly pale. On mid-femora a pale spot may be present towards tip, but is usually not conspicuous unless leg is viewed somewhat from posterior aspect, so that pale area at back of joint and extending somewhat on to femur and tibia is displayed, when it can be seen that any spot present is a small extension of this; this effect is quite distinct from the large conspicuous dorsal spot seen in var. *simlensis* and var. *baileyi*. Tibiæ in all legs pale at base and tip, on hind legs with a triangular pale area at the swollen tip. Tibio-tarsal and tarsal joints narrowly pale-banded, usually about equally basal and apical. Coxæ noticeably pallid, first and second with a few scales anteriorly, third with a few scales posteriorly. Trochanters pallid, first pair with some scales, others with hairs only.

Abdomen pale, with pale hairs; devoid of scales even on cerci.

ADULT ♂.—In general as in ♀. *Antenna* with some dark scales on first flagellar segment. *Palpi* with club-segments constricted at joint 4–5; marginal hairs on seg. 5 inconspicuous, those on seg. 4 forming series 4–5 deep along both margins of ventral aspect; numerous hairs at the swollen

apex of seg. 3; fine and silky, light yellowish in colour. Distal $\frac{2}{3}$ of seg. 5 pale, a broad pale band at 4–5, chiefly on 5, and a broad pale band at base of club and at pseudo-joint; in some specimens greater part of dorsum of club pale. *Wings* usually with dark markings more restricted than in ♀; a preapical pale area on costa extending on to vein 2.1 is commonly seen. *Ungues* with a stout basal spur. *Abdomen* devoid of scales, but numerous dark scales on outer aspects of coxites.

Hypopygium *: parabasal spines 2; inner about half length of coxite, slightly shorter and slightly stouter than outer, flattened towards end and hooked (bill hook-shaped); outer $\frac{1}{4}$ as long again as inner, straight, ending sharply in fine straight point. A well-marked internal spine about $\frac{2}{3}$ down coxite; numerous small hairs on anal surface. Harpago with three (or four) flattened spines on dorsal portion of dorsal lobe, these with rounded ends and fine terminal points; a stout, flattened spine arising separately internal to these, and two long, and usually a third small, hairs on inner lobe (fig. 22, **9**). Phallosome relatively short, $\frac{1}{3}$ coxite, somewhat squat and broad at base, shaft tapering; with about seven leaflets, including spicules, as shown in fig. 22, **8**. Ninth tergite with marked processes, about as long as interval between the processes, slightly clubbed †.

PUPA (var. *simlensis*) ‡.—*Paddle*: index 1·4; external border denticulate almost to anterior extremity, teeth less marked in basal quarter, in posterior third abruptly replaced by thin, short hairs which extend as far as the short paddle-hair.

Spine: (VIII) stem with 2–3 stout hairs on each side at its base and dividing apically into 4–5 stout hairs, accessory hair simple. (VII) curved, *slightly pointed*, $\frac{1}{3}$ segment; (V–VI) ditto, but $\frac{1}{4}$ segment; (II–IV) much reduced, non-chitinised.

Hair B: (IV–VII) branched, almost as long as the segment (3 br. on VII, 4 on VI, 4–5 on IV–V); (III) 5–6 br., half segment.

Hair C: (VII) stout, simple, slightly longer than segment; (VI) 2 br., slightly longer than segment; (III–V) several branches, about length of segment or a little shorter or longer; (II) 3 br., half segment.

Hair 5: *simple on all segments.*

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* HYPOPYGIUM: Christ. 1915, p. 386; King 1931, p. 753.

† King states that these are not apparent in the Philippine variety; they are practically as large as in *A. hyrcanus* in all the Indian forms.

‡ PUPA: Senevet 1931, p. 83 (as *A. lindesayi*: see Senevet 1932).

LARVA *.—The largest anopheline larva occurring in the Indian area, length 7–10 mm.

Clypeal hairs: *ic* simple; *oc* about half their length, and with 2–3 or more branches. *Frontal hairs* normal. *Antenna* rather stout, with only very minute spinous projections on shaft; hair arising from internal aspect at about ¼ from base, a little longer than breadth of antenna, with 5–8 br.; terminal hair with 3–5 br.; cone and finger ⅛ sabres. *Mentum* with four teeth on each side of median tooth, the three anterior equidistant, fourth further back; median and next tooth rounded, anterior pair also blunt and small.

Shoulder hairs: inner without conspicuous basal tubercle, with 3–8 lateral br.; middle about three times the length of inner, with 8–10 long br.; outer short, simple, arising from tubercle of middle hair. *Metathoracic* hair no. 1 not developed as palmate hair, the hair very short, with 3–6 br. *Pleural hairs* as in subgroup, except that *dp*1 is split into 2–4 and *vp*1 longer than usual, ¼ length of anterior hairs.

Palmate hairs well developed on III–VII; hair no. 1 on I and II very short, with not above 5 br. Leaflets with undifferentiated filament; indentations shallow and scattered along border of distal half of leaflet; length of leaflet on mid-abd. seg. 0·119 mm. *Lateral hairs* on I–III long, stout, feathered; on IV–V long and split near base into 3–5 and 2–3 br. respectively; on VI–VII very short, with 4–8 and 3–5 br. *Tergal plates* of moderate size. *spc* well marked; *mps* fairly broad anteriorly. *Pecten* with 6–8 long and 14–16 short projections. *ps* long, 4–6 br.; *osc* with 6–8 long branches, ends forming rather poorly developed hooks.

EGG.—Unknown.

IDENTIFICATION.—*A. gigas* or its varieties cannot be mistaken for any other Indian species. *A. edwardsi* from Japan, which somewhat resembles it, has three spots on vein 6; scales on the ventral aspect of seg. 7 in the female; a fringe spot at 5.2 and scales on the lateral portions of the anterior promontory brown, not black, as in *A. gigas*.

The different varieties are distinguished as follows:—

1. Mid-femur with a large pale spot on dorsum towards apex; vein 6 without a pale spot on outer half; bases of femora with conspicuous pale ring twice diameter of of femur, and milky white ... . 2.
   Mid-femur without such spot; vein 6 with a pale spot on outer half; bases of femora only inconspicuously pale ..... 3.

* LARVA: Swelleng. 1919 *a*, p. 24 (Sumatran var.); Iyengar 1922 *a*, p. 632 (tail-hooks); Carter 1925, p. 84 (*refutans*); Puri 1928 *b*, p. 521; 1931, p. 113 (type and var. *simlensis*); King 1931, p. 751 (var. *formosus*).

2. Fringe dark at vein 3 and throughout rest of extent, except for usual spot between veins 5.2 and 6 (see also remarks under this form)	var. *baileyi*.
Fringe pale at vein 3, and possibly at other veins following this (see also remarks under this form)	var. *simlensis*.
3. Fringe-spots present at 3, 4.1, 4.2, and 5.1 (see also remarks under this form)	type-form.
Fringe all dark from vein 3 onwards, except for usual spot between 5 and 6	var. *refutans* *; var. *formosus*; var. from Sumatra.

DISTRIBUTION †.—All the forms of *A. gigas* are normally recorded only from high altitudes, usually 6,000 feet or over.

The type-form occurs, so far as is known, only at high altitudes in the Nilgiris and other hills of SOUTH INDIA. It has been recorded from Coonoor, Nilgiri Hills (6,000 feet); Ootacamund, Nilgiri Hills (7,000 feet); Kodaikanal, Palni Hills; Neutral Saddle, Lower Palni Hills.

A. gigas is stated by me (1916) to occur at Pachmarhi (4,000 feet, in the Central Provinces). The Pachmarhi specimens are, however, no longer in the collection, and it is not known whether they were the type or other forms. As this locality is widely separated from the others, and some doubt even exists as to the correctness of the record, confirmation of the presence of the species is necessary. The same remark applies to the record by Nurse from Deesa, Palumpur Agency, Gujarat ‡.

BIONOMICS.—A wild species, not normally found frequenting houses. It is apparently attracted by light, and at Ootacamund sometimes taken at the billiard-table, etc. Cornwall did not succeed in getting the type-form to feed on human blood, but succeeded with pigeons; it has also been observed to feed on chickens (*Samuel*) and on a bull (*Senior White*, 1921).

The type-form breeds in fresh-water springs and ponds with vegetation at the edges, seepage ponds connected with springs, marshy places among grass, and small pools along shallow trickling hill-streams (*Puri*, 1931). At Coonoor it breeds practically all the year round (*Cornwall*).

RELATION TO DISEASE.—Nothing is known regarding the power to transmit malaria under experimental conditions, and in nature it is extremely improbable that it acts as a carrier-species (*Covell*).

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* These forms appear very similar and, until more studied, it would be premature to attempt to separate them.

† See Christ, 1931; King 1931; and references given by these authors.

‡ Given by Thec, 1907, p. 31.

8 *a*. **Anopheles gigas** var. **simlensis** James, 1911 †.

James, in James and Liston, Anop. Mosq. of India, 2nd ed. p. 66, 1911 (*Patagiamyia simlensis*). TYPE-LOC. : Western Himalayas. TYPE : specimens were seen by James from Mahasu near Simla, from Garhwal, and from Murree ; a specimen from the last locality is in the Brit. Mus., and two specimens from Mahasu in the Malaria Survey of India collection.

ADULT ♀.—Differs from the type-form in the following particulars :—No pale spot on vein 6 ; mid-femur with a large pale spot on dorsum towards apex (fig. 22, **6**) ; inner accessory dark spot on costa short, not extending to extreme base, and shorter than external spot. The palpi are more distinctly banded, rings whiter ; the white scaled bases of the femora are whiter and broader, more sharply defined and conspicuous.

The fringe in this form shows two conditions : form *a* with pale fringe-spots at vein 3 (if not included in apical spot) and 4.1 only (with usual spot, however, at 5–6), and form *b* with pale fringe-spots at veins 3, 4.1, 4.2, and 5.1, in addition to the usual spot at 5–6 (thus in this particular resembling the type-form). It is not known if these are distinct varieties, but, if so, they frequently occur together.

ADULT ♂.—Fringe commonly dark, without interruption from the apical spot, as in var. *baileyi*.

Hypopygium differs from the type-form as follows :—Leaflets of phallosome more numerous, larger, and with more obviously serrated leaflets (see fig. 22, **11**) ; harpago with six or more spines on the dorsal lobe, four forming a group on the more dorsal portion, and two somewhat larger spines arising more or less separately more ventrally (see fig. 22, **12**).

LARVA ‡.—*Clypeal hairs* : *oc* simple ; *pc* usually split into 2–5 br. instead of simple, as in the type-form ; leaflets of palmate hairs somewhat shorter (0·09 mm.) ; hair no. 2 on abd. seg. II has 4–6 in place of 6–10 in the type-form.

PUPA.—See under type-form.

DISTRIBUTION.—The WESTERN HIMALAYAS from the United Provinces to the Indus. What is probably this form has been recorded from the following localities, those from which specimens have been seen by me being marked with an asterisk :—UNITED PROVINCES, Kalighat (Garhwal) (6,000 feet), Banbassa, Dehra Dun (2,000 feet) *, Roorkee (plains), Bareilly (plains), Saharanpur (2,500 feet) * ; PUNJAB, Simla (7,000 feet) *, Mahasu (8,000 feet) *, Kasauli (6,000 feet) *, Dharmpur (4,000 feet) *, Murree (7,000 feet) *, Karnal (plains) * ; KANGRA, Manali (6,000 feet), Rahla (8,000 feet),

† SYSTEMATIC : James 1911, p. 66 ; Christ. 1916 *a*, p. 467 ; 1924 *c*, pp. 25, 84; 1924 *a*, p. 12 ; 1931, p. 317; Yamada 1924, p. 240; Edwards 1929, p. 323.

‡ LARVA : James 1911, p. 68 ; Puri 1931, p. 117.

Karaun ; CHAMBA, Bakloh (6,000 feet) *, Dalhousie *, Bara Nullah ; KASHMIR, Gulmarg (8,500 feet) *, Nara Nag (7,000 feet) *, Arau (8,000 feet) * ; N.W.F. PROVINCE, Abbottabad (4,000 feet) *.

BIONOMICS.—An alpine form rarely occurring below 6,000 feet altitude, but taken sometimes at lower altitudes near the hills (see "Distribution"). At Karnal (Cattle-breeding Farm) it was taken by Dr. G. Macdonald breeding in a well †. It is a wild form, not normally found in houses (*James*, 1911 ; *Gill*, 1920). The female in captivity will suck human blood (*James*, 1911).

The variety breeds in small ponds (*James*) and in permanent pools (*Gill*), and especially in suitable pools by the sides of streams, usually under an overhanging rock. In Kashmir it was found breeding in peaty water on uplands (*Christophers*, 1931). It is commonly taken about April or May around Kasauli ; on the higher hills usually August and September, at which latter time it is very abundant in Kashmir ; it was taken in February at Saharanpur by Bruce Mayne † ; see also Irvine, 1929.

RELATION TO DISEASE.—There is no experimental evidence regarding its power of transmitting malaria, nor any reason to suppose it acts as a carrier in nature (*Covell*).

8 *b*. **Anopheles gigas** var. **baileyi** Edwards, 1929 ‡.

Edwards, Bull. Ent. Res. xx, p. 323, 1929 (*A. gigas* var. *baileyi*). TYPE-LOC. : Yatung, Tibet (10,000 feet) ; Sept. 1927 (*Lt.-Col. F. M. Bailey*). TYPE : ♀ in Brit. Mus.

ADULT.—Very similar to var. *simlensis* except for the continuous dark fringe, as described. It may show (as also may var. *simlensis*) an uninterrupted subapical dark spot, but equally often has an interruption as is usual in var. *simlensis*. The leaflets of the phallosome are very similar to those of var. *simlensis* except that they may possibly be even somewhat stouter and more serrated ; the harpago shows a similar arrangement of spines to var. *simlensis*.

LARVA §.—As described by Strickland, 1925 (as *A. gigas*), has simple outer clypeal hairs.

DISTRIBUTION.—This appears to be the form of *A. gigas* which occurs in the EASTERN HIMALAYAS, ASSAM, and UPPER BURMA, and further east outside the Indian area.

Outside the Indian area it is recorded from || CENTRAL CHINA (Szechuan) and TIBET (Yatung). In the Indian

† Private communication.
‡ SYSTEMATIC : Edwards 1929, p. 323 ; Christ. 1931, p. 317.
§ LARVA : Strickland 1925, p. 562.
|| Faust 1926 ; Edwards 1929.

area what is probably this form has been recorded from the following localities, those verified by examination of specimens being marked with an asterisk :—UPPER BURMA, Kalaw (5,000 feet) * ; ASSAM, Shillong (5,000 feet) *, Dumpep (Khasi and Jaintia Hills), Doom Dooma (400 feet) *, Lakhimpur, Leboc (Cachar) * ; NORTH BENGAL, Saidpur (plains) *.

BIONOMICS.—A wild form, but taken in cattle-sheds and servants' lines in scanty numbers at Shillong (*Shortt*; *McCombie Young*, 1924) ; two specimens caught in houses in Upper Assam (*Watson*, 1927). Captured by Strickland † attempting to feed at Yatung.

Breeds in small pools cut off from the main stream or formed by springs or leaks ; prefers pools of which the depth is comparatively great as compared with the area (*Shortt*) ; clear rocky pools or perennial springs (*McCombie Young*). At Shillong prevalent from October to March (*McCombie Young*, 1924) ; taken at Yatung by Col. Bailey (*Edwards*, loc. cit.), by Capt. Mulligan † in September, and by Dr. Strickland † in July.

RELATION TO DISEASE.—Nothing known.

8 *c*. **Anopheles gigas** var. **refutans** Alcock, 1913 ‡.

Alcock, Journ. Lond. Sch. Trop. Med. ii, p. 161, 1913 (*A. gigas* var. *refutans*). TYPE-LOC. : hills of Ceylon. TYPE : 2 ♀ in Brit. Mus. from Maskeliya, Ceylon, are probably the types.

According to Edwards, 1929, this form has the wing-fringe all dark (except for the usual spot at 5–6) and a small pale spot on the middle femur above. The palpi of the female are sometimes, but not always, pale at the tip (*Carter*). The *larva* § has been described by Carter and has the outer clypeal hairs usually with 2–3 br., but sometimes simple.

Recorded only from CEYLON.

(*b*) Series **Lophoscelomyia.**

Edwards, 1932, Gen. Insect.

Lophoscelomyia Theo., Entom. xxxvii, p. 12, 1904. Type, *A. asiaticus* Theo.

Type-species, *A. asiaticus* Theo.

For characters, see key under group *Anopheles*. The affinities of the series are somewhat intermediate between *Anopheles* and *Myzorhynchus*, but the hypopygial characters most nearly approach the former.

One species (with variety) is recorded from the Indian area.

† Private communication ; Capt. Mulligan's and Dr. Strickland's specimens are in the Kasauli collection.

‡ SYSTEMATIC : Alcock 1913 *b*, p. 161 ; Carter 1925, p. 68 ; Edwards 1929, p. 323 ; Christ. 1931, p. 317.

§ LARVA . Carter 1925, p. 85.

9. **Anopheles annandalei** Baini Prashad, 1918 *.

Baini Prashad, Rec. Ind. Mus. xv, p. 123, 1918 (*A. annandalei*). TYPE-LOC. : Sureil (5,000 feet), Darjeeling Dist., Eastern Himalayas. TYPE : described from 1 ♂ in Indian Mus., Calcutta.

SYNONYM :

djajasanensis Brug, 1926, Geneesk. Tijds. Ned. Indie, lxvi, p. 591, and Bull. Soc. Path. Exot. xix, p. 805, Nov. 1926 (*Lophoscelomyia annandalei* var. *djajasanensis*). TYPE-LOC. : Djajasana, Garoet, Java (1,300–1,400 m.). TYPE : described from 10 ♂♂ and 6 ♀♀ bred from larvæ. Cotypes in Brit. Mus. SYN. by Puri, Ind. Journ. Med. Res. xvii, p. 386, 1929.

RECOGNIZED VARIETY :

interruptus Puri, 1929 : see under *A. annandalei* var. *interruptus*.

A. asiaticus of Christ., 1915, referred to as sent from Ceylon by Col. James, and the hypopygium of which is described, is the variety of *annandalei* (*vide* Puri, 1929, p. 394). *A. asiaticus* is not recorded from the Indian area ; for points of distinction, see under " Identification."

Most of the material available for study from India relates to the variety. The type-form differs only very slightly from this in not possessing a pale spot on the costa at the subcostal junction, in a less heavy scaling of the mesonotum, and in having only 2–4 oblanceolate scales, in place of 8–12 truncated scales, connected with each group of the sterno-pleural hairs. The larval characters are identical except that the dorsal anterior pleural hair of each segment is simple in place of being finely barbed, as in the variety. Description of this species will therefore be given under the variety.

The type-form was originally described from Sureil (Darjeeling), and further specimens have been obtained from Sukna and Kurseong, in the same neighbourhood. It has been recorded (as var. *djajasanensis*) by Brug from Java, *vide* Puri, *loc. cit.*

9 *a*. **Anopheles annandalei** var. **interruptus** Puri, 1929. (Fig. 23.)

Puri, Ind. Journ. Med. Res. xvii, p. 387, 1929 (*A. annandalei* var. *interruptus*). TYPE-LOC. : Sukna, Darjeeling Dist., Eastern Himalayas. TYPE : cotype ♂♂ and ♀♀ in Brit. Mus. and Indian Mus., Calcutta ; paratypes in Malaria Survey of India collection.

ADULT ♀.—A small anopheline (length of wing about 3 mm.) ; at once picked out by the large conspicuous tufts, readily visible to the naked eye, on the hind femora.

Head : vertex between eyes of normal character ; scales over occiput of usual type, with a well-marked pale vertical area. Vertical chætæ white, in a single row of about eight each side, the anterior somewhat flattened, forming poorly

* SYSTEMATIC : Baini Prashad 1918, p. 123 ; Christ. 1924 *c*, pp. 22, 82 ; Brug 1926 *a*, p. 591 ; 1926 *b*, p. 805 ; Puri 1929 *a*, p. 386. For hypopygium, larva, and egg see under var. *interruptus*.

developed vertical tuft; a well-marked line of ocular scales and some scattered ones on vertex. *Antennæ* with some small, but conspicuous, white scales on torus; some inconspicuous dark scales on first flagellar segment. *Palp* rather thick, but not markedly shaggy; index 0·6; apex dark and with narrow pale bands at bases of segments 3, 4, and 5.

Pharynx as for the group; dorsal papillæ 8.

Thorax: *apn* with black scale-tufts; propleural hairs 3–4, with one or two pale scales. Mesonotum with median area dark, but contrasting with the still darker fossæ and lateral areas; median area covered diffusely with scattered narrow, curved, almost hair-like white scales, aggregated to form a median tuft on anterior promontory; lateral areas of anterior promontory without scale-tufts. Pleuræ dark; some pale scales on sternopleuron; spiracular hairs present (3); prealar 5–6, with some pale scales; sternopleural upper and lower group each with 3–4 hairs and fairly numerous white broadish scales (8–12); upper mesepimeral few (3).

Wings: *af* about ¼ length of wing; about half as long again as its petiole; index 1·9. Scaling on greater part of veins of small, rather broad, rounded scales, max. str. about 8, of a dull grey colour; at cross-veins, bifurcations and other situations, as shown in fig. 23, 1, are aggregations of much larger and broader scales, max. str. 16, of a deep black, giving a marked effect to the naked eye of conspicuous black spots. A conspicuous pale apical costal spot, more or less continued across wing to fringe-spot at 3; a pale spot at subcostal junction not involving first vein, and a narrow pale interruption at the humeral, with an area on vein 1 which generally appears to be bare and shows up somewhat palely. The only distinct pale spot is on 2.2. Fringe without spots other than that mentioned; border-scales dark, extending nearly to base of wing.

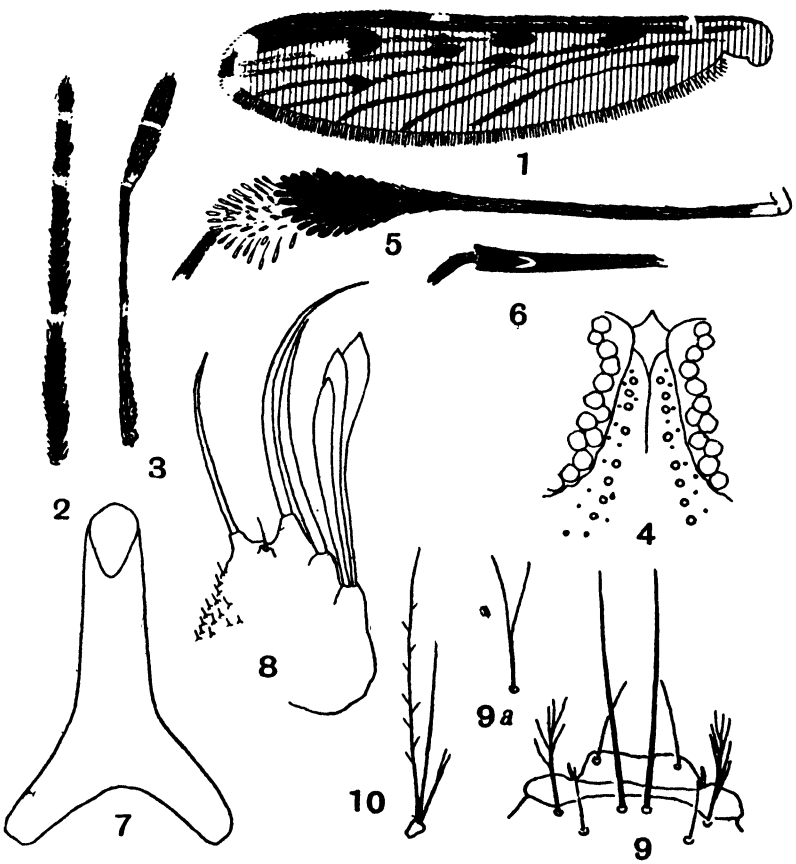
Legs: front femora somewhat swollen in their basal half. All femora with a white band at base about equal to diameter and (except for the special ornamentation referred to below) dark beneath and at their tips. Mid-femur with a V-shaped white spot on dorsum near apex. Hind femora with apical third covered with long outstanding scales, white distally and black more proximally, forming remarkable conspicuous tufts almost as large as the head of the mosquito, and at once apparent, even on naked-eye examination. Tibiæ dark throughout, including tips. Tarsi entirely dark. Femora and tibiæ sometimes somewhat mottled. Fore coxæ darkish, mid and hind pallid; fore and mid with a conspicuous tuft of curved outstanding scales on posterior external surface.

Abdomen dark; some darkish scales dorsally and ventrally on VIII; cerci devoid of scales.

ADULT ♂.—In general as in ♀. *Antennæ* with some dark scales on first flagellar segment. *Palpi* clubbed; dark except for a narrow pale band across club at base of apical segment; one at base of club and one at pseudo-joint; marginal hairs few and inconspicuous. *Ungues* with spur. *Abdomen* with scales dorsally and ventrally on VIII and on coxites.

Hypopygium *: parabasal spines 2; inner shorter than outer, but only slightly thicker; both with fine recurved

Fig. 23.



A. annandalei var. *interruptus*.

1. Wing of ♀. 2 & 3. ♀ and ♂ palps, same scale. 4. Vertex. 5. Hind femur. 6. Apical portion of mid-femur, showing V-shaped spot. 7. Phallosome, standard scale. 8. Harpago, ditto. 9. Clypeal hairs of larva (after Puri). 9*a*. Outer clypeal hair, showing another form of branching (after Puri). 10. Pleural hairs of right side of mesothorax (after Puri).

* HYPOPYGIUM: Christ. 1915 *b*, p. 385.

sharp points. A well-developed internal spine slightly below half-way down coxite. Harpago with three expanded blades arising from dorsal lobe, two large spines on crest, and a smaller hair-like spine on inner lobe (see fig. 23, **8**). Phallosome poorly chitinised, without leaflets or terminal thickening. Ninth tergite with blunt everted processes.

PUPA.—Undescribed.

LARVA*.—*Clypeal hairs*: *ic* simple, *oc* branched (see fig. 23, **9**). *Frontal hairs* greatly modified; inner about as long as normal, but delicate and simple; middle and outer much reduced, very short, with appearance of ordinary small branched hair. *Subantennal hair* peculiar, with 3–7 dorsal branches and one long ventral, curved downwards and stout. *Antennæ* dark and, for tree-hole breeding species, stout; hair short, a little longer than width of antenna in some larvæ, arising from external surface about $\frac{1}{3}$ from base; cone long, half length of sabres. *Mentum* with a row of five teeth on each side of median tooth, first three subequal and large, next two small.

Shoulder hairs: inner without basal tubercle, fairly large, with 10–13 br.; middle twice length of inner, 14–19 br.; outer rising from tubercle of middle hair, very short, but usually bifurcate or trifurcate at tip. *Pleural hairs* as given for subgroup. The chitinous tubercles with the projection very poorly developed, but produced into tiny spine near its dorsal end on the meso- and metathorax. Hair no. 1 on metathorax with 7–12 br. rising close together, usually flattened.

Palmate hairs well developed on II–VII; hair no. 1 on I very short, and may be simple. Leaflets uniformly coloured, with shallow serrations and filament usually imperfectly differentiated; length of filament 0·1 mm. *Lateral hairs* on I–III long, stout, feathered; on IV–VI also long, but not so stout, rising from basal tubercle and feathered; on VII very short, 5–6 br. *Tergal plates* rather small. Spiracular chitinisation well developed, not touching, though close to, anterior portion of median plate. *Pecten* with large number of spinous projections, most of which are long (16–19), and 5–7 of which are a little shorter than the others. *ps* long, simple or bifid. *osc* with 6–8 comparatively long branches, the amount of hooking shown by which is very variable.

The whole ventral and lateral surfaces of the larva are covered with conspicuous small curved setæ, giving it a characteristic shagreened appearance.

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* LARVA: Puri 1931, p. 107. See also Baini Prashad 1918, p. 123; Brug 1926 *a*, p. 591; 1926 *b*, p. 805; Iyengar 1922 *b*, p. 526; Puri 1928 *b*, p. 521; 1929 *a*, p. 385.

EGG *.—Boat-shaped. Upper surface moderately broad, marked with polygonal network ; lower surface with reticular pattern as on upper surface. Floats extending nearly from end to end of egg, touching margin of dorsal surface ; nearly as broad in median area as lateral aspect of egg, but narrowing sharply to fine points at ends ; float-ridges about 25 in number. Frill narrow, restricted to a very small anterior and posterior demarcated area not above $\frac{1}{12}$ of the egg-length.

IDENTIFICATION.—The only species that can be confused with *A. annandalei* are the Malayan species *A. asiaticus* and *A. wellingtonianus*, the former breeding commonly in bored bamboos, the latter found under conditions similar to its close relative *A. lindesayi*. The following table gives the chief points of distinction between the species having outstanding femoral tufts :—

1. Tuft formed of black scales only, with a white area of flattened scales proximal to black	*wellingtonianus*.
Tuft formed of white and black scales, white scales distal to black	2.
2. Palpi of ♀ unbanded, or with some pale scales only at joints 3–4 ; mesonotum with hairs only except anteriorly ; scaling at base of *af* forming moderate aggregation of moderately broad scales ; no fringe-spot at 3 ; abd. seg. VIII with conspicuous yellow scales. Larva with antennal hair branched and subantennal hair simple ; integument not shagreened ventrally	*asiaticus*.
Palpi of ♀ with three pale bands ; mesonotum with numerous scales over whole median area ; scaling at fork very dense and scales very broad ; a fringe-spot at 3 ; abd. seg. VIII not yellow. Larva with simple antennal hair and branched subantennal hair ; integument shagreened ventrally	3.
3. Subcostal spot present ; mesonotum more scaly ; more numerous scales on pleuræ ; dorsal anterior pleural hairs of all segments with fine barbs	[*interruptus*. *annandalei* var.
No subcostal pale spot ; dorsal anterior pleural hairs simple	*annandalei* (type-form).

DISTRIBUTION.—Not recorded out of the Indian area. Within the area has been taken at Sukna, Tindharia, and Kurseong, near Darjeeling, in the EASTERN HIMALAYAS ; at Silchar and Nongpoh, in the Khasi and Jaintia Hills, ASSAM ; and in CEYLON (see note under type-form).

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* EGG : Puri 1929 *a*, p. 387 ; Christ. and Barraud 1931. p. 172.

BIONOMICS.—Both the type and var. *interruptus* have only been taken breeding in tree-holes, usually in deep forest or wooded country. Gravid females have been collected in nature and oviposited under artificial conditions (*Puri*). Some first-stage larvæ collected at Nongpoh by the writer, and brought nearly 2,000 miles in the train to Kasauli during the winter, hatched out eventually as full-sized specimens, being fed on fragments of insects and without other precautions.

RELATION TO DISEASE.—There is no evidence regarding its power to transmit malaria or of its playing any rôle in this disease ; it is very improbable that it ever acts as an important malaria carrier.

(*c*) Series **Myzorhynchus.**

Edwards, 1932, Gen. Insect.

Myzorhynchus Blanchard, 1902, C. R Soc. Biol. liv, p. 793. Type, *A. sinensis* Wied.

Type-species, *A. hyrcanus* var. *sinensis* Wied.

For characters of the series, see under group *Anopheles*. In addition to characters there given, the series differs from series *Anopheles* and *Lophoschelomyia* in having the harpago more compacted and chitinised and with a fused club on the dorsal lobe, and the *dp*1 pleural hair of the larva stout and branched near the base into 3–6 spine-like branches. They are all large blackish anophelines, with a very pronounced anopheline attitude, marked prothoracic tuft, and mixed scaling on the wings.

The following species and varieties are recorded from the Indian area :—

Palpi without pale markings in the female :

A. barbirostris Van der Wulp.
A. barbirostris var. *ahomi* Chowdhury.
A. pseudobarbirostris Ludl.
A. umbrosus Theo.

Palpi with pale markings in the female :

A. hyrcanus var. *sinensis* Wied.
A. hyrcanus var. *nigerrimus* Giles.

The following gives the more obvious distinctions between such forms of the *Myzorhynchus* series as occur, or might possibly occur, in the Indian area :—

♀ palpi entirely dark *.

With a scale-tuft on venter of 7 segment in ♀ ..... *barbirostris* and allies †.
Without such a tuft ..... *umbrosus* and allies †.

* There are often patches (not bands) of white scales on the palpi of the male in *A. barbirostris* ; the broad wing-scaling will at once show that it is not *A. hyrcanus*.

† See under these species for further details.

♀ palpi with some pale scales.
Last tarsal segment of hind leg completely white. No scale-tuft on clypeus * ..... *albotæniatus* ; *monotanus*.
Last tarsal segment of hind leg not so.
Without scale-tufts on venter of VII (in ♀), or on clypeus towards base (♂♀).
Leaflets of phallosome very large, serrated ..... *separatus*.
Phallosome without leaflets .... *hunteri*.
With scale-tuft on VII (in ♀) and on clypeus (♂♀). Leaflets of phallosome small, delicate, ⅓ or less length of whole organ..... *hyrcanus*.

10. **Anopheles hyrcanus** var. **nigerrimus** Giles, 1900 †. (Fig. 24.)

Giles, Handb. of Gnats or Mosq. ed. i, p. 161, 1900 (*A. nigerrimus* ‡). TYPE-LOC. : Calcutta, India. TYPE : ♀ described ; type ♀ in Brit. Mus.

SYNONYMS :

? *nero* Doleschall, 1851, Nat. Tijds. Ned. Indie, xiv, p. 383 (*Culex nero*). TYPE-LOC. : Gombong, Middle Java (*vide* Edwards, Ind. Journ. Med. Res. x, p. 473, 1932). TYPE non-existent.

indiensis Theo., 1901, Mono. Cul. i, p. 145 (*A. sinensis* subsp. *indiensis*). TYPE-LOC. : Madras. TYPE : ♀ in Brit. Mus. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 29, 1924.

? *pursati* Laveran, 1902, C. R. Soc. Biol. liv, p. 907 (*A. pursati*). TYPE-LOC. : west of Pursat, Cambodia. TYPE : ♀ described. SYN., of *A. hyrcanus*, by Edwards, Gen. Insect. 1932 ; this is most probably var. *nigerrimus*, but may be var. *sinensis*.

bentleyi Bentley, 1902, Ind. Med. Gaz. xxxvii, p. 15 (*A. bentleyi*). TYPE-LOC. : Tezpur, Assam. TYPE : ♀ described ; location unknown. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 29, 1924.

minutus Theo., 1903, Mono. Cul. iii, p. 91 (*Myzorhynchus minutus*). TYPE-LOC. : Lahore, Punjab, India. TYPE : described from 1 ♀ ; type in Brit. Mus.* SYN. by James and Liston, Anop. Mosq. of India, ed. 2, p. 120, 1911.

argyropus Swelleng., 1914, Geneesk. Tijds. Ned. Indie, liv, p. 334 (*Myzorhynchus argyropus*). TYPE-LOC. : Java. SYN. by Barraud and Christ., Rec. Mal. Surv. ii, p. 271, 1931. See also p. 153.

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* In the *argyropus* form of *A. hyrcanus* the last segment may be mainly or entirely white ; the scales on the clypeus will decide.

† SYSTEMATIC : Christ. and Khazan Chand 1915, p. 196 ; Christ. 1924 *c*, pp. 28, 86 ; Yamada 1924, p. 223 ; Edwards 1929, p. 321. See also Giles 1900, p. 161 ; 1902, p. 305 ; Theobald 1901 *a*, pp. 134–145 ; 1902, p. 373 ; 1903, pp. 89, 91 ; 1907, p. 86 ; 1910 *a*, p. 51 ; James and Liston 1904, p. 79 ; 1911, p. 120 ; Blanchard 1905, p. 190 ; Leicester 1908, p. 30 ; Stanton 1912 *b*, p. 8 ; Strickl. 1913 *a*, p. 139 ; Alcock 1913 *a*, p. 101 ; Christ. 1916 *a*, p. 480 ; Schüff. and Swell. 1917, p. 20 ; Mangk. 1919, p. 47 ; Edwards 1920, p. 129 ; 1921 *b*, p. 274 ; Rodenwaldt 1921, p. 156 (pilot.) ; Walch 1924 *a*, p. 18 ; Carter 1925, p. 69 ; Borel 1929, p. 28 ; Martini 1930, p. 146 (Turkest.) ; Barraud and Christ. 1931, p. 271 ; Baisas 1931, p. 425. See also references on pp. 146, 149–51 (footnotes).

‡ Called also by Giles (*ibid.*) *Anopheles* sp. *b*, from Calcutta.

For synonomy of *A. hyrcanus* Pallas and its varieties, other than those dealt with here, see Christophers, 1924 *c*, p. 28; Edwards, Bull. Ent. Res. xx, p. 324, 1929; and Yamada, 1924, p. 230.

Walch (Meded. Volks. Ned. Indie, xix, D. 1, p. 44, 1930) has described a larva having the characters of Leicester's description of *A. peditœniatus*, and, pending further information, *A. peditœniatus* Leic. has not been placed among the synonyms of this form.

Until Edwards (Bull. Ent. Res. x, p. 129, 1920) grouped *A. sinensis* along with *A. pseudopictus* and allied forms, under *A. hyrcanus*, the Indian variety was very generally known as *A. sinensis* Wied. Christophers and Khazan Chand (1915, p. 199), followed by Christophers (1916 *a*, p. 480), distinguished a Chinese form (*sinensis*) as distinct from the darker Oriental form. This was first named var. *vanus*, but as Walker's *vanus* was clearly not a form of *A. hyrcanus*, it was later (1924) given by the latter author as var. *nigerrimus*, which name has precedence over other synonyms.

The varieties of *A. hyrcanus* now generally recognized are: var. *pseudopictus* (Italy, etc.); var. *pictus* (Eastern Mediterranean and Palestine); var. *mesopotamiæ* (Lower Mesopotamia); var. *sinensis* (China, etc.); var. *nigerrimus* (Oriental Region) *. All these forms are difficult to distinguish in some individuals at least, and close similarity in the leaflets of the phallosome and larval characters, as seen in material available, seem to indicate that they are no more than varieties. Senevet has indicated pupal differences, notably in the paddle, of *A. hyrcanus* (Palestine) and var. *nigerrimus*. These differences appear to me, however, less definite than implied by the author mentioned, and to be at most a matter of some difference in degree.

ADULT ♀.—Large (length of wing 3·5–5 mm.); very dark; anopheline attitude very marked.

Head: scales on occiput of normal type, extending low down on postgenæ; a well-marked white vertical spot; vertical chætæ forming a single line extending to front of vertex; white chætæ very slightly modified, forming a conspicuous tuft; ocular scales well developed and long. *Antennæ* with some small pale scales on torus and numerous broad white scales, usually on the first five or more flagellar segments. *Palp* with index 0·6, covered throughout whole length with long erect scales, giving markedly shaggy effect; black, with a white apical band and narrowish pale bands at 2–3, 3–4, and 4–5 †; some scales on membrane at base. *Clypeus* with a large tuft of black scales laterally towards base. *Mandible* with about 40 teeth; *maxilla* 16.

Pharynx ‡ as for group; dorsal papillæ 8.

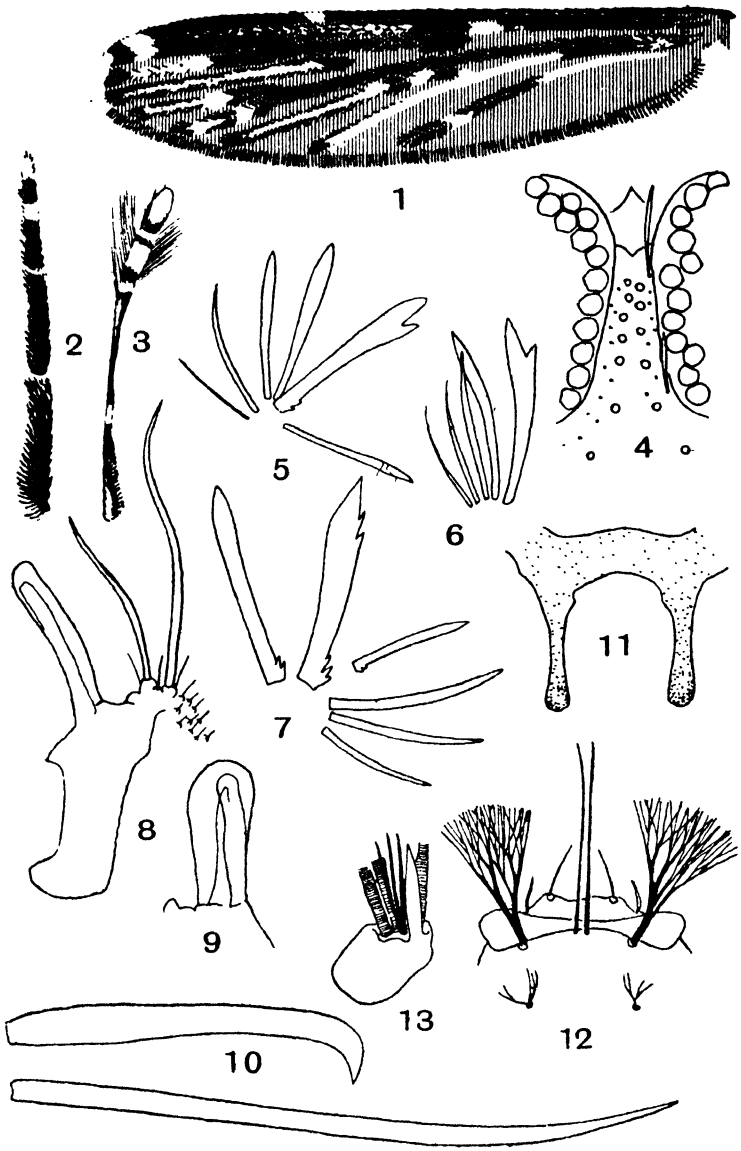
Thorax: *apn* furnished with dense tuft of outstanding black scales; propleural hairs 4 or more. Mesonotum dark, almost black, median area not markedly lighter than fossæ and lateral areas; median area covered with rather

* The following varieties are described from Russian territory:—var. *marzinowskii*, var. *flerowi*, and var. *mahmouti*. For further particulars of these and the above-mentioned forms, see under "Identification."

† Sometimes with indefinite white scaling along upper surface.

‡ PHARYNX: Manalang 1929, p. 435.

Fig. 24.



A. hyrcanus var. *nigerrimus*; also var. *sinensis* (7).

1. Wing of ♀. 2 & 3. ♀ and ♂ palpi, same scale. 4. Vertex. 5. Leaflets of phallosome (form from Siam with very broad tarsal banding), standard size for leaflets. 6. Ditto (specimen from Purnea Dist., India). 7. Ditto, var. *sinensis* (specimen from Kalaw), same scale. 8. Harpago, $_{1}^{7}{}_{0}$ standard scale. 9. Club seen on flat. 10. Parabasal spines. 11. Processes of 9th tergite. 12. Clypeal hairs of larva. 13. Pleural hairs of prothorax.

numerous light curved hairs, becoming scales in the middle of anterior promontory, where a tuft of white scales is formed ; very marked tufts of scales on lateral areas of promontory, often somewhat palish above ; fossæ with scantier hairs. Scutellum with the large hairs dark. Pleuræ dark, marked with the usual pale horizontal lines ; spiracular hairs present, usually about 5 ; prealar numerous (about 15) ; upper mesepimeral about 10 ; sternopleural with the upper and lower groups numbering about 4 and 10 respectively, latter usually with a scale or two.

Wings large (three times length of thorax) ; *af* about ¼ length of wing ; index 1·5 ; petiole about half length of cell. Ornamentation of wing as shown in fig. 24, 1 ; pattern often somewhat confused, owing to dark and pale scales both being present on the veins together ; often pale scales present in middle of vein, and laterally extended scales dark ; in some places dark scales present on lower surface of wing, and are seen through wing-membrane when upper scales are pale.

The apparent apical pale spot is really subapical, being proximal to the junction of vein 1 with the costa, and not continuous with the pale apical fringe-area ; apex of wing is very characteristically widely and continuously pale to beyond vein 3. In this variety the subcostal spot does not usually completely, if at all, involve vein 1 and is very commonly small and fleck-like ; stems of veins 2 and 4 usually all dark, but not invariably so ; usually no fringe-spot at 5.2, but one is occasionally present ; border-scales often conspicuously pale or creamy, but may be darkish, especially in middle portion of wing. Scaling heavy and profuse ; scales broadly fusiform and laterals widely spread, in anterior portion of wing meeting, or nearly meeting, scales of contiguous veins ; max. str. about 12.

Legs : anterior femora markedly swollen in basal half. Femora dark to base or nearly so ; front pair dark beneath, often with a pale area towards apex posteriorly, others usually more or less pale beneath ; dark or narrowly pale apically. Tibiæ usually pale on one aspect for whole length, and also usually pale at base and more or less apically. Tarsi very variable in extent of marking ; usually with pale apical bands of moderate extent on segments 1–3 on fore and mid-legs and segments 1–4 on the hind legs, very commonly with the joint 3–4 on the hind legs with banding also ; in many series the extent of paling is much greater, involving half the segment on the front legs and a large part of the more distal segments on the hind legs, these being sometimes almost entirely pale (*argyropus* form). Front coxæ with dark and often pale scales anteriorly, the mid and hind with

a conspicuous tuft of erect pale scales externally towards apices. Trochanters with scales on fore and mid-legs, those of the hind legs with hairs only.

Abdomen dark, devoid of scales, except a few towards posterior border of tergite VIII and a tuft of black scales ventrally towards the apex on segment VII. Cerci with hairs only.

ADULT ♂.—In general as in ♀. *Antenna* without scales on first flagellar segment. *Palpi* clubbed, the last two segments clearly articulated and constricted somewhat at joint. Marginal hairs on segment 5 few and inconspicuous; forming a row 4–5 deep on either border of segment 4; numerous hairs arising from apex of 3. Scaling rather profuse and inclined to form tufts, with black and white ornamentation; apical segment white apically and usually over greater part of outer surface, dark at base and edges, some white scales along inner dorsal margin; preceding segment pale at apex and over greater part of median area; segment 3 pale at apex and usually with pale line of conspicuous scales along dorsum; a well-marked white area at pseudo-joint and often some pale scales on segment 2. *Ungues* with basal spur. *Abdomen* devoid of scales (and lacking ventral tuft shown by female), but with numerous scales on coxites.

Hypopygium *: parabasal spines 2; inner about ¼ length of coxite, stouter than, but about half length only of outer; end flattened, sharply pointed and shortly recurved; outer nearly straight, tapering, and not recurved at end. A well-marked internal spine about half-way down coxite. Harpago with a flattened club on dorsal lobe and two simple spines on inner lobe (fig. 24, 8). Phallosome approaching half length of coxite; usually with about 5 leaflets, but sometimes as few as 2; leaflets small, delicate, the largest lanceolate, serrated, and often with subterminal tooth, giving it a very characteristic bifid appearance (fig. 24, 5, 6). Ninth tergite with long processes, about as long as the interval between them, distinctly clubbed.

PUPA †—*Paddle*: index 1; external border in middle ⅓ with small, appressed spines, replaced in posterior ⅓ by delicate hairs; paddle-hair short, straight, or nearly so, simple; acc. hair ⅔ paddle hair.

Spine: (VIII) poorly developed, with 2–3 fine lateral branches and 2 fine terminal branches; acc. hair as long as spine,

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* HYPOPYGIUM: Christ. 1915, p. 389; Swelleng. 1921 *a*, p. 109; 1921 *b*, p. 38; Borel 1929, p. 28; Paisas 1931, p. 444.

† PUPA: Senevet 1931, p. 86. See also Cogill 1903, p. 328.

simple ; (II–VII) short, blunt, thick, reduced in size on more anterior segments.

Hair B: (VII) half length segment, 6–7 br. ; (III–VI) half length of segment, 15–16 br.

Hair C: (VII) ⅔ length of segment, 2–3 br. ; (III–VI) about half length segment, 3–6 br. on 5 and 6, more numerous br. on 3 and 4 ; (II) reduced, 7–8 br.

Hair 5 bifurcate on segs. III–VI, simple on VII. Most of the other hairs simple or bifurcate, except hairs 3 and 4 on segs. 2–4, which may have several branches.

LARVA *.—*Clypeal hairs*: *ic* simple, *oc* dendritically branched, with. 50–60 terminal branches (fig. 24, 8) ; *pc* with 2–3 br. or rarely 4–5. *Frontal hairs* normal, long. *Antennæ* very stout, uniformly pigmented, small spines well developed on inner aspect ; hair arising from internal aspect about middle of antenna, with 8–12 br. ; terminal hairs 6–10 br. ; sabres relatively long, a little less than half length antenna. Long setæ forming cluster on dorso-external surface about middle of mandible, markedly plumose, not simple as in other larvæ. *Mentum* very small, with four teeth on each side of median tooth, last of series often very small.

Shoulder hairs : inner without conspicuous basal tubercle, short, simple, or sometimes split into 2 or 3 ; middle stout, feathered ; outer simple, arising independently. *Metathoracic hair no.* 1 developed as palmate hair. *Pleural hairs* as in subgroup, *dpl* having 3–4 stiff branches.

Palmate hairs well developed on III–VII ; hair no. 1 on I and II poorly developed, with 9–13 leaflets. Leaflets lanceolate, with shallow indentations scattered along distal ⅓ ; length of leaflet on mid-abd. seg. 0·126 mm. *Lateral hairs* on I–III long, stout, feathered ; on IV–V long and split near base into 2–3 br. ; on VI–VII very short, with 4–6 br. *Tergal plates* not very long, but fairly broad. Spiracular chitinisation poorly developed and widely separated from median plate, which is not very broad anteriorly. *Pecten* with 6–9 long and 12–17 short projections, which are without serrations along their dorsal borders, the two outermost projections somewhat longer than the other long ones.

* LARVA : Puri 1931, p. 121. See also Steph. and Christ. 1902 *b*, p. 7 ; James and List. 1904, p. 79 ; 1911, p. 122 ; Stanton 1912 *b*, p. 8 ; 1915, pp. 160, 170 ; 1916, p. 128 ; Swell. and Swell. 1919 *a*, p. 18 ; 1920 *b*, p. 86 ; Mangkoewinoto 1919, p. 47 ; Swell. 1921, p. 110 ; Lamborn 1921, p. 91 (tail-hooks) ; Iyengar 1921, p. 216 (thor. app.) ; 1922 *a*, p. 630 (tail-hooks) ; Carter 1925, p. 84 ; Senior White 1925, p. 217 ; Puri 1928 *b*, p. 521 ; Walch and Sœsilo 1929, p. 464 (pecten) ; Walch 1930, p. 44 (*peditœniatus*) ; Borel 1929, p. 28 ; Montschadsky 1930, p. 556 (spir. app.) ; Baisas 1931, p. 425 (Philipp.).

ps with 3–4 br. *osc* with 5–6 long br., with stout ends, but not very sharply curved, and forming poorly developed hooks. Hair no. 0 very short and split near its middle into 3 br. on II–VIII.

EGG*.—Of whale-back type. Upper surface narrow, straight, extending from end to end of egg; unornamented. Lower surface with network of pale polygonal markings. Frill very narrow, reduced practically to white line, striated, extending all round upper surface. Floats not touching margin of upper surface; long, occupying about middle $\frac{2}{3}$ of egg; moderately broad, occupying about half lateral aspect of egg; with small crescentic float-terminations; float-ridges 30–35, narrow, very regular and smooth.

VARIATION.—*A. hyrcanus* shows a considerable amount of individual variation in the wing-markings, and the somewhat indefinite type of wing-pattern makes such variation difficult to define. The range is chiefly in more or less darkness or paleness of the wing and discreteness and vividness of the spotting. The effect is largely dependent on the amount of pale scaling on the stems of veins 2 and 4; where these are practically all pale a wing with discrete wing-spots is more likely to result; their uniform darkness is largely responsible for the general dark effect of the wing in var. *nigerrimus*. The extent of scattered pale scales on vein 1 also largely affects the general appearance of the wing. Scaling of the remigium is nearly always pale except in var. *nigerrimus*, in which form it may be either dark or pale. The extent of pale marking on the tarsi varies very greatly in var. *nigerrimus*, but, apparently, less so in other forms. Many specimens of var. *nigerrimus* fail to show any pale basal banding on segment 4 of the hind leg.

Larvæ of *A. hyrcanus* from Palestine do not appear to differ in any particular from those of var. *nigerrimus* †. The pupal characters as given by Senevet for the Palestine form and var. *nigerrimus* would appear to differ in some respects, but as regards the paddle characters, those given by Senevet for var. *nigerrimus* appear to us identical with those for the Palestine form as shown by such material as is available for study. Baisas has indicated a difference between the characters of the leaflets of the phallosome in var. *nigerrimus* and var. *sinensis*, but this appears to require further

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* EGG: Steph. and Christ. 1902 *a*, p. 12; Christ. and Barraud 1931, p. 173.

† Dr. I. M. Puri has kindly examined some larval skins brought by Capt. P. J. Barraud from Palestine, and is unable to find any characters which differ from those shown in var. *nigerrimus*.

work before it can be accepted as, though the somewhat bifurcate main leaflet is seen in var. *nigerrimus* from Amritsar to Siam, yet the more lanceolate leaflet is also seen in many Indian specimens, regarding which there seems no reason to doubt their being of this variety.

A satisfactory subdivision of the species is at present scarcely possible, but the following appear to be varietal forms which can be more or less readily recognized :—

1. Tarsal banding narrower; hind tarsus with apices of segments only pale (if segment 4 is involved the whole segment may be diffusely pale). Subcostal spot larger, and involving vein 1 equally with the costa	2.
Tarsal banding broader; hind tarsus very commonly shows also base of segment 4 pale. Subcostal spot smaller, not involving, or only incompletely involving, vein 1; often fleck-like (comma-shaped). Wing dark; stems of 2 and 4 dark; a fringe-spot at 5.2 unusual. Dark area at base of vein 5 usually long. Female palpi with the more basal bands poorly marked, that at 3–4 not nearly so distinct as that at 4–5. Commonly produces forms with marked tarsal ornamentation. Oriental Region	var. *nigerrimus*.
2. Female palpi with the more basal bands poorly marked, that at 3–4 not nearly so distinct as that at 4–5. A fringe-spot at 5.2 commonly present. Dark area at base of vein 5 short, usually dot-like. China, etc.	var. *sinensis*.
Female palpi with the pale band at 3–4 as broad as that at 4–5. Dark area at base of vein 5 long	3.
3. Segment 4 of hind leg pale or flavescent through whole length	var. *pseudopictus* *.
Segment 4 of hind leg not so	*hyrcanus* (type) (var. [*pictus*).
Form with wings discretely spotted, much as in var. *pseudopictus*	(var. *pictus*.)
Form with suffused wings and many pale scales on costa, etc.	(var. *mesopotamiæ* †.)
Form with dark wings; stems of 2 and 4 dark	(var. *mahmouti* †.)

Martini gives for Asia Minor, the Caucasus, and Turkestan the following, additional to the above :—Palpi without

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* Edwards considers it doubtful if this is a geographical form, and thinks it probable that it may be a variant of *pictus*.

† Though very distinct in many respects, it is doubtful how far *mesopotamiæ* forms a true variety; along with it in Mesopotamia are forms which correspond to Martini's description of var. *mahmouti*, and for the present it seems preferable to regard all these as *hyrcanus* type, corresponding to var. *pictus* of Edwards.

pale markings—var. *marzinowskii* Schingarew ; from seg. 3 to apex of hind tarsus pale—var. *flerowi* Potsch ; fifth segment largely pale (as in *argyropus*)—*popowi* Sching. ; tarsi dark except for apical banding, the wings with dark pattern very pronounced, and dark scaling in region of cross-veins forming large dark area with that on costa (*i.e.*, vein 1 without scattered pale scales and stems of 2 and 4 dark)—*mahmouti* Martini.

A. argyropus Swell. is the extreme form of var. *nigerrimus* in which paling of the hind tarsus has proceeded so far that the last few segments are largely pale and the last segment sometimes, though rarely completely, white.

DISTRIBUTION.—*A. hyrcanus* var. *nigerrimus* has a wide distribution in the Oriental Region. Outside the Indian area it is recorded from CELEBES ; TIMOR ; ALOR ; PHILIPPINES * ; BORNEO ; SUMATRA (with Nias, Riouw, Linga, Banka, Enggano, Natuna, Billiton, Karimondiawa Is.) ; JAVA (with Krakatau) ; COCHIN-CHINA ; TONKIN ; SIAM ; MALAY PENINSULA.

In the Indian area *A. hyrcanus* is represented by this variety except for a comparatively small area in the north-west of Burma, where var. *sinensis* also occurs. The variety has been recorded from many localities throughout India, Burma, and Ceylon, its limits so far as present records go being Peshawar, Kohat, and Bannu in the north-west and the frontier of Assam, and north and south Burma in the east. It has been recorded in all the subdivisions used by Covell except in Baluchistan and the Andamans.

BIONOMICS.—*A. hyrcanus* var. *nigerrimus* is a wild form breeding independently of the proximity of habitations and not commonly found resting in houses and cattle-sheds, though often captured in an incidental way among other species in such situations (1–2 per cent. of collective catches in Bengal by Sur and Sur). It feeds readily on human and animal blood, usually at dusk or by night, but also sometimes by day even in full sunshine. Watson, 1921, records it at Krian in houses feeding on the inhabitants, and Feegrade (Lashio, Katha) found it feeding at dusk freely on cattle. 68 per cent. of captured females were found containing blood by Walker and Barber, 1914, and 45 per cent. by Lamborn, 1922. Out of twelve precipitin reactions obtained by Walch and Sardjito, ten were for human blood.

A. hyrcanus breeds especially in association with rice-fields (*Kenrick*, 1914 ; *McCombie Young*, 1924). It is commonly found also in lakes, grassy pools, tanks, moats, swamps, borrow-pits, drains, edges of slowly moving water (grassy streams and

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* Baisas 1931, p. 437.

ditches) (*Ramsay*; *Iyengar*, 1926; *Phillips*, 1923; *Gill* and *H. Singh*, 1920; *Feegrade*). It is usually found in open waters, but is recorded by James and Liston in deep shady pools and by Hodgson in pools in shady gardens, etc. Usually there is much aquatic vegetation. It is a clean-water breeder, but Feegrade records it as commonly found in somewhat fouled water. It is not usually a brackish-water species, but is given by Covell, 1930, in the list of species found in brackish or salt water.

A. hyrcanus, being essentially a rice-field and swamp breeder, is not commonly found at considerable altitudes, unless these conditions are present. It has not been recorded as yet from the lakes and marshes of the vale of Kashmir (5,000 feet), and was not found by Gill, 1920, at Murree, but occurs on the Shillong (5,000 feet) and Nilgiri (7,000 feet) plateaus.

RELATION TO DISEASE.—The variety has not been experimentally infected in India or Ceylon, but has been shown to harbour all three forms of the malaria parasite by Swellengrebel and others in the Dutch East Indies. It has been found naturally infected by Stanton in Malaya (2 gut-infections out of 87 dissected) and commonly by Walch and Walch, Doorenbos, and others in the Dutch East Indies. It was found playing the chief part as carrier in an epidemic of malaria on the east coast of Sumatra by the first-mentioned of these authors. It is not thought in general to be an important carrier in India (*Covell*).

10 *a*. **Anopheles hyrcanus** var. **sinensis** Wied., 1828 *.

Wiedemann, Auss. zweifl. Ins. p. 547, 1828 (*A. sinensis*). TYPE-LOC.: Canton, China. TYPE: ♂ and ♀ described; type in Vienna Mus. (*vide* Yamada, 1924, p. 229, who found this identical with his specimens from Tokyo, Japan).

SYNONYMS:

plumiger Dönitz, 1901, Insektenbörse, xviii, p. 37 (*A. plumiger*). TYPE-LOC.: Hong Kong. TYPE: in Zool. Mus. Berlin (*vide* Yamada, 1924, p. 230, who found this identical with var. *sinensis*).

jesoensis Tsuzuki, Gunigakkai Zas. no. 123, Suppl. Oct. 1901 (*yesoensis*); also Cent. f. Bakt. Abt. 1, xxxi, p. 763, 1902 (*jesoensis*). TYPE-LOC.: Sapporo, Hokkaido (Jeso). TYPE: unknown. SYN. by Theo., Mono. Cul. iv, p. 86, 1907, and by Yamada, 1924, p. 223.

For characters and distinction from other varietal forms, see under *A. hyrcanus* var. *nigerrimus*.

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* Theo. 1901 *a*, p. 137; Christ. and Khazan Chand 1915, p. 199; Yamada 1924, p. 223; Edwards 1921 *c*, p. 629; 1929, p. 321; Ch'i Ho 1931, p. 107 (hypop.); Feng 1931, p. 504 (larva). For distribution see Faust,

DISTRIBUTION.—Specimens of this form have been seen only from Ukhrul, Manipur; Kalaw, S. Shan States (5,000 feet), and Namtu, N. Shan States, BURMA.

Outside the Indian area it is recorded from CHINA; KOREA; JAPAN; FORMOSA; PHILIPPINES; TONKIN.

RELATION TO DISEASE.—Nothing is known regarding its habits in India as distinct from var. *nigerrimus*. It is considered to be an important malaria carrier in China and Japan, and has been experimentally infected with B.T. and Q parasites, but not with M.T.

11. **Anopheles barbirostris** Van der Wulp, 1884*. (Fig. 25.)

Van der Wulp, Notes from the Leyden Museum, vi, p. 248, 1884 (*A. barbirostris*). TYPE-LOC.: Mount Ardjoeno, East Java. TYPE: described from a single ♀.

SYNONYMS:

? *vanus* Walker, 1860, Journ. Proc. Linn. Soc., Zool. iv, p. 91 (*A. vanus*). TYPE-LOC.: Makessar, Celebes. TYPE: ♂ (lacking abdomen) in Brit. Mus. Edwards, (Gen. Ins. 1932) says that the type is either *A. barbirostris* or *A. barbumbrosus* (var. *pallidus* Swell.), but it is not possible to determine which, and that if these forms are regarded as varieties of one species the name *vanus* should be used.

? *martini* Laveran, 1902, C. R. Soc. Biol. liv, p. 907 (*A. martini*). TYPE-LOC.: west of Pursat, Cambodia. TYPE: unknown. SYN. ? by Edwards, 1932, Gen. Ins.

ADULT ♀.—A large black anopheline (length of wing 3·8–4·6 mm.); attitude markedly anopheline.

Head: scales on occiput of normal type, but rather short, broad, and close set, and extending well down on postgenæ a small, pale, vertical spot; interocular vertex narrow, straight; vertical chætæ very stout, mainly dark, forming a line the anterior hairs of which rise very close together; the usual lines of ocular scales associated with these. *Antennæ* with some small dark scales on *t* and numerous dark, and some paler, scales on *fs* segment. *Palpi* markedly shaggy, covered throughout with long outstanding, broad, ligulate scales; entirely without pale markings; index 0·73. *Labium* shaggy in basal portion. *Clypeus* without a scale-tuft laterally.

Pharynx † as for group; dorsal papillæ 8.

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* SYSTEMATIC: Theo. 1901 *a*, p. 146; James and Liston 1904, p. 77; 1911, p. 118; Christ. 1924, pp. 32, 87; Haga 1924, p. 817; Brug 1925, p. 661; Baisas 1931, p. 425. See also James 1902, p. 35; Giles 1902, p. 308; Theo. 1903, p. 86; 1907, p. 82; 1908, p. 288; 1910 *a*, p. 50; Blanch. 1905, p. 197; Leic. 1908, p. 33; Alcock 1913 *b*, p. 160; Strick. 1913 *a*, p. 139; Ludlow 1914 *a*, p. 51; Roper 1914, p. 146; Christ. 1916 *a*, p. 462; Schüff. and Swell. 1917, p. 21; Mangk. 1919, p. 45; Rodenw. 1921, p. 156; Borel 1929, p. 33; Barraud and Christ. 1931, p. 273. See also references on pp. 158–59 (footnotes).

† PHARYNX: Manalang 1929, p. 435.

Thorax: *apn* carrying dense tufts of outstanding scales; propleural hairs 4 or more, with some scales. Mesonotum almost black, median area not paler than fossæ and lateral areas; whole surface, except for the usual narrow bare areas, covered with curved, pale, narrow, hair-like scales and chætæ, some of the latter dark on lateral areas; anterior promontory with some erect scales in median area and dense tufts of pale and dark scales laterally, dark scales passing down on to anterior surface; scutellum with some smaller pale hairs in addition to large chætæ. Pleuræ black, with frosty markings; spiracular, prealar, and upper mesepimeral hairs numerous; a number of hairs present in middle of mesipimeron, mixed with white scales, *i. e.*, lower mesepimeral hairs present.

Wing in general much as in *A. hyrcanus* (see fig. 25, 1), but without the broad apical pale fringe-area, and with apex often almost entirely dark, there being two milk-white spots at vein 1 and vein 3, latter variable in size. Number of pale scales scattered on base of costa varies considerably, but some usually present, and pale spots may be formed on edge of costa towards base; basal half of vein 6 has scattered black scales; an inconspicuous fringe-spot may be present at 5.2. This and related species are peculiar in having dark scales on the humeral cross-vein. Scales very broad and battledore-shaped, and the general effect of the wing-ornamentation is more speckly than in *hyrcanus*, due to the broader, stumpier scales and greater admixture of pale and dark scales in clusters. For significant points differentiating closely related species, see under "Identification."

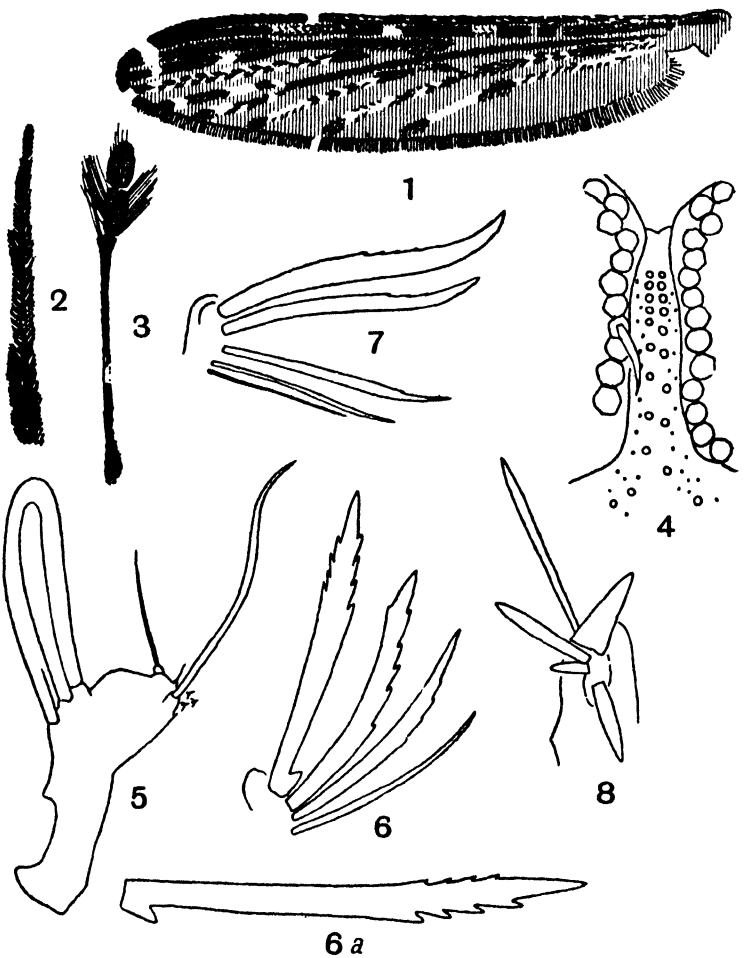
Legs.—Front femora markedly swollen in basal half. Femora more or less unicolorous, often with narrow, inconspicuous pale ring at base; fore femora somewhat pale beneath in inner third; mid- and, especially, hind femora with conspicuous internal and external white line, all narrowly pale at apex; mid-femur with a small white extension of this, forming a spot at apex anteriorly. Tibiæ unicolorous, pale at extreme base and at the tips, forming, especially on hind legs, a prominent mark. Fore tarsi dark, with narrow bands on segments 1 and 2; mid-tarsi often entirely unbanded, sometimes with bands on 1 and 2; hind tarsi with narrow pale apical bands on segments 1–4. Coxæ dark, fore with dark scales in front and pale scales externally, mid with a tuft of pale scales at base and others more towards tip, hind with a tuft of pale scales posteriorly towards tip. Trochanters dark, fore and mid with scales, former with a conspicuous ring of white scales apically.

Abdomen dark, with hairs only, except a few narrow pale scales on VIII; sternites with scattered broad pale scales

in median area; segment VII with a large tuft of black scales apically in the middle line. Cerci with hairs only.

ADULT ♂.—In general as in ♀. *Antennæ* with numerous dark scales on first flagellar segment. *Palpi* entirely dark; marginal hairs many rows deep on either side of penultimate

Fig. 25.



A. barbirostris; also *A. barbumbrosus* (**7**) and *A. bancrofti* (**8**).

1. Wing of ♀. **2** & **3.** ♀ and ♂ palp, same scale. **4.** Vertex. **5.** Harpago, $\frac{1}{16}$ standard scale. **6.** Leaflets of phallosome, $\frac{1}{8}$ standard scale. **6** *a*. Ditto, largest leaflet on usual scale. **7.** Leaflets of *A. barbumbrosus* (from specimens sent by Col. Brug); serrations are present on side of the leaflet, though much finer than in *A. barbirostris*, $\frac{1}{8}$ standard scale. **8.** Leaflets of *A. bancrofti* (specimen from Townsville, Australia, with fringe-spots), $\frac{1}{8}$ standard scale.

segment and a tuft at apex of seg. 3; some scattered hairs on apical segment. *Ungues* of normal type, basal spur rather stout and stumpy. *Abdomen* as in ♀, but lacking the tuft of black scales on venter of seg. VII; coxites with numerous scales on outer aspects.

Hypopygium *.—Parabasal spines 2; inner less than ⅓ length of coxite, stouter than outer, tapering rapidly after swollen basal part, the end pointed, sharply bent at angle; outer twice as long as inner, rather slender, straight or nearly so, tapering to point, end not recurved. A well-developed internal spine about half-way down coxite. Harpago much as in *A. hyrcanus*, but smoothly chitinised to origin of two inner hairs; inner hairs more delicate, papillated portion with small hairs much reduced (fig. 25, 5). Phallosome long, narrow, straight, about ⅔ length of coxite; carrying 4–5 large, strongly chitinised leaflets; larger leaflets strongly serrated on both borders towards apex (fig. 25, 6). Ninth tergite with moderately developed processes, these not so long as interval between, diffusely rounded and flat, not knobby as in *A. hyrcanus*.

Pupa †.—*Paddle*: index 1·5: external border and paddle-hair as in *hyrcanus*.

Spine: (VIII) rather short, with fine lateral branches and some terminal branches; acc. hair as long as spine. (II–VII) short, blunt, thick, reduced in size on more anterior segments.

Hair B: (III–VII) very short, tufted, about ¼ length segment or less.

Hair C: similar to *B*.

All other hairs very short; hair 5 simple; hair 4 with a number of branches; hair 3 with 5 br. on seg. IV, otherwise these small hairs, simple or bifid.

Larva ‡.—Colour of full-grown larva varies from yellowish green to dark brown or nearly black, with a varying number of silvery grey spots on thorax and abdomen; head dark §.

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* Hypopygium: Christ. 1915, p. 390; Swell. 1921 *a*, p. 118; 1921 *b*, p. 38; Brug 1925, p. 661; Borel 1929, p. 35; Baisas 1931, p. 444.

† Pupa: Senevet 1930, p. 368.

‡ Larva: Stanton 1915, p. 165; Swell. and Swell. 1919 *a*, p. 20; Swell. 1921, p. 120; Puri 1931, p. 125; Baisas 1931, p. 425. See also Steph. and Christ. 1902 *b*, p. 7; James and Liston 1904, p. 78; 1911, p. 119; Stanton 1912 *b*, p. 9; Swell. and Swell. 1916, p. 144; 1920 *b*, p. 86; Stanton 1917, p. 275; Mangk. 1919, p. 45; Lamborn 1921, p. 93 (tail-hooks); Iyengar 1921, p. 216 (thorac. app.); 1922 *a*, p. 632 (tail-hooks); Rodenwaldt 1923 *c*, p. 304; Carter 1925, p. 82; Senior White 1925, p. 217; Puri 1928 *b*, p. 521; Walch and Soesilo, 1929, p. 464 (pecten); Borel 1929, p. 33; Chowdhury 1929, p. 986; Baisas 1931, p 425.

§ Rodenwaldt, 1923 *c*, says that the dark brown larvæ become males and the lighter females.

The larva has a very curious habit of lying with the body apparently distorted.

Resembles *A. hyrcanus* very closely, differing only as follows :—*is* not simple as in *A. hyrcanus*, but with 6–8 br. ; hair no. 13 on ventral aspect of prothorax is split into 4–6 br. near its base, not feathered with 6–9 br. as in *A. hyrcanus* ; hair no. 13 on the abdomen has a larger number of branches ; the pecten has 9–11 long and 8–11 short processes, and the long processes have transparent wing-like expansions along their dorsal and ventral borders ; as in *A. hyrcanus*, they do not show any serrations.

Egg *.—Resembles very closely the egg of *A. hyrcanus* var. *nigerrimus* ; the dorsal surface was noted by Christ. and Barraud, 1931, to be slightly broader and the floats possibly slightly longer (0·75 of egg-length).

Identification.—The following table differentiates species closely resembling *A. barbirostris*. Neither *A. barbumbrosus* nor *A. bancrofti* have been recorded from the Indian area ; for the position in regard to *A. pseudobarbirostris*, see under this name †.

1.	Femora and tibiæ distinctly speckled with white scales ; centre of mesepimeron without a patch of white scales ; white scales present on venter of abdomen ...	2.
	Femora and tibiæ not so marked ; centre of mesepimeron with a patch of white scales ; white scales on venter present or absent	3.
2.	Fringe-spots at 4.1, 4.2, 5.1, and 5.2 ; leaflets of phallosome small, the shorter ones broadly conical. (Australia.)	*bancrofti*.
	Not so ; a fringe-spot may be present at 5.2 ; leaflets of phallosome simple, without serrations. Larva : *oc* with 60 or more branches ; *ic* with some fine lateral branches in apical half ; lateral hair of abd. seg. VI long ‡. (Philippines, Celebes ; recorded from Ceylon)	*pseudobarbirostris*.

* Egg : Christ. and Barraud 1931, p. 173.

† For information about these species see especially (*barbumbrosus*) Swell. and Swell. 1919 *a*, p. 21 ; Swell. 1921, p. 120 ; Haga 1924, p. 815 ; Brug 1925, p. 661 ; Strickl. and Chowd. 1927 *b*, p. 18. (*bancrofti*) Giles 1902, p. 511 ; Bancroft 1908, Ann. Queens. Mus. no. 8, p. 14 ; Cooling, Proc. Roy. Soc. Queens. xxxiii, p. 166, 1921 (larva) ; Edwards, Bull. Ent. Res. xiv, p. 353, 1924 (hypop.) ; Brug 1925, p. 661.

‡ The figure given by Baisas for the leaflets of *A. pseudobarbirostris* is clearly identical, or nearly so, with these structures as found by me in specimens of *A. bancrofti* from Queensland. The fringe-spots in the Queensland specimens are, however, extremely conspicuous, so that it is difficult to believe this is the species called *pseudobarbirostris* by Baisas where these are not described or figured.

3. Commonly without a dark interruption at apical spot (4); *oc* of larva with 50 or more branches ..... 4.
Commonly with a dark interruption of apical spot; venter of abdomen without pale scales; leaflets of phallosome simple, without serrations; *oc* with 11–22 br. only. [*dus*).
(Celebes, Dutch East Indies.)..... *barbumbrosus* (*palli-*
4. Venter of abdomen with white scales; leaflets of phallosome with marked serrations; *ic* simple, or one, or rarely both, may be bifurcate; lateral hair of seg. VI in larva short. (Oriental Region.)..... *barbirostris*.
Venter of abdomen without white scales; *ic* with fine lateral branches in apical portion. (Assam.)..... *barbirostris* var. *ahomi*.

DISTRIBUTION.—*A. barbirostris* is very widely distributed in the Oriental Region. It has been recorded from NEW GUINEA; MOLUCCAS (Soela, Boeroe *, Ceram *, Amboina *); CELEBES (Moena, Boëton); LESSER SUNDA ISLANDS (Lombok *, Soemba, Soembawa, Timor, Alor, Wetar); JAVA (with Noesa Kambangan); SUMATRA (with Riouw, Nias, Linga, Siberoet); PHILIPPINE ISLANDS; BORNEO; TONKIN; ANNAM; COCHIN-CHINA; MALAY PENINSULA; SIAM; BURMA; CEYLON; and INDIA.

The only traceable locality in China appears to be Shaohyling, given by Theo., 1910, p. 50, but without further particulars; Faust's (1926) map appears to give Hong Kong, but this is untraceable, and seems to be an error. Japan is given by Theobald, and Formosa in the same way indicated in Faust's map, but Yamada definitely says it has not, to his knowledge, occurred in either.

In the Indian area recorded from numerous localities in almost every one of Covell's subdivisions, except those in the north-west (Rajputana, Sind, Punjab south-west; N.W.F. Province and Baluchistan). It is abundant in the Andaman forest.

BIONOMICS.—*A. barbirostris* is to a large extent a wild species. In the Indian area it is not a common house species, but it appears to become so further eastwards. Sur and Sur, in Bengal, out of 15,389 anophelines caught in houses and 6,773 from cattle-sheds, obtained only four and seven specimens of this species respectively. Coveli, 1927 (Andamans), out of 2,500 *Anopheles* caught in the houses in the Andamans found only one *barbirostris*. It is, however, recorded from houses at Hazaribagh (*Basu*, 1929), and was the third commonest species in houses and cow-sheds on Salsette (*Marjoribanks*). At Timor it formed one-third of the total

* Given as doubtful by Brug 1926 *c*, p. 471.

mosquitoes caught inside houses (*Rodenw.*, 1923); in Siam it was commonly found in mosquito nets, but was more frequent in sheds than in dwellings (*Barnes*). Mangkoewinoto records that fairly large numbers are caught in houses in Sumatra, and it is commonly found in this situation in Sarawak (*Stookes*). In Ceylon it is recorded as easily found in houses in Kurunegala (*Gunesekara*), but Carter, 1914, says it does not commonly enter houses.

A. barbirostris attacks and feeds readily on man in shade in forest in the daytime, in the Andamans (*Christ.*, 1912). It was found with blood in sleeping-nets (*Barber* et. al., 1915), and 49 per cent. caught in nature were fed. Two out of four were found with human blood with the precipitin test (*Walch* and *Sardjito*). It is recorded among the species feeding on cattle at dusk at Katha (*Feegrade*).

Breeding places are especially rather deep stagnant water containing much vegetation, and preferably in the shade, such as margins of lakes, swamps, sluggish rivers, and streams, also stagnant irrigation cuts, ponds, borrow-pits, brick-field pits, standing water in rice-fields, and quite commonly in wells.

A. barbirostris is generally recorded more or less all the year round or as occurring late in the year. It is classed by Strickland among the species occurring especially during the rains in Assam. It is rarely taken at any great altitude.

Relation to Disease.—The species has been experimentally infected with M.T. and B.T. parasites, but no observations to the sporozoite stage are recorded, and its susceptibility is low. It has been found infected in nature in the Dutch East Indies (0·5 per cent.) and Malaya (1 out of 52). It is not considered an important carrier (*Covell*). Sundar Rao and Iyengar have observed development of filaria embryos in this species; only a small proportion, however, undergo normal development.

11 *a*. **Anopheles barbirostris** var. **ahomi** Chowdhury, 1929 *.

Chowdhury, Ind. Journ. Med. Res. xvi, p. 986, 1929 (*A. barbirostris* var. *ahomi*); Type-loc.: Upper Assam.

The differential characters of this variety will be found in the section on "Identification" under *A. barbirostris*. Baisas (1931, p. 427), judging from the description given, thought that this form came under *A. pseudobarbirostris*, as now known, in the Philippines. This, however, does not appear to be so, as some specimens sent by Dr. Fraser from Assam,

* Chowdhury 1929, p. 986; Baisas 1931, p. 427.

with larval skins showing the characters of *ahomi*, did not show speckling of the femora, etc., to any distinct degree; the other larval characters of these specimens also appear to agree with those of typical *barbirostris*. A noticeable feature of all the specimens was that the female was entirely devoid of pale scales on the venter of the abdomen. Unfortunately, there were no males to ascertain the characters of the leaflets, but Chowdhury notes that they appeared almost similar to *A. barbirostris*. This may, therefore, be considered for the present a varietal form of *A. barbirostris*. Examination of adult material in the Kasauli collection showed that *A. barbirostris* normally shows white scaling on the venter, except, apparently, in the case of specimens from the Andamans. No material at the moment is available to determine the larval characters of the Andaman form.

12. **Anopheles pseudobarbirostris** Ludl., 1902 *.

Ludlow, Journ. N.Y. Entom. Soc. x, p. 129, 1902 (*A. pseudobarbirostris*). TYPE-LOC.: Hagonoy, Bulacan, Luzon, P.I. TYPE: ♀ described; two ♀ types in U.S. Nat. Mus., Washington (*vide* Dyar and Shannon, Insect. Ins. Mens. xiii, p. 86, 1925).

The record of this species for India is due to two specimens taken at Ganemulla and Colombo, provisionally referred to the species by Carter (1925, p. 69). The characters of the larvæ were not known, but the femora, tibiæ, and first tarsal segments of all the legs were conspicuously speckled with yellow, and other characters agree with the description of *A. pseudobarbirostris*. For points of distinction between this and allied forms, see under *A. barbirostris*.

13. **Anopheles umbrosus** Theo., 1903 †. (Fig. 26.)

Theo., Mono. Cul. iii, p. 87, 1903 (*A. umbrosus*). TYPE-LOC.: Pekan, Pahang, Fed. Malay States. TYPE: ♀ described; type in Brit. Mus. Nec var. *umbrosa* Theo., Mono. Cul. iii, p. 34, 1903 (=*funestus*); nec *A. umbrosus* Edwards, Bull. Ent. Res. ii, p. 142, 1911 (=*A. nili*); nec *A. umbrosus* of authors relating to tropical Africa (=*A. obscurus*).

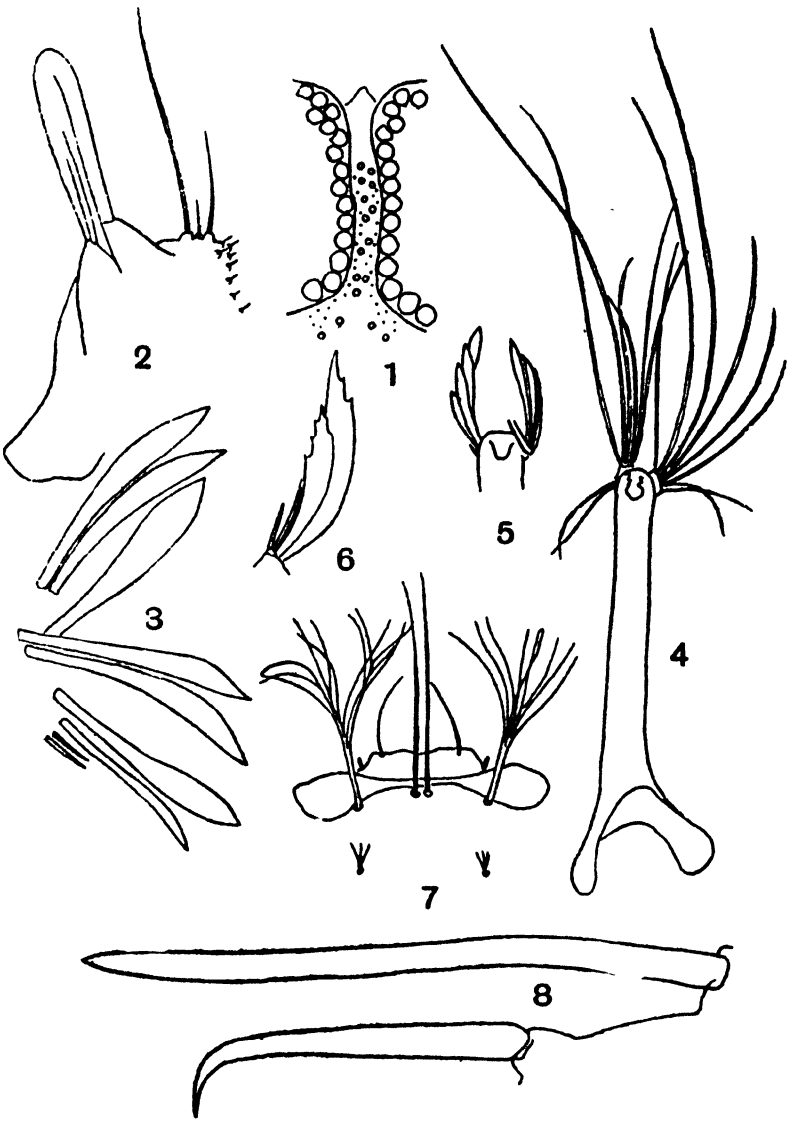
For var. described by Swell. and Swell., 1919, and *A. similis* Strickl. (*A. similissimus* Strickl.), formerly placed as synonyms, see section on "Identification."

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* Ludlow 1902 *a*, p. 129; 1914 *a*, p. 53; Theo. 1907, p. 83; 1910 *a*, p. 50; Christ. 1924 *c*, p. 32; Carter 1925, pp. 69, 84; Brug 1925 p. 661; Baisas 1931, p. 425.

† For references, see pp. 164–6 (footnotes).

Fig. 26.



A. umbrosus; also *A. novumbrosus* (4) and *A. separatus* (6).

1. Vertex. 2. Harpago, standard scale. 3. Leaflets of phallosome, standard scale; probably leaflets of both sides are included. 4. Phallosome, *A. novumbrosus*, ⅔ standard scale. 5. Tip of phallosome, *A. umbrosus*, same scale. 6. Leaflets of one side, *A. separatus*, same scale. 7. Clypeal hairs of larva (after Puri). 8. Parabasal spines, same scale as leaflets.

ADULT ♀ *.—A large black anopheline very similar in general appearance to *A. barbirostris* and *A. hyrcanus*.

Palpi entirely dark and somewhat thinner than in *A. barbirostris*; clypeus without scale-tuft; vertex narrow, sulcus-like; vertical bristles pale or mainly so. Propleural hairs few in number (3); mesepimeron entirely devoid of scales or hairs (except the usual upper mesepimeral); rest of pleura devoid of patches of white scales or nearly so; coxæ without conspicuous pale scale-tufts and anterior coxæ without scales anteriorly.

Wings without scattered pale scales on costa; vein 1 entirely dark-scaled except at subcostal and sector pale spots; vein 6 very much as in *A. hyrcanus*, with no black scattered scales on basal portion or a very few towards extreme base; apex of wing very similar to *A. barbirostris*, a small pale apical spot and a pale spot from 2.2–3; the subcostal spot small and sometimes almost obscured; vein 5 often pale throughout the greater part of its extent.

Legs: femora rather pale beneath in their basal portions; apices of femora and tibiæ only very inconspicuously picked out with white; tarsal banding very narrow and inconspicuous, often scarcely to be made out on fore legs.

Abdomen entirely without scales and lacking any tuft of dark scales on sternite VII.

Pharynx as for the group, much narrowed at pharyngeal bar; dorsal papillæ 10.

ADULT ♂.—In general as in ♀.

Hypopygium †: parabasal spines 2; inner short, about ¼ length of coxite, somewhat stouter than outer, and bent sharply and finely at tip; outer almost twice length of inner, straight, somewhat blade-like, tapering, not bent at end. An internal spine about half-way down coxite. Harpago with club on dorsal lobe rather narrow and with two rather delicate, not very long, but variable, hairs arising on a chitinised portion of the inner lobe, a small hair between these, or up to 4 longish hairs may be present. Phallosome rather short and stout, somewhat less than half the coxite in length, with about 5 leaflets on each side; leaflets actually more numerous and broader than they appear if imperfectly displayed, smooth, lanceolate, pointed. Processes of ninth tergite, short, stumpy, much shorter than the interval between them.

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* SYSTEMATIC: Theo. 1903, p. 87; Roper 1914, p. 146; Swell. 1921 *a*, p. 125; Christ. 1924, pp. 31, 87; Edwards 1932.

See also Theo. 1910 *a*, p. 51; Leicester 1908, p. 35; Edwards 1912, p. 250; Stanton 1912 *b*, p. 4; Alcock 1913 *a*, p. 104; Strickl. 1913 *a*, p. 140; Stanton 1914 *b*, p. 518; Mangk. 1919, p. 43; Rodenw 1921, p. 158 (pilotaxy); Stanton 1926, p. 89.

† HYPOPYGIUM: Swell. 1921 *a*, p. 126; Christ. 1924 *c*, p. 87.

PUPA *.—*Paddle*: external border smooth in basal $\frac{2}{3}$, then a small extent of short, curved spines, followed by nearly bare border; paddle-hair short, straight; acc. hair about the same length and bifurcate at end.

Spine: (VIII) short, with 4–5 lateral branches; neighbouring parts of segment *strongly spiny*; acc. hair rising from a chitinised projection. (II–VII) short, blunt, becoming smaller on anterior segments

Hair B: (III–VI) with many branches and from $\frac{1}{3}$ to $\frac{2}{3}$ length of segment; (II) absent.

Hair C: (IV–VII), $\frac{1}{2}$–$\frac{2}{3}$ length of segment, simple on VII, trifurcate on V–VI, 6 br. on IV; (III) short, with 10–15 br.; (II) short, with fewer branches.

Hair 4 with about 8–10 br. on segs. III–VI, 3 br. on VII. Hair 5 with about 6 br. on III–VI, 4 br. on VII. Other hairs mostly small, branched.

LARVA †.—*Clypeal hairs*: *ic* simple; *oc* like those of *hyrcanus*, but with only 5–10 br.; *pc* short, 2–3 br. *Frontal hairs* normal. *Subantennal hair* feathered, with branches at end short and arising in cluster from truncated tip. *Antenna* stout, spiny; hair $\frac{2}{3}$ length of antenna, with 9–12 br., arising on inner aspect at $\frac{1}{8}$ to $\frac{1}{4}$ from base. *Mentum* with 4 teeth on each side of median tooth, anterior 3 more or less equidistant, fourth placed further back, first and last much smaller than other two.

Shoulder hairs: inner short, half or less length of outer and many times shorter than middle, without chitinised base; middle long, with 6–8 lateral br., arising from poorly developed tubercle. Hair no. 1 poorly developed on mesothorax; not developed as palmate hair on metathorax. *Pleural hairs* in the group; *dp*1 with 3–4 spine-like branches; *vp*2 $\frac{1}{4}$ length of anterior hairs.

Palmate hairs: not developed on any segment; hair no. 1 6–11 br., but these not flattened. Hair no. 2 lies external to no. 1 on VI, and not internal and posterior as in all larvæ with the palmate hair differentiated on this segment. *Lateral hairs* on IV and V long and split into 2–5 br.; on VI and VII very short, splitting near their base into 5–7 stiff br. Hair no. 0 fairly conspicuous on II–VII, and about as large as some of the other hairs; it lies posteriorly and external to the anterior tergal plate. *Tergal plates* fairly small; a small chitinous plate on ventral surface of VII, not found in any

* PUPA: Senevet 1930 *a*, p. 364.

† LARVA: Stanton 1912 *b*, p. 4; 1912 *a*, p. 390; 1915, p. 171; 1917, p. 275; Mangk. 1919, p. 43; Swell. and Swell. 1919 *a*, p. 16; 1920 *b*, p. 84; Swell. 1921 *a*, p. 127; Lamborn 1921, p. 93 (tail-hooks); Stanton 1926, p. 55; Strickl. and Chowd. 1927 *b*, p. 32; Essed 1928, p. 220 (and *separatus* etc.); Puri 1928 *b*, p. 521; Brug 1928, p. 921; Walch and Soesilo 1929, p. 464 (pecten); Borel 1929, p. 37; Puri 1931, p. 117.

other Indian anopheline, is present. *spc* poorly developed and *mps* very narrow anteriorly. *Pecten* with 9–10 long and 7–9 very short alternating projections, all practically free from serrations at bases. Caudal hooks poorly developed, not more than 5 main hooked bristles (*Lamborn*, 1921, p. 931).

IDENTIFICATION.—The group-characters, with unbanded palpi, absence of scattered white scales on the costa, absence of numerous scattered black scales on the basal portion of vein 6, absence of scale-tuft on sternite VII, in the adult, and absence of palmate hairs in the larva readily distinguish this form from all species so far described from the Indian area.

A number of similar forms having larvæ without palmate hairs, and the adults in some cases almost indistinguishable from *A. umbrosus*, are described from Malaya, and some at least may eventually be recorded from Eastern India. The following is a list of these species, with their chief differentiating characters * :—

Adult closely resembling *A. umbrosus*, i. e., palpi entirely dark, no scale-tuft on sternite VII of ♀.

A. umbrosus: larva without palmate hairs on any segment; *oc* with 5–10 br. only; *pc* branched; suturals 1–3 br.; leaflets lanceolate, unserrated, ½ or less length of phallosome; processes of ninth tergite short, stumpy.

A. novumbrosus Strickl.: larva with palmate hairs on IV–V; *oc* as in *umbrosus*; *pc* simple; leaflets enormously elongate, longer than phallosome, hair-like; processes of ninth tergite elongate.

A. similissimus Strickl.: larva without palmate hairs; *oc* as in *hyrcanus*, with 50–60 br.

A. umbrosus var. Swell. & Swell. †: larva without palmate hairs; *oc* as in *umbrosus*, but branches may be more numerous (20); inner clypeals frayed; frequents brackish water. May be *similissimus*.

Adult with pale band on palps; no scale-tuft on sternite VII of ♀.

A. separatus Leic. (=*A. snidjersi* Swell.): larva without palmate hairs; *oc* with 11–16 br.; *pc* simple; suturals 5–6 br.; leaflets large, expanded, serrate, half length of phallosome; processes of ninth tergite short.

A. hunteri Strickl.: larva without palmate hairs; *oc* 6–10; *pc* simple; suturals 1–2; leaflets absent; processes of ninth tergite long, nearly as long as distance apart.

DISTRIBUTION.—*A. umbrosus* has a wide distribution in the Oriental Region, but has not been noted east of Celebes ‡,

* For further information about these forms, see Strickland, Ind. Journ. Med. Res. iv, p. 263, 1916 (*hunteri*); *ib.* iv, p. 271, 1916 (*novumbrosus*); *ib.* iv, p. 611, 1917 (*similis*=*similissimus* Strickl. & Chowdh., 'Illus. Key Anop. Larvæ etc.' 1927); Swell., 'Die Anop. Ned. Oost-Indie,' pp. 114, 141, 1921; Christ., Ind. Med. Res. Mem. no. 3, p. 31, 1924; Strickl. and Chowd., 'Illus. Key, etc.' pp. 19, 32, 35; Essed, Meded. Volks. Ned. Indie, xvii, p. 221, 1928; Strickland, Geneesk. Tijds. lxxi, p. 770, 1931; Edwards, 'Gen. Insect.' 1932.

† See Swell. and Swell. 1919 *a*, p. 16; 1920 *b*, p. 84.

‡ Brug 1926 *c*, p. 471.

nor from any part of China. It has been recorded from CELEBES; PHILIPPINES *; BORNEO; JAVA (and Noesa Kambangan); SUMATRA (and Riouw, Bangka, Billiton Islands); NATUNA ISLANDS; TONKIN †; COCHIN-CHINA ‡; MALAY PENINSULA; EASTERN INDIA.

From the Indian area it has been recorded only from the Andaman Islands and Assam.

BIONOMICS.—*A. umbrosus* is essentially a forest and heavy jungle species. It comes under the designation of a wild species, though it is described by Watson (1921) as occurring abundantly in Malaya in houses near jungle. It feeds fiercely on man in nature (*Watson*), and can be fed experimentally (*Barber*, 1918; see also *Roper*, 1914).

In Malaya it breeds in stagnant pools and morasses in the forest, and in pockets of water in wet ground between the roots of trees in flat forest land, also commonly in the inner mangrove zone, often in association with *A. ludlowi* (*Watson*). In Sumatra it is recorded as breeding in mountain brooks and their springs and in swamps formed by them in the valleys, in fairly dirty slow-running brooks in virgin forest, and in fresh-water pools between Nipa palms, also in brackish water behind the mangrove zone (along with the *umbrosus* var.); it prefers, but is not dependent on, shade (*Swell.* and *Swell.*, 1919). In Assam the species was found breeding in stagnant shallow water with dead leaves, etc., on mud in creek-beds cut off from small streams in the forest (*Covell* §).

It is believed to be a strong flier, as it is found at considerable distances from its breeding places (*Barber*, 1918).

RELATION TO DISEASE.—*A. umbrosus* has been experimentally infected with M.T. and B.T. malaria parasites in Malaya and the Dutch East Indies; also found naturally infected in Malaya, Borneo, and the Dutch East Indies.

Subgenus *MYZOMYIA* Blanchard.

Blanchard, C. R. Soc. Biol. liv, p. 795, 1902; Christophers, Ind. Journ. Med. Res. iii, p. 383, 1915 (subgenus emended).

Grassia Theo., Journ. Trop. Med. v, p. 181, 1902. Preoccupied (nec Fisch), *vide* Blanchard, *loc. cit.* TYPE, *A. rossii* Giles.

Myzomyia Blanchard, *loc. cit.* TYPE, *ib.*

Type-species, *A. subpictus* Grassi (*A. rossii* Giles).

ADULT.—Coxite with 5 parabasal spines arising close together in cluster from surface of coxite and not from any lobe, the four more basally situated with recurved ends, the more apically situated spine longer, resembling an ordinary hair.

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* Mieldazis 1930.
† Bordes 1930.
‡ Borel 1929 *a*, p. 37.
§ Private communication.

Pharyngeal bar with an armature of teeth. Dorsal papillæ, except sometimes in group *Neomyzomyia*, always 6, posterior pair widely separated from others.

Propleural hairs most frequently few in number or may be absent. Ornamentation of wing for the most part on a fixed plan; bifurcations of veins 2 and 4, all cross-vein junctions, and junction of most veins with wing-margin pale *; costa normally with 4 dark spots; a pale area extending to edge of costa at about level of origin of vein 2; fringe-spots, if present, usually at all vein-junctions except or including that of vein 6 †.

PUPA.—With spines V–VII usually long and pointed; paddle-hair long and usually hooked or curled; hair C at least as long as the segment, generally simple or bifurcate on V–VII.

LARVA.—Antennal hair never branched, always small and situated on outer aspect of shaft; *ic* always wide apart, distance between their bases at least equal to that between *ic* and *oc* of same side; leaflets of palmate hairs never lanceolate and always with shoulder and terminal filament. Pleural hairs, except in group *Neomyzomyia*, where they are simple, with at least some long hairs feathered.

Key to Groups.

1. Pharyngeal armature with a single row of teeth separated by intervals, teeth not developed as rods and cones.
   Long pleural hairs of larva all simple.
   Propleural hairs of adult present; usually several. Pronotal lobes usually with scale-tuft; legs usually speckled. About 17 species in Australian, Oriental and Ethiopian Regions. Type-species, *A. leucosphyrus* Don. ‡ ..... Group *Neomyzomyia*.
2. Pharyngeal armature with rods and cones; the cones without roots; base of cones with lateral teeth conspicuous; crest narrow, with a single row of spines; posterior view of crest not bifid.
   Long pleural hairs of larva with one only of the metathoracic hairs feathered (one prothoracic also feathered).
   Propleural hairs of adult present; commonly 1 (or 2). Pronotal lobes without scale-tuft; legs usually dark, never speckled; palpi of ♀ white-tipped. About 30 species in Ethiopian, Oriental, and Mediterranean Regions. Type-species, *A. funestus* Giles ‡ ..... Group *Myzomyia*.

* Except in the species *A. rhodesiensis* and *A. dthali*, where the wing-field is normally without any pale markings.

† Absent in the species referred to in the previous note and *A. smithi*, two fringe-spots only present in *A. culicifacies* and *A. nili*.

‡ See remarks under the group-names on the nomenclature, and type-species.

3. Pharyngeal armature with rods and cones; the cones with deep and narrow roots (buttresses); bases of cones bulbous; crest with a single row of spines; posterior view of crest not bifid.

Long pleural hairs of larva with both metathoracic hairs feathered (one prothoracic and sometimes one mesothoracic with a few branches); the tubercles all with sharp spines.

Propleural hairs of adult present; usually several. Pronotal lobes (in Indian species) without scale-tuft, legs more or less banded or speckled; palpi of ♀ white-tipped. About 6 species in Oriental and Ethiopian Regions. Type-species, *A. subpictus* Grassi *..... Group *Pseudomyzomyia*.

4. Pharyngeal armature with rods and cones, usually with some indication of roots; bases of cones bulbous, with lateral teeth inconspicuous or absent; crest with a single row of spines, posterior view not bifid.

Long pleural hairs of larva with both metathoracic and one prothoracic feathered; both mesothoracic also feathered in *A. turkhudi*.

Propleural hairs of adult present, usually several. Pronotal lobes without scale-tuft; legs dark; palpi of ♀ usually dark-tipped. About 7 species in Mediterranean Subregion, E. and S. Africa, and Northern India. Type-species, *A. turkhudi* Liston *..... Group *Paramyzomyia*.

5. Pharyngeal armature with rods and cones; the cones without roots; the bases of the cones with distinct lateral teeth; the crest broad, with 2 rows of spines, more or less widely separated; posterior view of crest bifid.

Long pleural hairs of larva with both metathoracic and one prothoracic feathered and one mesothoracic sparsely branched.

Propleural hairs of adult absent. Hind tarsi usually white-tipped. About 18 species, mostly in the Oriental Region. Type-species, *A. maculatus* Theo. *..... Group *Neocellia*.

6. Pharyngeal armature with rods and cones; closely resembling the pharyngeal characters of *Pseudomyzomyia* and *Paramyzomyia*, but as yet inadequately worked out.

Long pleural hairs of larva with both metathoracic hairs feathered; characters here also imperfectly known.

Propleural hairs of adult present; usually several. Pronotal lobes with scale-tuft; abdominal segments all with projecting lateral scale-tufts. About 5 species, confined to the Ethiopian Region. Type species, *A. pharoensis* Theo. ..... Group *Cellia*.

* See remarks under the group-names on the nomenclature, and type-species.

These six groups, with the exception of group *Paramyzomyia*, are as given by me in 1924, based mainly on adult characters. They have since been strongly supported and made more precise by the recent work of Sinton, Covell, and Barraud on the pharyngeal characters and of Puri on larval characters, and still further emphasized by study of the details of the pharyngeal armature, the results of which are given in this volume. *Paramyzomyia*, formerly included under *Myzomyia*, appears sufficiently distinct on these new criteria to be recognized as a group, as has been done also by Edwards (1932) under the term "*turkhudi* group." It is, perhaps, desirable that it should have a name in keeping with the other groups and as there is no generic type available I have adopted the name *Paramyzomyia* given by Christophers and Barraud in their paper on the eggs of Indian *Anopheles*.

The groups appear to be quite well differentiated on the characters given in the key, and some further general characters are given later. *Neomyzomyia*, *Neocellia*, and *Cellia* comprise in the main highly ornamented species with marked scale development. *Myzomyia* shows relatively poor ornamentation and scale development. *Paramyzomyia* and *Pseudomyzomyia* are intermediate.

REPRESENTATION IN THE INDIAN AREA.

	Species.	Varieties.
Group *Neomyzomyia*	3	1
,, *Myzomyia*	10	1
,, *Pseudomyzomyia*	3	—
,, *Paramyzomyia*.....	2	—
,, *Neocellia*.....	12	1
,, *Cellia*	—	—
Total.....	30	3

Group *NEOMYZOMYIA*.

Christophers, Ind. Med. Res. Mem. no. 3, p. 70, 1924.

Feltinella Theo., Mono. Cul. iv, p. 56, 1907. TYPE, *F. pallidopalpi* Theo.

Neomyzomyia Theo., Mono. Cul. v, p. 29, 1910. TYPE, *A. elegans* James.

Christophersia James, Paludism, no. 1, p. 33, 1910. TYPE, *C. halli* James.

Dactylomyia Newst. & Carter, Ann. Trop. Med. and Par. iv, p. 377, 1910. TYPE, *D. ceylonica* Newst. & Carter.

Type-species, *A. leucosphyrus* Dön. (*A. elegans* James) *.

* Strictly, the genus *Feltinella*, with *A. smithii* Theo. (*A. pallidopalpi* Theo.) as type-species, has priority. But rather than make awkward changes in the nomenclature of these groups, as though they still held generic rank, I have adopted the names which have been in use and seem most generally suitable (see also changes that would be necessitated in *Myzomyia* and *Pseudomyzomyia* if strict procedure as for generic rank were followed).

Pharyngeal armature of about 10 or less teeth forming a single row, teeth of similar character, and separated by intervals (fig. 27, 10), lying, as a rule, almost in plane of ventral plate of pharynx, and thus well displayed when pharynx is mounted flat. Each tooth usually shows a pale *bulla* demarcated by a dark chitinous line; a stout lateral tooth usually present at base on one or both sides; teeth without a well-developed pediment-crest projecting backwards as in other groups; rods entirely absent*. Lateral flanges bar-like.

Propleural hairs variable, but usually a number are present.

Wing commonly with multiple small dark spots on some veins, not seen in other groups, a condition usually expressed as "sixth vein with more than 3 dark spots"; some species, however, e. g., *A. kochi* among Indian species, do not show this character. Legs commonly speckled and tarsi ornamented. Palpi usually strikingly ornamented with 4 or more bands. A tuft of scales on pronotal lobes commonly present, though an unusual feature in other groups †. Hypopygium with the usual 5 parabasal spines of subgenus *Myzomyia*, but in the three Indian species of the group spine 4 is rather widely separated from the three more basal spines.

Pupa: in several respects resembling subgenus *Anopheles*; spine on V–VII rather short, shorter than half the length of the segment; paddle-hair short, straight, undulating or bent, but not usually hooked ‡; hair *C* on V–VII commonly bifurcate or branched and distinctly shorter than the segment §.

Larva: *ic* far apart, *oc* commonly short and rising close to *ic*, thus emphasizing distance apart of latter. In all the Indian species the tergal plates are very small. The pleural hairs for the group so far as ascertained are given below; in the unbranched character of the long hairs they closely approach subgenus *Anopheles*, and are distinct from all other groups in subgenus *Myzomyia*.

	1.	2.	3.
da	Long, simple.	Long, simple.	Long, simple.
va	Long, simple.	Long, simple	Long, simple.
dp	About ½ length anterior, simple ‖.	Very short.	Minute.
vp	Long, simple.	Fairly short, simple.	Fairly short, split into 2–3 br.

* *A. rhodesiensis* has this type of pharynx, but the pleural hairs of the larva are as in *Myzomyia*. The position of *A. nili* is uncertain, as the larval characters have not been confirmed.

† Absent or with a few scales only in *A. tessellatus* (and in *A. nili*).

‡ Short but hooked in *A. nili*.

§ Simple in *A. punctulatus* (Senevet).

‖ Sometimes bifid in *A. kochi*.

Species recorded from the Indian Area *.

The following species and varieties are recorded from the Indian area :—

A. kochi Dön.
A. leucosphyrus Dön.
A. tessellatus Theo.

14. **Anopheles kochi** Dönitz, 1901 †. (Fig. 27.)

Dönitz, Insektenbörse, xviii, p. 36, 1901 (*A. kochi*). TYPE-LOC. : Padang, Sumatra.

ocellatus Theo., 1901, Mono. Cul. i, p. 174 (*A. ocellatus*). TYPE-LOC. : Taiping, Perak, Fed. Malay States. TYPE : described from 2 ♀♀ in Brit. Mus. SYN. by Theo., *ib.*, footnote.

flava Ludlow, 1908, Canad. Entom. xl, p. 32 (*Cellia flava*). TYPE-LOC. : Camp Wilhelm, Tayubar, Luzon, P.I. TYPE : 4 ♀ types in U.S. Nat. Mus. Washington (*vide* Dyar and Shannon, Insect. Insc. Mem. xiii, p. 87, 1925). SYN. by Edwards, Bull. Ent. Res. iv, p. 222, 1913.

halli James, Paludism, no. 1, p. 33 (*Christophersia halli*). TYPE-LOC. : Sylhet, Assam, India. TYPE : ♀ and ♂ described ; type ♀ in Indian Mus., Calcutta. SYN. by James and Stanton, C. R. 3^{e} Congr. F.E.A.T.M. p. 515, 1914.

Referred to as *Anopheles* 1 *a* by Schüffner, Zeit. f. Hyg. xli, p. 91, 1902. Probably *M. tessellata* of Mathis and Leger, Bull. Soc. Med. Chir. de. l'Indochine, s. de 15 Nov. 1910, and also the species near to *mastersi* referred to by these authors.

ADULT ♀.—A medium-sized, fawn-coloured anopheline (length of wing 3–4 mm.).

Head: scales of normal type, forming a large and broad pale vertical spot ; vertical chætæ milk-white, passing almost at once into several rows of slightly curled flattened chætæ which form a conspicuous bifurcate frontal tuft ; ocular scales forming a dense line at the sides. *Antennæ* with a few minute white scales on *t* and numerous white scales on first *fs*. *Palpi* ornamented, as in fig. 27, 2, with 4 white, 3 yellow, and 5 narrow black bands, 1 yellow and 1 black at extreme base, the black bands at base of each segment. *Labium* golden in apical half and usually with some spots of

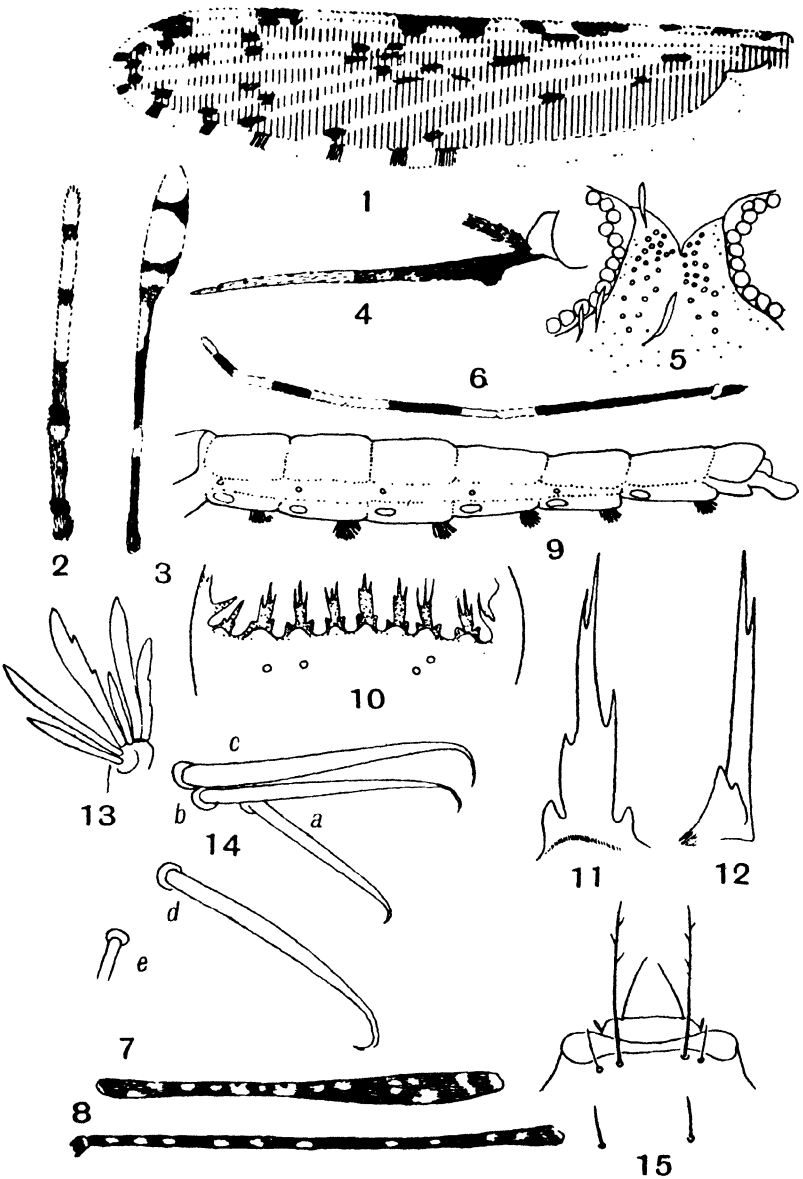
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* Other species included in the group are : (Oriental) *A. watsoni* Leic., *A. aurirostris* Watson ; (Australian) *A. annulipes* Walk., *A. amictus* Edw., *A. punctulatus* Dön., and var. *moluccensis* Swell. & Swell., *A. longirostris* Brug ; (Ethiopian) *A. smithi* Theo., *A. nili* Theo., *A. ardensis* Theo., *A. natalensis* Hill & Hayden, *A. kingi* Christ., *A. machardyi* Edw., *A. multicinctus* Edw.

† SYSTEMATIC : Leicester 1908, p. 46 ; James 1910, p. 33 ; Stanton 1914 *a*, p. 129 ; Swell. 1916, p. 115 ; 1921 *a*, p. 83 ; Christ. 1924 *c*, pp. 71, 104 ; Baisas 1931 *b*.

See also Dönitz 1902, p. 67 ; James and Liston 1911, p. 123 ; Edwards 1913, p. 222 ; Roper 1914, p. 142 ; Ludlow 1914 *a*, p. 59 ; Christ. 1916 *a*, p. 469 ; Mangk. 1919, p. 75 ; Rodenw. 1921, p. 147 ; Yamada 1925, p. 489 ; Borel 1925, p. 224 ; 1929, p. 69. See also references on pp. 174–6 (footnotes).

Fig. 27.



A. kochi.

1. Wing of ♀. **2.** ♀ palp, same scale ; the lighter shading is yellow. **3.** ♂ palp, same scale. **4.** Lateral view of labium, showing ornamentation and basal scale-tuft. **5.** Vertex. **6.** Hind tarsus. **7.** Fore femur. **8.** Mid-tibia. **9.** Lateral view of abdomen, showing ventral scale-tufts. **10.** Pharyngeal armature. **11.** Front view of a single tooth, standard scale for pharyngeal teeth. **12.** Lateral view of isolated tooth, same scale. **13.** Leaflets of one side of phallosome, standard scale for leaflets. **14.** Parabasal spines, standard scale for harpago ; spines 1–5 respectively are labelled [illegible]. **15.** Clypeal hairs of larva (after Puri).

yellow on the basal black portion ; labella and extreme tip of labium usually a duller yellow.

Pharynx * with characters of subgenus and group. Dorsal papillæ 6 ; lateral flanges poorly developed, not much wider than posterior part of pharynx ; pigmented area somewhat hour-glass-shaped ; post-pharyngeal ridges absent ; pharyngeal bar very broad, straight ; teeth with filament strap-like, with fimbriated extremity.

Thorax with scale-tuft on *apn* ; propleural hairs 2. Mesonotum, including fossæ and lateral areas, pale, with a dark eye-spot on each side of dorsum, covered with pale scales and hairs, former broader over fossæ and laterally, forming large median and lateral tufts on anterior promontory, latter tuft passing into black scales on face of promontory. Pleuræ dark, mapped out strikingly into pattern by broad pale lines ; spiracular hairs absent ; sternopleural as usual ; subalar about 6 ; prealar about 3 ; some scales mixed with most groups of hairs.

Wings as in fig. 27, 1 ; pale areas light yellow ; dark spots often still further reduced than shown in figure. Scales rather broad ; plume-scales short and ovoid, somewhat ballooned in some situations, notably on basal portion of stem of vein 4 ; max. str. about 10–12 ; some very large scales on subcosta.

Legs: front femora swollen in basal half. Femora speckled ; tibiæ and first and second tarsal segments on all legs with rather regularly spaced pale spots or flecks laterally ; front tarsus with apical and basal banding at all joints except last, usually with anterior aspect mainly affected ; mid-tarsus apically banded ; hind tarsus with first segment narrowly banded apically, remaining joints with broad apical and basal pale bands ; apical half of segment 5 white.

Abdomen with narrow yellow scales and hairs on II–VII, scaling becoming denser on posterior segments ; venter bare except for prominent tuft of black scales on each segment from II–VII ; a conspicuous pale spot on either side of each of sternites II–VII towards anterior end ; cerci with yellow scales.

ADULT ♂.—In the main as in ♀. *Antennæ* with a few dark scales on first flagellar segment. *Palpi* ornamented as in figure ; marginal hairs forming a tuft at apex, especially ventrally, of segment 3, hairs 2 or 3 lines deep along the margins of segment 4 and a single line of less noticeable hairs on either margin of segment 6. *Labium* as in ♀ but with more numerous pale interruptions on basal dark area. *Abdomen* as in ♀, with numerous scales on coxites. *Ungues* without special feature.

* PHARYNX : Manalang 1929, p. 431.

Hypopygium *: parabasal spines 5; as for subgenus, but spine no. 4 more widely separated than usual from basal group. Harpago with apical hair somewhat longer than club; one or two small hairs arising near base of apical hair. Phallosome short, squat, less than half length of coxite; leaflets about 6 on each side; the longest about ¼ length of phallosome, one or two showing serrations.

PUPA †.—*Paddle*: external border smooth basally, with fine sharp spines along the apical third, abruptly replaced by very fine scattered hairs on the posterior border; paddle-hair short, bent, simple, or bifurcate at end; acc. hair about same length, fine, simple, or bifurcate at end.

Spine: (VIII) rather short, half segment or less; accessory hair simple. (VII) about ¼ length segment, somewhat sharp-pointed. (III–VI) decreasing in size and somewhat blunt, very small and blunt on III and IV. (II) absent or very rudimentary.

Hair B: (VI–VII) about ⅔ length of segment, bifid. (V) trifurcate. (III–IV) branched.

Hair C: (V–VII) about ⅓ length segment, simple. (IV) trifurcate. (III) branched. *C'* (seg. VI) simple or bifid.

LARVA ‡.—*Clypeal hairs* § as in fig. 27, **15**: *ic* very finely frayed, the fraying visible only under a high magnification; *pc* with one or both sometimes bifid. *Antenna* with the hair rising about ⅓ to ¼ length of antenna from base; terminal hair split about middle into 2–4 br. *Mentum* with four teeth on each side of median tooth, the last much smaller than the others and placed a little removed from them.

Shoulder hairs: inner without conspicuous base, not stout, with 3–10 br.; middle 2 to 3 times length of inner; outer rising independently. Hair no. 1 on metathorax forming poorly developed palmate hair, the leaflets not arising in a whorl. *Pleural hairs* as given for the group; the chitinous tubercles are of moderate size, the projection on the prothorax produced into a very short process near the dorsal border.

Palmate hairs well developed on segments III–VII; that on I poorly developed, that on II fairly developed. Leaflets

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* HYPOPOGIUM: Christ. 1915, p. 391; Swell. 1916, p. 121; 1921 *a*, p. 86; Baisas 1931 *b*.

† Hitherto undescribed; the above is a short description.

‡ LARVA: Stanton 1915, p. 168; Swell. and Swell. 1919 *a*, p. 40; Swell. 1921 *a*, p. 86; Puri 1931, p. 127; Stanton 1926, p. 49.

See also Christ. 1911 *b*, p. 67; Stanton 1912 *b*, p. 8; 1914 *a*, p. 129; Mangk. 1919, p. 75; Swell. and Swell. 1920 *b*, p. 85; Swell. 1916, p. 124; Lamborn 1921, p. 93 (tail-hooks); Puri 1928 *b*, p. 524; Walch and Soesilo, 1929, p. 463 (pecten); Borel 1929, p. 73; Baisas 1931 *b*.

§ In this subgenus the frontal hairs and subantennal hair will only be described when in any way unusual.

more or less uniformly coloured in basal two-thirds, but unpigmented and somewhat transparent in distal half; filament poorly developed, indentations shallow and somewhat scattered. *Lateral hairs* on IV–VI long and split into 2–4 br.; on VII short, with 3 br. *Tergal plates* very small, also posterior median plates, which in some specimens may be very faintly indicated. *spc* poorly developed, but *mps* widened out anteriorly and nearly touching these. *Pecten* with 3 or 4 long and 7–11 very short spinous projections, the serrations at base of these very fine and inconspicuous. *ps* with 3–5 br. Caudal hooks 5; poorly formed. Anal papillæ much longer than anal segment.

Egg.—According to Stanton (1914*a*, p. 129) the egg does not differ in any detail from that of *A. tessellatus*, q.v.

Identification.—There is no species with which this can be confused, nor any varietal form described. Any anopheline found in the eastern Indian area and resembling *A. subpictus* and *A. vagus* in general coloration, but with broadly banded hind tarsi, is most probably *A. kochi*; confirmed by the abdominal scale-tufts.

Distribution.—*A. kochi* is a widely distributed Oriental species, but not apparently occurring in North China or India west of Bengal. It has been recorded from Moluccas (Ternate, Ceram, Halmaheira); Philippines; Formosa *; China (Canton) †; Lesser Sunda Islands (Bali, Lombok, Soemba, Soembawa, Flores); Java (and Noesa Kambangan); Sumatra (with Nias, Riouw, Batoe, Billiton, and Linga Islands); Borneo (with Poeloeh Laoet); Cochin-China; Annam ‡; Tonkin; Siam; Malay Peninsula; Burma and N.E. India.

In the Indian area it has a restricted distribution, being recorded only from Upper and Lower Burma, Assam, and N.E. Bengal. It has not so far been recorded from the Andamans or Ceylon.

Bionomics.—*A. kochi* is a moderately domestic species, being found in houses, stables and cow-sheds (*Walch*, 1924; *Doorembos*, 1924; *Ramsay*); it is, however, recorded by Chalam, 1923, at Nalbari, Assam, among species not found in houses; it is also to be caught very commonly in the jungle in Assam (*Ramsay*, private comm. through Covell). It feeds on man and cattle, and 39 per cent. of caught females were found by Lamborn, 1922, to show blood in the gut. It is recorded in Java (*Mangkoewinoto*, 1919) as one of several species seen entering houses at twilight.

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* Recorded by Kinoshita, but doubtful if Formosan species (*vide* Yamada).

† Buddle 1928.

‡ Swell. 1916.

A. kochi breeds by preference in small, shallow, often muddy collections of water in the open, such as small pools, with or without grass, stagnant drains, buffalo-wallows, hoof-marks, and collections in fallow rice-fields (*Swell.* and *Swell.*; *Hacker*; *Watson*, 1921; *Stookes*; *Gater* and *Rajahmoney*); also in streams (*Borel*). In Malaya, whilst usually occurring in the open, it is also commonly found breeding in drains in the jungle (*Gater* and *Rajahmoney*). According to Stookes it specially frequents artificial containers such as broken chatties and cut bamboos; also Feegrade found it breeding in such situations when there was no lack of natural breeding places near by.

RELATION TO DISEASE.—*A. kochi* has been experimentally infected to the oocyst state with M.T. and B.T. It has been found naturally infected in the Dutch East Indies by a number of observers, showing an infection rate from 0·4 to 11·5 per cent.

15. **Anopheles leucosphyrus** Dön., 1901*. (Fig. 28.)

Dönitz, Insektenbörse, xviii, p. 37, 1901 (*A. leucosphyrus*). TYPE LOC.: Kajoe Tanam, Sumatra.

SYNONYM:

elegans James, 1903, in Theo., Mono. Cul. iii, p. 51 (*Myzomyia* (?) *elegans*). TYPE-LOC.: Karwar, West Coast, India. TYPE: ♀ described; type in Brit. Mus. SYN. by James and Stanton, Paludism, no. 5, p. 60, 1912, and Stanton, C. R. 3e Congr. F.E.A.T.M. p. 516, 1914.

RECOGNIZED VARIETY:

hackeri Edwards, 1921, Bull. Ent. Res. xii, p. 70 (*A. leucosphyrus* var. *hackeri*). TYPE-LOC.: Fed. Malay States. TYPE: ♀ described; type in Brit. Mus. Not recorded from Indian area †.

ADULT ♀.—Size moderate (length of wing 3–3·7 mm.).

Head: scales of normal type, with pale vertical spot; vertical chætæ forming single row, milk-white and somewhat flattened, forming rather thin vertical tuft. *Antenna*: *t* devoid of scales; some pale and dark scales on first *fs*. *Palpi*: basal portion somewhat shaggy; apical segment long, index 0·65; with four pale bands (fig. 28, 2), due to pale scales at the apex of each segment except *rbs*. *Labium* dark, with the scales ventrally at base forming tuft, but not so pronounced as in *A. kochi*; labella pale.

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* SYSTEMATIC: Theo. 1901, p. 307; James and Liston 1904, p. 82; 1911, p. 105 (*elegans*); Leicester 1908, p. 28; Edwards 1921, p. 70.

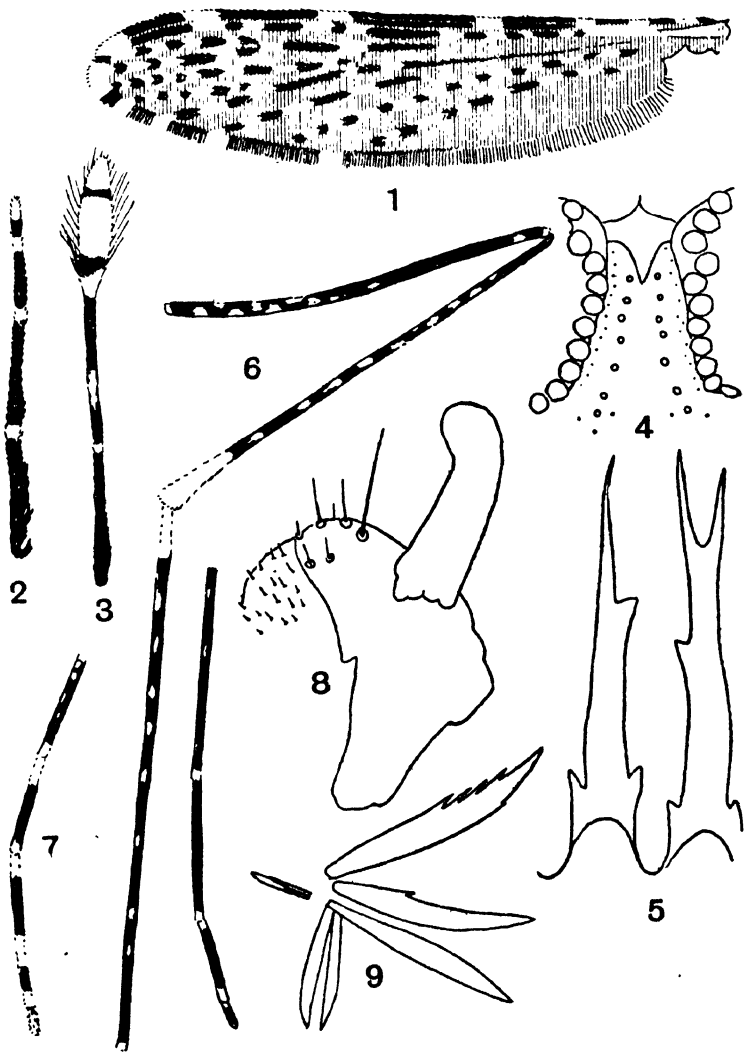
See also Dönitz 1901, p. 37; 1902, p. 56; Theo. 1903, p. 51 (*elegans*); 1907, p. 77; 1910, p. 44; Cogill 1903, p. 330; Swell. 1916, p. 82; 1921, p. 82; Christ. 1916 *a*, p. 469; 1924 *c*, pp. 71, 103; Mangk. 1919, p. 74; Rodenw. 1921, p. 153 (pilot.); Borel 1929, p. 64; Baisas 1931 *b*. See also references on pp. 179–180 (footnotes).

† See Hacker, F.M.S. Mal. Bur. Repts. 1920 (1921), p. 33; Mal. Bur. Annual Repts. 1921 (1922) and 1922 (1923); Borel 1929, p. 65; Gater and Rajahmoney 1929, p. 10.

Pharynx: very similar to *A. kochi*, but filaments of cones longer, more or less as in fig. 28, 5: cones with two lateral teeth and devoid of crest.

Thorax with marked black scale-tufts on *apn*; propleural hairs 2. Mesonotum dark, without differentiation of median

Fig. 28.



A. leucosphyrus.

1. Wing of ♀. 2 & 3. ♀ and ♂ palpi, same scale. 4. Vertex. 5. Two pharyngeal teeth, standard scale. 6. Hind leg, showing tibio-tarsal band. 7. Fore tarsus. 8. Harpago, standard scale. 9. Leaflets of one side of phallosome, standard scale.

and lateral areas, but often with silvery eyespot on fossa and crescentic silvery line delimiting the fossa posteriorly; covered with golden hairs and dark chætæ; anteriorly scales form prominent median and lateral tufts, the latter with an area of black scales extending on to face of promontory; a few scattered scales on fossæ and lateral areas near wing-roots. Scutellum with lateral portions pale, median area black and rather swollen. Pleuræ dark, with some pale lines; spiracular hairs small, 1–2; prealar about 4; upper mesepimeral few in number (about 4).

Wings as in fig. 28, 1, with six or more dark spots on vein 6 and similar spotting on veins 5 and 5.2; no fringe-spot opposite 6, or none at 5.2 or 6, but spots present between these vein-junctions; border scales extending only a little distance basal to junction of vein 6.

Legs: front femora swollen in basal half. Femora and tibiæ of all legs very much spotted, much as in *A. kochi*, but legs darker; apical $\frac{1}{6}$ or so of hind tibiæ, together with an extent of base of first tarsal segment, conspicuously pale, forming a broad pale tibio-tarsal band easily visible to the naked eye; first tarsal segment on all legs splashed with pale spots; fore tarsi apically and basally banded at all joints, or sometimes apical only at some of these, basal bands sometimes broader than apical and last segment sometimes more or less pale; mid-tarsi variably banded; hind tarsi narrowly apically banded, or with basal bands also at some joints, extreme apex of last segment pale. Coxæ darkish, with some light hairs but no conspicuous scales.

Abdomen dark, with dark hairs on dorsum except on VIII, where there are numerous golden hairs; venter with lateral pale spots on III–VII towards the front of the segment as in *A. kochi*, and an apical tuft of black scales on VII with some scales or a tuft on VI, or also on V; ventral aspect of the cerci and VIII dark, without golden hairs.

ADULT ♂.—In general as in ♀. *Antenna* with a few scales on first flagellar segment. *Palpi* as shown in fig. 28, with marginal hairs forming single row on seg. 4. *Abdomen* with rather numerous scales on dorsum of VIII and coxites and scale-tufts as in ♀, or scales representing these on V–VIII. *Ungues* with a rather long basal spur.

Hypopygium *: parabasal spines 5; spine no. 4 somewhat separated from basal group as in *A. kochi*. Harpago with apical hair shorter than club; some smaller hairs present in addition to main hair. Phallosome short, less than half length coxite; carrying about 6–7 leaflets on each side,

* HYPOPYGIUM: Christ. 1915, p. 391: Swell. 1916, p. 82; 1921 *a*, p. 81; Borel 1929, p. 68; Baisas 1931 *b*.

the largest about $\frac{1}{3}$ length of phallosome measured to base, excluding leaflets, one or two showing serrations.

PUPA *.—*Paddle*: very similar to *A. kochi*, but spines on external border stouter.

Spine: (VIII) about $\frac{3}{4}$ length of segment; acc. hair simple. (V–VII) about $\frac{1}{4}$ length of segment, pointed. (III–IV) very short, blunt. (II) rudimentary.

Hair B: (III–VII) branched; about $\frac{2}{3}$ length of segment.

Hair C: (V–VII) bifid, approaching length of segment. (III–IV) branched. *C'* (VI) simple.

LARVA †.—*Clypeal hairs* very similar to those of *A. kochi*; *ic* simple or finely frayed, as in *A. kochi*. *Antenna* rather slender; hair arising $\frac{1}{3}$ to $\frac{1}{4}$ length of antenna from base. *Mentum* as in *A. kochi*, but the four teeth on either side of the median tooth somewhat longer.

Shoulder hairs: inner stout and feathered, with conspicuous base, usually fused with that of the middle hair; middle hair not disproportionately larger than inner; outer hair arising from base of middle hair. *Metathoracic hair no.* 1 not differentiated as palmate hair. *Pleural hairs* as given under the group; basal tubercles as in *A. kochi*.

Palmate hairs well developed on III–VII; hair no. 1 on I and II not developed as palmate hairs; leaflets more or less uniformly coloured, not so transparent in apical portion as in *A. kochi*, the filament varying from half to $\frac{1}{3}$ length of blade. *Lateral hairs* on IV–VI long, somewhat slender and split near base into 2 on IV and V and 2–3 on VI; very short, with 3–4 br. on VII. *Tergal plates* very small. *spc* well developed and *mps* fairly broad anteriorly, its anterior border nearly touching the chitinisation. *Pecten* with 4–5 long and 7–10 short processes, practically all with some serrations at their bases. *ps* with 4–5 long br. Caudal hooks 5–6, somewhat shallow. Anal papillæ exceptionally long, three times or more length of anal segment.

EGG.—Unknown.

IDENTIFICATION.—The broad pale tibio-tarsal band on the hind legs suffices to distinguish *A. leucosphyrus* from all other Oriental forms except its variety *hackeri*, which has not been recorded from the Indian area. The latter differs

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* Hitherto undescribed, the above is a very brief description.

† LARVA: Stanton 1915, p. 168; 1926, p. 50; Swell. and Swell. 1919 *a*, p. 33; 1920 *b*, p. 83; Puri 1931, p. 133.

See also Cogill 1903, p. 330; James and Liston 1904, p. 82; 1911, p. 107; Theo. 1907, p. 77; Stanton 1912 *b*, p. 6; Swell. 1916, p. 87; 1918, p. 398; 1921, p. 87; Mangk. 1919, p. 74; Puri 1928, p. 524; Stookes 1929, p. 111; Walch and Soesilo 1929, p. 463 (comb); Borel 1929, p. 68; Baisas 1931 *b*. See also refs. to var. *hackeri*, p. 177.

from the type-form, according to Edwards, in the following particulars :—Bands on the female palpi very narrow, the apical segment white at the extreme tip only ; proboscis unusually long, longer than the palpi by almost, or quite, or even more than, the length of the last two palpal bands ; dark markings on the wing more extensive, the dark spots on vein 1 more fused. The var. *hackeri* appears to breed especially, if not exclusively, in bamboos *.

DISTRIBUTION.—*A. leucosphyrus* has a wide distribution in the Oriental Region, but has not been recorded from China, or, apparently, from the Moluccas or Lesser Sunda Islands. It has been recorded from CELEBES † ; SANGIR ISLAND † ; TALAUD ISLAND † ; PHILIPPINES ‡ ; BORNEO (with Poeloeh Laoet) ; JAVA ; SUMATRA (and Nias Islands) ; COCHIN CHINA ; MALAY PENINSULA ; SIAM ; INDIA, CEYLON, and BURMA.

In the Indian area it is recorded from many localities in eastern India, including Upper and Lower Burma, Andamans, Assam, and Bengal, and also in South India from the west coast (Konkan), Nilgiris, Coorg, Malabar, and Mysore (Kadur in the west). There is, therefore, an intervening area, including Hyderabad, the Madras Presidency, Central Provinces, and Bihar and Orissa, from which it has not yet been recorded. It is recorded from Ceylon by Senior White, 1925, and Carter, 1925.

BIONOMICS.—In the Indian area *A. leucosphyrus* is a wild species found breeding in deep jungle and forest, but recorded from houses by McCombie Young, 1921, and Lalor, 1912. Roper, in Borneo, commonly found it gorged with blood in the nets of the men in a coolie line near a swamp.

Breeding places in the Andamans are pools by sides of rocky streams in forest (*Christophers* ; *Covell*) and in a disused well (*Covell*) ; in the Bengal terai Puri, 1931, found it breeding in rainwater in borrow-pits alongside the road in thick forest ; in the Konkan recorded as found in pools besides forest streams (*Cogill*) and from nullahs densely shaded by foliage (*Strickland*, 1923) ; in Ceylon in streams descending from heavy jungle (*Senior White*, 1925), and in a heavily shaded swamp and in a densely shaded stream (*Carter*, 1925). It may be found also on occasions in pools in the open (*Cogill* ; *Covell* ; *Puri*) and at some distance from forest (*Senior White*, 1926). Recorded as found 800 metres from its breeding place by Baisas.

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* According to Gater (private communication), *hackeri* is probably specifically distinct from *leucosphyrus* ; there is a constant difference in the larvæ as well as in breeding habits and in adult morphology, as noted above. For references to this form, see footnote to p. 177.

† Given by Rodenwaldt from these areas as var. *hackeri*.

‡ Baisas 1931 *b*.

RELATION TO DISEASE.—Suspected by Roper, on epidemiological grounds, to be a carrier of malaria in Borneo. Has been experimentally infected with B.T. and also found infected in nature (1·7 per cent.) in the Dutch East Indies. It is not thought to play any part in malaria transmission in India owing to its rarity, except as a jungle species.

16. **Anopheles tessellatus** Theo., 1901*. (Fig. 29.)

Theo., Mono. Cul. i, p. 175, 1901 (*A. tessellatum* mentioned as MS. name, but described as *A. punctulatus* Dön.). TYPE-LOC.: Taiping, Perak, F.M.S. TYPE: described from a single ♀; type in Brit. Mus.

formosæ Hatori, Kampo, no. 5534, p. 275, 1901 † (*A. formosæ*). TYPE-LOC.: Formosa. SYN. by Yamada, Sci. Repts. Govt. Inst. Inf. Dis. iv, p. 483, 1925.

deceptor Dönitz, 1902, Zeit. f. Hyg. xli, p. 60 (*A. deceptor*). TYPE-LOC.: Sumatra. TYPE: ♀ described. SYN. by Stanton, Bull. Ent. Res. iv, p. 129, 1913.

thorntonii Ludlow, 1904, Canad. Entom. xxxvi, p. 69 (*Myzomyia thorntonii*). TYPE-LOC.: Oras Samar and Cottabato, Mindanão, P.I. TYPE: 3 ♀♀ types in U.S. Nat. Mus. Washington (*vide* Dyar and Shannon, Insect. Ins. Mens. xiii, p. 87, 1925). SYN. by Edwards, Bull. Ent. Res. iv, p. 221, 1913.

ceylonica Newstead & Carter, 1910, Ann. Trop. Med. and Par. iv, p. 377 (*Dactylomyia ceylonica*). TYPE-LOC.: Trincomalee, Ceylon. TYPE: described from a single ♀; type in L'pool. Sch. Trop. Med. SYN. by Stanton, *loc. cit.* 1913.

kinoshitai Koidzumi, Dobuts. Zas. xxix, p. 133, 1917 † (*A. kinoshitai*). TYPE-LOC.: Formosa. SYN. by Yamada, *loc. cit* 1925.

taiwanensis Koidzumi, *ib.* (*A. taiwanensis*). TYPE-LOC.: Formosa. SYN. by Yamada, *loc. cit.* 1925.

This is the *A. punctulatus* of many authors writing of all except the more eastern part of the Oriental Region, and the *A. punctulatus* of India of James and Liston. It was also referred to for a time by Indian authors as *A. thorntonii*.

ADULT ♀.—Size medium (length of wing 2·5–3·7 mm.).

Head: scales of normal type, with a broad pale vertical spot; vertex broad; vertical chætæ forming a single line, or nearly so, on either side, white and forming a rather sparse frontal

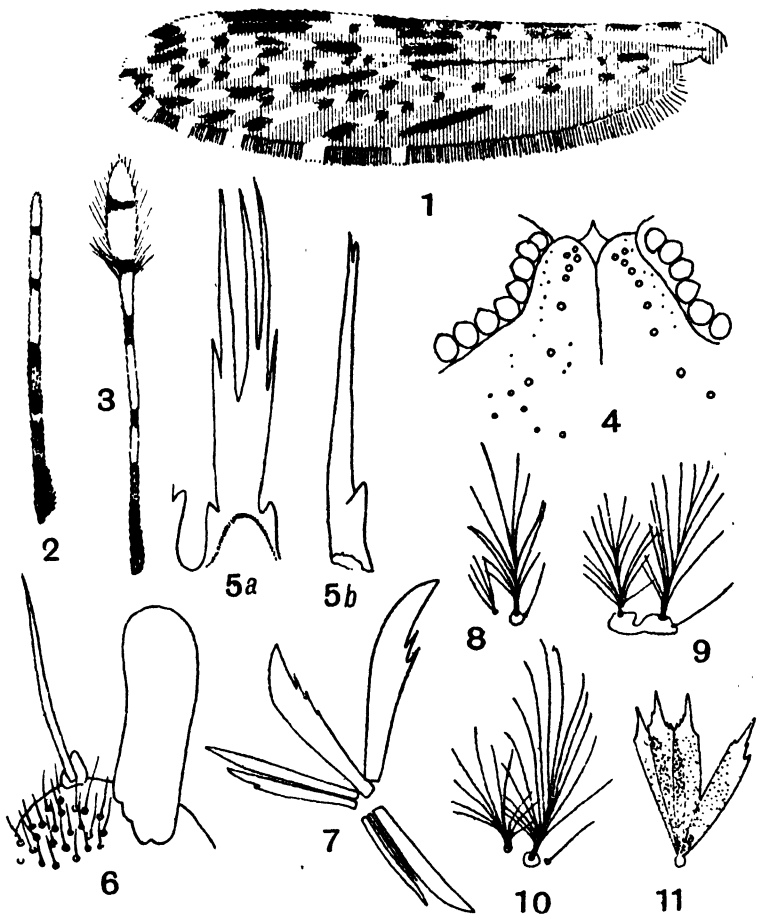
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* SYSTEMATIC: Theo. 1901 *a*, p. 175; Edwards 1913, p. 221; 1921 *a*, p. 71; Yamada 1925, p. 483; Borel 1929, p. 74.
See also (*tessellatus*) Stanton 1912 *b*, p. 6; 1913, p. 129; 1915, p. 255; 1926, p. 32; Christ. 1916, p. 482; 1924, pp. 72, 105; Schuff. and Swell. 1917, p. 19; Swell. 1919, p. 3; Koidzumi 1924, p. 100; 1930, p. 234; Carter 1925, p. 75; Baisas 1931 *b*. (*punctulatus*) Theo. 1901 *b*, p. 306; 1903, p. 55; Cogill 1903, p. 331; James and Liston 1904, p. 84; 1911, p. 104; Leicester 1908, p. 27; Mathis and Leger 1911; Roper 1914, p. 144; Swell. 1916, p. 73; 1921, p. 70. See also references on pp. 184–5 (footnotes).

† Orig. ref. in Japanese; taken from Yamada, *loc. cit.*

tuft. *Antennæ*: a few minute scales on *t* and a patch of white scales on first *fs*. *Palpi*: apical segment long, index 0·7; of moderate thickness, with three broad white apical bands separated by two narrow black bands, a further narrow pale band at apex of segment 2 and a patch of pale scales on 3 (fig. 29, 2). *Labium* with apical half and labella golden-yellow, a dark spot at end of labium; base of

Fig. 29.



A. tessellatus; also *A. leucosphyrus* (**9, 11**) and *A. kochi* (**10**).

1. Wing of ♀, standard scale. **2 & 3.** ♀ and ♂ palpi; same scale. **4.** Vertex. **5** *a*. Pharyngeal tooth, standard scale, anterior view. **5** *b*. Same, lateral view. **6.** Summit of harpago, standard scale **7.** Leaflets of one side of phallosome, standard scale for leaflets. **8.** Shoulder hairs of larva. **9.** Ditto, *A. leucosphyrus*. **10.** Ditto, *A. kochi*. '1. Some leaflets of palmate hair, of *A. leucosphyrus*; those of *A. kochi* and *A. tessellatus* are very similar (**8–11** after Puri).

labium without any prominent tuft, but scales somewhat long in this situation.

Pharynx * very similar to *A. kochi*.

Thorax usually with a few dark scales on *apn*; propleural hairs 1. Mesonotum unicolorous, usually with some broad frosty markings about fossa and lateral area, giving some approach to a dark lateral eye-spot towards front of lateral area; clothed with pale hairs and with narrow white scales forming median and lateral tufts on promontory. Pleuræ dark, without conspicuous scales; spiracular hairs absent; prealar about 2; upper mesepimeral few (4). *Halteres* entirely pale, including knob.

Wing (fig. 29, 1), with general resemblance to that of *A. leucosphyrus*, but with a fringe-spot at vein 6 and border scales extending nearly to base of wing.

Legs: front femora markedly swollen in basal half; femora and tibiæ spotted very similarly to *A. kochi* and *A. leucosphyrus*; the hind tibiæ only narrowly pale at apices, and base of tarsal segment 1 dark; tarsal segments narrowly apically banded on 1–3, and on 4 on hind legs; extreme tip of last tarsal segment on hind legs pale or dark.

Abdomen with hairs only, these somewhat denser and golden on the last segment. Cerci without definite scales.

ADULT ♂.—In general as in ♀. *Antenna* with one or two dark scales on first flagellar segment. *Palpi* with marginal hairs forming about a double row on segment 3. *Ungues* as in *A. leucosphyrus*. Coxites with numerous pale and some dark scales.

Hypopygium †: very similar to *A. kochi* and *A. leucosphyrus*; parabasal spine 4 widely separated from the more basal 3. Harpago with apical hair stout, about the same length or a little longer than club. Phallosome about half length of coxite; with about 6–7 leaflets on each side, the largest about half the length of phallosome; the larger leaflets broad, claw-shaped, with some serrations on concavity.

PUPA ‡.—*Paddle*: very similar to *A. leucosphyrus*, but the spines on the external border give place posteriorly to stout hairs with conical bases, these not quite extending to paddle-hair, the interval between having delicate hairs.

Spine: (VIII) about half length of segment, with 4 lateral and 2 terminal br.; acc. hair trifurcate. (V–VII) about

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* See also Manalang 1929, p. 423.

† HYPOPYGIUM: Christ. 1915, p. 391; Swell. 1921 *a*, p. 73 (*punctulatus*); Borel 1929, p. 78; Baisas 1931 *b*.

‡ Hitherto undescribed; the above is a brief description from material kindly furnished to me by Dr. Puri. See also Lamborn 1921, p 96 (paddle-hair).

$\frac{1}{8}$ of segment on VII, shorter on succeeding two segments, moderately pointed. (III–IV) minute.

Hair B: (VI–VII) half to $\frac{2}{3}$ length segment, 5 br. (IV–V) 4 br. (III) 6 br.

Hair C: (VI–VII) $\frac{2}{3}$ length segment, trifurcate. (IV–V) 4 br. (III) 6 br. *C'* (seg. VI) simple.

LARVA *.—*Clypeal hairs*: very similar to *A. kochi*; *ic* finely frayed.

Shoulder hairs: inner short, with 3–5 br., less than half length of middle; without conspicuous tubercle; arising near base of middle hair. *Metathoracic hair no.* 1 forming poorly developed palmate hair. *Pleural hairs* as given under group.

Palmate hairs well developed on III–VII; hair no. 1 not developed as palmate hair on I and II; leaflets in colour and general character similar to those of *A. kochi*. Hair no. 2 on I very short and hair no. 0 very minute. Ventral anal papillæ longer than dorsal, which are shorter than the plate of the anal segment.

EGG †.—Of whale-back type. *Upper surface* narrow, linear; bosses at terminations clear and light coloured. *Lower surface* ornamented with polygonal pale markings. *Floats* narrow, occupying slightly less than middle $\frac{2}{3}$ of egg, not touching margins of upper surface; float-terminations of moderate size, more or less rounded; float-ridges about 18 in number, deeply indented, with well-marked crest, giving serrated outline to floats when viewed from above. *Frill* fairly broad, erect, and not extended laterally; present all round margin of dorsal surface; markedly striated in full extent.

IDENTIFICATION.—The characteristic female palpi and the numerous spots on the sixth vein in the male, without the outstanding features of *A. kochi* (ventral scale-tufts) and *A. leucosphyrus* (tibio-tarsal band), suffice to distinguish *A. tessellatus* from all other Indian species.

The absence of broad scales over the mesothorax will distinguish it from *A. punctulatus*, occurring in the more eastern portions of the Oriental Region. *A. longirostris* Brug ‡ resembles *A. tessellatus*, but is distinguished by the very long proboscis and base of *pf* being nearer base of wing

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* LARVA: Stanton 1915, p. 171; 1926, p. 54; Swell. and Swell. 1919 *a*, p. 38 (*punctulatus*); 1920 *b*, p. 85 (*punctulatus*); Puri 1931, p. 131.

See also Stanton 1912 *b*, p. 6; Mangk. 1919, p. 70 (*punctulatus*); Swell. 1921 *a*, p. 73; Lamborn 1921, p. 93 (tail-hooks); Carter 1925, p. 91; Senior White 1925, p. 218; Walch and Soesilo 1929, p. 463 (pecten); Baisas 1931 *b*.

† EGG: Stanton 1913, p. 129; Christ. and Barr. 1931, p. 174.

‡ Brug, Meded. Volks. Ned. Indie, xvii, p. 424, 1928.

than that of *af.* It has only so far been recorded from New Guinea.

DISTRIBUTION.—*A. tessellatus* has a wide distribution in the Oriental Region; it has been recorded from NEW GUINEA *; MOLUCCAS * (Boeroe, Ceram, Amboina, Ternate); PHILIPPINES; FORMOSA; CHINA (Hong Kong); LESSER SUNDA ISLANDS (Soembawa, Soemba †, Alor); SUMATRA (with Nias); JAVA; BORNEO (with Poeloe Laoet); COCHIN CHINA; TONKIN; ANNAM; MALAY PENINSULA; SIAM; BURMA, INDIA, and CEYLON.

In the Indian area it is recorded from localities throughout Burma, the Andamans, Ceylon, and East, South, and Central Peninsular India, but not from anywhere north-west of Gujarat, Indore, and Delhi, nor from the United Provinces.

BIONOMICS.—*A. tessellatus* in the Indian area is rarely taken except in small numbers at a time, but has been frequently recorded from houses and cow-sheds, and may be regarded as more or less a domestic species (*Christophers*, 1912; *Covell*, 1927; *James* and *Liston*; *Sweet*; *Ramsay*; see also *Walch*). Stookes, however, seldom found it in houses, even though larvæ were abundant.

It is recorded as attacking man (*Barnes*; *Yamada*), and 59 per cent. of females were found by Lamborn with blood in the gut. It has also been caught feeding on buffaloes (*Brug* and *Walch*), and found with buffalo-blood by the precipitin test (*Walch* and *Sardjito*).

In the Indian area *A. tessellatus* breeds especially in small pools (*Covell*; *Feegrade*); it has been found in excavations by the side of swamps (*Samuel*), in furrows in sugar-cane brakes (*Lalor*), in rice-fields (*Fry*, 1912; *Strickland*, 1923), and in irrigation and seepage channels (*Rao*, 1929). Gater and Rajahmoney class it as typically a shade-breeder, with a preference for dirty stagnant water; Swellengrebel and Swellengrebel, 1919, also note its occurrence in dirty water.

RELATION TO DISEASE.—*A. tessellatus* has been infected with M.T. parasites, but its susceptibility is low. In nature it has been found infected in the Dutch East Indies once in 1,553 dissections.

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* Records may relate to *A. punctulatus* in part.

† Sch. Stekhoven, Geneesk. Tijds. lxii, p. 656, 1922 (*punctulatus*).

‡ The type-species for subgenus *Myzomyia* is *A. subpictus* Grassi, which does not belong to the present group, and there is no other of the earlier genera with a type-species included in the group as at present constituted. Strictly, therefore, a new name should be given to the present group if it is to be treated as a genus. But Theobald, though he first gave *A. rossii* (*A. subpictus*), later gave *A. funestus* Giles as the type, and I have therefore selected this species as the type without changing the name of the group.

Group *Myzomyia*.

Christophers, Ind. Med. Res. Mem. no. 3, p. 44, 1924.

Type-species, *A. funestus* Giles ‡.

Pharyngeal armature with a double row of teeth differentiated as "rods" and "cones," the cones without roots, a strong lateral tooth on either side; crest of pediment with a single row of spines, usually rather short, posterior view not usually bifid. Lateral flanges broad, often with some teeth.

Propleural hairs of adult present; usually a single hair.

Female palpi with the apical segment short, wholly included in apical pale band; pronotal lobes never with a scale-tuft; mesonotum commonly with hairs or hair-like scales; if covered with scales these are usually narrowish; ornamentation of wing very regular, pale areas on costa usually of moderate extent; femora and tibiæ never speckled, tip of hind tarsus rarely white; tarsal banding, if present, usually narrow; abdomen without scales, except some commonly on coxite.

Harpago usually with a stout apical hair, at most only somewhat longer than the club, and a stout hair at least half its length between this and the club. Leaflets of phallosome usually shaped like a short pruning-knife blade and serrated on one edge.

Pupa: spine on segments IV–VII (inclusive) large or of moderate size and sharp, on IV not suddenly reduced and blunt; III minute, usually unchitinised. Hair *C* branched on IV; in this group *C* is also not infrequently bifid or branched on some or all of segments V–VII, but the branches are leash-like, not stiffly diverging, as with hair *C* in its usual condition when branched.

Larva: clypeal hairs usually simple, but may be frayed or with short lateral branches; the cone-shaped appendage on the maxillary palp is not bifid. The full characters of the pleural hairs for the group are given below:—

	1.	2.	3.
da....	Long, feathered (pectinate).	Long, simple §.	Long, feathered (pectinate).
va	Long, simple.	Long, simple.	Long, simple.
dp	One-third length anterior, split into 2–3, or with 4–5 scattered br.	Extremely short, simple.	Extremely short, simple.
vp	Long, simple.	One-sixth length ‖ anterior, simple.	Short, slender; may be split into 2–6 br.

‡ See footnote ‡ on opposite page.

§ Sparsely feathered in *A. sergenti* and *A. rhodesiensis*.

‖ Bifid sometimes in *A. culicifacies*; split into 2–3 in *A. sergenti*; split into 3–4 and short in *A. majidi*.

Species recorded from the Indian Area *.

The following species and varieties are recorded from the Indian area :—

A. dthali Patton.
A. sergenti Theo.
A. culicifacies Giles.
A. fluviatilis James.
A. minimus Theo.
A. varuna Iyengar.
A. aconitus Dön.
A. jeyporiensis James.
A. jeyporiensis James, var. *candidiensis* Koidzumi.
A. majidi McCombie Young & Majid.

The following gives a general grouping of the species; for further particulars in identification see Key and notes under the species :—

Wing-field and fringe without pale spots †; head-scales linear; mesonotum shiny; frontal tuft ill developed. Extreme N.W. of India only ..... *A. dthali.*

Wing-field with pale spots; fringe, or apex at least, with pale area; head-scales normal; mesonotum not so markedly shiny

Tarsi unbanded or, if banded, very narrowly so, and not with pure white.

Palpal banding narrow or only the apical band at all broad. (For further particulars see under *A. culicifacies* ..... *A. sergenti*; [*A. culicifacies*; [*A. fluviatilis.*

Palpi of female with two broad apical bands. (For further particulars see under *A. fluviatilis.*) ..... *A. minimus*; [*A. varuna*; [*A. aconitus.*

Tarsi narrowly or broadly banded with white.

Hind tarsal bands narrow; last segment not white ..... *A. jeyporiensis.*

Hind tarsal bands broad; last segment white ..... *A. majidi.*

17. **Anopheles dthali** Patton, 1905‡. (Fig. 30.)

Patton, Journ. Bomb. Nat. Hist. Soc. xvi, p. 627, 1905 (*A. dthali*). TYPE-LOC.: D'thala, Hardeba, Sulek, Nobat (Aden Hinterland). TYPE : unknown.

rhodesiensis of Christ. and Khazan Chand, 1915, and of Kirkpatrick, 1925, and other authors referring to India, Egypt, etc. Nec *A. rhodesiensis* Theo. of South-East and West Africa (*vide* Christ. and Puri, Ind. Journ. Med. Res. xix, p. 1133, 1931).

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* Other species included in the group are : (Oriental) *A. filipinæ* Manalang; (Ethiopian) *A. rhodesiensis* Theo., *A. funestus* Giles, *A. marshalli* Theo., *A. austeni* Theo., *A. domicolus* Edw., *A. freetownensis* Evans, *A. flavicosta* Edw., *A. hargreavesi* Evans, *A. moucheti* Evans, *A. pitchfordi* Giles, *A. brunnipes* Theo., *A. rufipes* Gough, *A. distinctus* Newst. & Carter, *A. walravensi* Edw., *A. longipalpis* Theo., *A. transvaalensis* Carter, *A. theileri* Edw., *A. wellcomei* Theo. (not *A. garnhami* Edw., as given by Edwards, 1932).

† Sometimes some pale areas are present at cross-veins.

‡ For references, see next page.

ADULT ♀ *.—A small, light-coloured, rather delicate anopheline resembling in appearance *A. culicifacies*, with black eyes, pale head, and shiny, transparent looking thorax (length of wing 2·5–3·6 mm.).

Head: scales narrow, rod-like, unusually long, expanded only at the apex, and striations extending only about halfway down the scale, not extending below level of neck, and throughout of a light yellowish or yellow-brown colour; interocular vertex rather narrow; vertical bristles yellow, short, unmodified hairs, forming a single row of about five on either side; about an equal number of narrow ocular scales; some pale lanceolate head-scales extending forward in the middle; frontal tuft practically absent or inconspicuous. *Antennæ*, including torus, without scales. *Palpi* thin and of uniform thickness to base, the last segment very short; index 0·3; apex, including short last segment, dark or, if pale, in certain lights, there is no definite band; narrow pale apical bands present at 2–3, 3–4, often indistinct, or palps even appear unbanded; *rbs* devoid of scales.

Pharynx: as for group. Filaments of cone flat, tapering, with fimbriated end; one or more sharp lateral teeth on each side; crest with a single row of numerous spines. Rods with narrow ends, tapering from laterally flattened melon-seed-shaped bases, with some spicules arising posteriorly towards base.

Thorax with chætæ only on *apn*; propleural hairs 1. Mesonotum unicolorous, shiny, often bluish, olivaceous, or yellow, and having a somewhat transparent glabrous appearance, with lines of dark chætæ, but no scales or scale-like hairs even anteriorly. Pleuræ devoid of scales; spiracular hairs usually absent; prealar hairs absent or inconspicuous; upper mesepimeral about 7.

Wings as in fig. 30, 1, the wing-field and fringe, including apex, usually entirely devoid of pale interruptions, but there may sometimes be some pale areas at cross-veins. Scaling of wing narrow and rather scanty; max. str. 5–6.

Legs uniformly darkish except for some paling at apices of femora and tibiæ. Tarsus unbanded. Coxæ without scales.

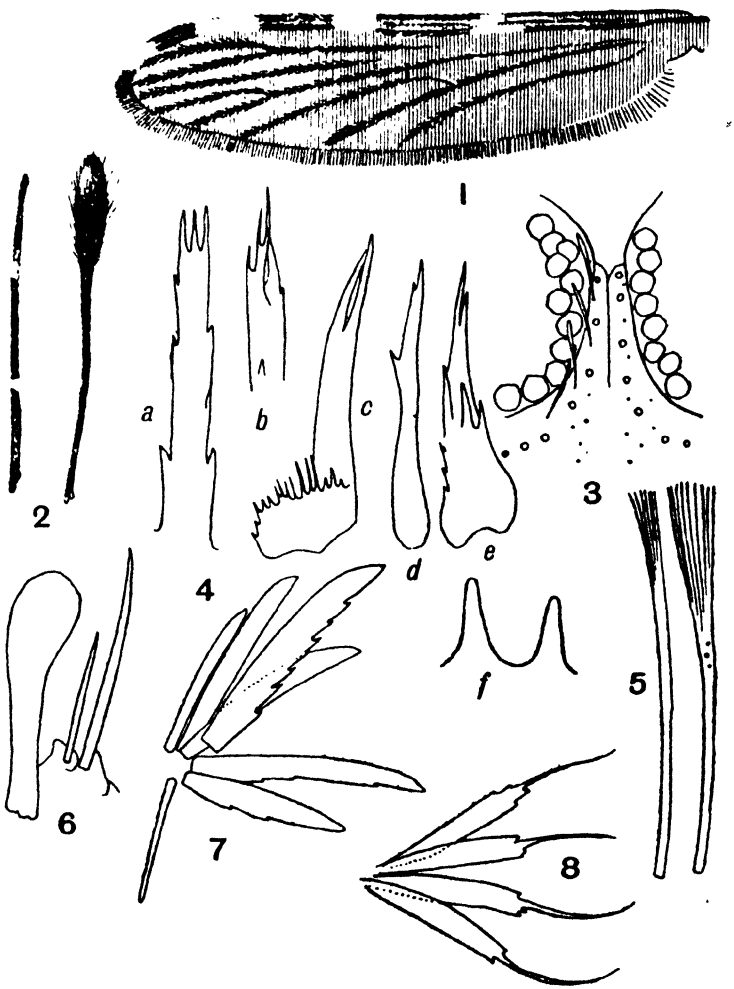
Abdomen without scales; usually blotched with dark and light patches; hairs noticeably light coloured. Cerci with hairs only.

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* SYSTEMATIC: Patton 1905, p. 627; Christ. and Khazan Chand 1915, p. 182; Christ. 1916 *a*, p. 476; 1924 *c*, pp. 49, 92; Edw. 1921 *b*, p. 278; Séguy 1924, pp. 155; Kirkp. 1925, pp. 53, 172; Martini 1930, p. 183; Christ. and Puri 1931, p. 1133. See also references on pp. 191–2 (footnotes).

ADULT ♂.—In general as in ♀. *Palpi* with the club narrow; usually uniformly dark except for diffuse pale area on dorsal border of last segment; rarely a pale spot may be present at base of club (apex 3); marginal hairs forming a single row dorsally and a double row ventrally. *Ungues* of normal type. *Abdomen* entirely devoid of scales. Coxites with a few small scales.

Fig. 30.



A. dthali.

1. Wing of ♀, standard scale. 2. ♀ and ♂ palpi. 3. Vertex. 4. Pharyngeal teeth: (*a*) anterior view, cone; (*b*) more fimbriated example; (*c*) lateral view, cone; (*d*) rod, anterior view; (*e*) rod, lateral view; (*f*) posterior view of crests. 5. Head-scales. 6. Apex of harpago. 7. Leaflets of phallosome, standard scale. 8. Leaflets of palmate hair (after Puri).

Hypopygium * : harpago with a stout hair slightly longer than the club and a hair about half its length, also stout, between this and the club. Phallosome about half length of coxite; with about 6–7 leaflets on each side, longest somewhat more than $\frac{1}{3}$ length of phallosome, several with not very marked serrations and several largish ones plain. The leaflets appear to differ from those of *A. sergenti* in being somewhat more numerous and more equal in size, with a larger number of well-formed leaflets unserrated.

PUPA †.—*Paddle*: external border with spines extending to base, the spines thin, pointed, replaced by hairs on posterior border, which do not extend beyond the paddle-hair; paddle-hair long, hooked; acc. hair branched.

Spine: (VIII) with 6–8 lateral branches; about length of segment; acc. hair branched. (IV–VII) sharp, well developed, from $\frac{1}{3}$ to half length of respective segments. (III) small, chitinised.

Hair B: (III–VII) branched, from half to over $\frac{3}{4}$ length segments.

Hair C: (V–VII) simple (occasionally forked), longer than segment. (III–IV) branched, less than length of segment. *C'* (seg. 6) simple.

LARVA ‡.—*Clypeal hairs* simple; *oc* slightly longer than half length *ic*; *pc* about same length as *oc*. *Antenna* darker towards distal end; hair arising $\frac{1}{4}$ or a little more of length of antenna from base; terminal hair split about middle into 3–6 br. *Mentum* with three teeth on each side of median tooth, adequal and equidistant; a smaller tooth sometimes present basally.

Shoulder hairs: the inner and middle arising from separate chitinised bases, both feathered and large. *Metathoracic hair no.* 1 fairly developed as palmate hair. *Pleural hairs* as given under group; *dp*1 with 4–5 br.; the chitinised tubercles with the projection on 1 produced into a pointed spine, those on 2 and 3 poorly developed.

Palmate hairs well developed on II–VII; that on I with poorly differentiated filament. Leaflets more or less uniformly pigmented, the serrations at the shoulder not very deep and the filament long and pointed, about $\frac{2}{3}$ length of blade. *Lateral hair* with 4–7 br. on IV, 3–5 on V and VI, very short, with 3–5 br. on VII. *Tergal plates* with the anterior plate moderately large, the posterior plate a little behind this and

* HYPOPYGIUM: Christ. 1915, p. 392 (*rhodesiensis*); Kirkp. 1925, p. 53 (*rhodesiensis*); Christ. and Puri 1931, p. 43.

† PUPA: Kirkp. 1925, p. 55 (*rhodesiensis*); Senevet 1931, p. 106 (*rhodesiensis*).

‡ LARVA: Patton 1905, p. 627; Kirkp. 1925, p. 55 (*rhodesiensis*); Puri 1928, p. 522 (*rhodesiensis*); Christ. and Puri 1931, p. 1136; Puri 1931, p. 145.

two submedian oval plates. *spc* poorly developed; *mps* not so broad anteriorly as in *A. culicifacies*, and approaching the chitinisation only near its lateral ends. *Pecten* with 4–5 long and 7–9 short projections, nearly all with basal serrations. *ps* hair with 5–7 long br. Caudal hooks 6–7; some branches of the *isc* also thick and hooked. *Anal papillæ* very short, vestigial.

Egg *.—As described by Patton resembles very much that of *A. sergenti*, but according to Puri this is incorrect, the egg resembling in general characters that of *A. superpictus*. Upper surface broad, approximating to width of egg. Lower surface unornamented. Floats absent. Frill broad, about ¼ width of upper surface, extending all round margin of surface and striated throughout.

Identification.—*A. dthali* has a superficial resemblance to *A. culicifacies*, but it cannot be mistaken for this or any other Indian species if closely examined. It resembles in the general character of its markings *A. rhodesiensis* (with which it has usually been confused), but differs in the following respects, among others:—Head-scales not black over occiput, with pale vertical spot, but all pale and much narrower; palpi inconspicuously banded only; mesonotum shiny and scaleless in *A. dthali*, but not in *A. rhodesiensis*; wing-spots less pronouncedly black and white and legs not so black. For other differences, see Christ. and Puri, Ind. Journ. Med. Res. xviii, p. 1133, 1931. For differentiation from *A. sergenti*, see under that species.

Distribution.—Recorded from Palestine; Sinai; Somaliland †; Sudan †; S. Algeria †; Upper Mesopotamia; Aden Hinterland; Muscat; Baluchistan and N.W. India.

In the Indian area confined to the extreme north-west, and up to the present not recorded outside Baluchistan and the North-West Frontier Province.

Bionomics.—*A. dthali* has been found in tents, barracks, and houses (*Patton*; *Sinton*, 1917, 1922; *Kirkpatrick*), and feeds readily in nature on man (*Patton*; *Kirkpatrick*).

Patton found it breeding in springs and in a well. It was found in the same area by Khazan Chand (*Christophers* and *Khazan Chand*, 1915) in pools in a river-bed. At Muscat

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* Egg: Patton 1905, p. 627; Edw. 1921 *b*, p. 268; Puri (in Christ. and Barraud, *loc. cit.*); Christ. and Barraud 1931, p. 181.

† Specimens in the British Museum collected at Buran, 3,000 feet, Brit. Somaliland (*Major T. H. Twigg*), Khor Gwob, Eastern Sudan (*Dr. R. C. M. Darling*), and Djanet, Southern Algeria (*Dr. Brousses*). From the last-mentioned locality one male was sent in 1928 together with a number of ♀♀ of *A. hispaniola*; it has hitherto been overlooked. —F. W. Edwards.

Gill (1916) found it in pools in the beds of nullahs, especially holes in volcanic rock fed by underground water, in an underground aqueduct and its tank, and in wells. In Sinai (*Kirkpatrick*) it bred, in almost all available water, in stagnant weedy pools with a salinity of 0·38 per cent., in swiftly flowing small drain with salinity of 0·5 per cent., in slow-moving fresh water running over grass, and in weedy pools by the side of fresh-water streams. In India it is recorded in deep pools full of water-plants and algæ in the bed of a river (*Browse*, 1927).

It was found prevalent by Sinton from July to September and up to an altitude of 2,080 feet (Khajuri).

Relation to Disease.—Suspected by Patton to be a carrier in Arabia, also by Kirkpatrick in Sinai, where at Kossaima 100 per cent. of the occupants of a police post contracted malaria, and this was by far the commonest species. Covell, states that there appear to be no records of dissections.

18. **Anopheles sergenti** Theobald, 1907*. (Fig. 31.)

Theo., Mono. Cul. iv, p. 68, 1907 (*Pyretophorus sergentii*). Type-loc.: Algeria. Type: described from 2 ♀♀; type in Brit. Mus.

culicifacies (Africa) of Edwards, 1912, 1913, and of Alcock, 1913, Gough, 1914, and Langeron, 1921.

Adult ♀.—A small anopheline somewhat resembling in appearance *A. culicifacies* (length of wing 2·5–3·6 mm.).

Head: scales of normal type, dark over occiput, with a pale vertical spot; vertex rather narrow; vertical bristles pale, forming a row on either side of about 8, anterior ones flattened; ocular scales broad, numerous, forming overlapping line; some pale lanceolate head-scales passing forwards; frontal tuft not well developed but distinct. *Antenna* without scales on *t*, some narrow pale scales on first and often succeeding *fs*. *Palpi* thinnish, of uniform thickness to base; last segment very short and entirely involved in pale apex, index 0·3; apex pale, with narrow but well-marked pale bands at 2–3 and 3–4; *rbs* with scales.

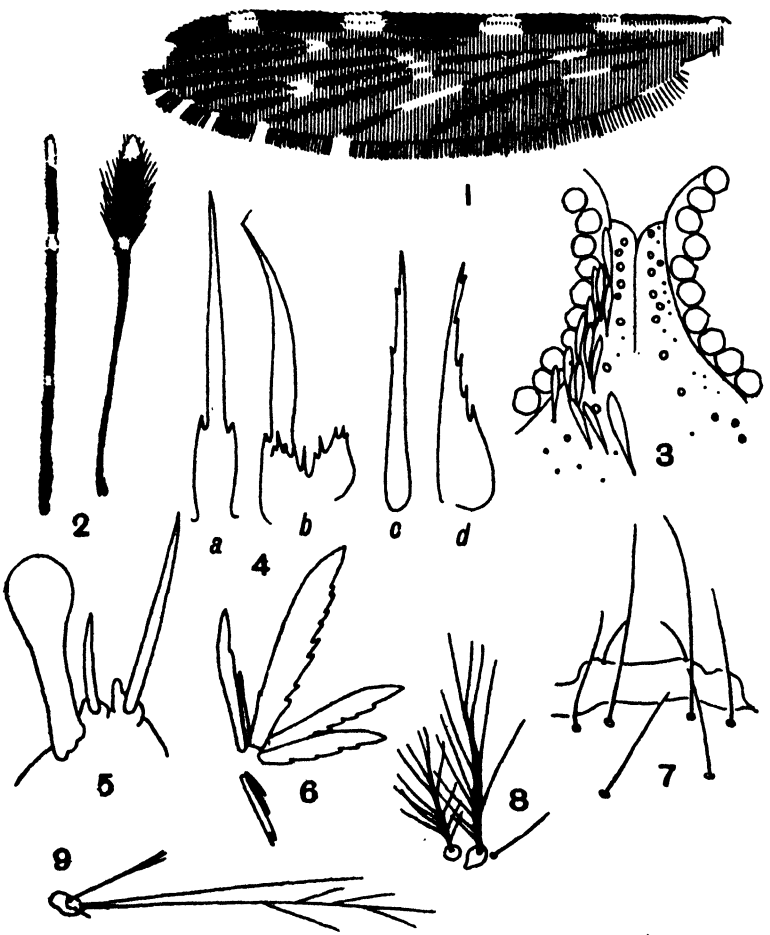
Pharynx: as for the group. Filament of cone thorn-like; crest with posterior portion somewhat divided off by notch. Rods with expanded oval base, apical portion thorn-like, tapering, with two or three spinous projections arising along length posteriorly.

Thorax with chætæ only on *apn*; propleural hairs 1. Mesonotum somewhat darker over fossæ and lateral areas

* Systematic: Christ. 1924 *c*, pp. 47, 93; 1929, p. 523; Edw. 1921 *b*, p. 279; Kirkpatrick 1925, p. 56; Séguy 1924, p. 159. See also Sergent, Ed. and Et., 1906, p. 249; 1909, p. 122; 1910, p. 909; Theo. 1907, p. 68; 1910 *a*, p. 38; Edw. 1912, p. 248; 1913, p. 48. See also references on pp. 195–6 (footnotes).

than in median area, but not markedly so, and varying with the specimen and light-incidence; covered with palish hairs; a conspicuous median tuft on anterior promontory and a few narrow scales extending back from this a variable distance up to about at most ⅓ of the length of the mesonotum; no lateral tufts. Pleuræ devoid of scales; spiracular hairs 2; prealar 3; upper mesepimeral 8.

Fig. 31.



A. sergenti.

1. Wing of ♀, standard scale. 2. ♀ and ♂ palp, same scale. 3. Vertex. 4. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) lateral view of same; (*c*) anterior view of rod; (*d*) lateral view of same. 5. Apex of hypopygium. 6. Leaflets of phallosome of one side, standard scale. 7. Clypeal hairs of larva. 8. Shoulder hairs of right side. 9. Mesothoracic pleural hairs.

Wing as in fig. 31, 1; fringe with well-marked spots at all veins except 6; vein 1 internal to inner dark costal spot, all pale; vein 3 usually dark, but may show an indistinct palish area about middle. Scaling rather narrow; max. str. 7–8.

Legs: front femora not swollen in basal half, uniformly darkish except for pale markings at tips of femora and tibiæ of all legs; tarsi entirely unbanded. Coxæ without scales.

Abdomen without scales; dark, with light hairs. Cerci without scales.

ADULT ♂.—In general as in ♀. *Palpi* with club narrow; uniformly dark except for diffuse pale area at apex and pale band at base of club (apex 3); marginal hairs forming a single row. Coxite with some scales on outer aspect.

Hypopygium *: harpago with stout spine about same length, or a little longer or shorter, than the club, a second stout spine about half its length between this and the club. Phallosome somewhat less than half length of coxite; with about three broadish leaflets and some more rod-like and spicular ones, the main leaflet nearly one-half or one-third longer than the next largest, all the flat leaflets distinctly serrated through most of their length.

PUPA †.—*Paddle*: external border with fine spines on anterior third, which change gradually to hairs in posterior third and extend to paddle-hair; paddle-hair long, hooked; acc. hair branched.

Characters of the spine and chief hairs as in *A. dthali*, except that hair *C* is somewhat shorter on VI and only about as long as the segment on VII; *C* has 2–3 br. on IV, and the spine on III is very reduced and slightly chitinised and blunter.

LARVA ‡.—Very similar to *A. dthali*, but differing markedly in the pleural hairs and to a slight extent in *spc* and pecten §.

Pleural hairs as for the group, but *da*1 (long hair) is sparsely feathered; *dp*1 with 4–5 lateral branches; *vp*2 split into 2–3 br. The chitinized tubercles are well developed; they carry a curved spine on the prothorax, and the flattened projections on the other segments are well developed.

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* HYPOPYGIUM: Kirkp. 1925, p. 57.

† PUPA: Kirkp. 1925, p. 59; Senevet 1930, p. 303.

‡ LARVA: Langeron 1921, p. 367 (*culicifacies*); Buxton 1923, p. 78; Kirkp. 1925, p. 58; Puri 1928, p. 524; 1931, p. 165.

§ Puri, 1931, notes that specimens from the Canary Islands show the inner shoulder hair with a chitinous base and two oval tergal plates as described above, but that in specimens bred from the egg, on the N.W. Frontier, the inner shoulder hair was without a chitinised base and the small oval plates absent. Langeron (Tunis) gives the species as with a chitinous base to the inner shoulder hair.

Spc very poorly developed. The *pecten* with 6–8 long and 4–8 short processes, *i. e.*, more long processes in proportion than in *A. dthali* and *A. culicifacies*.

Egg *.—Upper surface with demarcated areas anteriorly and posteriorly, anterior approximately same length and width as posterior; each about ¼ length of egg. Lower surface unornamented. Floats occupying about middle two-thirds of egg and extending to about an equal distance from either end; touching margin of upper surface; float-ridges 13–15; float-terminations rather large, rounded. Frill narrow, not continued past floats and ending in well-marked tags.

Identification.—See under group characters and under *A. culicifacies*. The outstanding features of the species are: main dark costal spot about equally long on vein 1 as on costa, dark vein 3, well-marked fringe-spots, vein 1 all pale in the basal area, and as a rule some darkening of the lateral areas of the mesonotum. The leaflets of the phallosome should afford assistance in the case of the male (see figures). Larval characters useful in differentiation are the mesothoracic pleural hairs and the low origin of the antennal hair. When *A. dthali* has pale areas at the cross-veins, the head-scales and dark fringe, besides other features, distinguish it from *A. sergenti*.

Distribution.—With a wide distribution in the Mediterranean region. Recorded from Canary Islands; Algeria; Tunis; Egypt; Palestine; Syria; N.W. India.

In the Indian area recorded only from the extreme north-west, the only locality recorded up to date being Jandola, Waziristan (*Puri*).

Bionomics.—*A. sergenti* has been recorded as flying into rooms and common in house (*Annandale*); frequent in houses (*Buxton*); in tents (*Barraud*, 1921); common house-frequenting species, and formed proportion of house-caught *Anopheles* tested for human blood (*Kligler*, 1928); readily enters houses and bites fiercely after dark (*Kirkpatrick*).

A. sergenti has been found in Palestine breeding in small pools and springs among stones at edge of lake (*Annandale*), often under the stones (*Buxton*); rare in marshes and chiefly in small affluents from springs or marshes or pools associated with larger bodies of water (*Buxton*); swamps from overrunning irrigation ditches and streams, slow-moving streams, seepage channels, sluggish parts of wadis, seepage under rocks and pebbles (*Kligler*, 1924). In Egypt it is found breeding in rice-fields or stagnant or slowly moving water in channels feeding rice-fields and sometimes in borrow-pits, usually with aquatic vegetaion (*Kirkpatrick*). In the Canary Islands it was found in pools in ravines, especially small rock-pockets

* Egg: Theodor 1924, pp. 378, 381; Christ. and Barr. 1931, p. 181.

(*Christophers*, 1929). In N.W. India it was found breeding by Puri in irrigation channels and small pools in river-bed.

A. sergenti appears to be a strong flier, as it readily traverses distances under 2 kilometres, and was found in numbers 2½ kilometres from nearest breeding place (*Kligler*, 1924). Both sexes are positively phototropic (*Kirkpatrick*).

In Palestine and Egypt it is most prevalent in Sept.–Oct. (*Buxton*; *Kligler*; *Kirkpatrick*). Large numbers of adults were found by the last-mentioned author in underground aqueducts, and he thinks they may lie up in such situations in spring and summer and issue in autumn to breed in the rice-fields.

RELATION TO DISEASE.—The seasonal prevalence of *A. sergenti* in Palestine closely coincides with that of M.T. malaria (*Buxton*), but the only dissections recorded by Covell are those of Kligler, in which 294 were all negative, 400 with 1 positive and 195 with 1 positive respectively. It has been infected experimentally by Kligler, 1930, with M.T.

19. **Anopheles culicifacies** Giles, 1901 *. (Fig. 32.)

Giles, Entom. Month. Mag. (2) xii, p. 197, 1901 (*A. culicifacies*). TYPE-LOC.: Hoshangabad, Central Provinces, and the Berars, Deccan, India. TYPE: ♂ and ♀ described; type ♀ in Brit. Mus.; type ♂ a specimen of *A. turkhudi*.

SYNONYMS:

listonii Giles, 1901, Entom. Month. Mag. (2) xii, p. 197 (*A. listonii*). TYPE-LOC.: Ellichpur, Berars, India (*Lieut. W. G. Liston*). TYPE: ♂ and ♀ described, both *A. culicifacies*; ♂ and ♀ types in Brit. Mus. SYN. by Theo., Mono Cul. iii, p. 41.

indica Theo., 1901, Mono. Cul. i, p. 183 (*A. indica*). TYPE-LOC.: Madras. TYPE: described from a single ♀; type in Brit. Mus. SYN. by Theo., Proc. Roy. Soc. lxix, p. 377, 1902.

punjabensis James, 1911, in James and Liston, Anop. Mosq. India, p. 72 (*M. culicifacies* var. *punjabensis*). TYPE-LOC.: Punjab, India. TYPE: type ♀ in Brit. Mus. SYN. (pigment anomaly) by Christ., Ind. Jour. Med. Res. iii, p. 463, 1916.

RECOGNIZED VARIETY:

adenensis Christ., 1924, Ind. Jour. Med. Res. xii, p. 296, 1924 (*A. culicifacies* var. *adenensis*). TYPE-LOC.: Daral Amir, Aden Hinterland. TYPE: numerous specimens in Mal. Survey of India collection and in Brit. Mus. Not recorded from Indian area.

The ♂ type of *A. culicifacies* Giles is a specimen of *A. turkhudi* (*vide* Theo., 1903, p. 41) as also Theobald's description of the ♂ taken from Giles's type (Theo., 1901, p. 310). Giles, however, gives no distinctive description of the ♂, so that Brunetti's contention (Brun., 1912, p. 404) that the name *culicifacies* should have been retained for the male may be regarded as invalid.

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* SYSTEMATIC: Liston 1901, p. 365; James and Liston 1904, p. 106; 1911, p. 69, Edw. 1912, p. 248; 1921 *b*, p. 279; Christ. 1916, p. 463; 1924 *c*, pp. 20, 81. See also (*culicifacies* and *indicus*) James 1902, p. 33; Giles 1901 *a*, p. 197; Theo. 1901, p. 183 (*indicus*), 309; 1902, p. 377 (*indicus*), 379; 1903, p. 39; 1910 *a*, p. 25; 1910 *b*, p. 2. See also references on pp. 200, 201 (footnotes).

A. sergenti Theo. was given by Edwards, 1912, p. 248, as synonymous with *A. culicifacies*, and has on this account been referred to by some writers as this species.

The varietal form (var. *adenensis*), from Aden Hinterland only, differs from the type-form in the very wide costal pale areas, and is only provisionally considered as distinct.

ADULT ♀.—Size small to medium (length of wing 2·5–3·5 mm.); attitude during life somewhat *Culex*-like.

Head: scales of normal type, with a not very white vertical pale spot; vertex rather narrow; vertical chætæ pale or darkish, not flattened, forming row of about five hairs on either side, making very imperfect frontal tuft; ocular scales narrow, scanty. *Antennæ*: *t* devoid of scales, a few minute scales only on first *fs*. *Palpi* with terminal segment very short, index 0·37; a narrowish pale apical band (involving, however, the whole of the short terminal segment) and narrow bands at 2–3, 3–4; dark area between apical and subapical pale bands many times length of apical pale area.

Pharynx: filament of cones rather narrow at base, long, tapering towards end, with some spicular branches towards termination and slightly fimbriated ends; a well-developed lateral tooth on either side, with three or four post-filament spines continued into line of spines along crest; the crest rather short. Rods tapering rapidly from expanded base, where there may be a few spicules, terminal portion simple, rod-like.

Thorax with chætæ only on *apn*, propleural hairs 1. Mesonotum rather pale, unicolorous; median area with dark chætæ and small, light-coloured, somewhat thickened, curved hairs; fossæ bare, with chætæ only; *ap* sometimes with a few pale scales in middle line, usually bare of scales or nearly so. Pleuræ devoid of scales; spiracular hairs 0–2 (minute); prealar about 4; upper mesepimeral about 13.

Wings as in fig. 32, 1; base of costa with an interruption just external to humeral *cv*, and usually a further interruption at inner end of inner dark costal spot, vein 1 opposite the first such interruption with a dark spot. Vein 3 all dark, but sometimes with a pale area about its middle. Fringe usually with rather inconspicuous spots at 4.2 and 5.1 only, sometimes lacking. Scaling of wing narrow, but the plume-scales rather long and noticeable; max. str. 7–8.

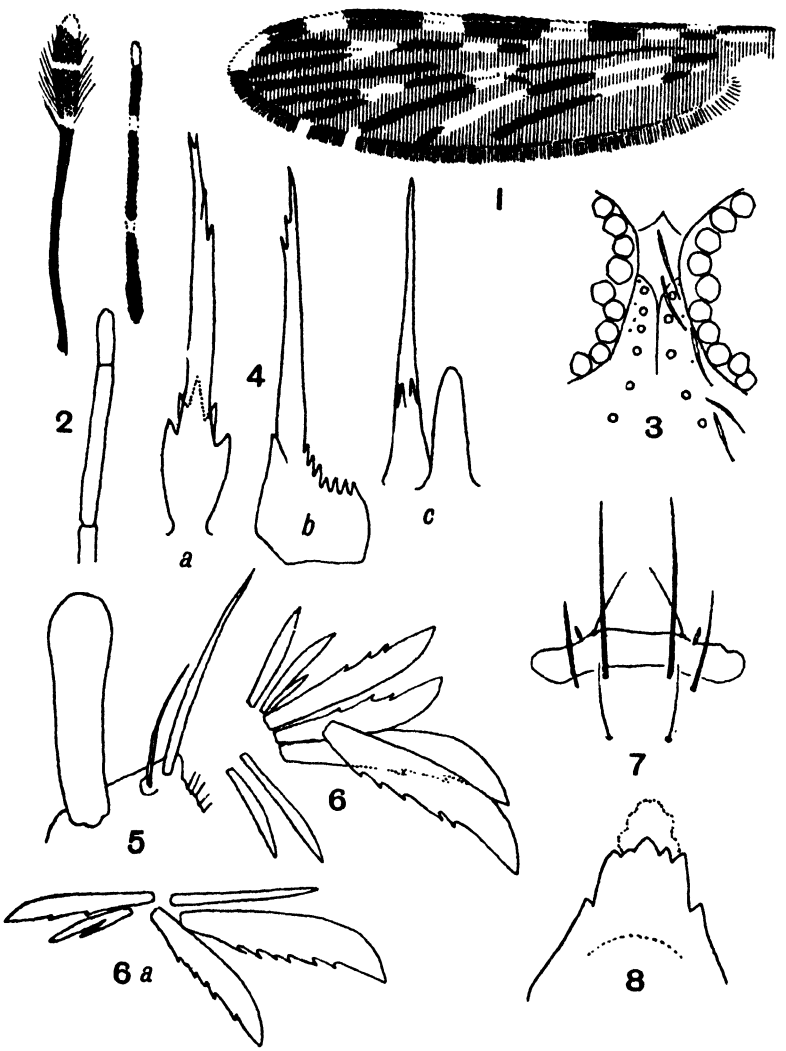
Legs: front femora not swollen in basal half. Femora unicolorous, with little or no paling beneath or at base or apex; tibiæ similarly dark, but somewhat pale at apices; tarsi usually entirely unbanded. Coxæ pale, devoid of scales.

Abdomen entirely devoid of scales even on cerci.

ADULT ♂.—Markings in general as in ♀. Antennæ with some dark scales on first *fs*. *Palpi* ornamented, as in fig. 32, 2;

a well-marked pale area at basal articulation of club ; marginal hairs forming a row of about two deep along margins of segments 4 and 5. Abdomen entirely without scales even on coxites.

Fig. 32.



A. culicifacies.

1. ♀ wing, standard scale. 2. ♂ and ♀ palp, the two upper figures same scale ; lower figure showing short apical segment. 3. Vertex. 4. Pharyngeal teeth : (*a*) anterior view of cone ; (*b*) lateral view of same ; (*c*) a rod and posterior view of crest. 5. Apex of harpago. 6. Leaflets of phallosome of one side, standard scale. 6 *a*. Ditto, var. *adenensis*. 7. Clypeal hairs of larva. 8. Mentum.

Hypopygium *: harpago with apical spine about same length as club, and a smaller spine between this and club. Phallosome somewhat less than half length of coxite, with six or more leaflets on each side, at least four of these being large, well developed and serrated, the largest leaflet between ⅓ and half length of phallosome, the next largest almost as long.

Pupa †.—*Paddle*: external border smooth basally, spines only becoming prominent in posterior third, these long, fine-pointed, gradually changing to hairs which do not quite continue to the paddle-hair. Paddle-hair long, hooked; acc. hair simple or bifid at end.

General arrangement of spines and chief hairs as in *A. dthali*, but spine on IV still about half length of segment, that on III minute, non-chitinised. Hair *C* on V–VII only somewhat longer than the segments, with 4–5 branches on IV. *C'* (seg. VI) simple.

Larva ‡.—*Clypeal hairs*: simple, rather stout; *oc* ⅔ to ¾ length *ic*; *pc* a little shorter than *oc*. *Antenna* dark near distal end; hair arising about ⅓ length of antenna from base; terminal hair split about its middle into 3–5 br. *Mentum* usually with three teeth on either side of the median tooth, the first of the series very short, the next larger and projecting as far forward as the second, the third placed further back, sometimes with another small tooth behind it.

Shoulder hairs: inner and middle stout and feathered, both arising from chitinous bases. *Metathoracic hair no.* 1 forming fairly well-developed palmate hair. *Pleural hairs* as given under group; *dp*1 split into 2–3 br.; *vp*2 bifid in some specimens.

Palmate hairs well developed on I–VII, that on I not so well developed as the others; leaflets more or less uniformly pigmented except near distal end, which is somewhat darker; the filament broad at its base, long and pointed, somewhat over two-thirds length of blade; serrations rather shallow. *Lateral hair* on IV–VI long and split near base into 2–3 br.; that on VII very short, with 2–3 br. *Tergal plates* with the anterior plates fairly large, and two submedian oval plates present. *spc* well marked; the *mps* fairly broad anteriorly, its anterior border nearly touching *spc*. *Pecten* with 3–4 long

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* Hypopygium: Christ. 1915, p. 392.

† Pupa: Senevet 1931, p. 66.

‡ Larva: Puri 1931, p. 141. See also James 1902, p. 34; Steph. and Christ. 1902 *b*, p. 8; Theo. 1903, p. 42; James and Liston 1904, p. 102; 1911, p. 71; Edw. 1922, p. 91; Iyengar 1922, p. 631; Strickl and Chowd. 1927, p. 40; Puri 1928, p. 522.

and 10–13 short processes, all with fine serrations on their basal half. *ps* hair rather short, with 6–9 br. arising near base. Caudal hooks 5–6, fairly well formed.

Egg *.—Whale-back-shaped. Upper surface about $\frac{1}{3}$ width of egg, elongate oval or slightly hourglass-shaped. Ventral surface unornamented. Floats not touching margin of upper surface, occupying a little less than the middle $\frac{2}{3}$ of the egg-length, and extending to about an equal distance from the two ends of the egg. Float-ridges about 15–18, moderately smooth and regular, and not crested as in *A. fluviatilis* ; float-terminations rather large, rounded, somewhat flattened. Frill moderately broad, extending all round margin of upper surface, and striated throughout.

Identification.—The following are differential characters from *A. sergenti* and *A. fluviatilis* :—

Fringe with numerous spots ; vein 1 pale in basal area. Front of thorax with scales.	
Middle costal spot scarcely shorter on vein 1 than on costa ; sides of mesonotum not markedly darker than median area ; vein 3 dark ; phallosome with more than three leaflets on each side	*sergenti.*
Middle spot distinctly shorter on vein 1 than on costa ; sides of mesonotum markedly darker than median area ; vein 3 usually extensively pale ; phallosome with three leaflets and sometimes an additional small spicule on each side	*fluviatilis.*
Fringe with at most two spots ; vein 1 with a dark spot opposite the pale interruption on costa outside humeral cross-vein. Mesonotum unicolorous, rather light-coloured ; vein 3 dark, sometimes with a pale spot ; leaflets more than three on each side. Front of thorax with few or no scales	*culicifacies.*

In *A. sergenti* the head-scales are darker over the occiput, the frontal tuft somewhat more developed, and the penultimate segment of the palps may be longer, with, in some instances, a rather broad second pale band. In *A. fluviatilis* the frontal tuft is much more conspicuous and the markings of the wing usually more vivid.

From *A. turkhudi* the male can be distinguished by the absence of the extensive white areas on the shaft of the palpi and other characters.

Distribution.—Recorded outside the Indian area only from Siam ; Tonkin † ; South Arabia (Muscat, Aden).

In the Indian area recorded from innumerable localities from Burma to Baluchistan and including Ceylon. It has not been recorded from Kashmir proper (altitude throughout

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* Steph. and Christ. 1902 *b*, p. 8 ; Christ. and Barraud 1931, p. 182.

† Private communication from Dr. Toumanoff.

over 5,000 feet), but occurs up to moderate altitudes on the Himalayan foothills. The western limit given by Indian records is from Seistan (Kharan), the Zhob and Quetta-Peshin Districts of Baluchistan and Waziristan, Bannu, Kohat, Peshawar and Hazara Districts of the N.W. Frontier Province. The eastern limit of records extends to the extreme N.E. of Assam (Sibsaugar and Lakhimpur Districts) and the eastern frontier of Upper Burma through the districts of Myitkyina, Bhamo, and the Northern and Southern Shan States; in Lower Burma it is only recorded from Papun (Salween Dist.). It has not been recorded from the Andamans.

BIONOMICS.—Found abundantly in houses, cow-sheds, out-houses etc. Often difficult to estimate numbers from its habit of secreting itself in holes, among dung-cakes, in chaff etc. (*Adie*; *James* and *Liston*; *Fry*, 1912; *Richmond* and *Mendis*). Feeds readily on man in nature and experimentally; observed feeding actively on cattle at dusk (*Feegrade*, Katha); found to feed readily in laboratory on pigeons and sparrows (*James* and *Liston*).

Breeds in a large variety of situations, but usually in clean fresh water; found especially in irrigation channels, in leaks, pools in canal beds etc.; in slow-moving streams and nullahs and pools in sandy river-beds; in freshly formed collections of rainwater of various kinds, in shallow tanks, borrow-pits especially with grassy edges, in fallow rice-fields (*James*, 1903; *James* and *Liston*; *Hodgson*; *Graham*; *Senior White*, 1930; *Sinton*, 1931; *Covell* and *Baily*). Also frequently recorded from wells (*Bentley*; *Gill*, 1916). Recorded from brackish water (*Chalam*, 1924).

Ordinarily a plains species and occurring at moderate altitudes, but recorded at 5,500–6,500 feet (Quetta, *Davys*); a single specimen found at 7,500 feet (Murree, *Gill*, 1923). Most prevalent in northern India in May to November, and winters as larva (*James*, 1903; *Christophers*, 1911; *Graham*; *Hodgson*; *Sinton*, 1917; *McCombie*; *Young* and *Majid*; *Richmond* and *Mendis*).

RELATION TO DISEASE.—The most important malaria-carrying species in India, except perhaps in the eastern areas. Transmits all forms of the parasite experimentally, and has frequently been found infected in nature with both gut and gland infections, the percentage commonly 5 per cent. or more.

20. **Anopheles fluviatilis** James, 1902*. (Fig. 33.)

James, Sci. Mem. Govt. India, n. s. no. ii, p. 31, 1902 (*A. fluviatilis*). TYPE-LOC.: described from specimens from the Duars (Jalpaiguri Dist.), Nagpur, and the Jeypore Hill Tracts. TYPE: unknown.

listonii Liston, 1901, Ind. Med. Gaz. xxxvi, p. 361 (*A. listonii*). TYPE-LOC.: Ellichpur, Central Provinces, India. TYPE: two ♀♀ labelled "Deccan, Capt. Liston" in Brit. Mus. SYN. by Edwards, Gen. Insect. 1932.

leptomeres Theo., 1903, Mono. Cul. iii, p. 38 (*Myzomyia leptomeres*). TYPE-LOC.: India (Lahore). TYPE: described from a single ♀; type in Brit. Mus. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 49, 1924.

Edwards, 1932, has recently elected for the name *fluviatilis*, which is the correct name for the species, *vide* Christ., 1924 *c*, pp. 46, 49 †. Theobald, Mono. Cul. iv, p. 51, 1907, wrongly sank both *A. fluviatilis* James and *A. listonii* Liston under his *A. christophersi*, which species was, however, later shown by Edwards, Bull. Ent. Res. iv, p. 222, 1913, to be distinct, and the correct name for which was later, Bull. Ent. Res. vi, p. 156 (footnote), 1915, given by him as *A. minimus* Theo.

Recently Strickland, Ind. Jour. Med. Res. xii, p. 145, 1924, followed by some other authors, has considered *A. listonii* (*fluviatilis*) and *A. christophersi* (*minimus*) as synonymous with the African species *A. funestus*, but incorrectly, as shown by Christ. and Puri, 1931, p. 486; in addition to differential characters there given, it may be noted that the leaflets of the phallosome are quite different, as described later ‡.

A. listonii of Kinoshita, 1906, p. 635, and some other Japanese authors, of Secrete, 1917, p. 418, of Carter, 1925, p. 71, and possibly of Barnes, 1923, p. 121, is *A. minimus*; *A. listonii* of Cogill, 1903, p. 327, is probably *A. varuna*, vide Edw., Bull. Ent. Res. xiii, p. 90, 1922, and Iyengar, Ind. Jour. Med. Res. xii, p. 27, 1924.

ADULT ♀.—Size small to medium (length of wing 2·4–3·6 mm.); attitude markedly anopheline-like.

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* SYSTEMATIC: Liston 1901, p. 361; James and Liston 1904, p. 103; 1911, p. 73; Edw. 1913, p. 222; 1915, p. 156; 1922, p. 90; 1931; Christ. and K. C. 1915, pp. 186, 190 (*leptomeres*); Christ. 1916, pp. 466, 467 (*leptom.*); 1924, pp. 46, 49 (*leptom.*), 95. See also (*fluviatilis* or *listonii*) James, 1902, p. 311; Theo. 1901, p. 311; 1903, pp. 27, 38 (*leptom.*); 1907, p. 51; 1910, p. 24; Stanton 1914, p. 517; Iyengar 1924, p. 24; Strickland 1924, p. 145; Shingarew 1926, pp. 47, 48; Martini 1930, p. 175. See also references on pp. 206–7 (footnotes).

† *A. listoni* Giles by description and type is clearly *A. culicifacies*. *A. listoni* Giles as described by Liston was, however, actually the new species which Giles presumably intended to describe, and which has hitherto been known as *A. listonii* Liston; the latter name is, of course, preoccupied by *A. listoni* Giles, and the next name in precedence is *A. fluviatilis* James.

‡ The South African *A. funestus* var. *leesoni* Evans (1931) is very close indeed to *A. fluviatilis*, and from the data available appears probably specifically distinct from *funestus*. If eventually shown to be conspecific with *fluviatilis*, it will provide another instance of an anopheline species common to India and Africa (cf. *A. dthali*).

Head: scales of normal type, with an extensive white vertical area; vertical chætæ white, anterior ones flattened, forming a row ending in a cluster of three or four hairs; ocular scales forming several rows; frontal tuft well developed. *Antennæ*: *t* devoid of scales; first, and sometimes second, *fs* with a few narrow inconspicuous scales. *Palpi* rather thin, straight, cylindrical; index 0·47; scales present on *rbs*; ornamented as in fig. 33, 2, apical segment all white, with extreme tip of preceeding segment and narrow pale bands at 2–3 and 3–4; black band between apical and subapical pale band usually four to five times length of subapical pale band and at least half length of dark area between subapical and more basal pale band. *Labium* dark, without flavescence of any kind.

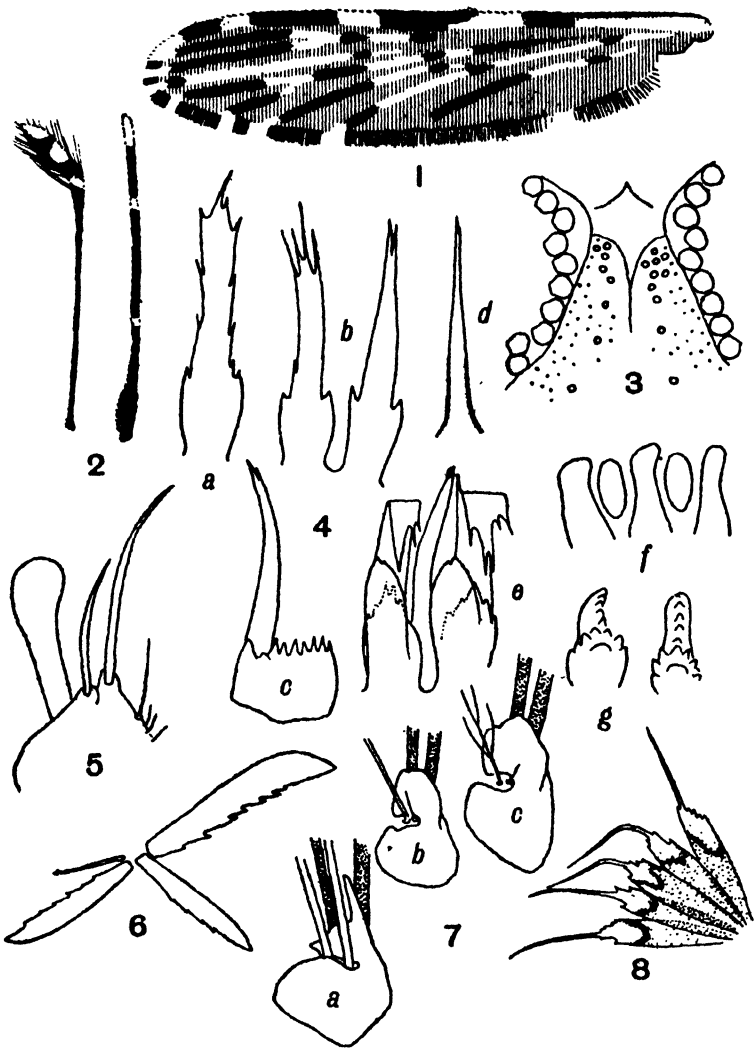
Pharynx as for group. Filaments strap-like, with fimbriated ends and some lateral spicules; lateral teeth moderately developed and spines behind base of filament and thence along crest; crest stout, conical or somewhat club-shaped in optical section. Rods about length of cones or a little shorter; conically tapering, with slightly bulbous swelling in basal half; terminal portion simple, thorn-like, without spicules.

Thorax with chætæ only on *apn*; propleural hairs 2. Mesonotum with median area pale, fossæ and lateral areas dark brown; median area covered with pale hairs or hair-like scales, sometimes a little broader along the line internal to the fossæ and lateral bare areas, the scaling somewhat broader sometimes in large specimens, especially from the north-west area, but never clear white as in *A. jeyporiensis*; a median-scale tuft on *ap* and sometimes some dark scales on lateral angles. Pleuræ dark, often with horizontal pale lines in the usual situations; spiracular hairs 0–2 minute.

Wing as in fig. 33, 1; *af* very long, twice or more length of petiole; costa towards base uninterruptedly dark and continuous with dark area of inner spot; vein 3 usually extensively pale but not unfrequently dark or largely dark; no fringe-spot at vein 6. Two forms of wing-ornamentation appear to occur; in one the branches of veins 2 and 4 and 5.1 external to the cross-vein are continuously dark (form *a*), in the other there is a pale spot on 5.1 and commonly on 4.1 (form *b*); it cannot be said that these are definite varieties. Scaling of wing rather narrow; max. str. 8–9.

Legs: front femora not swollen in basal half. Femora uniformly dark, little or no paler beneath, very narrowly pale at base and without pale band apically; tibiæ similarly dark; tarsus on all legs uniformly dark, sometimes with

Fig. 33.



A. fluviatilis.

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp, same scale. 3. Vertex. 4. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) two other cones, showing variation; (*c*) lateral view of cone; (*d*) anterior view of rod; (*e*) two cones and a rod, the partly dotted teeth are the post-filament spines, the unbroken line above them posterior views of crest; (*f*) crests and bases of rods, viewed from above; (*g*) cones, showing crest and post-filament teeth. 5. Apex of harpago. 6. Leaflets of one side of phallosome, standard scale. 7. Basal tubercles of pleural hairs of left side: (*a*) prothorax; (*b*) mesothorax; (*c*) metathorax. 8. Leaflets of palmate hair. (7 and 8 after Puri.)

a faint indication of narrow banding at the joints. Coxæ commonly pale, devoid of scales.

Abdomen dark, with darkish hairs, entirely devoid of scales even on cerci.

ADULT ♂.—Markings in general as in ♀. *Antennæ* with a few small dark scales on first *fs*. *Palpi* ornamented as in fig. 33, 2; marginal hairs stoutish, dark, forming about a double row. *Abdomen* entirely devoid of scales except on coxites, which have dark scales on outer surface.

Hypopygium *: harpago with large stout apical spine somewhat longer than the club and a spine about $\frac{2}{3}$ its length between this and club. Phallosome between half and $\frac{1}{3}$ length of coxite, with three leaflets and sometimes a small additional spicule on each side, the longest about $\frac{1}{3}$ length of phallosome, the other two about $\frac{2}{3}$ its length or smaller; all markedly serrated. Ninth tergite with angular projections.

PUPA †.—*Paddle*: external border with spines fine and sharp, prominent only in posterior third, giving place gradually to hairs which extend to paddle-hair; paddle-hair long, hooked; acc. hair removed about its own length, branched.

Arrangement of spines and chief hairs very similar to that in *A. culicifacies*; spine IV–VII approximately half length segment, that on III minute, non-chitinised. Spine VIII short; acc. hair trifid at end. Hair *C* on V–VII longer than segment, on IV with rather numerous branches (or 3 as figured by Senevet). *C'* (seg. VI) simple or bifid.

LARVA ‡.—*Clypeal hairs* simple; *ic* and *oc* stout, the latter half to $\frac{2}{3}$ length of former; *pc* slender, about half length *ic*. *Antenna* dark or dark distally; hair arising $\frac{1}{3}$ length of antenna from base; terminal hair with 4–6 br. *Mentum* with four teeth on each side of median tooth, first tooth small and blunt, next two equal, fourth smaller and placed further back.

Shoulder hairs: inner and middle arising from basal tubercles, which may or may not be fused; inner less than half length of middle, stout, with numerous branches; outer arising in some cases from basal tubercle of middle hair. *Metathoracic hair no.* 1 forming very well-developed palmate hair. *Pleural hairs* as given under group; *dpl* with 3–4 br. Basal tubercles large, the projection on 1 forming a sharp spine, on 2 and 3 broadly rounded.

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* HYPOPYGIUM: Christ. 1915, p. 392 (*funestus*).

† PUPA: Senevet 1930, p. 309.

‡ LARVA: James 1902, p. 32; James and Liston 1904, p. 105; 1911, p. 74; Iyengar 1922, p. 632 (tail-hooks); Strickl. 1924, p. 145; Strickl. and Chowd. 1927, p. 39; Puri 1928, p. 522; 1931, p. 153.

Palmate hairs well developed on I–VII, that on I somewhat smaller than the others. Leaflets with distal end almost invariably very light in colour, with deeply pigmented area just proximal to this; filament about half length of blade, very fine and drawn out, its distal end difficult to see and appearing shorter than in *A. minimus*; serrations at shoulder very variable. Lateral hair on IV long and split near base into 3 br.; on V and VI ditto with 3–4 br.; on VII very short and slender, with 3–5 br. *Tergal plates* with the anterior plate extremely large, sometimes nearly as wide as the width of the larva, and including the median posterior plate, whilst the two submedian oval plates are free. Hair 0, arising a little behind posterior border of tergal plate, better developed than in most species and somewhat more so than in *A. minimus*; it is simple or bifid on II, and may be split about its middle into 2–5 br. on other segments. *spc* poorly developed; *mps* narrow in anterior portion, with finger-like projections extending towards spiracles. *Pecten* with 5–8 long and 8 short projections, all finely serrated on basal half, length of the long spines very variable. *ps* hair with 6–9 long branches arising near base. Caudal hooks 5–6. *Anal papillæ* a little shorter than anal segment.

Egg *.—Whale-back type. Upper surface about $\frac{1}{4}$ total width of egg; elongate-oval or most usually divided into two shorter ovals, the surfaces in either case entirely surrounded by frill. Lower surface unornamented. Floats not touching margin of upper surface, occupying a considerable portion of the egg-length, but with at least $\frac{1}{8}$ of the egg-length left at either end; float-ridges very well marked, somewhat crowded together, with double contoured crests; float-terminations moderately large and not markedly elongate. Frill narrow; reduced almost to a line in its middle portion when upper surface is not broken into two.

Identification.—See under main synoptic table, under the group, and notes under *A. culicifacies*. Distinction from *A. minimus*, and especially from *A. varuna*, may be difficult if the palpal ornamentation is ambiguous. The leaflets are very similar in *fluviatilis* and *minimus*, though distinct from *A. varuna* and *A. funestus*. Differences in the larva between *fluviatilis* and *minimus* are small (see under respective descriptions). Specimens with typically marked palpi, which form the great majority, should offer no difficulty. *A. jeyporiensis* should be borne in mind; in that species, if the tarsal banding is not perhaps so distinct as usual, the mesothoracic scaling is quite distinctive, and the interrupted base of the costa will usually arouse suspicion.

* Egg: Christ. 1911 *b*, p. 66; Christ. and Barraud 1931, p. 182.

DISTRIBUTION.—Recorded outside the Indian area only from SIAM; TONKIN *; TURKESTAN.

Has a wide and general distribution throughout India, especially in foothill areas and hilly or rocky tracts. In Burma, especially in Lower Burma, it is less frequent and is only recorded from the Akyab District in the latter area. It is very abundant in the north-west, and is recorded from various districts throughout Baluchistan and the N.W. Frontier Province, including Swat Territory, and also Kashmir. It appears to occur in Ceylon, and there is a specimen from this area in the collection at Kasauli, but possibly some of the records relate to *A. minimus*.

For a list of verified localities see Christ. and Puri, 1931.

BIONOMICS.—Occurs commonly in houses and cowsheds (*Graham*; *Christ.*, 1911: *Richmond* and *Mendis*) and may exhibit a preference for the former (*Perry*). It feeds readily on man in nature and experimentally and readily on pigeons and sparrows in the laboratory (*James* and *Liston*).

It breeds especially in pools in stream-beds and slow-flowing water with vegetation, springs and irrigation leaks etc., also at edges of swamps, at lake margins, and in drains, ponds and tanks (*Graham*; *Sinton*, 1917; *Christ.*, 1911). Records for wells, chiefly from South India, possibly relate to *A. varuna*. Some older references to breeding in flowing streams in the eastern areas probably relate to *A. minimus*.

It has a prevalence in North India similar to that of *A. culicifacies* (*Sinton*, 1917); at Peshawar it occurred from May to November, but neither larvæ nor adults were found from July to October (*Richmond* and *Mendis*). It is recorded at 6,000 feet in Kashmir (*Gill*, 1920), and two specimens were taken by this author (1923) at Murree (7,500 feet). James and Liston state that it is a strong flier and has been found in houses more than half a mile from breeding places.

RELATION TO DISEASE.—Though *A. fluviatilis* is regarded, together with *A. minimus*, to which the earlier observations of natural infections relate, as an important malaria carrier, there are no experimental successful feedings recorded. Nevertheless Perry found 4 per cent. gland infections in the Jeypore Hill Tracts in what was, as far as is known, this species, and there is no reason to doubt that, with other members of the *minimus* group, it is, where it occurs, an important carrier species.

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* Private communication from Dr. Toumanoff, who has kindly sent specimens of this species.

21. **Anopheles minimus** Theo., 1901 *. (Fig. 34.)

Theo., Mono. Cul. i, p. 186, 1901 (*A. minimus*). TYPE-LOC.: Pokfulam, Hong Kong. TYPE: described from a single female noted by Theobald as in Dr. Rees's collection.

christophersi Theo., 1902, Proc. Roy. Soc. lxix, p. 378 (*A. christophersi*). TYPE-LOC.: Bengal Duars, India. TYPE: described from 2 ♀♀; type ♀ in Brit. Mus. SYN. by Edwards, Bull. Ent. Res. vi, p. 156 (footnote), 1915.

formosaensis I Tsuzuky, 1902, Arch. f. Schiffs. vi, p. 287 (*A. formosaensis I*). TYPE-LOC.: Formosa. TYPE: ♂ and ♀ specimen in balsam in Brit. Mus. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 49, 1924.

cohœsa Dönitz, 1903, Zeit. f. Hyg. xliii, p. 233 (*A. aconitus* var. *cohœsa*). Change of name by Dönitz, *loc. cit.*, for Tsuzuky's species *A. formosaensis I*. SYN. by admission of describer.

alboapicalis Theo., 1910, Mono. Cul. v, p. 25 (*M. christophersi* var. *alboapicalis*). TYPE-LOC.: Meenglas, Bengal Duars. TYPE: described from ♀; type in Brit. Mus. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 50, 1924.

flavirostris Ludlow †, 1914, Bull. no. 4, Surg.-Gen. Off., Washington, and also Psyche, xxi, p. 30 (*Myzomyia flavirostris*). TYPE-LOC.: Camp Wilhelm, Tayabas, Luzon, P.I. TYPE: 4 ♀ types in U.S. Nat. Mus. (*vide* Dyar and Shannon, Insec. Insc. Mens. xiii, p. 87, 1925). This is the species previously referred to by Ludlow as *A. funestus*, vide Ludlow, Bull. Ent. Res. vi, p. 155, 1915. SYN. by Christ., *loc. cit.*

merak (*cohœsa*) Mangkoewinoto, 1919, Meded. v. d. Burg. Geneesk. Ned. Indie, 1919, D, ii, p. 57 (*M. aconita* var. *merak* (*cohœsa*)). TYPE-LOC.: Merak, West Java. TYPE: unknown. SYN. by Christ., *loc. cit.*

There had been a great deal of confusion regarding the nomenclature of this species until Edwards, Bull. Ent. Res. vi, p. 156, 1915, established the synonymy of *A. christophersi* Theo. as *A. minimus*, following up his previous distinction of this form from *A. listonii*, Bull. Ent. Res. iv, p. 222, 1913. For this reason records of, and references to, these species and to *A. aconitus* prior to about 1916 cannot be trusted as necessarily referring to the species named. Even up to quite recently the identification of these related forms has been very uncertain, *vide* Christ. and Puri, 1931.

The Philippine forms *mangyanus* Banks and *febrifera* Banks have

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* SYSTEMATIC: Edw. 1913, p. 222; 1915, p. 156; Ludlow, 1915, p. 155; Christ. 1916, p. 473; 1924 *c*, pp. 49, 95; Koidzumi, 1924, p. 98; 1930, p. 233; Rodenw. 1921, p. 153; Swell. 1919, p. 5; 1921, p. 66; Swell. and Swell. 1920, p. 88; Iyengar 1924, p. 24; Strickland 1924, p. 150; 1925, p. 11; Yamada 1925, p. 447; Borel 1929, p. 42; Manalang 1930, p. 247; Christ. and Puri 1931, p. 488; King 1932. Only the more recent references are given; for a more detailed list Yamada should be consulted. See also references on p. 211 (footnotes).

† According to King (1932 *b*) the Philippine form (var. *flavirostris*) differs in some respects from typical *A. minimus* as occurring at Hong Kong. The characters given by King as distinguishing the var. *flavirostris* are also found in the Indian *minimus*, but further research is needed before it can be established whether the Indian is strictly identical with the Philippine form, and what is the exact relation of both to the Hong Kong type.

been regarded as synonymous with *A. minimus*, but very recently have been treated by King (1932) as a distinct species (see under "Identification").

A. minimus is the *A. listoni* of Kinoshita and of Stephens and Christ., and probably of many early references to *A. listonii*. It is also the *A. funestus* of Ludlow, 1905, of Barber and Walker, 1914, and more recently in part of Strickland, Carter, Manalang and some other authors. A very full description, with synonymy, is given by Yamada, 1925, p. 447.

ADULT.—Closely resembles *A. fluviatilis* and other members of the series, the chief characteristics by which it is distinguished being given in the section on identification.

The female palpi have two broad white bands apically, the subapical one usually as broad, or nearly as broad, as the apical, and the dark area between the bands usually about the same extent as either of the pale bands, rarely exceeding twice the extent of the subapical pale band, and usually $\frac{1}{3}$ or less of the extent of the dark area between the subapical and the more basal band. The proboscis may be dark or may show a small flavescent area in the distal half on the ventral aspect, which, when present, is very characteristic of the species. The wing rarely shows a fringe-spot at vein 6 and the base of the costa is very constantly with a small pale interruption at the inner side of the inner costal spot. This may be only a scale or two, or perhaps only on one wing, but it is generally to be seen in some form if carefully looked for, thus differing from *A. fluviatilis* and *A. varuna*, where such an interruption, however small, is rare. The other wing-characters are too variable to be used in identification; the outer half of vein 6 is usually continuously dark; base of vein 3 usually has one or two dark spots. The same variation is seen in the wings as in *A. fluviatilis*, but the lighter form, *i. e.*, with pale spots on veins 5.1 and 4.1, is the commoner. Pale spots are present in the course of 2.1 and 2.2 sometimes. The ornamentation of the ♂ palp is shown in figure.

Pharynx: resembling *A. fluviatilis*, but filaments narrower and more thorn-like, without fimbriated ends or lateral spicules, lateral teeth more conspicuous, and posterior view of crest appears even more rounded and club-like.

Hypopygium: appears to be indistinguishable, or almost so, from *A. fluviatilis*. Harpago as in *A. fluviatilis*. Leaflets of phallosome three on each side, sometimes with an additional small spicule, one leaflet larger and two about half to $\frac{2}{3}$ length of larger leaflet, as in *A. fluviatilis*; the two smaller leaflets are possibly usually less broad than in *A. fluviatilis*.

PUPA.—In characters of paddle and general arrangement of spines and chief hairs very similar to *A. fluviatilis*.

LARVA *.—Closely resembles *A. fluviatilis*, differing only in certain minor detalls. Filaments of palmate leaflets less tenuous and appear longer than in *A. fluviatilis*; average length of blade of leaflet from a mid-abdominal segment is 0·58 mm., av. breadth 0·38. Tergal plates about as large as in *A. fluviatilis*, but not quite so broad. Hair 0 has same position and relationship to tergal plate as in *A. fluviatilis*, but not quite so developed. In exceptional cases it may arise touching the tergal plate, but never rises directly from it.

EGG †.—Believed to resemble that of *A. fluviatilis*, but with a somewhat narrower upper surface; the characters require confirmation.

IDENTIFICATION.—The following is a provisional synopsis of the species resembling *A. fluviatilis* and *A. minimus*, with their chief differentiating characters :—

1. Female palpi of *fluviatilis* type : one broad apical band and a narrow subapical band. Wing without fringe-spot at vein 6; proboscis all dark. Larva with clypeal hairs not branched or frayed.

a. Leaflets of phallosome three on each side, with sometimes a small additional spicule; inner sutural hair of larva branched; oval plates not included in the anterior tergal plate; hair 0 not arising from plate.

Costa broadly interrupted at base ..... *arabica* ‡.

Costa without an interruption at base; larval head-pattern without transverse bar. Egg of whale-back type, ends of floats not closely approaching ends of egg, float-ridges narrow .... [var. *leesoni* ‡. *fluviatilis*; *funestus*

b. Leaflets of phallosome more numerous, at least four well-developed serrated leaflets and several largish spicules; inner sutural hair simple; oval plates included in anterior tergal plate; hair 0 arising from the plate, long and thin. Egg not of whale-back type, floats touching margin of upper surface. Head-pattern of larva with transverse bar ..... [African type). *funestus* ‡ (West

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* LARVA : Stephens and Christ. 1902 *a*, p. 13; 1902 *b*, p. 9; Swell. and Swell. 1919 *a*, p. 30; Iyengar 1922, p. 632 (tail-hooks); Strickland 1924, p. 150; Koidzumi 1925, pp. 336, 375; Strickl. and Chowd. 1927 *b*, p. 39; Puri 1928, p. 522; 1931, p. 148.

† EGG : Stephens and Christ. 1902 *a*, p. 13; 1902 *b*, p. 9; Christ. and Barraud 1931, p. 183.

‡ Not occurring in Indian area.

2. Female palpi of *minimus* type: two broad apical bands, with a short intervening dark area. Inner sutural hair branched; head-pattern of larva without transverse bar; oval tergal plates not included in anterior plate.

a. Wing usually without a fringe-spot at vein 6; clypeal hairs of larva not branched or frayed.

Costa with one pale interruption at base, or at least a pale scale or so on one wing; proboscis, if flavescent, with a patch ventrally towards apex; leaflets of phallosome as in *A. fluviatilis*; hair 0 not arising from the plate ..... *minimus* *.

Costa with *two* basal interruptions always present; proboscis always dark; hair 0 arising from the plate..... *mangyanus* †.

Costa without any basal interruption or trace of same; proboscis, if flavescent, uniformly so in apical half, often very faint; leaflets of phallosome more numerous, four or more on each side, as in *A. funestus*; hair 0 arising from plate, short and stout ..... *varuna*.

b. Wing usually with a fringe-spot at vein 6; clypeal hairs of larva branched or frayed. With or without interruption on costa at base.

Proboscis with apical half markedly flavescent; leaflets of phallosome very similar to *A. minimus*, but may be more numerous. Egg of whale-back type, ends of floats almost reaching ends of egg, float-ridges broad and square ..... *aconitus*.

Proboscis dark; leaflets of phallosome in specimen dissected five on each side ..... *filipinæ* †.

DISTRIBUTION.—*A. minimus* has a wide distribution in the Oriental Region, being recorded from CELEBES (with Sangir Islands); PHILIPPINES; FORMOSA (with Lyu-kyu Islands); CHINA; LESSER SUNDA ISLANDS (Alor); JAVA; SUMATRA (with Poeloeh Weh, Nias Islands); COCHIN CHINA; ANNAM; TONKIN; MALAY PENINSULA; SIAM; BURMA, CEYLON, and INDIA.

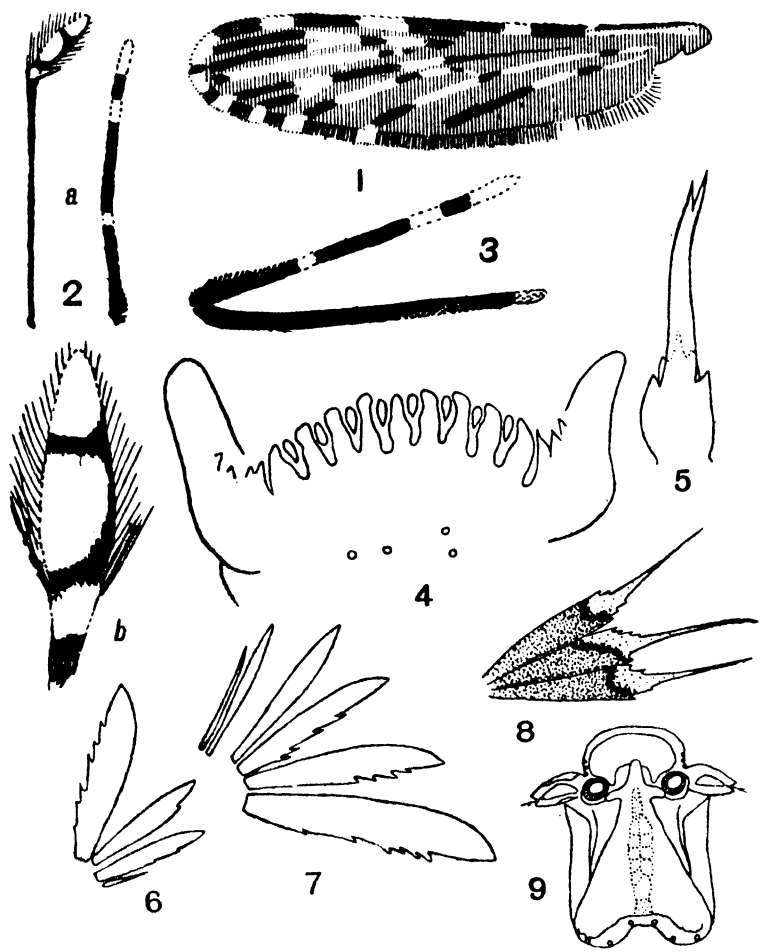
It is very widely prevalent in Burma and eastern India, notably Assam, and is recorded from all the eastern and southern areas of the Peninsula with the exception of the eastern United Provinces, Central Provinces and northern Bombay. Verified examples, however, have only been seen

* Including var. *flavirostris*. † Not occurring in Indian area.

by Christ. and Puri, 1931, from the more eastern areas, including western United Provinces and northern Madras.

BIONOMICS.—Very similar in its adult habits to *A. fluviatilis*, being commonly found abundantly in houses and cattle-sheds (*Shortt*; *Christ.*, 1925; *Watson*, 1924; *Ramsay*).

Fig. 34.



A. minimus; also *A. funestus* (7) and *A. aconitus* (9).

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp: (*a*) same scale; (*b*) tip of ♂ palp more highly magnified. 3. ♀ palp and proboscis. 4. Pharyngeal armature: clubbed appearance of crests in a particular view. 5. Single cone, anterior view. 6. Leaflets of phallosome of one side, standard scale. 7. Ditto, *A. funestus*, same scale. 8. Leaflets of palmate hair. 9. Spiracular apparatus, *A. aconitus* (after Puri); that of *A. minimus* is very similar.

In the Philippines found to be especially a house-loving species (*Barber* et al., 1915 (*febrifera*)).

A. minimus breeds especially in slow-running streams with grassy edges, at the edges of swamps, in irrigation channels, borrow-pits, paddy-fields and seepages from springs (*Strickl.* and *Chowd.*, 1928, Assam; *Christ.*, 1925; *Yamada*; *Feegrade*, Hsipaw, Lashio). Ramsay notes that it breeds during the monsoon in clean grassy streams and drains, especially where there is a certain amount of shade, and in seepage from springs, but in the cold weather in permanent rivers and streams, grassy tanks and swamps. It is not found in dense virgin jungle, but breeds freely in streams covered with secondary jungle (*Ramsay*).

A. minimus occurs chiefly at low or moderate altitudes, but is abundant at 2,000 feet at Nongpoh, and is recorded as present in small numbers at 5,000 feet at Shillong (*Shortt*).

RELATION TO DISEASE.—*A. minimus* has been infected experimentally with M.T. parasites in Formosa (as *listonii*) and in the Philippines (*febrifera*). It has been found infected in nature with sporozoites in the glands by Steph. and Christ. in Bengal (*christophersi*) and by Lalor in Burma (*alboapicalis*).

22. **Anopheles varuna** Iyengar, 1924 *. (Fig. 35.)

Iyengar, Ind. Jour. Med. Res. xii, p. 24, 1924 (*A. varuna*). TYPE-LOC.: vicinity of Calcutta. TYPE: in coll. Bengal Malaria Research Lab. Calcutta; cotypes in Indian Mus. Calcutta (Iyengar, 1924).

This has generally been treated as a variety of *A. minimus*, but it appears to be a distinct species. *A. fluviatilis* of Cogill, 1903, is considered by Edwards to be this species (*vide* Edw., 1922, p. 90, and Iyengar, 1924, p. 27). Some references to *A. listonii*, especially in respect to breeding in wells, probably relate to *A. varuna*, as possibly do many records of *A. minimus* in South India.

ADULT.—Very closely resembles *A. minimus* except that (*a*) the basal area of the costa is invariably without an interruption or any trace of such; (*b*) the female proboscis usually shows faint, or sometimes marked, flavescence over the outer half of the organ, above as well as below. The wing is usually relatively dark, *i. e.*, resembling the (*a*) type of *A. fluviatilis*. The tarsi are always very free from any trace of banding.

Pharynx: very similar to *A. aconitus*; as in *A. minimus*, but posterior portions of crests appear more pointed viewed from behind.

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* SYSTEMATIC: Cogill 1903, p. 327; Edw. 1922, p. 90; Iyengar 1924, pp. 24, 27; Christ. 1924 *b*, p. 298; 1924 *c*, pp. 51, 95; Christ. and Puri 1931; p. 481. See also under "Larva."

Hypopygium: similar to *A. fluviatilis*, but leaflets of phallosome more numerous, four or more on each side.

LARVA *.—According to Puri the full-grown larva is shorter and darker than that of *A. minimus*, and the head in the majority of specimens is more or less uniformly dark brown, with no conspicuous spots to be made out, though I am informed by this author that in specimens taken otherwise than in wells the spots are more distinct and resemble those of *A. minimus*.

The larva closely resembles that of *A. minimus*, but (*a*) the palmate hair on the metathorax is larger and the leaflets are long and drawn out, with pointed ends, instead of appearing more or less truncated; (*b*) the palmate hairs on the abdomen are also larger, the average length from a mid-abdominal segment being 0·083 mm. as against 0·071 mm. in *A. minimus*; (*c*) the tergal plates are comparatively broader and more rectangular, the lateral ends being comparatively very broad: on II the rounded median plate always lies within the anterior tergal plate; (*d*) hair 0 rises from the tergal plate itself much nearer the middle than the posterior border of the plate, except on VIII, where it lies close to the posterior edge; it is shorter than in *A. minimus* and simple except on IV–VII, on which it may be bifid.

PUPA and EGG.—Undescribed.

DISTRIBUTION.—Not recorded outside the Indian area. In India recorded from various localities in the east and south. Christ. and Puri, 1931, give localities, in the following general areas, from which they have verified specimens:—Bengal, Bihar and Orissa, United Provinces, North and South Madras, Coorg, Mysore, Bombay Pres., Gujarat. It is also recorded from Upper Burma. Specimens in the British Museum from Ceylon determined by Senior White as *listonii* are this species.

BIONOMICS.—Adults have been found in houses and cattle-sheds (*Sur* and *Sur*).

A. varuna breeds, according to Iyengar (*loc. cit.*), in stagnant fresh water in ponds and ditches, and during and soon after the monsoon in collections of storm-water by the roadside around Calcutta. It was found by Puri (1931) in small pools in slow-running streams and in wells at Yellapur, N. Kanara, in February. The outstanding feature is its evident predilection for breeding in wells.

RELATION TO DISEASE.—It has been found infected in nature wtih sporozoites (1 in 25 dissected) by Iyengar (*Covell*).

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* LARVA: Puri 1928, p. 522; 1931, p. 155; Christ. and Puri 1931, p. 489.

23. **Anopheles aconitus** Dönitz, 1902 *. (Fig. 35.)

Dönitz, Zeit. f. Hyg. xli, p. 70, 1902 (*A. aconitus*). TYPE-LOC.: Kajoe-Tanam, Sumatra; Willem I., Soekaboemi, Java. TYPE: unknown.

albirostris Theo., 1903, Mono. Cul. iii, p. 24 (*Myzomyia albirostris*). TYPE-LOC.: Kuala Lumpur, F.M.S. TYPE: described from two specimens; ♂ and ♀ type in Brit. Mus. SYN. by Edw. Bull. Ent. Res. vi, p. 156 (footnote), 1915; also Stanton, *ibid.* p. 162.

brahmacharii Christ., 1912, Paludism, no. 5, p. 11 (*A. brahmacharii*). Described by Brahmachari, Ind. Med. Gaz. xlvi, p. 268, 1911. TYPE-LOC.: Calcutta. TYPE: specimens from Dr. Brahmachari in collection at Kasauli. SYN. by Christ., Sci. Mem. no. 56, p. 7, 1912 (as *A. albirostris*).

? *vincenti* Laveran, 1901, C. R. Soc. Biol. liii, p. 993 (*A. vincenti*). TYPE-LOC.: Van-Linh (Haut Tonkin). TYPE: unknown.

This species was known among writers in the F.M.S. for many years as *A. albirostris*, until Stanton, 1915, gave *albirostris* as synonymous with *aconitus* Dön. In India it was first noted as distinct under the name *brahmacharii*, until recognized to be synonymous with *albirostris* and later with *aconitus*, as noted above. It is the *A. christophersi* of Mathis and Leger, 1910 and 1911, as shown by their figure.

Laveran's description of *A. vincenti* ("Trompe brun clair a son extrémité . . . . Pattes non annelees de blanc aux tarses, non renflées aux femur aux tibias de la 1ère paire . . . Longueur 5 mm. trompe comprise") appears to indicate *A. aconitus*, and if the type still exists and the above surmise is shown to be correct this name will take precedence.

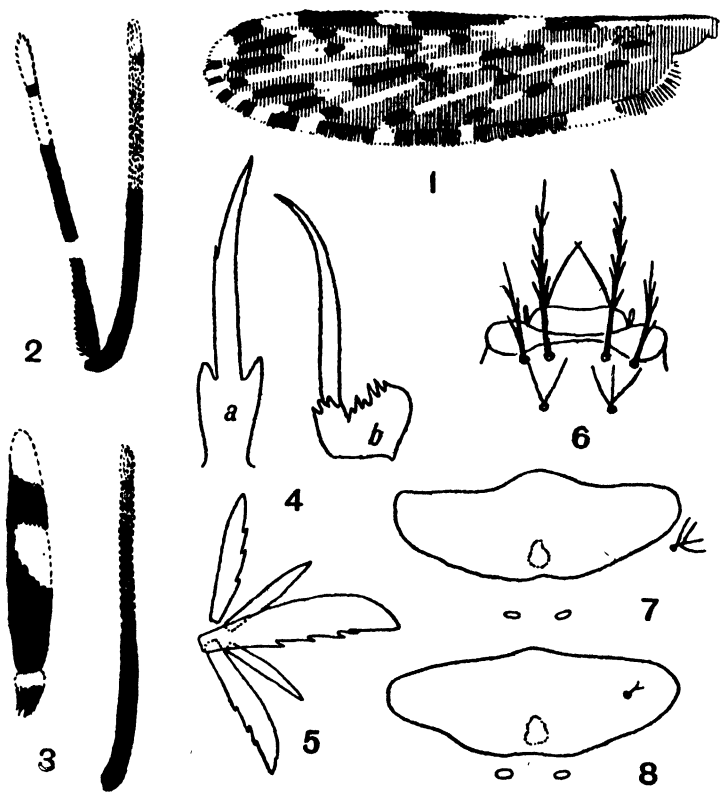
ADULT.—Closely resembles *A. minimus*. The female palpi show two broad apical bands as in *minimus*, but commonly the intervening dark band is more encroached upon and not infrequently the dark band is entirely absent, the whole apical portion of the palps being continuously pale. The proboscis is light yellow (flavescent) in its apical third to half, above as well as below.

The wings are as in *minimus*, but usually with greater development of the pale areas. The most differential point is the presence of a pale fringe-spot at vein 6, which is fairly constant; other wing-markings are too variable to be of much assistance in identification. There may or may not

* SYSTEMATIC: (*aconitus* and *albirostris*) Theo. 1903, pp. 24, 30; 1910 *a*, pp. 20, 28; Leic. 1908, p. 23; Mathis and Leger 1910, 1911; James and Stanton 1912, p. 60; Strickl. 1913, p. 10; Stanton 1914 *b*, p. 517; 1915 *b*, p. 252; 1926, p. 27; Edw. 1915, p. 156; Christ. 1916, p. 475; 1924 *c*, pp. 51, 95; Swell. 1916, p. 63; Schuff. and Swell. 1917, p. 19; Mangk. 1918, p. 475; 1919, p. 55; Swell. 1919, p. 3 1920 (?), pp. 4, 5, 25; Swell. and Swell. 1920 *b*, p. 88; Rodenw. 1921, p. 152; Swell. 1921, p. 61; Iyengar 1924, p. 23; Strickl. 1924, p. 150; Carter 1925, p. 72; Borel 1929, p. 30; Manalang 1930, p. 247; Barraud and Christ. 1931, p. 274. (*brahmacharii*) Brahmachari 1911, p. 268; Christ. 1912 *a*, p. 43; 1912 *b*, p. 11; 1912 *c*, p. 6. (*vincenti*) Blanchard 1905, p. 175 (quotes Laveran's description). See also references on p. 218 (footnotes).

be an interruption in the basal area of the costa. Vein 3 lacks the small dark spots at its base only in about one specimen in three; vein 6 usually shows three dark spots, but the outer half of the vein may be uninterruptedly dark. There are usually pale spots on 2.1, 2.2, 4.1 and 4.2, or the whole basal portion of the fork may be pale, due to blending

Fig. 35.



A. aconitus; also *A. varuna* (3, 5, 8).

1. Wing of ♀, standard scale. 2. ♀ palp and proboscis. 3. Club of ♂ palp and ♀ proboscis, *A. varuna*. 4. Pharyngeal teeth: (*a*) anterior; (*b*) lateral view of cone. 5. Leaflets of phallosome of one side. 6. Clypeal hairs. 7. Tergal plates and hair 0 of larva. 8. The same, *A. varuna*.

of adjacent pale areas. The middle dark costal spot is usually about $\frac{2}{3}$, but often only about half, represented by the dark scaling on vein 1.

The legs not unusually show a certain amount of narrow tarsal banding, but not so marked nor so white as in *A. jeyporiensis*.

The male palpi are ornamented as in *A. minimus*; the proboscis in the male is not flavescent.

Pharynx *: as in *A. minimus*, but lateral teeth larger and filament at base narrow; crest viewed from behind more conical and not so rounded or clubbed.

Hypopygium †: very similar to *A. minimus*, but leaflets of phallosome usually appear to be four or more.

Pupa ‡.—Paddle very similar to *A. fluviatilis*, but paddle-hair long and *straight*, and fine short, delicate, spaced hairs are continued past the paddle-hair to the internal border.

Arrangement of spines and chief hairs very similar to *A. fluviatilis* except that hair *C*, in place of being simple, is commonly simple or bifid on VII, bifid or trifid on VI, and 3–5-branched on V, but retaining its character of a long hair (about as long as the segment) and more resembling the simple hairs usually seen in *Myzomyia* on these segments than hair in *C* its usual branched condition. The figure given by Senevet makes these hairs appear rather shorter and more stiffly branched than in specimens seen by me. The spine on IV appears longer than indicated by Senevet, being about $\frac{1}{4}$ the segment and not markedly shorter than on V.

I am much indebted to Dr. Puri for a number of verified pupal skins of this species, the pupal characters of which are less exceptional than might appear at first.

Larva §.—Closely resembles *A. minimus*, differing mainly in the inner and outer clypeal hairs being frayed.

Inner and outer clypeal hairs shorter than in *A. minimus*, *ic* with short lateral branches, sometimes showing as fine fraying and at others as more spine-like branches; *oc* with 2–10 lateral branches varying much in thickness, usually spine-like and scattered irregularly, those in the middle of the hair about four times as long as the width of the hair; *pc* split near base into 2–5 br. Hair 0 on segments II–VIII simple or bifid, rising just at edge of tergal plate, though occasionally just internal to posterior border. Wing-like expansion near anterior end of *mps* longer than in *A. minimus*.

Egg ‖. –Of whale-back type and highly characteristic.

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* Pharynx: Manalang 1930, p. 43.

† Hypopygium: Christ. 1915, p. 392 (*albirostris*); Swell. 1921, p. 62.

‡ Pupa: Senevet 1931, p. 69.

§ Larva: Stanton 1912 *a*, p. 388; 1912 *b*, p. 4; 1915 *a*, p. 162; 1926, p. 41; Swell. 1918, p. 399; Mangk. 1918, p. 462; 1919, p. 57; Swell. and Swell. 1919 *a*, p. 28; 1920 *b*, p. 85; Carter 1925, p. 86; Senior White 1925, p. 218; Strickl. and Chowd. 1927 *b*, p. 39; Chowdhury 1928, p. 41; Borel 1929, p. 38; Puri 1931, p. 155.

‖ Egg: Stanton, in Lamborn, 1922, pp. 129, 131; Christ. and Barraud, 1931, p. 183.

Upper surface very narrow, slit-like. Lower surface unornamented. Floats not touching margin of upper surface, nearly as long as egg, leaving only about $\frac{1}{12}$ of the egg-length free at each end; float-termination long, narrow; float-ridges very wide antero-posteriorly, almost as wide as width of float seen from above, and giving a characteristic cellular effect, with well-marked double contour crests, but less contorted than in *A. fluviatilis*. Frill very narrow, little more than a line in the greater part of its extent, striated.

IDENTIFICATION.—See under *A. minimus*. *A. aconitus* is, as a rule, readily distinguished from other members of the series by the presence of a fringe-spot at vein 6 and the marked and uniform flavescence of the distal half of the proboscis. The proboscis may be similarly pale in some specimens of *A. varuna*, but a fringe-spot in this species is practically never seen. Further, the frayed clypeal hairs of the larva serve to distinguish *A. aconitus* from all other members of the series except *A. filipinæ*, in which the proboscis is not flavescent.

DISTRIBUTION.—*A. aconitus* has a wide distribution in the Oriental Region, being recorded from CELEBES; PHILIPPINES; BORNEO; LESSER SUNDA ISLANDS (Timor, Wettar, Alor, Flores, Pantar, Soemba, Soembawa); JAVA; SUMATRA (with Riouw Islands); TONKIN; COCHIN CHINA; MALAY PENINSULA; SIAM; BURMA, CEYLON and INDIA. Recorded as in Formosa by Brug, 1926, p. 472, also Faust, 1926, p. 142, but not given by Yamada or Koidzumi. The form in the Philippines appears to be var. *filipinæ* Manalang, here treated as a distinct species.

In India *A. aconitus* has been recorded from various localities in the eastern and southern areas; it is unrecorded in the north-western half of India. Some of the earlier records may refer to *A. minimus* or *A. varuna*. Christ. and Puri, 1931, record localities in the following areas on specimens verified by them:—Burma, Andamans, Assam, Bengal, Bihar and Orissa, Madras (north), Mysore, Hyderabad, Central Provinces, Ceylon.

BIONOMICS.—Commonly taken in houses and cattle-sheds (*Christ.* 1912; *Covell*, 1927, Andamans; *Ramsay*; *Sweet*; see also *Walch*; *Watson*, 1921; *v. Breemen*). In F.M.S. noted as especially common, or most frequently captured, species in houses (*Lamborn*, 1922; *Kingsbury*) Feeds readily on man and animals; 68 per cent. of females caught in nature with blood in the gut (*Lamborn*); caught feeding on buffaloes (*Brug* and *Walch*) and with buffalo and human blood (*Walch* and *Sardjito*).

Breeds in Burma in freshwater pools with grassy edges, pools with much aquatic vegetation and shade, arms of lakes,

pools in creek and river-beds and rice-fields (*Feegrade*, Bhamo, Akjab, Kyankpyu ; common in Calcutta in clean tanks with grassy edges (*Brahmachari*), also in ponds and roadside storm-water drains (*Iyengar*, 1920) ; in Assam found especially in tanks with grassy edges, streams and drains (*Ramsay*) ; in Bengal very characteristic of dead and dying rivers (*Strickl.* and *Chowd.*, 1927). In the F.M.S. breeding places are usually in the open, with a preference for swamps with clear slowly flowing water. In the rice-fields larvæ do not appear until the end of November, when the crop is about half-grown, after which they increase rapidly up to the time of harvest (*Gater* and *Rajahmoney*).

Normally occurs at moderate altitudes ; recorded by Mangkoewinoto in Java at 2,800 feet. In Assam found breeding throughout the year (*Ramsay*).

Relation to Disease.—*A. aconitus* has been experimentally infected with M.T. parasites in Malaya (*albirostris*). It has been found infected in nature in the Dutch East Indies and in Malaya ; also by Feegrade in Burma (1 gut in 58). For further particulars see Covell.

24. **Anopheles jeyporiensis** James, 1902 *. (Fig. 36.)

James, Sci. Mem. Govt. India, n. s., p. 32, 1902 (*A. jeyporiensis*). Type-loc. : Patingi, Jeypore Hill Tracts, Vizagapatam Dist. Theobald also described this species under the same name from the same locality (Mono. Cul. iii, p. 66, 1903, spelt *jeyporensis*). Type : Theobald's description is from 3 ♀♀ and 2 ♂♂ ; ♀ and ♂ type (of Theobald's) in Brit. Mus.

Recognised Variety :
candidiensis Koidzumi, 1924 (see p. 225).

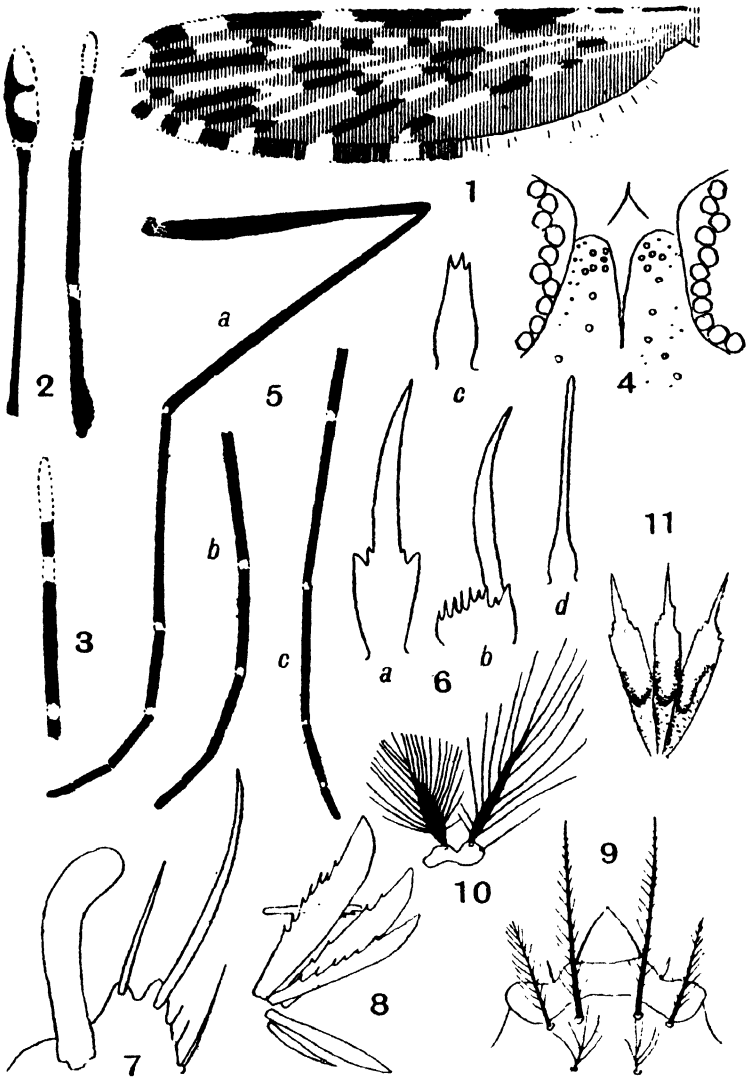
Adult ♀.—Size small to medium (length of wing 2·5–3·5 mm.).

Head : scales of normal type, with a well-marked white vertical spot, chetæ forming short row ending in cluster of 5–6, mostly flattened, forming well-developed frontal tuft. *Antennæ* : *t* devoid of scales, some pale narrow scales on first *fs*. *Palpi* thin, straight, cylindrical, and appearing very long ; index 0·4 ; apical segment all white, with tip of preceeding segment and narrow pale bands at 2–3, 3–4, dark area between apical and subapical pale bands usually 4–5 times length of subapical and about as long or slightly longer than apical pale band. *Labium* all dark.

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* Systematic : James 1902, p. 32 ; Theo. 1903, p. 66 ; James and Liston 1904, p. 101 ; 1911, p. 81 ; Blanchard 1905, p. 621 (name only) ; Theo. 1907, p. 70 ; 1910 *a*, p. 39 ; Christ. 1916, p. 468 ; 1924 *c*, pp. 51, 96. See also references on pp. 223–4 (footnotes).

Fig. 36.



A. jeyporiensis.

1. Wing of ♀, standard scale. **2.** ♂ and ♀ palp, same scale. **3.** ♀ palp, var. *candidiensis*. **4.** Vertex. **5.** Legs: (*a*) fore leg; (*b*) mid-tarsus; (*c*) hind tarsus. **6.** Pharyngeal teeth: (*a*) anterior, (*b*) lateral view of cone; (*c*) posterior view of crest; (*d*) rod. **7.** Apex of harpago. **8.** Leaflets of phallosome of one side, standard-scale. **9.** Clypeal hairs of larva. **10.** Shoulder hairs of right side. **11.** Leaflets of palmate hair. (**9–11** after Puri.)

Pharynx: in general as for group. Filament of cones narrow, thorn-like, tapering, without fimbriæ or lateral spicules; lateral teeth well developed and spines passing in from these behind root of filament to become continuous with crest-teeth; posterior view of crest conical. Rods simple, conically tapering at base, without branches or spicules.

Thorax: with chætæ only on *apn*; propleural hairs 1–2. Mesonotum with median area covered with narrow whitish scales (str. about 6), more numerous anteriorly, forming tuft in median area, lateral areas of *ap* with usually a few dark flattish scales; fossæ and lateral areas dark brown, contrasting with the lighter median area, without scales laterally anterior to root of wings, or, if scales present, these are few and narrow, not forming a definite line of overlapping scales. Pleuræ devoid of scales; spiracular hairs 1; prealar about 3; upper mesepimeral about 5–7.

Wing as in figure; *af* rather long, approaching twice length of petiole; cell-index 2. Base of costa usually with pale interruptions forming two long dark basal accessory spots, of which the inner usually extends to root of wing; vein 1 in this part of its extent entirely pale. Median dark costal spot with a distinct accessory sector or dark area on vein 1 distinctly shortened, an interruption towards outer end unusual. Preapical dark costal spot frequently with a pale interruption on vein 1, nearly always towards inner end of spot. Usually a pale interruption on 2.1, often on 2.2, 4.1, and 4.2. In some cases 2.1 and 2.2 are extensively pale on inner portions, with obliteration of spots. Vein 3 most frequently as shown in figure, dark area in some cases shorter, as in *A. fluviatilis*, or rarely the whole vein may be dark. Vein 6 most usually shows three dark areas, but the outer half may be continuously dark. A fringe-spot at vein 6 is usual; when no fringe-spot is present the border-scales are often pale. Border-scales towards base of wing pale almost to vein 6. Scaling of wing rather narrow. Max. str. about 9.

Legs with femora slightly swollen in basal half. Femora uniformly dark and little or no paler beneath or at junction with coxæ, and scarcely any paling at tips; tibiæ similarly dark but tipped with pale; tarsus of fore and mid-legs with segments 1 and 2, and sometimes 3, with narrow pale white apical bands, hind legs with segments 1–4 similarly banded. Coxæ dark, devoid of scales except for a few dark scales anteriorly on coxæ 1 and a few pale scales on coxæ 3.

Abdomen entirely devoid of scales even on cerci.

ADULT ♂.—Markings in general as in ♀. Palpi as in fig. 36, 2; marginal hairs forming row one to two deep on either margin

of club ; hairs stoutish, dark ; shaft of club all dark. Abdomen entirely devoid of scales except that pale scales are present on outer aspects of coxites.

Hypopygium * : harpago indistinguishable from that of *A. fluviatilis*, with a longish hair between club and apical hair. Leaflets about 5–6 on each side, of the usual type in the series, serrated on straight edge (see fig. 36, 8).

PUPA †.—*Paddle* with spines on external border extending to posterior angle and continued as hairs to inner border ; paddle-hair long and undulating, acc. spine simple.

Arrangement of spines and chief hairs as for group ; spine on IV but little shorter than that on V, that on III minute. Hair *C* simple on segs. V–VII, about as long as segments ; *C'* (seg. VI) simple. Spine on VIII short ; acc. hair simple.

LARVA ‡.—*Clypeal hairs* : *ic* stout and conspicuously frayed for their whole length ; *oc* a little more than half length *ic*, stout and pinnate ; *pc* about half length of *oc*, bifid or branched. *Antenna* strongly chitinised, with moderately long spinous projections ; hair arising $\frac{1}{4}$ to $\frac{1}{6}$ length of antenna from base ; ventral edge of truncated end of antenna produced into pointed process about as long as the finger ; terminal hair split about middle into 3–5 br. *Mentum* with three teeth on either side of median tooth, about equidistant, the first tooth the smallest.

Shoulder hairs : inner and middle with basal tubercles which are fused ; both hairs stout and pinnate. *Metathoracic hair no.* 1 forming fairly well-developed palmate hair. *Pleural hairs* as for group ; *dp*1 split into 3–5 br. ; *dp*2 sometimes distally bifid. The chitinous tubercles are as in *A. minimus*.

Palmate hairs well developed on I–VII. Leaflets rather broad, somewhat colourless and transparent in distal third, with pigment just proximal to this ; filament somewhat over half length of blade ; fairly broad at the base, the indentations shallow and spread along leaflet. Lateral hairs on IV–VI long and slender, splitting near base into 3–5 br. *Tergal plates* : anterior comparatively large, covering about $\frac{1}{3}$ length of segment ; plate on VIII nearly covering dorsum ; their posterior border on anterior segments concave, with the median plate lying a little behind and separate ; oval plates absent. *spc* very poorly developed ; *mps* narrow anteriorly, the wing-like expansions short, not touching spiracles. *Pecten* with 4–6 long and 8–9 short processes

* HYPOPYGIUM : Christ. 1915, p. 392.

† PUPA : Senevet 1931, p. 55.

‡ LARVA : James 1902, p. 32 ; Theo. 1903, pp. 41, 68 ; James and Liston 1904, p. 103 ; 1911, p. 82 ; Strickl. and Chowd. 1927 *b*, p. 47 ; Chowdhury 1928, p. 40 ; Puri 1928 *a*, p. 515 ; 1928 *b*, p. 522 ; 1931, p. 157.

ps hair with 6–8 long br. near base. Caudal hooks 5–6; *isc* slender, some slightly hooked. Anal papillæ about as long as anal segment.

Egg *.—Not of whale-back type. Upper surface broad, as broad as width of egg, slightly narrowed in middle portion, anterior demarcated area somewhat broader than posterior. Lower surface unornamented. Floats touching margin of upper surface, occupying about middle half of egg or slightly more; float-ridges 13–17; float-terminations large, round; frill moderately broad, striated, ending in distinct tags at junction with floats.

Identification.—This usually offers no difficulty in unrubbed specimens, as the mesothoracic scaling and narrowly but distinctly white-banded tarsi are very characteristic. From *A. moghulensis* it is distinguished by the absence of the line of scales at the sides of the thorax anterior to the wing-roots and by other characters (see further remarks under *A. moghulensis*).

The species is rather variable, especially in the wing-markings. The proportion of dark and pale on the female palpi is also rather variable, making it difficult, especially in specimens from the west coast (Bombay), to be sure whether these should be called type-form or variety.

Distribution.—The type-form has not with certainty been recorded out of India (see under var. *candidiensis*). In India many records relate no doubt to *A. moghulensis* or to the var. *candidiensis*. In general the distribution of the type-form is over the east and south of the Peninsula, extending on the west as far north as Bombay. The type-form has been verified by me from various localities in Orissa, Central Provinces East, Madras N., Madras S., Coorg, Mysore, Bombay Pres. (North Kanara, Colaba). Records of the species from Ceylon appear doubtful.

Bionomics.—Commonly taken in houses and cattle-sheds (*Steph.* and *Christ.*; *Perry*; *Ramsay*; *Sweet*). In some places it may form 40 per cent. of captures (*Goverdhan*). Sweet's catches totalled in Mysore 10,746 from cattle-sheds and 1,228 from houses. It feeds freely on man, and has been observed by the writer attacking fiercely in the open towards evening.

A. jeyporiensis breeds especially in streams and flowing water connected with rice cultivation (*James* and *Liston*), in grassy streams (*Ramsay*), in grass-grown edges of lakes and in swampy land (*Feegrade*; *McCombie Young* and *Baily*); it is recorded as very common in the Central Provinces in small sandy nullahs (*Kenrick*, 1914), where, as the water dries up, the

* Egg: Christ. and Barraud 1931, p. 183.

larvæ may bury themselves in the wet sand and emerge after rain (this probably, however, refers to *A. moghulensis*).

The species occurs at low and also at considerable altitudes; it is common in the Jeypore Hills at 2–3,000 feet and on the Nilgiri plateau (6,000 feet).

RELATION TO DISEASE.—Though suspected by Stephens and Christophers, and Perry, to be concerned with malaria transmission, large numbers of dissections have failed to show natural infection in this species. There are no experimental observations.

24 *a*. **Anopheles jeyporiensis** var. **candidiensis** Koidzumi, 1924*.

Koidzumi, Trans. 5th Cong. F.E.A.T.M. p. 98, 1924 (*A. candidiensis*). TYPE-LOC.: Lake Candidus, Formosa. TYPE: probably in Koidzumi's collection at the Hygienic Dept. Govt. Res. Inst., Formosa (*Yamada*, 1925, p. 490).

SYNONYM:

tonkinensis Toumanoff, 1931, C. R. Soc. Biol. cvii, p. 375 (*A. aconitus* var. *tonkinensis*). TYPE-LOC.: Tonkin.

ADULT.—As in the type, but pale apex of ♀ palpi more extensive, and second band often broader; dark intervening area much shorter, half length or less of apical pale area. Interruption in preapical dark spot on vein 1 more frequent than in type-form, and, when present, often situated towards middle of spot instead of near inner end. Fore and mid-tarsi more frequently show banding on seg. 3 than in the type-form. Mesothoracic scaling as in the type-form, without the line of scales seen in *moghulensis*.

LARVA.—This shows a difference from the type, as pointed out to me by Dr. Puri, in the branching of the inner clypeal hairs, the branches being fewer in number and stouter.

The above description is from a number of specimens of adult and larva (var. *tonkinensis*) very kindly sent to me by Dr. Toumanoff. On examination of Indian material it was found that all specimens from eastern India, as distinct from the Peninsular area, showed the palpal markings as described for the variety, specimens from the type-locality (Jeypore Hill Tracts) and South India showing the long dark area and narrow second band on the palpi. Dr. Edwards informs me that the former is the condition seen in specimens of *A. jeyporiensis* from Hong Kong, and as it is extremely probable that this is the form representing the species in the Burmo-Chinese subdivision, it may be taken provisionally as synonymous with *candidiensis*, under which form, as a

* (*candidiensis*) Koidzumi 1924, pp. 94, 98; 1925, pp. 343, 375 (larva); 1926, p. 28; 1927, p. 215; 1930, p. 233; Yamada 1925, p. 490 (*tonkinensis*) Toumanoff 1931 *a*, p. 375; 1930 *b*, p. 961 (larva).

variety of *jeyporiensis*, I have now placed it. Though specimens from Bombay sometimes show a very similarly marked palp, there is otherwise a very clear demarcation of the type-form and the variety in the Indian area.

DISTRIBUTION.—Recorded from FORMOSA; CHINA (Hong Kong); TONKIN; BURMA and INDIA.

In the Indian area has been verified by me from specimens in the Malaria Survey collection from BURMA, Mandalay Dist.; ASSAM, Khasia and Jaintia Hills, Cachar; BENGAL, Jalpaiguri Dist.; UNITED PROVINCES, Naini Tal Dist.

BIONOMICS AND RELATION TO DISEASE.—Var. *tonkinensis* is recorded by Toumanoff, *loc. cit.*, as breeding in running water in grassy drains. This author has found 6 per cent. with natural infection of the mid-gut.

25. **Anopheles majidi** McCombie Young & Majid, 1928*. (Fig. 37.)

McCombie Young and Majid, Ind. Med. Res. xvi, p. 469, 1928 (*A. karwari* var. *majidi*). TYPE-LOC.: Coorg. TYPE: a number of the describers' original specimens in the collection of the Mal. Surv. at Kasauli. Given as distinct species by Puri, Ind. Journ. Med. Res. xvi, p. 525 (footnote), 1928.

ADULT ♀.—Size small to medium (length of wing 3·0 3·7 mm.).

Head: scales normal, with a marked white vertical area; vertical chætæ white, forming a short line ending in a clump of 4–6 flattened chætæ which form a well-marked bifurcate frontal tuft; ocular scales and fusiform scales in median area numerous. *Antennæ*: torus bare, first flagellar segment with narrow white scales. *Palpi* of moderate thickness, cylindrical; apical segment rather short, index 0·37; with two broad white apical bands and a narrow, more basal band at 2–3; the broad apical bands including, respectively, apical segment and apex of 4 and base and apex of 4 and 3, dark intervening space somewhat shorter than either apical band. *Labium* dark.

Pharynx: of group *Myzomyia* type.

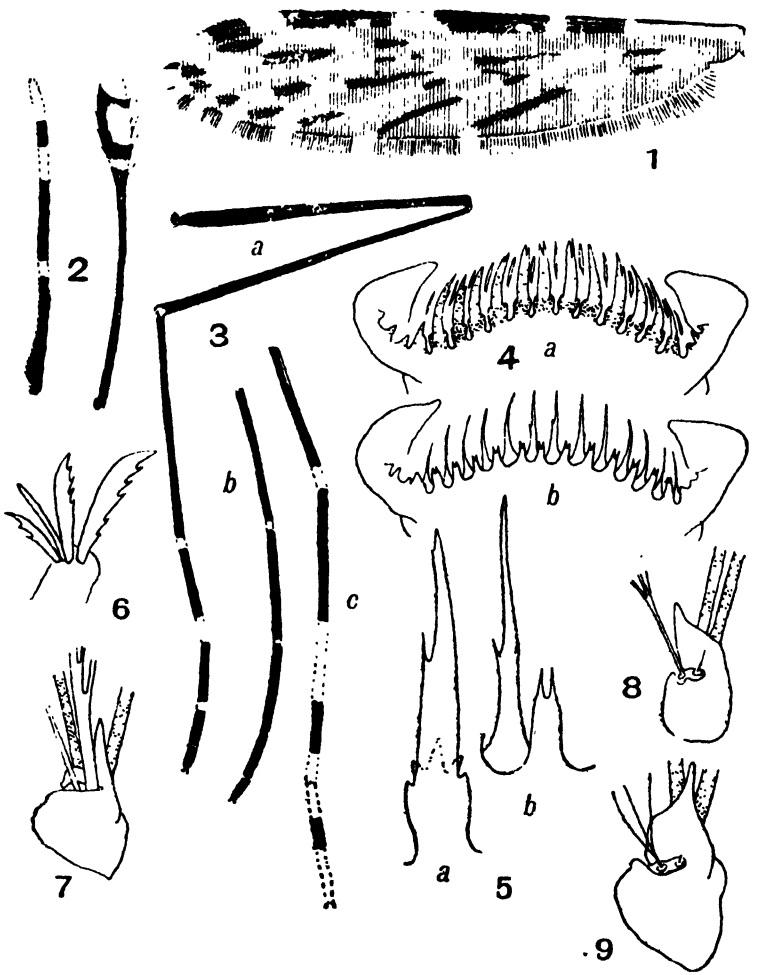
Thorax with chætæ only on *apn*; propleural hairs 1. Mesonotum dark; median area somewhat lighter, clothed throughout with rather narrow pale scales, aggregated to form median lateral tufts on *ap*, some dark scales beneath the pale in the latter situation: fossæ and lateral areas largely bare, but with a line of scales external to bare patch extending forwards from root of wing. Pleuræ dark, without scales;

* McCombie Young and Majid 1928, p. 469 (adult, larva); Puri 1928, p. 525 (adult, larva); Iyengar 1929 *b*, p. 2 (adult, larva); Puri 1931, p. 160 (larva).

spiracular hairs absent; prealar about 3; upper mesepimeral about 4.

Wings as in figure, but dark areas very variable in extent and arrangement; preapical pale spot may be bridged

Fig. 37.



A. majidi.

1. Wing of ♀, standard scale. 2. ♀ and ♂ palp, same scale. 3. Legs: (*a*) front leg; (*b*) mid-tarsus; (*c*) hind tarsus. 4. Pharyngeal armature: (*a*) oriented to show anterior portion of pediments and filaments; (*b*) to show posterior view of crest and rods. 5. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) rod and posterior view of crest. 6. Leaflets of phallosome of one side, standard scale. 7–9. Basal tubercles of pro-, meso- and metathoracic pleural hairs.

or absent; veins 2.1, 2.2, 4.1 and 4.2 may be all dark except at their terminations; vein 3 may be mainly dark; vein 6 may be dark except at extreme base, or as shown, or with apical dark area interrupted and basal dark spot absent; a fringe-spot at vein 6 may be absent, in which case the border scales may be white in this position. In very dark examples the wing may resemble very much that of *A. fuliginosus*.

Legs with front femora slightly swollen in basal third. Femora uniformly very dark, with at most a few pale scales at apices; tibiæ very dark, but with pale apices; front tarsus rather broadly banded with white at apices of segs. 1–3.; mid-tarsus largely dark, with narrow bands usually at apices of 1–2; hind tarsi marked as in fig. 37, 3, very closely simulating the markings in *A. karwari* and *A. maculatus*.

Abdomen without scales even on cerci.

ADULT ♂.—In general as in ♀. *Palpi* ornamented as in figure. *Abdomen* without scales except on coxites.

PUPA.—Undescribed.

LARVA.—*Clypeal hairs*: *ic* long, rather stout, simple; *oc* a little less than half length *ic*, stout; *pc* slender, much shorter than *oc*, simple. *Antenna* uniformly dark brown, rather stout: hair arising $\frac{1}{4}$ to $\frac{1}{3}$ length of antenna from base; terminal hair pectinate. *Mentum* with three teeth on either side of median tooth, arranged as in *A. culicifacies*, the teeth very small.

Shoulder hairs: inner and outer arising from basal tubercles, both hairs stout and feathered. *Metathoracic hair no.* 1 formed into very well developed palmate hair. *Pleural hairs* as for group; *dp*1 split into 3–5 br. The basal tubercles large, a pointed process on each segment, these arising from the dorsal instead of the ventral edge, as is usual.

Palmate hairs well developed on I–VII. Leaflets rather broad and marked as in *fluviatilis* and *minimus*, much resembling the leaflets of those species, except that the filament is only about $\frac{1}{4}$ length of blade. *Lateral hairs* on IV–VI long and slender, showing 4–7, 5–6, and 6–8 br. respectively; on VII very short, with 4–6 br. *Tergal plates* fairly large, about $\frac{1}{3}$ length of segment on anterior segments and nearly covering dorsum of VIII; median plate not included in anterior plate; small oval plates absent. *spc* very poorly developed; *mps* fairly broad anteriorly but not touching the chitinisations. *Pecten* with 4–5 long and 6–10 short projections. *ps* hair long, with 8–9 br. *Saddle hair* long and split into 2–3 in distal quarter. Caudal hooks 5–6; some branches of *isc* also forming hooks. Hair 13 on I–VII unusual in being of similar form, increasing in size from before backwards.

EGG.—Undescribed.

IDENTIFICATION.—Superficially somewhat resembles *A. karwari*, but differs in absence of the additional pale band on the female palpi and in the darker wings and coloration generally.

DISTRIBUTION.—Not recorded outside the Indian area. In the Indian area known as yet only from BENGAL (Darjeeling and Jalpaiguri Dist.), COORG, MALABAR DIST., and MYSORE.

BIONOMICS.—Young and Majid found the species breeding in grassy slow-running streams; Iyengar records the breeding places as "jhoras" or small open drains in tea-gardens, also on fallow rice-terraces.

RELATION TO DISEASE.—Nothing is known of any relation to malaria.

Group *PSEUDOMYZOMYIA*.

Christophers, Ind. Med. Res. Mem. no. 3, p. 57, 1924.

Grassia Theo., Journ Trop. Med. v, p. 181, 1902. Preoccupied (nec Fisch), *vide* Blanchard, C. R. Soc. Biol. liv, p. 795, 1902. TYPE: *A. rossii* Giles.

Myzomyia Blanchard, *loc. cit.* p. 795. TYPE: *A. rossii* Giles.

Howardia Theo., *loc. cit.* p. 181. Preoccupied (nec Dalla Torre), *vide* Blanchard, *loc. cit.* p. 795. TYPE: *A. costalis* Theo.

Pyretophorus Blanchard, *loc. cit.* p. 795. TYPE: *A costalis* Theo.

Aldrichia Theo., Mono. Cul. iii, p. 353, 1903. TYPE: *A. error* Theo.

Pseudomyzomyia Theo., Mono. Cul. iv, insert.-slip, 1907. TYPE: *A. rossii* Giles.

Aldrichinella Theo., Mono. Cul. v, p. 3, 1910. TYPE: *A. error* Theo.

Nyssomyzomyia James, Paludism, no. 1, p. 37, 1910. TYPE: *A. rossii* Giles.

Palæomyzomyia Swell. & Rodenw., Die Anoph. v. Niederl.-Ostindien, p. 114, 1932. TYPE: *A. parangensis* Ludl.

Type-species, *A. subpictus* Grassi *.

Pharyngeal armature with two rows of teeth, differentiated as cones and rods, the cones with deep roots; crest of pediment with a single row of spines, not appearing bifurcate in posterior view, the crest usually very long; pediments in anterior view appearing bulbous, usually without definite lateral teeth; filaments usually long, flat, with spicular branches; rods with flattened posterior extension. Lateral flanges large.

Propleural hairs of adult present, usually several.

Palpi of female with apical segment long, though usually wholly included in apical pale band; pronotal lobes usually

* Edwards, 1932, suggests that, if *A. gambiæ* be included, this group should be *Pyretophorus*. Strictly, of course, it should be *Myzomyia*, but I have kept to the name so far usually employed, especially as *A. gambiæ* is in several respects not a very representative species, though it clearly seems to belong to the group.

without a scale-tuft *; mesonotum usually with mainly hairs †; ornamentation of wing much as in group *Myzomyia*, but light ornamentation predominating, and the pale costal areas usually broad in apical half of wing; tarsi in all cases banded, and in some species the femora and tibiæ speckled, though the terminal segments of the hind tarsi are never white; abdomen usually with some scales on the last segment and cerci, without lateral tufts.

Harpago with a long apical hair, usually about twice length of club, and accessory hair or hairs quite small; leaflets of phallosome lanceolate or blade-like, with a varying degree of serration.

Pupa: spine on V–VII long and sharp, but that on IV short and usually blunt. Hair *C* branched on IV, always simple on V–VII. Spines on external border of paddle more or less saw-like.

Larva: clypeal hairs simple; the cone-shaped appendage on the maxillary palp bifid. The full characters of the pleural hairs for the group are given below :—

	1.	2.	3.
da	Long, split about middle into 2–3 br. ‡	Long, simple, sometimes split in distal half into 2–4 br.	Long, feathered.
va	Long, simple.	Long, simple	Long, feathered §.
dp	One-third anterior, simple or bifid.	Extremely short, simple	Reduced to tiny papilla.
vp	Long, simple.	Short, slender, simple.	Very short, slender, bifid.

The projection from the basal tubercle on each segment is prolonged into a sharp-pointed spine.

Species recorded from the Indian Area ||.

The following species or varieties are recorded from the Indian area :—

A. subpictus Grassi.
A. vagus Dön.
A. sundaicus Rodenw. (*A. ludlowi* var. *sundaicus*).

The following synopsis of the Oriental forms in this group may be useful for reference (see also remarks on identification given under *A. subpictus* and *A. sundaicus*. For further details King, Phil. Journ. Sci. xlvii, p. 305, 1932, should be consulted).

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* A tuft is present in *A. gambiæ*.
† Scaly in *A. gambiæ*.
‡ Feathered in *A. gambiæ* and *parangensis*; simple in *vagus*
§ 4–6 long lateral branches in distal half in *A. vagus*; simple in *gambiæ*.
|| In addition to the Oriental species and varieties given above, there are two African species, *A. gambiæ* Giles and *A. christyi* Newst. & Carter.

With femora and tibiæ speckled.

A. parangensis Ludlow	Philippines, Celebes.
A. ludlowi Theo.	Philippines (fresh water), Formosa (*hatorii*).
A. litoralis King	Philippines (salt water).
A. sundaicus Rodenw.	Sunda Islands, Malaya, India.

Femora and tibiæ not speckled.

Outer clypeal hairs of larva half or more length of inner.

A. subpictus Grassi	India.
,, var. *indefinita* Ludl.	Philippines, Formosa.
,, var. *malayensis*	Malaya, Sunda Islands (?).

Outer clypeal hair of larva very short, about ¼ length of inner.

A. vagus Dön.	Sunda Islands, Malaya, India.
,, var. *limosus* King	Philippines.

26. Anopheles subpictus Grassi *. (Fig. 38.)

Grassi, Atti d. R. Accad. Lincei (5), viii, p. 101, Feb. 1899 (*A. subpictus*). TYPE-LOC.: described from a specimen sent by Ross from India (Calcutta). TYPE: in Rome Univ. Mus. (*vide* Brunetti, Rec. Ind. Mus. xvii, p. 98, 1920).

SYNONYMS:

rossii Giles, Journ. Trop. Med. ii, p. 63, Oct. 1899 (*A. rossii*) TYPE-LOC.: India (probably Calcutta). TYPE: ♂ and ♀ type-specimens, the former labelled "Ross, dapple-winged mosquito," neither with locality, in Brit. Mus. SYN. by Edwards Bull. Ent. Res. x, p. 129, 1920.

error Theo., Mono. Cul. iii, p. 353, 1903 (*Aldrichia error*). TYPE-LOC.: Calcutta (*C. W. Daniels*). TYPE: ♀ in Brit. Mus Stated to be composite specimen by Alcock, Entom. for Med. Off. p. 69, 1911.

RECOGNIZED VARIETIES:

indefinitus Ludlow, Canad. Entom. xxxvi, p. 299, Oct. 1904 (*M. rossii* Giles, var. *indefinita*). TYPE-LOC.: Bayamban, Mangarin, Guimaras Is., Philippines. TYPE: 4 ♀ co-types in U.S. Nat. Mus., Washington (*vide* Dyar, Insect. Insc. Mens. xiii, p. 86, 1925, and King, Phil. Journ. Sci. xlvii, p. 305, 1932). Nec *A. indefinitus* of Theo., Mono. Cul. iv, p. 47, and many other authors (*vide* under *A. vagus*). Not recorded from Indian area.

malayensis Hacker, F.M.S. Mal. Bur. Repts. ii, p. 1, 1921 (*A subpictus* var. *malayensis*) †. TYPE-LOC.: Fed. Malay states. TYPE: series in Brit. Mus.; type not selected. Not recorded from Indian area.

This species is the *A. rossii*, in part, of numerous authors prior to 1920. The type of *A. subpictus*, if still in existence, has not, so far as I know, been recently examined, but Grassi's description of the specimen from Calcutta as having the last two palpal segments,

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* SYSTEMATIC: Theo. 1901 *a*, p. 154; James and Liston 1904, p. 109; 1911, p. 98; Ludlow 1915, p. 155; Christ. 1916 *a*, p. 476; Edw. 1920, p. 129; Rodenw. 1922, p. 185; Christ. 1924 *c*, pp. 57, 97; King 1932, p. 305; Edw. 1932. See also Giles 1900, p. 149; Liston 1901, p. 364; James 1902, p. 44; Theo. 1903, p. 45; Swell. 1917 *a*, p. 490; 1917 *b*, p. 42; Mangk. 1919, p. 62; Swell. and Swell. 1920 *b*, p. 89; Rodenw. 1923 *a*, p. 20; Carter 1925. p. 72. See also references on pp. 235–6 (footnotes).

† See also Barber 1918, p. 2.

taken together, dark in the proximal and light in the distal *half*, appears to remove any ambiguity in the synonymy.

That *A. rossii* included two distinct species was not recognized until the name *A. subpictus* came into use; records under the name of *A. rossii* cannot, therefore, be usually accepted as necessarily relating to *A. subpictus*, except for areas where it is known that *A. vagus* does not occur; but the same objection does not hold for records where the name *subpictus* has been used, which is a strong reason for not going back, as some writers have advocated, to the name *rossi*.

References to *A. subpictus* in areas east of India are generally understood to apply to other forms than the type-form, but this is, perhaps, still uncertain. The *A. rossii* of Strickland., 1915 *a*, of Christ., 1912 *c*, of Swell., 1916, p. 38, and of Schüff. and Swell., 1917, is *A. vagus*. *A. vagus* of Schüff. and Swell., 1917, and *A. indefinitus* of Swell., 1916, p. 55, are *A. subpictus*.

ADULT ♀.—Size medium (length of wing 2·3–4·0 mm.).

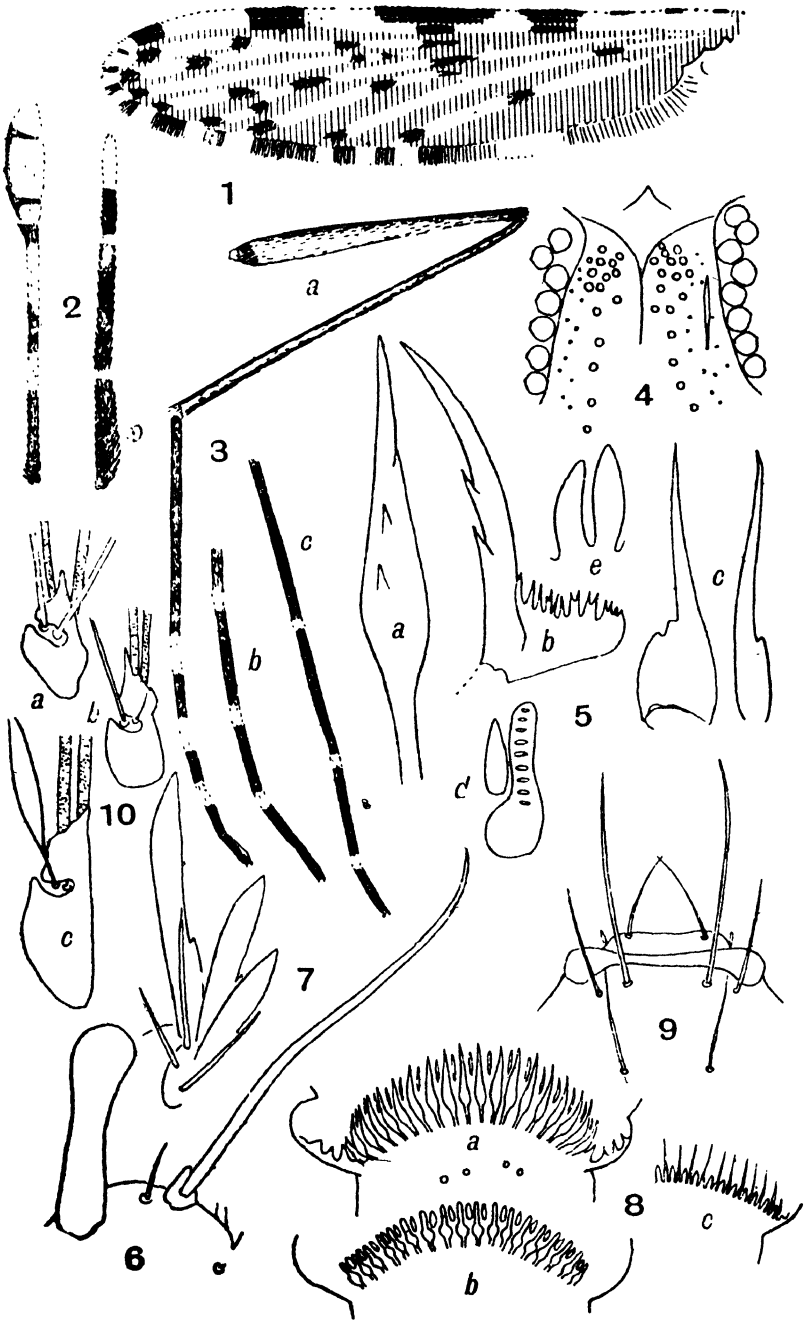
Head: scales normal, with a conspicuous vertical area; vertical chætæ white or pale, an anterior cluster of ten or more forming a well-marked frontal tuft; ocular scales rather narrow. *Antennæ*: torus sometimes with a few minute scales; inner aspect of first flagellar segment with white scales. *Palpi* rather shaggy throughout large part of extent; apical segment about half the preapical in length, index 0·49; ornamented with a broad apical band and two narrow pale bands, apical band involving whole of apical segment and distal end of preceding segment; apical pale area about same length as dark area between apical and preapical pale bands. *Labium* uniformly dark.

Pharynx †: cones and rods each numbering about 20. Cones with pediment bulbous, with narrow neck passing into long root-ridge and no obvious lateral teeth; filament broad, tapering to point, with some spicular teeth rising on anterior aspect in basal half; crest much elongated, with a single row of spines, appearing blunt and with a somewhat truncated apex in posterior view. Rods with a flattened basal expansion

† PHARYNX: Sinton and Covell 1927, p. 306; Barraud and Covell 1928, p. 675; 1929, p. 101; Manalang 1929, p. 431.

1. Wing of ♀, standard scale. **2.** ♂ and ♀ palp, same scale. **3.** Legs: (*a*) front leg; (*b*) mid-tarsus; (*c*) hind tarsus. **4.** Vertex. **5.** Pharyngeal teeth: (*a*) anterior view of cone, showing root; (*b*) lateral view of same, direction of root indicated by dotted line; (*c*) lateral and anterior view of rod; (*d*) looking down on crest, the cone itself and rod at side directed towards observer—a very usual view when armature is mounted whole, the general effect given in **8** *b*; (*e*) posterior view of crest (right) and scallop (left), from which rod arises (see **8** *c*). **6.** Apex of harpago. **7.** Leaflets of phallosome of one side, standard scale. **8.** Three views of armature as a whole: (*a*) oriented to show cones as in **5** *a*, the rods oblique and only partially in focus; (*b*) oriented to show as in view **5** *d*; (*c*) oriented to show as in **5** *e*, the rod placed in somewhat schematically. **9.** Clypeal hairs of larva. **10**, *a*–c. Basal tubercles of pro-, meso- and metathoracic pleural hairs of larva.

Fig. 38.



A. subpictus.

(For explanation of figure, see opposite page.)

posteriorly and sometimes with one of two spicules in this position, termination simple, rod-like. Post-armature ridges with very long spines.

Thorax with chætæ only on *apn*; propleural hairs 2–3. Mesonotum pale, lateral areas somewhat darker than median area; median area covered with short, golden, curved hairs, with median and lateral tufts of narrow white scales on *ap*, area below latter with numerous erect black scales; fossæ with some scattered broader scales and some scales on lateral areas. Pleuræ with a few scales sometimes present on sternopleuron: spiracular hairs 6–9; prealar 12–13; upper mesepimeral about 20; upper sternopleural group about 6, lower about 8, the two groups more or less continuous, with a few scales between.

Wings as in fig. 38, **1**; base of costa usually with three small dark accessory spots, the two inner ones sometimes partially or wholly continuous, or sometimes the middle spot obliterated; middle dark spot of costa usually about twice as long as the others, dark area on vein 1 shorter, both internally and externally, than the dark costal area, so that it is usually about half the length of this, sometimes a dark spot present on vein 1 at inner end of spot. Preapical dark spot about equal to, or a little smaller than, pale area on either side; fringe commonly with an additional pale area between termination of vein 6 and base, and often one between 5.2 and 6. The pale areas in general greatly preponderating, and dark spots on the wing-field liable to obliteration in various degrees. Scaling of wing moderately broad; max. str. 9–10, but some scales to 12.

Legs with front femora distinctly swollen in basal half. Femora more or less unicolorous, each with a dark ring at base about equal to the diameter; under surface of front femora variable, often dark or with pale patch basally; mid- and hind femora markedly pale beneath throughout entire length except for the narrow basal band and a somewhat longer dark area towards apex: all femora, especially middle pair, with a double pale spot or band towards apex on dorsal aspect, beyond which the scaling is often darker; actual tips of femur dark. Tibiæ of fore legs broadly pale beneath, especially at tips, which are conspicuously pale in this situation, also with a thin, often broken, pale line on external surface; mid- and hind tibiæ similarly marked, with a thin pale line on anterior surface expanding at apex; the tips pale, especially on mid- and hind legs. Tarsi banded as in fig. 38, **3**; fore tarsi broadly banded apically and basally at 1–2, 2–3 and 3–4, sometimes an apical or apical and basal band at 3–4, bands yellowish; tarsi of mid- and hind legs with much narrower bands, usually mainly apical. Coxæ pale, devoid of conspicuous scale-tufts.

Abdomen light, thickly clad with golden hairs and some narrowish yellow scales, or sometimes some darkish scales, at posterior border of VII and VIII; venter sometimes with some pale scales on VII laterally and numerous dark hairs, and not infrequently some dark scales, in middle line apically. Cerci usually with numerous dark scales; some light scales also sometimes present.

ADULT ♂.—In general as in ♀. *Palpi* with club and stem largely pale, ornamented as in figure. *Abdomen* with hairs only except on dorsum of VIII, where there are numerous moderately broad pale scales; usually a few narrow scales on ventral aspect of VII. Coxites with numerous pale and dark scales.

Hypopygium *: harpago with very long apical spine, more than twice length of club; a very small spine, much less than ¼ length of apical spine, arising between this and club. Phallosome rather strongly bent; about ⅓ length of coxite; carrying about 6–7 leaflets on each side, largest leaflet about half length of phallosome; leaflets blade-like, the larger ones showing some shallow serrations in basal portion. Average length of largest leaflet, according to King (1932), is 57 μ, varying from 51–59 μ, this leaflet longer and narrower than that of *A. indefinitus*.

PUPA—*Paddle* †: external border bare in anterior quarter, followed by some short denticles, becoming rather short stoutish spines posteriorly, abruptly replaced by hairs decreasing in size and not reaching paddle-hair; paddle-hair long, hooked; acc. hair simple.

Spine: (VIII), length somewhat less than half segment. (V–VII) curved, pointed, those on VI and VII somewhat more and that on V somewhat less than half length segment. (III–IV) short, blunt.

Hair B: (III–VII) branched, from half to ⅔ segment.

Hair C: (V–VII) simple, somewhat longer than segment. (IV) 2–3 br., about as long as segment. (III) 4–6 br., shorter than segment. *C′* (VI) simple.

Hair T: (I) simple.

LARVA ‡.—*Clypeal hairs* slender, simple; *oc* a little over half length *ic*; *pc* a little shorter than *oc*, arising rather far back. *Antennæ* rather slender; hair arising about

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* HYPOPYGIUM: Christ. 1915, p. 393; Swell. 1921 *a*, p. 52; 1921 *b*, p. 43; King 1932, p. 329.

† PUPA: Senevet 1931, p. 38.

‡ LARVA: Puri 1928, p. 524; 1931, p. 136. See also Steph. and Christ. 1902 *a*, p. 12; 1902 *b*, p. 14; James 1902, p. 44; Theo. 1903, p. 45; Liston 1908, p. 879; James and Liston 1904, p. 110; 1911, p. 98; Stanton 1912 *b*, p. 5; Mangk. 1918, p. 481; 1919, p. 62; Swell. and Swell. 1919 *a*, p. 38; Iyengar 1922 *a*, p. 631 (tail-hooks); Walch and Soesilo 1929, p. 3 (pecten); King 1932, p. 328; Ghosh 1932, p. 1085.

middle of antenna; terminal hair 3–4 br. *Maxillary palp* with the cone bifid from about its middle. *Mentum* with four teeth on either side of median tooth, all adequal and equidistant except last in row, which is a little smaller; an extra small tooth may be present at end of row.

Shoulder hairs: inner without conspicuous basal tubercle, slender, sparsely feathered; middle with poorly-formed tubercle, about 1½ times length of inner. *Metathoracic hair no.* 1 resembling ordinary hair, short, simple, or split into 2–5 br. *Pleural hairs* as given under group. Projection on mesothoracic tubercle arising from ventral edge.

Palmate hairs well developed on II–VII; hair no. 1 on I with 6–9 poorly-developed filaments. Leaflets uniformly but poorly pigmented; filament nearly as long as blade, the shoulder sharply defined. *Lateral hairs* on IV–VI long, splitting near base into three slender branches (sometimes into two on VI); on VII very short, split into 2–3 br. *Tergal plates* very small and narrow. *spc* well developed, with projecting spur; *mps* very broad anteriorly and nearly touching chitinisation. *Pecten* with 4–5 long and 10–11 short processes, the number and length very variable. *ps* hair long, with 5–6 br. arising near base; *osc* with 6–8 long br., forming poorly-developed hooks with very shallow curves. *Anal papillæ* rather stout, about twice as long as anal segment.

Egg *.—Upper surface as wide throughout as the egg-body, middle portion not narrowed, or only very slightly so; covered throughout with pale punctæ. Lower surface with (or sometimes without ?) pale punctæ. Floats nearly touching margin of upper surface; occupying about the middle two-thirds and extending to about an equal distance from either end of the egg, or slightly nearer one or the other; float-ridges 30–40, narrow, regular, rather smooth; float-terminations relatively small, rounded, flattened. Frill very broad, stiff, extending laterally, continued all round the margin of the upper surface except at the ends; coarsely striated throughout its whole extent, rather thick and opaque or milky; when fully displayed as broad as ⅓ of width of deck.

Identification.—*A. stephensi* often has a general resemblance to *A. subpictus* from its often light fawn colour, but the speckling of the femora and tibiæ, the two broad apical palpal bands, and heavily scaled mesonotum readily distinguish it.

A. sundaicus is readily distinguished in unrubbed specimens by the speckling of the femora and tibiæ; otherwise the

* Egg: Steph. and Christ. 1902 *a*, p. 12; 1902 *b*, p. 14; Christ. and Barraud 1931, p. 175.

points of distinction between this species and *subpictus* are somewhat limited (*vide* remarks under *A. sundaicus*).

A. vagus is distinguished by the much longer pale apical area on the female palp, three or four times the length of the preceding dark band, whereas in *A. subpictus* it is about equal in extent, a distinction usually to be confirmed by the presence, in the female, of a pale tache in *A. vagus* towards the end of the proboscis. The short outer clypeal hairs also serve to distinguish *A. vagus* sharply from *A. subpictus*.

Differentiation between the males of *A. subpictus* and *A. vagus* is difficult. Rodenwaldt gives as a distinguishing point the broad apical banding of joints 3–4 of the front tarsus in *A. subpictus*, this being less conspicuous in *A. vagus* and either apical or possibly basal, but not both; but it is doubtful how far this holds good. As in the female, the prehumeral dark accessory spot is usually continuous in *A. vagus*, and extends to the extreme base of the wing, whilst it is divided, and with more white scaling on the costa, in *A. subpictus*. A definite difference appears to exist in the character of the leaflets of the phallosome; these are larger in *A. vagus* (average measurement by King 72 μ) than in *A. subpictus* (average 58 μ).

The following synopsis of the various forms of *A. subpictus* and *A. vagus* may be useful for reference; it is taken, for the most part, from King, 1932:—

1. Larva with outer clypeal hair much shorter than half length of inner. Apical pale band on ♀ palpi 3–5 times preceding dark band.

   Dark area on vein 1 on inner costal spot usually less than half as long as that on costa; prehumeral dark acc. costal spot usually undivided and extending to extreme base of costa; subapical dark costal spot distinctly shorter than pale spot on either side. Lateral hair on seg. IV of larva with 2 br. Leaflets of phallosome large, the first very long, the others progressively shorter.

   (*a*) With a tache on ♀ proboscis towards extremity. Posterior clypeal hairs of larva approaching bases of inner and approximated (fig. 39, **6**):

   Prehumeral dark spot with white scales anteriorly. Leaflets of phallosome average 72 μ ..... *vagus*.

   (*b*) Without such a tache. Posterior clypeal hairs of larva wider apart and further back (fig. 39, **7**).

   Prehumeral dark spot without white scales anteriorly. Leaflets of phallosome average 68 μ. *vagus* var. *limosus*.

2. **Larva with outer clypeal hair somewhat more than half length of inner. Apical pale band on ♀ palpi same length as preceding dark band, or not more than twice this.**

Dark area on vein 1 on inner costal spot usually more than half as long as that on the costa. Lateral hair on seg. IV of larva with 3 br. Leaflets of phallosome large or small.

(*a*) Preapical dark band on ♀ palpi variable, averaging about half the apical pale band. Leaflets of phallosome short (av. 36 μ) and more or less of even length. Prehumeral acc. dark costal spot usually undivided and extending to extreme base of costa.

Palmate hair on abd. seg. I less developed; shoulder hairs less branched (av. 13·2 and 12·2 br. resp.); leaflets of palmate hair on seg. IV not so large, filaments approx. 0·8 of blade. Subapical dark costal spot given as longer than, or as long as, the pale area on either side ..... *subpictus* var. *indefinitus*.

Palmate hair on abd. seg. I more typically developed; shoulder hairs more branched (av. 17·5 and 15·8 br. resp.); leaflets of hair on seg. IV larger, filament approximately same length as blade. Subapical dark costal spot in specimens seen appears to be usually rather short, as in the type, *A. subpictus*. Largest leaflet of phallosome slightly longer and narrower than in *A. subpictus*. *subpictus*. var. *malayensis*.

(*b*) Preapical dark band on palpi about same length as apical pale band. Leaflets of phallosome long (57 μ) and more as in *A. vagus*.

Prehumeral dark acc. costal spot nearly always divided or in part obliterated, the base of the costa with more pale scaling and prehumeral not extending to extreme base; subapical dark costal spot shorter than pale spot on either side .... *subpictus* (type-form).

Prehumeral undivided and extending to base; subapical dark costal spot longer ..... *subpictus* (salt water, [India).

DISTRIBUTION.—The species, including varieties, is widely distributed in the Oriental Region. It is recorded from NEW GUINEA; MOLUCCAS (Amboina, Ceram, Geser, Halmaheira, Haraku, Ternate); CELEBES (Celebes, Boeton Bangaai);

SULA; PHILIPPINES; FORMOSA (?); S. CHINA (?); LESSER SUNDA ISLANDS (Alor, Bali, Boeroe, Flores, Lombok, Pantar, Roma, Soemba, Soembawa, Timor, Wettar); JAVA; SUMATRA (with Nias, Biliton and Riouw); BORNEO; TONKIN; COCHIN CHINA; MALAY PENINSULA; SIAM; INDIA, BURMA, and CEYLON.

King, 1932, does not include the type-form as occurring in the Philippines. Kinoshita's record (repeated by Faust) for Formosa refers to *A. vagus* (vide *Yamada*, 1925, p. 454), or possibly var. *indefinitus*. The validity of records for China must also be considered doubtful, some of those given by Faust relating to *indefinitus* (*vagus* or the true *indefinitus*), leaving only the Canton records (*Faust*, specimens collected by Campbell and identified by Banks; *Buddle*, 1928, p. 90). Further, it is uncertain to what extent the records from the Dutch East Indies, etc., include the type-form. Some specimens collected by Hill from New Guinea, in the Kasauli collection, appear to have much more definitely scaled mesonotum than any other forms seen by me, and are probably at least varietally distinct.

In the Indian area *A. subpictus* is recorded from numerous localities throughout the whole area, including Loralai, Quetta-Peshin and Zhob districts of Baluchistan, numerous localities in the N.W. Frontier Province, Sind, and Gujarat, throughout the whole Peninsula and the extreme south, including Ceylon, in numerous localities in Upper and Lower Burma to the Salwee. It is not recorded from the Andamans. Many records, however, clearly relate in the eastern areas in large part to *A. vagus*.

In the collection of the Malaria Survey the species is abundantly represented from many localities in the North-West and over the whole Peninsula, but less so from Bihar and Orissa and Bengal, where the majority of specimens are *A. vagus*. There is only one specimen from Assam (Sylhet) and one general locality (Pyinmana and neighbourhood, Yamethin Dist.) in Burma. Up to the present this last record is the most easterly locality from which the type-form of *A. subpictus* has been seen.

Specimens of *A. subpictus* throughout the Indian area for the most part conform to King's description of the type-form. A number of specimens, however, from Falta and Dum Dum in Bengal, Ennur near Madras, and the salt-pan area near Bombay have the prehumeral spot undivided and continued to the base, and the preapical dark costal spot variable, but usually longer than in the type-form. This appears to be a salt-water variant, since the palpi and leaflets of the phallosome are as in the type-form. So far as known var. *malayensis* does not occur in the area.

BIONOMICS.—*A. subpictus* is a markedly domestic form, breeding especially in the neighbourhood of habitations,

and to be caught often in very large numbers in occupied and unoccupied rooms of houses, in outhouses, barracks, stables, cow-sheds, and such like situations (*Adie*, 1905). The female feeds readily in nature and experimentally on animals and man (*Phillips*, 1923 ; *Gill*, 1925), and specimens caught both in houses and cattle-sheds have been found by the latter author, by means of the precipitin test, to contain human blood

A. subpictus breeds especially in collections of water, often of a very temporary kind, such as form in excavations and hollows, especially during the monsoon, about villages and towns (*James* and *Liston* ; *Christ.*, 1904, 1911 ; *Hodgson*). It is commonly encountered in borrow-pits, buffalo-wallows, brick-pits, drains, pools from leaks and waste water, cement-sumps, etc., and during the rainy period often in furrows in gardens and cultivated ground, collections of water in roof-gutters, hollows in scrapped machinery, and other miscellaneous breeding places It is recorded as occurring in rice-fields (*King* and *Krishnan*), in irrigation channels (*Richmond* and *Mendis* ; *McCombie Young* and *Majid*), and in wells (*Strickland*, 1923 ; *Gill*, 1917) ; it may also occur in such situations as weedy lake-margins, moats, sluggish rivers etc., especially if near habitations (*Gill* and *Harnam Singh*, 1920). It is especially noticeable for its power of breeding in dirty or more or less polluted water (*Thomson*, 1909 ; *Sinton*, 1917 ; *Gill*, 1917 ; *Iyengar*, 1917). It also exhibits considerable powers of breeding in brackish or salt water (*James*, 1902 ; *Chalam*, 1924). In Batavia van Breemen, 1920, has recorded it as breeding, along with *sundaicus* (*ludlowi*), in fishponds, and as being even more resistant to salinity than that species, and still occurring even when the salinity rose to 8·6 per cent.

The seasonal prevalence in the Punjab and north-west is more or less confined to the period during and following the monsoon ; it first usually appears about June and is very prevalent from July to November, and still present in reduced numbers in December, after which it virtually disappears (*Christ.*, 1911 ; *Sinton*, 1917, 1922). In the United Provinces it has been found in small numbers in January and February, as well as before the monsoon (*Graham*, 1913). In South India and Burma the species occurs more or less throughout the year (*Fry*, 1912 ; *Russell*, 1923 ; *Feegrade*, Akyab).

Relation to Disease.—*A. subpictus* has been experimentally infected, as far as the oocyst stage, with all three forms of the malaria parasite. Gland infection with B.T. is recorded by Gill, 1925, in the Punjab and with M.T. and B.T. by Soesilo at Batavia. A small percentage infection (0·02–0·04 per cent.) has been observed in the Dutch East Indies, but, so far, though numerous dissections have been

made, there is no certain record either of gut or gland infection in nature in India. Since the species carries experimentally, Soesilo ascribes the small amount of natural infection to the fact that the species feeds mainly on cattle. In view of Gill's results this requires confirmation.

27. **Anopheles vagus** Dönitz, 1902 *. (Fig. 39.)

Dönitz, Zeit. f. Hyg. xli, p. 80, 1902 (*A. vagus*). TYPE-LOC.: ♀, Fort de Kock, Sumatra; ♂, Banjoe-Biroe, Java. TYPE: not known.

SYNONYMS:

indefinita of Theo., Mono. Cul. iv, p. 47, 1907; Stanton, Journ. Lond. Sch. Trop. Med. ii, p. 6, 1912, and Bull. Ent. Res. vi, p. 169, 1915; Edwards, Bull. Ent. Res. vi, p. 67, 1915; Strickland, Bull. Ent. Res. vi, p. 157, 1915, and other authors. Nec *A. indefinita* Ludlow.

immaculatus James, Sci. Mem. Govt. India, n. s. no. 2, p. 35, 1902 (*A. immaculatus*). TYPE-LOC.: Ennur, near Madras, India. TYPE: described from a single ♀; type in Brit. Mus. Theobald, Mono. Cul. iii, p. 23, 1903, described the same specimen under the same name, but afterwards, Mono. Cul. iv, p. 14, referred to it as James's species. The type-loc. of Goa, given by Theobald in his first description, was later corrected by him. SYN. by Edwards, Bull. Ent. Res. xii, p. 70, 1921. This is a flavescent form of *A. vagus*, not infrequently met with.

flava Swelleng., Geneesk. Tijds. Ned. Ind. lvii, p. 807, 1917 (*Myzomyia flava*). TYPE-LOC.: Soerabaia, Java. TYPE: described from 3 ♀♀ and 3 ♂♂; type ♀ in Brit. Mus. SYN. (of *A. immaculatus*) by Edwards and Swellengrebel, in Swell. and Swell., Bull. Ent. Res. xi, p. 77, footnote.

javanensis Swell. & Swell. Bull. Ent. Res. xi, p. 91. Name in table, which should read *flava*.

RECOGNISED VARIETY:

limosus King, Phil. Journ. Sci. xlvii, p. 330, 1932 (*A. vagus* var. *limosus*). TYPE-LOC.: Philippine Islands.

The synonymy connected with this species is somewhat complex. A distinction between a form with broader palpal band and type *rossii* was first indicated by Edwards (in Ludlow), Bull. Ent. Res. vi, p. 157, 1915. This form was later given by Christophers, 1916, p. 477, as synonymous with *A. vagus* Dön. Following this generally accepted synonymy, two species, *A. vagus* and *A. subpictus*, were recognized, with broader and narrower pale areas on the palpi respectively. *A. indefinitus* Ludlow, as also *A. formosaensis II*, were generally

* SYSTEMATIC: (*vagus* or *indefinita*) Edw. 1915, p. 157 (footnote); Ludlow 1915, p. 155; Christ. 1916 *a*, pp. 477, 479; 1924 *c*, pp. 58, 97; Swell. 1921 *a*, p. 38; Rodenw. 1922, p. 185; Yamada 1925, p. 454 (*formos. II*); King 1932, p. 305. See also Schüffner 1902, p. 90; Theo. 1907, p. 47; 1910 *a*, p. 34; Stanton 1912, p. 6; Ludlow 1914 *a*, p. 34; Strickl. 1915 *b*, p. 157; Swell. 1917 *a*, p. 490; 1917 *b*, p. 42; Schüff. and v. Heyden 1917, p. 40; Mangk. 1919, p. 64; Swell. 1919, p. 3; Rodenw. 1921, p. 151; Hacker 1921, p. 1; Strickl. 1925, p. 19; 1927, p. 875. (*immaculata* or *flava*) James 1902, p. 35; Theo. 1903, p. 23; Swell. 1916, p. 7; 1917 *c*, p. 807; Swell. and Swell. 1920 *b*, p. 77; Edw. 1921 *a*, p. 70; Senior White 1923, p. 34; Strickl. 1927, p. 875.

taken to be the former species. Recently King, 1932, has shown that the true *A. indefinitus* is different, whether treated as a distinct species or placed as a variety of *A. subpictus*. Further, *A. formosaensis II* Tsuzuky, considered by Yamada, 1925, as synonymous with *vagus*, is thought by King to be nearer *A. indefinitus* than *A. vagus*. Further, the Philippine form of *A. vagus* is considered to be a variety, var. *limosus* (*vide* Key, p. 237).

A. vagus is the *A. rossii* of Leicester, 1908; Christ., 1912; Strick., 1915; Swell., 1916, and many other authors. *A. stephensi* of Mathis and Leger, 1910, and var. *malayensis* of Tiedemann, 1927, p. 226, appear to be *A. vagus*.

ADULT.—Very closely resembles *A. subpictus*, but differs in the following respects:—Subapical dark band on ♀ palp much narrower, usually not much longer than it is broad, and only about $\frac{1}{4}$ to $\frac{1}{5}$ length of pale apical area; prehumeral dark accessory spot at base of costa either continuously dark or, more usually, with pale scales anteriorly, dark scales connecting the two portions along inner border of costa; joint between segments 4–5 of front tarsus in ♂ unbanded, or with narrow apical or basal pale band only. The subapical dark spot on the costa is usually short, as in *A. subpictus*.

Pharynx *: closely resembles that of *A. subpictus*.

Hypopygium †: in general as in *A. subpictus*. Phallosome, however, with 4–5 stout leaflets and one or more shorter spikes on each side; first leaflet straight and very long, next three or four progressively shorter; length of longest leaflet about 72 μ (*King*).

PUPA ‡: *Paddle* in general as in *A. subpictus*, but spines on external border longer, stouter, and more sharp pointed; acc. hair half length of paddle-hair, bifurcate.

General arrangement of spines and chief hairs as in *A. subpictus*.

LARVA §.—According to Puri, in the main as in *A subpictus*, but differing especially in the clypeal hairs. *ic* slightly stouter than in *A. subpictus*; *oc* very short, between $\frac{1}{3}$ and $\frac{1}{4}$ length of inner and arising much closer to the inner hairs than in any other species except in *Neomyzomyia*. *pc* short, simple, placed far forwards, and much internal to *ic*. The inner sutural slightly shorter than in *A. subpictus*.

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* PHARYNX: Sinton and Covell 1927, p. 306; Barraud and Covell 1928, p. 675; 1929, p. 101; Puri 1928 *b*, p. 526; Manalang 1929, p. 431.

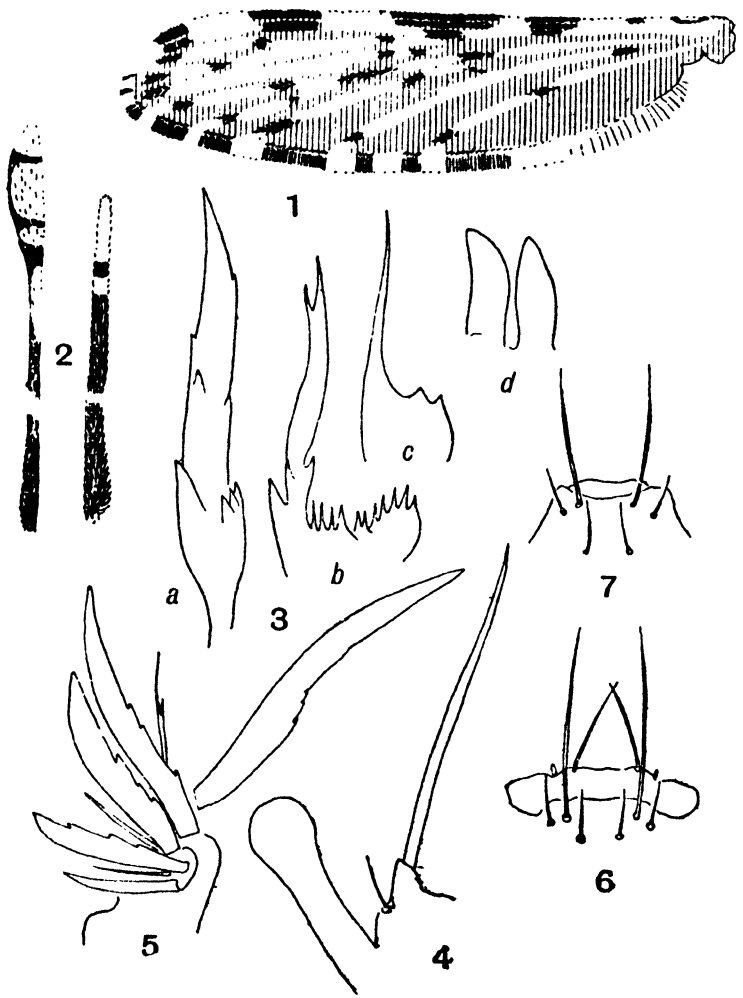
† HYPOPYGIUM: Christ. 1915, fig. 23 (*rossi*); Swell. 1921, p. 38; King 1932, p. 329.

‡ PUPA: Senevet 1931, p. 72.

§ LARVA: Stanton 1915 *a*, p. 169; Strickl. 1915 *a*, p. 321; Swell. and Swell. 1919 *a*, p. 34; Lamborn 1921, p. 91 (tail-hooks); Mangk. 1918, p. 483; 1919, p. 64; Swell. 1921 *a*, p. 41; Iyengar 1922 *a*, p. 63 (tail-hooks); Borel 1925, p. 225; 1929, p. 49; Carter 1925, p. 87; Senior White 1925, p. 219; Stanton 1926, p. 52; Puri 1928 *b*, p. 524; 1931, p. 139; King 1932, p. 311.

Pleural hairs: *da*1 simple, not split into 2–3 as in *A. subpictus*; *da*2 very rarely bifurcate. On the metathorax only one of the long hairs is markedly feathered, the other having only 4–6 long lateral branches on its distal half.

Fig. 39.



A. vagus.

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp, same scale. 3. Pharyngeal teeth: (*a*) anterior view of cone, isolated tooth and full-length root not shown; (*b*) lateral view of same; (*c*) lateral view of rod; (*d*) posterior view of cone (right) and basal scallop of rod (left). 4. Apex of harpago. 5. Leaflets of phallosome of one side, standard scale. 6. Clypeal hairs of larva (after Puri). 7. Same, var. *limosus* (after King).

Lateral hair on IV–V split only into 2 br. ; usually, also, the hair on VI.

Egg *.—Very similar to *A. subpictus*, but smaller (measuring in examples seen 0·49 mm. in length), with narrower frill and somewhat shorter floats. Floats occupying about the middle half of the egg ; float-terminations of moderate size, rounded ; float-ridges 20–30. Frill striated throughout, but narrower and more transparent than in *A. subpictus*.

Identification.—This is usually not difficult in the ♀, as the palpal differences between *A. vagus* and *A. subpictus* (type-form), which alone occurs in the Indian area, are quite distinctive, and in most cases any doubt is removed by the light tache on the proboscis, which is a very constant feature of *A. vagus*. In the male the absence of a broad basal and apical band at 3–4 on the fore legs, and the uninterrupted prehumeral dark acc. costal spot extending to the base of the costa, may to some extent serve to distinguish *vagus* from *subpictus*, especially supplemented by examination of the leaflets ; the larval characters should be used wherever possible. For further details see section on identification under *A. subpictus*.

A variant of this species which has caused some speculation is the so-called "*immaculatus*" form. Various degrees of pigment deficiency are seen, but, when marked, the whole mosquito may be a light fawn colour, with only sometimes the faintest indication of markings. This condition appears to be much more common in *A. vagus* than in any other species, but marked "*immaculatus*" examples have been seen in the case of *A. subpictus*, *A. stephensi*, and *A. pallidus*.

Distribution.—*A. vagus* has a wide distribution in the Oriental Region, being reported from New Guinea ; Moluccas (Ceram, Amboina) ; Celebes (with Boeton and Moena) ; Philippines ; Formosa (with the Pescadores) ; S. China ; Borneo ; Lesser Sunda Islands (Lombok, Soembawa, Flores, Alor, Kisser, Soemba, Timor) ; Sumatra (with Poeleh Weh, Poeleh Radja, Simaloer, and Nias) ; Java ; Tonkin ; Annam ; Cochin China ; Malay Peninsula ; Siam ; Burma, India, and Ceylon.

In China it is recorded only from Hong Kong. The Formosan form is considered by King, from Yamada's description, to be nearer var. *indefinitus* than *vagus*. In the Philippines it occurs as the variety *limosus*.

In the Indian area *A. vagus* has been recorded from numerous localities throughout East and South India, Burma, the

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* Egg : Strickland 1915, p. 321 (*rossi*) ; Christ. and Barraud 1931 p. 175.

Andamans and Ceylon. It does not extend into the north-western part of the Peninsula, *i. e.*, beyond a line crossing India from the Gulf of Cambay to Nepal.

BIONOMICS.—*A. vagus* is found abundantly in houses, cattle-sheds and similar situations. Lamborn, 1922, found 76 per cent. of females caught in nature fed. Brug and Walch caught large numbers feeding on buffaloes, and Walch and Sardjito obtained four positive precipitin reactions out of nineteen tested for buffalo-blood, but none for human.

The breeding habits are very similar to those of *A. subpictus*, the species breeding especially in pools, borrow-pits, drains, etc. (*Strickl.*, 1923; *Ramsay*) and notably in shallow rain-filled puddles, hoof-marks etc., especially about villages (*Christ.*, 1912; *Covell*, 1927, Andamans; *Feegrade*, 1927, Hsipaw). It occurs also in grassy swamps and in numbers in fallow and cultivated rice-fields (*Covell*, 1927; *Feegrade*, 1927, Lashio; *Gater* and *Rajahmoney*, 1929). It is recorded from brackish water at Bombay (*Chalam*, 1924.)

RELATION TO DISEASE.—*A. vagus* has been experimentally infected with M.T. and B.T. parasites but its susceptibility is low. It has been found infected in nature, in the Dutch East Indies, but very rarely (three out of 3,721 dissected).

28. **Anopheles sundaicus** Rodenwaldt*. (Fig. 40.)

Rodenwaldt, Meded. Volks. Ned. Indie, 1926, D. 1 (foreign ed.), p. 87 (*Myzomyia ludlowi* var. *sundaica*). TYPE-LOC.: Sunda Islands. TYPE: unknown.

(?) *flavescens*, Swellengr. Anop. v. Ned. Oost-Indie, Kolon. Inst., Amsterdam, Meded. xv, p. 47. 1921 (*Myzomyia ludlowi* var. *flavescens*). TYPE-LOC.: Soerabaia, Java. TYPE: unknown. SYN. by Christophers, Ind. Med. Res. Mem. no. 3, p. 60. See also King, Phil. Journ. Sci. xlvii, p. 322, 1932.

ludlowi, of many authors (nec Theobald).

The name *flavescens*, used by Swellengrebel for a hypomelanic form of what he believed to be *A. ludlowi*, if really shown to be this species, would antedate the name here used. Meanwhile it seems simplest to retain it as a doubtful synonym of *A. sundaicus*.

A. sundaicus is the *A. ludlowi* of the majority of writers. True *A. ludlowi*, so far, is known to occur in the Philippines and Formosa (*hatorii*). *A. vagus* as described by Schüffner and Swellengrebel, 1917, p. 17, is this species.

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* SYSTEMATIC: James and Liston 1911, p. 101; Swell. 1916, p. 48; 1921 *a*, p. 44; Strickland 1915 *a*, p. 321; Christ. 1924 *c*, pp. 59, 98; Yamada 1925, p. 459; Rodenw. 1926 *a*, p. 80; King 1932, p. 316. See also Stanton 1912 *b*, p. 6; 1915 *b*, p. 254; 1926, p. 83; Roper 1914, p. 145; Christ. 1916 *a*, p. 470; Swell. 1917 *b*, p. 42; 1922, p. 120; Swell. and Swell. 1920 *b*, p. 89; Mangk. 1919, p. 60; Rodenw. 1921, p. 152 (pilotaxy); Ter Poorten 1924, p. 10; Stookes 1929, p. 108; Urbino 1930, p. 523. See also references on pp. 246–8 (footnotes).

For a recent revision of *ludlowi*-like forms, see King, Phil. Journ. Sci. xlvii, p. 305, 1932. Two of these, *A. ludlowi* Theo. (fresh water) and *A. litoralis* King (salt water), occur in the Philippines, in addition to the somewhat similar *A. parangensis* Ludlow. The *A. ludlowi* of the Dutch East Indies, Malay, and India is distinct from either of these, and has been treated as a distinct species by King (*loc. cit.*). This seems to be justified, as the leaflets of the phallosome in *A. ludlowi* and *A. sundaicus* are quite distinctly different.

ADULT.—In general characters and ornamentation closely approaches *A. subpictus*, except that the legs are "speckled." Its general coloration is also somewhat darker than in *A. subpictus* or *A. vagus*, and the lateral areas of the thorax more contrastingly dark as compared with the median area than in these species.

Dark subapical area on ♀ palp about same length or a little shorter than apical pale area. Proboscis entirely dark. Prehumeral dark accessory spot continuous from extreme base of costa to humeral *cv* or nearly so, without pale scales anteriorly as described for *A. vagus*; middle dark costal spot almost always with a dark spot on vein 1 internal to accessory sector pale spot; preapical dark spot longer than pale areas, especially subcostal pale spot; an extra fringe-spot between 5.2 and 6 only very occasionally present. Specimens from the Andamans usually show the dark spot on 5.2 external to the cross-vein only about $\frac{1}{10}$ of the length of the branch. Similarly specimens from Bengal may show this area short or sometimes up to about twice this length. As pointed out by King, *A. sundaicus* has the stem of the anterior forked cell relatively very short, distinctly less than the length of the cell.

Femora, tibiæ, and first tarsal segments spotted and banded with irregular areas of yellow scaling, producing the effect of yellow spots along the segments or narrow dark flecks and bands depending on the relative extents of dark and pale areas. Remaining tarsal segments without yellow spots except at the joints, these as in *A. subpictus*, i. e., broadly banded apically and basally except at last joint on fore legs, somewhat more narrowly so on mid-legs, and mainly apically banded on hind legs.

Scaling very similar to *A. subpictus*, but usually few or no broadish scales on fossæ of mesonotum. There may be rather prominent black scales on seventh segment ventrally.

Pharynx *: very similar to *A. subpictus* (see figures).

Hypopygium †: in the main as in *A. subpictus*, but the leaflets of the phallosome are short and fusiform, without obvious serrations towards the base. The harpago is similar

* PHARYNX: besides Sinton and Covell, and Barraud and Covell, see Manalang 1929, p. 433 (Philippine forms).

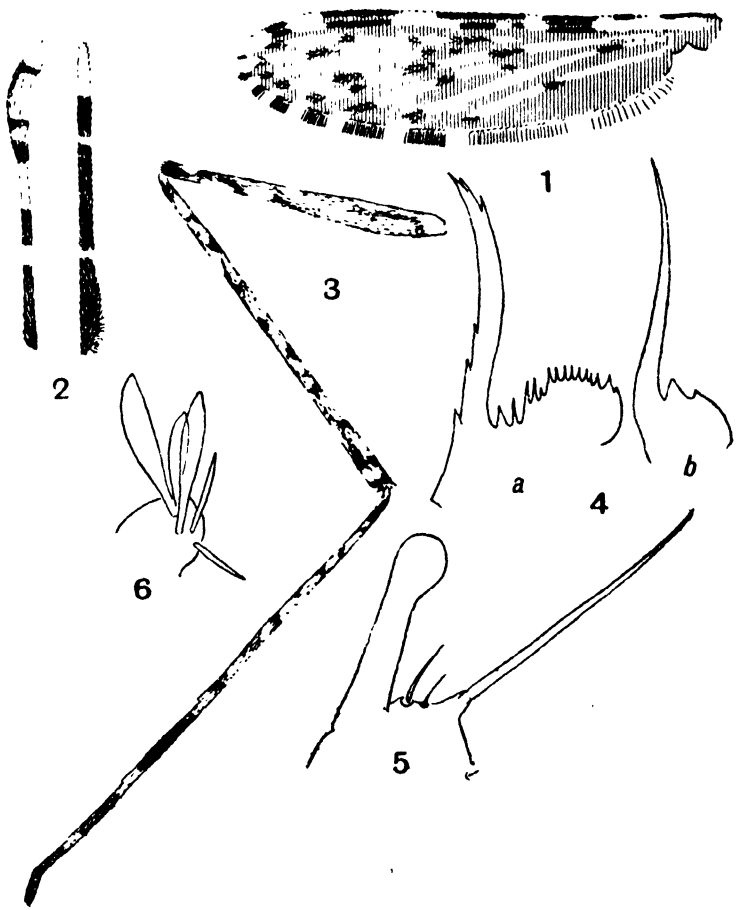
† HYPOPYGIUM: Christ. 1915, p. 393; Swell. 1921 *a*. p. 47; King 1932, p. 320.

but the apical hair at most 1½ times the length of the club as against twice in *A. subpictus*.

PUPA.—Undescribed.

LARVA *.—Closely resembles *A. subpictus* in almost every particular. Ghosh, 1932, has recently called attention to the

Fig. 40.



A. sundaicus.

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp, same scale. 3. Front leg. 4. Pharyngeal teeth: (*a*) lateral view of cone; (*b*) same of rod. 5. Apex of harpago. 6. Leaflets of phallosome of one side, standard scale.

* LARVA: Stanton 1912 *b*, p. 6; Strickl. 1915 *a*, p. 321; Mangk. 1919, p. 60; Swell. and Swell. 1919 *a*, p. 36; 1920 *b*, p. 87; Lamborn 1921, p. 93 (tail-hooks); Walch and Soesilo 1929, p. 453 (pecten); Puri 1928 *b*, p. 524; 1931, p. 139; King 1932, p. 316; Ghosh 1932, p. 1085.

head-pattern and the method of branching of hair no. 5 (*Puri*) on the mesothorax. In *A. subpictus* the three dark spots lying behind the frontal hairs are entirely distinct, but in *A. sundaicus* they are joined up into a transverse band by a cloud; a similar appearance is, however, seen in salt-water *A. subpictus*. Hair no. 5 in *A. sundaicus* normally has 3 branches on either side, rarely 3 on one side and 2 on the other, or sometimes 4 and 3 branches, and the branches arise towards the base of the hair; in *A. subpictus* it normally has 2 branches on either side, only rarely 3 and 2, and very rarely indeed 3 on either side, and the branches arise anywhere along the length of the hair, in the two exceptional cases noted the third branch arising towards the apex.

EGG *.—Somewhat resembles that of *A. vagus*, but the frill, though continued over the floats, is transparent and without striations in this portion of its extent. The upper surface is ornamented with punctæ only around the margins. The floats have about 20 ridges, as against about 25 in *A. vagus* and nearly 40 in *A. subpictus*; they are also somewhat narrower.

IDENTIFICATION.—The three forms *A. ludlowi*, *A. litoralis*, and *A. sundaicus* are given by King as distinct species (see table of differences given in this section). So far as known, only the form *sundaicus* occurs in the Indian area.

A. stephensi has a superficial resemblance to *sundaicus*, but is at once distinguished by the two broad palpal bands and the broad scaling of the mesothorax.

No difficulty normally exists in distinguishing *A. sundaicus* from *A. subpictus* or *vagus* in the case of unrubbed specimens where the speckling is not obscured or a false effect of speckling caused by irregular rubbing off of scales in the two latter species. The most useful subsidiary methods of identification in such circumstances are the longer preapical dark spot, the shorter petiole of the anterior forked cell, the absence of broad scales on the fossæ, and in the case of the male the very characteristic difference in the leaflets, which can be seen, even without special preparation, to be noticeably much shorter in *A. sundaicus*.

The following characters (taken from King's work) give the chief points of distinction between the various speckled-legged *ludlowi*-like forms, none of which, however, except *A. sundaicus*, have been recorded in or near the Indian area :—

1. Sixth vein with three dark spots; an extra fringe-spot between 5.1 and 5.2; male genitalia very peculiar	*parangensis*.
Sixth vein with two dark spots; no fringe-spot between 5.1 and 5.2; genitalia of *subpictus* type	2.

* Egg. Strickl. 1915 *a*, p. 321 · Christ. and Barr. 1931 p. 175.

2. Costal accessory spot commonly bridged; prehumeral basal accessory costal spot with white scales anteriorly; main costal spot with two dark areas on vein 1; fossæ with scattered broad scales; fore legs yellow-scaled beneath; leaflets of phallosome short, blade-like, fusiform ..... *litoralis*.
   Costal accessory spot not bridged; prehumeral basal accessory costal spot without pale scales anteriorly; fossæ without broad scales; fore legs dark or largely dark beneath ..... 3.
3. Main costal spot with three dark areas in vein 1; fringe-spot between 5 and 6 commonly present; petiole of anterior forked cell not markedly shorter than cell; tarsus of mid-legs usually without basal pale banding; main leaflet of phallosome long, somewhat S-shaped, with some marked serrations ..... *ludlowi*.
   Main costal spot with two dark areas on vein 1; fringe-spot between 5 and 6 unusual; petiole of anterior forked cell markedly shorter than cell; tarsus of mid-legs usually with basal banding; leaflets of phallosome short, blade-like, fusiform, without obvious serrations ..... *sundaicus*.

DISTRIBUTION.—*A. sundaicus* is distributed through the coastal regions of a large part of the Oriental Region, being recorded from MOLUCCAS (?) (Ceram, Amboina, Ternate); CELEBES (?) (with Boeton); LESSER SUNDA ISLANDS (Flores, Soembawa, Pantar, Alor, Wetar, Roma, Timor); JAVA (with Edam and N. Kambangan); SUMATRA (with Poeleh Weh, Riouw, Linga, Biliton, Simaloer, Sabang, Nias, and Engano Islands); ANAMBA ISLANDS; BORNEO; MALAY PENINSULA; SIAM; INDIA, BURMA, and ANDAMANS.

A. ludlowi (*sundaicus*) is given as recorded from S. China by Brug, 1926, yet I have been unable to trace any other record. It does not seem to have been recorded (in any form) from any part of French Indo-China. *A. hatorii* Koidzumi from Formosa is considered by King to be most probably *A. ludlowi* (type) and *A. sundaicus* presumably does not occur in Formosa or the Philippines. Walch and Soesilo, 1929, p. 184, state that the island of Laboean Marege is the northern limit, and that *A. ludlowi* (*sundaicus*) has not been correctly recorded up to date from Celebes. The same probably applies to records from the Moluccas, where *A. parangensis* has very probably been mistaken for this species. *A. sundaicus* is for the most part recorded only from coastal localities, but it occurs inland in certain areas in Sumatra (Padang, Tapanoeli, Lake Toba).

In the Indian area *A. sundaicus* is recorded with certainty only from the Sundarbans (deltaic area of Ganges and

Brahmaputra), the Andaman Islands, and Lower Burma. *A. ludlowi* is recorded by James, 1914, p. 263, in his list of Colombo mosquitoes, but it has not been recorded since, and is thought not to occur by Carter.

BIONOMICS.—*A. sundaicus* is found abundantly in houses, cow-sheds and such like situations, and is recorded as being taken gorged with human blood in sleeping rooms and nets (*Christ.*, 1912 ; *Schüffner, Swell.* et al., 1919 ; *Barnes*, 1923 ; *Stookes*, 1929 ; *Covell*, 1927, Andamans, and others). Out of 51 specimens Walch and Sardjito obtained a precipitin reaction with both human and buffalo blood, 25 caught in houses giving 16 human and 9 buffalo, and 26 caught in stables giving 3 human and 23 buffalo.

Apart from its special predilection for human blood, the outstanding features of its bionomics are its close association with coastal conditions and its preference for breeding in brackish water. The species breeds pre-eminently in salt swamps, collections of brackish water behind coastal bunds, and suchlike situations (*Lalor*, 1912 ; *Christ.*, 1912 ; *Covell*, 1927, Andamans ; *Iyengar*, 1931). In the Dutch East Indies it is especially associated with the numerous fish-ponds on the coast. It is usually found associated with vegetable and algal growth, especially the alga *Enteromorpha*, which forms a felt-work on the surface of the water in the Javanese fish-ponds (vide *Breemen*, 1919, 1920 ; *Walch* and *Schuurman*, 1929). It was found breeding by Covell in clear-water pools without vegetation on the coral beach. It is recorded as frequently breeding in polluted water (*Lalor*, 1912 *b* ; *Rodenw.* and *Essed*, 1925). According to Rodenwaldt and Essed it thrives best in 1·2 to 1·8 per cent. salt, but unless the water contains more than 3 per cent. salt it is indifferent to salinity ; it disappears when the salt reaches 4 per cent. Christophers, in the Andamans, and also Iyengar, 1931, in Bengal, found the usual salt-content of breeding places about 0·4 per cent.

The species is a strong flier, and may cover up to 5 kilometres distance from its breeding places (vide *Breemen*, 1919).

RELATION TO DISEASE.—*A. sundaicus* has been infected experimentally with all three species of malaria parasites, and has transmitted M.T. malaria experimentally. It has been frequently found infected in nature and associated with the active transmission of malaria. It is one of the most effective carriers of the disease known.

Group *PARAMYZOMYIA*.

Puri, Ind. Med. Res. Mem. no. 21, p. 62, 1931 (Group 6).
Christophers and Barraud, Rec. Mal. Surv. ii, p. 168, 1931 (*Paramyzomyia*).
Edwards, Gen. Insect. Fasc. 194, p. 48, 1932 (Group D, *A. turkhudi* group).

Type-species, *A. turkhudi* Liston *.

Pharyngeal armature with two rows of teeth differentiated as cones and rods, the cones with short roots; crest of pediment with a single row of spines, not appearing bifurcate in posterior view; pediment in anterior view bulbous, with narrowed neck, and lateral teeth inconspicuous. Lateral flanges well developed.

Propleural hairs of adult present, usually several.

Palpi of ♀ with apical segment long; apex dark, or last segment with a dark area and not included in pale apical band †. Ornamentation otherwise much as in group *Myzomyia*.

Pupa: spine well developed on segs. III–VII or even II–VII; hair *C* simple on seg. IV.

Larva: posterior clypeal hairs usually very long; cone-shaped appendage on maxillary palp in some cases at least bifid. Pleural hairs varied, those of *A. turkhudi* and *A. hispaniola* peculiar, those of *A. multicolor* as in group *Neocellia*. The following gives the characters of the pleural hairs so far as known :—

	1.	2.	3.
da	Long, feathered.	Long, feathered [1].	Long feathered.
va	Long, simple.	Long, feathered [2].	Long, feathered.
dp	Long, approaching [3] length of anterior hairs, feathered.	Very minute [4].	Very minute.
vp	Long, simple.	Short, slender [5], splitting distally into 2–3 br.	Very short, split [6] distally into 2–3 br.

In *A. multicolor* ‡ :—[1] Sparsely feathered. [2] Simple. [3] One-third length anterior only, simple or 2–3 br. [4] Extremely short, simple. [5] One-fourth length anterior, simple. [6] Short, simple.

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* The other species that appear to belong to this group are *A. hispaniola*, *A. italicus*, *A. flaviceps*, *A. listeri*, *A. multicolor*, *A. broussesi*, and *A. cinereus*.

† All species of the group have the apex of the palps dark except *A. cinereus*, where, however, the apical segment is largely dark.

‡ On the characters of the pleural hairs, as pointed out by Puri, *A. multicolor* would be included in group *Neocellia*. I have placed it in the present group, however, on the characters of the pharyngeal armature, in which it clearly resembles *A. turkhudi*, and is quite unlike group *Neocellia*; other differences from *Neocellia* are: propleural hairs present; spines of the pupa not as in *Neocellia*, but resembling *turkhudi*; palpi of female dark-tipped.

Species occurring in the Indian Area.

The species at present included in the group are chiefly North African and Mediterranean, and the Indian members of the group clearly belong to this fauna. The following are recorded from the Indian area :—

A. turkhudi Liston. *A. multicolor* Cambouliu.

29. **Anopheles turkhudi** Liston, 1901 *. (Fig. 41.)

Liston, Ind. Med. Gaz. xxxvi, p. 441, Dec. 1901 (*A. turkhudi*). TYPE-LOC. : Ellichpur, Berars, India. TYPE : ♀ in Brit. Mus.

SYNONYM :

persicus Edwards, 1921, Bull. Ent. Res. xii, p. 280 (*A. turkhudi* var. *persicus*). TYPE-LOC. : East Persia (*Major J. A. Sinton*). TYPE : ♂ in Brit. Mus. SYN. by Edw., Riv. di Mal. v, p. 284, 1926, and Gen. Insect. p. 55, 1932.

RECOGNIZED VARIETY :

azriki Patton, 1905, Journ. Bomb. Nat. H. Soc. xvi, p. 632 (*A.* (*Myzomyia*) *azriki*). TYPE-LOC. : Azrika Spring, near D'thala, Aden Hinterland. Given as var. of *A. turkhudi* by Christ., 1924 *c*, p. 54 ; see also Christ. and Khazan Chand, 1915, p. 190.

The ♂ type of *A. culicifacies* Giles. Aug. 1901, is a specimen of *A. turkhudi* (see note under *A. culicifacies*).

A. azriki Patton differs in no respect, as described by Patton, from *A. turkhudi* except in the all dark fringe ; though still retained as a variety, it is probably synonymous with *A. turkhudi*. *A. flaviceps* Edw., Bull. Ent. Res. xii, p. 69, 1921, from the Anglo-Egyptian Sudan, must be very closely related and has pharyngeal characters closely resembling those of *A. turkhudi*. *A. turkhudi* var. *persicus* was described from a damaged male, which is apparently a typical *turkhudi*, with which was associated in error a female *multicolor*.

A. multicolor and *A. hispaniola*, with their synonyms, were incorrectly sunk by Gough, 1914, p. 133, under *A. tukhudi*, and have been referred to by some authors under this name ; the *A. turkhudi* of Bahr, Journ. R.A.M.C. xx, p. 606, 1918, and Lancet, 10 Jan. 1920, p. 79, and of Storey, Bull. Soc. Entom. Egypt, 1918, no. 4, p. 93, are *A. multicolor*.

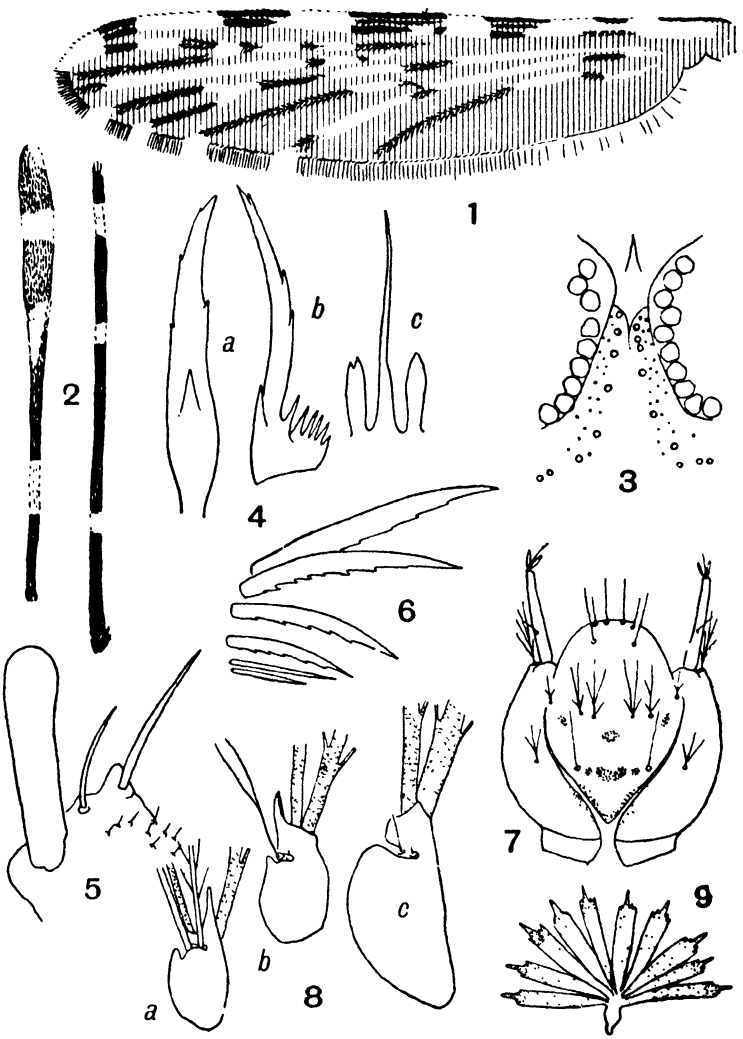
ADULT ♀.—Size large (length of wing 3·3–4·6 mm.).

Head : scales of usual type, with a small pale vertical spot ; vertical chætæ dark or parti-coloured, forming a single line of about five hairs ; ocular scales narrow, numerous. *Antennæ* : torus devoid of scales ; pale scales present on first flagellar segment. *Palpi* long and thin, cylindrical and smooth to base ; apical segment long, about $\frac{1}{3}$ of the long preceding segment, index 0·37 ; apical segment dark, except for its basal portion, with rather conspicuous stout

* SYSTEMATIC : Liston 1901, p. 441 ; James and Liston, 1904, p. 115 ; 1911, p. 78 ; Christ. and K. C. 1915, p. 190 ; Langeron 1921, p. 371 ; Christ. 1924 *c*, pp. 53, 93 ; 1929, p. 521. See also James 1902, p. 9 ; Theo. 1902, p. 379 ; 1903, p. 48 ; 1907, p. 52 ; 1910 *a*, p. 26 ; Christ. 1916, p. 483 ; 1930, p. 192. See also references on pp. 255–6 (footnotes).

black chætæ at tip; dark apical area usually somewhat longer, but sometimes about equal to, or double, the pale band over joint 4–5; further pale bands at 3–4 and 2–3.

Fig. 41.



A. turkhudi.

1. Wing of ♀, standard scale. **2.** ♂ and ♀ palp, same scale. **3.** Vertex. **4.** Pharyngeal teeth: (*a*) anterior view of cone; (*b*) lateral view of same; (*c*) rod and two crests in posterior view. **5.** Apex of harpago. **6.** Leaflets of phallosome of one side, standard scale. **7.** Head of larva. **8.** Basal tubercles of pleural hairs of larva; *a–c*, pro-, meso- and metathoracic. **9.** Palmate hair of abd. seg. IV. (**7–9** after Puri.)

Pharynx: cones and rods each numbering about 20; former with short roots; filament broad at base, merging into anterior portion of pediment, long, tapering, with spicular processes along edges and rising from convexity, the termination pointed; pediment bulbous, constricted at neck, without obvious lateral teeth, but with some narrow, sharp, post-filament spines and an anterior spine; crest with a single row of spines, its posterior portion narrow, pointed in optical section. Rods somewhat shorter than cones, with conically expanded bases, portion swollen, ending rather abruptly in fine, terminal, simple filament. Lateral flanges well developed. Posterior pair of dorsal papillæ sometimes about equally distant to the others.

Thorax with chætæ only on *apn*; propleural hairs about 4. Mesonotum rather uniformly coloured, without conspicuous contrast between lateral and median areas; the median area covered with small, curved, light-coloured hairs, or sometimes rather broader false scales, narrow pale scales present in median area of promontory and extending backwards a variable distance; fossæ and lateral areas with chætæ only except over root of wings, where there are some small curved hairs. Pleuræ pale ochraceous, often greenish, devoid of scales; spiracular hairs 2; prealar 9; upper mesepimeral numerous (21).

Wing as in fig. 41, 1; base of costa mainly dark, with a pale interruption just external to humeral and a further, usually broader, interruption internal to inner costal spot, vein 1 in this area more or less dark, dark area usually more or less opposite line of dark scales on costa between interruptions rather than opposite inner pale interruption, as in *A. culicifacies*; amount of dark scaling somewhat variable. Middle dark costal spot with a marked acc. sector on vein 1; pale interruptions in apical portion of costa rather wide, as extensive as the dark, or nearly so. Not infrequently there may be a pale interruption on 2.1 and sometimes one on 4.1. Vein 3 is most usually light scaled in greater part of its extent, but is often all dark. The apical pale area usually extends just beyond 2.1, the fringe then being dark to the pale spot at 4.2, but often showing some indication of spots at 2.2 and 3, the border scales, however, usually dark in these situations; border scales dark to about half-way between junction of vein 6 and base of wing, when they cease. Scaling of wing narrow; max. str. 7–8.

Legs with front femora not swollen. Femora uniformly darkish, with little or no paling beneath or at articulation with trochanters, the apices indistinctly, if at all, pale; tibiæ similarly dark, but with distinct pale scales amounting to a narrow band at apices; the first tarsus, and often some

of the other joints, just picked out by apical taches scarcely amounting to bands. Coxæ pale, devoid of scales.

Abdomen lightish or mottled, clothed with light hairs; entirely devoid of scales even on cerci.

ADULT ♂.—In general as in ♀. *Palpi* ornamented as in fig. 41, 2, club mainly dark, extreme apex more or less pale, but usually with dark chætæ; a pale area extending some distance down stem and a broad pale area at pseudo-joint involving about apical ⅓ of seg. 2; marginal hairs forming about a double row on sides of seg. 4. *Abdomen* entirely devoid of scales, even on the coxites.

Hypopygium *: parabasal spines rather slender. Harpago with apical spine about same length or somewhat longer than club, a smaller spine, about half its length, between apical spine and club. Phallosome somewhat less than half length of coxite, with about 5–7 leaflets on each side, longest between half and ⅓ length of phallosome; larger leaflets narrow, pointed, rather finely serrated on flatter edge. Ninth tergite with angular dorso-lateral expansions.

PUPA †.—*Paddle*: external border with spines on posterior half large, coarse, blunt, resembling somewhat teeth of a saw, these extending a little beyond corner on posterior border and without hairs continued towards the paddle-hair; paddle-hair long, strong, hooked; acc. hair simple.

Spine: (VIII) about half length segment; the core flattened, acc. hair simple, expanded. (II–VII), spine half to ⅔ length of segment.

Hair B: (III–VII) 3–4 br., about as long as segment.

Hair C: (IV–VII) simple, somewhat longer than segment or about same length. (III) 2–3 br.. about as long as segment.

LARVA ‡.—*Clypeal hairs* simple; *ic* long, slender; *oc* about half length of inner; *pc* very long, a little longer than inner, usually lying external to outer and extending well beyond end of fronto-clypeus. *Frontal hairs* with only 2–6 br., arising near base, the distal ends hardly reaching bases of posterior clypeal. *Subantennal hair* with only 3–6 rather stout branches on each side. *Antenna* with hair arising about ⅓ from base; cone nearly twice as long as finger; terminal hair stout, simple. *Mandible* and *mouth-brush* peculiar (see *Puri* and *Iyengar*). *Maxilla* with the cone with conspicuous bifid tip. *Prementum* produced into 5–6 strong teeth, the median process with 3 teeth also present,

* HYPOPYGIUM: Christ. 1915, p. 190; Martini 1930, p. 192.

† PUPA: Senevet 1931, p. 19.

‡ LARVA: James 1902, p. 49; Steph. and Christ. 1902 *b*, p. 11; Theo. 1903, p. 49; James and Liston 1904, p. 116; 1911, p. 80; Iyengar 1930 *b*, p. 1189; Puri 1928 *b*, p. 525; 1931, p. 169.

as in other larvæ. *Mentum* with 4 teeth on either side of median tooth, about equal and equidistant; sometimes an extra small tooth at end of row.

Shoulder hairs: inner and middle arising from separate, slightly chitinised basal tubercles; both hairs about same size, feathered. *Metathoracic hair no.* 1 resembles ordinary hair, very short, 2–4 br. *Pleural hairs* as given under group; the chitinous tubercles very large, larger than those of any other Indian species; a well-marked spur on all the segments.

Palmate hairs developed only on IV–VII; leaflets small; filament short, about $\frac{1}{4}$ length of blade; serrations at shoulder absent or very poorly developed. *Lateral hairs* on IV–VI feathered, though not so stout as those on I–III; that on VI with only 5–6 br.; on VII very short, with 3–5 br. *Tergal plates* rather small, without paired oval plates. *spc* well developed; anterior portion of *mps* fairly broad, but not touching chitinisation. *Pecten* with 3–5 long and 4–7 short processes, some of the latter very short, the serrations fine, inconspicuous. *ps* hair 3–5 br. Caudal hooks 5–6, well defined. *Ventral surface* devoid of minute setæ except for patch on either side of anal opening.

Egg *.—Smooth, without floats or other structures, other than a small oval patch on one surface towards larger end suggesting a vestigial upper surface and frill; a scalloped line around larger end of egg. Closely resembling a *Culex* egg.

Identification.—*A. multicolor* is the only other Indian species having a dark apex to the palpi in the female. It is distinguished from *A. turkhudi* by the broad scaling covering the mesonotum, more vivid wing-markings and broader scales on some of the veins, and three clearly-defined dark spots on vein 6. In the case of the male, the presence or absence of leaflets at once differentiates the two species.

Besides the character of the female palpi, *A. turkhudi* is distinguished from *A. culicifacies* by the following:—Base of vein 4 pale; border scales not extending to base of wing; fringe-spots present at all veins but 6; apical banding of tibiæ more marked; tarsi usually showing some light points at joints. Further, the dark area on vein 1 in the basal area if, present, is placed opposite the dark area on the costa, not opposite the pale gap as in *A. culicifacies*. The male *turkhudi* is distinguished at once by the extensive pale area on the shaft of the palp, and commonly the palp has black, not pale, chætæ at the tip.

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* Egg: James 1902, p. 49; Steph. and Christ. 1902 *b*, p. 11; Theo. 1903, p. 49; James and Liston 1904, p. 116; 1911, p. 80; Gill 1912, p. 3; Edw. 1921 *b*, p. 268; Christ. and Barraud 1931, p. 184.

The male is distinguished from *fluviatilis* by the presence of interruptions at the base of the costa and the extensive pale area on the shaft of the palp as referred to above.

DISTRIBUTION.—Recorded outside the Indian area only from EAST PERSIA and S.W. ARABIA (Aden Hinterland). In India recorded from many localities in the north-west and the central and western portions of the Peninsula, including Gujarat and the Madras Deccan. It has not been recorded from United Provinces east, Bihar and Orissa, or any area east of this, nor south of Mysore.

BIONOMICS.—Adults are caught, where the species is prevalent in houses, *e. g.*, in villages in the Kasauli area (see also *Gill*, 1912).

It is found breeding especially in pools, or shallow seepages, with much algal growth in sandy river-beds, nullahs, etc., also in pools in the bed of hill-streams (*Christ.*, 1911 ; *Gill*, 1912 ; *Kenrick*, 1914).

It occurs in the plains but is not uncommonly found at some elevation ; has been found breeding near Kasauli at 4,000–5,000 feet (*Christ.*, 1911), and adults have been captured at 6,000 feet at Kasauli (*Gill*, *Acton*, and *Christ.*, 1911) and at Murree at 7,000 feet (*Gill*, 1912).

RELATION TO DISEASE.—*A. turkhudi* has been experimentally infected with M.T. malaria to the zygote stage (*Steph.* and *Christ.*, 1902) ; no dissections of the species in nature are recorded.

30. **Anopheles multicolor** Cambouliu, 1902 *. (Fig. 42.)

Cambouliu, C. R. Acad. Sci. cxxxv, p. 704, 1902 (*A. multicolor*, a). TYPE-LOC. : Suez, Egypt. TYPE : ♀ described ; location unknown.

impunctus Dönitz, 1902, Zeit. f. Hyg. xli, p. 67 (*A. impunctus*). TYPE-LOC. : Wadi-Natrun, near Alexandria, Egypt. TYPE : described from a balsam specimen. SYN. by Edw., Bull. Ent. Res. xii, p. 280, 1921. *impunctata* of Blanchard, 1905, p. 622.

chaudoyei Theo., 1903, Mono. Cul. iii, p. 68 (*Pyretophorus chaudoyei*). TYPE-LOC. : Touggourt, Algerian Sahara. TYPE : described from a series of ♀♀ ; type ♀ in Brit. Mus. SYN. by Edw., *loc. cit.*

cleopatræ Willcocks, 1910, Ann. Trop. Med. and Par. iii, p. 586 (*Pyretophorus cleopatræ*, name without description). TYPE-LOC : Cairo, Egypt. TYPE : in L'pool Sch. Trop. Med. (see Christ., 1924 *c*, p. 24). SYN. by Edw. *loc. cit.*

nigrifasciatus Theo., 1907, Mono. Cul. iv, p. 65 (*Pyretophorus nigrifasciatus*). TYPE-LOC. : Peshin, British Baluchistan, India. TYPE : ♀ in Brit. Mus.

In North Africa this species was long known as *A. chaudoyei*. In N.W. India it was known as *A. nigrifasciatus*, though possibly not all later references under that name relate to the species. *A. nigrifasciatus* of Davys, Paludism, no. 5, p. 46, 1912, is *A. superpictus*, with the extra dark band on the palps.

* For references see next page.

ADULT ♀ *.—Size rather large (length of wing 3·6–4·7 mm.). *Head*: scales of usual type, with a diffused pale vertical area; vertical chætæ dull yellowish, forming a row ending anteriorly in a clump of about 10 short chætæ which form a short frontal tuft; ocular scales numerous, broadish. *Antennæ*: torus and first 3–4 flagellar segments carrying some small pale scales. *Palpi* long, thinnish, smooth and cylindrical to base; apical segment about ¼ of the long preapical, index 0·24; this segment dark except basally, with very conspicuous stout chætæ forming brush-like tuft at apex; dark apical area preceded by band over joint 4–5, usually about the same extent as the dark apical area; two further pale bands at 3–4 and 2–3.

Pharynx †: very similar to *A. turkhudi*. Rods and cones about 15–16 in each row; crest with single line of spines, slightly differentiated from line of post-filament spines; filament broad as pediment at base, with a median anterior spicule and lateral and terminal spicules in distal half; posterior view of crest narrow, papilliform. Rods as in *A. turkhudi*.

Thorax with chætæ only on *apn*; propleural hairs two or more. Mesonotum somewhat darker at sides; median area and fossæ, as well as laterally over wing-roots, covered with narrow but distinct creamy scales, somewhat broader on fossæ; str. about 7–8. Anterior promontory with a median tuft and often some pale scales laterally. Pleuræ with some pale scales on sternopleura; spiracular hairs 5; prealar 10, with some scales; upper mesepimeral about 16.

Wings as in fig. 42, 1. Costa pale at extreme base and at humeral *cv*, also usually a pale interruption at inner side of inner costal dark spot; vein 1 in this area with some dark scaling; middle dark costal spot with dark area on vein 1 considerably shorter at inner end than that on costa, or latter also short when whole spot is short; pale areas on costa in apical half as wide as, or wider than, the dark. Branches of 2 with marked interruptions; vein 3 mainly pale; branches of 4 with interruptions, and base of stem extensively pale; some of the dark spots on wing-field, *e. g.*, at base of 4.2 and

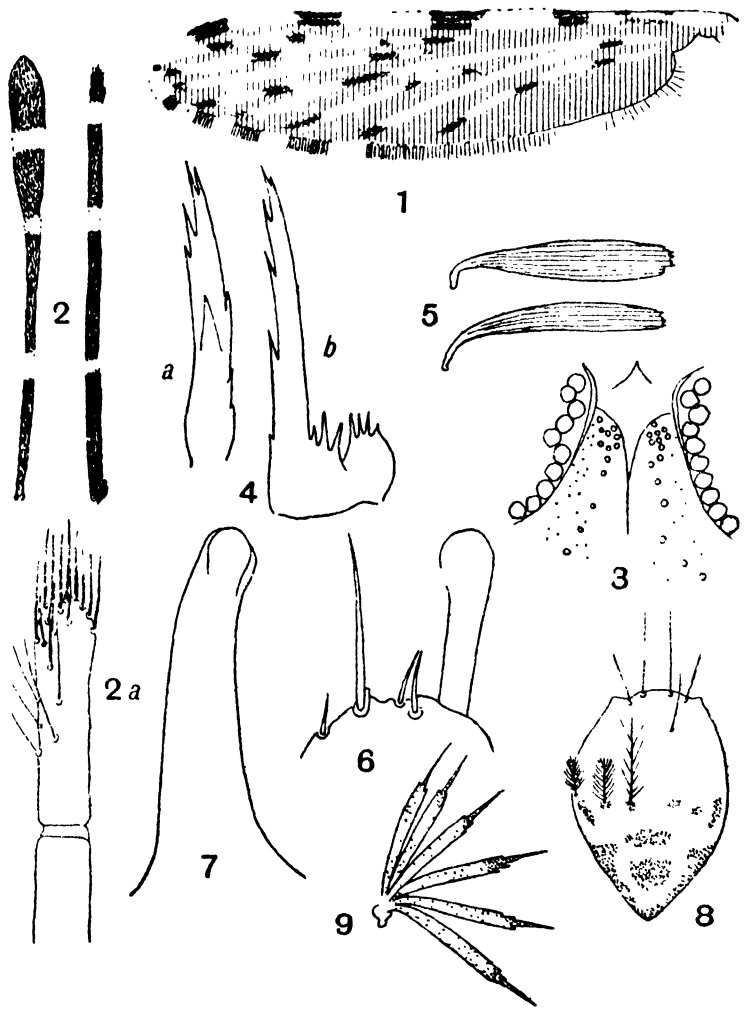
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* SYSTEMATIC: Foley 1912, p. 49 (*chaud.*); Sergent and Foley 1914, p. 419 (*chaud.*); Edw. 1912, p. 249; 1921 *a*, p. 280; 1926, p. 284; Langeron 1921, p. 371; Christ. 1924 *c*, pp. 54, 93; Seguy 1924, p. 156 (*chaud.*); Kirkp. 1925, p. 62; Edw. 1929 *b*, p. 87; Christ. 1929, p. 522. See also Sergent, Ed. and Et., 1905, p. 6; Theo. 1903, pp. 54, 68; 1904, p. 68; 1907, p. 126; 1910, pp. 29, 38, 85; James and Liston 1911, p. 83; Gough 1914, p. 133; Christ. 1916 *a*, p. 483; Martini 1930, p. 177. See also pp. 260–1 (footnotes).

† PHARYNX: besides Sinton and Covell, and Barraud and Covell, see Puri 1928 *b*, p. 527.

stem 2, sometimes deficient, or branches of 4 and 5.1 may be without pale areas ; vein 6 nearly always with three dark spots, but sometimes with outer half continuously dark. Apical pale spot extensively involving 2.1 ; fringe-spots as shown ; border scales scattered after about 5.1 and deficient

Fig. 42.



A. multicolor.

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp, standard scale. 2 *a*. Apical segment of ♀ palp. 3. Vertex. 4. Pharyngeal teeth : (*a*) anterior, (*b*) lateral view of cone. 5. Thoracic scales. 6. Apex of harpago. 7. Phallosome. 8. Head of larva. 9. Portion of palmate hair of segment IV. (8–9 after Puri.)

for most of the distance internal to vein 6. Scaling of wing narrow to moderately broad ; max. str. 8–9.

Legs with front femora not swollen in basal half. Femora pale beneath throughout whole extent ; tibiæ somewhat pale at base and with well-marked pale area at apices ; tarsi not definitely banded, but sometimes with apical taches ; last segment of hind tarsus often indefinitely pale.

Abdomen entirely devoid of scales even on cerci.

ADULT ♂.—In general as in ♀. *Palpi* with club mainly dark; apex dark or mainly so, some scattered dark chætæ at tip, ornamented as shown, pseudo-joint with a pale band of moderate extent ; marginal hairs in rows of about two deep on seg. 4. *Abdomen* devoid of scales except on coxites.

Hypopygium * : parabasal spines rather slender. Harpago with apical hair shorter than club ; usually with two small hairs about $\frac{1}{4}$ length apical hair between this and club and a similar hair internal to apical hair. Phallosome distinctly less than half length of coxite, rather broad and massive at base ; leaflets absent.

PUPA †.—*Paddle* : spines on posterior half of external border long, thin, and sharp, abruptly replaced by hairs a little longer than the spines, which are continued to the paddle-hair ; paddle-hair elongate, often twisted ; acc. hair short, trifurcate.

Spines and chief hairs as in *A. turkhudi*, but hair *C* simple also on seg. III, and on other segments somewhat longer than in that species.

LARVA ‡.—*Clypeal hairs* simple ; *ic* moderately stout ; *oc* about $\frac{2}{3}$ length of inner ; *pc* a little longer than, or about equal to, *ic*, lying external to, and their distal ends reaching far beyond, the bases of these. *Frontal hairs* normal. *Subantennal hair* normal. *Antenna* with hair arising $\frac{1}{3}$ to half length of antenna from base ; the cone about twice length of finger ; terminal hair split about middle into 2–3 br. *Mandible* with teeth of usual character. *Maxillary palp* with cone very dark and bifid for $\frac{1}{3}$ to half its length. *Mentum* with four teeth on either side of median tooth, three about equal and equidistant, the fourth a little smaller and further back.

Shoulder hairs : inner without conspicuous tubercle, shorter and with fewer branches than middle hair ; middle hair with moderately developed tubercle. *Metathoracic hair*

* HYPOPYGIUM : Edw. 1921 *a*, p. 280 ; Kirkp. 1925, p. 63 ; Senevet and Prunelle 1928, p. 483.

† PUPA : Theodor 1925, p. 380 ; Kirkp. 1925, p. 65 ; Senevet 1930, p. 316.

‡ LARVA : Foley 1912, p. 49 ; 1918, p. 549 ; Langeron 1918, p. 291 ; 1921, p. 371 ; Edw. 1921 *a*, p. 280 ; Séguy 1924, p. 158 ; Theodor 1925, p. 379 ; Edw. 1926, p. 284 ; Puri 1931, p. 174.

no. 1 resembling ordinary hair, very short, and split into 2–3 br. *Pleural hairs* as given under group; the general arrangement as in group *Neocellia*.

Palmate hairs well developed on III–VII, less well developed on II; leaflets more or less uniformly pigmented, narrow; filament well differentiated, about $\frac{2}{3}$ length of blade, rather broad at base and sharply pointed distally; shoulder well marked, but serrations poorly developed. *Lateral hairs* on IV–VI slender, with 2–3 br.; on VII short, with 3 br. *Tergal plates* small, without paired oval plates. *spc* fairly well developed; anterior portion of *mps* very broad, its borders nearly touching the chitinisation. *Pecten* with seven long and seven short projections, finely serrated on basal half. *ps* hair with 4–5 long br. Caudal hooks 6–7, poorly defined; *ventral caudal* with the longest hairs hooked at ends. *Anal papillæ* very short, reduced to stumps.

Egg *.—Upper surface broad, surrounded by well-developed fringe at ends, but this deficient in middle region, where floats are ordinarily present. Floats absent. Eggs, probably due to absence of floats making lateral areas convex, tend to form themselves in straight lines on the water.

Identification.—The following are points in which *A. multicolor* differs from *A. turkhudi* and *A. superpictus*, the species on the Indian list most resembling it in general characters:—(*a*) In *multicolor* the fossæ at the sides of the mesonotum are covered with scattered broad scales, this area being devoid of scales in *turkhudi* and *superpictus*; (*b*) the extreme base of the costa is light in *multicolor*, dark in *turkhudi* and *superpictus*; (*c*) there is a well-marked patch of scales on the upper part of the sternopleuron in *multicolor*, few or no scales in the other two species; (*d*) there is a dark tuft of spines at the tip of the ♀ palpi in *multicolor* and to a somewhat less extent in *turkhudi*; the chætæ at the tip are pale in *superpictus*, even when the extra dark band is present on the palpi in this species.

In the case of the ♂ the palpi are usually dark at the extreme tip in *multicolor*, whilst in *turkhudi* the tip is usually distinctly pale-scaled and in *superpictus* markedly so; the chætæ are dark in the first-mentioned species, pale in the latter. In *A. superpictus* there is a spot towards the upper edge of the club, instead of the transverse band across the organ as in *multicolor* and *turkhudi*; the stem is extensively pale in *turkhudi*, not so in *multicolor*.

Distribution.—A desert species with a distribution ranging throughout the Sahara to Baluchistan. Recorded

* Egg: Foley 1912, p. 49; Edw. 1921 *b*, pp. 268, 280; 1926, pp. 261, 284; Langeron 1921, p. 374; Séguy 1924, p. 157; Christ. and Barraud 1931, p. 187.

from NORTH AFRICA (South Oran, South Constantine, Central Sahara, Tunis); CYPRUS; ANATOLIA; EGYPT; PALESTINE; EAST PERSIA; BALUCHISTAN.

In the Indian area recorded only from Baluchistan (Peshin, Fort Sandeman) and the Persian frontier (Duzdap, Seistan). The specimens previously recorded as this species from Waziristan (Derajat area) are *A. turkhudi*.

BIONOMICS.—*A. multicolor* in Egypt readily enters houses and bites by night (*Kirkpatrick*).

It breeds in saline desert waters. Sergent, Ed. & Et., and Foley state that it can live in water with up to 144·9 NaCl per litre. It has been reared in 2 per cent. salt by Gough in Egypt, and recorded from salt-pans in Palestien (*Buxton*). Kirkpatrick notes that it breeds most often in small pools, with or without weeds, stagnant or flowing, and in disused shallow wells; it was never found in rice-fields. It occurred in water of various salinities from 0·1 per cent. upwards, the highest percentage found being 5·96. *Cleopatræ* was found breeding by Willcocks in 2·56 to 3·25 per cent. salt. The species travels considerable distances on the wind and has been found 8 miles from the nearest possible breeding place (*Kirkpatrick*).

RELATION TO DISEASE.—The species has been infected experimentally with M.T. parasites by Bahr (*turkhudi*), 96 oocysts being found in the one specimen infected. Covell notes that, though suspected on epidemiological grounds to be a carrier, it does not seem to have been found infected in nature. It is the recognized carrier species of Saharan oases, where it is often the only, or only abundant, anopheline present (*Foley* and *Yvernault, Sergent, Ed. & Et., Foley, Parrot*).

Group *NEOCELLIA*.

Christophers, Ind. Med. Res. Mem. no. 3, p. 62, 1924.

Neocellia Theobald, Mono. Cul. iv, pp. 23, 111, 1907. TYPES: *A. indica* Theo., *A. dudgeoni* Theo., and *A. intermedia* Rothwell.

Type-species *A. maculatus* Theo.*

Pharyngeal armature with two rows of teeth, differentiated as cones and rods, the cones without roots; crest broad, bifurcate, with two rows of spines separated by an interval, giving the appearance, when looked down upon, of a molar

* In addition to the Indian species given below, the following belong to this group :—(N. China) *A. pattoni* Christ.; (Oriental) *A. schüffneri* Stanton; (Ethiopian) *A. maculipalpis* Giles, *A. pretoriensis* Theo. The following species are noted by Puri as having larval pleural hairs of *Neocellia* type :—*A. multicolor* Cambouliu, *A. broussesi* Edw., *A. christyi* Newst. & Carter, and *A. parangensis* Ludl. The pharynx in these latter, however, entirely lacks the characteristic armature of *Neocellia*, and all have propleural hairs.

tooth with parallel rows of cusps; posterior view of crest bifid.

Propleural hairs of adult entirely absent.

Pronotal lobes without a definite scale-tuft, a few scales sometimes present; mesonotum with a covering of broad scales; wing-ornamentation of the usual pattern, commonly with brilliant contrast of dark and white, or nearly white, scaling; legs with tips of hind tarsi, in the great majority of species, white for a variable number of segments, and the tarsi of all the legs conspicuously banded with white; femora and tibiæ commonly speckled; abdomen commonly with scales at least on the last segment or two, often with small or more definite lateral scale-tufts on last few segments or more.

Pupa: spines on segs. V–VII well developed, that on IV short and usually blunt; hair *C* simple on segs. V–VII, branched on IV.

Larva: inner clypeal hairs usually frayed or branched; outer simple or more commonly branched; cone of maxilla commonly bifid. The characters of the pleural hairs are given below:—

	1.	2.	3.
da ..	Long, feathered.	Long, sparsely * feathered.	Long, feathered.
va ..	Long, simple.	Long, simple.	Long, feathered †.
dp ..	One-third length ‡ anterior, may be split into 2–3 or with 4–5 br.	Extremely short, simple.	Minute, simple.
vp ..	Long, simple.	⅓–½ anterior, slender, simple, or bifid distally.	Very short, slender, split distally into 2–4 br.

The processes on the basal tubercles may be produced into a sharp point on 1, 2, and 3, or on 1 and 2 only.

Species recorded from the Indian area.

The following species and varieties are recorded from the Indian area:—

A. superpictus Grassi.
A. moghulensis Christ.
A. stephensi Liston.
A. maculatus Theo. and var. *willmori* James.
A. theobaldi Giles.
A. karwari James.
A. jamesi Theo.
A. ramsayi Covell.
A. splendidus Koidzumi.
A. annularis v. d. W.
A. philippinensis Ludl.
A. pallidus Theo.
A. pulcherrimus Theo.

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* Devoid of branches in basal third in *A. superpictus*.

† Devoid of branches in basal third in *A. superpictus*.

‡ Rather stout, with somewhat truncated end and a number of short lateral branches in *A. ramsayi*; with one or two lateral branches in *A. annularis*.

31. **Anopheles superpictus** Grassi, 1899 *. (Fig. 43.)

Grassi, Atti R. Accad. Lincei (5), viii, p. 560, 1899 (*A. superpictus*). TYPE LOC. : Italy.

palestinensis Theo., 1903, Mono. Cul. iii, p. 71 (*Pyretophorus palestinensis*). TYPE-LOC. : Ain-ed-delb, Sidon, Palestine. TYPE : ♂ and ♀ type in Brit. Mus. SYN. by Edw., Bull. Ent. Res. xii, p. 278, 1921.

nursei Theo., 1907, Mono. Cul. iv, p. 66 (*Pyretophorus nursei*). TYPE-LOC. : Quetta, India. TYPE : described from a single ♀; type in Brit. Mus. SYN., as *palestinensis*, by Edw., Journ. Asiatic Soc. ix, p. 48, 1913 ; as *superpictus* by Edw., *loc. cit.* 1921.

cardamatisi Newstead & Carter, 1910, Ann. Trop. Med. and Par. iv, p. 379 (*Pyretophorus cardamatisi*). TYPE-LOC. : Athens, Greece. TYPE : ♂ and ♀ type in coll. L'pool Sch. Trop. Med. SYN., as *palestinensis*, by Edw., *loc. cit.* 1913 ; as *superpictus*, by Edw., *loc. cit.* 1921.

vassilievi Portchinsky, 1913 (?), ref. by Vassilief, *vide* Rev. App. Entom. ser. B, i, p. 196 (*A. superpictus* var. *vassilievi*). TYPE-LOC. : Russian Turkestan. SYN. by Shingarew, Bull. Soc. Path. Exot. xix, p. 896, 1926.

macedoniensis Cot & Hovasse, 1917, Bull. Soc. Path. Exot. x, p. 890 (*Pyretophorus macedoniensis*). TYPE-LOC. : Salonica. SYN. by Waterston, Bull. Ent. Res. ix, p. 4, 1918, and Edw., *loc. cit.* 1921.

berestnewi Shingarew, 1926, Russ. Journ. Trop. Med. iv, no. 2, p. 47, and Bull. Soc. Path. Exot. xix, p. 899 (*A. superpictus* var. *berestnewi*). TYPE-LOC. : Turkestan.

This species was first shortly described by Grassi as *A. pictus* Loew (Atti R. Accad. Lincei, viii, p. 101, 1899), but the species so described was later recognized as distinct and called *A. superpictus* (*ibid.* p. 560), a full description following under this name in 1900 (Stud. d. uno zool. s. Malaria, ed. 1, p. 78).

Until the synonomy was determined by Edwards, it was very generally known in the Mediterranean area as *A. palestinensis* and in N.W. India as *A. nursei*. It has been correctly recorded only from the extreme north-west of the Indian area.

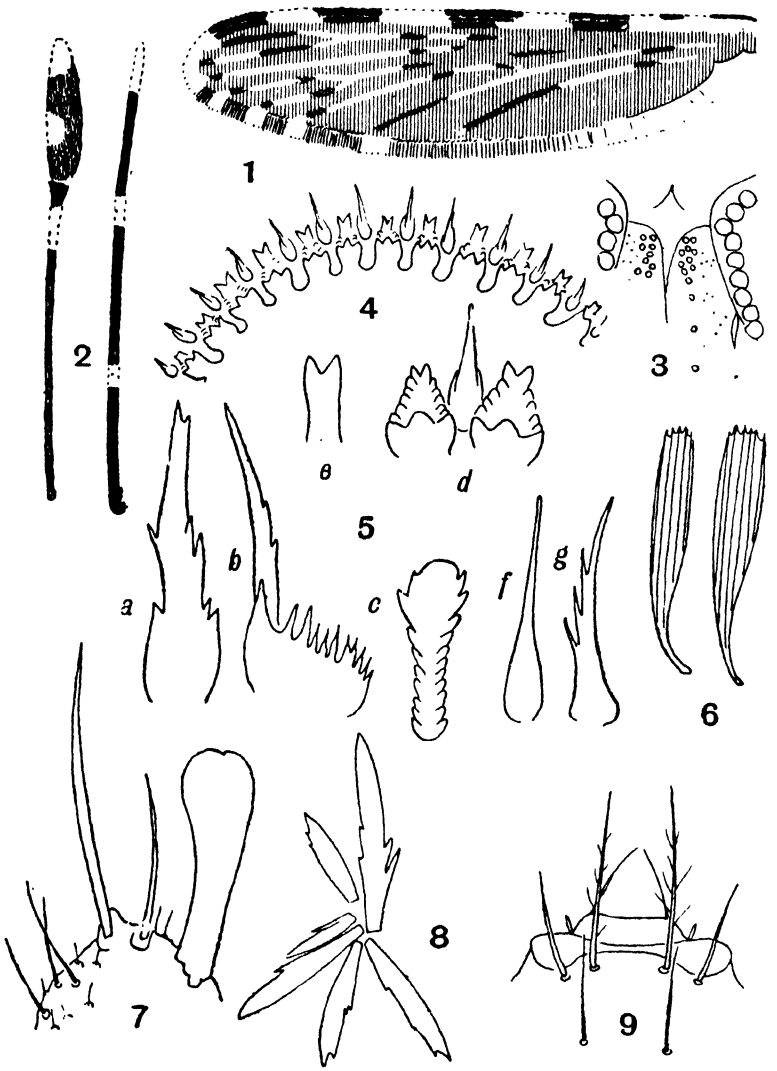
ADULT ♀.—Size medium to large (length of wing 3–4·7 mm.).

Head: scales of usual type, with a well-defined pale vertical area ; vertical chætæ pale, forming a cluster anteriorly of about 10 flattened chætæ, which form a well-marked frontal tuft ; ocular scales numerous. *Antenna*: torus devoid of scales ; white scales present on first two or three flagellar segments. *Palpi* long and thin, very smooth, cylindrical almost to base ; apical segment about $\frac{1}{3}$ of preapical, which is extraordinarily long, almost as long as segment 3

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* SYSTEMATIC : Grassi 1901, p. 115 ; Newst. and Carter 1910, p. 379 (*cardamit.*) ; Edw. 1912, p. 249 ; 1913 *b*, p. 48 ; 1921 *b*, p. 278 ; 1926, p. 281 ; Christ. 1924 *c*, pp. 55, 95 ; Seguy 1924, p. 160 ; Kirkpatrick 1925, pp. 59, 174. See also Ficalbi 1899, p. 135 ; Giles 1900, p. 145 ; Theo. p. 151 ; 1903, p. 71 ; 1907, p. 66 ; 1910 *a*, pp. 38, 39 ; Christ 1916 *a*, p. 475 ; Martini 1930, p. 187. See also pp. 266–8 (footnotes).

Fig. 43.



A. superpictus.

1. Wing of ♀, $\frac{5}{7}$ standard scale. 2. ♂ and ♀ palp, same scale 3. Vertex. 4. Pharyngeal armature, as frequently seen (see 5 *d*). 5. Pharyngeal teeth: (*a*) anterior, (*b*) lateral view of cone, spines of one side only shown; (*c*) view of crest from above, filament at thick end projecting towards the observer; (*d*) two cones and a rod, former with crest showing somewhat foreshortened, filament directed towards observer, rod also foreshortened; (*e*) posterior view of crest; (*f*) rod, anterior view; (*g*) rod, lateral view. 6. Mesonotal scales. 7. Apex of harpago. 8. Leaflets of phallosome of one side, standard scale. 9. Clypeal hairs of larva (after Puri).

in many cases, index 0·32–0·35 ; apical pale area involving whole of apical segment, but very commonly there is an extra dark band on this segment when the apical pale area becomes of small extent and the palp four-banded ; chætæ at the tip always pale ; the remaining bands over joints 3–4 and 2–3 rather broad.

Pharynx * : filament of cones broad at base, tapering, pointed with coarse lateral spicules ; crest double, the two rows of spines widening out at sides of filament to continue into sharp, conspicuous lateral teeth, bifurcate in posterior view. Rods with oval expanded base, tapering, pointed, with 3 or 4 spicules arising posteriorly in series.

Thorax with chætæ only on *apn*. Mesonotum with fossæ and lateral areas darker than median area ; median area covered, except over bare spaces, with narrow pale scales, str. about 8–9, with a median scale-tuft and a few dark scales, usually laterally on the promontory ; fossæ devoid of scales ; a line of scales at the sides on the lateral area in front of level of root of wing. Pleuræ devoid of obvious scales ; spiracular hairs 1–3 ; prealar 4 ; upper mesepimeral about 7.

Wing as in figure. Base of costa mainly dark, with a pale interruption in region of humeral and one internal to inner dark costal spot ; vein 1 in this area entirely pale. The pale interruptions on outer half of costa about same length or a little shorter than corresponding dark areas. Stem of 4 extensively pale towards base, 4.1 and 4.2 usually each with an interruption, but often uninterruptedly dark, especially 4.2 ; 5.1 usually with a pale spot in outer portion, but sometimes continuously dark in this region ; vein 6 usually continuously dark in outer half. Apex of wing with the apical pale costal spot extending beyond vein 3, but sometimes with an imperfectly developed dark fleck between 2.1 and 2.2. Border scales extending only to a short distance basal to junction of vein 6. Scaling of wing rather narrow, the general effect of the wing-field being a thin and sparse ornamentation ; max. str. 8–9.

Legs with front femur a little swollen at extreme base. Femora somewhat pale beneath, otherwise dark ; tibiæ dark, somewhat pale at base and with distinct pale area at apex, forming moderately conspicuous knee-spots ; tarsi usually without banding, but small indistinct taches sometimes present at ends of one or more segments, giving faint appearance of banding. Coxæ pale, devoid of conspicuous scales.

Abdomen entirely devoid of scales even on cerci.

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* PHARYNX : Sinton and Covell 1927, p. 305 ; Barr. and Covell 1928, p. 674 ; 1929, p. 101.

ADULT ♂.—In general as in ♀. *Palpi* with apex of club pale and with pale apical chætæ; ornamented as shown in figure; marginal hairs forming about a double row on seg. 4. Abdomen with some dark scales on coxite.

Hypopygium *: harpago with apical hair somewhat longer than club, a hair somewhat more than half the length of this between it and the club (or there may be two hairs, one of which may be near the club) and 3–4 largish hairs, somewhat thinner and shorter than the last-mentioned hair, arising among numerous small hairs from inner aspect of harpago. Phallosome between ⅓ and half length of coxite; leaflets about six on each side; largest considerably less than half length of phallosome; all leaflets delicate, lanceolate, with characteristic serrations.

PUPA †.—*Paddle*: external border having posterior two-thirds with hairs not amounting to spines; acc. hair bifurcate or branched.

Spine: (VIII) about half length segment. (V–VII) sharp, pointed, half length of segment. (IV) thick, short, blunt, half length of preceding. (III) rudimentary. (II) absent.

Hair B: 2–4 br., about half length segments.

Hair C: (V–VII) simple, longer than segment. (IV) bifurcate or trifurcate, ⅔ segment. *C'* (VI) simple.

LARVA ‡.—*Clypeal hairs*: *ic* rather slender, with slight lateral fraying seen under high magnification; *oc* simple, about half length inner; *pc* simple, a little longer than outer. *Antenna* with hair arising about ⅓ length of antenna from base; terminal hair with 3 br. *Maxillary palp* with cone bifid at extreme tip. *Mentum* with four teeth on either side of median tooth, adequal, equidistant; submentum with a row of six teeth on either side of median double tooth.

Shoulder hairs: inner without conspicuous tubercle, a little more than half length middle, feathered from near base; middle often split near base into two hairs, both pinnate. *Metathoracic hair no.* 1 forming poorly-developed palmate hair with narrow leaflets, but not forming whorl. *Pleural hairs* as given for the group; *dp*1 split about middle into 2–3 br.; *da* and *va* devoid of branches on basal third. Tubercles on 1 and 3 with pointed process, that on 2 with process broadly rounded.

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* HYPOPYGIUM: Christ. 1915, p. 393; Kirkp. 1925, p. 61.

† PUPA: Buxton 1924, p. 311; Kirkp. 1925, p. 61; Stankovic 1926, p. 107; Senevet 1930, p. 319.

‡ LARVA: Joyeux 1918, p. 541; Edw. 1921 *b*, p. 279; Buxton 1923 *b*, p. 78; Grassi 1925, p. 689; Cuboni 1926, p. 49; Stankovic 1926, p. 106; Montschadsky 1930, p. 551 (spir. app.); Puri 1928 *b*, p. 523; 1931, p. 178.

Palmate hairs well developed on II–VII; hair no. 1 on I like an ordinary hair; leaflets in some larvæ with variable amount of pigmentation at distal ends, moderately broad, filament about ⅔ length of blade, well differentiated, drawn out and whip-like, never very broad at base, the serrations at shoulder variable. *Lateral hairs* on IV–VI long, slender, with 2–6 br. *Tergal plates* small, oval; small paired plates absent. *spc* moderately large; *mps* rather broad, nearly touching chitinisation. *Pecten* with 4–5 long and about 10 short processes. *ps* hair with 4–5 br. Caudal hooks 6–7, well defined. *Anal papillæ* about as long as anal segment.

Egg *.—Upper surface as broad as the egg, and middle area only slightly, if at all, narrowed; ornamented with irregular reticulation. Lower surface unornamented. Floats entirely absent. Frill very broad, nearly as broad as half the width of the upper surface, continued all round the margin of the upper surface and striated through its whole extent.

Identification.—In the female the unicolorous legs without obvious tarsal banding, the narrow mesonotal scales, and the pale-tipped palpi serve to distinguish *A. superpictus* from all Indian forms except *A. jeyporiensis* and *A. moghulensis*, the latter of which only occurs in the same areas as *A. superpictus*; in the last case the definite, even if narrow, bands on some at least of the tarsi and the darker wing should serve to distinguish the species. From large specimens of *A. fluviatilis*, where the thoracic scaling may be broader than usual, the pale interruptions at the base of the costa and wider pale interruptions in the apical half of the costa usually serve to distinguish *A. superpictus*. In the male the mesothoracic scaling, the absence of black chætæ at the apex of the male palpi, and the ornamentation of these organs are together sufficient for identification (see also under *A. multicolor*).

A form with an extra dark band on the last segment of the palpi is fairly common, and has in India been sometimes incorrectly taken as *A. nigrifasciatus* (*A. multicolor*). Var. *berestnewi* from Tashkent is described as distinguished from *A. superpictus* by its larger size(5–6 mm.) and more marked ornamentation, by the absence of pale interruptions at the base of the costa, and by the apex of the wing being black. It is, perhaps, incorrectly included as a synonym.

Distribution.—Widely distributed in S. Europe and S.W. Asia. Recorded from Spain; Italy; Dalmatia; Jugo-Slavia; Albania; Macedonia; Greece; Bulgaria; Thrace; Anatolia; Cyprus; Caucasus and Transcaucasus;

* Egg: Grassi 1925, p. 689; Theodor 1925, p. 377; Stankovic 1926, p. 105; Christ. and Barraud 1931, p. 176.

CILICIA ; SYRIA ; PALESTINE ; SINAI ; UPPER MESOPOTAMIA ; TURKOMEN REP. (Transcaspia) ; COSSACK REP. (Tashkent) ; BOKHARA ; PERSIA ; N.W. INDIA.

The occurrence of *A. superpictus* in N. Africa is somewhat doubtful, and the few records appear to show that the species, even if correctly recorded, is rare. Records from Tonkin and Mashonaland are incorrect.

In the Indian area *A. superpictus* has so far been correctly recorded only from Baluchistan and the N.W. Frontier Province.

BIONOMICS.—In Macedonia, Palestine, and Upper Mesopotamia *A. superpictus* is an important malaria-carrying species. It is especially associated with hilly or mountainous country and adjoining plains, and may occur up to a considerable altitude (4,000–5,000 feet). Partially or completely hibernating females are found in the cold season, and living larvæ have been obtained under or enclosed in ice (*Lacaze*). It breeds especially in pools in the beds of small mountain or submontane streams and rivers and in connection with irrigation. It is commonly found in flowing water. In Italy (valley of the Po) it forms 7–10 per cent. of the anophelines captured in rice-fields (*Giardina* et al.) (For an account of the habits of the species, see *Waterson*, 1918, 1922 ; *Wenyon*, 1921 ; *Buxton*, 1924 ; *Christ.* and *Shortt*, 1921 ; *Kirkpatrick*, 1925 ; *Stankovic*, 1926 ; *Kligler*, 1924–1928.)

In the Indian area it occurs in and around the hilly and mountainous country west of the Indus. It has been studied at Quetta by Davys, 1912, where, next to *A. culicifacies*, it is the commonest mosquito. Adults are found in native houses, servants' quarters, bungalows, and barracks. The species feeds readily experimentally, and is found full of blood under natural conditions. It breeds in open pools not under shade and in irrigation channels, and can maintain itself in water flowing with a central velocity up to 2·1 miles per hour if the banks are weedy or have bays. The larvæ, when disturbed, may remain at the bottom for as long as 8 minutes. Females having the appearance of hibernating individuals were found by Browse in a cow-shed in March. Davys considers that it may pass the cold weather in the egg-stage. Adults were found from May to November. Larvæ have been found up to a height of 7,000 feet (near Quetta).

RELATION TO DISEASE.—*A. superpictus* has been experimentally infected with B.T. and M.T. parasites in Macedonia and Palestine, and also found infected in nature in these countries and in Upper Mesopotamia.

32. **Anopheles moghulensis** Christophers, 1924 *. (Fig. 44.)

Christophers, Ind. Journ. Med. Res. xii, p. 296, 1924 (*A. jeyporiensis* var. *moghulensis*). TYPE-LOC.: N.W. India and Deccan. TYPE: described from numerous examples in collection of Malaria Survey; type ♂ and ♀, with paratypes, in Brit. Mus. Given as a distinct species by Puri, Ind. Journ. Med. Res. xvi, p. 514, 1928.

This is the *A. jeyporiensis* of Kenrick and other early writers in connection with the Central Provinces and some other areas before differentiation of the two species.

ADULT.—Rather closely resembles *A. jeyporiensis* in markings and general appearance, but differs in a number of points. *Palpi* of ♀ with terminal segment about ⅓ length of preceding (index 0·34); dark area between apical and preapical pale band usually noticeably long; preapical pale band usually basal as well as apical. *Propleural hair* absent; mesonotal scaling usually broader and more profuse, with line of white overlapping scales on lateral areas in front of wing-root. *Wing* with *af* rather short, the cell about the same length as its petiole, bifurcation slightly or markedly further from base of wing than that of *pf* (as in *A. nili*). Basal costal area usually uninterruptedly dark; middle costal spot usually showing a well-marked acc. sector pale spot, and another pale spot on vein 1 towards outer extremity. Apex of wing usually extensively pale, apical pale area extending without interruption to beyond junction of vein 3; usually no fringe-spot at vein 6; border scales dark nearly to base of wing. *Legs* with front femora slightly swollen in basal third; ornamented as in *A. jeyporiensis*, but mid-tarsi commonly unbanded. Scales present on cerci of ♀ and coxites in ♂.

Pharynx †: filaments of cone broad at base, serrated, tapering to point; crest double, with widely separated rows of spines, in posterior view markedly bifid. Rods with bulbous base and rod-like terminal portion; simple, without branches or spicules.

Hypopygium: harpago with apical hair somewhat longer than club; a smaller hair, less than half its length, between this and club; 2–3 hairs, somewhat shorter and thinner than last-mentioned hair, internal to apical hair. Phallosome between half and ⅓ length of coxite; leaflets 6–7 on each side; the largest about half length of phallosome, blade-like with fine serrations; the others blade-like or lanceolate, some with serrations.

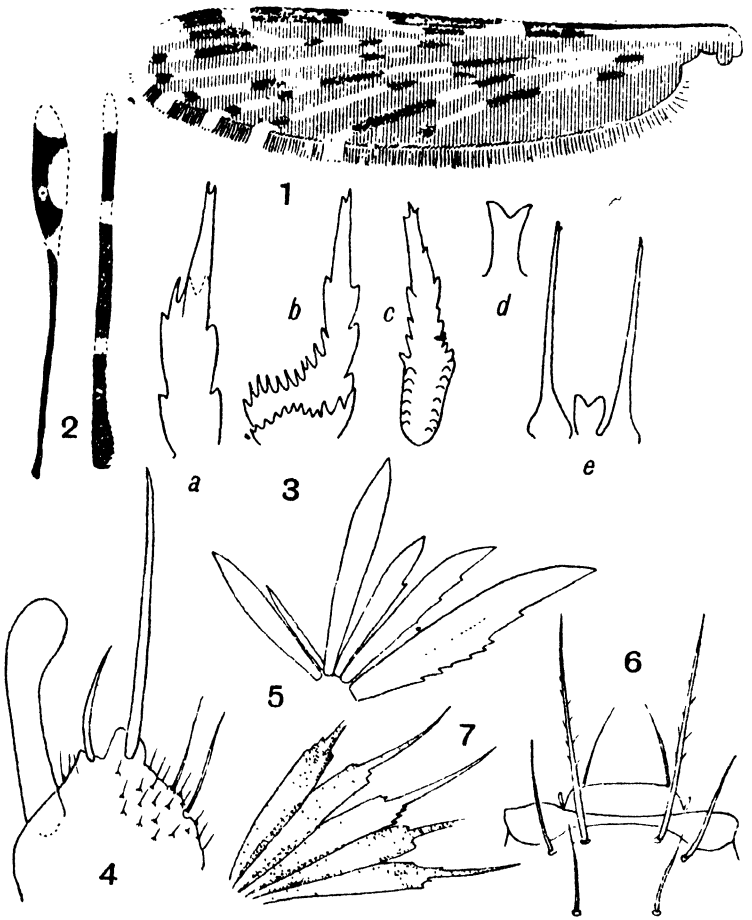
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* SYSTEMATIC: Christ. 1924 *b*, p. 295; 1924 *c*, pp. 52, 96; Puri 1928 *a*, p. 514; Martini 1930, p. 177. See also pp. 271–2 (footnotes).

† PHARYNX: Barraud and Covell 1928, p. 674; 1929, p. 101.

PUPA *.—*Paddle*: external border in posterior half with fine spines, which change to hairs continued to paddle-hair; paddle-hair long, hooked, arising from a marked basal tubercle; acc. hair 4–5 br.

Fig. 44.



A. moghulensis.

1. Wing of ♀, standard scale. 2. ♂ and ♀ palp, same scale. 3. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) lateral view of same, slightly tilted; (*c*) view of crest from above, filament also shown; (*d*) posterior view of crest; (*e*) two rods and posterior view of a crest. 4. Apex of harpago. 5. Leaflets of phallosome of one side; these appear narrow, curved rods as most ordinarily seen. 6. Clypeal hairs of larva. 7. Leaflets of palmate hair. (6 and 7 after Puri.)

* PUPA: Senevet 1931, p. 26.

Spine : (VIII) rather short, somewhat less than half length segment. (V–VII) about half length segment. (IV) $\frac{1}{3}$ length preceding spine, blunt.

Hair B : (IV–VII) branched, half to $\frac{2}{3}$ segment.

Hair C : (IV–VII) simple, somewhat longer than segment. (II–III) very stout, branched. *C'* (VI), simple.

LARVA *.—*Clypeal hairs* : *ic* rather long and stout, but drawn out distally into very fine point, finely frayed on middle two-thirds, with minute hair-like branches ; *oc* stout, simple, a little less than half length inner ; *pc* simple. *Antenna* usually dark brown in distal half, or whole may be dark ; hair arising about $\frac{1}{3}$ length of antenna from base ; terminal hair split about its middle into 3–5 long br. *Mentum* with four teeth on either side of median tooth, equidistant and adequal.

Shoulder hairs : both hairs stout, feathered, arising from separate conspicuous tubercles. *Metathoracic hair no.* 1 forming well-developed palmate hair. *Pleural hairs* as given under group ; *dp*1 with 4–5 br. Basal tubercle on 1 with a sharp spine, the projection on 2 more or less rounded, that on 3 blunt, triangular.

Palmate hairs well developed on II–VII ; that on I an ordinary branched hair, with 9–11 long filamentous branches. Leaflets somewhat darker near distal ends ; filament well differentiated, narrow and pointed, about $\frac{2}{3}$ length of blade. *Lateral hairs* on IV–VI long and slender, splitting near base into 3–5 br. ; that on VII very short, with 3–5 br. *Tergal plates* very small. *spc* well marked ; *mps* very broad anteriorly, nearly touching the chitinisation. *Pecten* with 4–5 long and 8–9 short processes, all finely serrated on basal half, the ventralmost spine and that near the dorsal end longer than the others. *ps* hair with 6–7 br. Caudal hooks 6–7, well defined ; some of the branches of the ventral caudal hairs also with curved tips but very slender. *Anal papillæ* about as long as plate on anal segment.

EGG †.—Upper surface with an anterior and posterior demarcated area, former about twice as long as, and considerably broader than, latter, middle portion narrowed by encroachment of floats, which nearly meet in middle line. Ventral surface unornamented. Floats touching margin of dorsal surface, occupying somewhat less than middle $\frac{2}{3}$ of egg-length and broad ; with about 17–20 float-ridges, rather crested and waved ; float-terminations large, round. Frill rather narrow, striated, ending in tags where it meets floats.

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* LARVA : Puri 1928 *a*, p. 516 ; 1931, p. 182.

† EGG : Christ. and Barraud 1931, p. 176.

IDENTIFICATION.—From *A. jeyporiensis* the present species is distinguished especially by the scaling of the mesonotum being broader, and with a line of broad, overlapping scales at the sides in front of wing-root (see also other points given under description). From *A. superpictus* it is distinguished by its darker colour and the distinctly banded tarsi.

DISTRIBUTION.—Unrecorded outside the Indian area except, possibly, from Turkestan *.

In India the area of distribution is chiefly the central and west Peninsula and N.W. INDIA, extending into Baluchistan and possibly beyond (Turkestan). It has been recorded as far south on the west of the Peninsula as Malabar and Coimbatore, and on the east from Vizagapatam and Bellary. It appears to be especially prevalent in the western Central Provinces, where it has been known by many authors as *A. jeyporiensis*.

BIONOMICS.—Taken in coolie lines and outhouses by Kenrick, 1915, in the western Central Provinces (as *A. jeyporiensis*). Breeds especially in small rocky pools in connection with hill-streams, springs, and seepages (*Puri*, 1928, 1931) and, according to Kenrick, in streams with shady banks and stony or sandy bottoms. Has been taken by Browse in Baluchistan breeding in streams at 6,000 feet and up to 3,500 feet in the Peninsular area.

RELATION TO DISEASE.—Nothing known.

33. **Anopheles stephensi** Liston, 1901 †. (Fig. 45.)

Liston, Ind. Med. Gaz. xxxvi, p. 441, 1901 (*A. stephensi*). TYPE LOC.: Ellichpur, Berars, Deccan, India. TYPE: ♀ described.

metaboles Theo., 1902, Proc. Roy. Soc. lxix, p. 374 (*A. metaboles*). TYPE-LOC.: Lahore, Punjab, India. TYPE: described from 5 ♀♀; type in Brit. Mus. SYN. by James and Liston, Ann. p. Mosq. India, ed. 2, p. 113, 1911.

intermedia Rothwell, 1907, Entomologist, xl, p. 34 (*Neocellia intermedia*). TYPE-LOC.: Deesa, Gujarat, India. TYPE: described from 3 ♀♀ and 1 ♂; type ♀ and ♂ in Brit. Mus. SYN. by James and Liston, *loc. cit.* p. 116.

folquei de Mello, 1918, Anais Scientificor da Fac. ai Med. do Porto, iv, no. 3 (*A. folquei*). TYPE-LOC.: Pragana (Portuguese possession), Gujarat, India. TYPE: type ♀ in Indian Mus., Calcutta. SYN. by Christ., Ind. Med. Res. Mem. no. 3, p. 63, 1.24.

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* Martini 1930, p. 177.

† SYSTEMATIC; Liston 1901, p. 441; James 1902, p. 45; Theo. 1902, p. 374; 1903, p. 93; James and Liston 1904, p. 113; 1911, p. 113; Edw. 1921*b*, p. 277; 1926, p. 280; Christ. 1924*c*, pp. 63, 98; Martini 1930, p. 186. See also p. 276 (footnotes).

Carter's statement (in Theo., Mono. Cul. v, p. 73, 1910) that the female only is described by Rothwell is incorrect, as both sexes are described in Rothwell's original paper, though the female only is given by Theobald, Mono. Cul. iv, p. 115, 1907.

ADULT ♀.—Size medium (length of wing 2·5–4·0 mm.).

Head : scales of usual type, with a well-marked pale vertical area ; vertical chætæ white, with a cluster of about nine flattened chætæ forming well-marked frontal tuft ; ocular scales anteriorly forming about a single line. *Antennæ* with small pale scales on torus ; white scales on first 2–4 flagellar segments. *Palpi* moderately thick, cylindrical, smooth except towards base ; apical segment half length or more of preceding segment (index 0·58) ; apical segment all pale, forming, with apex of next segment, a broad pale apical band ; a broad apical and basal pale band at 3–4, the dark intervening area narrower than either band ; a narrow pale band at 2–3 and some spots formed by patches of white or pale scales on dorsum of segment 3, these, though sometimes absent, being very characteristic of the species.

Pharynx : filament of cones rather broad, flat, short, with lateral spicules and fimbriated ends ; crest broad, with double row of spines, bifid in posterior view ; rods with swollen base, tapering to rod-like terminal portion, simple.

Thorax usually with a few pale scales on *apn*. Mesonotum brown, fossæ and lateral areas a little darker than median area ; median area thickly covered with pale narrow scales (str. about 5–6), forming lateral tufts of white scales, with dark scales beneath on promontory ; fossæ with scattered scales and a heavy line of scales on lateral area in front of wing-root, some scales with 8–9 str. Pleuræ without obvious scales ; spir. hairs 2–3 ; upper mesep. 5–6.

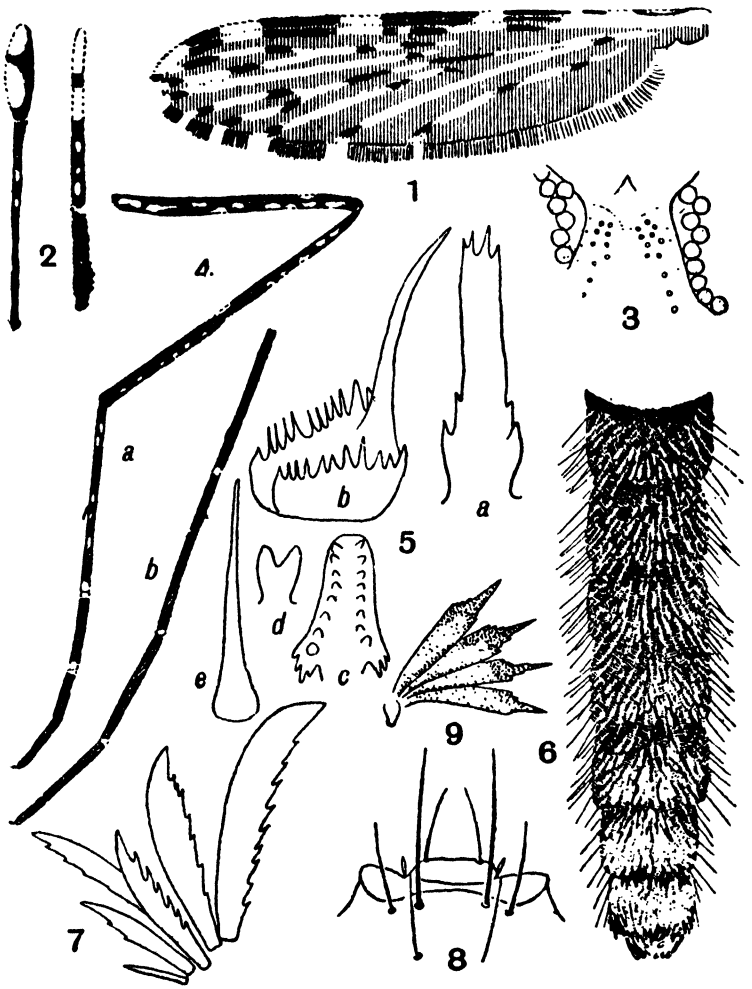
Wing as in fig. 45, 1, usually with prehumeral dark acc. costal spot undivided with white scales anteriorly ; an interruption present or not at inner end of inner costal spot ; marking on vein 1 in middle costal spot very variable, as shown in figure, or with a small dark spot also at inner end, or both small dark spots absent ; dark spots on stem 2, 2.1, base 3, and some others very variable in extent.

Legs with front femora only very slightly swollen in basal portion ; femora and tibiæ speckled as shown in figure, hind femora and tibiæ usually pale on inner aspect ; first tarsal segment with some spots ; others dark, with apical and basal bands on joints 1–2 and 2–3 on fore legs, narrower apical banding on mid- and hind legs, the mid-tarsus often mainly dark.

Abdomen with narrow scales on tergites II–VIII, increasing in extent towards posterior segments, which are rather

heavily covered with narrow oblanceolate scales mixed with pale hairs, VIII with dark scales at lateral posterior angles; some dark scales apically in mid-line on venter of VII; cerci with dark scales.

Fig. 45.



A. stephensi.

1. Wing of ♀, ⅚ standard scale. 2. ♂ and ♀ palp, same scale. 3. Vertex. 4. Legs: (*a*) front leg; (*b*) hind tarsus. 5. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) lateral view of same; (*c*) crest, looked down upon; (*d*) posterior view of crest; (*e*) rod. 6. Dorsum of abdomen of ♀. 7. Leaflets of phallosome of one side, standard scale. 8. Clypeal hairs of larva. 9. Leaflets of palmate hair. (8 and 9 after Puri.)

ADULT ♂.—In general as in ♀. *Antennæ* without scales on first flagellar segment. *Palpi* ornamented as shown; marginal hairs forming about a single row above and a double row ventrally. *Coxites* with numerous scales.

Hypopygium * : harpago with apical hair somewhat longer than club; a hair about half its length or less between this and club, and from 1–3 longish hairs internal to apical hair, with numerous rather large smaller hairs about apex. Phallosome between half and $\frac{1}{3}$ coxite, with 5–6 leaflets on each side; practically all the leaflets broad, blade-like, with marked serrations along straighter edge; the largest about half length of phallosome.

PUPA †.—*Paddle* : spines on posterior half or so of external border fine, pointed, giving place to hairs on the posterior border, which do not extend beyond the paddle-hair; paddle-hair long, hooked.

Spine : (VIII) rather long, more than half length segment; (V–VII) about half length of segment; (IV) about half length of preceding spine, usually blunt (sometimes pointed and rather longer); (III) small, about $\frac{1}{4}$ length preceding; (I) minute, unchitinised.

Hair B : (V–VII) about $\frac{2}{3}$ length of segment: about 3 br., leash-like.

Hair C : (V–VII) simple, longer than segment; (IV) 2–3 br., leash-like.

Hair 4 on segs. III–VI rather long, approaching half segment, simple.

LARVA ‡.—*Clypeal hairs*: simple, *ic* sometimes very finely frayed; *oc* about $\frac{2}{3}$ length of inner; *pc* about the same length as *oc*. *Antenna* with hair arising about $\frac{1}{3}$ length of antenna from base; terminal hair split about middle into 2–4 br. *Maxillary palp* with the cone slightly bifid at extreme tip. *Mentum* with four teeth on either side of median tooth, the first of these very short and rounded, the first three more or less equidistant.

Shoulder hairs : inner and middle hairs arising from separate basal tubercles, variable in amount of development, but tubercle of middle hair always better developed than that of inner; both hairs feathered, inner somewhat shorter than middle. *Metathoracic hair no.* 1 like ordinary hair, usually with three branches (sometimes 4–5). *Hair no.* 5 on prothorax long and feathered, its distal end drawn out and not having truncated appearance. *Pleural hairs* as given

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* HYPOPYGIUM : Christ. 1915, p. 393.

† PUPA : Senevet 1930, p. 325; 1931, p. 105.

‡ LARVA: Steph. and Christ. 1902*b*, p. 10; James 1902, p. 46; Theo. 1903, p. 95; James and Liston 1904, p. 113; 1911, p. 115; Edw. 1926 p. 280; Puri 1928*b*, p. 523; 1931, p. 191.

under the group; *dp*1 with 3–4 br. Tubercles moderately large, that on 1 and 3 with the projection sharp and spine-like, that on 2 blunt and bifid.

Palmate hairs well developed on III–VII; hair no. 1 on I not developed as palmate hair, that on II poorly developed. Leaflets uniformly pigmented, broad; filament short, broad at base, about ¼ length of blade; may be longer in specimens from N.W. Frontier Province. *Lateral hairs* on IV–VI split some distance from base into 3 br., sometimes 4 or 5 on IV and 4 on VI; on VII very short, with 3–5 br. *Tergal plates* rather small. *spc* poorly developed; *mps* very broad anteriorly and touching chitinisation. *Pecten* with 3–5 long and 8–11 short processes, all serrated on basal half. *ps* with 5–6 br. Tail-hooks poorly developed.

IDENTIFICATION.—There is no species with which this can well be confused; it is the only Indian species with broad thoracic scaling and a double broad pale band on the palpi in which the hind legs are not conspicuously marked with white.

DISTRIBUTION.—Recorded outside the Indian area only from MUSCAT and LOWER MESOPOTAMIA. In the Indian area has a wide distribution throughout the Peninsula from the extreme north-west to the extreme south and east. It is also recorded from localities in Upper Burma, but only from Rangoon in Lower Burma, and it is not recorded from Ceylon.

BIONOMICS.—*A. stephensi* is commonly found in houses, barracks, cow-sheds, and suchlike situations (*James*, 1902; *Adie*, 1905; *Davys*, 1912; *Richmond* and *Mendis*, 1930; *Sweet*, 1930). Christophers and Shortt note that the adult is secretive in its habits and difficult to find. It feeds readily experimentally and in nature on man (*Gill*, 1925).

It breeds under natural conditions in pools in river- and stream-beds (*Christ.*, 1911; *Hodgson*; *Marjoribanks*), also in sluggish creeks, drains, pools and miscellaneous breeding places, usually preferring clean water and small pools. It has been recorded in water contaminated with sullage (*Iyengar*, 1919; *Roy*, 1931). In the Peshawar area it breeds abundantly in irrigation channels (*Richmond* and *Mendis*). It has been recorded from brackish water (*Gholap*, 1910; *Chalam*, 1924), but at Busra was notable for selecting fresh as against brackish water (*Barraud*, 1920). It breeds equally in places exposed to direct sunlight and in dark places (*Covell*, 1928). Its larvæ have the power to sink deeply and to remain long periods without reappearing at the surface (*Hodgson*; *Covell*).

It is especially noticeable for its power to breed in wells, cisterns, and various artificial breeding places (*James* and *Liston*; *Sinton*, 1917), and for this reason is the species concerned

with malaria transmission in large cities such as Bombay. Under such circumstances it breeds in all kinds of miscellaneous sources, such as wells, cisterns, water collected about unfinished or abandoned buildings, flooded cellars, fountain-basins, and artificial receptacles (*Liston*, 1908 : *Bentley*, 1910, 1911 ; *Covell*, 1928, 1930).

RELATION TO DISEASE.—*A. stephensi* is, next to *A. culicifacies*, probably the most important malaria-carrying species in India. It has been infected experimentally to the oocyst stage with all forms of the malaria parasite, and with M.T. and B.T. to the sporozoite stage ; it has frequently been found infected in nature, both gut and gland infection.

34. Anopheles maculatus Theo., 1901 *. (Figs. 46, 47.)

Theobald, Mono. Cul. i, p. 171, 1901 (*A. maculatus*). TYPE-LOC. : Hong Kong. TYPE : described from several ♀♀ and two ♂♂ ; a type ♂ now in Brit. Mus., the ♀ type being a specimen of *A. karwari* (see remarks under that species).

SYNONYMS :

pseudowillmori Theo., 1910, Mono. Cul. v, p. 65 (*Nyssorhynchus pseudowillmori*). TYPE-LOC. : Meenglas, Jalpaiguri Duars. TYPE : ♀ described ; type in Indian Mus., Calcutta. SYN. by James and Liston, Anop. Mosq. India, ed. 2, p. 87, 1911.

dravidicus Christophers, 1924, Ind. Journ. Med. Res. xii, p. 297 (*A. maculatus* var. *dravidicus*). TYPE-LOC. : Nilgiri Hills, South India. TYPE : in Brit. Mus. SYN. by Christ., Rec. Mal. Surv. ii, p. 329, 1931.

hanabusai Yamada, 1925, Sci. Repts. Govt. Inst. Inf. Dis. iv, p. 471 (*Myzomyia hanabusai*). TYPE-LOC. : Kagi, Formosa. TYPE : The syntype (no. 15) consists of 4 ♀♀ and 2 ♂♂ from the above locality (Yamada, *loc. cit.*). SYN. by Christ., *loc. cit.*

RECOGNIZED VARIETY :

willmori James, 1903 (see below).

A. metaboles of Stephens and Christ., 1902 *a* ; *A. willmori* of Leicester, Cul. Malaya, 1908 ; also of some Formosan writers (see Yamada, 1925). For discussion of variation in this species, see Christ., 1931.

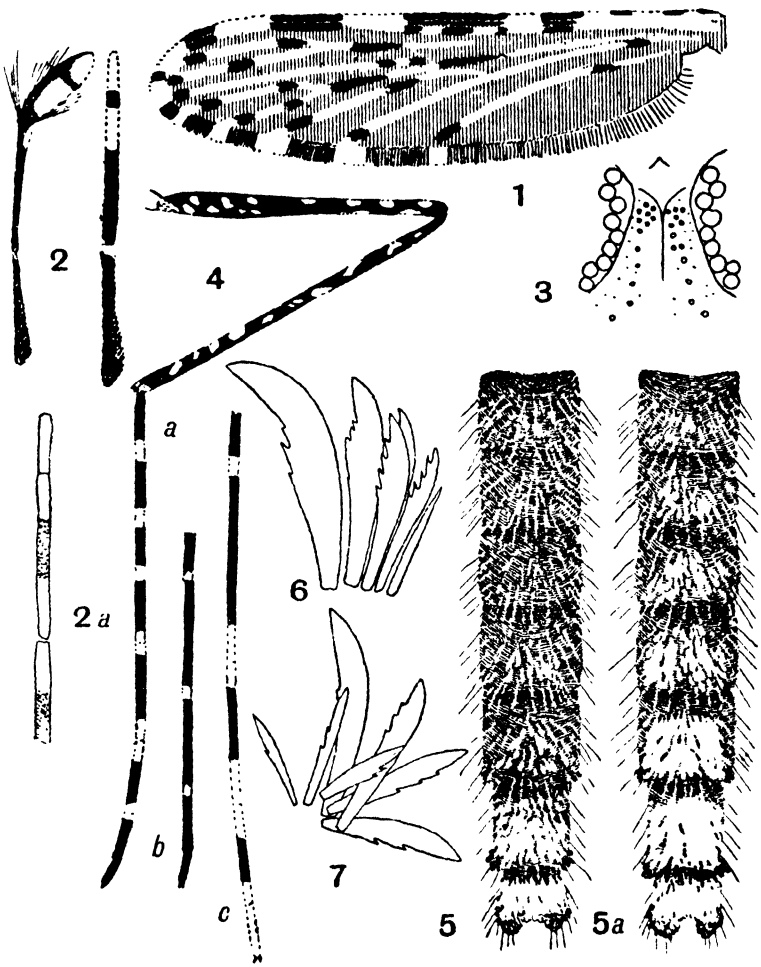
ADULT ♀.—Size moderate (length of wing 2·7–4·2 mm.).

Head : scales of usual type, with a conspicuous pale vertical area, vertical chætæ forming a cluster of 8–9 flattened chætæ, which make a well-developed frontal tuft ; ocular

* SYSTEMATIC : James and Liston 1904, p. 99 ; 1911, p. 84 ; Christ., 1924 *b*, p. 297 ; 1924 *c*, pp. 65, 101 ; 1931, p. 323 ; Yamada 1925, p. 471 (*hanabusai*). See also James 1902, p. 47 ; Theo. 1901 *a*, p. 171 ; 1902, p. 69 ; 1903, pp. 96, 101 ; 1907, p. 97 ; 1910, p. 58 ; Kinoshita 1906, p. 643 ; Leicester 1908, pp. 41, 42 ; Mathis and Leger 1911 ; Takaki 1911, p. 142 ; James and Stanton 1912, p. 62 ; Strickl. 1913 *b*, p. 203 ; Roper 1914, p. 143 ; Stanton 1914 *b*, p. 517 ; 1915 *b*, p. 254 ; 1926, pp. 30, 85 ; Christ. 1916 *a*, p. 471 ; Schüff. and v. Heyden 1916, p. 387 ; 1917, p. 31 ; Swell. 1916, p. 105 ; 1921 *a*, p. 98 ; Mangk. 1919, p. 54 ; Koidzumi 1924, p. 98 ; 1930, p. 234 ; Carter 1925, p. 74 ; Senior White 1925, p. 213 ; Borel 1929, p. 58 ; Iyengar 1929, p. 6 ; Barraud and Christ. 1931, p. 277. See also pp. 281–3 (footnotes), and under var. *willmori*.

scales forming about a single line in front. *Antenna* with some minute white scales on torus; black scales at base, numerous white scales on first flagellar segment, and scales on second and sometimes third segment. *Palpi* moderately thick, with erect scales towards base; the apical segment

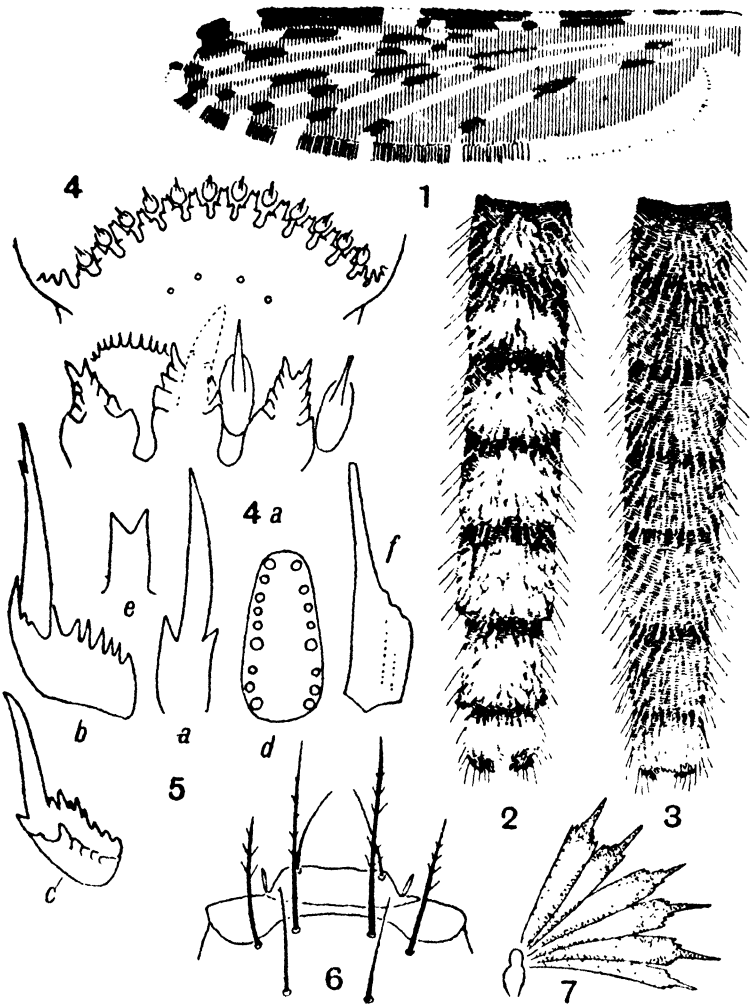
Fig. 46.



A. maculatus.

1. Wing of ♀, ♀ standard scale. 2. ♂ and ♀ palp, same scale. 2 *a*. Terminal segments of ♀ palp, showing relation of bands to segments. 3. Vertex. 4. Legs: (*a*) front leg; (*b*) mid-tarsus; (*c*) hind tarsus. 5. Abdomen of type-form, normal scaling. 5 *a*. Abdomen of type-form, showing "*willmori*-like" scaling. 6. Leaflets of phallosome of one side, type-form. 7. The same, "*pseudowillmori*" form. (6 and 7 standard scale.)

Fig. 47.



A. maculatus (cont.).

1. Wing of ♀, var. *willmori*, ♮ standard scale. 2. Dorsum of abdomen of same. 3. Dorsum of abdomen, form *pseudowillmori*. 4. Pharyngeal bar as commonly seen when pharynx mounted whole. 4 *a*. Portion of same, enlarged. 5. Pharyngeal teeth: (*a*) anterior view of cone; (*b*) lateral view of same, showing one row of teeth only; (*c*) cone tilted to show the two rows; (*d*) view looking down on crest, showing position of lateral and crest-spines; (*e*) posterior view of crest; (*f*) lateral view of rod. 6. Clypeal hairs of larva. 7. Leaflets of palmate hair of larva. (6 and 7 after Puri.)

about ⅓ length preceding segment (index 0·35); apical segment all white, with apex of next segment forming broad white band, a second broad white band as in *A. stephensi*; intervening black band usually about ⅓ or ¼ either pale band; a narrow band at 2–3.

Pharynx *: filaments of cones stout, rather thorn-like, tapering, without pronounced spicular processes; pediment with a large lateral tooth on each side, and two or three smaller teeth behind this at sides of base of filament; crest broad, with a double row of long, rather regular spines on each side, posterior view bifid. Rods with extreme base expanded, without branches or spicules, end sometimes shortly bifid.

Thorax with one or two pale scales on *apn*. Mesonotum with the fossæ and lateral areas slightly darker than the median area; median area covered with creamy white scales, 6–9 str.; scattered scales on the fossæ and a line of rather broad scales on lateral area. Pleuræ commonly with some scales on sternopleuron; spiracular hairs 5–7; prealar hairs about 5, with a small tuft of broad white scales; upper mesepimeral 8–9.

Wing as in fig. 46. 1; *af* very variable in length, petiole from ⅓ to ⅔ length of cell; costa usually with three small dark acc. spots, the inner two often more or less bridged; vein 1 at base usually all pale, but sometimes with a small patch of brownish scales; pale interruptions in apical half of wing very variable in extent, preapical dark spot usually about one and a half to twice apical, or may be up to four times this. Some of the small dark spots on wing-field often lacking, *e. g.*, on stem of 2, on 2.1 at base, on 4.2 at base. Apex of wing most commonly pale to beyond 2.1, and again from 2.2 to 3, but sometimes a dark fleck between 1 and 2.1, and more rarely between 2.2 and 3. Scaling of wing moderately broad; max. str. 9–10, some scales on subcosta about 12.

Legs with front femora very slightly swollen in basal half. Femora dark, covered on all aspects with pale spots, except usually on under surface of mid- and hind legs, where there is a narrow longitudinal pale area extending from base a variable distance along the femur, sometimes to its full length; apices of all femora narrowly pale. Tibiæ similarly spotted. Fore tarsus usually with broadish apical and basal pale bands, or taches restricted to the anterior surface, at 1–2, 2–3 and 3–4, sometimes without a band at 3–4, or with a small pale spot at apex of 4; mid-tarsus usually with pale apical banding

* PHARYNX: besides Sinton and Covell, and Barraud and Covell, see Manalang 1929, p. 435.

or taches in the same situations, sometimes with basal banding also; hind tarsus ornamented as in figure, with or without some narrow basal banding on segment 2. First tarsal segment, less commonly second, and sometimes third, on hind legs with a few small pale spots. Coxæ dark, second with a patch of white scales on its external surface, third with one towards its apex posteriorly.

Abdomen with a very variable amount of scaling on dorsum, commonly with a few scattered scales on segs. I and II, a segment or so possibly without scales and an increasing number of scales on the more terminal segments; or fairly numerous scales are present on all segments from II, though there is rarely a definite patch of broad scales on II as in var. *willmori*; in the common Himalayan form there are very few scales, these being narrow and restricted to segment VIII, mixed with hairs and inconspicuous (*pseudowillmori* form). Black scales present at lateral posterior angles of a variable number of segments, often forming well-marked tufts on VII and VIII, or also on VI. Sternite VIII commonly has flat pale scales at sides, black scales commonly present in median line apically on a variable number of sternites from V–VII, and a few scattered pale scales may also be present. Cerci with densely tufted black scales and usually some indistinct palish scales towards apex; some pale scales between bases of cerci dorsally.

ADULT ♂.—In general as in ♀. *Antennæ* with dark scales on first flagellar segment. *Palpi* ornamented as shown; marginal hairs forming about a double row. *Abdomen* with scaling in the main as in ♀; ventral surface of VIII (rotated) heavily covered with narrow pale scales and some black scales on its posterior border. Coxites with dark scales on dorsal aspect and at sides, ventral surface heavily covered with pale scales and long pale hairs apically.

Hypopygium *: harpago with apical hair a very little longer than club: no accessory hair between this and club; numerous small hairs and about three larger ones internal to apical hair. Phallosome 0·4 of coxite, with 6–7 leaflets on each side; the largest leaflet 0·47 of phallosome (0·05 mm.), blade-shaped, with a few serrations: remaining leaflets broadish, blade-shaped, with some serrations. The largest leaflet of the Himalayan form (*pseudowillmori*) appears to be narrower and somewhat smaller.

PUPA †.—Very similar to *A. stephensi*, but hairs on posterior border of paddle appear usually to be carried beyond the paddle-hair in Indian specimens.

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* HYPOPYGIUM: Christ. 1915, p. 394; Swell. 1921 *a*, p. 99.
† PUPA: Senevet 1931, p. 47.

LARVA *.—*Clypeal hairs*: *ic* very finely frayed on distal two-thirds, the fraying variable, and in some larvæ difficult to see even under a high magnification; *oc* about half length of inner, frayed; *pc* a little shorter than outer, simple. *Antenna* as in *A. stephensi*; *mentum* as described under *A. stephensi*, but first lateral tooth not short and rounded.

Shoulder hairs: inner and middle rather stout, feathered, with separate conspicuous basal tubercles. *Metathoracic hair no.* 1 very variable, but usually like ordinary hair, with 5–6 filamentous branches. *Pleural* hairs as described under the group; *dp*1 with 3–4 br. Tubercles as in *A. stephensi*.

Palmate hairs well developed on III–VII; hair no. 1 like an ordinary hair, on II poorly developed as palmate hair; leaflets broad, with varying amount of pigmentation towards end; filaments well differentiated, from $\frac{1}{3}$ to $\frac{1}{8}$ length of blade. *Lateral hairs* on IV–VI long, slender, with 4–7 br. on IV and 3–5 on V and VI, the branches arising near base and the hair more like a split hair than a feathered one; very short, with 5–6 br. on VII. *Tergal plates*, *scoop*, *pecten*, and *ps hair* similar to *A. stephensi*. Hair no. 4 on I with 5–8 br. Caudal hooks 6–7 well defined.

EGG †.—Galleon-shaped. Upper surface half to $\frac{1}{3}$ width of egg, with anterior and posterior demarcated areas, anterior somewhat longer and broader: demarcated areas commonly completely separated by frill from middle area, or one or other area, or both, joined to middle area, the junction marked by tags. Ventral surface unornamented. Floats touching margin of upper surface, occupying about middle third of egg, narrow, roll-like: float-ridges about 15–16; float-terminations moderately large, rounded. Frill completely surrounding the anterior and posterior demarcated areas or ending in tags where these are continuous with middle portion of upper surface.

IDENTIFICATION.—Apart from varieties or varietal forms, identification offers no difficulties, and there are no other species with which *A. maculatus* can well be confused. *A. karwari* and *A. majidi* have somewhat similarly marked tarsal segments of the hind leg, but the legs are not speckled, and in *A. karwari* there is an additional narrow pale palpal

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* LARVA: Steph. and Christ. 1902 *a*, p. 14 (*metaboles*); James 1902, p. 47; James and Liston 1904, p. 100; 1911, p. 86; Stanton 1912 *b*, p. 7; 1915 *a*, p. 169; 1926, p. 51; Mangk. 1918, p. 474; 1919, p. 54; Swell. 1916, p. 108; 1921 *a*, p. 108; Swell. and Swell. 1919 *a*, p. 30; Lamborn 1921, p. 91 (tail-hooks); Iyengar, 1921, p. 216 (thor. app.); 1922 *a*, p. 630 (tail-hooks); 1928, p. 284 (thor. app.); Carter 1925, p. 89; Senior White 1925, p. 89; Puri 1928 *b*, p. 523; 1931, p. 186.

† EGG: Christ., Paludism, no. 3, p. 67, 1911; Christ. and Barraud 1931, p. 179.

band just proximal to the preapical one. *A. theobaldi* differs in the last two tarsal segments being entirely white, without a dark band on segment 4. This band may sometimes, however, be absent in *A. maculatus* as an individual variation, though as a rule one leg at least shows some indication of it.

The distinction between the type-form and var. *willmori* lies in the extent and profusion of the scaling of the abdomen, especially in the presence in the variety of a well-marked patch of flat scales on seg. II; other differences of doubtful definitive value in individual cases are given under the variety. In the type-form in some areas, particularly at high altitudes, some specimens have numerous and broad scales, but in the same series other individuals are not so. This variability in individuals from the same area, or even from the same batch of reared specimens, is very characteristic, and may be taken as an indication that the type-form is being dealt with.

The Formosan form (*hanabusai*) has been distinguished by Yamada as a distinct species on the following points:— Scales of mesonotum oval, not pointed; pale bands on hind tarsi broader; more segments of abdomen with black scales laterally and on apex of segment ventrally.

The type-form in the Himalayan area has the scales restricted to segment VIII, these being narrow, inconspicuous, and heavily mixed with hairs. This is probably a definite geographical variety to which the male *pseudowillmori* might be applied; it has not been recognized here, as its distinction, at present at least, from the variable type-form would be difficult to maintain in individual specimens or even in some series.

DISTRIBUTION.—*A. maculatus* has a wide distribution in the Oriental Region, including China, but not the Moluccas. It has been recorded from CELEBES (with Boeton): PHILIPPINES; FORMOSA; S. CHINA; BORNEO; LESSER SUNDA ISLANDS (Timor, Alor, Flores); JAVA; SUMATRA (with Bangka, Nias, Riouw, Linga); ANAMBA and S. NATUNA ISLANDS; TONKIN; ANNAM; COCHIN CHINA; MALAY PENINSULA; SIAM; BURMA, CEYLON, and INDIA.

In the Indian area recorded from many localities throughout Burma and Assam, in various parts of Peninsular India, notably in the Nilgiris and other hilly areas in South India and the West Coast, in Ceylon, and to the north and west from many localities along the foot of the Himalayas as far north as Swat and Kohat; it is not recorded from Baluchistan. It is not commonly found in the great alluvial plains, except where rivers debouch from the hills, and is not recorded from Rajputana, Gujarat, or Sind.

BIONOMICS.—Evidence on the occurrence of *A. maculatus* in houses, etc., is somewhat conflicting. Many writers record it as infrequent in houses (*Chalam*, 1923; *Wats*, 1925; *Kingsbury*, 1928), and Kingsbury, who notes that it is more frequently caught in traps than in houses, states that it is not a house-loving species. It is, however, evidently commonly taken in houses and cattle-sheds in certain areas or circumstances (*Graham*, 1912, 1913; *Shortt*; *Watson*, 1924; *Ramsay*). It appears probable that it commonly enters houses, but leaves again after feeding (*Feegrade* 1927, Hsipaw, Lashio). It feeds readily on human blood (*Shortt*; *Green*, 1929) and has been observed feeding on cattle (*Feegrade*, 1930, Katha). It feeds by night and by artificial light (*Shortt*, *Essed*). It is attracted by light (*Essed*).

A. maculatus in India is essentially a stream and river-bed breeder (*Kenrick*, 1911; *Shortt*; *Christ.*, 1925; *Strickland*, 1924, 1925; *Strickl.* and *Chowd.*, 1928, Duars); it is also recorded from pools, springs, seepages, borrow-pits, lake-margins and rice-fields (*McCombie Young*, 1924; *Feegrade*, 1927, Hsipaw; *Ramsay*). Its breeding places have been much studied in the Federated Malay States, where it is classed as a small pool breeder, as very commonly found in drains, and as the species most commonly found in fast-flowing streams with grassy edges (*Gater* and *Rajahmoney*); it has been found in polluted water, hoof-marks, etc., and artificial receptacles (*Wilson*, 1930).

RELATION TO DISEASE.—*A. maculatus* has been infected experimentally with B.T. and M.T. to the sporozoite stage, and with quartan to the zygote stage (*Green*, Bull. Inst. Med. Res. F.M.S. no. 5, 1929), and has been found naturally infected in Malaya, the Dutch East Indies, and Burma. It is regarded, especially in the Malay Peninsula, as one of the most important malaria-carrying species.

34*a*. **Anopheles maculatus** var. **willmori** James, 1903*. (Fig. 47.)

James, in Theo., Mono. Cul. iii, p. 100, 1903 (*Nyssorhynchus willmori*). TYPE-LOC.: Kashmir. TYPE: ♀ described; type in Brit. Mus. Given varietal rank by Alcock, Journ. Lond. Sch. Trop. Med. ii, p. 164, 1913, and recently by Christ., Rec. Mal. Surv. ii, p. 330, 1931.

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* James and Liston 1904, p. 88; 1911, p. 109; Christ. 1915, p. 394 (hypop.); 1924 *b*, p. 297; 1924 *c*, p. 65, 101; 1931, p. 330; Puri 1931, p. 190 (larva); Christ. and Barraud 1931, p. 180 (egg); Senevet 1931, p. 47 (pupa). See also James, in Theo. 1903, p. 100; Theo. 1907, p. 97; 1910 *a*, pp. 57, 73; 1900 *b*, p. 3; James and Stanton 1912, p. 62; Christ. 1916, p. 484; Sinton 1917, p. 207; Strickl. 1925, p. 563 (larva); Christ. 1911, p. 69 (larva, pupa).

indica Theo., 1907, Mono. Cul. iv, p. 111 (*Neocellia indica*). TYPE-LOC.: Dehra Dun, Western Himalayas. TYPE: described from 3 ♀♀ and 1 ♂; ♂ and ♀ type in Brit. Mus. SYN. by James and Liston, Anop. Mosq. Ind. 2nd ed. p. 112, 1911.

dudgeoni Theo., 1907, Mono. Cul. iv, p. 113 (*Neocellia dudgeoni*). TYPE-LOC.: Kangra Valley, Western Himalayas. TYPE: described from several ♂♂ and ♀♀; type ♂ and ♀ in Brit. Mus. SYN. by James and Liston, *loc. cit.*

maculosa James & Liston, 1911, Anop. Mosq. Ind. 2nd ed., p. 112 (*Neocellia willmori* var. *maculosa*). TYPE-LOC.: Pathankot and other localities at foot of Western Himalayas; Kurseong, Eastern Himalayas. TYPE: a specimen labelled by James "*willmori* var. *maculosa*" in Brit. Mus. Syn. by Christ., Ind. Journ. Med. Res. iii, p. 484, 1916.

The *A. willmori* of Leicester, 1908, and some other writers mostly relate to moderately scaly forms of the typo.

ADULT.—Resembles the type-form in most respects except that the scaling of the tergites is much more profuse and the scales broader, the whole area of tergites III–VII having a covering of broad scales, whilst there is a well-developed patch of broad scales present also on seg. II.

The following are also characters in which var. *willmori* differs from the more usual appearances seen in the type-form:—Fore tarsus more frequently apically banded only; mid-tarsus scarcely, if at all, banded, a common condition being taches on the front of the joint not amounting to a band; $\frac{1}{5}$ and $\frac{1}{3}$ of segs. 2 and 3 on hind tarsus white, as against $\frac{1}{6}$ and $\frac{1}{4}$ in the type-form; preapical dark costal spot longer, usually several times length of apical dark spot. None of these characters are, however, definitive.

In a large proportion of individuals of var. *willmori* a conspicuous feature is speckling of the palpi (*maculosa* form). This form has not been seen from the N.W. Frontier Province or Kashmir, but appears to be the usual form elsewhere, and the presence of speckling of the palpi in series further east may be useful in distinguishing var. *willmori* from the type-form of *maculatus*. Where there is a speckling of the palpi, as noted also by James and Liston, there are often present small pale spots on the second tarsal segments of the fore and mid-legs and the third segment of the hind legs. This is not usually present in the type-form, but occurs even more commonly in the *pseudowillmori* form, and is described by Yamada in *hanabusai*.

LARVA.—According to Puri, resembles that of the type-form in every character.

PUPA.—Senevet has described a pupa with a simple hair *C* on seg. IV, but specimens examined in India appear to show no essential differences from *A. maculatus* as described by Senevet.

EGG.—Indistinguishable from that of the type-form.

DISTRIBUTION.—Abundant along the foothills of the whole Himalayan range between altitudes of about 2,000–8,000 feet, and extending to the N.W. Frontier Province from the Malakand to N. Waziristan, but not recorded from Baluchistan. Typical specimens of the maculose form have been seen from Shillong and from Kalaw in the Southern Shan States, Burma. For further details Christ., 1931, should be consulted.

BIONOMICS.—Commonly taken in houses in the villages about Kasauli and in Kashmir. It breeds in the stream-beds of mountain-streams and torrents in the Himalayan area (*Graham*, 1912 ; *Gill*, 1920).

35. **Anopheles theobaldi** Giles, 1901 *.

Giles, Entom. Month. Mag. (2), xii, p. 198, 1901 (*A. theobaldi*). TYPE-LOC. : Ellichpur, Amraoti Dist., Central Provinces. TYPE : ♀ described ; type in Brit. Mus.

Closely resembles *A. maculatus*, but dark band on segment 4 of hind tarsus consistently lacking, last two tarsal segments of hind leg being continuously white.

Base of costa usually darker than in *A. maculatus*, with a tendency to fusion of the acc. dark spots ; dark areas on costa more extended ; fore tarsi apically banded only and commonly all dark underneath, mid-tarsi dark or very narrowly banded, and underside all dark. No differences have been detected in hypopygium, pharynx or larva.

This was considered a variety of *A. maculatus* by Alcock (Journ. Lond. Sch. Trop. Med. ii, p. 164, 1913), but is probably distinct, though very closely related.

DISTRIBUTION.—Theobald, 1910, p. 58, gives the Philippine Islands on the authority of Ludlow, ' Mosq. of the Phil. Isls.' 1908, which reference I have verified. There appears to be no other record of *A. theobaldi* outside India.

In India it is a common species in the central and western portions of the Peninsular plateau. It is also recorded from scattered localities in other parts of India and Burma, though some of these records may apply to individual variations of *A. maculatus*. The record of *A. theobaldi* from Ceylon by Chalmers, 1905, p. 165, is considered probably incorrect by Carter, 1925, p. 59.

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* Liston 1901, p. 365 ; James and Liston 1904, p. 97 ; 1911, p. 95 ; Christ. 1915, p. 394 (hypop.) ; 1924 *c*, pp. 66, 100 ; 1931, p. 330 ; Puri, 1931, p. 190 (larva). See also Giles 1901 *a*, p. 198 ; Theo. 1900 *b*, p. 311 ; 1903, p. 95 ; 1907, p. 98, 1910 *a*, p. 58 ; Kenrick 1915 (bion.) ; Christ. 1916, p. 482.

36. **Anopheles karwari** James, 1903 *. (Fig. 48.)

James, in Theo., Mono. Cul. iii, p. 102, 1903 (*Nyssorhynchus karwari*). TYPE-LOC.: Karwar, West Coast, India. TYPE: ♀ described; type ♀ in Brit. Mus.

nigrans Stanton, 1912, Journ. Lond. Sch. Trop. Med. ii, p. 7 (*A. nigrans*). New name for *A. karwari* James. SYN. by Christ., Ind. Journ. Med. Res. iii, p. 469, 1916.

The existing ♀ type of *A. maculatus* is a specimen of *A. karwari* (*vide* Stanton, Journ. Lond. Sch. Trop. Med. ii, p. 7, 1912), and for this reason Stanton gave the name *nigrans* to the species in place of *karwari*. But Theobald's description of *maculatus* is correct for that species, though not some later references by Theobald; the original female types must, therefore, have been, in part at least, *A. maculatus*.

ADULT ♀.—Size medium (length of wing 2·5–4·3 mm.).

Head: scales of usual type, with a well-marked pale vertical area; vertical chætæ white, forming single row ending anteriorly in small cluster of 3–4; ocular scales forming single line anteriorly. *Antenna* with white scales on torus and first flagellar segment. *Palpi* moderately thick; apical segment very long, more than half preceding; index 0·64; with two broad pale bands and an extra narrow band near these, seemingly as in *A. maculatus*, but ornamentation really entirely different; apical segment not all white, intervening dark band situated towards base of this segment, next pale area involving large part of segment 4, and the apparent extra band being the usual band at 3–4.

Pharynx †: very similar to that of *A. maculatus*.

Thorax with *apn* devoid of scales. Mesonotum more or less unicolorous, showing eye-spot effect in places in certain lights; covered, including fossæ and lateral areas, with broad white scales. Pleuræ without conspicuous scales; stigmatic hairs 2–4.

Wings as in figure; a small dark spot usually on stem of 4 between cross-veins; outer half of vein 6 forming a long dark spot; an extra fringe-spot between those at 5.1 and 6; scaling similar to *A. maculatus*.

Legs with front femora swollen in basal half. Femora dark, somewhat paler beneath and narrowly pale at apices. Tibiæ dark, narrowly pale at apices, the mid with a linear pale spot on outer aspect towards base, a smaller, similar

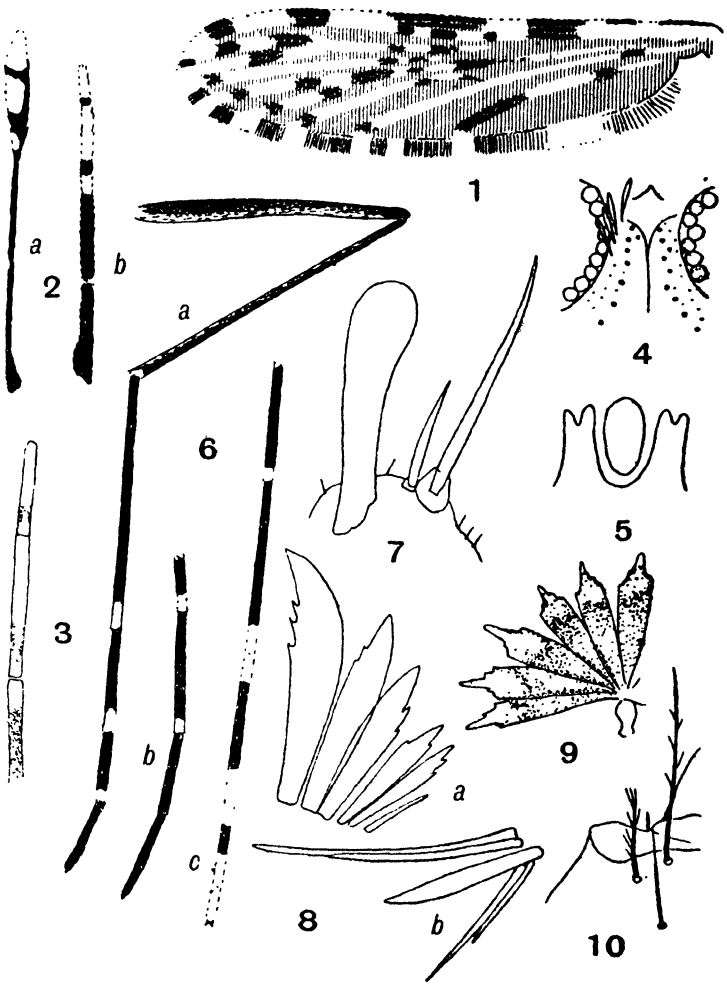
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* SYSTEMATIC: James, in Theo., 1903, p. 102; James and Liston 1904, p. 89; 1911, p. 96; Leicester 1908, p. 39; Christ. 1916 *a*, p. 469; Baisas 1931 *b*. See also Cogill 1903, p. 334; Theo. 1910 *a*, p. 58; Schüff. and v. Heyden, 1917, p. 33; Rodenw. 1921, p. 155; Swell. 1916, p. 110; 1921 *a*, p. 102; Christ. 1924 *c*, pp. 67, 104; Stookes 1929, p. 103.

† PHARYNX: in addition to Sinton and Covell, and Barraud and Covell, see Manalang 1929, p. 431.

spot on hind tibia. Front tarsi with broad pale apical bands on 1–3, middle with narrower apical bands on 1–2, hind marked very similarly to *A. maculatus*.

Fig. 48.



A. karwari.

1. Wing of ♀, ♀ standard scale. 2. Palp of (*a*) ♂, (*b*) ♀, same scale. 3. Apex of ♀ palp, showing joints. 4. Vertex. 5. Pharyngeal armature: posterior view of two crests, with base of rod. 6. Legs: (*a*) fore leg; (*b*) mid-tarsus; (*c*) hind tarsus. 7. Apex of harpago. 8. Leaflets of phallosome, standard scale: (*a*) fully flattened: (*b*) seen on edge. 9. Leaflets of palmate hair (after Puri). 10. Clypeal hairs of larva (after Puri).

Abdomen dark, with light yellowish hairs and narrow golden scales and hairs on dorsum of VIII; cerci with light scales above, dark below.

ADULT ♂.—In general as in ♀. *Palpi* ornamented as shown; marginal hairs short and stout. *Abdomen* as in ♀; VIII with conspicuous black hairs at apex ventrally (tergite); cerci with pale and dark scales.

Hypopygium *: harpago with apical hair about as long as, or a little longer than, the club, a stout hair (sometimes two), half its length or less between apical hair and club. Phallosome approaching half length of coxite; leaflets about six on each side, the largest broad, shaped like blade of pruning-knife, approaching half length of phallosome (0·054 mm.), serrated only on apical half, the others blade-like, serrated only in apical half.

PUPA.—Undescribed.

LARVA †.—Closely resembles *A. maculatus*, but fraying of inner clypeal hairs never so fine as to be indistinguishable; hair no. 1 on metathorax never differentiated into palmate hair, this having 4–9 br., which do not arise from the same place, so that it resembles a short feathered hair; leaflets of palmate hairs shorter, filament shorter and blunter, serrations at shoulder poorly marked and shallow. A number of hairs are more branched than in *A. maculatus*; hair no. 5 on II with 6–8 br. (in place of 4–5 in *A. maculatus*); lateral hairs on IV–VI with 5–8, 5–10, and 7–10 br.; ventral submedian (no. 13) on II, III, and VI with 6–9, 7–9, and 7–12 br. respectively, instead of 3–6, 3, and 5–7 in *maculatus*. Caudal hooks less well developed.

EGG ‡.—According to Stanton (in Lamborn, Bull. Ent. Res. xiii, p. 129, 1922), precisely similar to that of *A. maculatus*.

IDENTIFICATION.—The peculiar ornamentation of the palpi is quite characteristic; the unspeckled legs, with broadly banded hind tarsi, also distinguishes the species from all but *A. majidi*, to which it bears a superficial resemblance, but which is distinguished by the female palpi, darker wings, presence of a propleural hair, and other characters.

DISTRIBUTION.—With a wide distribution in the Oriental Region, being recorded from CELEBES; PHILIPPINES §; CHINA

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* HYPOPYGIUM: Christ. 1915, p. 393; Swell. 1921 *a*, p. 104; Baisas 1930 *b*.

† LARVA: James and Liston 1904, p. 89; 1911, p. 96; Stanton 1912 *b*, p. 7; 1915 *a*, p. 167; Swell. and Swell. 1919 *a*, p. 32; Lamborn 1921, p. 93 (tail-hooks); Senior White 1925, p. 218; Walch and Soesilo 1929, p. 463 (pecten); Baisas 1930 *b*; Puri 1928 *b*, p. 523; 1931, p. 190.

‡ Stanton, in Lamborn, Bull. Ent. Res. xiii, p. 129, 1922; Christ. and Barraud 1931, p. 20.

§ Baisas 1930 *b*.

(Hong Kong); TONKIN; COCHIN CHINA; BORNEO; MALAY PENINSULA; SIAM; INDIA, BURMA, and CEYLON.

In the Indian area recorded from the eastern, southern and Malabar areas. Not recorded from the United Provinces or Central Provinces, or any locality north-west of these; on the West Coast not recorded north of Bombay.

BIONOMICS.—Adults found in houses and cow-sheds (*Watson*, 1921; *Lamborn*, 1922; *Strickl.* and *Chowdh.*, 1928, Duars); *Ramsay*; *Sweet*). Feeds on man (*Barber*, 1918; *Barnes*). 85 per cent. of caught females found with blood (*Lamborn*, 1922).

Breeds in the Federated Malay States in small pools in open; also in drains, seepages, and swamps (*Gater* and *Rajahmoney*). In the Indian area recorded in Assam as breeding in springs, seepage water, weedy tanks, and pools, slow-running streams, and drains with free vegetable growth (*Ramsay*). Recorded as usually found in Bengal in seepages and seepage pools (*Sur*, 1926), and as found particularly where water runs over rock rather than earth (*Senior White*).

RELATION TO DISEASE.—Has been infected with M.T. parasites and given as highly susceptible (*Barber*, 1918). Covell gives no record of its having been found infected in nature.

37. **Anopheles jamesi** Theo., 1901 *. (Fig. 49.)

Theo., Mono. Cul. i, p. 134, 1901 (*A. jamesii*). TYPE-LOC.: Quilon, Travancore, S. India. TYPE: ♀ in Brit. Mus.

A. jamesii Liston, 1901 (Dec.) is *A. annularis*. *A. jamesii* of Steph. and Christ., 1902; Giles, 1902; Mathis and Leger, 1911, and allied species 1 and 3 of James, 1902, are *A. splendidus*. *A. jamesii* of Theo., 1903 (pl. xliii); 1910 *a*, p. 63 (in part); of James and Liston, 1904, p. 93, and 1911, p. 91; of Barnes, 1923; and probably of Carter, 1925, are *A. ramsayi*.

ADULT ♀.—Size small to medium (length of wing 2·5–3·6 mm.).

Head: scales of usual type, with a broad pale vertical area; vertical chætæ white, forming a cluster anteriorly of about 6; ocular scales forming in the main a single row. *Antenna* with white scales on torus and first flagellar segment. *Palpi* moderately thick, cylindrical; apical segment about half length preceding, index 0·5; a broad white apical band involving whole of apical and apex of preapical segment,

* SYSTEMATIC: Covell 1927 *a*, p. 1022. See also Theo. 1901 *a*, p. 134; 1902, p. 371; James 1902, p. 40; Cogill 1903, p. 328; Christ. 1916 *a*, p. 468 (in part); 1924 *c*, pp. 66, 100; Mangk. 1919, p. 50; Swell. 1919, p. 4; Borel 1929, p. 55; Feegrade 1929 *a*, p. 251. See also p. 292 (footnotes).

followed by a dark band of about the same extent; two further narrow pale bands at 2–3 and 3–4.

Pharynx: very similar to *A. annularis*; the crest in posterior view is markedly bifurcate and with constricted neck.

Thorax with a few dark scales on *apn.* Mesonotum dark, unicolorous, covered (including fossæ and lateral areas) with rather small, broad scales, narrower in median area and broader over fossæ, max. str. 7–8. Pleura dark, without scales; spiracular hairs present (6); upper mesepimeral about 7.

Wing ornamented as in fig. 49, 1; general coloration light and markings somewhat as in *A. stephensi* or *A. karwari*; two small dark, discrete, accessory basal spots; pale areas in apical half of wing about equal to dark; vein 5 extensively pale; vein 6 with three small dark spots.

Legs with front femora swollen in basal half. Femora and tibiæ not conspicuously pale beneath and not markedly pale at apices; with pale spots along their length, somewhat variable in size in different specimens and not so large and conspicuous as in *A. splendidus*. First tarsal segment with a few spots; front tarsi broadly apically banded on 1–3; mid-tarsi narrowly banded; segment 1 of hind tarsus without apical banding, segment 2 with about $\frac{1}{8}$ white and remaining segments all white.

Abdomen clothed with golden hairs on dorsum of all segments and a conspicuous dense covering of golden hairs and narrow golden scales on the last two segments and the cerci; venter of segment VIII with broadish scales.

Hypopygium *: apical hair of harpago somewhat longer than club, a hair about half length of club between it and club and a longer hair internal to it. Leaflets rather small (0·042 mm.), most leaflets with some serrations.

Pupa.—Undescribed.

Larva †.—Very closely resembles *A. annularis*, but hairs of head shorter; outer clypeal more regularly branched; both shoulder hairs, especially the inner, very swollen; *dp*3 very minute, much shorter than in *A. annularis*; hair no. 1 on I not developed as a palmate hair; that on II poorly developed; filaments of palmate hairs shorter, being about half length of blade. Chitinous tubercles of pleural hairs are large (especially that on III), with long sharp spines.

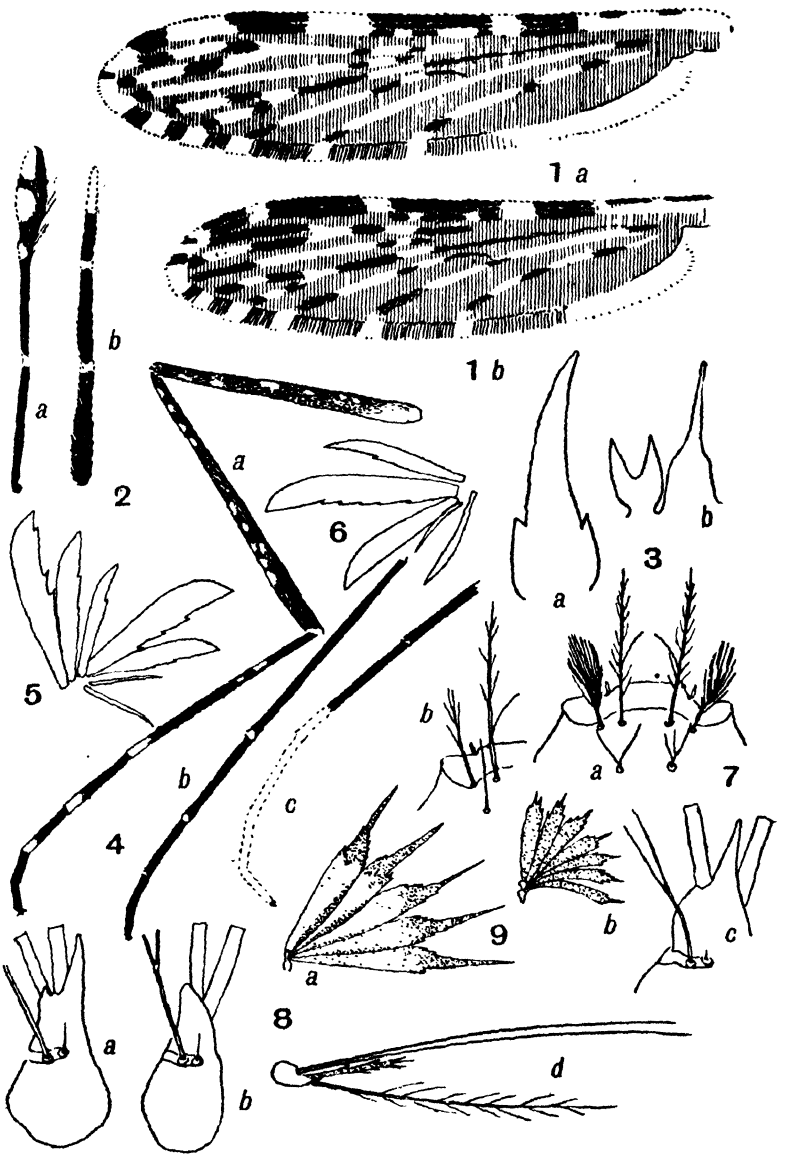
Egg ‡.—Upper surface not so broad as egg; anterior demarcated area about $\frac{1}{4}$ length of egg and nearly twice

* Hypopygium: Christ. 1915, p. 393.

† Larva: Puri 1927, p. 511; 1928 *b*, p. 523; 1931, p. 204. See also Cogill, 1903, p. 328; Mangk. 1919, p. 50; Carter 1925, p. 88 (?); Senior White 1925, p. 128; Borel 1929, p. 55.

‡ Egg: Christ. and Barraud 1931, p. 178.

Fig. 49.



A. jamesi and *A. ramsayi*.

1. Wing of ♀, standard scale: (*a*) *A. jamesi*; (*b*) *A. ramsayi*. **2.** Palp of (*a*) ♂, (*b*) ♀, *A. jamesi*. **3.** Pharyngeal teeth, *A. jamesi*: (*a*) anterior view of cone; (*b*) posterior view of crest and rod; the teeth of *A. ramsayi* are very similar. **4.** Legs: (*a*) fore leg; (*b*) mid-tarsus; (*c*) hind tarsus, *A. jamesi*. **5.** Leaflets of phallosome, standard scale, *A. jamesi*. **6.** Ditto, *A. ramsayi*. **7** Clypeal hairs of larva: (*a*) *A. jamesi*; (*b*) *A. ramsayi* (after Puri). **8.** Pleural hairs of larva (after Puri): (*a*) chitinous base of prothoracic hairs, *A. jamesi*; (*b*) *A. ramsayi*; (*c*) base of metathoracic hair, *A jamesi*; (*d*) prothoracic pleural hairs, *A. ramsayi*. **9.** Leaflets of palmate hairs: (*a*) *A. jamesi*; (*b*) *A. ramsayi* (after Puri).

length of posterior area. Floats touching margin of upper surface, occupying about middle half of egg-length, and extending somewhat nearer to posterior end; float-ridges 11–13, rather broad; float-terminations large, flattened, rounded. Frill narrow, striated.

IDENTIFICATION.—The species can only be confused with *A. ramsayi* (see remarks under that species) and *A. splendidus*. From the latter it is distinguished by the presence of only one broad band on the palpi and absence of speckling on these organs. In addition, the lighter wings, less pronounced speckling of the legs, and presence of scales on the fossæ are points of distinction.

DISTRIBUTION.—Recorded outside the Indian area only from TONKIN and COCHIN CHINA. The records from Siam and Dutch East Indies appear probably to relate to *A. ramsayi* (see *Barraud* and *Christ.*, 1931, and *Swellengrebel* and *Rodenwaldt*).

In the Indian area recorded from Lower Burma and Ceylon, also in the eastern areas (Assam, Bengal, Chota Nagpur, and Orissa), the Malabar and Konkan (as far north as Nasik), and S. INDIA. Not recorded from Bihar or N.W. and Central India except from Bhandara in Central Provinces west.

BIONOMICS.—Found in houses and stables (*Ramsay*; *Sweet*). Given as breeding in interstices of *Cypereus* and *Salvinia* in lakes, and also rain-pools and ponds with grass (*Feegrade*, Bhamo). Puri, 1931, gives pools in river-beds and springs, and surface-wells. Some earlier records of breeding places may relate to *A. ramsayi*.

RELATION TO DISEASE.—No evidence.

38. **Anopheles ramsayi** Covell, 1927 *. (Fig. 49.)

Covell, Ind. Journ. Med. Res. xiv, p. 1019, April 1927 (*A.* (*Myzomyia*) *ramsayi*). TYPE-LOC.: Cachar, Assam, India. TYPE: ♂ and ♀ in Brit. Mus.

pseudojamesii Strickland & Chowdhury, May 1927, Ind. Med. Gaz. lxii, p. 240 (*A. pseudojamesii*). TYPE-LOC.: Bengal. TYPE: Calcutta. SYN. by Puri, Ind. Journ. Med. Res. xv, p. 516, 1927.

This species was formerly confused with *A. jamesi* (see remarks under that species and references below). It has not so far been recorded from West India.

ADULT.—A small anopheline (length of wing 2–3 mm.). Similar to *A. jamesi* in general markings, but differing in a number of characters. Palpi of ♀ as in *A. jamesi*, index 0·5.

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* SYSTEMATIC: Theo. 1903 (p. xliii) (*jamesi*); 1910, p. 63 (in part); James and Liston 1904, p. 93 (*A. jamesi*); 1911, p. 91 (*jamesi*); Carter 1925, p. 73 (*jamesi*); Covell 1927 *a*, p. 1020; Strickl. and Chowd. 1927 *a*, p. 240; Chowdhury 1928 *b*, p. 41. See also p. 295 (footnotes).

Pronotal lobes without scales. Mesonotum covered with broad scales involving fossæ and lateral areas also. Wing much darker than in *A. jamesi*; base of costa mainly dark; pale interruptions in apical half of wing narrow; a dark area on vein 5 in middle Femora, tibiæ, and first tarsal segment conspicuously pale beneath, otherwise very similar to *A. jamesi*, but apex of seg. 1 of hind tarsus with pale band. Abdomen dark, with golden brown hairs and lacking the light golden covering of hairs and scales seen in *A. jamesi*.

Pharynx: very similar to *A. jamesi*.

Hypopygium: very similar to *A. jamesi*; possibly fewer leaflets and smaller (0·038 mm.).

PUPA.—Undescribed.

LARVA *.—*Clypeal hairs*: *ic* frayed: *oc* half to $\frac{2}{3}$ inner, stout, with 3–8 short lateral br.; *pc* simple. Inner sutural about as long as posterior clypeal, simple. *Antenna*: terminal hair at $\frac{1}{3}$ to $\frac{1}{4}$ length of antenna from base, split about middle into 3–5 br. *Mentum* with seven teeth, the three on each side of median tooth about adequal and equidistant. Submentum peculiar in having single median tooth.

Shoulder hairs: inner short, without basal tubercle, except a very small one occasionally; middle about $1\frac{1}{2}$ times length of inner. *Metathoracic hair no.* 1 not transformed into palmate hair. *Pleural hairs* as given for group, except that *dp*1 is rather stout, with somewhat truncated distal end, and has a number of short spinous lateral branches. Lateral branches of feathered pleural hairs also comparatively short and stiff. Chitinous tubercles large, 1 and 3 with long sharp spines, 2 with rounded spine. *dp*3 very minute, as in *A. jamesi*.

Palmate hairs well developed on III–VII; hair no. 1 on I not developed as palmate hair; that on II poorly developed. Leaflets more or less uniformly pigmented, but sometimes somewhat darker at end; filament short, about $\frac{1}{3}$ length of blade. Lateral hairs on IV–VII long, splitting near base into 2–3 on IV and V and 3–4 on VI. Tergal plates of moderate size. *spc* well marked; *mps* very broad anteriorly, nearly touching chitinisation. *ps hair* with 3–5 br., two short and the rest long. *Pecten* with three long and nine very short processes, all finely serrated on basal half. Caudal hooks 6–7, rather poorly developed.

EGG †.—Very similar to *A. jamesi*; float-ridges somewhat less numerous.

IDENTIFICATION.—From *A. jamesi* this species is at once distinguished by lacking the golden-yellow covering of the

* LARVA: Strickl. and Chowd. 1927 *a*, p. 240; Chowdhury 1928 *b*, p. 41; Covell 1928 *a*, p. 1061; Puri 1927, p. 515; 1928 *b*, p. 523; 1931, p. 200.

† EGG: Christ. and Barraud 1931, p. 178.

apical portion of the abdomen and by the darker wings with narrow pale costal interruptions and dark on vein 5. The conspicuous pale under surface of the femora, tibiæ, and first tarsal segments also gives a ready means of differentiation. The outer clypeal hairs of the larva distinguish *A. ramsayi* from *A. jamesi*, but are somewhat similar to those of *A. splendidus*; the very long inner clypeal hairs and the peculiar dorsal posterior pleural hair of the prothorax readily distinguish *A. ramsayi* from *A. splendidus*.

DISTRIBUTION.—Outside the Indian area recorded from SIAM; JAVA; SUMATRA. In the Indian area recorded only from BURMA, CEYLON, and eastern areas (Assam, Bengal, Orissa). From Burma it has only been recorded so far from Bhamo in UPPER BURMA.

BIONOMICS.—Is found in houses and cow-sheds (*Ramsay*; *Sur* and *Sur*). Breeds, according to Covell, 1927 (Mem. no. 7), in pools containing algæ and in swamps. Ramsay gives grassy tanks, permanent pools, and swamps with clear standing water in which long grass grows abundantly.

RELATION TO DISEASE.—*A. ramsayi* has been found infected (sporozoites) in nature in Bengal (*Strickland*), and in Cachar (*Ramsay*).

39. **Anopheles splendidus** Koidzumi, 1920 *. (Fig. 50.)

Koidzumi, Daiwan.Kenkyujo Hokoku, viii, pp. 23, 32, 55, 1920 (*A. splendidus*). TYPE-LOC.: Formosa.

indiensis Theo., Mono. Cul. iii, p. 99, 1903 (*N. maculipalpis* var. *indiensis*). TYPE-LOC.: Nagpur, Central Provinces, India. TYPE: type ♀ in Brit. Mus. SYN. by Edwards, Gen. Insect. 1932. (Nec *A. sinensis* var. *indiensis* Theo., 1901.)

maculipalpis James & Liston, Anop. Mosq. of India, ed. 1, p. 95, 1904 (*A. maculipalpis*). TYPE-LOC.: India. SYN. (of *indiensis*) by Christ., Ind. Med. Res. Mem. no. 3, p. 66, 1924. Nec *A. maculipalpis* Giles, 1902.

A. maculipalpis Giles is the African form, shown by Christ., 1924, to be distinct (variety), and since considered by Yamada, 1925, a distinct species. The name *indiensis* is, however, preoccupied (*vide* Christ., 1924 *c*, p. 67), so that the correct name for the species is *A. splendidus* Koidzumi. (See also note under *A. jamesi*.)

ADULT ♀.—Size medium to rather large (length of wing 2·5–4·3 mm.).

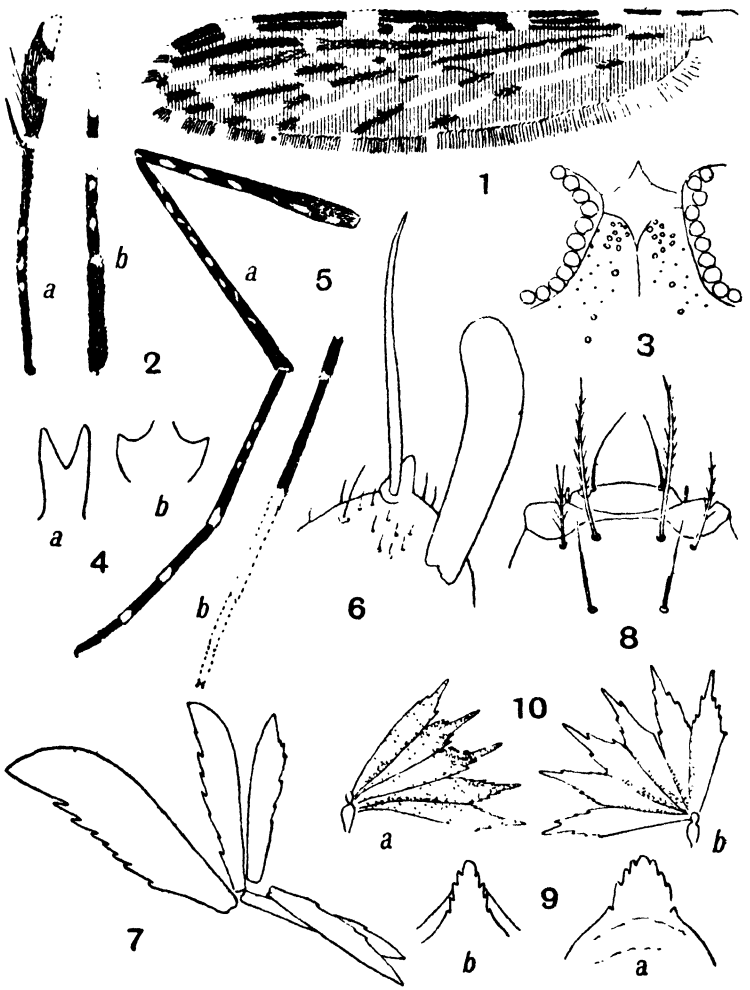
Head: scales of normal type, with a well-marked white vertical area; vertical chætæ forming a cluster anteriorly of about 9; ocular chætæ about a single row in front. *Antenna* with a few minute scales sometimes on torus and white

* SYSTEMATIC: Yamada 1925, p. 476 (*indiensis*). See also James 1902, p. 41; James and Liston 1904, p. 95; 1911, p. 93; Theo. 1903, p. 99; 1907, p. 98; 1910, p. 62; Christ. 1916 *a*, p. 471; 1924 *c*, pp. 66. 101; Koidzumi 1924, p. 99; Chung and Lin 1929. See also pp. 298–299 (footnotes).

scales on first flagellar segment. *Palpi* of moderate thickness, index 0·5, with two broad apical bands; intervening dark area shorter than either pale band, and a narrow band at 2–3; two or more distinct white spots on segment 3.

Pharynx.—Very similar to *A. annularis*.

Fig. 50.



A. splendidus.

1. Wing of ♀, ♀ standard scale. **2.** Palp of (*a*) ♂, (*b*) ♀, same scale. **3.** Vertex. **4.** Pharyngeal teeth: (*a*) posterior view of crest; (*b*) base of cone, anterior view. **5.** Leg: (*a*) fore leg; (*b*) hind tarsus. **6.** Harpago. **7.** Leaflets of phallosome, standard scale. **8.** Clypeal hairs of larva (after Puri). **9.** (*a*) mentum; (*b*) submentum, showing single apical tooth. **10.** Leaflets of palmate hair of larva (after Puri): (*a*) and (*b*) two different forms of leaflet.

Thorax usually without any scales on *apn*. Mesonotum dark, and darker still on fossæ and lateral areas; median area covered with rather narrowish white scales, broader in places, fossæ largely bare, the usual dark scales on promontory, and a well-marked line on lateral area in front of wing-roots. Pleuræ dark, with white chætæ but no conspicuous scales; spiracular chætæ present (1–6); upper mesepimeral about 9. A conspicuous tuft of scales on middle coxa.

Wings as in fig. 50, 1, dark and very similar in general ornamentation to *A. annularis*; subcostal pale area often bridged with dark on vein 1; scaling, especially on vein 2, rather profuse.

Legs with front femora somewhat swollen in basal half. Femora and tibiæ with rows of round and oval large conspicuous white spots, without marked paling beneath or marked apical banding. First tarsal segment also with some spots; tarsi otherwise marked very similarly to *A. annularis*, about $\frac{1}{8}$ of segment 2, with all the remaining segments on hind legs white.

Abdomen dark, with hairs only, except some darkish inconspicuous scales on hinder border of VIII and venter of VII. Cerci with dense black scales.

ADULT ♂.—In general as in ♀. *Palpi* ornamented as shown; marginal hairs forming about a double row on segment 4; segment 3 speckled as in ♀. *Abdomen* with narrow pale scales dorsally on VIII; coxites with dark and pale scales.

Hypopygium *: harpago with apical hair somewhat longer than club; no other large hair present, but a small hair, with base on inner aspect, less than $\frac{1}{4}$ length of apical hair. Phallosome a little less than half length of coxite, with about five leaflets on each side; largest leaflet about half length of phallosome (0·055 mm.), very broad, serrated in full length; remaining leaflets all serrated. The very broad main leaflet appears characteristic.

PUPA †.—Similar in general to *A. stephensi*, but hairs continued on posterior border of paddle beyond paddle-hair and hair *C* on segs. V–VII with lateral leashiform branches; hair 4 inconspicuous.

LARVA ‡.—*Clypeal hairs*: *ic* stout, conspicuously frayed; *oc* about $\frac{2}{3}$ length of inner, with lateral branches; *pc* slender, simple, or sometimes bifid distally. Inner sutural about

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* HYPOPYGIUM: Christ. 1915, p. 394.

† PUPA: Senevet 1931, p. 33.

‡ LARVA: Steph. and Christ. 1902 *b*, p. 13 (*jamesi*); James and Liston 1904, p. 96; 1911, p. 94; Puri 1928 *b*, p. 523; 1931, p. 197.

as long as posterior clypeal, split into 2–4 (usually 3) br. *Antenna* with hair arising ⅓ to half length of antenna from base; terminal hair split about middle into 2–4 br. *Mentum* with nine teeth, the first and last of the four on either side smaller than the others.

Shoulder hairs: inner and middle arising from tubercles, often more or less confluent; both hairs stout, feathered, the middle a little longer than inner; resembling shoulder hairs of *A. maculatus*, but tubercles a little larger. Metathoracic hair no. 1 not forming palmate hair. *Pleural hairs* as given for group; the hairs and their tubercles as in *A. maculatus*.

Palmate hairs well developed on III–VII, hair no. 1 on I like an ordinary hair; the palmate hair on II poorly developed. Leaflets more or less uniformly pigmented and fairly broad; filament about ⅓ length of leaflet, very broad at base, shoulder serrations poorly developed. *Lateral hairs* on IV–VI long, split near base into 3–4 on IV, 2–6 on V, and 3–5 on VI; very short and split into 4–5 on VII. *Tergal plates* small, like those of *A. maculatus*. *spc* and *mps* as in *A. maculatus*. *ps hair* with 5–7 br. *Pecten* with five long and about twelve short processes, finely serrated on basal half. *Caudal hooks* 5–7, fairly well formed.

Egg *.—Galleon-shaped. Upper surface about ⅓ width egg-body, with an anterior and posterior demarcated area each about ⅓ length of egg. Ventral surface unornamented. Floats touching margin of upper surface, occupying about middle half of egg-length, extending very slightly nearer posterior end of egg; float-ridges about 20; float-terminations large, rounded. Frill ending in tags at junction with floats, striated.

Identification.—See remarks under *A. jamesi*. *A. splendidus* is distinguished from *A. maculipalpis* Giles (African) by the much greater extent of white on segment 2, of the hind tarsus in the latter species (half to ⅓), also by the palpal index.

Distribution.—This appears to be a northerly Oriental form with a distribution across south Asia, but not extending into the Malay Peninsula and Dutch East Indies. It has been recorded from China (Canton, Swatow, Hong Kong); Formosa; Tonkin; Siam; Burma and India.

In the Indian area it is recorded from the extreme north-west (Baluchistan, Chitral) to Upper and Lower Burma and S. India, but not from Sind or Rajputana up to date. Though recorded for Ceylon by Chalmers, 1905, this is

* Egg: Steph. and Christ. 1902 *b*, p. 13 (*jamesi*); Christ. and Barraud 1931, p. 178.

probably erroneous (*vide* Carter, Sess. Paper, no. 7, 1927 p. 8).

BIONOMICS.—*A. splendidus* is found, usually in small numbers, in houses, outhouses, cow-sheds, etc. (*Graham*, 1913; *Kenrick*, 1915; *Strickl.* and *Chowdh.*, 1928, Duars, 2 per cent. of total; *Sweet*; *Richmond* and *Mendis*). Its breeding places in North-West India are especially pools with alga and vegetation in river-beds. It is also recorded in clear pools in river-beds in Burma (*Lalor*, 1913, Katha), and in jungle-streams in the Central Provinces (*Goverdhan*, 1912) ponds with aquatic vegetation (*Feegrade*, 1927, Lashio), in tanks with weeds (*Kenrick*, 1914), and from a marshy lake margin (*Graham*, 1914).

RELATION TO DISEASE.—The species was found infected in nature at Saharanpur (*Robertson*, 1910); otherwise the small number of observations made have been negative.

40. **Anopheles annularis** Van der Wulp, 1884*. (Fig. 51.)

Van der Wulp, Notes from the Leyden Museum, vi, p. 249, 1884 (*A. annularis*). TYPE-LOC.: Mount Ardjoeno, East Java. TYPE: described from a single ♀; type in Leyden Mus.

fuliginosus Giles, 1900, Handb. Gnats or Mosq. ed. 1, p. 160 (*A. fuliginosus* (species "*a*," from Calcutta)). TYPE-LOC.: Calcutta. TYPE: original description is of a ♀ with two hind tarsal segments white; type ♀ in the Brit. Mus., labelled "Calcutta, Dr. C. W. Daniels," has three hind tarsal segments white. SYN. by Edwards, Gen. Insect. 1932. I have followed Edwards, as I understand that the original type of *annularis* has been seen by Col. Brug, who considers it to be the species now generally known as *fuliginosus*.

leucopus Dönitz, 1901, Insectenbörse, xviii, p. 37, Jan. (*A. leucopus*). TYPE-LOC.: Doerian, Sumatra. SYN. by Theo., Mono. Cul. ii, p. 307, 1901. There is no doubt from Dönitz's figures that this species is *A. annularis*, and not *A. philippinensis*.

jamesi Liston, 1901, Ind. Med. Gaz. xxxvi, p. 441, Dec. 1901 (*A. jamesi*). TYPE-LOC.: Ellichpur, Berars, Deccan, India. SYN. by Theo., Mono. Cul. iii, p. 93, 1903.

nagpori James & Liston, 1904, Anop. Mosq. India, ed. 1, p. 101 (*A. nagpori*). TYPE-LOC.: Nagpur, Central Prov., India. SYN. by Christ., Ind. Journ. Med. Res. iii, p. 465, 1916. *A. jamesi*, allied species 2 of James, 1902, is this form.

adiei James & Liston, 1911, Anop. Mosq. India, ed. 2, p. 89 (*Nyssorhynchus fuliginosus* var. *adiei*). TYPE-LOC.: Punjab, India. SYN. by Christ., *loc cit.*

Chagasia lineata of Ludlow (Canad. Entom. xl, p. 50, 1908) has been placed by Dyar and Shannon as synonymous with *A. fuliginosus*, but as these authors' conception of this species is very wide, it may be one of the allied forms. The so-called var. *nagpori* is the form with an extra dark band on the apical segment of the palpi; var. *adiei* is the form with an extra dark band on the hind tarsus, giving only two segments continuously white; both these are melanic variations, and the latter is usually seen as a winter form.

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* For references see next page.

ADULT ♀ *.—Size medium (length of wing 2·3–4·2 mm.).

Head: scales of usual type, with a well-marked white vertical area; vertical chætæ white, ending in a cluster of about five flattened chætæ anteriorly, which form a rather scanty frontal tuft; ocular scales forming about a single row in front. *Antenna*: torus sometimes with some small scales; white scales on first flagellar segment and commonly on 2–6 succeeding segments. *Palpi* shaggy; apical segment somewhat less than half preceding (index 0·42); all pale, forming a broadish apical pale band, sometimes with dark scales forming an extra dark band; narrow pale bands at 2–3 and 3–4.

Pharynx †: filament of cones broad, rather abruptly tapering, indefinitely fimbriated; crest very broad, massive; with two rows of spines ending anteriorly in several well-developed lateral spines; two post-filament spines present; posterior view bifid.

Thorax usually with one or two dark scales on *apn.* Mesonotum almost black, unicolorous, covered throughout with broad, short, oval white scales, somewhat broader on fossæ and lateral areas, and with the usual arrangement on the promontory, including many dark scales laterally on anterior face. Pleuræ with an occasional pale scale, but no definite patches except on bases of coxæ; spiracular chætæ present (2–4); upper mesepimeral about 6.

Wing as in fig. 51, 1; base of costa mainly dark; subcostal pale area bridged by dark scaling on vein 1; 5 largely dark, or with at least a dark area in middle near origin of branch. Scaling heavy, lateral scales long, and almost, or quite, touching those of contiguous veins on anterior portion of wing; scales rather broad, fusiform; max. str. 10–12.

Legs with front femora swollen in basal half. Front femora ornamented as shown; mid-femora with a conspicuous pale spot on anterior surface towards apex. Tibiæ dark, usually with pale stripe and pale at apices. Front tarsus broadly apically and somewhat basally banded on segs. 1–3;

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* SYSTEMATIC: James and Liston 1904, p. 91; 1911, p. 87; Christ. 1916*a*, p. 464; 1924*b*, p. 300; 1924*c*, pp. 63, 74, 99; Sur 1928, p. 45; Covell 1928*a*, p. 1059 (tarsal banding); Feegrade 1929*b*, p. 253; Edwards 1932, p. 3. See also Liston 1901, p. 441 (*jamesi*); James 1902, p. 38; Dönitz 1902, p. 73 (*leucopus*); Manders 1903, p. 265; Theo. 1902, p. 370; 1907, p. 99; 1908, p. 288; 1910*a*, p. 63; Brahmachari 1912, p. 186; Ludlow 1914, p. 55; Schüff. and v. Heyden 1917, p. 29; Mangk. 1919, p. 49; Rodenw. 1921, p. 154 (pilot); Koidzumi 1924, p. 100; 1930, p. 235; Borel 1925, p. 224; 1929, p. 51; Edw. 1928, p. 260; Dyar and Shannon 1925, p. 88; Carter 1925, p. 73; Barraud and Christ. 1931, p. 274. See also pp. 302, 304 (footnotes).

† PHARYNX: in addition to Sinton and Covell, and Barraud and Covell, see Manalang 1929, p. 431.

mid-tarsus more narrowly apically banded on same segments; hind tarsus with 1 broadly banded with white apically, 2 with about $\frac{1}{3}$ its length apically white, 3–5 in typical form continuously white, a dark band present, of varying extent, on base of 3 in many cases (var. *adiei*, or winter form).

Abdomen dark, with dark hairs; some dark scales apically, and especially laterally, on VII–VIII or VI–VIII dorsally, and commonly with some pale scales on VIII; pale scaling ventrally at sides on same segments; cerci with conspicuous dark scales.

ADULT ♂.—In general as in ♀. *Palpi* as shown; marginal hairs forming about a double row on segment 4. Abdomen with some scales much as in ♀, but with conspicuous black hairs at apex of VIII ventrally; coxites with scales.

Hypopygium: harpago with apical spine very short, shorter than the club; a hair almost as long between it and the club and about three longish hairs on inner side of harpago. Phallosome a little less than half coxite; leaflets about six on each side, the longest a little less than half length of phallosome; leaflets blade-shaped, well serrated through greater portion of length on one side and some serrations occasionally on the opposite side; length of longest leaflet 0·054 mm.

PUPA *.—Very similar to *A. stephensi*.

LARVA †.—*Clypeal hairs*: *ic* conspicuously frayed: *oc* half to $\frac{2}{3}$ length of inner, pinnately branched; *pc* about half length of outer, 2–4 branched or simple. *Inner sutural* about as long as *pc* and simple or bifid distally. *Antenna* with hair arising about $\frac{1}{3}$ length of antenna from base; terminal hair split into 3–4 br. *Mentum* with three teeth on either side of

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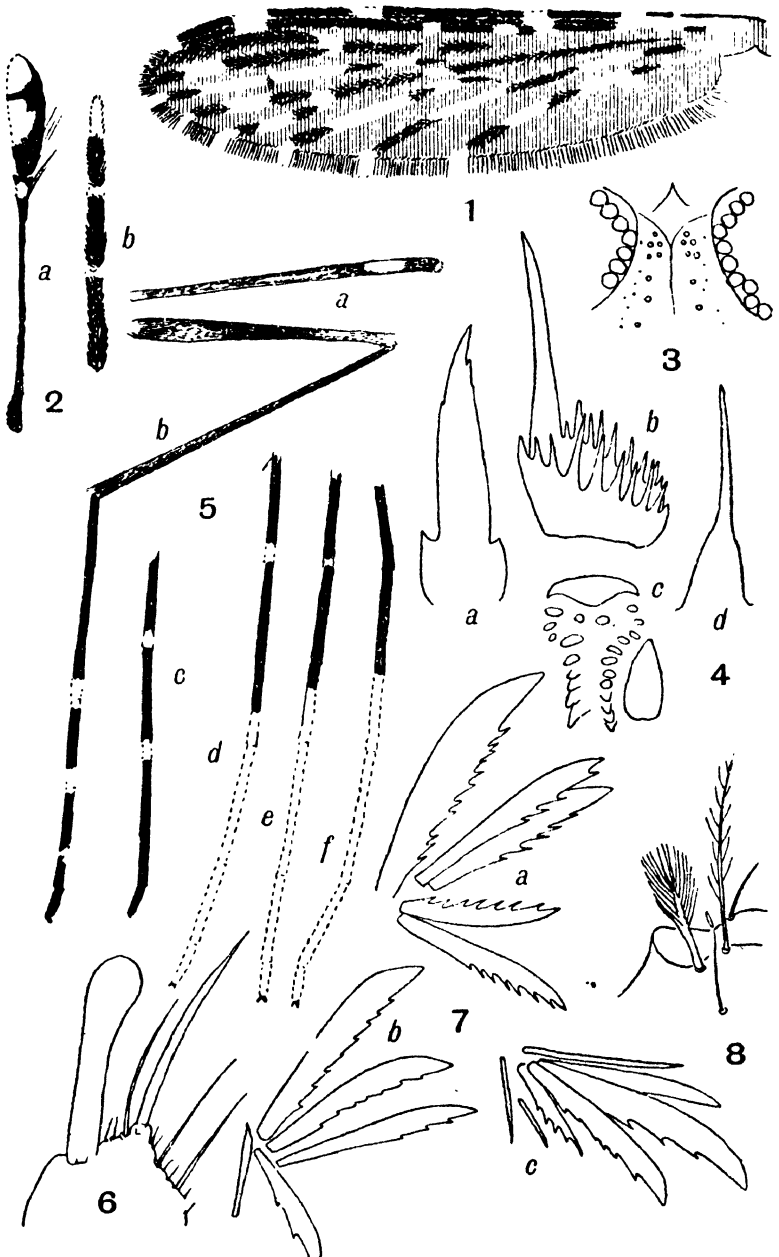
* PUPA: Senevet 1931, p. 62.

† LARVA: Iyengar 1929 *a*, p. 640; Puri 1927, p. 513; 1931, p. 207. See also Steph. and Christ. 1902 *a*, p. 12; 1902 *b*, p. 8; James 1902, p. 38; James and Liston 1904, p. 91; 1911, p. 87; Stanton 1912 *b*, p. 8; 1915 *a*, p. 166; 1915 *b*, p. 253; Swell. and Swell. 1919 *a*, p. 26; Mangk. 1919, p. 49; Lamborn 1921, p. 93 (tail-hooks); Senior White 1925, p. 218; Carter 1925, p. 87; Strickl. 1925, p. 562; Borel 1925, p. 224; 1929, p. 51; Walch and Sœsilo 1929, p. 463 (pecten).

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1. Wing of ♀, $\frac{4}{7}$ standard scale. 2. Palpi of (*a*) ♂, (*b*) ♀, same scale. 3. Vertex. 4. Pharyngeal teeth: (*a*) front view; (*b*) lateral view, showing both rows of crest-spines; (*c*) upper view of pediment, showing foreshortened filament and arrangement of crest-spines, base of a rod also shown; (*d*) rod. 5. Legs: (*a*) anterior view of mid-femur; (*b*) fore leg; (*c*) mid-tarsus; (*d*) hind tarsus; (*e*) hind tarsus, *A. philippinensis*; (*f*) ditto, *A. pallidus*. 6. Harpago. 7. Leaflets of phallosome, standard scale: (*a*) *A. annularis*; (*b*) *A. pallidus*; (*c*) *A. philippinensis*. 8. Clypeal hairs of larva (after Puri).

Fig. 51.



A. annularis ; also *A. pallidus* (5 *f*, 7 *b*) and *A. philippinensis* (5 *e*, 7 *c*).

(For explanation of figure, see opposite page.)

median tooth, third tooth smaller and placed further back than the others.

Shoulder hairs: inner and middle hair rising from fused basal tubercles, both hairs with thickened stem, the inner usually much dilated in proximal half, but sometimes longer and less swollen. *Metathoracic hair no.* 1 forming fairly well developed palmate hair. *Pleural hairs* as given under the group; *dp*1 with 1–2 lateral branches on one side; *dp*2 about half as long as chitinous projection of tubercle; chitinous bases with spinose projection on each segment.

Palmate hairs well developed on II–VII; that on I fairly developed; filament about ¾ length of blade, serrations at shoulder deep and well marked; leaflets pigmented, with deeper patch at end. *Lateral hairs* on IV–VI long and slender, splitting into three about middle on IV and V, and near base on VI. *Tergal plates* of moderate size. *spc* fairly well marked; *mps* fairly broad but not touching chitinisation. *ps hair* with 6–8 br., 4 of these fairly long. *Pecten* strongly chitinized, with 3–5 long and 10–12 short processes, all serrated, long processes longer than in most larvæ. Caudal hooks 5–7, fairly well defined.

Egg *.—Open boat shaped. Upper surface as broad as egg-body, without distinct demarcated areas and only slightly narrowed in median portion, the part with frill anteriorly somewhat longer and broader than that situated posteriorly. Lower surface unornamented. Floats touching margin of upper surface, occupying about middle half of egg; float-ridges about 20, rather smooth, regular; float-terminations of moderate size. Frill moderately broad, merging gradually into floats without tags.

Identification.—The black colour, with characteristic long white area on hind tarsi and non-speckled femora and tibiæ, distinguishes this species from any but those of the group of somewhat similar forms given below. It is distinguished from others of this group by vein 5 being extensively dark or having at least a dark spot in its middle area.

The following is a synoptic arrangement of Oriental forms having two or more hind tarsal segments continuously white and non-speckled femora and tibiæ:—

1. Vein 5 extensively pale, without any dark area in region of origin of branch; palmate hair on abd. seg. I of larva (in *pallidus* and *philippinensis*) vestigial.
   a. Two and a half segments of hind tarsus continuously pale, segs. 1 and 2 with apical white bands; pale apical band on palp involving half or more of subapical

* Egg: Steph. and Christ. 1902 *a*, p. 12; Stanton 1922, p. 131; Christ. and Barraud 1931, p. 177.

segment; scales on abdomen confined to posterior edge of segment 8 and cerci. Not recorded from Indian area ..... *schüffneri.*

b. Three tarsal segments continuously pale.

(1) Scattered broad white scales on ventral aspect of most abd. segments; no pale interruption on hind tarsus above white area; scales on 5 or 6 segments dorsally, scaling often rather heavy; a scale-patch on sternopleuron; scale-tuft on ventral aspect of seg. 7 in ♀ very conspicuous. Posterior clypeal hair of larva with 2–5 br.; filament of palmate hair half or more length of blade. General appearance brownish rather than black ..... *pallidus.*

(2) Few or no white scales except towards apex of venter; usually some degree of interruption at apex of seg. 1 of hind tarsus; scales usually on last few segments only dorsally; sternopleuron without patch of scales; scale-tuft on ventral aspect of seg. 7 in ♀ present but not so conspicuous; dark scales on lateral posterior angles of tergites often very conspicuous. Posterior clypeal hair of larva with 7–10 br.; filaments of palmate hair ¼ length of blade. General appearance black, like *A. annularis* .. *philippinensis.*

2. Vein 5 not so; either extensively dark or there is at least a dark spot in region of origin of branch. Palmate hair on abd. seg. 1 of larva well developed.

Two or three hind tarsal segments may be white, apex of seg. 1 always forming definite pale spot; no scattered white scales on venter except near apex; scales confined to last few abdominal segments dorsally; few or no scales on sternopleuron; scale-tuft on ventral aspect of seg. 7 in ♀ inconspicuous or absent ..... *annularis.*

For immediate purposes a good working table for the Indian members of this group is as follows:—

1. Vein 5 in female with a dark spot in region of origin of branch; a well-marked spot at apex of seg. 1 of hind tarsus ..... *annularis*

2. Vein 5 in female extensively pale; no interruption, or a not very marked one, at apex of seg. 1 of hind tarsus.

a. No trace of interruption on tarsus; scattered pale scales over most of venter ..... *pallidus.*

b. Varying degrees of interruption, rarely entirely without; any scattered pale scales restricted to last few apical segments ..... *philippinensis.*

DISTRIBUTION.—With a fairly wide distribution in the Oriental Region and recorded from * PHILIPPINES ; FORMOSA ; S. CHINA † ; BORNEO ; LESSER SUNDA ISLANDS (Soemba, Timor) ; JAVA (with Noesa Kambangan) ; SUMATRA (with Nias) ; TONKIN ; ANNAM ‡ ; COCHIN CHINA ; MALAY PENINSULA ; SIAM ; BURMA, CEYLON, and INDIA.

In the Indian area *A. annularis* is recorded from numerous localities in all the divisions given by Covell (except the Andamans and Baluchistan). It has been recorded from Putao in the extreme north-east of Burma, from Salween in the extreme south-east, from Nepal, Kashmir, and the extreme north-west to Chitral and North Waziristan. For further particulars, see *Covell.*

BIONOMICS.—*A. annularis* in the Indian area is pre-eminently a cattle-feeding species, being commonly found, often in very large numbers, in cattle-sheds and suchlike situations (*Fry*, 1912 ; *Kenrick*, 1914 ; *Shortt*, 1924 ; *Strickl.* and *Chowdh.*, 1928, Duars ; *Basu* ; *Ramsay* ; *Sweet*). It was obtained, gorged with blood, presumably cattle-blood, among bushes, grass-tufts, etc., away from habitations (*Christophers*, 1911). It is also found commonly in human habitations (*Adie*, 1905 ; *Graham*, 1912, 1913 ; *Phillips*, 1923, Moradabad), but usually not in such numbers or frequency as in places where cattle have been kept. Fry notes that it is scarce in bedrooms ; Shortt states that it comparatively seldom enters dwelling-houses in Shillong even when numerous in cattle-sheds ; Watson, 1928, in Assam, caught 2,054 in cattle-sheds and 60 in houses. Sur and Sur, however, in Bengal, making systematic catches, found the total about equal in houses and cattle-sheds. On the whole it is very distinctly a cattle-loving species as seen in the Indian area. Kingsbury, in the Federated Malay States, classes it among the non-house-loving species also.

It feeds readily on both human and animal blood ; 6 out of 14 specimens caught by Brug and Walch were attacking man ; Yamada gives it as feeding on human blood at night ; observed feeding on cattle (*Feegrade*, 1930, Katha) ; caught feeding on buffaloes (*Brug* and *Walch*) ; fed readily in laboratory on blood of pigeons and sparrows (*James* and *Liston*, 1904).

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* In all the countries given the occurrence of what appears to be true *A. annularis* (*fuliginosus*) has been verified by me from figures or descriptions given by the recorders. Brug, 1926, notes that this species appears to be absent from Borneo, Celebes, and the northern Sundas, but it has since been recorded from Borneo by Walch and Soesilo, Meded. Volks. Ned. Indie, xviii, p. 199, 1929.

† Kinoshita, Arch. f. Schiffs. x, p. 640, 1906.

‡ Given by Brug 1926 c, p. 471.

Breeding places are by preference clean, weed-grown, stagnant waters, notably margins of lakes, tanks, moats, dead rivers, swamps, also rice-fields, weed-grown ponds, borrow-pits, backwaters of canals, streams, drains, etc., in pools in river beds, when these are established with algæ and plants (*Fry*, 1912; *Kenrick*, 1911, 1914; *Gill*, 1917; *Graham*, 1914, Kumaon; *Phillips*, 1923, Moradabad; *Strickl.*, 1923; *Strickl.* and *Chowdh.*, 1928, Duars; *Feegrade*, 1927, Hsipaw; *Basu*), 1929; in wells with vegetation (*Marjoribanks*; *Gill*, 1917); in large canals with vegetation (*Hodgson*); grassy edges of slowly running streams, slow-running jhoras (*Ramsay*; *Strickl.*, and *Chowdhury*, 1928, Duars).

A. annularis is a powerful flier, covering considerable distances from its breeding places, and may be seen darting rapidly, when disturbed during the day, among bushes, etc. (*Christ.*, 1911). It appears to be attracted by light, as it may often be seen resting on walls near lamps in bungalows, etc.

It winters in North India, both as larva and adult; larvæ are found throughout the cold season in weedy waters, and the adults in cow-sheds (*Adie*, 1905; *Christophers*, 1911; *James* and *Liston*, 1911). It has been found breeding at 5,000 feet in Kashmir (*Christ.*, 1931), and taken up to 7,000 feet (*Graham*, 1913).

Relation to Disease.—It has been experimentally infected with M.T. and Q. malaria and found infected in nature, but always in very small percentages. Fry in Bengal found one infection in 1,245 dissections, and considerable numbers have been dissected by other observers in other parts of India without any positive result. Swellengrebel and Swellengrebel, in a summary of their results, found only 0·3 per cent. infected in 693 dissections. It is not thought to be an important carrier, but Covell notes that the numbers in which it occurs, for example in Bengal, may make it more important than it might otherwise seem. For further particulars, see *Covell*.

41. **Anopheles philippinensis** Ludlow, 1902 *. (Fig. 51, 5 *e*, 7 *c*.)

Ludlow, Journ. Amer. Med. Assoc. 23 Aug. p. 426, 1902 (*A. philippinensis*). Type-loc.: San José, Abra, Luzon, P.I. Type: 2 ♀ co-types in U. S.Nat. Mus., Washington (*vide* Dyar and Shannon, Insect. Mens. xiii, p. 88).

nivipes Theo., 1903, Entom. xxxvi, p. 258 (*Nyssorhynchus nivipes*). Type-loc.: Kuala Lumpur, F.M.S. Type: Described from 3 ♀♀. Syn. by Christ., Ind. Med. Res. Mem. no. 3, p. 64, 1924.

freeræ Banks, 1906, Phil. Journ. Sci. i, p. 993 (*Pyretophorus freeræ*). Type-loc.: Manila, P.I. Type: in Bureau of Sci., Manila. Syn. by Edwards, Gen. Insect. 1932.

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* For references, see next page.

pampangensis Brunetti, 1920, Rec. Ind. Mus. xvii, p. 114 (*A. pampangensis*). New name for *A. philippinensis* Ludl. SYN. by Dyar and Shannon, *loc. cit.* Brunetti gave the name thinking that Ludlow had described two different anophelines as *A. philippinensis*, whereas she had only transferred the species from one genus to another.

This is the *A. fuliginosus* of Stanton, 1915, and probably of some other authors. It was commonly known in India and Malaya as *A. nivipes* or *A. fuliginosus* var. *nivipes*. I have followed Edwards, 1932, in placing *A. freercæ* as a synonym of *A. philippinensis*, and not of *A. annularis*, as previously given by me (1924). *A. errabunda* Swell., Ned. Tijds. v. Geneesk. lxix, p. 1913 (*Cellia errabunda*), has been given by Edw., *loc. cit.*, as a doubtful synonym, and I have seen specimens of *A. philippinensis* in which the lateral tufts were very pronounced on a number of segments.

ADULT *.—In general very similar to *A. annularis*. In coloration it may be a somewhat brown mosquito, but more usually it is darker and closely resembles the above-mentioned species. It differs, similarly to *A. pallidus*, in that the wing is lighter and the fifth vein extensively pale ; there is usually no bridging of the subcostal spot in the female. Scaling is sometimes present on the pleura but is usually absent, as in *annularis*. Scaling of the abdomen is not so profuse on the dorsum of the segments as in *A. pallidus*, but the dark scales towards the posterior external angles of the terminal abdominal segments and on the under surface of these are usually more pronounced. The amount of white on segment 2 of the hind tarsus is variable, but often exceeds $\frac{1}{8}$, which is usually seen in *A. annularis*. There is usually some pale mark at the apex of segment 1, and this may be distinct, but commonly it is much less distinct than in *A. annularis*.

Pharynx † : very similar to *A. annularis*.

Hypopygium ‡ : very similar to *A. annularis*. The leaflets of the phallosome are of the same general character, and serrated in their whole length.

PUPA.—Undescribed.

LARVA §.—In general similar to *A. annularis*. *ic* conspicuously frayed and branches longer than in *A. pallidus* ; *oc* with the main hair split into two or three, each division with long lateral branches, giving appearance somewhat like a broom, with a very short handle ; *pc* split at their base into 5–11 br. which spread out like a fan and lie in one plane.

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* SYSTEMATIC: Ludlow 1902 *a*, p. 128 ; 1902 *b*, p. 426 ; 1914 *a*, p. 57 ; Theo. 1907, p. 103 ; 1910 *a*, p. 63 ; Christ. 1916 *a*, p. 465 ; 1924 *b*, p. 300 ; 1924 *c*, pp. 64, 100 ; Dyar and Shannon 1925, p. 88 ; Sur 1928, p. 45 ; Covell 1928 *b*, p. 1063.

† PHARNX : see also Manalang 1929, p. 431.

‡ HYPOPYGIUM : Christ. 1915, p. 393 (*nivipes*).

§ LARVA : Stanton 1915 *a*, p. 166 ; Chowdh. 1928 *a*. p. 39 ; 1928 *b* p. 41 ; Iyengar 1929 *a*, p. 642 ; Puri 1927, p. 514 ; 1931, p. 213.

Inner sutural 2–4 br. *Mentum* with the number of teeth variable, usually with three adequate teeth on each side of the median tooth and a small tooth further back, sometimes lacking. The shoulder hairs are shorter and basal tubercles not so strongly chitinised and conspicuous as in *A. pallidus*. Palmate hairs present on I–VII; leaflets deeply pigmented a little proximal to the distal end, which is fairly light in colour, the filament about $\frac{1}{3}$ length blade.

Egg.—Characters as yet doubtful (vide *Christ.* and *Barraud*, 1931, p. 177).

Distribution.—*A. philippinensis* has been recorded only from relatively few countries in the Oriental Region, but this is probably due to its not having been generally recognized up to date as distinct from *A. annularis*. The following are countries in which it is so far known to occur:—Philippines; Sumatra *; Java †; Tonkin ‡; Cochin China; Siam; Malay Peninsula; India and Burma.

In the Indian area recorded from the eastern areas as far west as Bihar (Purnea) and Chota Nagpur, and also from the West Coast (Malabar, Konkan, and Mysore).

Bionomics.—*A. philippinensis* has been found in houses, cattle-sheds and stables (*Stanton*, 1920; *Feegrade*, 1926, Bhamo; *Ramsay*; *Sur* and *Sur*; *Sweet*).

In the Andamans the species was found breeding by Christophers, 1912, and by Covell, 1927 (Andamans), in rice-fields, rush-swamp, and a tank covered with water-weed. Feegrade (Bhamo, Kyaukpyu), found the larvæ in quiet and shaded parts of a lake, ends of inundated nullahs and ponds, pools and borrow-pits with vegetation. Ramsay in Assam gives seepage water, tanks, pools, drains, ditches, swamps, borrow-pits rice-fields, and grassy edges of very slowly running streams.

Relation to Disease.—No evidence.

42. **Anopheles pallidus** Theo., 1901 §. (Fig. 51, 5*f*, 7*b*.)

Theo., Mono. Cul. i, p. 134, 1901 (*A. fuliginosus* var. *pallida*). Type-loc.: Sambalpur, Orissa, India. Type: ♀ in Brit. Mus.

fowleri Christ., 1911, Paludism, no. 2, p. 64 (*Neocellia fowleri*). Type-loc.: Amritsar, Punjab, India. Type: ♂ and ♀ in Brit. Mus. Syn. by Christ., Ind. Med. Res. Mem. no. 3, p. 65, 1924.

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* Brug and Edwards, 1931.

† Swell. and Rodenw., 1932.

‡ Morin, Farinaud, and Toumanoff, 1931.

§ Systematic: Christ. 1911 *a*, p. 64 (*fowleri*); 1916 *a*, p. 465 (*fowleri*); 1924 *b*, p. 297; 1924 *c*, pp. 64, 100; Sur 1928, p. 45; Dyar and Shannon 1925, p. 88; Soesilo 1932.

ADULT.—Very similar to *A. annularis*, but general coloration brown in place of black and with lighter wings. The sternopleuron has a considerable number of pale scales. The markings of the wing show more extended pale areas; vein 5 has no dark spot in its middle portion; subcostal spot not bridged by dark on vein 1; base of costa often more pale than dark. Between $\frac{1}{3}$ and half of segment 2 of hind tarsus is pale, and there is never any trace of a pale interruption on the tarsus above the extended pale area, *i. e.*, segment 1 of hind tarsus is entirely devoid of any trace of apical banding. The abdomen usually shows some scales from segment 4 onwards, rather as in *A. stephensi*, the amount of scaling present and the number of segments affected being variable. The venter has scattered broad white scales on most segments, and there is a conspicuous scale-tuft at apex of segment 7 in the male.

Pharynx: very similar to *A. annularis*.

Hypopygium *: very similar to *A. annularis*; leaflets about five on each side, serration in full extent, possibly somewhat smaller and narrower than in *A. annularis* (0·045 mm.).

PUPA.—Undescribed.

LARVA †.—Very similar to *A. annularis*, but inner clypeal hairs more chitinised, with somewhat more numerous, though shorter, branches, and these tending to become plumose on distal fourth of hair; main portion of *oc* commonly split into 2 or 3; *pc* with 2–5 br. (usually 3); inner sutural with 3–8 br. (usually 5); mentum with nine teeth, the posterior three in each row adequal, the anterior one somewhat smaller; palmate hair on thorax better developed; palmate hairs well developed on segments II–VII, that on segment I poorly developed.

EGG ‡.—Differing from *A. annularis* only in that the floats are noticeably very smooth; float-ridges possibly slightly broader, with the number not exceeding 18.

DISTRIBUTION.—Outside the Indian area recorded only from SIAM § and SUMATRA ‖; probably existing, but as yet unrecognized, in many areas.

In the Indian area recorded from localities throughout Upper and Lower Burma, the greater part of the Peninsula and Ceylon, but not north or west of Amritsar and Gujranwala

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* HYPOPYGIUM: Christ. 1916, p. 393.

† LARVA: Kenrick 1911, p. 65; Iyengar 1929 *a*, p. 641; Puri 1927, p. 513; 1928 *b*, p. 521; 1931, p. 209.

‡ EGG: Christ. and Barraud 1931, p. 177.

§ Barraud and Christ. 1931, p. 277.

‖ Swell. and Rodenw. 1932, p. 173.

in the Punjab, from Rajputana, Kathiawar, Sind, or Baluchistan.

BIONOMICS.—Is taken in houses, cow-sheds etc., (*Kenrick*, 1915 ; *Goverdhan*, 1912 ; *Basu* ; *Sur* and *Sur* ; *Sweet*), but especially abundantly in some places in stables and cow-sheds (*Gill* and *H. Singh*, 1920).

The breeding places are in general somewhat similar to those of *A. annularis*, and are recorded as lake-margins (*Annandale* and *Kemp*), ditches and ponds with vegetation (*Iyengar*, 1926), and also in shallow pools in beds of small streams and small ponds with vegetation along the edges (*Puri*, 1931). The species, in Central India at least, shows a special relation to rice cultivation, the larvæ being found in the rice-fields themselves, collections of water in embanked fields and ditches in the neighbourhood of rice cultivation (*Kenrick*, 1914).

RELATION TO DISEASE.—No experimental work has been done with the species, and the only authentic record of infection in nature is the finding of oocysts in two specimens in the Chanda Dist. of the Central Provinces by Goverdhan, quoted by Covell.

43. **Anopheles pulcherrimus** Theo., 1902 *. (Fig. 52.)

Theobald, Proc. Roy. Soc. lxix, p. 369, 1902 (*A. pulcherrimus*). TYPE-LOC. : Lahore, Punjab, India. TYPE : described from 3 ♀♀ ; type in Brit. Mus. Also described by James, Sci. Mem. no. 2, p. 48, 1902, from same locality, under same name, but Theobald's description has precedence (see Christ., 1924 *c*, p. 69).

atropotænæ Lindtrop, Russ. Journ. Trop. Med. 1924, no. 3, p. 38 (*A. pulcherrimus* var. *atropotænæ*). TYPE-LOC. : Azerbaijan, Caucasus. SYN. by Shingarew, Bull. Soc. Path. Exot. xix, p. 897, 1926.

ADULT ♀.—Size medium to rather large (length of wing 2·7–4·4 mm.).

Head : scales of usual type, with a large pale vertical area ; vertical chætæ white, the anterior ones forming cluster of about twelve flattened chætæ, making a conspicuous frontal tuft ; ocular scales broad, forming dense overlapping line : broad oval scales carried forwards in middle line *Antenna* with numerous small white scales on torus ; first five or so flagellar segments with white scales. *Palpi* shaggy especially in basal part : apical segment long, about half or more preapical, index 0·5–0·6 ; with four white bands, including the pale apex.

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* SYSTEMATIC : Theo. 1902, p. 369 ; 1903, p. 107; James and List[illegible] 1904, p. 86 ; 1911, p. 116 ; Edw. 1921 *b*, p. 277 ; 1926, p. 279 ; Martini 1930, p. 182. See also Vassiliev 1913 ; Christ. 1916 *a*, p. 476 ; 192[illegible] pp. 68, 102 ; Séguy 1924, p. 163.

Pharynx: filament rather long, broad, flat, tapering to point, without spicules; lateral teeth large; crest with double row of spines, bifid in posterior view.

Thorax with some pale scales at apex and on basal posterior aspect of *apn.* Mesonotum greyish, with lateral areas and fossæ not noticeably darker; the whole area, including the fossæ and lateral areas, evenly covered with broad, oval, almost orbicular, dull, opaque white scales, a conspicuous line in front of wing-roots and lateral tufts on the promontory, with numerous dark scales on face of promontory. Pleuræ with conspicuous patches of broad white scales on sterno-pleuron, mesepimeron, and elsewhere; spiracular hairs replaced by tuft of white scales.

Wings as in fig. 52, **1**; base of costa with two dark accessory spots; vein 6 usually with three dark spots; apex of wing pale to and including vein 3; an extra fringe-spot between veins 5.2 and 6; border scales and fringe pale from a little internal to vein 6.

Legs with front femora very slightly swollen in basal half. Femora on all legs pale beneath, front pair mainly pale, with dark speckling; middle pair dark above, with a white streak and a conspicuous oval spot on anterior aspect towards apex; hind pair with a similar but smaller spot; all with a dark ring near base about equal to diameter of part. Tibiæ mainly pale, with a black streak and dark towards apex, but actual apex on mid- and hind tibiæ pale. First tarsal joint mainly pale, darker at ends, front tarsus apically banded on 1–3, mid on 1–2 and hind tarsi ornamented as shown, with last three and from one-half to one-third of the preceding continuously pale.

Abdomen with dorsum of all segments (including I) densely covered with broad, white, battledore-shaped scales, some erect black scales of similar type at corners of tergites forming small but conspicuous tufts, those on middle segments most prominent. Sternites and pleuræ similarly covered. Cerci densely tufted with scales.

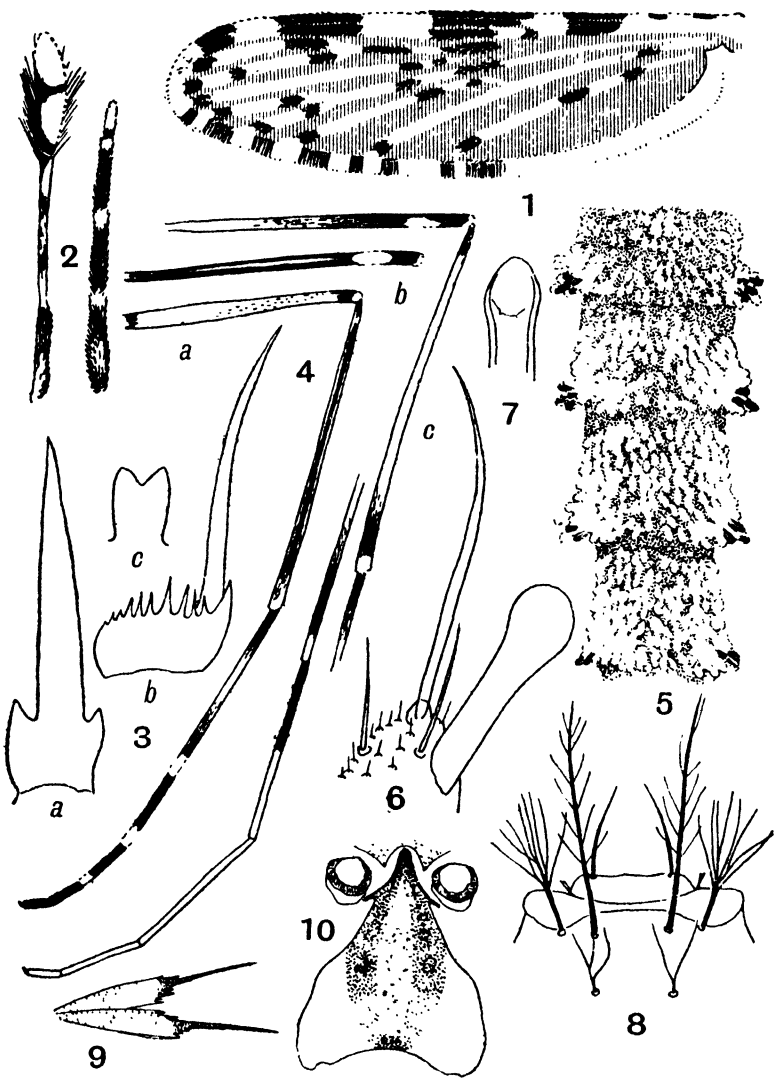
ADULT ♂.—In general as in ♀. *Antenna* with a few black scales on first flagellar segment. *Palpi* ornamented as shown in figure; marginal hairs forming a row four or five deep on either side of seg. 4. *Coxites* with numerous scales.

Hypopygium *: harpago with apical hair at least half as long again as club, with a small hair only between it and club and two somewhat larger hairs internal to apical hair; harpago with numerous small hairs at apex as well as on inner aspect. Phallosome somewhat over $\frac{1}{3}$ length of coxite; devoid of leaflets.

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* HYPOPYGIUM: Christ. 1915, p. 394.

Fig. 52.



A. pulcherrimus.

1. Wing of ♀ ½ standard scale. **2.** ♂ and ♀ palp, same scale. **3.** Pharyngeal teeth: (*a*) anterior view of cone; (*b*) same, lateral view, one row of crest-spines only shown; (*c*) posterior view of crest. **4.** Legs: (*a*) front legs; (*b*) mid-femur; (*c*) hind leg. **5.** Segments III–VI of abdomen, showing scaling. **6.** Apex of harpago. **7.** Apex of phallosome. **8.** Clypeal hairs of larva. **9.** Leaflets of palmate hair. **10.** Spiracles and median plate of scoop. (**8–10** after Puri.)

PUPA *.—*Paddle*: external border with long, fine, sharp spines on posterior half extending to posterior border and followed by short distance of fine scattered hairs which do not pass the paddle-hair. Paddle-hair long, curved; acc. hair simple.

Spine: (VIII) about half segment. (V–VII) $\frac{1}{3}$ to half segment or somewhat more. (III–IV) small, blunt. Acc. hair 1–3 br.

Hair B: (III–VII) branched.

Hair C: (V–VII) simple, longer than segment. (III–IV) branched, half to $\frac{2}{3}$ segment. *C'* (VI) simple.

LARVA †.—*Clypeal hairs*: *ic* with fine lateral branches in distal two-thirds; *oc* a little more than half length inner, ending in 4–12 adequal br.; *pc* half length outer, 1–4 br. *Antenna* with hair arising $\frac{1}{3}$–$\frac{1}{4}$ length of antenna from base; terminal hair branched; inner distal truncated edge of antenna produced into spinous projection. *Mentum* with four teeth on either side of median tooth, the anterior three adequal and equidistant.

Shoulder hairs: both hairs branched, not very stout; inner very variable in size and with or without a well-marked basal tubercle. *Metathoracic hair no.* 1 forming fairly well-developed palmate hair. Pleural hairs as given for the group; *dp* 1 with one or two lateral branches on one side.

Palmate hairs well developed on II–VII; that on I poorly developed: leaflets deeply pigmented at ends, the filament about as long as the blade, the shoulder indentations fairly deep and aggregated. *Lateral hairs* on IV–VI long, slender, 3–5 br.: that on VII very short, with 4–5 br. *Tergal plates* small. *spc* poorly developed; *mps* produced on each side into small processes which nearly touch chitinisation, the plate with the pigmented area forming a double band. *ps hair* with 6–8 br., 4–5 of which are long. *Pecten* with 4 long and 8–10 short processes.

EGG ‡.—Very flat and shallow. Upper surface as wide as the egg, middle portion not perceptibly narrowed, covered throughout with small pale punctæ. Lower surface unornamented. Floats touching margin of dorsal surface, but with frill intervening, rather short and occupying only about middle half of egg: float-ridges about 16, rather regular and smooth. Frill broad, continued round margin of dorsal surface and striated anteriorly and posteriorly, part lying over floats unstriated, somewhat narrower and transparent.

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* PUPA: Vassiliev 1913; Senevet 1931, p. 41.

† LARVA: Steph. and Christ. 1902 *b*, p. 9; James and Liston 1904, p. 87; 1911, p. 118; Vassiliev 1913; Montchadsky 1930, p. 553 (spir. app.); Puri 1928 *b*, p. 523; 1931, p. 216.

‡ EGG: Steph. and Christ. 1902 *b*, p. 9; Vassiliev 1913; Christ. and Barraud 1931, p. 180.

IDENTIFICATION.—This species cannot be confused with any other in the Indian area owing to the densely scaly abdomen with conspicuous projecting lateral tufts. The only other species in the Indian fauna which may approach this condition is *A. philippinensis*, which does not occur in the same districts, and has the legs quite differently marked.

DISTRIBUTION.—*A. pulcherrimus* has a distribution which includes the great alluvial basins of the Tigris and Euphrates, the Oxus, the Syr Darya, and the Indus. It has been recorded from CAUCASUS (Azerbaijan); MESOPOTAMIA; PERSIA; TURKESTAN (Transcaspia, Taschkent, Samarkand, Fergana); BOKHARA; N.W. INDIA.

In the Indian area it is recorded from numerous localities in the North-West, including Baluchistan, the N.W. Frontier Province, Sind, Gujarat, the Punjab, and the western United Provinces.

BIONOMICS.—*A. pulcherrimus* is found in houses, cattle-sheds, tents, barracks, etc., often in very large numbers (*Vassiliev*; *Christ.* and *Shortt*; *Richmond* and *Mendis*). In the Punjab it is commonly found resting in situations that are lighter than those selected by other species, *e. g.*, verandahs. It feeds on man and animals and may attack not only at night or in the evening, but viciously by day, being a very bold feeder; it also commonly attacks in the open (*Christ.* and *Shortt*; *Patton*; *Vassiliev*; *Brodski*).

It breeds in Mesopotamia, especially in open weedy water, and is found everywhere in the larger swamps (*Christ.* and *Shortt*), also in stagnant collections with vegetation, sometimes brackish (*Patton*; *Barraud*, 1920), and in Turkestan in rice-fields and pools formed by subsoil water (*Vassiliev*). It is a powerful flier and appears often to be carried long distances on the wind, since it frequently occurred in numbers in Mesopotamia following dust-storms, and has been taken on board ship 15½ miles from the nearest land (*Wright*, 1918). It is stated to be attracted by light (*Vassiliev*; *Lindtrop*, 1925). In Taschkent it hibernates in the larval stage (*Khodukin*).

RELATION TO DISEASE.—The species has been infected with B.T. to the sporozoite stage, and has been found infected in nature in Central Asia; also by Covell and Baily in Sind (5 gut infections in 453 dissected).

PART IV.—BIBLIOGRAPHY.

Sections.

A. List of Recent important Publications dealing with Indian Anophelini.

B. List of Catalogues, Keys and certain General Works of a similar nature dealing with Indian Anophelini; these are not quoted in the footnote references, except for special reasons.

C. Bibliography of Systematic References to Indian Species.

D. List of the more important References dealing with Distribution of Indian Species.

E. References quoted in the Sections on "Bionomics" and "Relation to Disease."

A.—List of Recent important Publications dealing with Indian Anophelini.

Systematic.

Synoptic Table for the Identification of the Anopheline Mosquitoes of India. By Christophers, Sinton, Covell, and Barraud. Health Bulletin, no. 10, 2nd ed. 1931. Govt. of India, Central Publication Branch, Calcutta. Price 4 annas.

Synoptic Tables for the Identification of Full-grown Larvæ of the Indian Anopheline Mosquitoes. By Puri. Health Bulletin, no. 16, 1930. Ditto. Price 6 annas.

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The Eggs of Indian *Anopheles*, with Descriptions of the hitherto undescribed Eggs of a number of Species. By Christophers and Barraud. Records of the Malaria Survey of India, ii, pp. 161–192, 1931.

Distribution.

The Distribution of Anopheline Mosquitoes in India and Ceylon. By Covell. Ind. Med. Res. Mem. no. 5, 1927. Thacker, Spink and Co., Calcutta. Price Rs. 3–8–0.

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B.—List of Catalogues, Keys, and certain General Works of a similar nature dealing with Indian Anophelini.

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APPENDIX.

—o—

THE DISTRIBUTION OF ANOPHELINE MOSQUITOES IN INDIA,

GIVING SUBDIVISIONS AND DISTRICTS FROM WHICH RECORDED.

[Taken, with Government's and the Author's permission, from 'Health Bulletin, No. 17 (Govt. of India): the Distribution of Anopheline Mosquitoes in India,' by Major G. Covell, Part I. For subdivisions, see accompanying map (fig. 53); for districts, see District Map of India, published by Survey of India. For actual localities from which recorded in the districts, see Covell's Memoir and Supplement. For all ordinary purposes the district gives sufficiently adequate information regarding distribution.]

aconitus.

ANDAMANS. ASSAM: Cachar, Darrang, Goalpara, Kamrup, Lakhimpur, Nowgong, Sibsagar, Sylhet. BENGAL: Backergunge, Bogra, Burdwan, Calcutta, Chittagong, Dacca, Darjeeling, Dinajpur, Faridpur, Hooghly, Howrah, Jessore, Khulna, Malda, Murshidabad, Nadia, Noakhali, Rangpur, Tippera, 24-Parganas. BIHAR: Purnea. BURMA, LOWER: Akyab, Kyaukpyu, Salween. BURMA, UPPER: Bhamo, Hsipaw State, North Hsenwi State, Upper Chindwin, Yaung Hwe State. C.P. EAST: Raipur. C.P. WEST: Hoshangabad, Jubbulpore. CEYLON. KONKAN: Savantvadi State. MADRAS COAST N.: Kistna, Vizagapatam. MALABAR: Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. U.P. EAST: Gorakhpur.

aitkeni.

ANDAMANS. ASSAM: Cachar, Darrang, Khasi and Jaintia Hills, Lakhimpur, Sibsagar. BENGAL: Darjeeling, Jalpaiguri. BURMA, UPPER: North Hsenwi State, Upper Chindwin, Yaung Hwe State. CHOTA NAGPUR: Singhbhum. KONKAN: North Kanara, Savantvadi State. MADRAS COAST N.: Vizagapatam. MADRAS S.E.: Coimbatore, Madura, Nilgiris, North Arcot. MALABAR: Coorg Province, Malabar. MYSORE STATE: Kadur.

aitkeni var. *bengalensis*.

BENGAL: Darjeeling.

annandalei.

ASSAM: Cachar, Khasi and Jaintia Hills. BENGAL: Darjeeling. CEYLON.

annandalei var. *interruptus*.

BENGAL: Darjeeling.

annularis (*fuliginosus*).

ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar, Sylhet. BENGAL: Backergunge, Birbhum, Bogra, Burdwan, Calcutta, Chittagong, Cooch Behar State, Dacca, Darjeeling, Dinajpur, Faridpur, Hooghly, Howrah, Jalpaiguri, Jessore, Khulna, Malda, Midnapur, Murshidabad, Mymensingh, Nadia, Noakhali, Pabna, Rajshahi, Rangpur, Tippera, 24-Parganas. BERAR: Amraoti, Yeotmal. BIHAR: Bhagalpur, Darbhanga, Gaya, Patna, Purnea, Santal Parganas, Shahabad. BOMBAY DECCAN: Belgaum, Dharwar, Nasik, Poona, Satara. BURMA, LOWER: Akyab, Kyaukpyu, Myaungmya, Rangoon, Salween, Tharawaddy. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Magwe, Mandalay, Minbu, Myitkyina, North Hsenwi State, Putao, Upper Chindwin, Yamethin, Yaung Hwe State. CENTRAL INDIA E.: Rewar State (Baghelkand Agency). CENTRAL INDIA W.: Bhopal State, Gwalior State, Indore State. C. P. EAST: Raipur. C. P. WEST: Balaghat, Betul, Bhandara, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Saugor, Seoni. CEYLON. CHOTA NAGPUR: Hazaribagh, Ranchi, Singhbhum. DELHI PROVINCE. GUJARAT: Ahmedabad, Baroda State, Daman, Gohelwar, Jhalawar, Kaira, Palanpur State, Surat. HYDERABAD SOUTH: Atraf-i-Balda. KASHMIR. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Savantvadi State. MADRAS COAST N.: Ganjam, Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kunool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, North Arcot, Salem, South Arcot, Tanjore. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. NEPAL. N.W.F.P.: Chitral State, Hazara, Kohat, Peshawar, Swat Territory. ORISSA: Angul, Cuttack, Patna State, Puri, Sambalpur. PUNJAB E. & N.: Ambala, Amritsar, Attock, Ferozepore,

Gujranwala, Gujrat, Gurdaspur, Gurgaon, Hissar, Hoshiarpur, Jhelum, Jullundur, Kangra, Kapurthala State, Karnal, Lahore, Patiala State, Rawalpindi, Rohtak, Sialkot, Simla. PUNJAB S.W.: Mianwali, Montgomery, Multan, Muzaffargarh. RAJPUTANA E.: Ajmer-Merwara Province. SIND: Hyderabad. U.P. EAST: Allahabad, Basti, Benares, Cawnpore, Fyzabad, Ghazipur, Gorakhpur, Jaunpur, Lucknow. U.P. WEST: Agra, Bareilly, Bijnor, Dehra Dun, Farrukhabad, Meerut, Moradabad, Muttra, Muzaffarnagar, Naini Tal, Pilibhit, Saharanpur, Shahjahanpur. WAZIRISTAN: Bannu Area, Derajat Area.

barbirostris.

ANDAMANS. ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar. BENGAL: Backergunge, Bankura, Bogra, Burdwan, Calcutta, Chittagong, Dacca, Darjeeling, Dinajpur, Cooch Behar State, Faridpur, Hooghly, Howrah, Jalpaiguri, Jessore, Khulna, Malda, Midnapur, Murshidabad, Mymensingh, Nadia, Noakhali, Pabna, Rajshahi, Rangpur, Tippera, 24-Parganas. BIHAR: Bhagalpur, Darbhanga, Patna, Purnea. BOMBAY DECCAN: Belgaum, Dharwar, Nasik, Poona, Sholapur. BURMA, LOWER: Akyab, Hanthawaddy, Kyaukpyu, Insein, Rangoon, Salween, Tharawaddy. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Mandalay, Minbu, Myitkyina, North Hsenwi State, Thayetmyo, Upper Chindwin, Yamethin, Yaung, Hwe State. CENTRAL INDIA W.: Bhopal State, Indore State. C. P. WEST: Betul, Bhandara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Saugor. CEYLON. CHOTA NAGPUR: Hazaribagh, Singhbhum. DELHI PROV.: GUJARAT: Baroda State, Daman, Diu, Surat. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Savantvadi State. MADRAS COAST N.: Godaveri, Nellore, Vizagapatam. MADRAS DECCAN: Annantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, Madura, Nilgiris, North Arcot, Salem, South Arcot. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. PUNJAB E. & N.: Amritsar, Ferozepore, Gurgaon, Karnal, Lahore. U.P. EAST: Ballia, Cawnpore, Ghazipur, Gonda, Gorakhpur. U.P. WEST: Agra, Bareilly, Bijnor, Meerut, Moradabad, Naini Tal, Pilibhit, Saharanpur, Shahjahanpur.

barbirostris var. *ahomi.*

ASSAM: Lakhimpur.

barianensis.

KASHMIR: PUNJAB E. & N.: Ambala, Kangra, Rawalpindi, Simla.

culicifacies.

ASSAM: Cachar, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar. BALUCHISTAN:

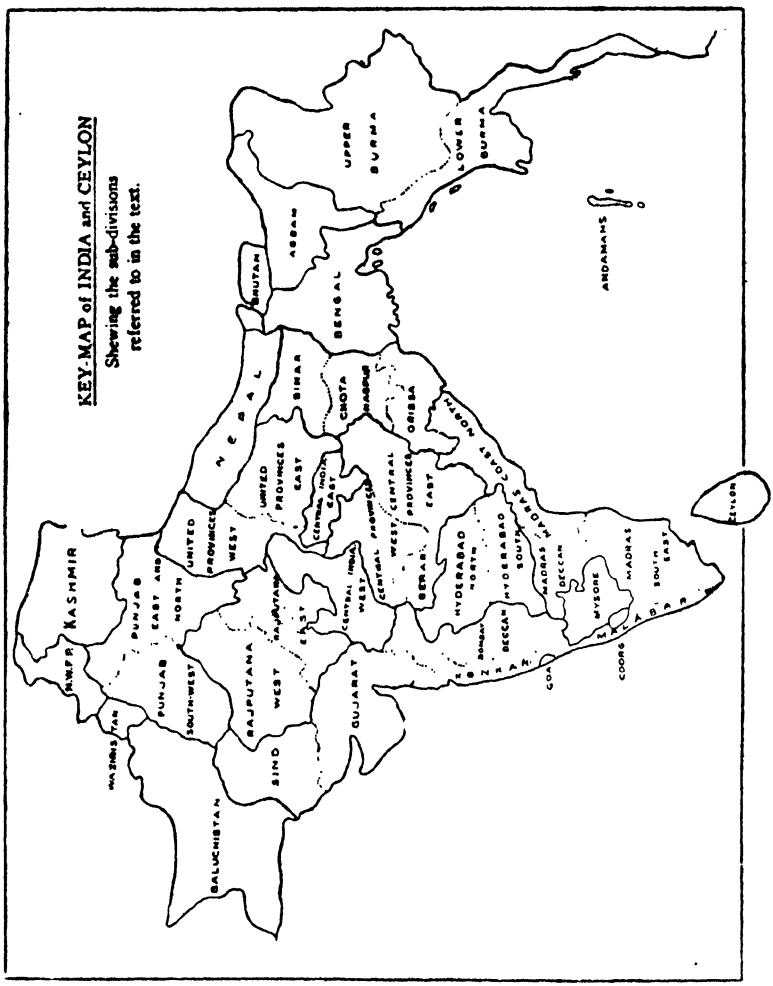


Fig. 53.

Loralai, Quetta-Pishin, Zhob. BENGAL: Birbhum, Bogra, Burdwan, Calcutta, Dacca, Darjeeling, Dinajpur, Howrah, Jalpaiguri, Jessore, Khulna, Malda, Murshidabad, Nadia, Pabna, Rajshahi, Rangpur, 24-Parganas. BERAR: Amraoti, Yeotmal. BIHAR: Bhagalpur, Champaran, Darbhanga, Gaya, Patna, Purnea, Santal Parganas, Shahabad. BOMBAY

DECCAN : Ahmednagar, Belgaum, Dharwar, Khandesh West, Nasik, Poona, Satara, Sholapur. BURMA, LOWER : Salween. BURMA, UPPER : Bhamo, Hsipaw State, Katha, Magwe, Mandalay, Minbu, Myitkyina, North Hsenwi State, Thayetmyo, Upper Chindwin, Yamethin, Yaung Hwe State. CENTRAL INDIA E. : Rewah State (Baghelkand Agency), Bundelkand Agency. CENTRAL INDIA W. : Bhopal State, Gwalior State, Indore State. C.P. EAST. Bilaspur, Raipur. C.P. WEST : Balaghat, Betul, Bhandara, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Nimar, Saugor, Seoni. CEYLON. CHOTA NAGPUR : Hazaribagh, Ranchi, Singhbhum. DELHI PROV. GUJARAT : Ahmedabad, Baroda State, Daman, Gohelwar, Halar, Jhalawar, Kaira, Palanpur State, Sorath, Surat. HYDERABAD N. : Aurangabad. HYDERABAD S. : Atraf-i-Balda. KASHMIR : Kohala. KONKAN : Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Savantvadi State, Thana. MADRAS COAST N. : Ganjam, Nellore, Vizagapatam. MADRAS DECCAN : Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E. : Chingleput, Coimbatore, Madras City, Madura, Nilgiris, North Arcot, Salem, South Arcot, Trichinopoly. MALABAR : Coorg Province, Malabar, Travancore State. MYSORE STATE : Bangalore, Chitaldrug, Kadur, Mysore. NEPAL. N.W.F.P. : Hazara, Kohat, Peshawar, Swat Territory. ORISSA : Angul, Cuttack, Mayurbhanj State, Patna State, Puri, Sambalpur. PUNJAB E. & N. : Ambala, Amritsar, Ferozepore, Gujranwala, Gujrat, Gurdaspur, Gurgaon, Hissar, Hosiarpur, Jhelum, Jind State, Kangra, Kapurthala State, Karnal, Lahore, Ludhiana, Patiala State, Rawalpindi, Rohtak, Sialkot. PUNJAB S.W. : Dera Ghazi Khan, Lyallpur, Mianwali, Montgomery, Multan, Muzaffargarh, Shahpur. RAJPUTANA E. : Ajmer-Merwara Province, Udaipur State. SIND : Hyderabad, Karachi, Larkana, Nawabshah, Sukkur, Thar and Parkar, Upper Sind Frontier. U.P. EAST : Ballia, Basti, Benares, Fyzabad, Gonda, Gorakhpur, Jaunpur, Lucknow. U.P. WEST : Agra, Bareilly, Bijnor, Dehra Dun, Etawah, Farrukhabad, Meerut, Moradabad, Muttra, Muzaffarnagar, Naini Tal, Pilibhit, Saharanpur. WAZIRISTAN : Bannu Area, Derajat Area.

culiciformis.

KONKAN : Goa, North Kanara, Savantvadi State. MADRAS S.E. : Nilgiris. MALABAR : Malabar.

dthali.

BALUCHISTAN : Qwetta-Pishin, Zhob. N.W.F.P. : Kohat. PUNJAB E. & N. : Jhelum. WAZIRISTAN : Bannu Area Derajat Area.

fluviatilis (*listonii*).

ASSAM: Cachar, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sylhet. BALUCHISTAN: Loralai, Quetta-Pishin, Zhob. BENGAL: Bogra, Burdwan, Calcutta, Cooch Behar State, Darjeeling, Dinajpur, Hooghly, Jalpaiguri, Malda, Murshidabad, Nadia, Rajshahi, Rangpur, 24-Parganas. BERAR: Amraoti. BIHAR: Champaran, Darbhanga, Purnea. BOMBAY DECCAN: Belgaum, Dharwar, Khandesh West, Nasik, Poona, Satara, Sholapur. BURMA, LOWER: Akyab. BURMA, UPPER: Hsipaw State, Mandalay, North Hsenwi State, Yaung Hwe State. CENTRAL INDIA E.: Rewah State (Baghelkand Agency). CENTRAL INDIA W.: Indore State. C.P. WEST: Balaghat, Betul, Bhandara, Chhindwara, Hoshangabad, Jubbulpore Mandla, Nagpur, Nimar, Saugor. CEYLON. CHOTA NAGPUR: Hazaribagh, Ranchi, Singhbhum. DELHI PROV. GUJARAT: Baroda State, Daman, Diu, Halar, Kaira, Surat. HYDERABAD N.: Aurangabad. KASHMIR. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette, Savantvadi State. MADRAS COAST N.: Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, Madura, Nilgiris, North Arcot, Salem, South Arcot. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore,, Chitaldrug, Kadur, Mysore. NEPAL. N.W.F.P.: Hazara, Kohat, Peshawar, Swat Territory. ORISSA: Angul, Kalahandi State, Puri. PUNJAB E. & N.: Ambala, Amritsar, Gujranwala, Gujrat, Gurdaspur, Hoshiarpur, Jhelum, Kangra, Kapurthala State, Karnal, Lahore, Ludhiana, Patiala State, Rawalpindi. PUNJAB S.W.: Lyallpur, Mianwali, Montgomery, Muzaffargarh. U.P. EAST: Basti, Ghazipur, Lucknow. U.P. WEST: Bareilly, Bijnor, Dehra Dun, Naini Tal, Saharanpur. WAZIRISTAN: Bannu Area, Derajat Area.

gigas (including vars.).

ASSAM: Cachar, Khasi and Jaintia Hills, Lakhimpur. BENGAL: Rangpur. BURMA, UPPER: Yaung Hwe State. CEYLON. C.P. WEST: Hoshangabad. GUJARAT: Palanpur State. KASHMIR. MADRAS: Madura, Nilgiris. N.W.F.P.: Hazara, Peshawar. PUNJAB E. & N.: Ambala, Chamba State, Gurdaspur, Kangra, Karnal, Rawalpindi, Simla. U.P. WEST: Dehra Dun, Garhwal, Naini Tal, Saharanpur.

hyrcanus var. *nigerrimus*.

ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Manipur State, Naga Hills, Nowgong, Sibsagar, Sylhet. BENGAL: Backergunge, Bankura,

Birbhum, Bogra, Burdwan, Calcutta, Chittagong, Cooch Behar State, Dacca, Darjeeling, Dinajpur, Faridpur, Hooghly, Howrah, Jalgaiguri, Jessore, Khulna, Malda, Midnapur, Murshidabad, Mymensingh, Nadia, Noakhali, Pabna, Rajshahi, Rangpur, Tippera, 24-Parganas. BIHAR: Bhagalpur, Darbhanga, Gaya, Patna, Purnea, Saran, Shahabad. BOMBAY DECCAN: Belgaum, Nasik, Poona, Sholapur. BURMA, LOWER: Akyab, Insein, Kyaukpyu, Rangoon, Salween, Tharawaddy. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Mandalay, Minbu, Myitkyina, North Hsenwi State, Putao, Upper Chindwin, Yaung Hwe State. CENTRAL INDIA W.: Indore State. C.P. EAST: Raipur. C.P. WEST: Betul, Bhandara, Hoshangabad, Jubbulpore, Nagpur, Saugor. CEYLON. CHOTA NAGPUR: Hazaribagh, Ranchi, Singhbhum. DELHI PROV.: GUJARAT: Daman, Gohelwar. HYDERABAD N.: Aurangabad. KONKAN: Goa, Kolaba, North Kanara. MADRAS COAST N.: Ganjam, Govaveri, Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, Madura, Nilgiris, North Arcot, Tanjore. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. N.W.F.P.: Kohat, Peshawar. ORISSA: Angul, Cuttack, Kalahandi State, Keonjhar State, Puri, Sambalpur. PUNJAB E. & N.: Amritsar, Ferozepore, Gujranwala, Gujrat, Kangra, Karnal, Lahore. PUNJAB S.W.: Dera Ghazi Khan, Multan. SIND: Hyderabad, Larkana, Upper Sind Frontier. U.P. EAST: Ballia, Benares, Cawnpore, Fyzabad, Ghazipur, Gonda, Gorakhpur, Lucknow. U.P. West: Bareilly, Dehra Dun, Etawah, Meerut, Moradabad, Muzaffarnagar, Naini Tal, Saharanpur, Shahjahanpur WAZIRISTAN: Bannu Area.

insulæflorum.

BENGAL: Darjeeling. CEYLON. KONKAN: North Kanara

jamesi.

ASSAM: Cachar. BENGAL: Chittagong, Darjeeling. BOMBAY DECCAN: Belgaum, Dharwar, Nasik, Poona. BURMA. LOWER: Insein. C. P. WEST: Bhandara. CEYLON. CHOTA NAGPUR: Singhbhum. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Savantvadi State. MADRAS COAST N.: Nellore, Vizagapatam. MADRAS DECCAN: Anantapur. MADRAS S.E.: Chingleput, Madras City, Madura, Nilgiris, North Arcot, Tanjore. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. ORISSA: Cuttack, Keonjhar State.

jeyporiensis.

ASSAM : Cachar, Khasi and Jaintia Hills, Sylhet. BENGAL : Jalpaiguri. BURMA, UPPER : Bhamo, Katha, Mandalay, Upper Chindwin, Yaung Hwe State. CENTRAL INDIA E. : Rewah State (Baghelkand Agency). CENTRAL INDIA W. : Indore State. C.P. West : Jubbulpore. CHOTA NAGPUR : Hazaribagh, Ranchi, Singhbhum. GUJARAT : Baroda State. KONKAN : Kolaba, North Kanara. MADRAS COAST N. : Nellore, Vizagapatam. MADRAS DECCAN : Bellary. MADRAS S.E. : Coimbatore, Madura, Nilgiris, Salem. MALABAR : Coorg Province, Malabar, Travancore State. MYSORE STATE : Bangalore, Chitaldrug, Kadur, Mysore. U.P. WEST : Naini Tal.

karwari.

ASSAM : Cachar, Sylhet. BENGAL : Jalpaiguri. BIHAR : Purnea. BOMBAY DECCAN : Belgaum, Nasik. BURMA, LOWER : Kyaukpyu. CEYLON. CHOTA NAGPUR : Singhbhum. KONKAN : Goa, Kolaba, North Kanara, Savantvadi State. MADRAS COAST N. : Vizagapatam. MADRAS DECCAN : Bellary. MADRAS S.E. : Coimbatore, Nilgiris, Tinnevelly. MALABAR : Coorg Province, Malabar, Travancore State. MYSORE STATE : Bangalore, Kadur, Kolar.

kochi.

ASSAM : Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar, Sylhet. BENGAL : Dacca, Darjeeling, Jalpaiguri. BURMA, LOWER : Kyaukpyu, Salween. BURMA, UPPER : Hsipaw State, Katha, Magwe, Myitkyina, North Hsenwi State, Upper Chindwin, Yamethin.

leucosphyrus.

ANDAMANS. ASSAM : Cachar, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar. BENGAL : Darjeeling, Jalpaiguri. BURMA, LOWER : Kyaukpyu. BURMA, UPPER : Upper Chindwin. CEYLON. KONKAN : Goa, North Kanara, Savantvadi State. MADRAS S.E. : Coimbatore, Nilgiris. MALABAR : Coorg Province, Malabar. MYSORE : Kadur.

lindesayi.

ASSAM : Khasi and Jaintia Hills. BALUCHISTAN : Quetta-Pishin. BENGAL : Darjeeling, Jalpaiguri. KASHMIR. N.W. F.P. : Kohat, Peshawar, Swat Territory. PUNJAB E. & N. : Ambala, Gurdaspur, Kangra, Rawalpindi, Simla. SIKKIM. U.P. WEST : Almora, Dehra Dun, Garhwal, Naini Tal. WAZIRISTAN : Bannu Area.

lindesayi var. *nilgiricus*.

MADRAS DECCAN: Anantapur. MADRAS S.E.: Madura, Nilgiris.

maculatus and var. *willmori*.

ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Naga Hills, Nowgong, Sibsagar, Sylhet. BENGAL: Darjeeling, Jalpaiguri, Rangpur. BOMBAY DECCAN: Belgaum, Nasik, Poona. BURMA, LOWER: Kyaukpyu, Salween. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Mandalay, Myitkyina, North Hsenwi State, Upper Chindwin, Yaung Hwe State. CENTRAL INDIA E.: Rewah State (Baghelkand Agency). C.P. WEST: Balaghat, Betul, Bhandara, Hoshangabad, Jubbulpore, Nagpur. CEYLON. CHOTA NAGPUR: Ranchi, Singhbhum. KASHMIR. KONKAN: Goa, Kolaba, North Kanara. MADRAS COAST N.: Vizagapatam. MADRAS DECCAN: Bellary. MADRAS S.E.: Coimbatore, Nilgiris, North Arcot, Salem. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Kadur. NEPAL. N.W.F.P.: Chitral State, Hazara, Kohat, Peshawar, Swat Territory. ORISSA: Kalahandi State, Keonjhar State. PUNJAB E. & N.: Ambala, Gurdaspur, Kangra, Karnal, Lahore, Patiala State, Rawalpindi. U.P. WEST: Almora, Dehra Dun, Naini Tal, Saharanpur. WAZIRISTAN: Bannu Area, Derajat Area.

majidi.

BENGAL: Darjeeling, Jalpaiguri. MALABAR: Coorg Province, Malabar. MYSORE STATE: Kadur.

minimus.

ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar, Sylhet. BENGAL: Bogra, Cooch Behar, Darjeeling, Dinajpur, Jalpaiguri, Jessore, Malda, Nadia, Rajshahi, Rangpur, 24-Parganas. BIHAR: Purnea. BURMA, LOWER: Salween. BURMA, UPPER: Hsipaw State, Katha, Magwe, Mandalay, Minbu, Myitkyina, North Hsenwi, Upper Chindwin, Yamethin, Yaung Hwe State. CHOTA NAGPUR: Ranchi Singhbhum. KONKAN: Savantvadi State. MADRAS COAST N.: Ganjam, Vizagapatam. MADRAS DECCAN: Bellery, Kurnool. MADRAS S.E.: Madura, Tanjore. MALABAR: Coorg Province, Malabar. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. U.P. WEST: Naini Tal.

moghulensis.

BALUCHISTAN: Qwetta-Pishin. BOMBAY DECCAN: Ahmednagar, Belgaum, Nasik, Poona, Sholapur. C.P. WEST:

Betul, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Nimar, Saugor, Seoni. CHOTA NAGPUR: Ranchi. DELHI PROV. GUJARAT. Baroda State. KONKAN: Bombay City, Kolaba, Salsette Island. MADRAS COAST N.: Vizagapatam. MADRAS DECCAN: Bellary. MADRAS S.E.: Coimbatore. MALABAR: Malabar. N.W.F.P.: Kohat, Peshawar, Swat Territory. PUNJAB E. & N.: Ambala.

multicolor.

BALUCHISTAN: Persian Frontier, Quetta-Pishin, Zhob. WAZIRISTAN: Derajat Area.

pallidus.

ASSAM: Kamrup, Khasi and Jaintia Hills, Sibsagar, Sylhet. BENGAL: Birbhum, Burdwan, Cooch Behar State, Darjeeling, Faridpur, Hooghly, Jessore, Murshidabad, Nadia, Pabna, Rangpur, 24-Parganas. BIHAR: Darbhanga, Gaya, Purnea, Shahabad. BOMBAY DECCAN: Belgaum, Dharwar, Sholapur. BURMA, LOWER: Salween. BURMA, UPPER: Mandalay. CENTRAL INDIA E.: Rewah State (Baghelkand Agency). CENTRAL INDIA W.: Bhopal State, Gwalior State, Indore State. C.P. EAST: Bilaspur, Chanda, Drug, Raipur. C.P. WEST: Balaghat, Betul, Bhandara, Chhindwara, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Saugor, Seoni. CEYLON: CHOTA NAGPUR: Hazaribagh, Singhbhum. DELHI PROV. GUJARAT: Ahmedabad, Baroda State, Kaira, Sorath. HYDERABAD S.: Atraf-i-Balda. KONKAN: Bombay City, Kolaba. MADRAS COAST N.: Ganjam, Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, Madura, North Arcot, South Arcot. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. ORISSA: Cuttack, Puri, Sambalpur. PUNJAB E. & N.: Amritsar, Gujranwala, Gurgaon, Karnal. U.P. EAST: Gorakhpur, Lucknow. U.P. WEST: Agra, Naini Tal, Saharanpur.

philippinensis.

ANDAMANS. ASSAM: Cachar, Goalpara, Kamrup, Lakhimpur, Nowgong, Sibsagar. BENGAL: Bogra, Chittagong, Cooch Behar State, Darjeeling, Dinajpur, Faridpur, Jalpaiguri, Jessore, Khulna, Malda, Murshidabad, Nadia, Pabna, Rajshahi, Rangpur, 24-Parganas. BIHAR: Purnea. BURMA, LOWER: Salween. BURMA, UPPER: Bhamo, Hsipaw State, Mandalay, Minbu, Myitkyina, North Hsenwi State, Upper Chindwin, Yaung Hwe State. CHOTA NAGPUR: Singhbhum. KONKAN: North Kanara. MALABAR: Coorg Province. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore.

pulcherrimus.

BALUCHISTAN : Quetta-Pishin, Zhob. DELHI PROV. GUJARAT : Ahmedabad. N.W.F.P. : Kohat, Peshawar. PUNJAB E. & N. : Amritsar, Ferozepore, Gujranwala, Gujrat, Gurgaon, Hissar, Kapurthala State, Karnal, Lahore, Rawalpindi, Rohtak, Sialkot. PUNJAB S.W. : Dera Ghazi Khan, Lyallpur, Montgomery, Multan, Muzaffargarh. SIND : Hyderabad, Karachi, Larkana Nawabshah, Sukkur, Thar and Parkar, Upper Sind Frontier. U.P. WEST : Bijnor, Dehra Dun, Muttra, Muzaffarnagar, Saharanpur. WAZIRISTAN : Bannu Area, Derajat Area.

ramsayi.

ASSAM : Cachar, Kamrup. BENGAL : Burdwan, Faridpur, Jalpaiguri, Jessore, Khulna, Malda, Mymensingh, Nadia, Noakhali 24-Parganas. BURMA, UPPER : Bhamo. CEYLON. ORISSA : Orissa Delta.

sergenti.

WAZIRISTAN : Derajat Area.

sintoni.

MALABAR : Malabar.

splendidus (*maculipalpis* var. *indiensis*).

ASSAM : Sylhet. BALUCHISTAN : Zhob. BENGAL : Birbhum, Burdwan, Darjeeling, Jalpaiguri. BERAR : Amraoti. BOMBAY DECCAN : Poona. BURMA, LOWER : Insein, Rangoon, Salween. BURMA, UPPER : Katha, Mandalay, Myitkyina, North Hsenwi State, Upper Chindwin, Yaung Hwe State. CENTRAL INDIA W. : Gwalior State, Indore State. C.P. WEST : Balaghat, Betul, Bhandara, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Saugor, Seoni. CHOTA NAGPUR : Hazaribagh, Ranchi, Singhbhum. DELHI PROV. GUJARAT : Baroda State. KASHMIR. KONKAN : Goa, Kolaba, North Kanara, Savantvadi State. MADRAS COAST N. : Vizagapatam. MADRAS DECCAN : Kurnool. MADRAS S.E. : Coimbatore, Madura, Nilgiris, Salem. MALABAR : Coorg Province, Travancore State. MYSORE STATE : Bangalore, Chitaldrug, Kadur, Kolar, Mysore. NEPAL. N.W.F.P. : Chitral State, Hazara, Kohat, Peshawar, Swat Territory. ORISSA : Cuttack, Patna State. PUNJAB E. & N. : Ambala, Amritsar, Ferozepore, Gujranwala, Gujrat, Gurdaspur, Hoshiarpur, Jhelum, Jullundur, Kangra, Karnal, Patiala State, Rawalpindi, Sialkot, Simla. U.P. EAST : Benares, Gorakhpur. U.P. WEST : Bareilly, Bijnor, Dehra Dun, Muzaffarnagar, Naini Tal, Saharanpur, Shahjahanpur. WAZIRISTAN : Bannu Area, Derajat Area.

stephensi.

ASSAM: Lushai Hills. BALUCHISTAN: Loralai, Quetta-Pishin, Zhob. BENGAL: Burdwan, Calcutta, Darjeeling, Nadia, 24-Parganas. BERAR: Amraoti, Yeotmal. BIHAR: Bhagalpur, Patna. BOMBAY DECCAN: Ahmednagar, Dharwar, Khandesh West, Nasik, Poona, Satara, Sholapur. BURMA, LOWER: Rangoon. BURMA, UPPER: Katha, Mandalay, Minbu, Mytkyina, Upper Chindwin. CENTRAL INDIA W.: Gwalior State, Indore State. C.P. EAST: Bilaspur, Chanda, Drug, Raipur. C.P. WEST: Balaghat, Betul, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Nimar, Saugor. CHOTA NAGPUR: Singhbhum. DELHI PROV. GUJARAT: Ahmedabad, Baroda, State, Daman, Diu, Gohelwar, Halar, Jhalawar, Kaira, Palanpur State, Sorath. HYDERABAD N.: Aurangabad. HYDERABAD S.: Atraf-i-Balda. KASHMIR. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Thana. MADRAS COAST N.: Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, North Arcot. MALABAR: Malabar. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. N.W.F.P.: Hazara, Kohat, Peshawar, Swat Territory. PUNJAB E. & N.: Ambala, Amritsar, Attock, Ferozepore, Gujranwala, Gujrat, Gurdaspur, Gurgaon, Hissar, Hoshiarpur, Jhelum, Jullundur, Kangra, Kapurthala State, Karnal, Lahore, Ludhiana, Patiala State, Rawalpindi, Sialkot. PUNJAB S.W.: Dera Ghazi Khan, Mianwali, Montgomery, Multan, Muzaffargarh. RAJPUTANA E.: Ajmer-Merwara Province, Udaipur State. SIND: Hyderabad, Karachi, Larkana, Sukkur. U.P. EAST: Allahabad, Benares, Cawnpore, Fyzabad, Ghazipur, Lucknow, Rai Bareli. U.P. WEST: Agra, Bareilly, Dehra Dun, Farrukhabad, Meerut, Moradabad, Muttra, Muzaffarnagar, Naini Tal, Saharanpur. WAZIRISTAN; Bannu Area, Derajat Area.

subpictus.

ASSAM: Darrang, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Nowgong, Sibsagar, Sylhet. BALUCHISTAN: Loralai, Quetta-Pishin, Zhob. BENGAL: Birbhum, Bogra, Burdwan, Calcutta, Chittagong, Dacca, Darjeeling, Dinajpur, Faridpur, Hooghly, Howrah, Jalpaiguri, Jessore, Khulna, Malda, Midnapur, Murshidabad, Mymensingh, Nadia, Pabna, Rajshahi, Rangpur, Tippera, 24-Parganas. BERAR: Yeotmal. BIHAR: Bhagalpur, Darbhanga, Gaya, Muzaffarpur, Patna, Purnea, Santal Parganas, Saran, Shahabad. BOMBAY DECCAN: Ahmednagar, Belgaum, Dharwar, Khandesh West, Nasik,

Poona, Satara, Sholapur. BURMA, LOWER: Akyab, Kyaukpyu, Rangoon, Salween, Tharawaddy. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Magwe, Mandalay, Minbu, Myitkyina, Sagaing, Shwebo, Yamethin, Yaung Hwe State. CENTRAL INDIA E.: Bundelkand Agency, Rewah State (Baghelkand Agency). CENTRAL INDIA W.: Gwalior State, Indore State. C.P. WEST: Balaghat, Betul, Bhandara, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Nimar, Saugor. CEYLON. CHOTA NAGPUR: Hazaribagh, Palamau, Ranchi, Singhbhum. DELHI PROV.: GUJARAT. Ahmedabad, Baroda State, Daman, Diu, Gohelwar, Halar, Jhalawar, Kaira, Palanpur State, Sorath, Surat. HYDERABAD N.: Aurangabad. HYDERABAD S.: Atraf-i-Balda. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Salsette Island, Savantvadi State, Thana. MADRAS COAST N.: Ganjam, Godavari, Nellore, Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah, Kurnool. MADRAS S.E.: Chingleput, Coimbatore, Madras City, Madura, Nilgiris, North Arcot, Salem, South Arcot, Tanjore. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore. NEPAL. N.W.F.P.: Hazara, Kohat, Peshawar, Swat Territory. ORISSA: Cuttack, Puri, Sambalpur. PUNJAB E. & N.: Ambala, Amritsar, Attock, Ferozepore, Gujranwala, Gujrat, Gurdaspur, Gurgaon, Hissar, Hoshiarpur, Jhelum, Jullundur, Kangra, Kapurthala State, Karnal, Lahore, Rawalpindi, Rohtak, Sialkot, Simla. PUNJAB S.W.: Lyallpur, Montgomery, Multan, Muzaffargarh, Shahpur. RAJPUTANA EAST: Ajmer-Merwara Province, Udaipur State. SIND: Hyderabad, Karachi, Larkana, Nawabshah, Sukkur, Thar and Parkar, Upper Sind Frontier. U.P. EAST: Allahabad, Basti, Benares, Cawnpore, Fyzabad, Ghazipur, Hamirpur, Jaunpur, Lucknow. U.P. WEST: Agra, Bareilly, Bijnor, Dehra Dun, Etawah, Farrukhabad, Meerut, Moradabad, Muttra, Muzaffarnagar, Naini Tal, Pilibhit, Saharanpur, Shahjahanpur. WAZIRISTAN: Bannu Area, Derajat Area.

sundaicus (*ludlowii*).

ANDAMANS. BENGAL: Backergunge, Chittagong, 24-Parganas. BURMA, LOWER: Akyab, Kalagauk Island, Kyaukpyu.

superpictus.

BALUCHISTAN: Quetta-Pishin, Zhob. N.W.F.P.: Chitral State, Kohat, Peshawar, Swat Territory. WAZIRISTAN: Bannu Area, Derajat Area.

tessellatus.

ANDAMANS. ASSAM: Cachar, Sibsagar, Sylhet. BENGAL Burdwan, Chittagong, Dinajpur, Jessore, Khulna, 24-Parganas. BIHAR: Shahabad. BOMBAY DECCAN: Belgaum, Nasik, Poona. BURMA, LOWER: Akyab, Kyaukpyu, Salween. BURMA, UPPER: Bhamo, Hsipaw State, Katha, Mandalay, Yaung Hwe State. CENTRAL INDIA W.: Indore State. C.P. WEST: Bhandara, Jubbulpore, Nagpur, Saugor. CEYLON. CHOTA NAGPUR: Ranchi, Singhbhum. DELHI PROV. GUJARAT: Ahmedabad, Baroda State. KONKAN: Bombay City, Kolaba, North Kanara, Salsette Island, Savantvadi State. MADRAS COAST N.: Vizagapatam. MADRAS DECCAN: Anantapur, Bellary, Cuddapah. MADRAS S.E.: Niligiris, Pondicherry. MALABAR: Coorg Province, Travancore State. MYSORE STATE: Bangalore, Chitaldrug, Kadur, Mysore.

theobaldi.

ASSAM: Cachar. BENGAL: Burdwan, Dacca. BERAR: Amraoti. BIHAR. BOMBAY DECCAN: Nasik, Poona. BURMA, UPPER: Mandalay. Myitkyina. CENTRAL INDIA E.: Rewah State (Baghelkand Agency). CENTRAL INDIA W.: Gwalior State, Indore State. C.P. WEST: Balaghat, Betul, Bhandara, Chhindwara, Damoh, Hoshangabad, Jubbulpore, Mandla, Nagpur, Narsinghpur, Nimar, Saugor, Seoni. CHOTA NAGPUR Hazaribagh, Singhbhum. DELHI PROV. GUJARAT: Baroda State, Surat. HYDERABAD N.: Aurangabad. KONKAN: Kolaba, North Kanara, Savantvadi State. MADRAS COAST N.: Vizagapatam. MADRAS DECCAN: Bellary. ORISSA: Kalahandi State Sambalpur. PUNJAB E. & N.: Lahore. U.P. WEST: Dehra Dun, Shahjahanpur.

turkhudi.

BALUCHISTAN: Quetta-Pishin, Zhob. BERAR: Amraoti. BOMBAY DECCAN: Dharwar, Nasik, Poona, Satara, Sholapur. C.P. WEST: Betul, Chhindwara, Damoh, Hoshangabad, Nagpur, Narsinghpur, Seoni. DELHI PROV.: GUJARAT. Halar, Jhalawar, Sorath. HYDERABAD N.: Aurangabad. KASHMIR. KONKAN: Kolaba, North Kanara. MADRAS DECCAN: Anantapur, Bellary, Kurnool. MYSORE STATE: Bangalore, Chitaldrug, Mysore. N.W.F.P.: Chitral State, Hazara, Kohat, Peshawar, Swat Territory. PUNJAB E. & N.: Ambala, Amritsar, Ferozepore, Gujrat, Gurdaspur, Kangra, Lahore, Patiala State, Rawalpindi, Sialkot, Simla. SIND: Hyderabad. U.P. WEST: Dehra Dun, Naini Tal, Saharanpur. WAZIRISTAN: Bannu Area, Derajat Area.

umbrosus.

ANDAMANS. ASSAM: Darrang, Nowgong, Sylhet.

vagus.

ANDAMANS. ASSAM: Cachar, Darrang, Goalpara, Kamrup, Khasi and Jaintia Hills, Lakhimpur, Sibsagar. BENGAL: Backergunge, Bankura, Birbhum, Bogra, Burdwan. Calcutta, Chittagong, Cooch Behar State, Dacca, Darjeeling, Dinajpur, Faridpur, Hooghly, Jalpaiguri, Jessore, Khulna, Malda, Midnapur, Murshidabad, Mymensingh, Nadia, Noakhali, Pabna, Rajshahi, Rangpur, Tippera, 24-Parganas. BIHAR: Darbhanga, Patna, Purnea, Shahabad. BOMBAY DECCAN: Belgaum, Dharwar, Nasik, Poona, Satara. BURMA, LOWER: Akyab, Insein, Kyaukpyu, Rangoon, Salween. BURMA, UPPER: Hsipaw State, Katha, Magwe, Mandalay, Minbhu, Myitkyina, North Hsenwi State, Thayetmyo, Upper Chindwin, Yamethin, Yaung Hwe State. C. P. WEST: Jubbulpore. CEYLON. CHOTA NAGPUR: Hazaribagh, Ranchi, Singhbhum. KONKAN: Bombay City, Goa, Kolaba, North Kanara, Savantvadi State. MADRAS COAST N.: Ganjam, Godaveri, Vizagapatam. MADRAS DECCAN: Anantapur. MADRAS S.E.: Chingleput, Nilgiris, Pondhicherry, South Arcot, Tanjore. MALABAR: Coorg Province, Malabar, Travancore State. MYSORE STATE: Bangalore, Chitaldrug. Kadur, Mysore. ORISSA: Cuttack, Sambalpur.

varuna.

BENGAL: Calcutta, Jalpaiguri, Jessore, Khulna, Murshidabad, Nadia, Pabna, 24-Parganas. BURMA, UPPER: Myitkyina. CEYLON. CHOTA NAGPUR: Singhbhum. GUJARAT: Baroda State. KONKAN: North Kanara. MADRAS COAST N.: Ganjam, Vizagapatam. MADRAS S.E.: Chingleput, Madras City, South Arcot. MALABAR: Travancore State. ORISSA: Cuttack. U.P. EAST: Gorakhpur.

ALPHABETICAL INDEX.

All names printed with a small initial letter indicate a species or variety.
All names printed in bold type are valid names of Indian Anophelines; names of genera or groups with a capital initial letter.
All names printed in italics are synonyms.
Thickened numerals refer to the page on which the "Systematic" treatment of the insect is given.

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