FURTHER NOTES ON THE MALE GENITALIA OF AMERICAN ANOPHELES.

By FRANCIS METCALF ROOT.

Reprinted from The American Journal of Hygiene, Vol. 4,
No. 5, 456-465, September, 1924

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(Received for publication May 2, 1924.)

Plates V–VII.

Since the publication of my previous paper on the male genitalia of American Anopheles mosquitoes (Root, 1923), I have received some new material which enables me to correct a few errors in the previous paper and give some further details regarding the " Arribalzagia " and " Nyssorhynchus " groups of species.

The first errors to be corrected lie in my descriptions of the mesosomal leaflets of *A. walkeri* and *A. pseudopunctipennis.* In my description of the male genitalia of *A. walkeri* (Root, 1923, p. 272) I said, " Mesosome long and slender, well chitinized, with three pairs of leaflets, all long and slender, first pair about twice the length of the last pair." Later Matheson and Shannon (1923, p. 64) said of the same species, " Aedoeagus narrow, elongate, strongly chitinized with four unequal rod-like leaflets at the tip." The examination of fresh material has convinced me that, in some specimens at least, four pairs of leaflets are present. Whether four or three pairs of leaflets are present, the last pair are about half the length of the first pair, while in *A. atropos,* whose genitalia, as a whole, are very similar, the last of the three pairs of leaflets is very short, only about one fifth the length of the first pair.

In my previous description of the genitalia of *A. pseudopunctipennis* (Root, 1923, p. 274), I said, " Mesosome rather short, without leaflets." In stating that no leaflets were present this description agrees with those of Howard, Dyar and Knab (1917, p. 1021, " Unci slender, columnar, short, rounded at tip ") and of Dyar (1922, p. 102, " Aedoeagus without spines at tip "). This description was based primarily on old balsam mounts from California specimens and a fresh mount from a Texas male. All of these specimens probably belonged to the form which was originally described as *A. franciscanus* McCracken. Recently I have received a number of males of *A. pseudo-*

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punctipennis from Tampico, Mexico, sent in for identification by Dr. M. E. Connor of the International Health Board field staff. Examination of a fresh mount of one of these males made me suspect that leaflets were present, but so delicate was their structure that I was unable to make out their shape or number, while studying them through the anal lobe, in an ordinary mount. Another mount was therefore prepared, with the anal lobe dissected off before mounting. In this the leaflets showed up very plainly, as shown in Fig. 1. There are two pairs of very delicate and transparent leaflets, the first pair slightly longer than the second. Both pairs are sparsely branched or toothed, the first pair on both sides, the second on one side only.

As to the previous descriptions, it seems most probable that these leaflets have been overlooked because of their transparency and their close apposition to the wrinkled surface of the anal lobe. It is barely possible, however, that no leaflets are present in the northern form (" *franciscanus* ") of the species. I have already noted (Root, 1922, p. 383) a difference in the hair of the antennal shaft in larval skins of *pseudopunctipennis* from Central America and from California, and it is always a possibility that similar variations occur in the leaflets of the mesosome.

Another error in my previous paper which should be corrected is in regard to the specimen whose genitalia I described as those of *Anopheles lutzi* Cruz (Root, 1923, p. 270 and p. 277). More careful study of this male and of the accompanying females has convinced me that they are not specimens of *A. lutzi*, nor even of any member of the " Myzorhynchella " group, but are some species of the " Nyssorhynchus " group, very close to and perhaps identical with *Anopheles braziliensis*. This leaves the male genitalia of the " Myzorhynchella " group entirely undescribed.

Now as to the " Arribalzagia " group of *Anopheles*. This group contains more described species than any other American group of the genus. In the adult stage, the wing pattern is extremely characteristic, because the areas of light scales, instead of spreading evenly, have broken up or fragmented, producing a multiplicity of small dark and light spots. In principle, this is probably the same as the process which has produced the " Neomyzomyia " group of *Anopheles* in the Old World tropics. The wing pattern of the " Arribalzagia " group may or may not also show a small amount of the admixture of light and dark scales which characterizes the Old World " Myzorhynchus " group. The easiest recognition mark for members of the " Arribal-

zagia '' group is the presence of more than three dark spots on the sixth vein, a feature found, among American *Anopheles,* only in this group and in two other, perhaps related, species.

In addition to the species listed by Dyar (1918, p. 146 ff.), *A. vestitipennis* undoubtedly belongs with this group, although I have not yet been able to examine its genitalia. The recently described *A. amazonicus* Christophers (1923) should probably also be included. The ventral scale tuft on the next to the last abdominal segment of the female, which led Christophers to assign this species to '' Myzorhynchus,'' is also present in a number of typical '' Arribalzagias,'' such as *intermedium, pseudomaculipes, punctimacula,* etc. Besides, the wing of *A. amazonicus* also shows several typical '' Arribalzagia '' features, such as the '' kink '' in the costa at the subcostal junction and the small dark spot in the same region, which were remarked upon by Christophers, the presence of four dark areas on the sixth vein, the location of a fringe spot *between* the tips of the veins instead of *at* the tips, the slight shifting of the apical costal spot toward the base of the wing, etc.

Two other South American Anophelines have more than three dark spots on the sixth vein and show some other features in common with the '' Arribalzagia '' group, although they are decidedly divergent in some other respects. These species are *A. annulipalpis* Arr. and *A. peryassui* D. and K. (= *Manguinhosia lutzi* Cruz). The genitalia of these species have not been described, and until they are brought to light it is hardly wise to attempt to determine their exact relationships.

One other species deserves mention in connection with the '' Arribalzagia '' group. *A.* (" Cyclolepteron '') *grabhamii* Theo. shows a wing pattern very similar to that of the Old World '' Myzorhynchus '' group. That is, about the degree of white spotting which is found in such a species as *A. punctipennis,* among American species, is present, though the white spots are of small extent. There is a good deal of the admixture of light and dark scales which is so characteristic of '' Myzorhynchus,'' and the wing also shows scattered '' balloon-shaped '' scales such as are found in *A. mediopunctatum* and, less distinctly, in other '' Arribalzagias.'' The larval characteristics would fit in either with '' Myzorhynchus '' or near *punctipennis.* There seem to be no resemblances to '' Arribalzagia '' in the larva. The male genitalia are, in the main, of the same type as those of

A. punctipennis. They show no features characteristic of "Myzorhynchus," and approach " Arribalzagia " only in the mesosomal leaflets, which, as is indicated in Fig. 4, do, to a certain extent, resemble some of the types seen in this group. Averaging up the characteristics of this peculiar species, it seems to me that we have in *A. grabhamii* a species which, while probably not in the main line of evolution, does nevertheless represent a stage intermediate between such a species as *punctipennis* and the " Arribalzagia " group.

The male genitalia of the " Arribalzagia " group present several very characteristic features. In my previous paper (Root, 1923) I described the genitalia of three species (*strigimacula, punctimacula, apicimacula*). Bonne (1923) has recently described the male hypopygium of *mediopunctatum,* and I have recently received males of *pseudomaculipes* and *intermedium* from Brazil, through the kindness of Dr. Mark F. Boyd of the International Health Board field staff. Descriptions of the genitalia of these two species will be found in the appendix to the present paper.

In general, the genitalia of the " Arribalzagia " group are in about the same stage of evolution as those of " Myzorhynchus." In all the primitive Anophelines the outer parabasal spine is longer and somewhat more slender than the inner one, but in " Myzorhynchus " and especially in " Arribalzagia " this length and slenderness of the outer spine is exaggerated, so that the outer spine is only about half the diameter of the inner one and about twice its length. This is well shown in the drawings in Figs. 10–14, which also show that in this respect *A. grabhamii* is closer to *punctipennis* than to either " Myzorhynchus " or " Arribalzagia." This elongation and slenderness of the outer parabasal spine, particularly the condition shown in *A. intermedium,* seems rather to suggest that this spine is in process of becoming reduced to an ordinary hair or even of disappearing altogether, which would leave something approaching the single parabasal spine of the " Nyssorhynchus " (*albimanus*) group.

From Bonne's (1923) description of the male genitalia of *A. mediopunctatum,* it would seem that this species represents a stage in this process even more advanced than that shown by *intermedium.* In Bonne's drawing, the outer spine is very hair-like and is widely separated from the inner spine, which latter seems to be inserted at the tip of a finger-like papilla, strongly reminding one of the appearance of the single parabasal spine of such a species as *argyritarsis.*

As in "Myzorhynchus," the claspette of the "Arribalzagia" group ordinarily bears on its ventral lobe a club, formed by the more or less complete fusion of three stout, clubbed spines. In both groups the dorsal lobe is ordinarily hairy and conical, bearing two or three long, hair-like spines near its apex. The most important difference between the two groups seems to be in the mesosomal leaflets. In Christophers' (1915) descriptions and figures, as well as in the two species of "Myzorhynchus" which I have been able to examine (*sinensis* and *mauritianus*), the mesosomal leaflets are of essentially the same type as in *punctipennis*, that is, they are all slender, lanceolate and rather delicate. In the "Arribalzagia" group, on the other hand, the first pair of leaflets in unusually broad, and sometimes very long, as well, while the other pairs are shorter and even more slender than usual, often almost linear. The number of pairs and the length of the leaflets varies considerably in the different species, as shown in Figs. 5–9, and these types seem to be very constant in the small number of mounts whch I have been able to examine. The relative length of the first and last pairs of leaflets seems to be a particularly valuable character.

In *strigimacula*, the first pair of leaflets might be considered to be in process of assuming the form of the other pairs. The heavily chitinized portion of this pair of leaflets is slender and somewhat linear, much like the second pair. But this chitinous rod serves to support a broader and more membranous portion, thus somewhat resembling the mid-rib of a leaf. In *mediopunctatum*, according to Bonne's drawing, there seems to be only a single pair of leaflets. This, like the parabasal spines of this species, might be looked upon as a tendency toward the "Nyssorhynchus" type. It is, of course, possible, that this author failed to represent one or more pairs of the slender linear leaflets which may have been present.

In the "Nyssorhynchus" group, the male genitalia are very similar in all the species. As was first noted by Miss Evans (1921), *A. argyritarsis* is sharply set off from the other members of the group by the presence of a single pair of mesosomal leaflets. And, as pointed out in my previous paper (Root, 1923), *A. albimanus* and *A. braziliensis* may be distinguished by the fused dorsal lobes of the claspette ("median lobe" of Miss Evans). At the time I wrote that paper, I had studied only a single balsam preparation of the genitalia of *A. tarsimaculata*, and in that I could find no difference between that species and *albimanus*. Recently I received a number

of males of *tarsimaculata* from Brazil, through the generosity of Dr. Mark F. Boyd, and a study of fresh preparations in alcohol shows that *tarsimaculata* is a very distinct species, having the fused dorsal lobes of the claspette drawn out into two large hairy lobes at the tip, while the fused dorsal lobes and their "bladder-like expansions" in *albimanus* are entirely bare. (See Figs. 15 and 16.) Evidently the specimens from Venezuela described as *albimanus* and *tarsimaculata* by Miss Evans must all have belonged to the latter species, since she describes the "median lobes" of both species as identical and hairy. With the cooperation of Dr. H. G. Dyar, a number of males from Panama, labelled *A. albimanus* in the collections of the U. S. National Museum, have been examined, and while a majority of these showed the typical bare "bladders" seen in Porto Rican *albimanus,* there were also several specimens which had hairy lobes, exactly as in Brazilian *tarsimaculata.* No intermediate forms were found. It would seem, then, that *albimanus* and *tarsimaculata* are distinct species, the latter of which may occasionally assume the palpal coloration usual for the former. While the exact distribution of the two species will have to be worked out anew on the basis of this, apparently constant, genitalic difference, it seems likely that the distribution is correctly stated in Howard, Dyar and Knab's Monograph (1917, p. 978).

"*A. tarsimaculata* occurs in tropical and sub-tropical South America east of the Andes, in the Lesser Antilles, and extends northward over the Isthmus of Panama to eastern Nicaragua. It is only from Panama northward that *tarsimaculata* and *albimanus* occur together, the latter species extending southward from Panama only on the western side of the Andes. . . . We have examined many specimens from Cuba, St. Domingo, Jamaica and Porto Rico and found them to be invariably *albimanus.*"

If this proves to be correct, it is to be expected that Brazilian specimens of "*albimanus*" will prove to be aberrant *tarsimaculata,* like Miss Evans' specimens from Venezuela.

In recent years a number of new species belonging to the "Nyssorhynchus" group have been described by Brazilian scientists, usually being placed by the describers in the Theobaldian "genus" Cellia. Specimens of two of these were included in the material which Dr. Boyd sent me. After careful study of a series of mounts, I can find no genitalic differences between *A. allopha* Lutz-Peryassu and *A. argyritarsis,* nor between *A. oswaldoi* Peryassu and *A. tarsi-*

maculata. The differential characters ascribed to the adult female are such as are known to be subject to variation in these and the related species (absence of lateral abdominal scale-tufts in *A. allopha* and greater extent of white markings on hind tarsi and palpi in *A. oswaldoi*). It seems logical, therefore, to relegate these two names to the synonymy of *A. argyritarsis* and *A. tarsimaculata*, respectively.

APPENDIX.

Descriptions of the male genitalia of *A. pseudomaculipes*, *A. intermedium* and *A. tarsimaculata*.

A. pseudomaculipes Chagas. Described from a single male from Rio de Janeiro, Brazil.

Sidepiece 1¾ times as long as wide, with many scales along outer side.

Parabasal spines two, the outer arising from a small papilla, the inner from a large papilla situated on a large, heavily chitinized prominence. Outer spine very long and slender, almost straight; inner spine about half the length and twice the diameter of outer, hooked at tip. Internal spine of sidepiece long, slender, curved.

Clasper about 1⅓ times as long as sidepiece, with three or more minute papillated hairs on outer side just before apex in addition to the usual internal row. Apical claw short and stout.

Claspette—ventral lobe heavily chitinized, bearing a club, formed by the more or less complete fusion of three stout, clubbed spines.

—dorsal lobe forming a conical prominence covered with minute non-papillated hairs and bearing at its tip one long stout spine and two somewhat shorter slender spines.

Mesosome rather stout, with two pairs of leaflets. The terminal pair are long and flattened, sharply pointed at tip. The other pair are about ⅔ as long as the first pair and very slender.

Processes of ninth tergite very short and slightly clubbed.

Anal lobe hairy.

A. intermedium Chagas. Described from a single male from Rio de Janeiro, Brazil.

Sidepiece 1½ times as long as wide, with many scales along outer side.

Parabasal spines two, the outer arising from a small papilla, the inner from a large papilla situated on a large prominence. Outer spine extremely long and slender, almost straight, inner spine about half the length and more than twice the diameter of outer, hooked at tip.

Clasper about 1⅓ times as long as sidepiece, with about three minute papillated hairs on outer side near apex in addition to the usual inner row. Apical claw short and stout.

Claspette—ventral lobe heavily chitinized, bearing a short, stout club, formed by the more or less complete fusion of three stout, clubbed spines.

—dorsal lobe forming a conical prominence covered with minute hairs and bearing near its apex one long stout spine and two shorter, slender ones.

Mesosome long and rather stout, with three pairs of leaflets. Terminal pair of leaflets short and flat, other two pairs shorter and very slender. Last pair about two-thirds as long as terminal pair.

Processes of ninth tergite very short, conical.

Anal lobe hairy.

A. tarsimaculata Goeldi. Described from four males from Rio de Janeiro, Brazil and one from Panama.

Sidepiece over twice as long as wide, with numerous scales.

Parabasal spines one, short, stout and straight, arising from a papilla at the end of an inwardly directed, finger-like prominence. Two accessory spines on a prominence almost halfway between base and apex of sidepiece, both long, stout and hooked at tip. Internal spine long, slender, almost straight.

Clasper about as long as sidepiece, with a single, rather long, papillated hair on outer side just before apex, in addition to the usual inner row. Apical claw long and slender.

Claspette—ventral lobe a stout projection carrying at its tip three flattened, ribbon-like spines, which curve ventrally and outwardly around the edge of the anal lobe.

—dorsal lobes fused into a median membranous structure, about as long as the mesosome, which is slender at its base, but swells out dorsally at its tip, forming a flat sloping area, divided into two lobes along the dorsal margin. In the median line of this area lies a groove, running from the depression of the very slightly bilobed tip, or ventral margin, to the deep indentation dividing the two lobes of the dorsal margin. Bordering this groove on either side are wrinkled ridges which extend dorsally into the lobes near their inner margins. The outer slopes of these ridges and the rest of the area lying outside them are thickly covered with hairs, which are short except along the margins of the lobes, where they are rather long. The inner slopes of those portions of the ridges which extend into the lobes also bear numerous long hairs.

Mesosome rather short and stout, slightly swollen at tip, without leaflets.

Processes of ninth tergite absent.

Anal lobe hairy at base.

Literature cited.

BONNE, C.
1923. The male hypopygium of *A. mediopunctatus*. Tijdsch. v. Ent., LXVI, pp. 115–117.

CHRISTOPHERS, S. R.
1915. The male genitalia of Anopheles. Ind. Jour. Med. Res., III, pp. 371–394.
1923. An Anopheles of the Myzorhynchus group (*Anopheles amazonicus*, n. sp.) from South America. Ann. of Trop. Med. and Parasit., XVII, pp. 71–78.

DYAR, H. G.
1918. Notes on American Anopheles. Ins. Insc. Menstr., VI, pp. 141–151.
1922. The mosquitoes of the United States. Proc. U. S. Nat. Mus., LXII, pp. 1–119.

EVANS, A. M.
1921. Notes on Culicidae collected in Venezuela. Ann. of Trop. Med. and Parasit., XV, pp. 445–454.

HOWARD, L. O., DYAR, H. G. AND KNAB, F.
1917. The mosquitoes of North and Central America and the West Indies. Vol. IV. Carnegie Inst. of Washington. Publication 159.

MATHESON, R. AND SHANNON, R. C.
1923. The Anophelines of northeastern America. Ins. Insc. Menstr., XI, pp. 56–64.

PERYASSU, A. G.
1921. Os Anophelineos do Brasil. Arch. Mus. Nac. Rio de Janeiro., XXIII, pp. 9–104.

ROOT, F. M.
1922. The larvae of American Anopheles mosquitoes. Am. Jour. Hyg., II, pp. 379–393.
1923. The male genitalia of some American Anopheles mosquitoes. Am. Jour. Hyg., III. pp. 264–279.

Legends for Figures.

FIGS. 1 TO 9. Mesosomal leaflets of various species of Anopheles.
Fig. 1. *A. pseudopunctipennis.*
Fig. 2. *A. punctipennis.*
Fig. 3. *A. mauritianus.*
Fig. 4. *A. grabhamii.*
Fig. 5. *A. punctimacula.*
Fig. 6. *A. strigimacula.*
Fig. 7. *A. apicimacula.*
Fig. 8. *A. pseudomaculipes.*
Fig. 9. *A. intermedium.*

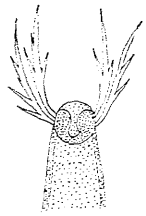
FIGS. 10 TO 14. Parabasal spines of various species of Anopheles.
Fig. 10. *A. punctipennis.*
Fig. 11. *A. grabhamii.*

Fig. 12. *A. mauritianus.*
Fig. 13. *A. pseudomaculipes.*
Fig. 14. *A. intermedium.*

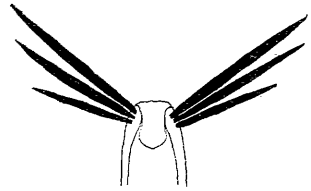
FIGS. 15 AND 16. Fused dorsal lobes of claspette, seen in dorsal view, of *A. albimanus* and *A. tarsimaculata.*

Fig. 15. *A. albimanus.*
Fig. 16. *A. tarsimaculata.*

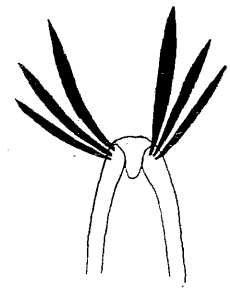
PLATE V.



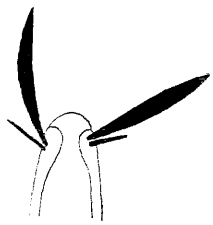
1.
pseudopunctipennis



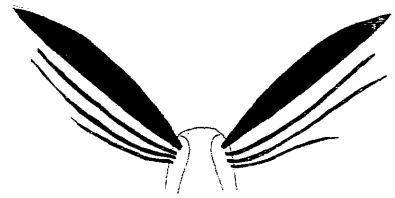
2. punctipennis



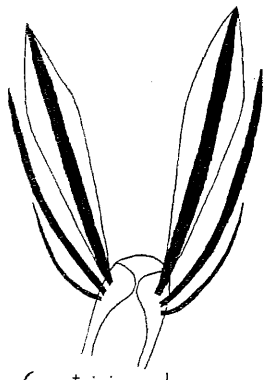
3. mauritianus



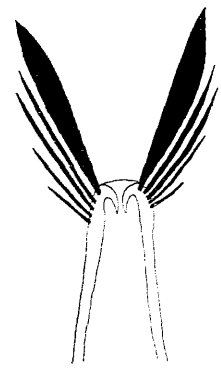
4. grabhamii



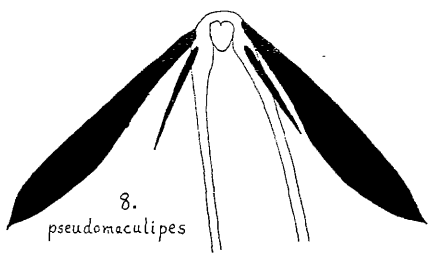
5. punctimacula



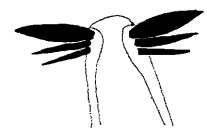
6. strigimacula



7. apicimacula



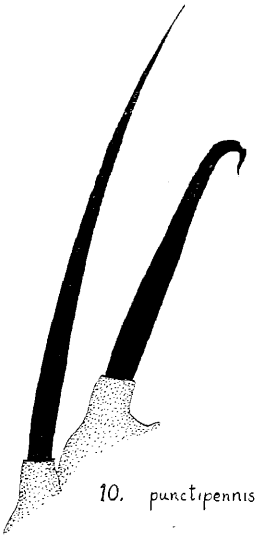
8.
pseudomaculipes



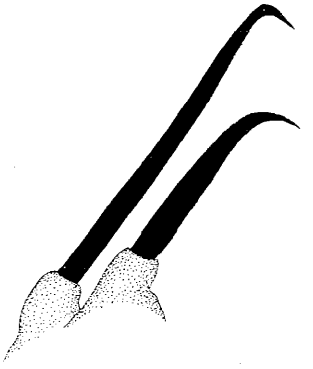
9. intermedium

Root, Francis Metcalf. Further notes on the male genitalia of American Anopheles.

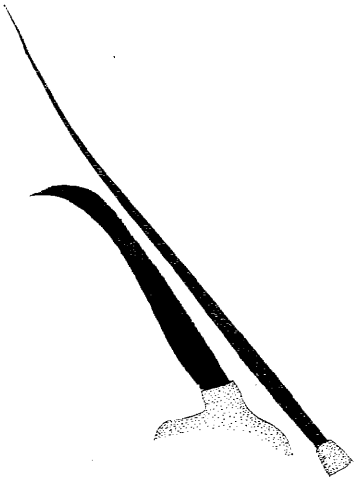
PLATE VI.



10. punctipennis

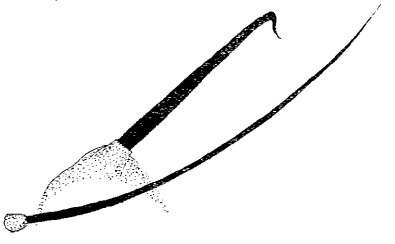


11. grabhamii



12. mauritianus

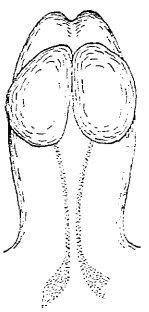
13. pseudomaculipes



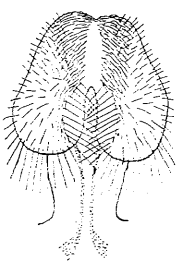
14. intermedium

Root, Francis Metcalf. Further notes on the male genitalia of American Anopheles.

PLATE VII



15. albimanus



16. tarsimaculata

Root, Francis Metcalf. Further notes on the male genitalia of American Anopheles.