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An Illustrated Key
to the Identification of
THE ANOPHELINE LARVAE

OF
India, Ceylon, and Malaya,

WEST OF WALLACE'S LINE

with Practical Notes on their Collection

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WITH A FOREWORD

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FOREWORD.

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Nothing is more urgently required than a book on the larvæ of Anopheline Mosquitoes. The information can indeed be found more or less accurately stated in text-books and in many scientific journals; but workers are obliged to consult all such works one after the other in order to gather a complete knowledge of the subject. Drs. Strickland and Choudhuri's handbook will therefore greatly facilitate the work of malariologists and medical men in the field. It is most necessary to distinguish the species of larvæ without waiting for them to hatch out, which is at present an unfortunate necessity for busy Health Officers or students of the subject.

Dr. Strickland is one of our greatest authorities on the subject of mosquito-control and has paid special attention to larvæ during many years. His book is simply and efficiently arranged, and is sure to meet a want much felt amongst the many persons who are now taking up the important study of the Prevention of Malaria in the field.

PREFACE.

No apology need be offered for this publication, save perhaps to those who either refuse to accept the doctrine of the mosquito transmission of malaria, or, accepting it, regard it of small moment in the Prevention of Malaria. It is to those in the East who follow the Reviewer in the *Lancet* (31st October, 1925) in believing that a system of identification of anopheline species is the correct practice in malaria-prevention schemes that the authors submit this Key as an aid to any endeavour in which they may be concerned.

The work is the natural sequel to the *Short Key to the Adult Anophelines* (1925) of the senior author, and the culmination after many delays due to various preoccupations, to an invitation by the Publishers of his *Short Key to the Anopheline Larvæ of the Malay Peninsula* (1915).

Too often, the authors assert, is it that malaria surveys* are conducted by men who only make use of the data obtained by hatching out adults from the anopheline larvæ which they have collected in the

* It is postulated that malaria surveys are made with a view to mapping out the sources of malaria in any locality and that of them the 'breeding places' of anophelines are very important.

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field, not realising the enormous amount of labour lost in this procedure. Some idea of the loss may be gathered from an analysis of the records collected recently during a three months' malaria survey of the Bengal Dooars Tea Gardens: 2,138 larvæ or pupæ were captured and of them 956* hatched out, the remainder 1,182 failing to do so; now if only those that had hatched out had been identified and the others thrown away, about 55 per cent. of the labour involved in the collection, or over a half of it, would have been quite wasted.

The primary object of the writers then is to indicate here how to save such lost time by making the best use of the material which has been collected, and in the second chapter, which includes the Key to the Identification of the Larvæ that object is attained. To this, however, will be prefixed a chapter on the Collection of Larvæ, which formed part of the senior author's Final Report on the Biology of the Anophelines of the Malay States as submitted to the local government. Without the Collection there would of course be nothing to identify. Appendices, on the staff and other important points, complete the work.

These prefatory remarks indicate the scope of the authors' intentions and the outcome completes

* This seems to be a higher proportion of hatching out than usual under the ordinary exigencies of field work.

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the second important part in any comprehensive description of Malaria Surveying* in which the senior has been concerned. Many other important sections remain; for instance those on the spleen-index in malariametry with notes on the diagnosis of splenic conditions; verifying malaria-sickness records *vis-à-vis* other fevers; statistical analysis in malariametry; the significance of the infectivity of anopheline species; the biology of anophelines, and making reports on the data collected in the survey. However, the student will probably now remark 'Sufficient unto the day is the evil thereof.'

ACKNOWLEDGMENTS.

In compiling the above Key we have as far as possible done so from our own experience of the larval species; but when we have not been personally cognisant of any we have borrowed from the descriptions of those authors who have written of them, and the list of References below, which has been made as complete a guide as possible to the literature on larval structure, will shew the names of those to whom we are indebted.

A further acknowledgment is due, and may be made here, to Mrs. C. Strickland, and to the School Artist Mr. B. A. Nag for their care bestowed on the drawings.

Finally we are greatly indebted to Lt.-Col. Stewart, I.M.S., Offg. Director of Public Health, Bengal, for many valuable suggestions in the production of the work.

*The first part was his Short Key to the Adults (1925). Thacker, Spink & Co., Calcutta.

CHAPTER I.

The Collection of Anopheline Larvæ.

Anopheline eggs, larvæ, and pupæ, are to be found on the face of most collections of water. The places where they cannot live are those in which there is considerable agitation of the surface, as at sea, or in great clear expanses such as lakes; or where there is a swift current and the larvæ have no visible means of support, like vegetable growth or debris.

They are usually recognised by the fact that when at rest they lie close to the surface and when progressing it is by a wriggling movement, tail foremost. Here an important point arises: not all the larvæ which one should collect are to be recognised in this way; there is one species* which does not lie near to the surface of the water, but holds its head dependent like a Culicine. In localities therefore where the adults of this species are caught, larvæ with a culicine attitude should also be collected. On the other hand the writers have at times been asked to inspect places whence anophelines have been reported and on examining these it has been found

* turkhudi.

they were specimens of Culicine *Aedes*, which, in some species, lie very close to the surface.

Anopheline pupæ can in their turn be distinguished by the naked eye as having wider breathing trumpets than have culicines.

When collecting larvæ or pupæ it is generally possible and the best plan to stir up with a stick any mud in the breeding-place, or to tramp in it, and then any larvæ which are present become visible, which is not the case where the water is clear. After that they may be caught: if there be no mud in the pool some may be thrown into it from outside.

For example in the case of a drain, in which the water is not too deep or swift-flowing, one should trample along it for a distance, making it muddy, and then return on the tracks, and look for larvæ: the collector must be there before the dragon-flies. Anything obstructing the visibility of a collection of water, such as surface-débris or tussocks of grass or rushes should be pulled out, or cut down, leaving an uninterrupted view of the surface. It is well-known that anopheline larvæ affect the edges of shelving banks of pools, and it is sometimes difficult to see them there even in muddy water, in which case one should have a cooly to dig away the shelving ground so that the pool has a deep margin, the dislodged earth being thrown into the centre of the pool

and stirred in, so as to render it muddy. Sometimes it may be more useful to dig a sump in the centre of a shallow pool, sufficiently deep to accommodate all the water of the pool, which drains into the centre carrying the larvæ in its stream. In the case of swiftly-flowing water it is impossible by stirring up mud from the bottom to make the water opaque, there usually being none to stir up, and it is best then not to clear away everything which obstructs the view of the water-surface because by so doing the protection which the larvæ derive from such material is taken away and they are washed away in the current: in such places the larvæ must be 'dipped' for among the grass or debris. Or the following device may be adopted:—the water at the edge of the stream is impounded by a little bank so that the larval lair is cut out of the current and the pool can then be made muddy. A useful plan to adopt when it is wished to examine a sample of swamp is to dig a pit in it, the suction exercised drawing in the larvæ which are resting in the swamp: especially if at the same time the vegetation close at hand be gently raked over so as to dislodge the larvæ and expose them to the suction current.

It will have been seen then that if it be desired to make as thorough a search as possible for larvæ in any locality, the whole place should be thoroughly prepared by a judicious use of dams, pits, tanks,

trowel, *changkol*, *kodali*, or rake. A few casual 'dips' is not enough.

When the larva has been seen it is caught in a 'dipper.' Of dippers it is advisable to have several sorts suitable for the various types of water which one may have to examine. For a very shallow pool a teaspoon only may be used; but the most generally useful article is a five-inch white enamel pan. If one has to dip in a part of a collection of water where it is not desired to have a swim in order to do it, a bamboo may be cut and the handle of a rather deep dipper wedged into the end of it, thus producing an instrument with as long a handle as is wished for. An occasionally useful dipper is a ten-inch pan with a comparatively sharp edge: this is used when a heavy sweeping movement is required to drive through grasses or weeds in which larvæ may be lurking, without the dipper being deflected. The correct knack of dipping must be learnt by experience, but this is soon acquired if the collector remembers that his one object in life is to catch the larva by quick movements and not to frighten it away by adopting slow and threatening attitudes.

When the larva has been caught in the dipper it is transferred with some water by means of a teaspoon with a sharp edge to a 2-ounce glass bottle. The collecting bottles should have field-numbers permanently scratched on them with a diamond and

should be well-corked, any old cork having been thrown away. Care must now be taken not to include the various other water-creatures (such as bloodworms, dragon-fly larvæ, hydrachnids, and bugs), which love to snaffle a nice succulent larva.

About a dozen bottles should be taken into the field by each collector, one bottle being used for each recorded breeding-place: if he fills all these in the course of the morning it will usually be time for him to remember another appointment, especially if it be a hot day.

Anophelines breeding in peculiar situations need the application of some device for catching them which the ingenuity of the collector will suggest. Thus the larvæ found in tree-holes, or bamboos, may be syphoned out by means of 12 or 18 inches of rubber hose pipe, or those in wells by a shallow dish suspended by three light chains at the end of a rope.

Included in the equipment with which the collector sets out should be a print, if available, of a large scale map (20, 16 or even 4 chains to the inch), or failing this a sketch plan of the locality to be visited *drawn on a large scale* and shewing the topography of any good small scale map: the sketch can be filled in with details by the collector himself as he goes along. Then when any specimen has been caught it is essential, in compliance with the idea of mapping out

the sources of the malaria, to note on one or other of the plans, as well as in a note-book, (*a*) where the catch was made, and (*b*) to further general knowledge in the subject, what was the nature of the 'breeding-place'; (*a*) and (*b*) bearing the same relation to each other as surgery to medicine, or topography to physiography.

The notes on the character of the breeding-places are essentially the interest of those engaged in research, and observations of the geology, physiography, physical, chemical, and biological properties of a breeding-place may one day prove very valuable. Many of them can be made in the field though the finer ones can only be carried out with the aid of instruments of precision in the laboratory.

A word may be added now with regard to suitable clothing for such work: anyone who has to indulge in it, and has had no experience of his own to guide him will find the following hints useful. The watchword should be serviceability. The gentlemen who turn out for field-work in full-dress with all medals up, as he would for the King's Birthday Parade, should be dismissed at once. He is made of worm-wood with a very thin veneer of teak.

Boots with leech-proof tongues should be of canvas with nailed soles: any Chinese boot-maker will turn out what is required at a moderate charge, or the ropesoled canvas boots sold in the big bazars

are useful. Canvas footwear is preferable to leather because one has constantly to wade in water and this runs out of canvas boots as easily as it runs in. Exceptionally, leather boots should be worn, when one is going into thorny jungle, like cane, for the great thorns of some plants can inflict very nasty wounds through canvas boots. Socks should be of thick wool, those known as jungle-socks like the 'old Army greys' are good. Oxford bags made of the stoutest khaki are good for the nether parts of the anatomy, for freedom at the knees is essential for log-hopping, however picturesque the variety of garment may be which laces up for about 12 inches at that part. Puttees should be sacrificed; they are insani-tary, unpleasant, difficult to put on, difficult to take off, difficult to clean, and dispose to skin diseases. Leeches are restrained from crawling up the legs by pulling the socks over the trousers, like the poilu on parade does.

A khaki flannel shirt has no advantages over a flannel singlet and a strong khaki coat, because it has not enough pockets and when working in the hot sun as in paddy-fields it is too thin for protection. The khaki coat should be made to button up at the neck and have field-service pockets. A sort of combination shirt and coat is now on the market and may be recommended. A wide pigsticker or similar pith *topi* should crown all.

Care must be taken to avoid chills by sensible measures when hot and work is over. Those who are unfortunate enough to get parasitic skin diseases, one form of which is especially common between the toes (foot-tetter), can cure them by Lin. Iodi and Tinct. Iodi equal parts, or Resorcin qs. in Tr. Benzoin Co. Prevention of these conditions like malaria is better than cure, so, after bathing, the skin between the toes should always be well dried, and occasionally antiseptic talc powder applied. It is hardly necessary to add that 5 grains of quinine daily as a prophylactic cannot do any harm.

Clothing when off duty should be equally serviceable as when on duty. The work connotes a liability to malaria and it is silly to sit about after dusk with 'shorts'* on. Trousers should be worn and the ankles covered with thick socks or canvas mosquito boots, while the neck and face may be protected by wearing a scarf anointed with citronella oil. Those who are bald might wear a little cap.†

*Or a *dhoti*, or *sarong*.

†It is well known that ethical codes and customs have often originated from the hygienic ideas of the elders of a community, and it is interesting to surmise that the use of the Gandhi and Khilafat head-dress had its origin in some idea of malaria prevention.

CHAPTER II.

How to Make the Best Use of the Field Collections.

(a) *Bringing the catch to the laboratory.*

This is an important item in the technique, for constant and prolonged agitation of the water in the bottle in which the larva is kept will drown it.

For this reason a tall narrow bottle kept upright is better than a wide flat one. It is also a good plan to put some small water plants into the bottle, such as species of *Azolla*, *Lemna* (duckweed), or *Chara*. The species of *Spirogyra* ('green-slime') are not so good, as they are apt to entangle the larvæ.

Any receptacle can be used for transporting a number of bottles. The main object should be to avoid the effects of shaking if possible, therefore a bedding of loose hay or tow at the bottom of a basket should be used. Too much sun shining on the catch is also deleterious, so a closed receptacle is advisable.

If it is thought that a particularly valuable or important catch has been made, the best means of transport is by hand. Motor transport is damaging. Train transport is not so harmful as one might think, probably the fact that trains in the East stop for

longer periods than they progress gives the larvæ a chance to resuscitate.

(b) *Sorting out the catch.*

As soon as the laboratory is reached the bottles are uncorked, carefully, as some larvæ may have been washed up between the cork and the bottle-neck, and the whole of the contents then emptied out into a white porcelain bowl.

Some larvæ will perhaps be found to have died. They must be set aside for identification, picking them out by means of a pipette. The point then arises what to do with the others. There is no doubt but that if one could hatch each out, the identification would take a shorter time, and as there is seldom anything to be gained by killing the specimens immediately, one should usually attempt to let them grow up. A possible exception to this practice is in the case of the youngest, which somehow or other have a habit of unaccountably disappearing from a bottle if they be left in it, perhaps their friends are more cannibalistic than one imagines, but even in their case one is tempted to leave them as hostages to fortune, for if killed their identification will certainly not be so easy or possible as in the older stages.

The writers always make a practice of separating off the biggest larvæ and pupæ into separate

confinement bottles. The object of this, in the case of the larva, is to save the larval skin from which the pupal instar emerges. Then should by any chance a new or rare species of adult eventuate, one will have the larval skin to study, and this affords the best means of studying this stage in correlation with the pupal skin and the adult. Another advantage is that should the pupa die, one can more easily identify the species from the larval skin. If the skin be shed in the company of growing larvæ these devour it.

When separating the larvæ dead in transit, and also the big living larvæ and pupæ from the others, one should be very careful to throw away all other small aquatic creatures which may have crept into the bottles, even the Culicines, many of which are carnivorous. This work is also conveniently effected by a small pipette.

(c) Registering the catch.

The field-notes must soon be transferred to a pucca register in which the collections are serially numbered and their topographical sources indicated by their registered number on a large scale map kept in the laboratory. Further, the big larvæ which have been separated off are designated A B C Etc. Later, when the identification has been made it should be entered in the register.

The form of register kept by the authors, filled in with an example, is as shewn here:—

District, Tigerpore.

Date, 29th February, 1957. Locality, The Jail.

Field No.	Breeding-places.	Registered.		Serial number of specimens.	IDENTIFICATION.			
		No.	Letter.		Adults hatching out.	Larval skins.	Dead larva.	
17	In a drain beside the Chittaranjan Chatterjee Tank; drain with short grassy edges, containing only clear seepage from the tank.	1703		1	<i>culicif</i> ♀		<i>rossi</i> <i>vagus</i> <i>culicif</i>	
				2				
				3				
				A	5	<i>culicif</i> ♀	<i>culicif</i>	
				B	6	<i>culicif</i> ♂	<i>culicif</i>	
				C	7			<i>rossi</i>
				D	8	<i>rossi</i> ♀	<i>rossi</i>	
				E	9	pupa died	<i>rossi</i>	
				F	10	<i>rossi</i> ♂ or <i>vagus</i> ♂	<i>vagus</i>	

As soon as the collections have been registered, the registered number should be grease-pencilled or Indian-inked on to the larva bottles, and every larva should for the rest of its career be designated by its number and letter.

(d) *After-care of the living larvæ.*

The bottles should be plugged with cotton-wool and placed in a good bright place like a verandah, though the sun should not be allowed to shine on them. There should not be too much water in the bottle and organic detritus should be provided for their food. Preferably the bottles should be left lying in an inclined position so as to allow the greatest possible surface to be exposed to the air; and for the same reason, to oxygenate the water, a tuft of grass, or duckweed, or *chara*, or moss, may be kept in the bottle.

Every day morning and evening they should be gone over. First any mosquitoes which have hatched out should be transferred to a wide glass tube. This is easily effected after a little practice without letting the mosquito escape: the mosquito usually tends to fly upward, or towards the better lighted part of the apparatus. The tube is then plugged with cotton-wool and the insect's register-number transferred to the tube and the mosquito can later be identified at leisure, while the pupal skin from which it developed must be preserved for the sake of research.

Then all the bottles one by one should be emptied into a white porcelain dish. This has the advantage for living larvæ of aerating the water and preventing the growth on them of bacteria, ciliates, and fungi.

All the dead larvæ, or at least their heads will be found at the bottom of the dish, if there has not been time for them to be devoured; they should be sucked up gently in a suitable pipette and preserved for identification.

(e) *Preservation of the larva and pupa.*

In the sections above we have referred to the setting aside for identification of (a) the larvæ dead in transit from the field; (b) the smallest larvæ which were killed rather than try to rear them; (c) the larval and pupal skins of the adults which have hatched out; and (d) the larvæ which have died during the attempt to rear them.

The point is how to kill and preserve them. This is conveniently done in rectified spirit and water, 3 : 1; or rectified spirit and glycerine equal parts, in small glass phials. These can be stored in an ordinary 50 cigar-box till one is ready to identify them. The larval skins, however, are so delicate that perhaps it is better to make permanent slide preparations of them immediately as described on page 16.

The registered number of the larva must be written on a piece of card and the slip placed in the tube. For this purpose Indian ink is very good, though some workers use a pencil. For safety's sake, the cork of the tube may be similarly numbered.

(f) *The examination of the larvæ.*

The naked eye appearance of the larva is sometimes useful. At this stage it is composed of three gross divisions: the head, thorax, and abdomen. The thorax of certain species* is very large and prominent and these are almost diagnosable accordingly, and some species have very definite markings which are diagnostic.†

A microscopic examination is then necessary. The best combination to use for routine work is a 2|3rd objective with No. 10 ocular; or 1|6th objective with No. 1 ocular, and the descriptions below are based on this practice. An oil-immersion lens is never necessary. A condenser is not essential. The great majority of larvæ can be identified without any variation in this routine but sometimes a difficult one crops up necessitating a higher ocular or objective.

The following method of subjecting the preserved larvæ‡ to examination is followed. The tubeful is emptied into a porcelain dish and then the larvæ with their dorsal surface uppermost are placed in a row on a clean glass slide by means of a pipette. To turn the larva with its dorsum uppermost, a pair of dissecting needles is used and the correct position

* *aconitus*, *funestus*, and *aitheni*, all species which live in rapidly running water.

† *asiaticus*, *barbirostris*, *hyrcanus* (often).

‡ The live larvæ can be treated in the same way.

ascertained with the help of a hand-lens; the eyes are then seen uppermost whereas if the venter be uppermost the mandibles are seen. The larvæ should be placed close together with their heads in a line and covered with a full-size cover-slip. In this way all those in a tube can be gone over very quickly, very often only the heads having to be examined for identification purposes.

The head structures should be examined first, then, if any confirmation is needed, either the thorax or abdomen as may be indicated by what one has seen on the head. It must be urged that unless the species is quite unequivocally diagnosed by looking at the head it is better practice to refer to other structures as well before coming to a diagnosis.*

In a great majority of larvæ the spirit specimens suffice for their identification but if there be any difficulty on any account, let the specimens be cleared first. In fact the beginner will probably be glad to clear all his specimens, for in them the structures stand out beautifully.

To clear them they are placed for about half an hour in pure liquid carbolic acid on a slide or in a receptacle, and when they have lost the opacity of the tissues (they may be left in the fluid for weeks), Oil

**vide* Carter (1925)—'whenever possible diagnosis should be based upon an assemblage rather than on a single series of characters.'

of Cloves is substituted for a few minutes. They may be examined in the oil, or a permanent preparation made in Canada-balsam. When mounting the larval skins, great care must be taken as otherwise the delicate hairs will be broken off.

If another opinion on their identification is desired the specimens should, if it be necessary, be carefully packed up, and sent to anyone whose opinion is sought, (*vide* Appendix IV).

(g) *The Identification.*

There are a large number of anophelines designated species and varieties by authors; Christophers' monograph (1924) being the most authoritative on their validity, but as one would suppose, in most cases, larval differentiation between the species is not so far advanced as in the adult state, and between the varieties still less so, up to the point of no differentiation at all. For this reason the varieties are not placed in this Key, leaving the following species for consideration:—

	Species.	Common Synonyms.
<i>acomitus</i>	Donitz	
<i>albotaniatus</i>	Theobald	<i>albirostris</i> Theobald
<i>aitkenii</i>	James	
<i>annandalei</i>	Prashad	
<i>asiaticus</i>	Leicester	
<i>aurirostris</i>	Watson	

The subgenus *Myzomyia* Christophers.

The deuteranopheline series.

In the deuteranopheline series of the subgenus, the adults of which have usually brightly spotted wings, with at least three golden spots on the costa, the larvæ have the anterior clypeal hairs separated comparatively widely and about equidistantly, and the antenna has usually no hair on its shaft.

	Species.	Common Synonyms.
<i>bancrofti</i> *	Giles	<i>pseudobarbistrostris</i> Ludlowi
<i>barbistrostris</i> <i>barbumbrosus</i> *	Van der Wulp <i>nov.</i>	<i>barbistrostris</i> var. <i>pallida</i> (Swellengrebel)
<i>brevipalpis</i>	Roper	
<i>culicifacies</i>	Giles	
<i>culiciformis</i>	Cogill	
<i>errabanda</i> †	(<i>vide</i> Brug 1926)	
<i>fuliginosus</i>	Giles	
<i>funestus</i>	Giles	<i>listoni</i> Liston, <i>minimus</i> Theobald
<i>gigas</i>	Giles	
<i>hunteri</i>	Strickland	
<i>hyrcanus</i>	Pallas	<i>sinensis</i> Wiedemann
<i>jamesii</i>	Theobald	
<i>jeyporiensis</i>	James	
<i>karwari</i>	James	
<i>kochi</i>	Donitz	
<i>leucosphyrus</i>	Donitz	
<i>lindesayi</i>	Giles	
<i>ludlowii</i>	Theobald	
<i>maculatus</i>	Theobald	
<i>maculipalpis</i>	Giles	
<i>mauritanus</i>	Darruty and D'Eurmaraz	
<i>novumbrosus</i>	Strickland	

* *bancrofti* has spotted legs, distinct from *barbistrostris*, and is considered by Christophers a valid species with *pseudobarbistrostris* a synonym. On the other hand Swellengrebel's *barbistrostris* var. *pallida* which is definitely stated by him to be like *barbistrostris*, and therefore without spotted legs, cannot be placed as a synonym of *bancrofti*. Now the variety *pallida* differs from *barbistrostris* in larval structure, so the two must be considered specifically distinct, there being considerable precedent for establishing the validity of a species on such grounds. Christophers however points out that the name *pallida* is preoccupied, so the name *barbumbrosus* is here given to it.

† of which there is no known description.

	Species.	Common Synonyms.
<i>pallidus</i> *	Theobald	
<i>parangensis</i> *	Ludlow	
<i>plumbeus</i>	Stephens	<i>barianensis</i> James
<i>pulcherrimus</i>	Theobald	<i>fowlari</i>
<i>punctulatus</i>	Donitz	
<i>rhodesiensis</i>	Theobald	
<i>schuffneri</i>	Stanton	
<i>separatus</i> †	Leicester	
<i>similissimus</i> ‡	<i>nov.</i>	<i>similis</i> Strickland
<i>stephensii</i>	Liston	
<i>subpictus</i>	Grassi	<i>rossii</i> Giles
<i>superpictus</i>	Grassi	<i>mursei</i> Theobald
<i>tesselatus</i>	Theobald	<i>punctulatus</i> Donitz
<i>theobaldi</i>	Giles	
<i>turkhudi</i>	Liston	
<i>umbrosus</i>	Theobald	
<i>vagus</i>	Donitz	<i>indefinita</i> Ludlow
<i>watsonii</i>	Leicester	
<i>wellingtonianus</i>	Alcock	
<i>willmori</i>	James	

The recorded geographical distribution and the typical habitat of each of these species is given below in Appendix V.

* Descriptions of *pallidus* and *parangensis* have come to hand too late to enable them to be placed in the body of the Key. They will be referred to in footnotes.

† No known description of the larva of this species is available.

‡ This new name is here given to *similis* Strickland, as the latter is preoccupied.

THE KEY.

While for such a large number of species it was possible, in the adult state, to construct a Key to their identification, in which but a single character sufficed to reveal the identity of each species, in the less differentiated larval state, and especially in the newly hatched larva, it would be more difficult to do so, and accordingly in this Key there are 'wheels within wheels,' as there are in the so-called dichotomous keys.

One may anticipate to say that, representing the biggest wheels, the main groups have been indicated by Christophers (1915 and 1924) being based by him on the structure of the male genitalia *with correlated differences in the larva*. These groups as far as Oriental Species are concerned are called:—

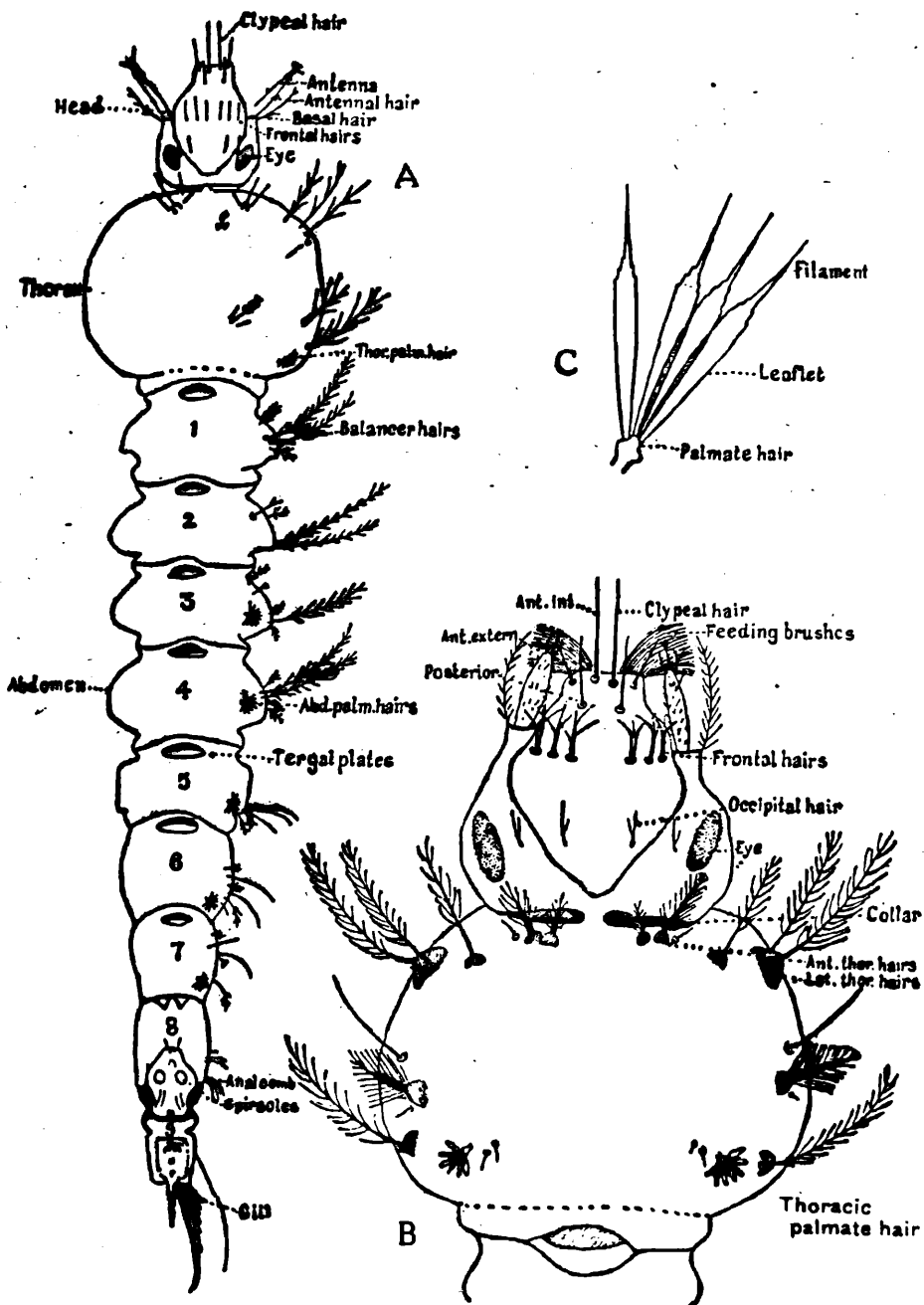
protanophelines corresponding to his subgenus *Anopheles*;

deuteranophelines corresponding to his subgenus *Myzomyia* (part)

neanophelines corresponding to his subgenus *Myzomyia* (part)

and in the Key each of these groups with the species lying in them will be considered in turn.

PLATE I
(after Carter 1925)



But at the outset it is necessary to denote the meaning of the technical terms which will be used in the Key and to point out certain structures which might otherwise be confused with those mentioned. Therefore the common characters of anopheline larvæ is here indicated.

Structure of an anopheline larva:

(Plate I, figures A B C.)

The larva, it must be repeated, consists of three gross divisions: the head, the thorax, and the abdomen.

The head—viewed dorsally, is more or less rounded with a blunt snout, the *clypeus*, projecting forward, and behind, limited by a chitinous thickening with a gap like a padre's collar. Laterally are *eyes* and in front of each an eminence carrying the *antenna*. From a ridge connecting the two antennal bases arise six more or less branched hairs (*the frontal hairs*), while from the external angle of the antennal articulation is a characteristic hair called the *basal hair*. The clypeus passes on to the *vertex*, which is narrowed behind by converging sutures. Anteriorly on each side is seen a large mass of hairs called "*feeding-brushes*" unless they happen to be retracted. The clypeal area between and over these brushes carries three pairs of hairs called the *antero-internal*, the *antero-external*, and the *posterior* pair of

clypeal hairs. The posterior part of the head is the *occiput* which bears a pair of small hairs on either side of the suture, the *internal* and *external occipital hairs*. On the ventral side of the head are the chitinous and complicated mouth parts.

The thorax—in full-grown larvæ the thorax is broader than the head or than any of the abdominal segments. It carries a number of branched hairs, and in some species can be seen a pair of hairs with differentiated leaflets arranged like a fan, the *palmate hairs*. The degree of development of these hairs varies greatly and is often difficult to detect against the dark background of the thorax. Amongst other numerous hairs present on the thorax, a group of three hairs, on each side antero-laterally, called the *antero-thoracic hairs* alone are of diagnostic importance: the outer hair of this group being nearly always unbranched and the middle one being always branched.

The abdomen—consists of nine visible segments bearing numerous variously formed hairs, the long lateral ones being called balancer hairs. The eighth segment carries dorsally two round chitinous respiratory openings (spiracles), while on each side of the segment is a chitinous toothed plate termed the *anal comb*. The ninth segment is small, carries four membranous processes, the *anal gills*, and numerous long hairs, which compose the so-called *ventral brush*.

On the dorsal surface of each abdominal segment, and situated near the anterior margin, is a chitinous plate, the *dorsal plaque*, *tergum*, or *scutum*: it varies in shape and size on the different segments, and to a considerable extent between some species. The *palmate hairs* are arranged in pairs on the dorsal surface of not more than the first seven segments, but often are fully developed only on the middle segments (3rd to 6th); those on the other segments being rudimentary. The shape and size of the palmate hairs, and particularly the form of the extremities of the leaflets—the *filaments*—varies greatly, and their characters are frequently of considerable diagnostic value.

The Subgenus *Anopheles* Christophers.

The protanopheline series.

In this subgenus which is the more primitive, and distributed over both hemispheres of the globe, most of the species have a jungly habitat, a sombre appearance, and wings in the adult which have no more than two light spots on the costa involving the first longitudinal, while *the larva has the following well-marked distinctions*:—

(1) The clypeal hairs are set closer together in relation to the clypeus than in the subgenus *Myzomyia*.

(2) The internal clypeal hairs in a great number of cases are quite close together.

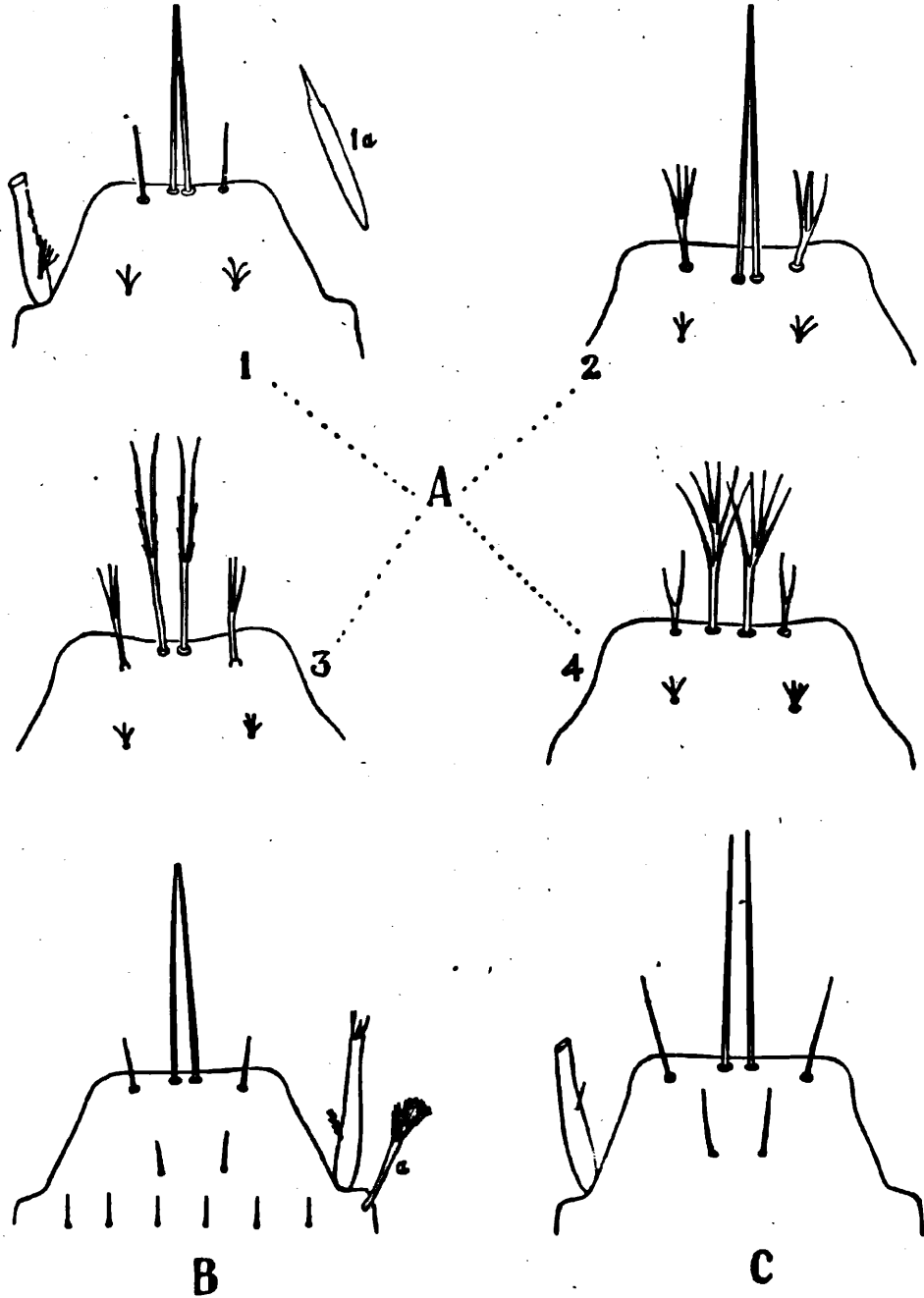
(3) There is usually a hair, simple or branched, on the antenna.

IF THE CLYPEAL HAIRS,		and the posterior being	and IF OTHER STRUCTURES are as below:—	as in Plate II, fig.:—	the SPECIES is:—
the antero- internal are	external being				
A. long, stout and simple (figs. 1-2) or bifurcated (3) or branched (4); close together (1-3) or further apart (4);	short, simple, or pronged;	small, branched:	(a) the palmate hairs slightly serrate with no filament:*	A.	<i>oitkenii</i> .
B. long, simple,	very short and simple;	very short, simple; placed very far apart†	(a) the basal hair a long stalk with a terminal tuft of fine hairs; (b) the palmate hairs with no filament; (c) the frontal hairs all simple:	B.	<i>culiciformis</i> .
C. long, simple; rather far apart,	short and simple;	short, simple, placed rather close together:	(a) the antennal hair simple and directed inwards; (b) the frontal hairs not well-developed; (c) palmate hairs absent:	C.	<i>brevipalpis</i> .

* In Type A1, they are sharply pointed (see fig. A1a) = var. *insulaeflorum*.

† The Plate gives a wrong representation in this respect.

PLATE II



IF THE CLYPEAL HAIRS,		and the posterior	and IF OTHER STRUCTURES are as below:—	as in Plate III, fig. —	the SPECIES is:—
the antero- internal are	external being				
A. delicate, unbranched or nearly so; rather close together,*	shorter delicate, unbranched* or nearly so;	minute, simple:	(a) antenna with a very minute hair externally; (b) no basal antennal hair; (c) no branched hair on the head, frontal hairs very small and simple; (d) abdominal segments 1-7 carry powerful triradiate spines and long feathered hairs; (e) well-developed palm, hairs on abd. segments 2-6 with long spear-like leaflets:	A. Aa.	<i>plumbeus.</i>
B. long, simple or bifurcated, rather close together,	short, simple;	fairly long, simple:	(a) frontal hairs, only the external branched; (b) well-developed palmate hair abdominal segment 2, small on 3-7 with filamentous leaflets:	B. Ba.	<i>asiaticus.</i>
C. long, simple, close at base,	pinnate, comparatively long;	shorter, simple:	(a) antenna with a small hair outside; (b) basal hair characteristic quite unlike <i>cuticiformis</i> ; (c) frontal hairs not well-developed;† (d) the antero-thoracic hairs with the external trifid; (e) long branched balancer hairs on abdominal segments 1-6; (f) palmate hairs, abdominal segments 2-3 small, on 4-7 developed; leaflets lanceolate:	C. Cb. Cf.	<i>annandalei.</i>

* Christophers' description gives simple hairs, while Lang shews them with a few fine branches.
† as in other tree-hole breeders.

PLATE III.

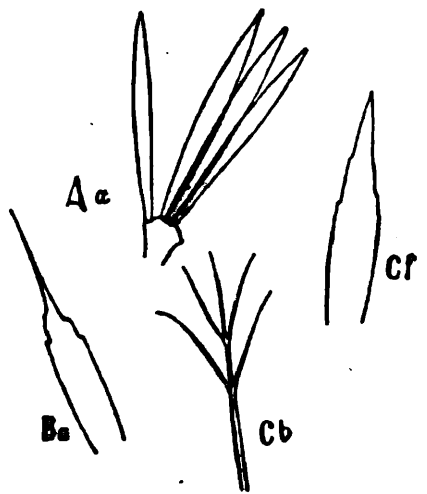
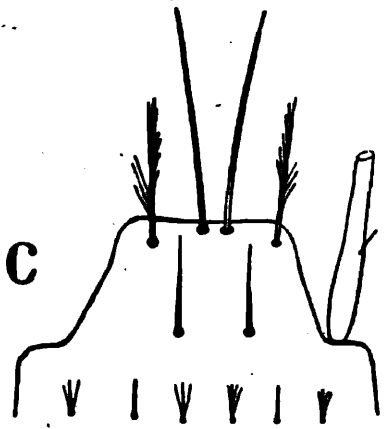
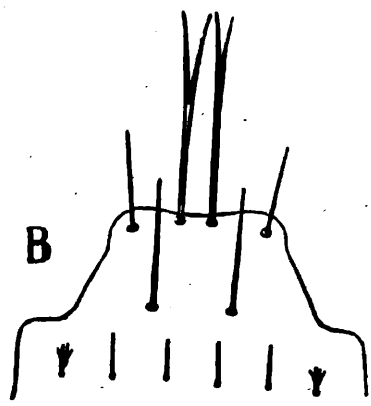
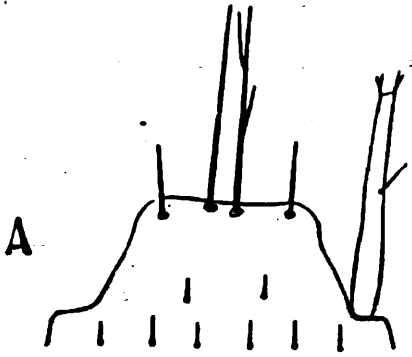
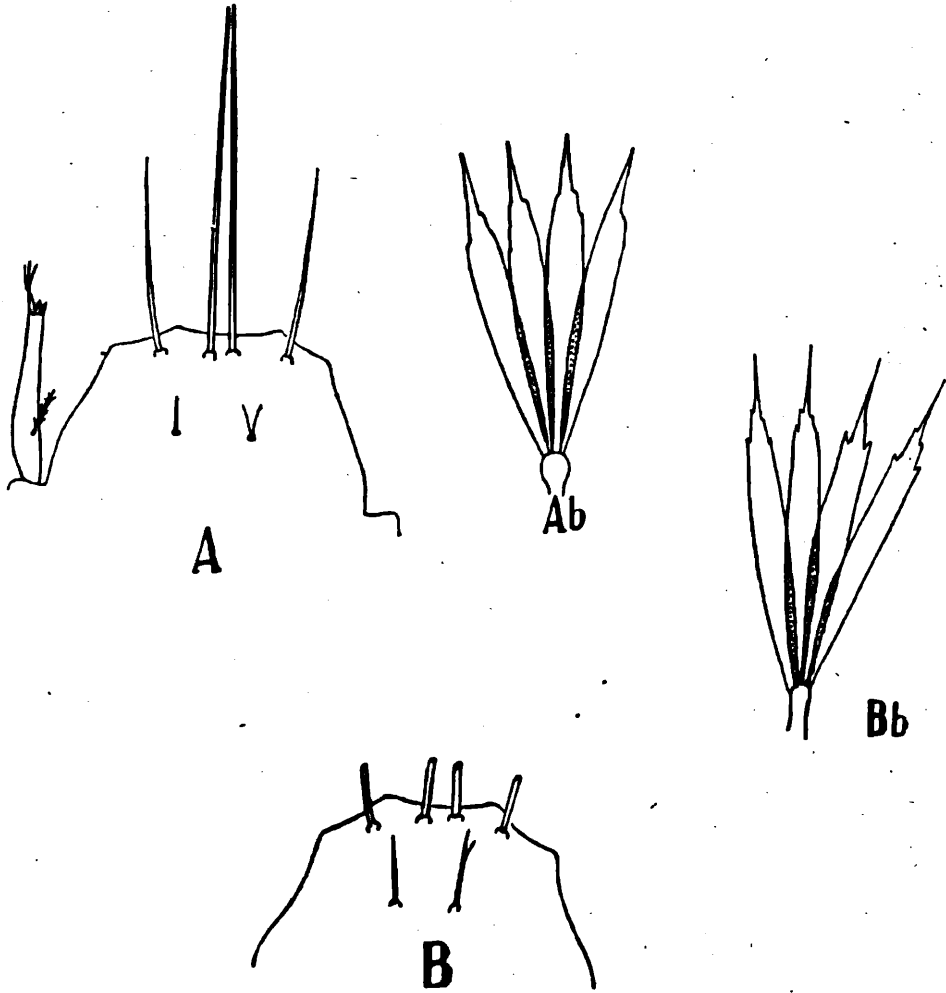


PLATE IV.



IF THE CLYPEAL HAIRS,			and IF OTHER STRUCTURES are as below:—	as in Plate IV, fig.:—	the SPECIES is:—
the antero-		and the posterior			
internal are	external being				
A. long, simple,	shorter, simple;	comparatively short, simple or forked:	(a) antennal hair small;	A.	<i>gigas</i> .*
			(b) well-developed pal- mate hairs only on abdominal segments 3rd to 7th inclusive, leaflets pointed:	Aa.	
B. long, simple,	shorter, simple;	comparatively long:	(a) antennal hair small;	B.	<i>lindesaii</i> .* or <i>wellington- ianus</i> .*
			(b) palmate hairs well- developed on abdomi- nal segments 2-7, leaflets with short filament:	Bb.	

* To be distinguished from Type 1 of *aitkenii* by the simpler posterior hairs and longer antero-external clypeal hairs.

IF THE CLYPEAL HAIRS,		and IF OTHER STRUCTURES are as below:—	as in Plate V, fig.:—	the SPECIES is:—	
the antero-					
internal are	external being	and the posterior			
A. long, simple* and close together,	with only a few branches;	small and branched:	(a) abdominal palmate hairs all filamentous:	A. Aa.	<i>umbrosus</i> .
B. long, simple and close together,	with only a few branches;	fine and simple:	(a) palmate hairs fully developed only on 4th and 5th abdominal segment, with no filament:	B.	<i>novumbrosus</i> .
C. long, simple and close together,	with only a few branches;	rather long and simple:	(a) abdominal palmate hairs all filamentous:	B. Aa.	<i>hunteri</i> .
D. long, simple and close together,	with only a few branches;	fine and simple or slightly branched:	(a) all as in <i>barbirostris</i> : (q. v.)	D.	<i>barbumbrosus</i> .
E. long, simple, and comparatively far apart,	the same as above, but set more squarely;	small, branched:	(a) antenna short and stumpy with internal strongly - branched hair; (b) ant.-thoracic internal hair simple; (c) palmate hairs not all filamentous; on thorax and abdominal segment 1-2, small; on abd. segment 3-7 well-developed, and like <i>hyrcanus</i> :	E. Ea. Ec.	<i>albotanatus</i> .

* Swellengrebel describes a form in which the internal hairs are like a test-tube brush (fig. Ab).

PLATE V.

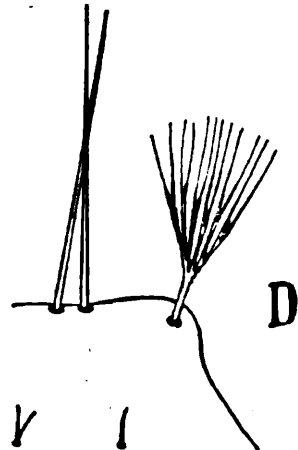
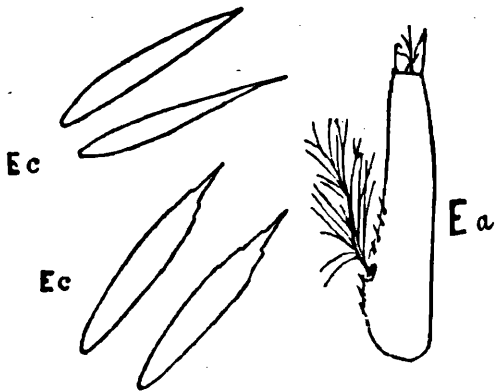
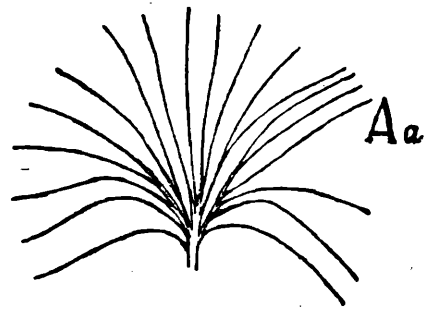
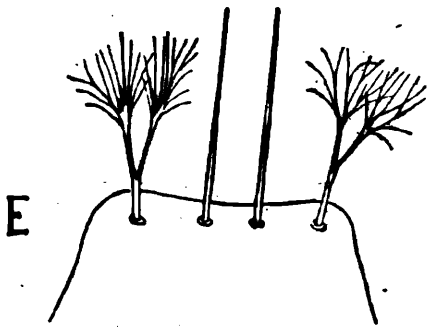
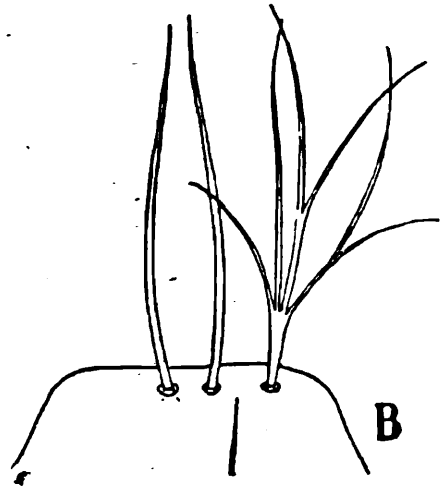
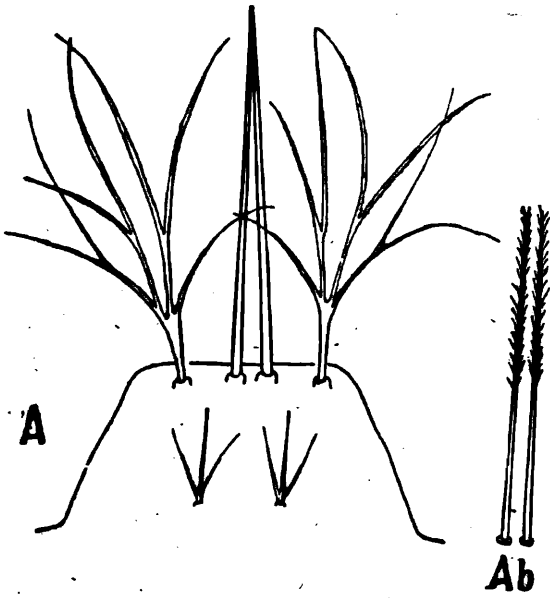
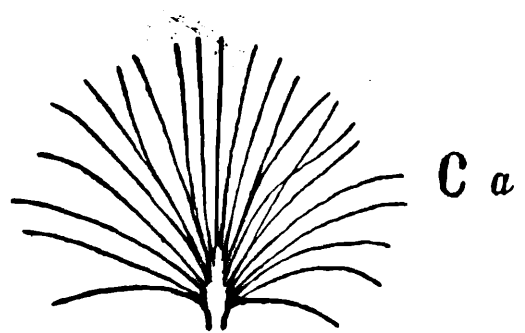
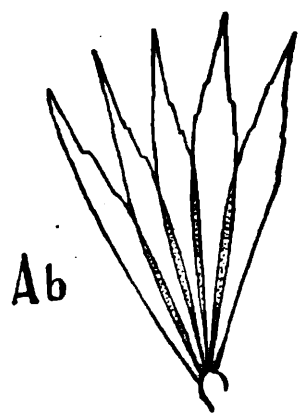
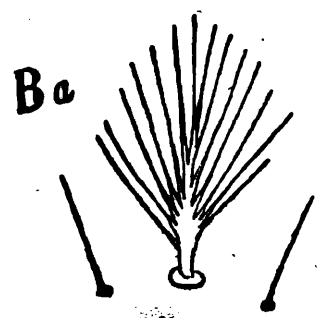
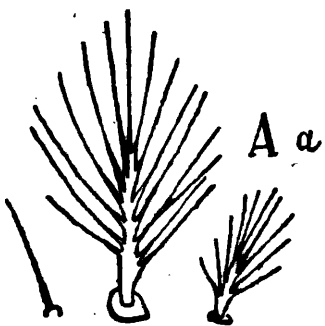
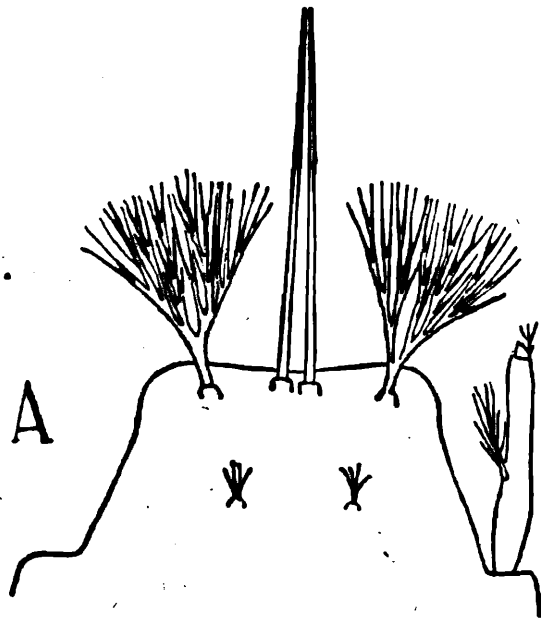
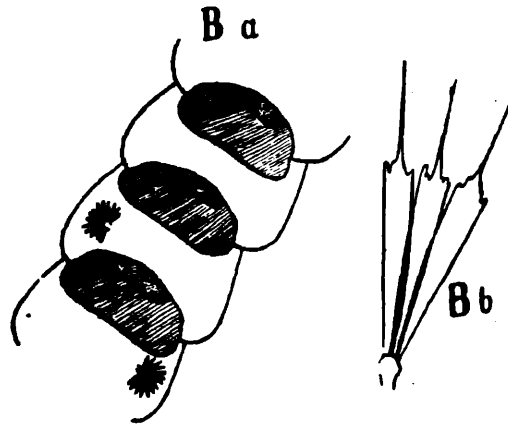
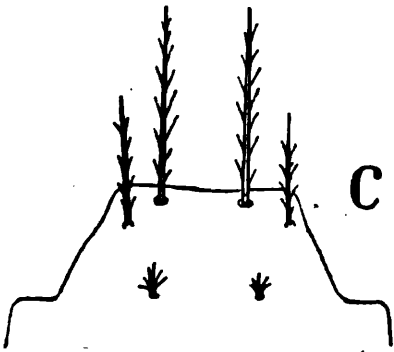
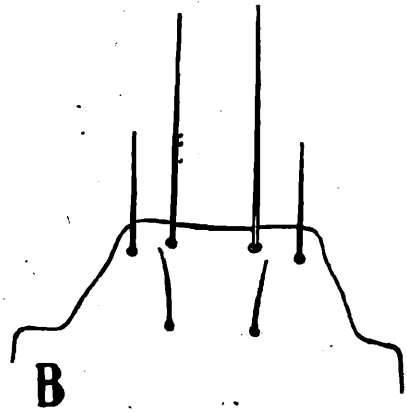
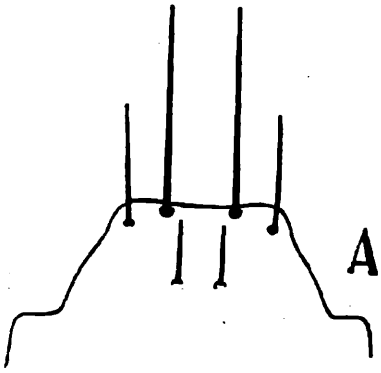


PLATE VI.



IF THE CLYPEAL HAIRS,			and IF OTHER STRUCTURES are as below:—	as in Plate VI, fig.:—	the SPECIES is:—
the antero-		and the posterior			
internal are	external being				
A. long, and simple,	a strong tuft with stem thick and branches numerous;	small and branched:	(a) the antero-internal thoracic hair branched; (b) abdominal palmate hairs pigmented proximally:	A. Aa. Ab.	<i>barbistrotris.</i> or <i>mauritanus.</i>
B. long, and simple,	a strong tuft with stem thick and branches numerous;	small and branched:	(a) antero-internal thoracic hair simple or bifid; (b) abdominal palmate hairs as in <i>barbistrotris</i> :	A. Ba. Ab.	<i>hyrcanus.</i>
C. long and simple,	a strong tuft with stem thick and branches numerous;	small and branched:	(a) palmate hairs represented by a series of filamentous cocades as in <i>umbrosus</i> and <i>hunteri</i> :	A. Ca.	<i>similis-</i> <i>simus.</i>

PLATE VII.



IF THE CLYPEAL HAIRS,			and IF OTHER STRUCTURES are as below:—	as in Plate VII, fig.:—	the SPECIES is:—
the antero-		and the posterior			
internal are	external being				
A. long and simple,	short and simple;	short, simple and placed between the ant.-int.:	(a) leaflets of palmate hairs with very long filaments:	A.	<i>vagus</i> .
B. long and simple,	short and simple;	short, simple and situated in a line with the ant.-int.:	(a) dorsal plaques large, with much pigment on the anterior margin;	Ba.	<i>funestus</i> , (= <i>minimus</i> and <i>listoni</i>).
			(b) leaflet of abdominal palmate hairs has 'cup and cone' extremity and a long filament;	Bb.	
			(c) thoracic palm-hair well-developed:		
C. long and definitely frayed,	short and frayed;	small and branched:	(a) the same as <i>funestus</i> :		<i>aconitus</i> .

IF THE CLYPEAL HAIRS,		and the posterior	and IF OTHER STRUCTURES are as below:—	as in Plate VIII, fig.:—	the SPECIES is:—
the antero-					
internal are	external being				
A. long and simple,	short and simple;	short, simple and almost in a line with the ant.-int.:	(a) ant.-thor. hairs strong and pigmented, the innermost with a conspicuous dark root; (b) thoracic palmate hairs small with 6 to 8 short leaflets; (c) abdominal palmate hairs with long filaments:	A. Ab. Ac.	<i>culicifacies</i> .
B. long and simple,	short and simple;	short, simple and almost in a line with the ant.-int.:	(a) thoracic palmate hair rudimentary with some hair-like branches:	A. Ba.	<i>subpictus</i> , (=rossi) or <i>theobaldi</i> , or <i>ludlowi</i> .*
C. long and simple;	short and simple,	shorter than the above, simple and almost in a line with the ant.-int.:	(a) int. antero-thoracic hairs much branched; (b) no rudimentary palmate hair on abd. seg. 1:	A.	<i>stephensi</i> .
D. long and simple,	short and simple;	short and simple:	(a) antenna with small spine half-way up its outer border; (b) rudimentary palmate-hair on abd. seg. 1:	A.	<i>rhodesiensis</i> .

* Since compiling this table Rodenwaldt's description of *parangensis* has come to hand. It belongs to the *rossi-ludlowi* group from which however it can apparently be distinguished by the following points:—the posterior clypeal hairs are set rather forward, projecting over the clypeus, the antero-thoracic hairs are more pigmented and strongly branched, the thoracic palmate hairs are rudimentary with 4 to 5 fine branches, and the 1st abdominal palmate hairs are typical though small. The other palmate hairs are well-developed and the leaflets extended gradually into a fine point.

PLATE VIII

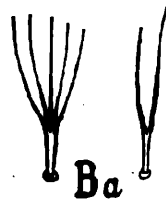
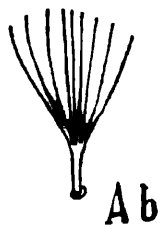
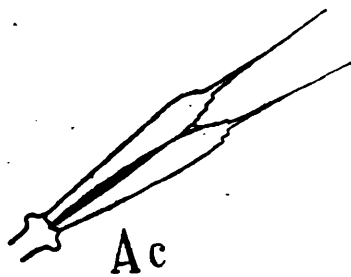
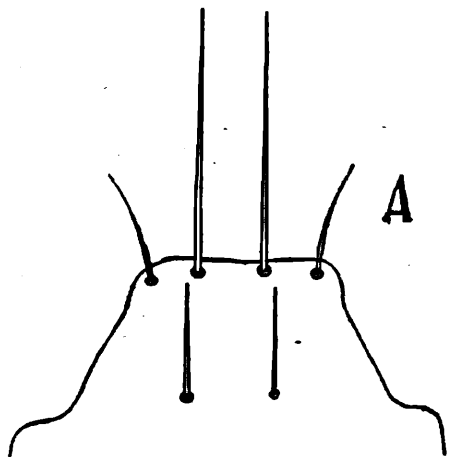
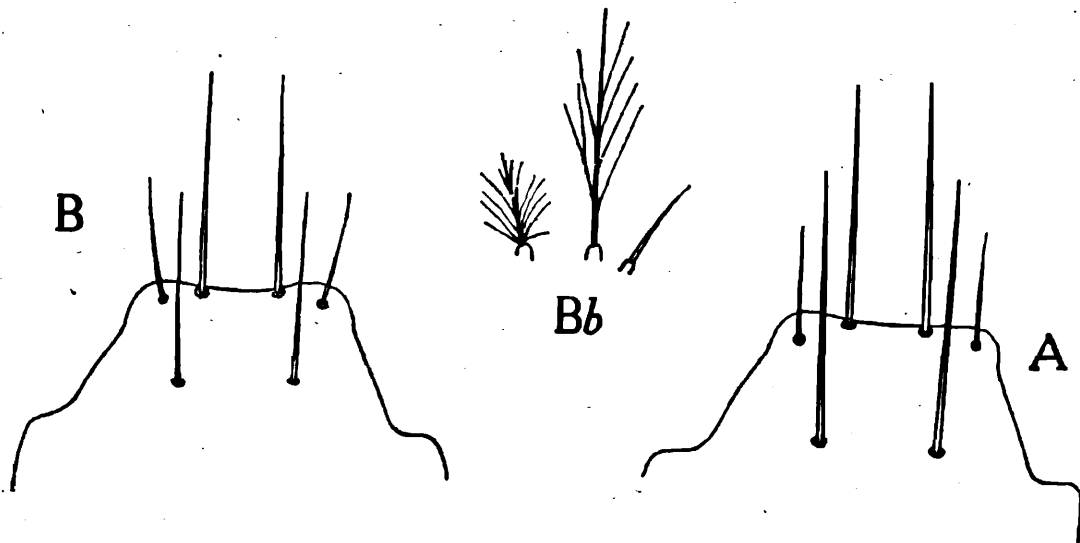


PLATE IX.



IF THE CLYPEAL HAIRS,		and the posterior	and IF OTHER STRUCTURES are as below:—	as in Plate IX, fig.:—	the SPECIES is:—
the antero-					
internal are	external being				
A. long and simple,	short and simple;	very long:	(a) int. ant.-thor. hair not plumose, slightly branched; (b) palmate hairs quite absent on abdominal segments 1—3: developed but small, with no filament, on segments 4—6 only:	A.	<i>turkhudi</i> .
B. long and simple,	short and simple;	comparatively long but not so long as in <i>turkhudi</i> :	(a) antenna with the hair at its base forked, and with hooked ends; (b) int. ant.-thor. hair much branched, plumose; (c) palmate hairs on abdominal segments 2—7, with moderately long filaments; (d) small fine hair on ext. side of antenna:	B. Bb.	<i>superpictus</i> .

IF THE CLYPEAL HAIRS,			and IF OTHER STRUCTURES are as below:—	as in Plate X, fig.:—	the SPECIES is:—
the antero-		and the posterior			
internal are	external being				
A. long and simple, perhaps slightly frayed,	shorter and simple or frayed;	short and simple:	(a) palmate hairs on abdominal segments 2 or 3 to 7 with filament as long as blade:	A.	<i>pulcherri- mus.</i>
B. long and much frayed,	shorter and thickly frayed;*	short and simple:	(a) palmate hairs well-developed on thorax and on abdominal segments 2—7, filaments shorter than above:	B.	<i>maculi- palpis.</i>
C. long, stout, and finely frayed,	short and frayed;	relatively long, stout and simple:	(a) abd. palmate hairs with leaflets sharply steeped and filament relatively short:	C. Ca.	<i>maculatus or willmori.</i>
D. long, stout, and finely frayed,	short, and frayed;	relatively long, stout and simple:	(a) palmate hairs on abdominal segments 2—7, leaflets stout and terminal part truncate:	C. Da.	<i>karwari.</i>

*The figure representing the anterior clypeal hairs makes the fraying too evident.

PLATE X.

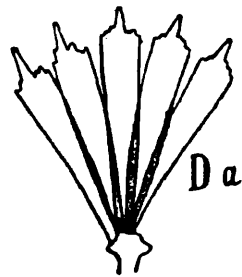
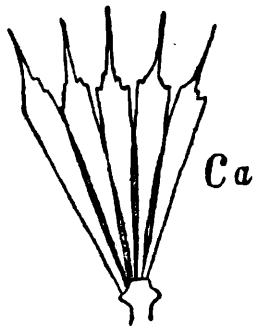
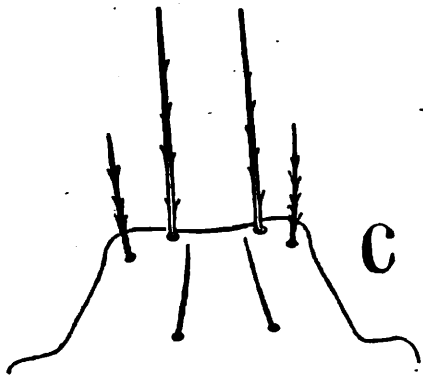
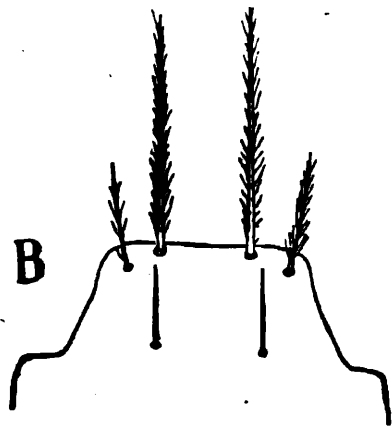
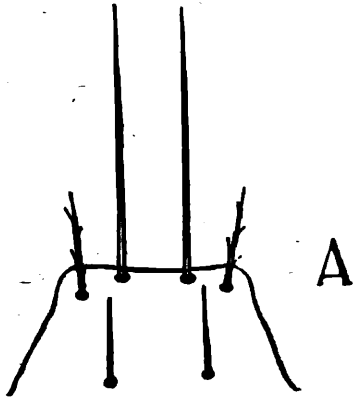
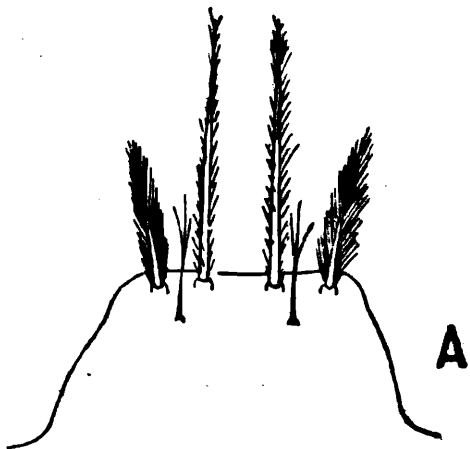
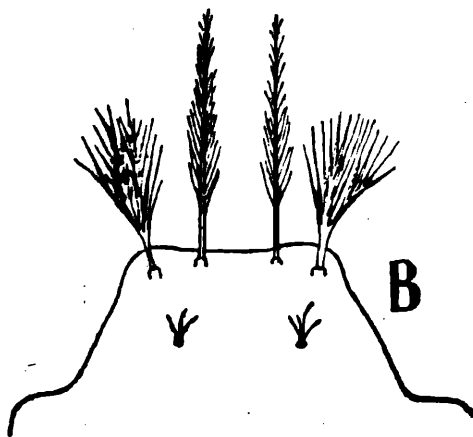


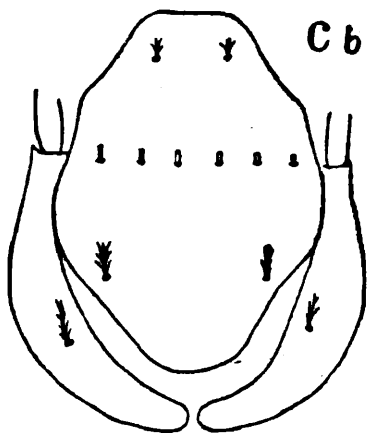
PLATE XI.



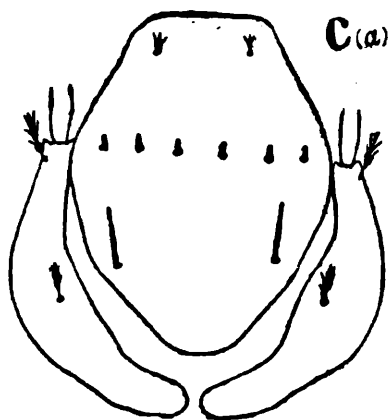
A



B



Cb



C(a)

IF THE CLYPEAL HAIRS,			and IF OTHER STRUCTURES are as below:—	as in Plate XI, fig. :—	the SPECIES is :—
the antero-		and the posterior			
internal are	external being				
A. long and thickly frayed,	shorter and more thick- ly frayed;	relatively long and branched:	(a) palmate hairs pre- sent on thorax: and on abdominal segments 1—7:	A.	<i>jeyporiensis</i> .
B. long and thickly frayed,	strongly branched;	short and branch- ed:	(a) ant. thor. hairs with stout pigmented stalk, and thickly branched;	B.	<i>fuli- ginosus.*†</i>
			(b) int. occipital hair branched:*	Cb.	
C. long and thickly frayed,	strongly branched;	short and branch- ed:	(a) internal occipital hair simple:*	B. Ca.	<i>jamesii.*</i>
D. long and thickly frayed,	strongly branched;	simple or bifid:		B. (in part)	<i>schuffneri</i> .

* The distinction between these species in the internal occipital hair which was put forward by Strickland (1925), and Carter (1925), cannot apparently now be sustained. This hair has been found by one of us (K. L. C.) to be always simple in *jamesii* but in a considerable proportion of *fuliginosus* also simple. There, however, appears to be a difference between the two species in the palmate hairs, which, in *fuliginosus*, are well-developed on abdominal segment 1, and in *jamesii* only rudimentary with no marked leaflets.

† *pallidus* since this Key was compiled has been found to be indistinguishable from *fuliginosus*. (K. L. C.)

The subgenus *Myzomyia* Christophers.

The neanopheline series.

Species of this series of the subgenus *Myzomyia* are in the adult distinguishable to a certain extent from the deuteranophelines, in details of the male genitalia, and in the 6th vein of the wing having at least three black spots; while *in the larva there are some characteristic and constant structural features*:—

(1) The *anterior clypeal* hairs are simple or slightly frayed. The antero-internal hairs are set as wide apart as in the deuteranophelines, but *the antero-external are placed closer to the internal than in deuteranophelines*:

(2) the antero-external hair is nearly always very short and delicate, and placed close to the antero-internal:

(3) the posterior-hairs very small and delicate:

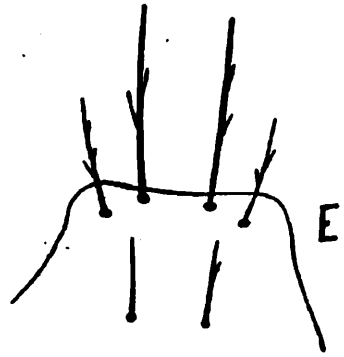
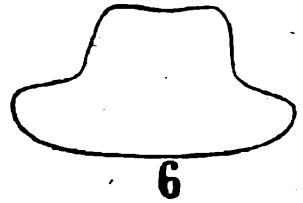
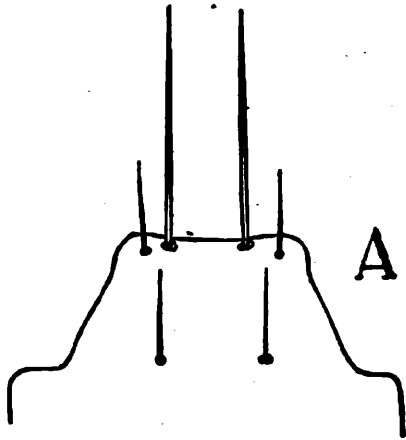
(4) the antenna without a hair on its shaft:

(5) the leaflets of the palmate hairs have their proximal part with a ground-glass appearance, the distal part translucent and carrying no filament: see Plate XI, fig. 5:

(6) the dorsal-plaques of the midabdominal segments a characteristic saddle-shape: see Plate XI, figs. 6, 6:

Moreover, their habitat is interesting as they may be considered semi-jungly species, and are often found in brackish water.

PLATE XII.



IF THE CLYPEAL HAIRS,		and the posterior	and IF OTHER STRUCTURES are as below:—	as in Plate XII, fig.:—	the SPECIES is:—
the antero-					
internal are	external being				
A. long, slender simple,	being very short and very close to ant.-int.;	short, slender and placed further back than in deuteranophelines:	(a) ant.-thor. hairs finely branched, internal long and with many branches; (b) palmate hair on thorax rudimentary:	A. Aa.	<i>kochi</i> .
B. shorter and thicker than in <i>kochi</i> .	very short and very close to ant.-int.;	short and fine:	(a) ant.-thor. hairs slender, the internal with 2 or 3 branches; (b) palmate hair on thorax small, on abdominal segments 1—2 small, on abdominal segments 3—7 well-developed:		<i>tessellatus</i> or <i>watsonii</i> .
C. shorter and thicker than in <i>kochi</i> , not frayed,	very short and very close to ant.-int.;	short and fine:	(a) ant.-thor. hairs usually pigmented, the internal stout with numerous branches; (b) palmate hair on thorax small not serrated, on abdominal segment 1 vestigial, on 2nd small, on 3—7 well-developed:		<i>leucosphyrus</i> .
D. shorter and thicker than in <i>kochi</i> , slightly frayed: almost as close together as in some protanophelines,			(a) int. ant.-thor. hair with 2 or 3 branches; (b) palmate hairs simpler than in <i>kochi</i> :		<i>aurirostris</i>
E. shorter and thicker than in <i>kochi</i> and with a few fine frays,	comparatively long; placed relatively close to the ant. internal;	short and fine:	(a) ant.-thoracic hairs heavy, as in <i>leucosphyrus</i> ; (b) palmate hairs on abdominal segment 1 small; on 2—7 complete, serrate, and pointed:	E. Eb.	<i>punctulatus</i> .*

* var. *moluccensis* Swell.

(g) Storing specimens.

Once the specimens have been determined it is best to preserve and store them for future reference if required. They may be returned to their phial of spirit, or may be mounted permanently on slides as described shortly on page 16; or after making a ring of hard paraffin on a slide by means of a 'ringer' machine, a brush, and molten paraffin, the larva uncleared is placed in the centre of the ring in sufficient preserving fluid to fill up the chamber: a round cover-slip is then applied and this is cemented down to the previously-made ring by some more molten paraffin. Finally, the ring of wax must be varnished with Brunswick-black.

The tubes or the slides, as the case may be, are then stored in suitable boxes.

APPENDIX 1.

Catching adults.

A method of mapping out 'the production areas' of anophelines is given by Sir Ronald Ross in his 'Prevention of Malaria.' It may be used when casual dipping has failed to find a suspected species. An old though whole mosquito-net is set up in the evening over the water to be examined and in the morning all those which have taken to wing within the confines of the net are conveyed to the laboratory for record.

The same principle is involved in the use of a bronze wire-mesh cage mounted on a stout teakwood frame which can be floated on water in tanks or borrow-pits to study the prevalence of anophelines among the masses of floating plants like water-hyacinth, duckweed, or water-lettuce.

The time-honoured method of catching adult anophelines in houses is to search for them in darksome nooks with the aid of a bright light, such as of an electric torch or acetylene lamp. When a mosquito is seen, a wide glass test-tube, at the bottom of which is a wad of cotton-wool carrying chloroform is placed over it, in this way a number being caught in one tube.

Regarding traps, a form which has been found by the writers to be very effective, is a box made of three-ply wood, in one side of which is cut a hole about 6 inches diameter. The interior is lamp-black, (it should not be painted), and a cover-flap on a swivel provided for closing the opening. If such a trap be set at sundown in any likely place it will certainly procure many anophelines. Early next morning they can be shaken out under a mosquito-net and the catch taken in test-tubes. A whole nest of these boxes can be made and are very light to transport.

A very good trap used by Colonel Clemesha, I.M.S. (retd.), though exceedingly heavy, is an ordinary basket leaped with cowdung and dried, a hole being provided in the lid as in the case of the boxes above.

Any dark cloth or leather article attracts anophelines and if such things be covered by a mosquito-net and shaken many of the insects may be caught.

APPENDIX 2.

Equipment required.

The equipment in the schedule below has been adumbrated in the various sections above, but a resourceful collector can improvise the wherewithal to capture his specimen when he has no regular equipment with him. Even whiskey, (or gin in the Netherlands-Malaya), can be used for preserving larvæ!

The amount of stock to be purchased depends of course on the strength of the staff engaged not forgetting that there should be a reserve in store.

For collection of larvæ. (Each collector's requirements.)

	in the field	in stock
Note-book and pencil.		
Maps of the locality.		
Bottles 2 oz.; wide-necked, corked.	12	132
Basket or Tray	1	1
Digging tools and rake ..	1 of each.	
Dippers, Enamel, white, 5 in. ..	1	
Iron, 10 in. ..	1	
Teaspoon	1	1
Bamboo for fitting small dipper into.	1	
Tow, or Jute, or Cotton waste	q. s.	5 lbs.

For collection of adults.

Mosquito-net and frame for setting net, any size.	1	
Acetylene-bicycle lamp or electric-torch.	1	spare dry cells kept in desiccator
Test-tubes, wide	12	36
Cotton-wool	1 oz.	15 oz.
Chloroform, condemned for human use.	1 oz.	15 oz.
Box-traps or Basket-traps ..	q. s.	
Grease-pencil.	1	1

	in the field	in stock
<i>In Laboratory.</i>		
Diamond for marking bottles ..	1	
Cotton-wool	1 lb.	15 oz.
Chloroform (that condemned for human use is cheaper).	1 oz.	15 oz.
Rectified Spirit or Methylated Spirit.	1 lb.	1 lb.
Glycerine, pure	1 lb.	1 lb.
Canada Balsam, in bottle, 1 oz.	1 oz.	1 oz.
Carbolic Acid, pure ..	1 lb.	1 lb.
Clove-oil	4 oz.	4 oz.
Slides	1 gross.	1 gross.
Cover-slip, $\frac{1}{4}$ in. circular, thick ..	1 oz.	1 oz.
Porcelain bowls	6	6
Pipettes with rubber-teats ..	6	6
Register-book for larvæ ..	1	1
Register-book for adults ..	1	1
Blue-grease pencil ..	1	1
Indian ink, 2 oz.	1	1
Card or vellum for tube-labels	q. s.	q. s.
Test-tubes, wide	$\frac{1}{2}$ gross.	$\frac{1}{2}$ gross.
Phials, 2 in., $\frac{1}{2}$ in.	1 gross.	1 gross.
Empty cigar-boxes and cigarette tins.	q. s.	
Microscope c. Obj. 2 3 and 1 6 in.	1	
Oc. 1 & 10. (Condenser and Moving stage not necessary.)		
Hand-lens, magnif. 8 to 15 ..	1	1
Needle-holders	4	4
Ring-ing-Machine, hard paraffin, camel-hair brush, and Brunswick black: if required.		

APPENDIX 3.

Staff required.

There is nothing of the work outlined above which cannot be taken in hand from start to finish by one suitably qualified man. This would, however, not be an efficient way of working, especially if as is usually the case, the *mosquito*-work is only part of a general malaria survey. A fully qualified medical man is advisable for taking the spleen-indices and verifying malarial records, and it would be a great waste of his time to put him to do routine laboratory work such as emptying-out bottles. In general it may be said that the more the labour is divided up and allocated to those most suitable for each job the more efficient does the survey become. A standard organisation might be taken to be as follows:—

Officers.

- (1) a Director.
- (2) a fully-qualified Medical Man for taking the spleen-indices.
- (3) a Field-Entomologist.

Ministerial staff.

- (1) Assistant to the Field-Medical Officer.
- (2) Assistant to the Entomologist.
- (3) a Laboratory-Assistant.
- (4) a Clerk.

Menials.

as many as are required and sanction can be obtained for, but a cooly for field earth-work is essential.

APPENDIX 4.

Packing specimens for posting.

This is an important point, especially when it be remembered that specimens very often are sent away because there is some difficulty in their diagnosis and that if they are not properly packed a valuable item of evidence may be smashed up in the Post.

The specimens to be sent away may be either mounted in balsam on a slide, or in a phial of spirit. If the former, it is advisable to let the balsam set for a few days, and then it is a good plan to place the slide in a cylinder, such as a tin shaving-stick box, which will ensure that nothing will come into contact with the cover-slip. Then either phial or tin can be packed in a card-board or wood-box tightly packed round with cotton-wool and the box covered and sent away.

APPENDIX 5.

A.

The recorded geographical distribution of the species.

This has been compiled from James and Liston (1911), Strickland (1916c), Christophers (1924), Carter (1925), Brug (1926), and from a few other papers, as follows:—

acônitus **Br. Ind.*, Asm., Beng.
Ceylon.
Br. Mal., Sel., Brneo., Phng., Trngnnu., Prk.,
 Mlcca., Kel., Prls., P. Well., Kdh., Png.
Neth. Mal., Java; Clbs., Mndo., Smtra., Smbwa.,
 Flores., Timor, etc.,
 also Siam, Sth. China, Formosa, Philippines, New
 Guinea.

* Abbreviations used are as follows:—

Br. Ind. British India and the few small foreign possessions of the Indian peninsula:—Asm.=Assam, Bom.=Bombay, Beng.=Bengal, C. P.=Central Provinces, U. P.=United Provinces, Swadi=Sawantwadi State, Jyp.=Jeypore hill-tracts, Pnjb.=Punjab, Trav.=Travancore, Mads.=Madras, Brma.=Burma, Hydd.=Hyderabad, Mnpr.=Manipur, Bichstn.=Baluchistan, Bhr.=Behar, Kshmr.=Kashmir, N. W. F.=North West Frontier Province.

Br. Mal. British Malaya:—The *F. M. S.*=Federated Malay States, Sel.=Selangor, Prk.=Perak, N. S.=Negri Sembilan, Phng.=Pahang, *The M. S.*=The Malay States (non-federated), Jhor.=Johore, Kdh.=Kedah, Kel.=Kalantan, Trngnnu.=Trengganu, Prls.=Perlis, Sggora.=Singgora, *The S. S.*=Straits Settlements, Sngpr.=Singapore, Mlcca.=Malacca, Png.=Penang, P. Well.=Province Wellesley, Brneo.=Br. Nth. Borneo.

Neth. Mal. The Netherlands-Indies of Malaya:—Clbs.=Celebes, Mndo.=Res Menado, Smtra.=Sumatra, Smbwa.=Sambawa, Brneo.=Borneo, Riau=The Riau Archipelago, Cram.=Ceram.

- albotarsatus* .. *Br. Mal., Prk.*
Neth. Mal., Smtra., Java, Brneo.
- aikeni* .. *Br. Ind.,* Bom., Goa, Beng. (Duars), Asm.
Ceylon.
Br. Mal., Sel., Mlcca., Prk., Phng., Jhor., Sngpr.,
Kel., Prls.
Neth. Mal., Mndo., Moluccas,
also Philippines and New Guinea.
- annandalei* .. *Br. Ind.* (Himalaya).
Ceylon.
*Neth. Mal.—*Java.
- asiaticus* .. *Br. Mal.,* Sel.
- aurirostris* .. *Br. Mal.,* Sel.
- bancrofti* .. *Ceylon*
also Queensland, Philippines.
- barbirostris* .. *Br. Ind.,* Beng., C. P., Pnjb., Asm., Bom., Trav.
Ceylon.
Br. Mal., Sel., Jhor., Prk., Png., Phng., P. Well.,
Trngnu., Mlcca., N. S. Kel., Kdh., Prls.,
Sggora.
Neth. Mal., Java, Smbwa., Clbs., Mndo., Brneo.,
Smtra.,
also New Guinea, Siam, Cochin-China, Annam,
Sth. China, Formosa, Philippines.
- barbumbrosus* .. *Neth. Mal.,* Mndo., Smtra., Java, Clbs., Amboyna,
etc.
- brevipalpis* .. *Br. Mal.,* Sel., Brneo.
Neth. Mal., Bangka.
- culicifacies* .. *Br. Ind.,* Pnjb., Beng., U. P., Orissa, Bom., Goa,
Aden, Mads., Asm., Jyp., C. P. (Berars, etc.),
Brma.
- culiciformis* .. *Br. Ind.,* Bom.
- errabanda* .. *Neth. Ind.,* Brneo.
- pallidus* .. *Br. Ind.,* C. P., Pnjb., Beng.
- fuliginosus* .. *Br. Ind.,* Beng., Himalaya (Kurseong) Pnjb.,
Mads., C. P. (Berars, etc.), Bom., Goa, Quilon,
Asm.
Ceylon.

- Br. Mal.*, Trngnu., Sel., Jhor., Phng., Prk.,
 Mlcca., Kel., Kdh., Prls.
Neth. Mal., Smtra., Java, Timor;
 also Philippines, Siam, Cochin-China, Annam,
 Sth. China, Formosa.
- funestus* *Br. Ind.*, C. P., Beng. (Duars, etc.), Jyp., Goa,
 Bom., Hydd., Pnjb., Asm.
Ceylon.
Br. Mal., Prk.
Neth. Mal., Clbs., Mndo., Java, Smtra;
 also Africa, and Formosa, Hong-Kong, Philip-
 pines, Siam.
- gigas* *Br. Ind.*, Mads. (hills); (Himalaya), Beng.,
 Assam.
Ceylon.
Neth. Mal.—Smtra.;
 also Philippines.
- hunteri* *Br. Mal.*, Negri-Semb., Jhor., Sngpr.
Neth. Mal., Smtra.
- hyrcanus* *Br. Ind.*, Beng., Pnjb., Asm., Mnpr., Bom., Mads.,
 Trav.
Ceylon.
Br. Mal., Sel., Phng., Trngnu., Prk., Jhor.,
 Sngpr., Kdh., Prls., P. Well., Png.
Neth. Mal., Java, Clbs., Mndo., Smtra., Brneo.,
 Timor, etc.;
 also Europe, Mesopotamia, Turkistan, China,
 Japan, Hong-Kong, Siam, Korea, Formosa.
- jamesii* *Br. Ind.*, Asm., Mads., Quilon, Beng., C. P.,
 Trav., Swadi.
Ceylon.
Neth. Mal., Smtra., Java;
 also Siam, Philippines.
- jeyporiensis* *Br. Ind.*, Jyp., C. P., Mads., Blchstn., Bom.
 (Deccan), Beng., Asm.
- karwari* *Br. Ind.*, Bom., Goa, Swadi., Beng., Asm.
Ceylon.
Br. Mal., Trngnu., Sel., Sngpr., Jhor., Prk.,
 Kel., Phng., Kdh., Png.

- Neth. Mal.*, Smtra., Riau, Bangka, Clbs.;
also Siam, Sth. China.
- kochi* *Br. Ind.*, Asm., Beng.
Br. Mal., Brneo, Trngnnu., Phng., Jhor., Sel.,
Mlcca., Sngpr., Kel., Kdh., Prls., Png.
Neth. Mal., Java, Clbs., Mndo., Brneo., Ternate,
Smtra., Riau., etc.;
also Philippines, Siam, Cochin-China.
- leucosphyrus* .. *Br. Ind.*, Bom., Brma., Andamans, Beng. (Duars),
Swadi., Asm.
Ceylon.
Br. Mal., Sel., Prk., Phng., Jhor., Mlcca., Kel.,
Png.
Neth. Mal., Mndo., Brneo., Smtra., Brneo., Java,
Clbs.;
also Siam.
- lindesaii* *Br. Ind.* (Himalaya), Mads. (Nilgiris), Asm.
- ludlowii* *Br. Ind.*, Brma. (Andamans, etc.), Beng.
Br. Mal., Sel., Mlcca., Jhor., Trngnnu., Prk.,
Png.
Neth. Mal., Java, Flores, Timor, Cram.;
also Philippines, Siam, Sth. China.
- maculatus* *Br. Ind.*, Beng. (Duars), (Himalaya), Mads.
(Nilgiris).
Ceylon.
Br. Mal., Sel., Prk., N. S., Phng., Kel., Kdh.,
Png., Mlcca., Jhor., Sngpr., Trngnnu., Prls.
Neth. Ind., Java, Flores, Smtra., Brneo., Clbs.,
Flores, Timor, etc.;
also Hong-Kong, Siam, Sth. China, Formosa.
- maculipalpis* .. *Br. Ind.*, C. P., Bom., Trav., Hindu-Kush
(Chitral), Orissa;
also Africa.
- mauritanus* .. *Neth. Mal.*;
also Africa.
- novumbrosus* .. *Br. Mal.*, Sel.
Neth. Mal., Smtra.
- parangensis* .. *Neth. Mal.*, Clbs., Mndo., Ternate;
also Philippines.

- plumbeus* *Br. Ind.* (Himalaya);
also Europe.
- pulcherrimus* *Br. Ind.*, Pnjb., N. W. F., Bom., Beng.
- pulcherrinus* *Neth. Mal.*, Ternate, Buru, Cram., Ambon.,
Moluccas;
also New Guinea.
- rhodesiensis* *Br. Ind.*, Aden;
also Africa.
- schuffneri* *Neth. Mal.*, Smtra., Java.
- separatus* *Br. Mal.*, Sel.
Neth. Mal., Smtra., Riau, Clbs.
- similissimus* *Br. Mal.*, Sel.
- stephensii* *Br. Ind.*, Pnjb., Beng., Mads., C. P. (Berars,
etc.), Bom., Asm. (Lushai Hills), Blchstn.,
Goa, Brma.
- subpictus* *Br. Ind.* (Lower Himalaya), Mads., Bom., Beng.,
Asm.
Ceylon.
Br. Mal., F. M. S., Brneo.
Neth. Mal.—Java, Smtra., Smbwa., Clbs., Buru,
Brneo., Cram., Bali, Lombok;
also the Philippines, Siam, Annam, Sth. China,
New Guinea.
- superpictus* *Br. Ind.*, Blchstn.;
also Palestine, Europe.
- tesselatus* *Br. Ind.*, Bom., Pnjb., C. P., Swadi., Asm., Beng.
Ceylon.
Br. Mal.
Neth. Ind., Brneo., Mndo., Ternate, Smtra., Java,
Buru, Clbs., etc.;
also Philippines, Siam, Cochin-China, Annam.
- theobaldi* *Br. Ind.*, C. P. (Berars, etc.), Jyp., Bhr., Bom.,
Swadi.
- turkhudi* *Br. Ind.*, C. P. (Berars, etc.), Hydd., Kshmr.,
Brma., Pnjb., Blchstn., Aden.
- umbrosus* *Br. Ind.*, Asm.
Br. Mal., Phng., Sel., Prk., N. S., Mlcca., Kel.,
Kdh., Png.

- vagus* *Neth. Mal.*, Java, Smtra., Riau, Brneo., Clbs.;
 also Africa.
 .. *Br. Ind.*, Mads., Asm., Beng., Swadi.
Ceylon.
Br. Mal., Sel., Jhor., Prk., Phng., Png., Mlcca.,
 Trngnu., Kel., Kdh., Prls., Sggora., P. Well.
Neth. Mal., Java, Smbwa., Clbs., Brneo., Smtra.,
 Flores, Timor;
 also Formosa, Cochin-China, Philippines.
- watsonii* *Br. Mal.*, Sel.
wellingtonianus *Br. Mal.*, Prk.
willmori *Br. Ind.*, Kshmr., Pnjb. (Himalaya and Hindu-
 Kush), Asm. (Hills).

APPENDIX 5.

B.

The commoner habitats of the species as larvæ.

In this section it is not proposed to give anything more than the shortest possible account of the 'production-areas' or 'breeding' places of the larvæ: what is aimed at is an indication of the typical place favoured by each species, within the geographical limits shewn above.

aconitus, funestus (= *listoni* and *minimum*), grassy-edged fast-flowing streams.

albotaniatus, brevipalpis, pools of brackish or sweet-water in jungle.
aitkenii, in swifty-flowing jungle-streams.

asiaticus, annandalei, bamboo-breeders.

aurirostris, leucosphyrus, and *watsonii*, in semi-jungly pools of clear water.

bancrofti, barbirostris, barbumbrosus, semi-jungly pools shaded by high grass.

culicifacies, rhodesiensis, superpictus, jeyporiensis, turkhudi, open pools in the beds of streams.

culiciformis, plumbeus, tree-holes.

errabanda, separatus, breeding places unknown.

fowleri, fuliginosus, hyrcanus, jamesii, mauritanus, schuffneri, similissimus, tesselatus, in paddy-fields and grassy swamps.

gigas, lindesaii, pools in nullahs in the hills.

hunteri, novumbrosus, umbrosus, in pools under jungle, in swamps or screambeds.

karwari, theobaldi, maculipalpis, in swamps of spring water at foot of hills and banks.

rochi, pulcherrimus, in small pools of water: with weedy edges.

ludlowii, parangensis in sea-water or brackish pools.

maculatus, willmori, in streams and pools of clear spring water in nullahs in the hills.

stephensii, in wells, cisterns, or pools of brackish or fresh water.

subpictus, vagus, in pools of stagnant water in ditches or open land or paddy-fields.

wellingtonianus, once found in a jungle-edged reservoir.

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