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A SHORT ILLUSTRATED GUIDE

TO THE

ANOPHELINES

OF

TROPICAL AND SOUTH AFRICA

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With ten text-figures and twelve plates

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CONTENTS

	PAGE
INTRODUCTION	3
IDENTIFICATION	7
KEY TO THE SPECIES	7
KEY TO THE LARVAE OF SIX SPECIES	11
SYSTEMATIC AND BIONOMIC ACCOUNT:—	
SUB-GENUS ANOPHELES	
GROUP ANOPHELES	13
GROUP CHRISTYA	16
SUB-GENUS MYZOMYIA	
GROUP PSEUDOMYZOMYIA	17
GROUP MYZOMYIA	23
GROUP NEOMYZOMYIA	41
GROUP CELLIA	43
GROUP NEOCELLIA	46
APPENDIX. THE VARIETAL FORMS OF <i>A. mauritanus</i>	51
BIBLIOGRAPHY	52

INTRODUCTION

The aim of this Memoir is to provide a collected account of the Ethiopian *Anophelines* embodying the changes, which Christophers (1924) has shown to be necessary with regard to the status of certain of the species, and also to bring together the chief facts known regarding the habits and breeding-places of the species. It is not in any sense of the word a monograph, and for a full account of the synonymy of the species the work of Christophers (1924) should be consulted. That synonymy has been followed in the present memoir except in the case of '*A. costalis*,'* *A. quadriannulatus*, and some of the forms allied to *A. marshalli*. Christophers' classification has also been followed because, based as it is on the morphological

* The name '*gambiae*' Giles has not been adopted for this species, because the writer has consulted many authorities who consider it inadvisable to do so in view of the great importance of this species. Since '*A. costalis* Loew' is not to be used for '*A. cinereus* Theo.', there can be no doubt as to what species is meant by '*A. costalis* Theo.'

as well as the vestitural characters of the species, it is obviously the most natural that has been proposed.

Original drawings have been used for the sake of uniformity, and are mainly intended to illustrate the characters employed in the key. Owing to the overwhelming importance of *A. costalis*, drawings of this species have been included in spite of the large number in existence.

The keys of Edwards (1912), Carter (1919), and Christophers (1924) have been consulted, but those given in this memoir are based also on the writer's own observations, examples of all the species except *A. jacobi* and *A. natalensis* having been studied.

In the keys and in the account of the species, which follows, reference is made to the size, which is often a helpful character from the point of view of identification. Owing to the amount of variation which exists, however, statements regarding the size are not made with great precision. Species are said to be 'large' when the average wing-length is about 5 mm. or more, and 'small' when the wings measure less than 3.2 mm. Species with the average wing length falling between these limits are described as 'medium-sized' or 'rather large'. It is regrettable that in many cases the key applies solely to females; a key for the identification of the males would in many instances involve the use of several obscure characters.

The species are described as 'rare' when the published records of their occurrence indicate that very few specimens have been found. It should, however, be emphasised that any of these species might prove to be common in a particular locality where the *Anopheline* fauna has not hitherto been studied very intensively. The provisional account of the distribution of the species is based on that given by Edwards (1912), later records being added. Within the last two years several species have been found to have a more extended range than that formerly known, and it is more than probable that many others will be discovered in regions from which they have not yet been recorded. It is also likely that the characters given for some of the less-known species will have to be modified with the discovery of further examples.

In many of the species there is a considerable amount of variation, especially with regard to the wing markings, so that specimens may

differ from the figures (Plates I-VI) in certain details, the most important of which are referred to in the text.

A complete list of references to the recorded observations on the pathogenicity of the species is not included; Chanal gave a very full account of this subject up to the year 1921.*

The *larvae* are not dealt with in a comprehensive manner, as the writer has not examined those of more than nine species. A key is given for the separation of the larvae of a few widely distributed species; details of these and others are illustrated, and in some cases brief descriptions are included in the text.

The writer is greatly indebted for valuable help and advice to Professor J. W. W. Stephens, F.R.S., and Professor R. Newstead, F.R.S., and also takes this opportunity of thanking Lieut.-Col. S. R. Christophers, F.R.S., who examined the Anopheline material in the collections of the Liverpool School of Tropical Medicine and gave us much valuable information concerning the species. Many of the specimens in our collection, which is partly the work of Mr. H. F. Carter, have been kindly presented from time to time by Dr. G. A. K. Marshall, C.M.G., F.R.S., and the School is also indebted to Mr. F. V. Theobald, M.A., for a valuable collection of type specimens. Much of the material has been presented by investigators in various parts of Tropical Africa to all of whom thanks are tendered. Acknowledgments are also due to Major E. E. Austen, D.S.O., and Mr. F. W. Edwards, B.A., for kindly granting permission and every facility to study the national collection of African Anophelini.

Some of the illustrations of the breeding places of *Anopheles costalis* are taken from the paper by Professor B. Blacklock (1921) on the 'Breeding places of Anopheline Mosquitos in Freetown, Sierra Leone.' The photographs of the larval haunts of *A. funestus*, in Nyasaland, are here published for the first time, and the writer is greatly indebted to Professor Newstead for permission to use them. My thanks are also due to Dr. Marshall for kindly lending the blocks illustrating the paper by Dr. A. Ingram and Dr. J. W. S. Macfie (1917) on 'The early stages of certain West African Mosquitos.'

* Very recently Major G. Covell has published a comprehensive work entitled 'A Critical Review of the Data recorded regarding the Transmission of Malaria by the different species of Anopheles; with notes on Distribution, Habits and Breeding places.' *Ind. Med. Res. Memoirs*, Memoir, No. 7, July, 1927.

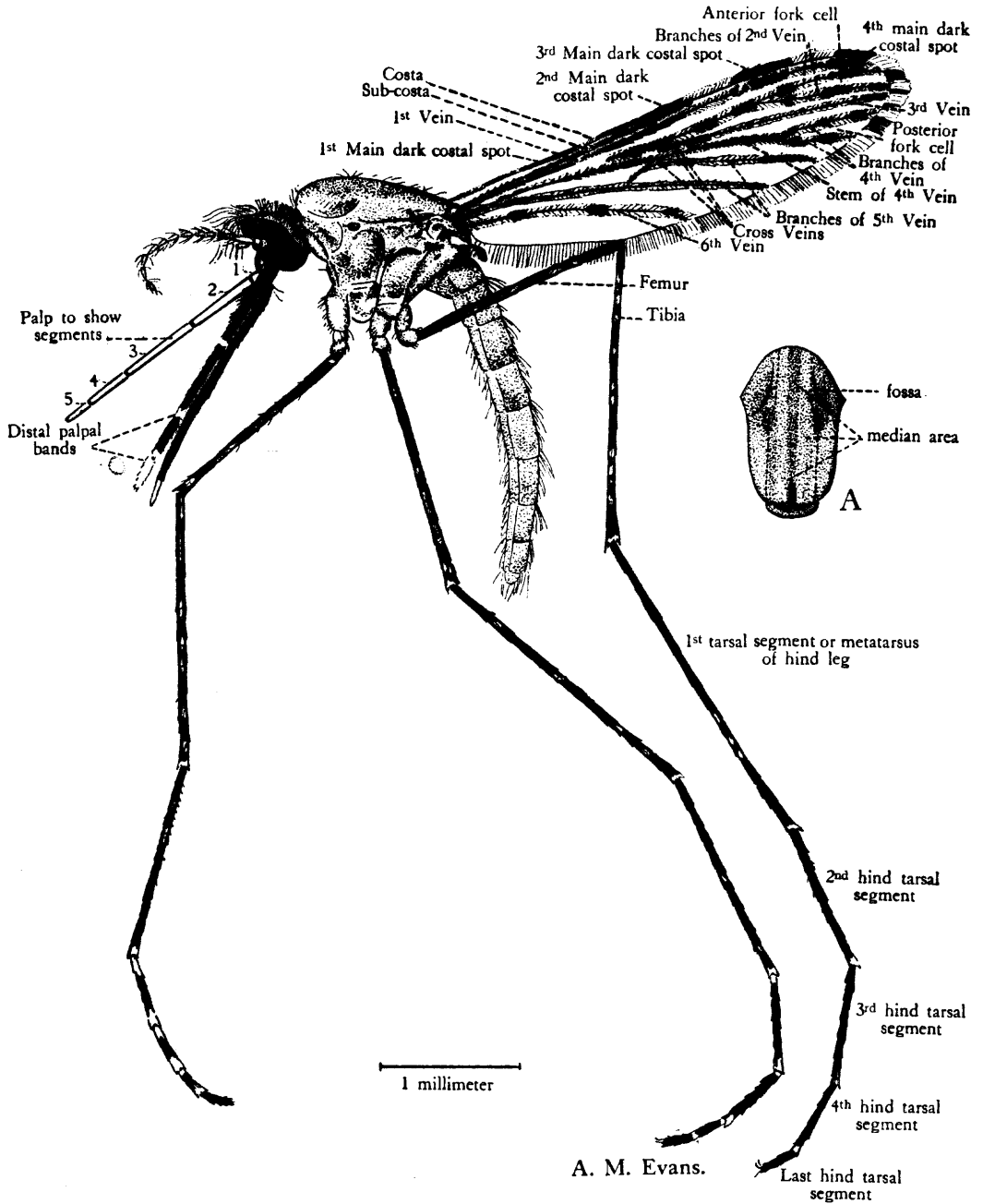


FIG. 1.—Diagram of an Anopheline mosquito, to illustrate the terms used in this Memoir. A—Thorax, dorsal aspect.

IDENTIFICATION

The chief requirements for the initial determination of the species of Anophelines are: a microscope with low magnification (about 30 diameters) and *a good illumination*; higher magnifications (see p. 34) are necessary in order to see the exact shape of the thoracic scales. When, however, the exact characters of the species encountered in a region have been determined it will generally be found that most of the species can then be identified by the use of a hand lens of about 10 diameters magnification.

In the case of the larvae of many species, the macroscopic characters are subject to so much variation that examination with the two-thirds objective of the microscope is necessary. This is not so, however, in the case of *funestus* (see p. 31).

KEY TO THE SPECIES

1. Abdomen with scales above and laterally-projecting tufts of scales. (Pl. VI, fig. 6)..... 25p. 10
 Abdomen with scales above, but no laterally-projecting tufts. (Pl. VI, fig. 4.)
 (East Africa) *christyi*p. 41
 Abdomen without scales above, but with long, projecting tufts of linear scales. (Pl. VI, fig. 5.)
 (East Africa; Belgian Congo; generally very rare) *implexa*p. 16
 Abdomen without scales above or projecting tufts of scales 2
2. Legs speckled. (Pl. I) 3
 Legs not speckled..... 11
3. Female palpi with three white bands 4
 Female palpi with four white bands 6
4. Hind tarsus with at least the last two segments entirely white. (Pl. V, figs. 6 and 7) 5
 Hind tarsus with none of segments entirely white, but first four rather narrowly pale-banded. (Pl. I.)
 (Widely distributed throughout the region, often by far the commonest species) *costalis*.....p. 17
5. Female palpi speckled with white. (Pl. IV, fig. 5.)
 Last three segments of hind tarsi entirely white.
 (Widely distributed) *maculipalpis*p. 49
 Female palpi not speckled with white. Last two segments only of hind tarsi entirely white.
 (Pl. V, fig. 7.)
 (Recorded from Nigeria and the Gold Coast as well as East and South Africa)..... *pretoriensis*.....p. 48

8 ANOPHELINES OF TROPICAL AND SOUTH AFRICA

6. Scales on dorsal surface of thorax as in *costalis*, i.e., narrow-curved in the middle and broad but obscure on the fossae. (see Pl. VI, fig. 1.) Medium-sized species 7
 Thoracic scales otherwise. Large species 8
7. Costa with only one well-marked pale spot. Very dark brown mosquito *costalis* var. *melas*...p. 23
 Costa as in *costalis*. (see Pl. I.)
 (Transvaal; very rare) *costalis* var. *quadriannulatus* p. 23
8. Hind tarsus with an uninterrupted pale area, with or without a dark terminal segment 9
 Hind tarsus without an uninterrupted pale area. (South Africa) *ardensis*p. 42
9. Last segment of hind tarsus dark. (Kenya Colony; Belgian Congo; rare)..... *kingi*p. 42
 Last segment of hind tarsus pale..... 10
10. Thorax with very broad golden scales on dorsal surface. (Transvaal; very rare) *aureosquamiger* ...p. 41
 Thorax with golden hairs on dorsal surface. (South Africa) *natalensis*p. 42
11. Last two segments of hind tarsi entirely white. (Pl. V, fig. 1) 12
 Last two segments of hind tarsi not entirely white..... 14
12. Female palpi very shaggy. (Pl. IV, fig. 8.) Costa with only two small, white interruptions. (Pl. III, fig. 1.) Large species (usually). (Widely distributed in East, West and South Africa; usually scarce but common in some localities) *mauritanus*p. 13
 Female palpi with last three segments smooth, and with two broad and one narrow white band. Costa with three or more white areas. Medium-sized species 13
13. Thorax clothed with flat, white scales above. (Pl. VI, fig. 3.) (Widely distributed) *rufipes*p. 47
 Thorax almost entirely clothed with long, narrow-curved scales; flat scales, if present, forming a small, overlapping group at sides in front. (Sierra Leone; Nigeria; South Africa; Belgian Congo; uncommon) *theileri*p. 47
14. Female palpi entirely dark; very shaggy. (Belgian Congo; widely distributed in West Africa) *obscurus*p. 15
 Female palpi with at least one pale band, but, if entirely dark, not very shaggy (darkest form of *smithii*) 15

22. Hind tarsi not definitely* banded..... 23
 Hind tarsi definitely, but narrowly, banded.
 (East Africa and Nyasaland; uncommon) *longipalpis*p. 33
23. A very small, dark species, average wing-length 3 mm.
 (Widely distributed and in some regions the
 commonest species) *funestus* †.....p. 29
 A medium-sized species, average wing length 3·8 mm.
 (East and South Africa; uncommon)..... *transvaalensis*p. 33
24. Female palpi with segments apically and basally
 banded, all four bands broad and conspicuous.
 (Pl. IV, fig. 1.) Hind tarsi narrowly but distinctly
 banded. (Pl. V, fig. 5.)
 (East and South Africa)..... *cinereus*p. 29
 Female palpi with segments apically banded only,
 hind tarsi not distinctly banded. CoCo some-
 times with basal half, or more, entirely dark.
 (North-east Rhodesia; rare) *distinctus*.....p. 26
25. Last segment of hind tarsi pale or pale-tipped..... 26
 Last segment of hind tarsi dark 28
26. Last segment of *fore* and *mid* tarsi dark. (Pl. V, fig. 2, A.)
 (Widely distributed; common in some regions) *pharoensis*p. 43
 Last segment of *fore* and *mid* tarsi pale or pale-
 tipped 27
27. Tip, only, of last tarsal segment in all legs pale.
 (South Africa; very rare) *jacobi*p. 46
 Whole of last tarsal segment in fore and hind legs
 pale (Pl. V, fig. 4) (mid legs ?; missing in Type).
 (Gold Coast; very rare) *cinctus*.....p. 46
28. Apical tarsal banding present on all legs. (Pl. V,
 fig. 3.)
 (Widely distributed)..... *squamosus*p. 44
 Apical tarsal banding not present on hind legs.
 (South Africa; rare) *argenteolobatus* ...p. 46

* In some specimens of *A. funestus* the segments of the hind tarsi are seen, when examined with a high magnification (30 × or more), to have the scales at the extreme apex paler than the rest, but they do not give rise to the appearance of definite bands or rings when examined with a low magnification.

† Wing pattern very variable (see Pl. II, figs. 4 and 5). In *funestus* var. *bisignata* pale spots confined to bases of fork cells, neighbourhood of cross-veins and costal region.

KEY TO THE 4th STAGE LARVAE OF SIX COMMON OR
WIDELY-DISTRIBUTED SPECIES

1. Antenna with branched hair on shaft (Text-fig. 2, B, p. 12)..... *mauritanus*.....p. 14
 Antenna without branched hair on shaft 2
2. Dorsal plates relatively very large (Text-fig. 6, A and C, p. 32) *funestus*p. 31
 Dorsal plates relatively small and inconspicuous (Text-fig. 6, B, D and E) 3
3. Outer clypeal hair plumose (Text-fig. 2, D, p. 12) *pharoensis, squamosus*
 PP. 44, 45
 Outer clypeal hairs simple or slightly branched 4
4. Inner clypeal hairs with delicate secondary hairs *(Text-fig. 2, C, p. 12). Palmate hair of 5th abdominal segment with narrow leaflets (Text-fig. 4, E, p. 22). Larvae almost always pale yellowish-brown or greenish with the lateral portions of the thorax opaque and whitish. Abdomen appearing unbanded to the naked eye..... *costalis*.....p. 21
 Inner clypeal hairs simple. Palmate hair of 5th abdominal segment with broader leaflets (Text-fig. 4, A, p. 22). Usually dark brown or greyish-black larvae with the abdomen appearing segmentally banded to the naked eye. (This appearance is also present in other species, i.e. *A. marshalli* var. *freetownensis*) *rhodesiensis*.....p. 26

* In examining a larva microscopically to decide this point the transmitted light should be cut down to a minimum. The secondary hairs are usually very difficult to see in specimens mounted in Canada balsam.

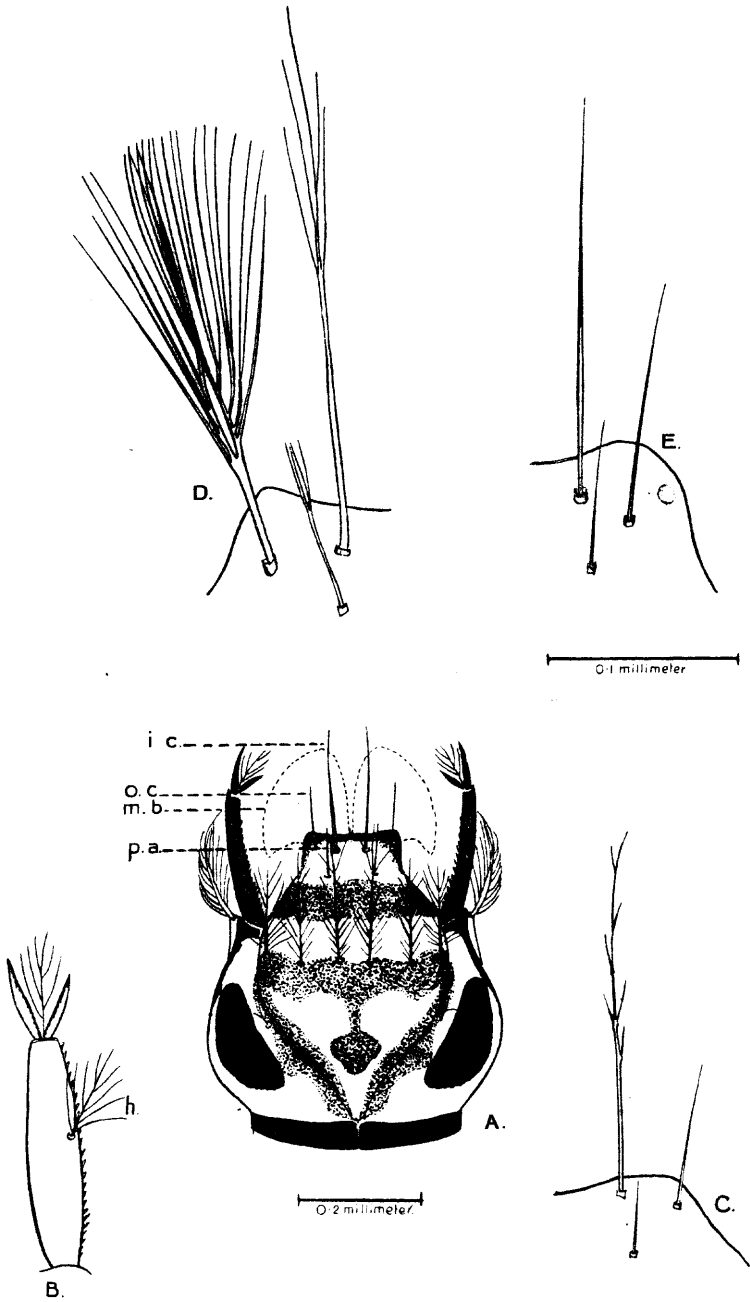


FIG. 2. A—*A. funestus*, head dorsal aspect. *i.c.*—inner clypeal hair; *m.b.*—outline of mouth brushes; *o.c.*—outer clypeal hair; *p.a.*—post antennal hairs. B—*A. mauritanus*: antenna (diagrammatic) showing position of branched hair (*h.*) on shaft. C—*A. costalis*; D—*A. pharoensis*; E—*A. funestus*: clypeal and post antennal hairs of one side to same scale.

SYSTEMATIC AND BIONOMIC ACCOUNT

Of the five subgenera of *Anopheles* recognised by Christophers (1924), two are represented in the Ethiopian region, namely *Anopheles* and *Myzomyia*, the former by only three species which are easily recognised.

Genus **ANOPHELES**

Subgenus ANOPHELES* Christophers

Group **Anopheles** Root (1922)

The two species in this group are distinguished from all the African members of the Subgenus *Myzomyia* by the following combination of characters: *wings with less than four main dark costal spots* (Plate III, fig. 1); *female palpi markedly shaggy* (Plate IV, fig. 8). In no species of the Subgenus MYZOMYIA here dealt with are both these characters present.

Anopheles mauritanus Daruty and D'Emmerez.*A. paludis* Theobald.*A. ziemanni* Grünberg.*A. tenebrosus* Dönitz.

A medium-sized or large species with conspicuous white terminations to the hind legs and heavily scaled wings, the black of the costa broken by only two small white spots, one of these at the apex (Plate III, fig. 1). The basal white band of the female palpi (see Plate IV, fig. 8) is sometimes represented by a very few white scales. The amount of white on the hind tarsi is subject to variation (Plate V, fig. 1), and a white band at the tibio-metatarsal articulation, which involves both the segments, is very variable in size.† There is a good deal of variation in the wing pattern, specimens differing from that here illustrated (Plate III), chiefly in the following respects:— 1st vein without scattered pale scales and also without a complete white spot under the costal spot at the junction of the Sub-costa ;

* For the diagnosis of these Subgenera the works of Christophers (1915) and (1924) should be consulted.

† Three varieties can now be distinguished from the typical form by these characters, see Appendix, p. 51.

3rd vein almost entirely pale-scaled; 4th vein with distal third largely white. The colour of the pale scales varies from white to bright yellow. Several of the specimens taken in Nyasaland by Davy and Newstead (1921) had no pale spots on the costa, the wing fringe entirely dark and the tips of the female palpi black.

Habits. According to observers in various parts of East Africa and the Belgian Congo, the adults freely enter houses in these regions, and bite human beings, but in the Gold Coast, Nigeria and Zanzibar, they appear to visit houses rarely. At Mabang, Sierra Leone, Dr. R. M. Gordon has recently taken a number of females in a bungalow, and Davy and Newstead found that in Nyasaland a few adults came into the lighted tents after dark, but did not shelter there in the daytime.

Breeding-places. Swamps are an important and in some regions the chief source of this species. In certain districts, however, the larvae are found in a large variety of situations, among which may be mentioned: rice-fields; comparatively permanent roadside puddles; backwaters of streams; reedy, slowly-flowing, stagnant streams and drains; pits dug near the banks of rivers; rock-pools associated with the courses of streams and drains; among standing weeds at the edges of large collections of water; in association with the water lettuce, *Pistia stratiotes*, Macfie and Ingram (1923).

Hill and Haydon (1907) record the species from sea-level up to 4,000 feet in Natal.

Larva. The presence of a branched hair on the shaft of the antenna (Text fig. 2, B, p. 12) readily distinguishes the larva of this species from those of the African species that have been described, but it is probable that the larva of *A. obscurus* resembles it in this and other characters.

The following additional characters are taken from Hill and Haydon (1907), who give a full description of the larva of this species:—outer clypeal hairs densely branched; inner clypeal hairs simple; thorax with rudimentary palmate hairs; first and second abdominal segments with small rudimentary palmate hairs; 3rd to 7th abdominal segments with palmate hairs of which the average radius is 0.116 mm. (according to the figures of these palmate hairs they most nearly approach those of *theileri* amongst the species here illustrated, but the jagged portion of the leaflets is much longer, being equal to almost half of the total length of the

leaflets); submedian thoracic hairs absent. Both MacGregor (1924) and Van Someren and De Boer (1926) emphasise the great variability of this species with regard to colour and pattern.

Pathogenicity. The available evidence tends to shew that this species is not an effective carrier of malaria parasites. MacGregor was unable to infect the species experimentally, at the same time obtaining heavy infections in *A. costalis* and *A. funestus* (see also Chanal, 1921).

Distribution. Widely distributed throughout the region. Common in some localities.

Anopheles obscurus Grünberg.

A. umbrosus Theobald (African records).

A. strahani Theobald.

This species was formerly regarded as identical with the oriental *A. umbrosus* Theo., but Christophers (1924) has shown that it is a distinct species and that *A. strahani*, described from Lagos, is the same as *A. obscurus*.

A large, very dark species with dark, shaggy palps and heavily scaled wings. In addition to the characters given in the key the following may be mentioned: wings with costa and first vein broken by two minute spots in the same position as those in *mauritanus* (see Plate III), 1st vein also with scattered pale scales, sometimes forming one or two spots on the basal two-thirds; rest of veins with pale scales mostly of a scattered nature and not giving rise to definite pale areas or spots; pale scales most numerous on the 3rd vein, forks of 4th and 5th veins and the 6th vein; fringe usually with a pale spot between the ends of the 3rd and 4th veins; tarsi with narrow, rather obscure, pale rings, sometimes apical and sometimes also basal.

Habits. Isolated specimens have been recorded from dwellings in regions, where larvae were not found to be numerous.

Breeding places. Blacklock (1925) reared this species from a larva taken in a swamp at Daru, Sierra Leone.

Larva. From the close resemblance between the adults of the two species it seems safe to assume that the larvae of *obscurus* will have the same general characters as those of *umbrosus*.

Distribution. Sierra Leone; Gold Coast; S. Nigeria; Belgian Congo.

Group **Christya** Christophers (1924)

The one species in this group is characterised by the peculiar abdominal vestiture.

Anopheles implexa Theobald.

The largest African anopheline and unmistakable on account of the conspicuous tufts of long, linear scales projecting at right angles from the abdomen, which is quite devoid of scales above. The species also possesses other peculiarities which make it unique among the African *Anophelini*. Edwards (1926) has recently called attention to and illustrated the following characteristics: the peculiar 'knotted appearance' of the female palpi, which is due to the fact that the black scales at the tips of the first two segments are sub-erect, but the white scales at the bases of segments 2 and 3 are appressed; the conspicuous pleural markings which consist of black patches separated by white lines; the paired large white integumental spots on the undersides of the abdominal segments.

The femora and tibiae are conspicuously ringed with white, the hind tarsus has a long continuous white area comprising the whole of the third and fourth and basal half of the segment, but the last one is dark. The wings are predominately dark, but there are two conspicuous creamy-white areas in the costal region, as well as smaller white spots. The rest of the veins have only small spots or areas of pale scales, and usually there are no white fringe spots at the ends of the 6th vein, lower branch of the 5th or upper branch of the 2nd vein. The dorsum of the thorax is deep, rich chestnut-brown with a rather thick covering of curved brassy hairs and a few small, creamy, flat scales near the lateral borders.

Early stages. The larvae and pupae have recently been fully described and illustrated by Edwards (1926). The larvae have no palmate hairs on the thorax and first, second and seventh abdominal segments; those on the third, fourth and fifth segments are large and each is composed of about 18 leaflets which are long, narrow, rather bluntly pointed with unbroken margin.

Distribution. Belgian Congo (Schwetz, 1927); Sudan; Uganda.

Subgenus MYZOMYIA (Blanchard) Christophers

Wings normally with four main dark costal spots. Among the African species are a number of aberrant forms not possessing this character, but in all such species the female palpi are not markedly shaggy.

The species fall into the following groups proposed by Christophers (1924):—

- group **Pseudomyzomyia***
- group **Myzomyia**
- group **Neomyzomyia**
- group **Cellia**
- group **Neocellia**

Group **Pseudomyzomyia** Christophers (1924)

This group is represented by only one species in the Ethiopian Region.

Anopheles costalis Theobald.

A. (Myzomyia) quadriannulatus Theobald.

This is the most widely distributed African *Anopheles*; in many regions it predominates to an overwhelming extent over all the other species.

A medium-sized species, the general colour rather a light brown, unless darkened by a recent meal of blood (Pl. I, small fig.). It is easily distinguished from all the other African species of the subgenus MYZOMYIA. The speckled legs (Pl. I) distinguish it from all the *Myzomyia* group, but the speckling is never very conspicuous to the naked eye, and examination with a lens is often necessary to decide this point. The three-banded female palps separate it from the *Neomyzomyia* group; the tarsal markings from the *Neocellia* group, and the absence of abdominal scales from the *Cellia* group. There is a good deal of variation in the details of the wing markings, even the characteristic interruption of the third large dark area on the first vein being occasionally missing. The scaling of the mesonotum is characteristic (Pl. VI, fig. 1): long, narrow-curved, pale yellowish scales occupy the middle area; a few

* This group is placed first owing to the importance of *A. costalis*.

quite broad, transparent greyish scales are seen on the anterior lateral angles or fossae (see also text-fig. 8, D and G).

Habits. Where this species is prevalent the adults usually form an overwhelmingly large proportion of the anophelines caught in dwellings, at any rate during part of the year. The females enter houses at night-time for the purpose of feeding, but, according to recorded observations, their behaviour, during the day-time, varies in different places.

Owing to the great importance of this phase of the life-history of malaria-carrying mosquitoes, which has been emphasised by James' recent investigations (1926), a short summary of some of the available information on the day-time behaviour of this species is given below.

A. costalis has been found to be present in houses in the day-time by many observers, amongst whom may be cited Newstead, Dutton and Todd (1907) in the Belgian Congo, who state that the species was 'present in the dwelling places of Europeans and natives in the day-time and at night'; Johnson (1919), who found that *costalis* formed on an average 54.3 per cent. of the total anophelines which he caught in his own bungalow in the mornings in three stations in Northern Nigeria; Blacklock (1925), at Daru, Sierra Leone, where daily catches of anophelines yielded very numerous *costalis* in native dwellings and also a few in the European quarters.

On the other hand, in Mauritius both Balfour (1921) and MacGregor (1924) emphasise the day-time scarcity of *costalis* in houses. The former observer states that it is 'in no sense of the word a domestic species'.

It was pointed out as long ago as 1900 by Stephens and Christophers that, when European houses are in close proximity to native huts, anophelines* preponderate to an overwhelming extent in the latter. The following quotation is taken from these authors' description of the conditions met with in the dry season in Freetown, Sierra Leone:—

'... But even here, in well-built, clean houses, it was difficult to obtain them in the early morning, such anopheles as entered at night appearing not to

* At the time these observations were made, the exact characteristics of *A. costalis* were not accurately known, but subsequent investigations on the distribution of anophelines in Freetown leave no doubt that there, at any rate, this was the species chiefly, if not solely, concerned.

remain. In small dirty and dark houses, however, a variable number were always to be obtained. Here and there in the district bordering upon the stream were certain thatched sheds in which native boys slept. The inmates of these lodging-houses numbered as many as twenty, all sleeping upon the ground in a space of about 1500 cubic feet. These overcrowded sheds were especially the abode of anopheles. In such places female anopheles were found in large numbers, while in houses immediately adjoining they were difficult to obtain. Males were also to be found, but much less frequently than the females. We would draw especial attention to the fact, of which we shall give further instances, that in native dwellings—and in these overcrowding is often extreme—anopheles are frequently present in enormous numbers . . .'

The following observation is also quoted from Stephens and Christophers', 1900, report :—

'That natives powerfully attract anopheles was well shown in the following experiment. In a tent in which a European had been accustomed to sleep, pitched in the compound at "A," only one or two anopheles were usually to be found in the morning. Two natives were then allowed to sleep in the tent, with the result that the first morning nineteen anopheles were captured. The second morning sixty-two anopheles, most of which had fed, were caught. The natives did not complain unduly of mosquitoes. The use of the tent by the natives was then discontinued, and the anopheles rapidly became fewer in number.'

The presence of *A. costalis* has been observed in bush away from the neighbourhood of villages. Dutton and Todd recorded that in the Belgian Congo :—

'Imagines were taken . . . in the mosquito nets of servants sleeping in the bush and, during the day-time, *far in the forest itself at a long distance from any village**.'

Seasonal variation. It is a matter of general observation that *A. costalis* is present in large numbers in both the larval and adult stages during and for a few weeks after the rains, but that, with the advance of the dry or cold season, larvae become difficult to find and the adults cease to be evident in European bungalows.

The causes of this restriction in numbers appear to vary in different regions according to the climatic conditions. Actual drying-up of the available breeding-places is evidently the chief cause in certain places, such as Lagos, where the temperature never becomes low enough to inhibit the activity of the species. Stephens and Christophers (1900) found that in certain parts of Freetown, where all the available water disappeared during the dry season, eggs (which developed into larvae) were laid as soon as imitation rock pools were constructed.

* The italics are mine.

At Dakar the low temperature prevailing in the winter is evidently responsible; Noc (1922) records temperatures as low as 14° C., and states that the species is found in the winter as hibernating females. It has been pointed out that in Mauritius and Nyasaland (see below under 'breeding places') the cause is probably to be found in the disappearance of green algae from the available waters during the dry or cold season.

It is commonly observed that a diminution in the numbers of *A. costalis* takes place at the height of the rains, when the continuous downpour washes out the larvae from pools on sloping ground.

Distance of flight. Patton (1905) demonstrated a flight half a mile for this species in Arabia.

Breeding places. *A. costalis* breeds chiefly in small collections of water and always in situations exposed to the sun, at least for a part of the day. Swamps, especially shallow ones, are in some regions an important source of this mosquito.

Typical breeding places are: small rain pools; roadside ditches; borrow-pits; water-holes; wells; water in hoof-prints; small pools at the margin of rivers or lakes. The bottom and sides of the breeding places are often of clay, or of rock such as laterite, or sand or gravel. Larvae may be found in large numbers in water entirely devoid of growing plants (macroscopic), but they may be found in equally large numbers when grass or weeds are growing thickly in the water or around the edges. Other important breeding places are:—marshes; small, shallow, slowly-flowing streams or drains; crab-holes; water in beached canoes; cement tanks (Pl. XII, fig. 4).

The chief source of this anopheline in the dry season in Freetown is to be found in the pools which remain in the beds of dried-up streams. Plates IX and X shew breeding places of this species in the course of streams, which flow through the town.

Larvae of this species have frequently been found in domestic artificial containers, including household pots and tins, especially at Lagos, Graham (1911) and others; Dalziel (1920) records a few larvae from roof-gutters in that town. Larvae are occasionally recorded from the edges of large lakes and slowly-flowing rivers.

Larvae have also been taken from small natural sources, such as rot-holes in living trees at Accra, Macfie and Ingram (1923) (Pl. XI, fig. 1); in banana stumps and in a cocoanut shell, Lagos,

Dalziel (1920) ; and in water at the tops of cocoanut palms, Dar-es-Salaam, Haworth (1922)*.

Macfie and Ingram (1923) include *costalis* in a list of larvae which can be reared from plants of the water lettuce, *Pistia stratiotes*, (Pl. XI, fig. 2), if these are taken together with a little water from pools or river backwaters.

Sea water is not inimical to the larvae which are sometimes found in pools which are flooded by the sea at high tide (Plate VIII, fig 2).

Water in which large numbers of chlorophyll-containing organisms are present seems peculiarly favourable to the growth of *A. costalis* larvae ; Graham (1910) refers to the presence of motile algae in the opaque water characteristic of small pools in which *costalis* breeds near Lagos. Recently, both Balfour (1922) in Mauritius and Lamborn (1925) in Nyasaland, have observed the largest numbers of larvae under such conditions, and the former authority suggests that the absence of larvae from completely shaded pools may be correlated with their dependence upon green organisms.

Larva. The larva is characteristically light in appearance, the pigmented portions being pale brown or green and the lateral parts of the thorax opaque creamy-white. It is rather difficult to distinguish with certainty from the other known species, owing to the absence of any striking characteristic. The non-possession of thoracic palmate hairs and the small size of the abdominal palmate hairs are constant characters, but some practice is needed before these points can be decided without a lengthy and tedious examination of the larva. The chief morphological characters are illustrated in Text-figs. 2, p. 12 ; 3, p. 22 ; 4, p. 22 ; 5, p. 27 ; 6, p. 32.

According to the figure given by MacGregor (1924) the larvae of specimens found in Mauritius have the inner clypeal hairs, not as in specimens from Sierra Leone and South Africa (see Hill and Haydon, 1907), but entirely without secondary hairs. It, therefore, seems possible that the Mauritian forms may represent a distinct variety.

Pathogenicity. In many parts of Africa, where malaria is prevalent, *costalis* is regarded as the chief carrier present. The earlier recorded observations on the natural infection of this species

* Recent investigations have cast doubts upon the reliability of Haworth's records. See Lester, A. R. (1927). The Coconut Palm. Its Potentialities in providing Breeding Places for Mosquitoes. *Journ. Trop. Med. & Hyg.*, Vol. XXX, p. 137.

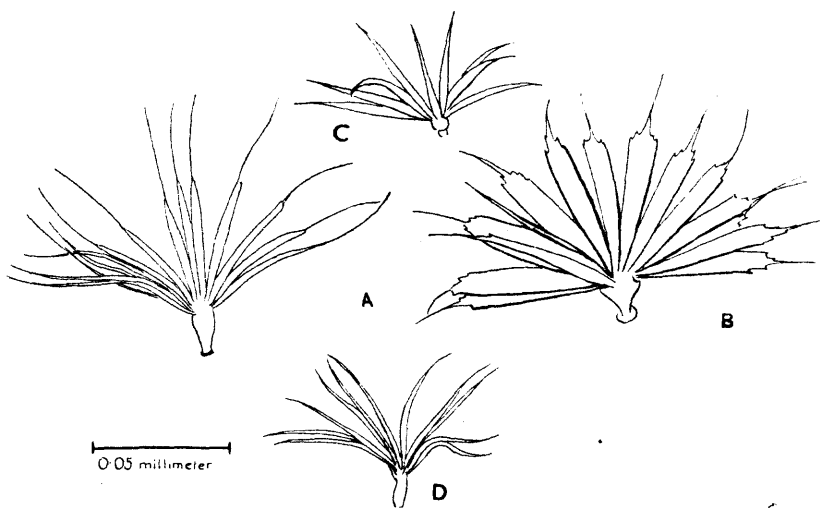


FIG. 3. A—*A. funestus*; B—*A. marshalli* var. *freetownensis*; C—*A. rhodesiensis*; D—*A. costalis*: palmate hairs of 1st abdominal segment.

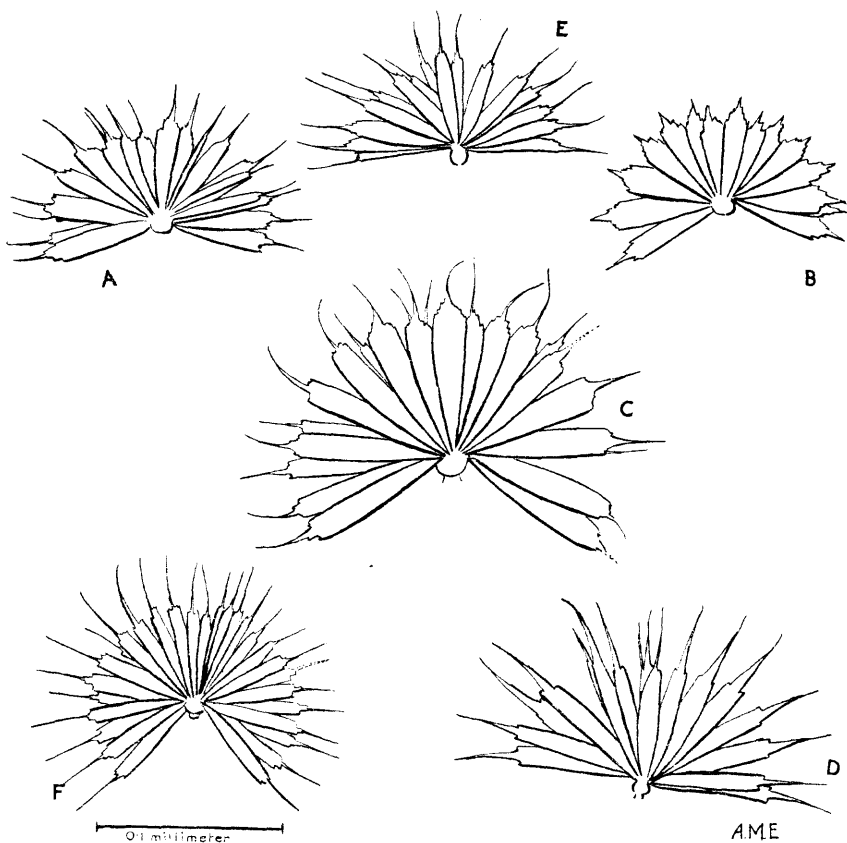


FIG. 4. A—*A. rhodesiensis*; B—*A. theileri*; C—*A. marshalli* var. *freetownensis*; D—*A. squamosus*; E—*A. costalis*; F—*A. funestus*: palmate hairs of 5th abdominal segment.

were mostly made in West Africa, but in 1908 d'Emmerez de Charmoy, in Mauritius (see Chanal, 1921), and Mansfield-Aders (1917), in Zanzibar, have recorded infection of the salivary glands with sporozoites. Recently, the latter author (1926) has recorded an average natural infectivity rate of 7 per cent. among specimens taken in buildings such as prisons in the Zanzibar Protectorate. Experimentally *costalis* has been infected with all three species of malaria parasites.

A. costalis is well known to be a potential transmitter of *Filaria bancrofti*, and Harvey (1908) recorded 25 per cent. naturally infected.

Distribution. Common throughout the Ethiopian Region.

Anopheles costalis var. **melas** Theobald.

A dark variety of *A. costalis*, differing from the type form chiefly in having the integument of the thorax and abdomen very dark, and the apical palpal band in the female divided into two narrow ones. In the Type, the costa is largely dark, only the second pale spot being present in addition to the rather obscure ones near the base, and the second and fourth veins are largely dark-scaled. Certain specimens from Southern Nigeria and Sierra Leone have the wings practically as in typical *costalis*, and in one Nigerian specimen the 'dark' ring separating the white palpal bands is pale ochraceous brown. The Type was taken by Dutton in the Gambia.

Anopheles costalis var. **quadriannulatus** Theobald.

The only difference from *A. costalis* is that the female palpi have four very narrow bands of white scales, one at the apex of each segment. Only one specimen is known; it was taken in the Transvaal and is now in the Liverpool School of Tropical Medicine.

Group **Myzomyia** Christophers (1924)

This subgenus is represented by eleven species of which some are rather difficult to separate. It is characterised as follows:—Femora and tibiae *not* speckled; hind tarsi *not* tipped with white; front tarsi *not* broadly banded apically and basally; wings with *not* more than three dark spots on sixth vein.

Anopheles wellcomei Theobald.

The peculiar distribution of black and yellow scales on the wings (Pl. II, fig. 2) makes this an unmistakable species. To the naked eye the wings seem yellow with a narrow, black anterior border. The first vein is almost entirely pale on the basal half in the Type form, but in some examples, there is almost, or quite, as much dark scaling on the first vein as on the costa. The costa has the apical half largely pale scaled, the scales in this region being white or pale ochraceous. The tarsi have very narrow, apical, yellow rings on most of the segments.

Habits. Balfour, who discovered this species in the Sudan, observed that the females boarded a steamer on the Baro river and bit freely. In Angola, Wellman and Fay (1907) noted that this species bit in the daytime, and even in bright sunlight. The latter observers also found that it was most often seen in wild, wooded country, and near large streams.

Distribution. N. Nigeria ; Angola ; Belgian Congo ; Sudan.

Anopheles smithii Theobald.

This species, which so far has only been found in the neighbourhood of Freetown, Sierra Leone, is peculiar in having the pale spots on the wings of the female reduced almost to extinction, while those of the male show well-marked pale areas (Pl. II, fig. 6). The legs are entirely dark ; the mesonotum is clothed with hairs except at the extreme anterior border ; and the female palpi show three very obscure pale bands, the apex being dark or occasionally having one or two pale scales.

Habits. A letter written by Major Smith, the discoverer of this species, to Major Austen is exhibited in the British Museum, and in it the writer states that females gorged with blood were taken on the barrack-room walls. Experimentally the present writer found that bred females of this species failed to feed on human blood, while under similar conditions 100 per cent. bred *costalis* engorged fully. It is possible, however, that the adults of *smithii* were not as healthy as those of *costalis*, because some difficulty was experienced in rearing the larvae to the adult stage.

Breeding places. Larvae have only been found in the upper, rocky parts of two streams which descend from the mountains

behind Freetown, Sierra Leone. The breeding places were described by Professor Blacklock and the writer (1926). Before the height of the rains very numerous small pools in the course of these streams contained larvae, but when the heavy rains converted the streams into torrents, larvae were confined to backwaters and sunken pools in the banks of streams. A considerable amount of shade was usually present, but in some cases the situations were exposed to the sun for some hours daily.

Larva. Blacklock and Evans, who first described the larva of this species, give the following brief diagnosis:—

‘The fourth stage larva is almost invariably dark, appearing black to the naked eye. When examined microscopically the pigment is usually seen to have a bluish green hue. The clypeal hairs are very coarse, the outer are divergent and almost equal in length to the inner. The thorax bears small rudimentary palmate hairs and the lateral combs have the teeth all long and approximately equal in length, except that at the ventral end one or two short teeth occur.’

Anopheles rhodesiensis Theobald.

Typical specimens of this small species can be readily distinguished from all the other African anophelines by the wings, which have four well-marked pale spots in the costal region, but the rest of the veins entirely dark scaled (Pl. II, fig. 1). Specimens do occur, however, in which an odd pale scale or two is seen in the neighbourhood of the cross-veins, and such examples might be mistaken for *funestus* var. *bisignata*; the female palpi are considerably longer than those of *funestus* and the white bands narrower and more widely separated (Pl. IV, fig. 3), the apical one being sometimes wanting altogether. The absence of scales from the upper surface of the thorax, except the extreme anterior edge, is an additional distinction between *rhodesiensis* and *funestus*; in the latter very narrow scales are scattered among the hairs over the surface. The male palpi are very dark and may be entirely without pale scales. The larvae are quite distinct from those of *funestus* (see p. 31).

Habits. This species is known to enter houses and tents and, in Egypt, according to Kirkpatrick (1925), it bites viciously in houses after dark; in some places where it is found, however, it appears to be a ‘wild’ rather than a domestic species.

Breeding places. *A. rhodesiensis* accommodates itself to a great

variety of breeding places, and the observations of Kirkpatrick in Egypt (1925), and Blacklock and Evans in Sierra Leone (1926) show that, in those parts of Africa, larvae may be found in almost any type of water where *Anopheles* larvae could occur. The latter authors found that, though widely distributed in the neighbourhood of Freetown, the larvae were always found in small numbers; further, they did not occur in the town portions of the streams.

Larva. Clypeal hairs simple, the outer considerably shorter than the inner. Submedian thoracic hairs with well separated bases (Text-fig. 5, B). Rudimentary palmate hairs present on thorax (Text-fig. 5, F), and on first abdominal segment (Text-fig. 3, C, p. 22). Palmate hairs on second abdominal segment, large but leaflets without well-developed shoulder. Typical abdominal palmate hairs (Text-fig. 4, A, p. 22) rather larger than in *A. costalis*. Dorsal plates small (Text-fig. 6, D, p. 32). Lateral comb (Text-fig. 10, E) without marked characteristics.

Pathogenicity. Although nothing has been proved against this species, it has been suspected on epidemiological grounds of acting as an agent in the spread of malaria.

Distribution. Sierra Leone; Gold Coast; Egypt; S. Rhodesia; Transvaal.

Anopheles distinctus Newstead and Carter.

A moderate-sized species, of which only a few specimens appear to be known. The Type, and the only other specimens the writer has seen, can be immediately distinguished from all the other species of the *Myzomyia* group by the wings. These have at least the basal half of the costa entirely dark and the rest of the veins not as in *wellcomei*, but with dark and light areas fairly evenly distributed. In the variety *melanocosta* Newst. and Carter, the costa is entirely dark except for one pale spot near the apex. It is evident, however, from Christophers' key, that he considers that the very dark costa is only a melanic variation peculiar to certain specimens, and that other examples of the species will probably be found showing a normal amount of white in this region. Such specimens would, however, run down to *distinctus* in the foregoing key.

Distribution. The species was originally described from N.E. Rhodesia, but a specimen has recently been recorded from the Katanga District, Belgian Congo (Edwards, 1926).

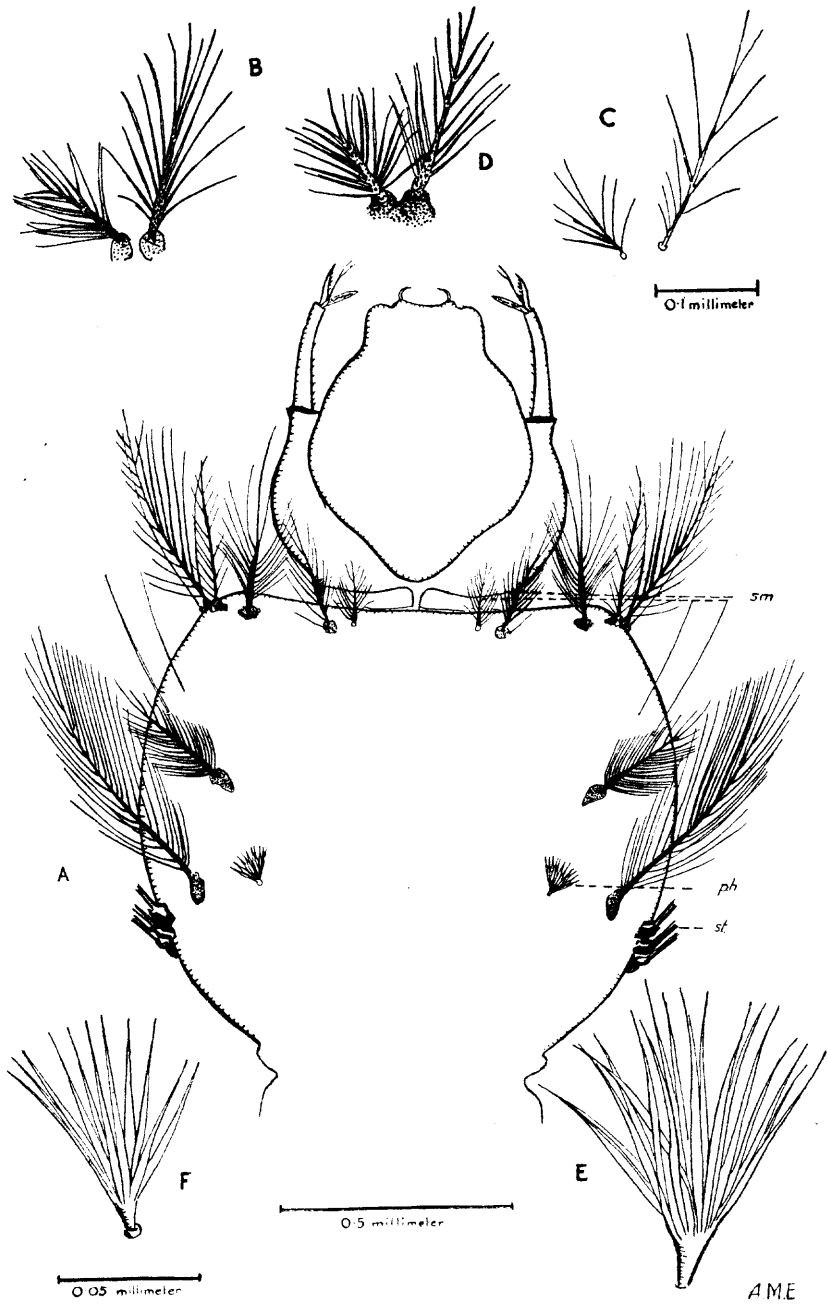


FIG. 5. A—Thorax of *A. smithii* to show the position of the submedian thoracic hairs: *sm*; and palmate hairs: *ph*. B—*A. rhodesiensis*; C—*A. costalis*; D—*A. marshalli* var. *freetownensis*: submedian thoracic hairs. E—*A. marshalli* var. *freetownensis*; F—*A. rhodesiensis*: thoracic palmate hairs.

Anopheles nili Theobald.

A small to medium-sized, very dark species, the wing markings resembling those of dark forms of *funestus*. Legs entirely dark-scaled; thorax clothed chiefly with hairs, a few long, narrow, whitish scales occurring anteriorly, but only extending back about one-eighth of the distance. The female is quite distinct from any of the African species on account of its palpi (Pl. IV, fig. 12), but the male might be mistaken for a dark *funestus*; it can, however, be distinguished by the fact that the base of the posterior fork cell is nearer to the base of the wing than is that of the anterior fork cell.

Habits. Blacklock (1925) found that in Daru, Sierra Leone, this species was not domestic in its habits. Only one adult was taken in a certain native hut, only fifty yards from the Moa River, where the species was breeding in large numbers. This was in striking contrast to the behaviour of *A. costalis* more than a hundred of which were taken in this dwelling, although its breeding ground was further away than that of *nili*. In Northern Nigeria, Johnson found only a very small number of adults indoors.

Breeding places. At Daru numerous larvae were found at the edges of the Moa River, Blacklock (1925). Macfie and Ingram took them in association with *Pistia stratiotes*.

Larva. The following description of the larva of this species is taken from Blacklock and Evans (1926). The larva was collected at Daru by Professor Blacklock. '*Head.* Antennae with no branched hair on shaft . . . Inner clypeal hairs very thick, widest a short distance beyond the base, distal third with several rather long coarse branches. Outer clypeal hairs slender, simple. Pre-antennal hairs reaching to the edge of the clypeus, simple. *Thorax.* Palmate hairs . . . situated at the posterior angles, very large, *c.* 0.14 mm. in diameter, the leaflets with well-developed shoulder and filament. *Abdomen.* Palmate hairs . . . relatively large, the leaflets with filament and rounded, serrated shoulder, markedly incised between serrations . . . Dorsal plates . . . wide, resembling in shape the thicker basal portions of the dorsal plates of *A. funestus*. Lateral combs with long and short teeth.'

Distribution. Sierra Leone; Gold Coast; N. and S. Nigeria; Sudan; Nyasaland; Zululand, Bedford (1926).

Anopheles flaviceps Edwards.

This is a very pale species owing chiefly to the fact that the integument is light in colour ; the scales of the mesonotum are narrow and hairlike. In the dark-tipped female palpi and in many other respects it resembles *A. turkhudi* to which it is closely allied, Edwards (1921).

Distribution. The only specimens known are from Erkowit, Anglo-Egyptian Sudan.

Anopheles cinereus Theobald.

This very large species can be readily distinguished from all the other species of the *Myzomyia* group, except *A. distinctus*, by the banding of the female palpi, which are relatively of great length (Pl. IV, fig. 1). The wings are very long, and the costal pattern can easily be made out with the naked eye. The markings differ from those of the specimen of *costalis* here illustrated, chiefly in having the third large dark area on the 1st vein not interrupted, and in having the dark areas on veins 2, 4, and 5 much more extensive. The unspeckled legs and unbanded tarsi at once distinguish it from that species. The male palpi have the last two segments, and especially the penultimate, of relatively great length, and apically white-scaled.

Habits. In Nairobi, according to Van Someren and De Boer (1926), the female readily enters buildings and bites after dark.

Breeding places. The above mentioned observers give a full account of the breeding places in and around Nairobi. Larvae are found in both running and standing water, and always in situations more or less exposed to the sun. Large receptacles are included in the list of situations, and in Muscat, Gill (1916) records larvae of this species from a tank.

Larva. Hill and Haydon (1907) describe the larva of this species, but state that they were not quite confident as to the identity.

Distribution. Kenya Colony ; S. Rhodesia ; Transvaal ; Natal ; Cape Colony ; Zululand (Bedford, 1926).

Anopheles funestus Giles.

A very small, dark anopheline ; female palpi with three pale bands, that at the apex usually broader than the one preceding it (Pl. IV, fig. 10) ; integument blackish ; mesothorax with vestiture

of hairs and long, very narrow curved scales, considerably longer and narrower than those of *A. costalis* (see Pl. VI, fig. 1, and compare Text-fig. 8, D and E, p. 37). Legs appearing entirely dark to the naked eye, but sometimes the tarsal segments are seen, under magnification, to have the scales at the extreme tip of the segments obscurely paler than the rest. The wing markings are subject to a considerable amount of variation, especially with regard to the base of the costa and the 3rd vein (Pl. II, figs. 4 and 5); the light area on the 3rd vein may be considerably longer than in the lighter wing here illustrated. In specimens the writer has examined, the last segment of the male palpi is broadly pale at the apex and the penultimate has a small pale patch at the distal border.

Habits. In regions where *funestus* is common the adults constitute a large proportion of the anophelines taken in houses. Not only do they enter houses for the purposes of feeding on the inhabitants, but, in certain regions at any rate, dwellings are used as day-time shelters. In Nyasaland, Davey and Newstead (1921) observed 'on many occasions large numbers flying into the tents in the early morning between dawn and sunrise, the chief point of entrance being at the upper portion of the opening, through which they passed in more or less continuous flight until the rising sun put an end to their movements.'

Seasonal variation. In certain regions, *funestus* disappears entirely or almost entirely during the dry season, but in others it is prevalent in large numbers throughout the year. Well-marked seasonal variation of this species was observed in Northern Nigeria, Johnson (1919), and in Mauritius, MacGregor (1924). In the Fort Johnston area, Nyasaland, where this species is characteristically perennial, Lamborn (1925) points out that the Shire River affords suitable breeding places at all seasons of the year. At Bukama, Belgian Congo, according to Bequaert (1913), it survives the dry season in the adult state.

Breeding places. The typical situation in which larvae are found is *amongst grass or weeds at the sides of slowly-running streams or rivers*. The situations may be either shaded or unshaded (Pls. VII; VIII, fig. 1, and XII, fig. 3).

Larvae are also found amongst vegetation in backwaters of rivers or streams; in pools in dried-up stream beds; in swamps, and

occasionally in water in pits. MacGregor (1924) in Mauritius, found larvae also amongst vegetation at the sides of pools and ponds and in open drains containing clean water and fallen leaves. Other recorded breeding places are : flooded rice-fields, Zanzibar, Mansfield-Aders (1917) ; slightly brackish water in a canoe on the foreshore at Lagos, Dalziel (1920). *A. funestus* is included by Macfie and Ingram (1923) in the list of species whose larvae are sometimes associated with the water plant, *Pistia stratiotes*, in the Gold Coast.

The larvae disappear from the surface with great rapidity at the approach of the collector, and MacGregor has emphasised the fact that, in consequence of this habit, they are apt to be missed in dipping. The larvae remain below the surface for a considerable time attached to the banks or to weeds in the water.

Larva. This very small, dark larva can be readily distinguished from those of all other African species known to the writer by the relatively great size of the dorsal plates* (Text-fig. 6). These plates are very conspicuous objects in cast skins of larvae ; they can also be recognised in living larvae by their shining brown surface and do, in fact, make it possible to distinguish *funestus* larvae with certainty with a hand lens. The clypeal hairs and a typical abdominal palmate hair are illustrated (Text-figs. 2, p. 12 ; 4, p. 22). Rudimentary palmate hairs are present on the thorax, and small ones on the first abdominal segment. (Text-figs. 3, p. 22 and 5, p. 27.)

Pathogenicity. This species is an important and, possibly in some localities, the most important carrier of malaria. Many observers have found the salivary glands naturally infected with sporozoites, and Stephens and Christophers (1908) record figures as high as 50/100 in Nigerian bush stations.

Lamborn has recently recorded natural infection of the species in Nyasaland, but shows that the seasonal incidence of malaria indicates that *costalis* is very much more important as a vector of malaria even in the Fort Johnston area, where *funestus* is extremely abundant.

The species has been proved experimentally to be susceptible to infection with *P. falciparum* and *P. malariae*.

* The importance of this character was first pointed out by Edwards (1922).

Mansfield-Aders (1926) has shown that in the Zanzibar Protectorate the natural infectivity rate of this species, among specimens caught in buildings such as prisons and police lines, is slightly higher than that of *costalis* taken under similar conditions. The figures are:—*funestus*: 1,065 specimens dissected, percentage

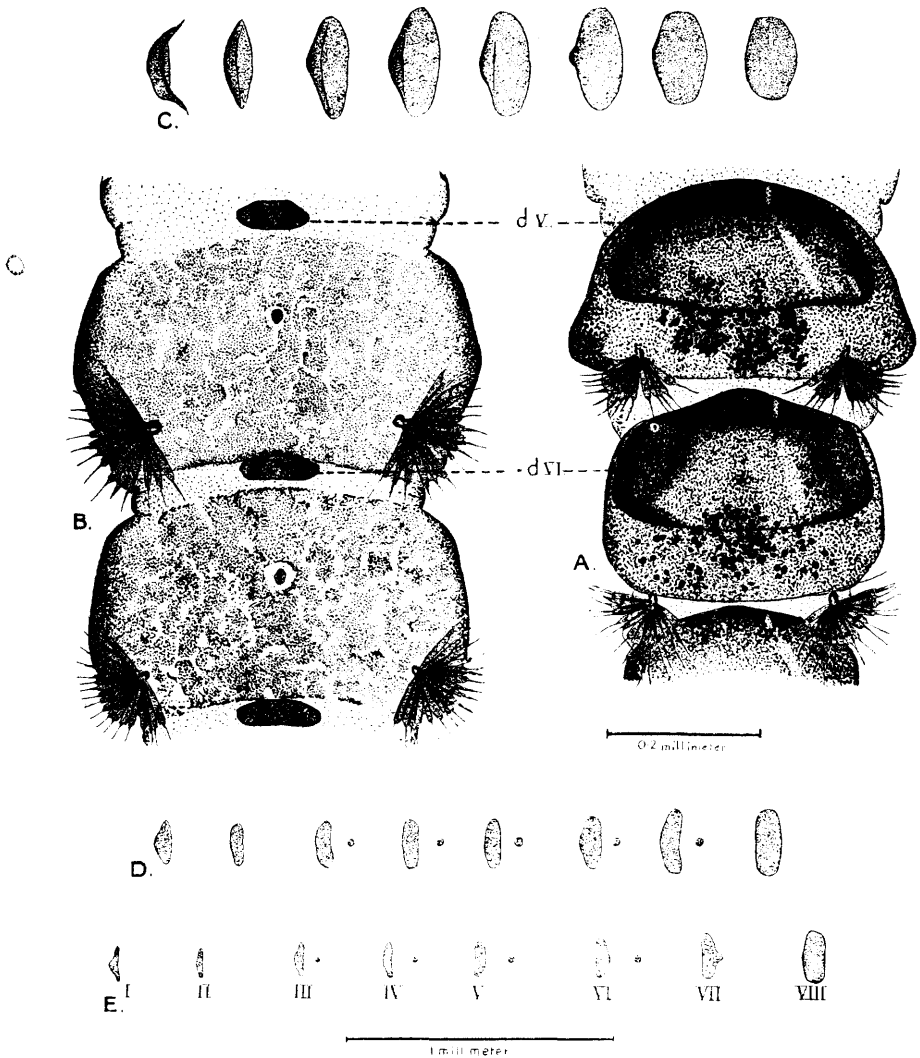


FIG. 6. A—*A. funestus*; B—*A. smithii*: 5th and 6th abdominal segments, *dv* and *dvi*: dorsal plates in situ. C—*A. funestus*; D—*A. rhodesiensis*; E—*A. costalis*: dorsal plates of 1st to 8th abdominal segments to same scale.

infected 7.3; *costalis*: 1,659 specimens dissected, percentage infected 7.0.

It is interesting to note that this latter observer found many specimens of *funestus*, as well as *costalis*, infected with *Microfilaria bancrofti*. The only other positive record of the former species being thus infected appears to be that of Laveran in 1903 (see Chanal 1921).

Distribution. Widely distributed throughout the Ethiopian region.

Anopheles funestus var. **bisignata** Grünberg.

In this form the pale scales on the wing field are confined to small spots at the bases of the fork cells and near the cross-veins.

Anopheles transvaalensis Carter.

In the key this species comes very near *A. funestus*, but it is considerably larger than that species, being about the size of a medium-sized *costalis*. It is not so dark looking as *funestus*, owing to the more white-spotted appearance of the wings, which have the pale areas more conspicuous than in *funestus*. The greyish-white, narrow curved scales of the thorax are distinctly broader than the scattered thoracic scales of *funestus*.

Habits. The adults were found in dwellings on several occasions by Van Someren and De Boer (1926) in Nairobi.

Breeding places. The breeding places have been described by the above mentioned observers, who found *transvaalensis* rather frequently in and around Nairobi. The typical breeding places were found to be rock-pools or seepage water in the course of streams. Larvae were also taken amongst upright vegetation at the side of swamps, and in irrigation trenches. A certain amount of shade was found to be constantly present, but sunlight, if not too strong, could be tolerated.

Distribution. Uganda; Kenya Colony; Transvaal; Natal; Belgian Congo, Schwetz (1927).

Anopheles longipalpis Theobald.

This species closely resembles *A. transvaalensis* in appearance, and in having the two distal pale bands of the female palpi very widely separated. Christophers (1924) notes that the wings are

much darker than in most species, the pale scales on the wing field of *A. longipalpis* being found only near the bases of the fork cells, and near the cross-veins, as well as on the lower branches of the fifth and sixth veins.

Distribution. Nyasaland; Kenya Colony; Zanzibar Protectorate, Mansfield-Aders (1926).

***Anopheles marshalli* Theobald.**

Pyretophorus pitchfordi Giles

Pyretophorus austenii Theobald.

Anopheles marshalli var. *flavicosta* Edwards.

Anopheles domicolus Edwards.

Anopheles marshalli var. *moucheti* Evans

Anopheles marshalli var. *freetownensis* Evans

Anopheles marshalli var. *hargreavesi* n. var.

This species, together with its older varieties, which were described as distinct species, was considered by Edwards (1916) to form a group 'the members of which are closely allied and difficult to separate and, in some cases, of doubtful specific rank.' After seeing examples of var. *moucheti*, Mr. Edwards made the following statement in a letter to the author, dated 7.iii.23: 'I am not sure that it would not be best to treat all the forms as varieties, rather than full species.'

Christophers (1924) lists *A. pitchfordi* Giles, *A. domicolus* Edw. and *A. austenii* Theo. as 'possibly distinct' species, and the discovery of further forms supports the view that all are varieties of a very variable species. It would be useful, however, if series were bred out in different localities and the adults and larval pelts studied and compared.

A. marshalli, itself, is a very variable species. Specimens from the Type locality have the female palpi with the dark band which separates the two broad pale bands, equal to, or slightly shorter than the pale bands. The scales covering most of the dorsal surface of the thorax are chiefly long and pointed, and definitely of the narrow-curved type. The writer has not been able to examine these scales in the Type series with a high magnification, but examination of the scales *in situ* with a magnification of $\times 220$ showed them to be intermediate in form between those of *funestus* (Text-fig. 8, E, p. 37) and *marshalli* var. *moucheti* (Text-fig. 8, B).

The lateral series of scales are broader and more truncate on the anterior border of the thorax. The wings differ from those of *costalis* chiefly in having the white areas on the outer half of the costa and 1st vein proportionally shorter than in that species. This character is, however, subject to considerable variation; the wing here illustrated (Text-fig. 7, A) shows the costal pattern according to Theobald (1903), but A' is based on a camera lucida

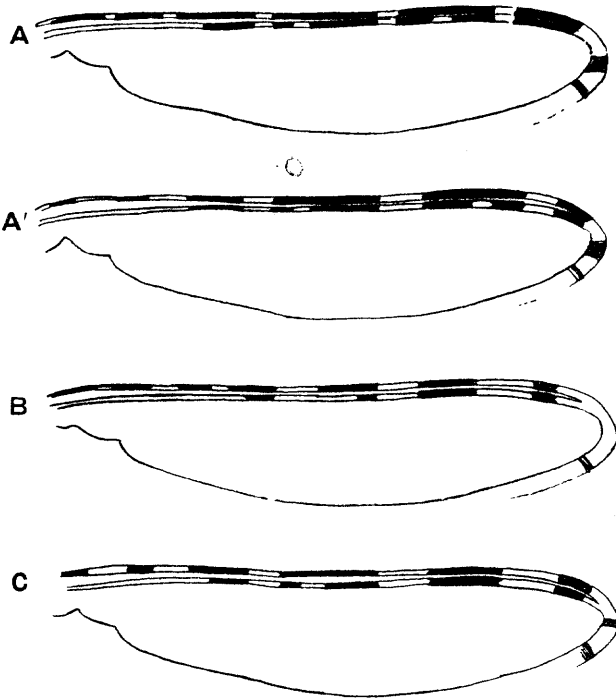


FIG. 7. Diagrams illustrating the distribution of light and dark scales on the costa and first vein. A. and A'.—*A. marshalli*; B.—*A. marshalli* var. *flavicosta*; C.—*A. marshalli* var. *pitchfordi*. All figs. conventionalised to the same size.

drawing, by the writer, of the wing of a specimen collected by Dr. Marshall in Mashonaland. The second vein is much darker than in typical *costalis*, and the plume scales are considerably longer than in that species.

Breeding places. Larvae are recorded from pools and river backwaters in association with *Pistia stratiotes* by Macfie and

Ingram (1917 and 1923), and in Nairobi, Van Someren and De Boer (1925) took them in both standing and running water.

Larva. This is fully described by Ingram and Macfie (1917), who state that it possesses the characters given for *rufipes* in Edwards' key (see p. 47), but is distinguished from the larva of that species by having no palmate hairs on the second abdominal segment.

Distribution. Mashonaland; Uganda; Kenya Colony; Nyasaland; S. Rhodesia; Transvaal; Angola; Gold Coast.

Anopheles marshalli var. **pitchfordi** Giles.

The pale areas near the apex of the costa are more extensive than in typical *marshalli* (see Text-fig. 7, A and C), this and the smaller size being the chief characters by which *A. pitchfordi* has been distinguished from that species in previous keys. The present writer is of opinion, however, that the form of the mesonotal scales affords a good distinction. In the original description, Giles states that the mesonotum is clothed with 'hair-like yellow scales behind, and creamy, narrow, curved ones in front.' The writer has examined the scales in the Type with a magnification of $\times 220$ (Reichert: Oc. 4, Obj. 3; tube at full), and finds that the scales covering at least the posterior two-thirds are of a much narrower type than those in the same position in *A. marshalli* from Mashonaland. Very little difference could be detected between these scales and those of *A. marshalli* var. *freetownensis* (Text-fig. 8, C). The tarsi have very narrow apical pale rings, and the female palpi have the subapical pale band sometimes slightly shorter than the apical; the dark intervening band is about equal to the sub-apical pale band.

Distribution. Original series from Zululand. Other records: Angola; Belgian Congo; Uganda.

Anopheles marshalli var. **austeni** Theobald.

This variety is characterised by having the front tarsi very broadly banded.

Habits. Wellman and Fay (1907) describe this as 'a quiet and unobtrusive, but domestic, mosquito.'

Breeding places. According to the above authors, this species breeds in fairly muddy pools.

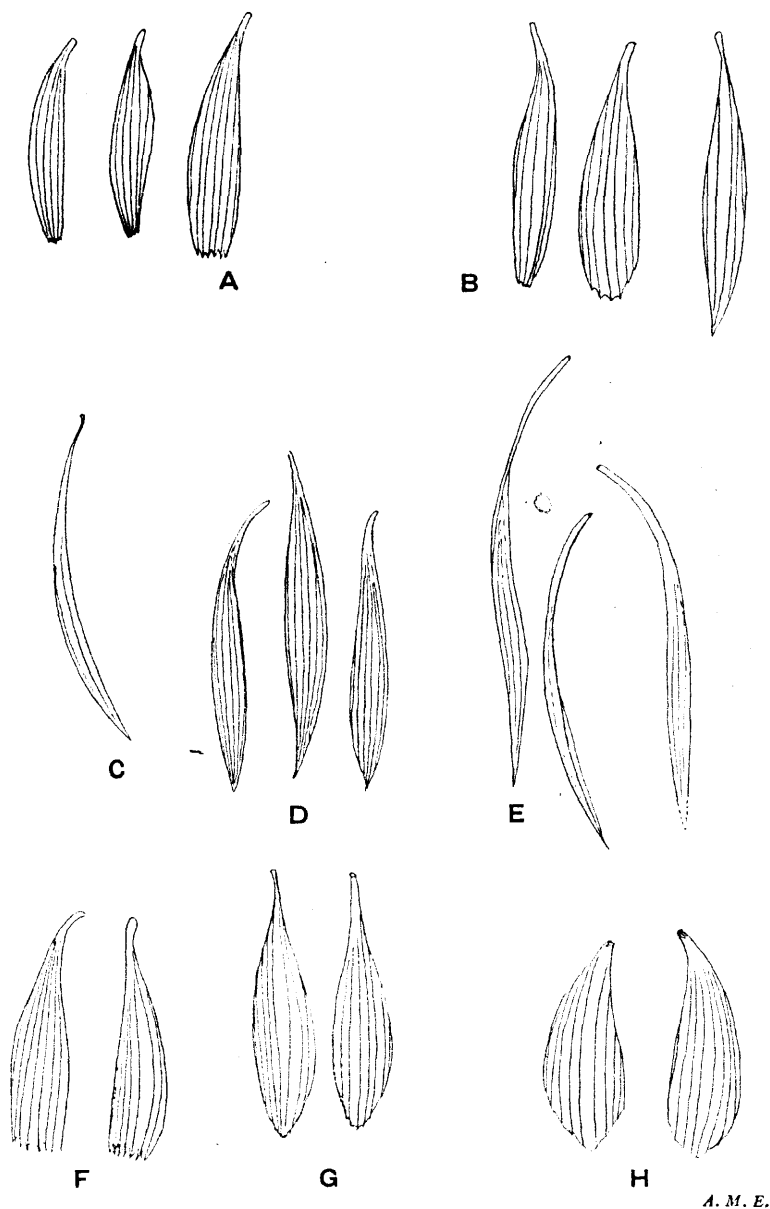


FIG. 8. Scales from median area of anterior half of mesonotum. A.—*A. marshalli* var. *hargreavesi*; B.—*A. marshalli* var. *moucheti*; C.—*A. marshalli* var. *frectowenensis*; D.—*A. costalis*; E.—*A. funestus*; F.—*A. maculipalpis*; H.—*A. pharoensis*. Scales from fossae. G.—*A. costalis*. Drawn with camera lucida from scales mounted in Canada balsam, magnification Oc.4, obj. 112; drawings reduced by one-half.

Pathogenicity. Wellman and Fay (1907) demonstrated this variety to be a carrier of malaria, stating that they found 'about 1% of the specimens taken in one village shewing parasites.'

Distribution. Angola.

Anopheles marshalli var. **flavicosta** Edwards.

Distinguished from typical *marshalli* by the wing markings. The outer quarter of the costal region is almost entirely pale, owing to the minute size of the fourth dark costal spot, and the absence of the dark fringe-spot at the apex of the wing (Text-fig. 7, B, p. 35); the pale scales of the wings, especially in the costal region, are characteristically bright yellow.

Distribution. Northern Nigeria.

Anopheles marshalli var. **domicolus** Edwards.

This variety, which approaches typical *marshalli* in size, differs from it chiefly in having the white rings on the hind tarsi basal as well as apical, and in the shorter and slightly broader wing scales. The third main dark spot on the first vein has no white interruption, and the mesonotal scales are narrow, slightly curved and white.

Habits. The original series consisted of six females caught by Dr. W. B. Johnson in a bungalow at Zungeru, N. Nigeria.

Distribution. Gold Coast; N. Nigeria.

Anopheles marshalli var. **moucheti** Evans.

This variety resembles typical *marshalli* in the banding of the tarsi, but is very much smaller, being as small as *funestus*, while *marshalli* is about equal to *costalis* in size. The wing scales are shorter and broader than those of *marshalli*, Type form, a difference that was pointed out to the writer by Mr. F. W. Edwards. A further distinction lies in the shape of the mesonotal scales; the scales on the *anterior half* of the mesonotum (Text-fig. 8, B) are distinctly shorter and broader than those of typical *marshalli*, but they are quite narrow on the posterior half; on the anterior quarter the lateral series consists of truncate overlapping scales.

The wing pattern is shown in the accompanying illustration (Text-fig. 9). In the female palpi the dark band separating the two broad pale ones is from one-quarter to one-half the length of either pale band.

Habits. Van den Branden and Van Hoot (1924) record that '*A. marshalli* var.' constituted 3 per cent. of the mosquitos taken in houses in Leopoldville, and there is very little doubt that the variety involved was var. *moucheti*.

Distribution. Widely distributed in the Belgian Congo.

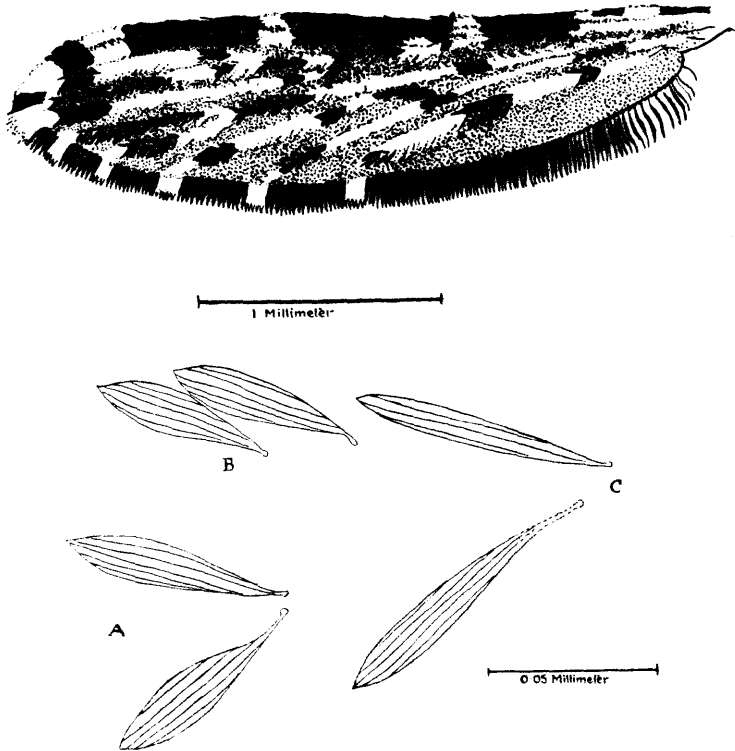


FIG. 9. *Anopheles marshalli* var. *moucheti* var. n. ♀ wing. Wing scales. A—Plume scales from upper branch of second vein; B—Lateral squames from distal dark area of third vein; C—Plume scales from stem of second vein near fork.

***Anopheles marshalli* var. *freetownensis* Evans.**

Another small variety about equal to var. *moucheti* in size. It differs from typical *marshalli* in the shape of the mesonotal scales, which are sparsely distributed and of the *very* narrow curved type (Text-fig. 8, C), closely resembling those of the Type of *pitchfordi*. The dark band near the apex of the female palpi is about half as long as the pale bands which it separates (Pl. IV, fig. 2). Wings with the third dark area not interrupted on the

first vein, but this area considerably shorter than that in *A. marshalli* Type form and the var. *moucheti*. Male palpi, as in many other species, with last two segments chiefly white-scaled with dark basal bands.

Breeding places. Blacklock and Evans, who discovered this variety, state that 'The character of the breeding places may be gathered from the fact that in four cases they were associated with the larvae of *A. smithii*, in one of those of *A. costalis*, and in another with those of *A. funestus*. When found alone the larvae were in streams where a certain amount of shade was present. The larvae were found from just above sea-level to 800 feet above sea-level.'

Larva. The following is taken from Blacklock and Evans' description of the larva :—

'In life the larva is usually dark grey with blackish pigment; the dorsal plates are small, and palmate hairs are present on the thorax and first seven abdominal segments; those of the third to seventh segments are relatively very large.'

The palmate hairs and other details are here illustrated (Text-figs 3, p. 22; 4, p. 22; 5, p. 27; 10, p. 45) for comparison with those of other varieties of *marshalli*.

Distribution. The neighbourhood of Freetown, Sierra Leone.

***Anopheles marshalli* var. *hargreavesi* n. var.**

The chief characteristic of this small variety is the great breadth of the mesonotal scales (Text-fig. 8, A), some of which have almost the same index as those of the *Neocellia* group (about 5.0 to 6.0). Many of the scales even in the median area are truncated.

The wings have the pale areas in the costal region of the same extent as those of *marshalli* var. *pitchfordi* Giles (see Text-fig. 7, C), and the wing scales appear to be of the same length and breadth as in that variety. The tarsi are distinctly banded, the bands on the hind legs being apical and very narrow. The palpi have the dark band, which separates the broad white bands, about one-half the length of either band.

Type ♀ and one other ♀ from Mabang, Sierra Leone, Mr. E. Hargreaves. The specimens were included in a consignment of material kindly sent to this School by the Imperial Bureau of Entomology. I have also seen specimens agreeing with this variety from S. Nigeria

Group **Neomyzomyia** Christophers (1924)

The five species representing this group in the region have the following characters: wings heavily scaled; female palpi with four pale bands; abdomen without projecting tufts and devoid of scales above, except in *A. christyi*. The femora and tibiae are conspicuously spotted, except in *A. christyi* (see below).

Anopheles christyi Newstead and Carter.

A large species, distinguished from all the other African *Anopheles* by the presence of long, flat, yellow scales on the upper surface of most of the abdominal segments (Pl. VI, fig. 4), the scales not forming projecting tufts. The female palpi with the four bands very narrow; thorax clothed with creamy scales approximating 'more to the narrow-curved than the spindle-shaped type' (Newst. and Carter); femora and tibiae with lines of pale scales, femora also with irregular pale blotches or bands; last segment of hind tarsus entirely dark. Wings (Pl. III, fig. 3), heavily scaled and with four very large dark areas in the costal region. There does not appear to be very much variation in the costal markings, or those of the 2nd, 3rd, or 5th veins. The type, however, which is from Uganda, differs from the Nairobi specimen, here illustrated, in the absence of the dark area on the stem of the 4th vein, just before the fork.

Habits. Adults were found commonly indoors in Nairobi.

Breeding places. Van Someren and De Boer (1926) found that, in Nairobi, the breeding places were similar to those of *cinereus* (see p. 29), but that larvae sometimes occurred in evil-smelling, stagnant water.

Distribution. Uganda; Kenya Colony.

Anopheles aureosquamiger Theobald.

A large species; the four pale bands of the female palpi narrow (Pl. IV, fig. 4); femora and tibiae with very distinct white speckling; metatarsi of hind legs with six or seven distinct white rings; last two and a half tarsal segments entirely white. Dorsal surface of thorax with lateral portions deep reddish brown, contrasting strongly with the pale grey median area; the latter adorned with conspicuous, broad, flat, golden scales. Abdomen with fine golden hairs above.

The wing pattern is of the same type as that of *christyi*, but there is a good deal of variation, and in one of the specimens in the collection of the Liverpool School of Tropical Medicine there are scarcely any white scales on the second and fourth veins and the third and fifth have only a few white spots. The base of the costa tends to be entirely, or almost entirely, dark.

Distribution. Transvaal.

Anopheles natalensis Hill and Haydon.

This species is described as having the thorax clothed with 'short golden hairs' but, as in all other respects it closely resembles *aureosquamiger* Theo., Christophers (1924) is doubtful as to whether it is really distinct from that species.

Breeding places. Hill and Haydon found larvae of this species on three occasions, once almost at sea level, and twice at 2,200 feet. The larvae were among the shoots of grass and rushes in eddies in fast-running streams.

Larva. The larva is well described and illustrated by Hill and Haydon (1907).

Distribution. Natal.

Anopheles ardensis Theobald.

A medium-sized or rather large species; the four pale bands of the female palpi narrow; thorax chiefly clothed with yellowish, curved hairs, a few very narrow curved, whitish scales on the anterior fifth; wings with the pale spots in the costal region very small; femora and tibiae regularly white-spotted, metatarsi with conspicuous white rings.

Habits and breeding places. According to Hill and Haydon (1907), the adults are captured in houses, and larvae have been taken in a quickly running streamlet under overhanging rocks.

Larva. The larva is fully described and illustrated by Hill and Haydon (1907).

Distribution. Natal.

Anopheles kingi Christophers.

This large, dark winged species was very fully described and illustrated by Christophers (1923). It can be readily distinguished from all the other African species of the subgenus *Myzomyia* by the

hind tarsi, which have the last segment black, but the whole of the fourth and the apical portions of the third segment creamy white. The wings have the veins heavily scaled, long plumose scales predominating. The wing scales are mainly dark, and the costa has only three very small pale spots, of which that nearest the base may be bridged across by dark scales, the costal markings then approaching those of *mauritanus*.

Habits. The first specimens found were caught while attempting to feed, during the day-time.

Distribution. The original series was taken at 7,000 feet in the Livingstone Range, Kenya Colony; specimens have recently been recorded from Elizabethville, Belgian Congo.

Group *Cellia* Christophers (1924)

The five Ethiopian species in this group all possess scale-tufts projecting laterally from the abdominal segments, most of which also have scales on the upper surface, at least at the posterior edge. The female palpi have four pale bands.

Anopheles pharoensis Theobald.

A moderate sized or rather large species, usually very light in appearance owing to the broad white scales on the thorax and abdomen, and the large amount of white scaling on the palps and wings; the pale appearance is sometimes also increased by the fact that the darker scales of the palps are light ochraceous-brown. The wings often have the pale scales white in the costal region but yellowish on the rest of the veins; there are sometimes more extended dark areas on the veins than are shown in the illustrations (Plate III, fig. 2); the stem of the fourth vein sometimes shows a long dark area before the fork. The laterally-projecting tufts of the abdomen may be bright ochraceous-brown or black. The legs may be predominantly pale-scaled.

Habits. In many districts where the species is prevalent the adults are commonly found in houses, although in Northern Nigeria they only formed 0.4 per cent. of those taken by Johnson (1919). They are said to be active in the evening, and if warm enough, in the morning twilight. At Dakar, according to Noc (1922), the species passes the winter as hibernating females.

Breeding places. The breeding places are rather varied and include rice-fields; marshes; small pools and borrow pits which have a thick growth of grass or weeds. The species is included in Macfie and Ingram's list of those that can be collected by taking a few plants of the water lettuce, *Pistia stratiotes*, together with a little of the surrounding water from pools or river backwaters. In Egypt, larvae have been recorded by Kirkpatrick (1925) from wells, on five occasions; and from water tanks, on two occasions. The same observer found that larvae occurred in waters in which the p.H. ranged from 7.2 to 10.0.

Larva. No distinction is made in Edwards' key between the larva of this species and that of *A. squamosus*. The clypeal hairs are here illustrated (Text-fig. 2, D, p. 12).

Pathogenicity. Dutton and Todd (1906) record malarial infection in one out of two caught specimens dissected at Boma, Belgian Congo; later Newstead, Dutton and Todd (1907) recorded that 'malaria parasites were seen to develop in this mosquito at Boma.'

Distribution. Gambia; Sierra Leone; N. and S. Nigeria; Angola; Egypt; Sudan; Tanganyika Territory (Dr. G. Maclean); Belgian Congo; S. Rhodesia; Madagascar.

Anopheles squamosus Theobald.

This species differs markedly in appearance from *A. pharoensis*, the colour being predominantly blackish, contrasting sharply with the pure white pale scales. Female palpi markedly shaggy, the four white bands very narrow. Wings with pale spots in costal region very small (Pl. II, fig. 3). Extent of white on rest of veins very variable especially on the third vein. Abdomen with dorsal scales black or bronzy brown, sometimes with a few pale ones intermixed; projecting tufts formed chiefly of black scales; last segment often with numerous white scales above, especially distally.

Habits. In certain places, where it is common, this species is found in some numbers in human dwellings.

Breeding places. The recorded breeding places are chiefly of the same type as those in which *A. costalis* larvae are usually found, but in Madagascar, according to Legendre (1918), rice-fields are the special breeding grounds. Hill and Haydon found the species on the coast in Natal and also up to 2,800 feet.

Larva. Hill and Haydon (1907) have described the larva of this species in detail. A palmate hair of the fifth abdominal segment, and a lateral comb are illustrated (Text-figs. 4, p. 22, and 10 below). The outer clypeal hairs, in some specimens at any rate, are pinnately branched, the branching being simpler than that of the

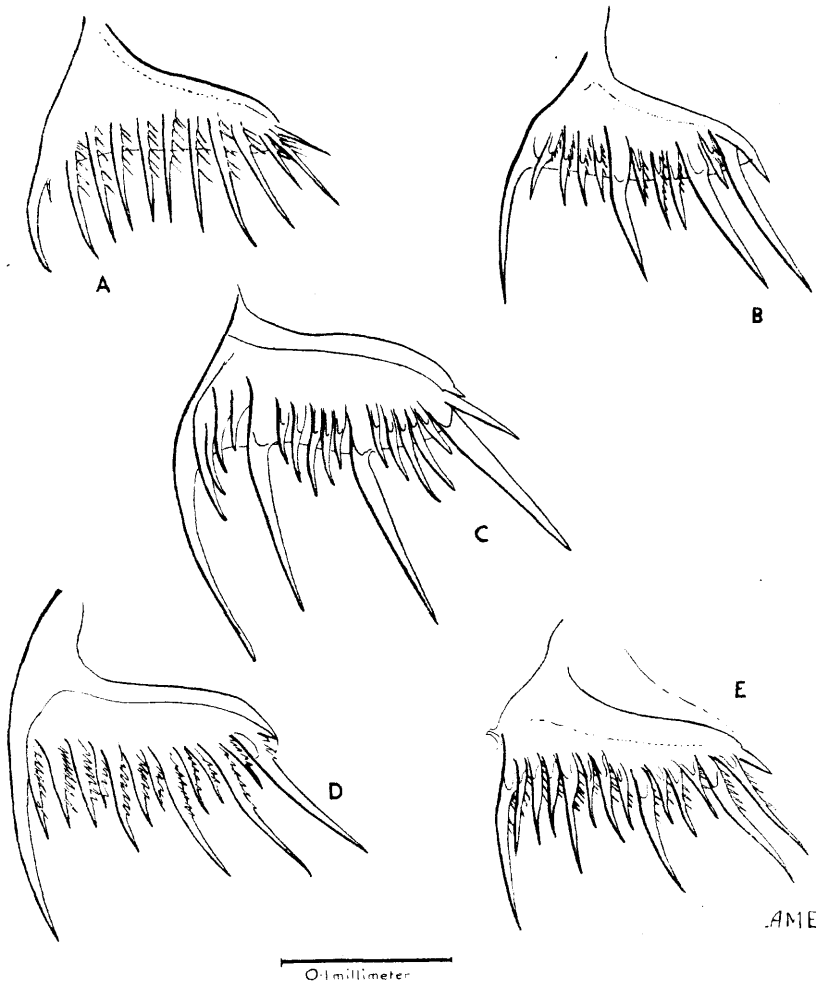


FIG. 10. Lateral combs. A—*A. smithii*; B—*A. theileri*; C—*A. squamosus*; D—*A. marshalli* var. *freetownensis*; E—*A. rhodesiensis*.

specimen of *pharoensis* here figured (Text-fig. 2, D, p. 12). I have not, however, examined enough specimens of either species to decide whether this is a constant difference. Rudimentary palmate hairs are present on the thorax.

Distribution. Widely distributed in West, East and South Africa.

Anopheles cinctus Newstead and Carter.

A small species, black and yellowish-white in colour, characterised by remarkably regular rings on the tarsal segments (Pl. V, fig. 4). The abdominal scales are mostly blackish with a few greyish-white ones intermixed, and are confined to the distal thirds of the segments. The last segment is largely covered with yellowish-white scales.

Distribution. The type female was caught at Broomassie, Gold Coast.

Anopheles argenteolobatus Gough.

This species is very similar in appearance to *A. squamosus*, but can be distinguished by the characters given in the key and by the fact that the fringe spots are indefinite.

Distribution. Transvaal; N.E. Rhodesia.

Anopheles jacobi Hill and Haydon.

Described as 'a large black and white mosquito with spotted legs' Hill and Haydon (1907). It may be distinguished from the other species in the group by the characters given in the key; a further distinction from *cinctus*, pointed out by Christophers, is that the speckling of the hind tarsi is confined to the metatarsi.

Breeding places. Hill and Haydon (1907) found the larvae in small springs at sea-level.

Larva. The larva has been described and illustrated in detail by its discoverers.

Distribution. Natal.

Group **Neocellia** Christophers (1924)

There are five species of this group in the region. They have the following characters: female palpi with three bands; mesothorax, except in *A. theileri*, with a vestiture of broad scales,* the breadth index may be as low as 4.3 (Text-fig. 8, F); hind tarsi with an extensive white area, except *A. brunniipes*.

* A variable proportion of these scales may be truncated, as shown in the illustration.

Anopheles rufipes Gough.

This rather small or medium-sized species is easily identified by the characters given in the key. The relative lengths of the white bands of the female palpi are similar to those of *A. pretoriensis* (see Pl. IV, fig. 6) ; the wing pattern resembles that of *A. squamosus* (Pl. II, fig. 3) in having the pale areas in the costal region reduced to very small spots, which contrast strongly with the black scales. The hind tarsi are variable (Pl. V, fig. 3), a dark band being sometimes present at the base of the third segment. In specimens the writer has seen the mesothorax has a large proportion of the scales complete (not truncated as in Text-fig. 8, F).

Habits. Johnson (1919) found that the species was present in comparatively large numbers in bungalows in Northern Nigeria ; it constituted 5.5 per cent. of the total anophelines caught.

Breeding places. Ingram and Macfie (1919) recorded two pupae from pools of clear water in a dry stream bed in the Northern Territories of the Gold Coast.

Larva. According to Edwards' (1912) key the larva possesses the following characters :—

Shaft of antenna without hair tuft ; hair at tip of antenna split into three ; internal clypeal hairs simple ; thorax entirely without palmate hairs ; palmate hairs of second abdominal segment rudimentary ; median thoracic hairs overlapping occiput well-developed.

Pupa. The pupa is fully described by Ingram and Macfie (1919).

Anopheles theileri Edwards.

This species is subject to considerable variation, especially with regard to the wing markings. Specimens from Sierra Leone and Elizabethville, show rather a close resemblance to *A. rufipes*, but differ in having the pale areas in the costal region about twice as long as in that species. They also have the pale scales of the wing creamy or yellowish, instead of white. Such specimens may have the small groups of flat scales at the side of the extreme anterior part of the mesonotum reduced to the point of extinction.

The type specimens from the Transvaal, on the other hand, have a great extension of the pale scales on the wing, particularly

on the first vein, which may be almost entirely pale. One of the female Types is in the collection of the Liverpool School of Tropical Medicine; in this specimen the first vein of one wing is more extensively pale than the other, and there is a group of about twelve overlapping flat scales at each side of the front of the mesonotum.

Breeding places. Larvae were found in the neighbourhood of Freetown, Sierra Leone, by Professor Blacklock and the writer. They were taken in clear running water; in seepage water near a river practically at sea level; in a large, clear, but weedy pool beside rocks just above a marshy area at about 800 feet above sea level.

Larva. The larval details were illustrated by Blacklock and Evans (1925). The chief characteristics are: typical abdominal palmate hairs with very broad leaflets, without filament (Text-fig. 4, B, p. 20); thorax with rudimentary palmate hairs; first abdominal segment with palmate hairs small, but well developed; clypeal hairs simple, length about as in *funestus* (see Text-fig. 2, p. 12).

Distribution. Transvaal; Zululand (Bedford, 1926); N. Nigeria; Sierra Leone; Belgian Congo (Schwetz, 1927).

Anopheles brunnipes Theobald.

The entirely dark legs distinguish this species from the others in the Neocellia group, and the broad, white scales on the mesonotum, which resemble those of *rufipes* (see Pl. VI, fig. 3), separate it from the varieties of *marshalli* for which it might possibly be mistaken. The wings have the white costal spots very small as in typical *rufipes* and *squamosus*.

Distribution. Angola; Belgian Congo.

Anopheles pretoriensis Gough.

This medium-sized species resembles *A. rufipes* in general appearance, but has the legs conspicuously speckled.

Habits. *A. pretoriensis* formed 0.5 per cent. of the anophelines taken indoors at Zungeru, Katagum, and Kaduna by Johnson (1919). Bedford (1926) took a specimen feeding on a cow in Zululand.

Breeding places. The larvae have been found in rock-pools in outcrops of quartzite in the Northern territories of the Gold Coast, Ingram and Macfie (1919). In Nairobi they were found in seepage water from murrum and rock strata; pools of clear water with

a certain amount of algal vegetation in quarries or stream beds, where the water was kept fresh; in pools of clear water along irrigated trenches, Van Someren and De Boer (1926). The larvae are among those recorded by Howarth (1922) from the tops of cocoanut trees in Dar-es-Salaam.* In Natal, Hill and Haydon (1907) found larvae in slowly-running water in ditches in October, March, April and May, near sea-level and also at 3,200 feet.

Larva. The larva is described and figured in detail by Hill and Haydon (1907), who add the following brief diagnosis: 'This species is recognised by the three pairs of smooth frontal hairs† the absence of any palmate hair on the thorax, and the relatively small size of these hairs on the abdominal segments.'

The larva differs from that of *rufipes* in having a well developed palmate hair on the second abdominal segment (Edwards, 1912).

Pupa. The pupa is fully described and illustrated by Ingram and Macfie (1919).

Distribution. Natal; Transvaal; Northern Nigeria; Northern Territories, Gold Coast; Dar-es-Salaam.

Anopheles maculipalpis Giles.

This species differs from *A. pretoriensis* by the characters given in the key. The female palpi (see Christophers, 1924) sometimes differ from those of *pretoriensis* in having the dark area separating the distal white bands less than either pale band.

Habits. The adults are known to enter houses at night for the purpose of feeding.

Breeding places. Seepage water is the most commonly recorded breeding place of this species; MacGregor (1924) and Iyengar (1926) state that seepages are the only source of *A. maculipalpis* in Mauritius and Bangalore City, India, respectively. Christophers (1916) refers to frequent occurrence of the larvae in pools associated with hill streams in India, and Van Someren and De Boer (1926) found that at Nairobi the breeding places were similar to those of *A. pretoriensis*, seepage water being one of the principal sources of that species.

* See footnote on p. 21.

† Clypeal and pre-antennal.

Larva. According to MacGregor's (1924) key to the larvae of the Mauritian species, the larva possesses the following characters:— Exterior clypeal hairs unbranched and simple; palmate hairs reduced to a brush or tassel form; comb large, composed of irregular sized teeth.

Pathogenicity. In Mauritius, this species has been found to be experimentally susceptible to malarial infection by MacGregor (1924). Earlier positive records had been obtained in India.

Distribution. N. Territories, Gold Coast; N. Nigeria; Angola; Belgian Congo; Kenya Colony; Dar-es-Salaam; Mauritius; S. Rhodesia; Transvaal; Natal.

APPENDIX

Mr. Edwards has recently shown that the varieties *paludis* Theobald, *ziemanni* Grünberg, and *tenebrosus* Dönitz can be distinguished from the type form. Since the completion of the main part of this Memoir, Mr. Edwards has very kindly permitted me to publish his diagnoses of these forms, together with notes on their distribution.

A. mauritianus (Daruty and D'Emmerez) type form, Edw.

Hind tibia with a broad white patch at the tip. Hind tarsus with first segment broadly white at the base, first and second segments rather broadly white at the tip, third segment with basal fourth black. Wing with no fringe spot opposite the end of the lower branch of the fifth vein.

Distribution. Chiefly an Eastern form.

Specimens from the Gold Coast differ in having the third segment of the hind tarsus entirely white (Pl. V, fig. 1B). Several of these examples were bred from larvae at Bole, by Dr. A. Ingram.

A. mauritianus var. *ziemanni* (Grünb.) Edw.

Similar to typical form, but less white at the tip of the hind tibia and base of the first hind tarsal segment (Pl. V, fig. 1A).

Distribution: Gold Coast; Sierra Leone; S. Nigeria; Congo; Sudan; Uganda; Tripolitania (Misurata).

Specimens from Katanga have the black on the third hind tarsal segment more extensive. The present writer has also seen an example of this variety from N.E. Rhodesia.

A. mauritianus var. *tenebrosus* (Dön.) Edw.

Hind tibia narrowly white at the tip. Hind tarsus with first segment dark at the base; first and second segments narrowly white at the tip, third segment black on the basal half or more, fourth and fifth segments white. Wings with no fringe spot opposite the lower branch of the fifth vein.

Distribution: Egypt; Palestine; Nyasaland.

A. mauritianus var. *paludis* (Theo.) Edw.

Hind tibia and tarsi as in var. *tenebrosus*, but third hind tarsal segment entirely white. Wing usually with pale fringe spot opposite the lower branch of the fifth vein.

Distribution. Chiefly Western: Sierra Leone; S. Nigeria; Congo. Also in British Museum collection from Tanganyika (Bukoba, Ritchie).

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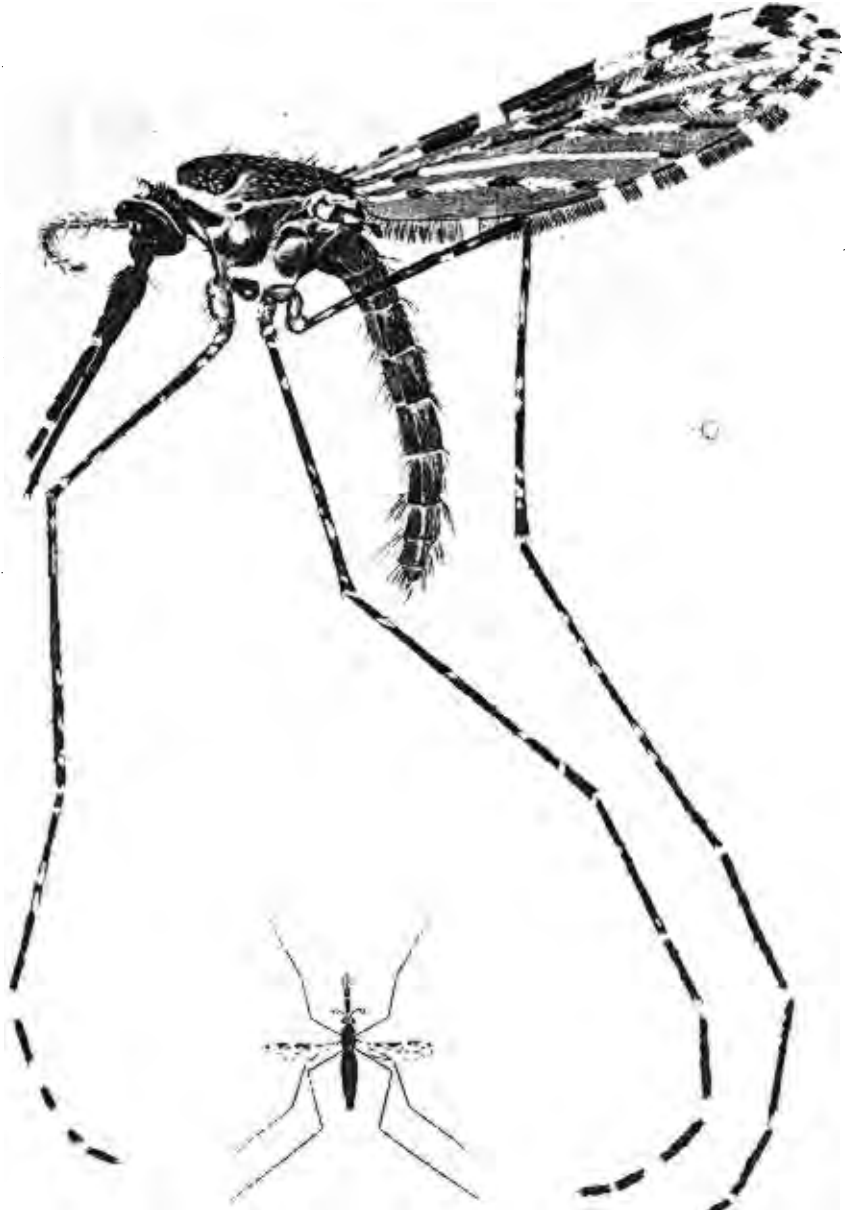
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EXPLANATION OF PLATE I

A. costalis, female ; lateral aspect. $\times c. 20$. (Left wing cut off at base ; legs and palps of right side not shown ; abdomen and hind femur foreshortened.) Drawn with camera lucida from a number of specimens. Small figure ; dorsal aspect. $\times c. 3$.



EXPLANATION OF PLATE II

Right wings $\times c. 29$. Drawn with camera lucida and under good illumination. The small figures give the appearance as seen with a hand lens.

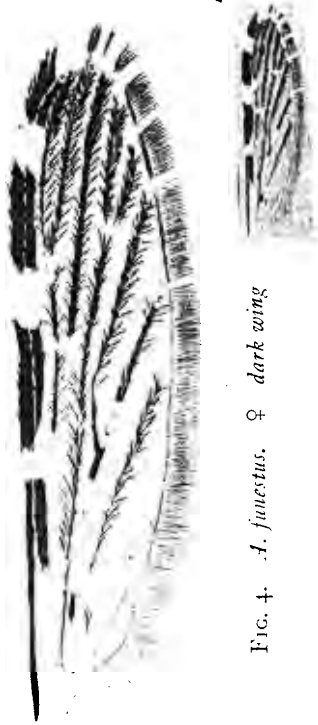


FIG. 4. *A. funestus*, ♀ dark wing



FIG. 5. *A. funestus*, ♀ wing



FIG. 6. *A. smithii*, A—♀; B—♂



FIG. 1. *A. rhodesiensis*, ♀



FIG. 2. *A. wellcomei*, ♀



FIG. 3. *A. squamosus*, ♀

EXPLANATION OF PLATE III

Right wings $\times c. 29$. Drawn with camera lucida and under good illumination. The small figures give the appearance as seen with a hand lens.



FIG. 1. *A. mauritanus*. ♂



FIG. 2. *A. pharoensis*. ♀



FIG. 3. *A. christyi*. ♂



EXPLANATION OF PLATE IV

Female palpi $\times c. 72.$



FIG. 1. *A. cinereus*



FIG. 2. *A. marshalli*, var. *freetownensis*



FIG. 3. *A. rhodesiensis*



FIG. 4. *A. aureosquamiger*



FIG. 5. *A. maculipalpis*



FIG. 6. *A. pretoriensis*



FIG. 7. *A. pharoensis*



FIG. 8. *A. mauritanus*



FIG. 9. *A. funestus*, a-typical



FIG. 11. *A. smithii*



FIG. 10. *A. funestus*, typical



FIG. 12. *A. nili*, palp and proboscis

EXPLANATION OF PLATE V

Tarsi of hind legs except where otherwise stated ; length of segments conventionalised and articulations indicated by short lines.

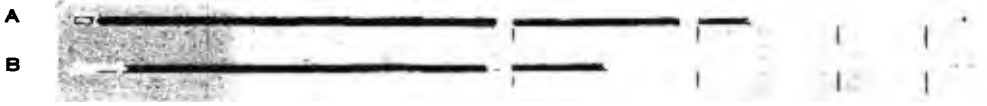


FIG. 1. *A. mauritanus*. Showing variation



FIG. 2. *A. pharoensis*. A—front; B—hind tarsus



FIG. 3. *A. squamosus*. A—front; B—hind tarsus



FIG. 4. *A. cinctus*

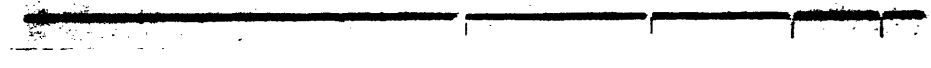


FIG. 5. *A. cinereus*



FIG. 6. *A. maculipalpis*



FIG. 7. *A. pectoriensis*



FIG. 8. *A. rufipes*. Showing variation

EXPLANATION OF PLATE VI

Figs. 1, 2 and 3. Thorax, dorsal aspect, to show scales (hairs omitted). $\times c.$ 54 diameters, showing appearance under good illumination.

Figs. 4 and 6. Last four and five segments of female abdomen, dorsal aspect, to show scales. $\times c.$ 35.

Fig. 5. Fourth and fifth segments of abdomen, dorsal aspect.
 $\times c.$ 26.



FIG. 1. *A. costalis*



FIG. 2. *A. pharoensis*



FIG. 3. *A. rufipes*



FIG. 4. *A. cristata*

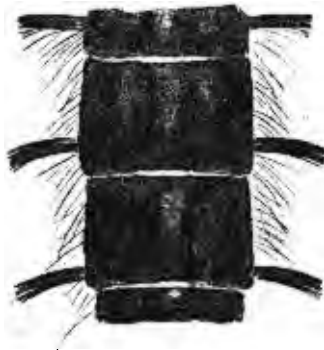


FIG. 5. *A. implexa*



FIG. 6. *A. pharocensis*

EXPLANATION OF PLATE VII

Fig. 1. Upper Shiri River, Nyasaland. The extensive stretches of Sudd on both sides form an intensive breeding place of *Anopheles funestus*.

Fig. 2. Breeding place of *Anopheles funestus*, Upper Shiri River, Nyasaland. View of the Sudd with papyrus in foreground.



FIG. 1

R. Newstead, Ph.D.

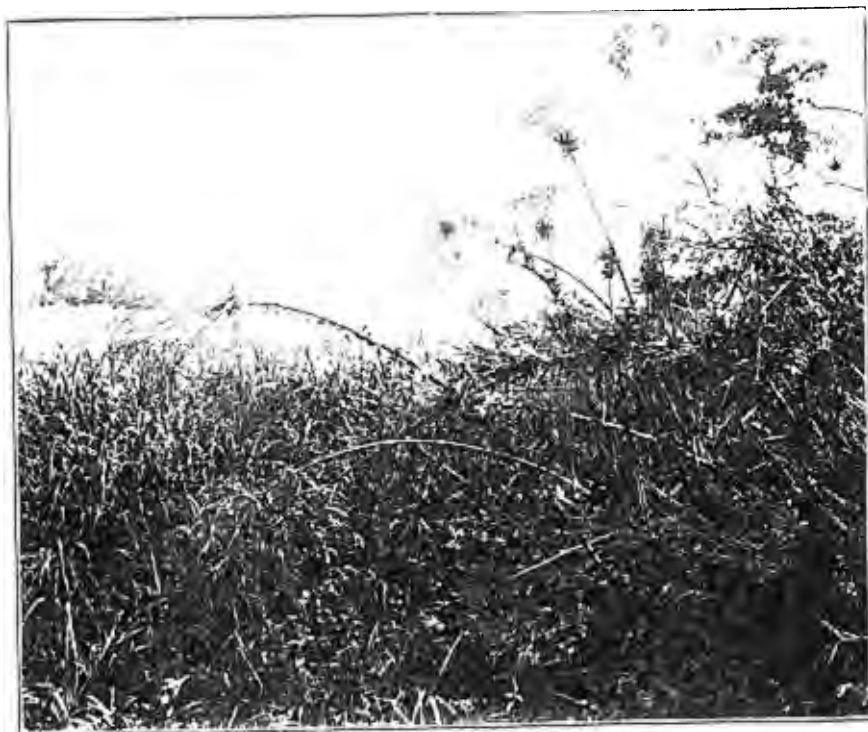


FIG. 2

R. Newstead, Ph.D.

EXPLANATION OF PLATE VIII

- Fig. 1. Breeding place of *Anopheles funestus*, Upper Shiri River, Nyasaland. View of the Sudd with *Pistia stratiotes* (water lettuce) and *Trapa bispinosa* (water caltrops) in the foreground.
- Fig. 2. Pool flooded by the sea at high tide, in which larvae of *Anopheles costalis* and *Culex thalassius* were found.

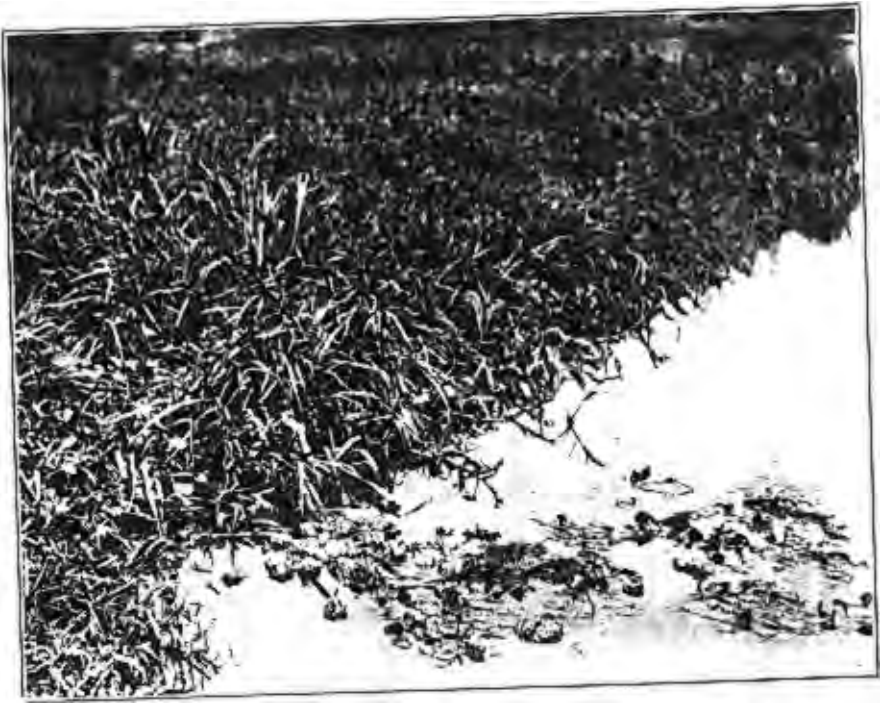


FIG. 1

R. Newstead, Photo.

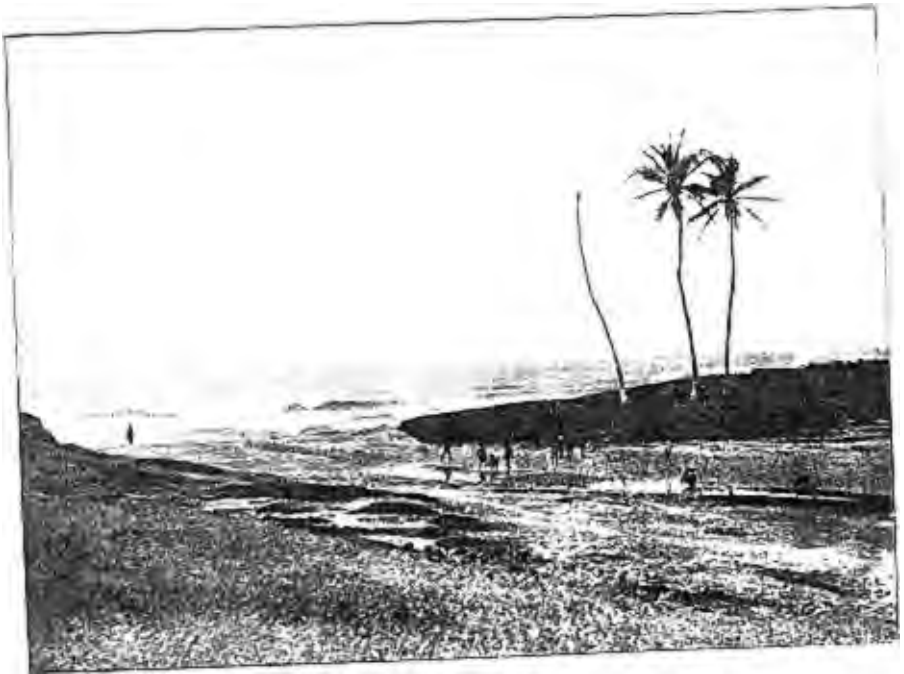


FIG. 2

Dugan & Mc... Photo.

C. Tilling & Co., Ltd., Imp.

EXPLANATION OF PLATE IX

Breeding place of *A. costalis* in Freetown. The man is standing in the water at the point at which larvae were found.



EXPLANATION OF PLATE X

Breeding place of *A. costalis* in the course of a stream flowing through Freetown. Behind the rock, in front of which the man is standing, is a pool in which larvae were found.

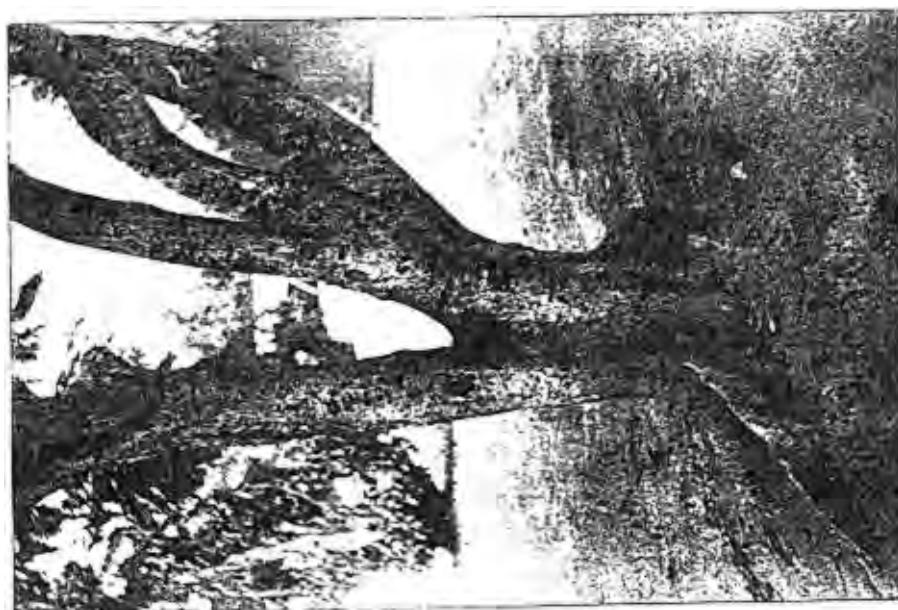


EXPLANATION OF PLATE XI

- Fig. 1. Flamboyant tree with a hole in the main fork in which were larvae of *Anopheles costalis* and *A. marshalli*, together with certain species of Culicini.
- Fig. 2. Pool covered by water-weed *Pistia stratiotes*; breeding place of *Anopheles costalis*, *A. marshalli*, *Mansonioides africanus* and other Culicini.



Ingram and Macfie, Photo.



Ingram and Macfie, Photo.

EXPLANATION OF PLATE XII

- Fig. 1. Breeding place of *A. costalis* and *A. rhodesiensis* in a town. The white arrow is pointing to a small pool from which larvae were taken.
- Fig. 2. Breeding place of *A. smithii*. The small rock-pool indicated by the arrow contained larvae of this species.
- Fig. 3. Breeding place of *A. funestus* just outside a town. The lower barb of the arrow is pointing to the floating weeds among which the larvae were found.
- Fig. 4. Breeding place of *A. rhodesiensis* and *A. costalis* in a town.



FIG. 1



FIG. 2



FIG. 3



FIG. 4