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The female terminalia of the Aedes mosquitoes occurring in New England.

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THE FEMALE TERMINALIA OF THE *AEDES* MOSQUITOES OCCURRING IN NEW ENGLAND

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CONTENTS

INTRODUCTION

The mosquitoes, because of their medical and economic importance, have been intensively studied. Certain problems, however, among them the structure of the female terminalia and their use for species identification, have not been thoroughly investigated.

The females of closely related mosquito species with their nearly identical appearance are difficult to distinguish. Their identification is presently based on setal arrangement and on scale pattern and color. For this purpose, perfect or nearly perfect specimens are required. Such specimens are, however, infrequently encountered in field-collected material since scales and bristles may often be rubbed off in collecting, and aging individuals are usually rubbed and weather-beaten by the time they are collected. Furthermore, it is not possible to use the standard procedure of identifying the females by association with the more easily identified males because the two sexes are rarely collected together. Even if males and females were collected together, association would be unreliable, especially in Aedes, because several species are usually present in a given area. Therefore, it is important to search for characters of value for direct identification of female specimens.

Preliminary investigation of the literature indicated that at least limited use could be made of the female terminalia for identification purposes. This paper includes the results of an anatomical study of the terminalia of twenty-three Aedes species occurring in New England and the author's conclusions as to the value of female terminalia for species

identification. Of the twenty-three species studied in this paper, the female terminalia of eight have not previously been described or examined for species differentiation.

REVIEW OF THE LITERATURE

Female terminalia have been little used in taxonomic work on mosquitoes. They have been studied, for the most part, for generic and subgeneric differences, but seldom for specific differences. The terminalia were first referred to by Howard, Dyar, and Knab (1912). These authors included a description of some of the structures and an explanatior of the form of the genitalia in relation to the mode of oviposition of the various genera. There were no illustrations, nor were the structures named.

Waterson (1918) illustrated the female genitalia of three mosquito species in lateral view, but he did not include an explanation of the illustrations, nor did he attempt to identify the structures.

The works of Brolemann (1919,1920), Macfie and Ingram (1922), and Davis (1926) were reviewed by Gerry (1932) and by Coher (1949). The earlier authors failed to draw out the retracted portions of the terminalia, and thus they did not study the ninth tergite and the atrial area. They did, however, make observations of generic and some subgeneric value for the material they studied.

Christophers (1925), in a histological study of the development of culicid female genitalia, first applied to the structures the names that have been used in subsequent descriptive work. His views concerning the homologies of the structures will be discussed in another section.

Gomperts (1924), in a study of the anophelines of the Netherlands Indies, included rough sketches of several species.

Freeborn (1926) included a short general discussion of the female terminalia and illustrated six species of California Aedes and one of Culiseta. His sketches indicate that he did not draw out the genitalia for complete examination.

Gerry (1932) studied nineteen species in eight genera of Cuban mosquitoes, including five species of Aedes. He based his morphological study on a phylogenetic examination on a series of Diptera and their mecopteran ancestors. Gerry extended the terminalia so that the sigma and insula could be closely studied, but his drawings, at least of the Aedes, are of questionable value, differing in detail from those of later authors. Gerry's interpretations will be discussed later.

Barraud (1934) illustrated the terminalia of fifteen species of the subgenus Aedes in India and included them in his discussion of the group.

Gjullin (1937), in his study of the Aedes of the Pacific Coast States, was the first to concentrate on a single genus in a specified area. He studied twenty species and constructed a key to separate six of them. The others were placed in two groups, one of ten species and the other of four. In his descriptions he included the ranges of variation in the grouped species. Gjullin's illustrations, unfortunately, are rather confusing. He has shown all the structures in ventral view, and, in so doing, has misplaced some of them. An example is his location of the dorsal cerci and ninth tergite. His illustrations show them located ventrad of the cowl and the anal membrane.

Marshall (1938) showed that the females of Aedes cinereus and A. geniculatus could be separated from other British Aedes by the relatively large eighth sternite, and from each other from the shape of the cerci. The cercal character is one that is still valid for separating the subgenus Finlaya

from the other subgenera. Marshall's illustrations indicate that he withdrew the genitalia, but he apparently did not study them in detail.

Edwards (1941) used the female terminalia to separate genera, subgenera, and, in a few cases, species of the African fauna. He thought it probable that female genitalia could be used for classification more than they had been previously. His illustrations tend to be sketchy, but they do show differences useful in generic diagnoses. Edwards' interpretation of the structures will be discussed later.

Taylor (1954) included a diagram showing genitalic structures, but went no further, noting that " ... there is practically nothing specific, so far as yet ascertained, about the female genitalic characters ...".

Roth (1946) separated the three U.S. species of Wyeomyia by female genitalia. He presented a key, illustrations, and descriptions which very nicely show the differences between the three species.

Ross (1947) distinguished the genera and, in Aedes, the subgenera using female genitalia. He illustrated twenty species of mosquitoes in various views, but he did not study the atrial area. He constructed a key for the genera and for the subgenera of Aedes, but not for the included species.

Coher (1949) investigated the female genitalia of certain mosquitoes for generic consideration. His material was neotropical except for two Aedes species which occur in Western North America. He concluded that the female terminalia of the mosquitoes he studied exhibited characters distinct for each, but that closely related species exhibited few or no differences in the female terminalia. His interpretations of the ventral structures will be discussed later.

La Casse and Yamaguti (1950) described the generic and subgeneric differences for Anopheles, Uranotaenia, Tripteroides, Armigeres,

Orthopodomyia, Mansonia, Culex, and Aedes. They did not describe the specific characters because they were " ... unable to detect any definite specific or subspecific differences." They illustrated the terminalia of many species but the illustrations lack certain details indicating that the terminalia were not drawn out sufficiently for close study.

Rees and Onishi (1959) studied both male and female terminalia in Culiseta inornata. They show the structures of the female genitalia both disarticulated and as a unit.

Hara (1957,1958) observed the terminalia of fifty species of Japanese mosquitoes in ten genera. He included in his papers short descriptions and illustrations for each species. His methods, however, did not allow him to study the atrial area in detail. He did not extend the genitalia, but rather he merely cleared the terminal segments and mounted them on slides as they were. His drawings were based on camera-lucida sketches, and the manner in which the structures are pictured indicates that Hara did not see them clearly.

Belkin and Hogue (1959) found certain characters of value at the species level in Deinocerites even though they did not study the female terminalia in detail. They used the outstanding external characters in their key to the species, and they indicated that further study should reveal differences other than the ones they had found.

Belkin's (1962) treatment of the South Pacific fauna is the most recent work known to me that refers to female terminalia. He discussed tribal characters but did not study the genitalia in detail.

METHOD OF PREPARATION AND STUDY

In order to evaluate the characters of the female terminalia, as many specimens of each species were studied as were obtainable. The species selected are included in Smith's (1958) key to the *Aedes* females of New England. She records twenty-five species of which two are not considered in this paper. *A. grossbecki* is a rare southern species, specimens of which were not available for me to study, and *A. implicatus* is a northern species of doubtful occurrence in New England. The material examined consisted of collected specimens determined by mosquito specialists and specimens reared from larvae when such were available. Questionably identified individuals were checked by Dr. Marion E. Smith.

The terminalia were clipped from the abdomen at the anterior end of the seventh segment. It was not necessary to relax the specimen, but care had to be taken to avoid breaking the remainder of the abdomen away from the thorax. The terminalia were then placed in cold 10% KOH where they remained for the shortest period of time necessary to disolve the internal material without removing the pigment from the delicate structures. The time ranged from one to three hours, or occasionally longer. The preparation was rinsed in distilled water and then put into distilled water to which a small amount of acetic acid had been added in order to stop the action of the KOH. It was again put into distilled water and the terminalia were drawn out of the sheath formed by the seventh segment. The segments were split along the pleural membrane, and the membrane between the eighth segment and the

genitalia was partially dissected. Because the genitalia are so small and might get lost, they were not cut free of the eighth segment until they were ready to be mounted on slides. The terminalia were stained in acid fuchsin when necessary. They were studied under the dissecting microscope in glycerine so that they would be held in a relatively stable position by the viscous liquid but could still be repositioned easily.

The terminalia were mounted on slides for the study of minute structures and setae using the compound microscope. They were positioned ventral side up with the insula folded forward when this was possible. Cellosolve was the clearing agent and Canada balsam the mounting medium.

Unmounted material was stored in vials containing a small amount of cellosolve.

THE STRUCTURE OF THE CULICID TERMINALIA: MORPHOLOGY AND TERMINOLOGY (Fig.1)

The modified parts of the female abdomen are the eighth, ninth, and tenth segments. The eighth segment is narrower than the seventh and is retractable within it. It is made up of a small tergite and a larger sternite, the subgenital plate. The ninth and tenth segments are clearly represented dorsally, the ninth by a single tergal sclerite, the tenth by the cerci, the anal membrane, and the membrane surrounding the bases of the cerci. Ventrally, however, the representation of these two segments is subject to different interpretations as will be shown in subsequent discussion.

The postgenital plate (PGP), so named because it is located posterior to the atrium (AT) or genital opening, is a lobe projecting from the rim of the atrium. It is free apically and fused basally to the posterodorsal arc of the atrial rim. Continuous basilaterally with the postgenital plate is the cowl (CL), a membranous area that extends laterally to the margin of the ninth tergite and posteriorly to merge with the anal membrane (AM).

The atrium, located ventrally between the eighth and ninth segments, is surrounded by a sclerotized rim called the sigma that somewhat resembles the curved metal rim of a partly opened lady's clasp purse. Both arcs of the sigma are directed posteriorly as a circle folded back on itself. The ventral arc or anterior sigma (AS) is less heavily sclerotized than the dorsal arc or posterior sigma (PS) and expands medially into a tongue-like area called the insula (IN).

There is some confusion in the literature concerning the segmental interpretation of the ventral structures of the genitalia and the terminology

applied to them. Christophers (1923) was the first to apply names to the structures. He speculated that the postgenital plate might be the ninth or tenth sternite, or perhaps not segmental at all. He interpreted the cowl as continuous with the anterior portion of the postgenital plate and the sigma as the anterior rim of the atrium.

Gerry (1932) agreed with Christophers' definition for the sigma. He said, however, that the narrow base of the postgenital plate is fused to the posterior margin of the ninth sternite, and thus interpreted the posterior rim of the atrium as the ninth sternite and the postgenital plate as the fused tenth and eleventh sternites. Gerry's cowl is the area " ... intervening between the base of the postgenital plate and the posterior margin of the ninth sternite".

Gjullin (1937) followed Gerry's interpretation that the postgenital plate consists of the tenth and eleventh sternites. He also called the anterior rim of the atrium the sigma and the posterior rim the ninth sternite.

Edwards (1941) assumed the genital opening to be located between the ninth and tenth sternites. On this basis he designated the insula as representing the true ninth sternite. He called the anterior rim of the atrium the sigma and restricted the cowl to the posterior rim. Edwards followed Gerry's interpretation of the postgenital plate as the fused tenth and eleventh sternites, the evidence of fusion being a slight constriction at about half the distance from base to apex.

Crampton (1942), in his discussion of the morphology of female terminalia in the Diptera, indicated that the atrium is located between the eighth and ninth sternites. He based his findings on phylogenetic studies of the Diptera and their mecopteran ancestors. Crampton referred to the

anterior rim of the atrium as the preatrial sclerite belonging to the eighth sternite, and the posterior rim as the postatrial sclerite belonging to the ninth sternite. He noted Gerry's interpretation that the postgenital plate may contain the tenth and eleventh sternites, but did not render an opinion.

Coher (1949) rejected Edwards' interpretation of the sternal portion of the terminalia. He based his rejection on Crampton's phylogenetic studies and reverted to Christophers' designations with a few modifications. Coher termed the portion of the posterior rim of the atrium just anterior to the postgenital plate the anterior cowl. The remainder of the atrial rim he called the sigma, using Christophers' (1923, p. 704) illustrations as the basis for his terminology. The membranous area continuous basilaterallywith the postgenital plate was called the posterior cowl, thus further delimiting Christophers' term. The remaining lateral portions of the posterior rim of the atrium were termed the posterior sigma; the anterior rim the anterior sigma.

Snodgrass (1959) said that the postgenital plate " ... looks as if it should be the projecting sternum of the ninth segment". He interpreted the entire rim of the atrium as the sigma based on Christophers (1923). He noted other authors' interpretations of the " ... dorsal arc of the sigma as the ninth sternum", indicating that they did so without specific evidence. Snodgrass cited Christophers' finding the structure of the atrial rim to be " ... formed as a sclerotization on the intersegmental membrane of the gonotreme" opening of the atrium. He also warned of confusion in the ways that earlier authors had interpreted and named the parts of the terminalia.

I have chosen to follow Snodgrass' interpretation of the terminalia in the interest of simplicity of terminology. I do feel, however, that Coher's designations of anterior sigma and posterior sigma are appropriate for des-

criptive purposes, the difference between Snodgrass' and Coher's interpretations being in the extent of the posterior sigma. Whether or not Coher's anterior cowl is morphologically correct, it is difficult to use in descriptions because there are no limits to separate the anterior cowl from the lateral arms of the posterior sigma.

The Genus *Aedes* Meigen, 1818.

Syst. Beschr. Bek. Eur. Zweifl. Ins. 1:13.

The terminalia of the *Aedes* females are characterized by a shield-shaped, posteriorly bilobed ninth tergite and a hood-like or domed anal membrane. In the closely related genus *Psorophora* the ninth tergite is greatly elongated and narrow, and the anal membrane is a narrow concave strip. The supporting characters for *Aedes* also apply to *Psorophora* and are summarized below:

Cerci flattened, leaflike, extending beyond postgenital plate. *Postgenital plate* elongate, free apically, with basilateral margins often distinct. *Posterior sigma* heavily sclerotized, ribbon-like, arched, sometimes with posterolateral shoulders dilated, lacking atrial plates. *Anterior sigma* lightly sclerotized, ribbon-like, expanded medially into a broad, tongue-like insula which usually bears groups of long setae. *Ninth tergite* bilobed posteriorly, the lobes bearing setae. *Eighth tergite* subtruncate posteriorly. *Eighth sternite* convex, bilobed, or emarginate posteriorly.

KEY TO THE FEMALE TERMINALIA OF THE AEDES OCCURRING IN NEW ENGLAND

1. Cerci extending but little beyond apex of postgenital plate (Finlaya) 2

   Cerci extending about half their length beyond postgenital plate 3

2. Postgenital plate broad, subquadrate (Fig. 2) .... atropalpus (pg. 16)

   Postgenital plate narrow, tapering to apex (Fig. 3) triseriatus (pg. 17)

3. Apical margin of eighth sternite with a deep median U-shaped indentation; postgenital plate with apex deeply notched (Aedimorphus) (Fig. 4) .... vexans (pg. 18)

   Apical margin of eighth sternite with only a shallow median indentation, or none; postgenital plate with apex straight, or shallowly emarginate 4

4. Eighth segment with basal two-thirds membranous, the terminalia capable of being only partially retracted into seventh segment (Taeniorhynchus) 5

   Eighth segment wholly sclerotized, the terminalia capable of being only partially retracted into seventh segment 6

5. Postgenital plate about as broad as the cerci, subtruncate to emarginate apically (Fig. 5)..... sollicitans (pg. 19) and mitchellae (pg. 20)

   Postgenital plate about three-fourths the width of the cerci, shallowly emarginate apically (Fig. 6)..... taeniorhynchus (pg. 20)

6. Eighth sternite with posterior margin sinuate; insula without long submedian setae (Aedes) (Fig. 7) ..... cinereus (pg. 21)

   Eighth sternite with posterior margin convex or emarginate, but never sinuate; insula bearing two groups of two to four long submedian setae 7

7. Ninth tergite with posterior lobes angulate, obtuse; eighth sternite shallowly and broadly emarginate (Feltianus) (Fig. 8) trichurus (pg. 22)

   Ninth tergite with posterior lobes broadly rounded; eighth sternite with posterior margin convex or slightly emarginate (Ochlerotatus) 8

8. Posterolateral shoulders of posterior sigma dilated (Fig. 9) .....

Posterolateral shoulders of posterior sigma not dilated (Fig. 10) .....

Range of Setal Counts on
communis and intrudens Groups

Table A - communis Group

Species	Number of specimens	Setae per lobe of ninth tergite	Subspical setae on postgenital plate
communis	14	7 - 10	11 - 13
abserratus	10	6 - 12	10 - 17
canadensis	13	4 - 6	13 - 15
cantator	8	5 - 7	8 - 10
excrucians	13	7 - 10	18 - 24
fitchii	4	10 - 14	12 - 17
punctor	12	4 - 6	11 - 13
sticticus	5	7 - 10	7 - 10
stimulans	40	4 - 8	8 - 10
trivittatus	5	6 - 8	5 - 8

Table B - intrudens Group

intrudens	6	8 - 10	8 - 10
aurifer	16	8 - 13	11 - 13
decticus	6	4 - 5	11 - 13
diantaeus	3	7 - 10	13 - 15
dorsalis	3	4 - 7	6 - 8

Aedes (Finlaya) atropalpus (Coquillett), 1902.

Fig. 2.

Can. Ent. 34:292.

References: Ross (1947, fig. 161 A, B).

Description: Cerci extending but little beyond postgenital plate, blunt. Postgenital plate broad, apex varying from subtruncate to moderately emarginate, apical corners rounded, each bearing a prominent seta, with numerous small subapical setae. Posterior sigma folded posterolaterally so the shoulders appear pointed, with the lateral arms short and convoluted. Insula bearing two groups of three to four submedian setae. Ninth tergite reduced, represented by two weakly sclerotized lobes bearing no setae. Eighth sternite more heavily sclerotized than tergite, with posterior margin convex.

Specimens examined: Loudville, Mass., May 1963 (V.A.Nelson), 15 (reared from larvae and pupae).

Discussion: Ross did not show the details of the atrial area, nor did he include a description. His illustrations, however, agree with my observations of this species.

Aedes (Finlaya) triseriatus (Say), 1823.

Fig. 3.

J. Acad. Nat. Sci. Phila. 3:12.

References: Ross (1947, fig. 160 A, B).

Description: Terminalia laterally compressed, higher than wide. Cerci extending but little beyond postgenital plate, blunt apically. Postgenital plate narrow, tapering, rounded apically, bearing numerous setae. Cowl continuous with postgenital plate to about two-thirds the distance from the apex. Posterior sigma broad, U-shaped, the lateral arms each with a sharp projection pointing mesad. Insula bearing two groups of three submedian setae. Ninth tergite with a deep median posterior notch and a flaring median anterior notch, with posterior lobes tapering, each bearing four to six setae. Eighth sternite with posterior margin shallowly and broadly emarginate.

Specimens examined: Cape Cod, Mass., early June 1943, 3; Vineland, New Jersey, 1948 (M.E.Smith), 1; Halifax, Mass., August 1963 (A. Main), 2.

Discussion: Ross did not show the details of the atrial area, nor did he include a description. His illustrations, however, agree with my observations of this species.

Aedes (Aedimorphus) vexans (Meigen), 1830.

Fig. 4.

Syst. Beschr. Zweifl. Ins. 6:241.

References: Gjullin (1937, fig. 14); Ross (1947, fig. 159 A, B); Hara (1957, pl. 48).

Description: Cerci tapering very slightly to a rounded apex. Postgenital plate with a deep median apical notch, bearing two pairs of apical setae, one dorsal, one ventral, and six to eight shorter subapical setae. Cowl continuous with postgenital plate to about one-third the distance from the apex. Posterior sigma with lateral shoulders dilated. Insula long, tongue-like, folded at about the middle, without long submedian setae. Ninth tergite bilobed apically, bearing seven to fourteen setae per lobe. Eighth sternite with a deep U-shaped median indentation in posterior margin.

Specimens examined: Cape Cod, Mass., August, September 1940 (R. L. Armstrong), 6; Amherst, Mass., 15 October (V. A. Nelson), 1.

Discussion: Gjullin counted five to six setae per lobe on the ninth tergite for the Pacific Coast fauna; Hara found four setae per lobe in the Japanese A. vexans nipponii; my counts ranged from seven to fourteen in the New England material. Hara stated that the North American form of A. vexans has two pairs of setae on the insula. Neither Gjullin nor I found this to be true. Ross illustrated the terminalia of this species, but did not include a description. His figure shows the apical notch on the postgenital plate to be shallower than was observed by Gjullin, Hara, and me.

Aedes (Taeniorhynchus) sollicitans (Walker), 1856.

Fig. 5.

Ins. Saund., Dipt. p. 427.

References: Ross (1947, fig. 164 A, B); Gerry (1932, figs. 9, 10).

Description: Cerci with outer margin rounded, inner margin more nearly straight, rounded apically. Postgenital plate about as broad as cerci, subtruncate to emarginate apically, bearing two pairs of strong apical setae, one dorsal, one ventral, and eight to ten smaller subapical setae. Cowl continuous with postgenital plate to about one-fourth the distance from the apex. Posterior sigma with posterolateral shoulders dilated. Insula bearing two groups of two submedian setae. Ninth tergite bilobed posteriorly, each lobe bearing six to eight setae, with large subquadrate notch anteriorly Eighth sternite bilobed posteriorly, with basal two-thirds membranous except for bases of setae, apical third sclerotized. Eighth segment mostly membranous, capable of being completely retracted into seventh.

Specimens examined: Ocean Park, Me., 2 September 1962 (V. A. Nelson), 4; Cape Cod, Mass., 6.

Discussion: Gerry noted a constriction and posterior expansion on the postgenital plate which were not evident in Ross' illustration nor in my observations. He further noted seven setae per lobe of the ninth tergite which falls within my range of six to eight.

Aedes (Taeniorhynchus) mitchellae (Dyar), 1905.

Fig. 5.

J. N.Y. Ent. Soc. 13:74.

Description: Characters those of A. sollicitans except as follows: Postgenital plate bearing three to five subapical setae. Lobes of ninth tergite each bearing four to six subapical setae.

Specimens examined: Unadilla, Ga., 25 June 1910 (J. C. Bradley), 1; Myrtle Beach, S. C., 27 March 1944, 2; Tyndall Field, Fla., 20 June 1942, 1.

Aedes (Taeniorhynchus) taeniorhynchus (Widemann), 1821.

Fig. 6.

Dipt. Exot. p. 43.

References: Gerry (1932, figs. 11, 12); Gjullin (1937, fig. 4).

Description: Characters those of A. sollicitans except as follows: Postgenital plate noticably narrower than cerci, about three-fourths the width, bearing four to eight subapical setae. Lobes of ninth tergite each bearing four to five setae.

Specimens examined: Cocoli, Canal Zone, 4 August 1954, 9; Ft. Gulick, Canal Zone, 3 June 1954, 13; Ft. Clayton, Canal Zone, 26 May 1954, 5.

Discussion: Gerry and Gjullin have described and illustrated the terminalia of this species and do not agree on the shapes of the postgenital plate and ninth tergite. My observations of the postgenital plate agree with Gjullin's, but I find the ninth tergite to be closer in appearance to that shown by Gerry. Gjullin's specimens were from Californis, Florida, and Delaware; Gerry's from Cuba. Gjullin noted four to five setae per lobe of the ninth tergite as did I.

Aedes (Aedes) cinereus Meigen, 1818.

Fig. 7.

Syst. Beschr. Zweifl. Ins. 1:13.

References: Gjullin (1937, fig. 16); Ross (1947, fig 166 A, B).

Description: Cerci with a narrow base, expanded laterally and then tapering sharply to a rounded apex. Postgenital plate emarginate apically, bearing two pairs of strong apical setae, one dorsal, one ventral, and ten to twelve smaller subapical setae. Cowl continuous with postgenital plate to about half the distance from the apex. Posterior sigma narrow, with posterolateral shoulders not dilated. Insula long, narrow, tongue-like, without setae. Ninth tergite bilobed posteriorly each lobe bearing ten to twelve setae, narrowing slightly anteriorly. Eighth sternite with posterior margin notched, sinuate.

Specimens examined: Northampton, Mass., May 1944 (M. E. Smith), 1; Dublin, N.H., 1, 2 June 1951 (M. E. Smith), 10; Location unknown, 3.

Discussion: Gjullin and Ross show the postgenital plate to be narrower at the apex than I observed. Gjullin found twelve setae per lobe on the ninth tergite; I found the count ranged from ten to twelve.

Aedes (Feltianus) trichurus (Dyar), 1904.

Fig. 8.

J. N.Y. Ent. Soc. 12:170.

Description: Cerci broad, tapering to apex from about three-quarters the distance from base, with several heavy setae, numerous finer setae, and scales. Postgenital plate subquadrate, with twelve to fourteen subapical setae. Posterior sigma narrow, with lateral shoulders not dilated, beset with tiny spines arranged in rosettes. Insula with two groups of four setae. Ninth tergite broader than long, with apical lobes angulate, obtuse, bearing eight to ten setae per lobe. Eighth sternite shallowly and broadly emarginate posteriorly.

Specimens examined: Amherst, Mass., April 1945, 3; Westhampton, Mass., May 1964 (F. C. Thompson), 1 (reared from larva).

Aedes (Ochlerotatus) communis (DeGeer), 1776.

Fig. 9 (Group).

Mem. des. Ins. 6:316.

Reference: Gjullin (1937, fig. 9).

Description: Cerci tapering to a rounded apex, bearing scales in addition to the setae. Postgenital plate emarginate apically, bearing two pairs of strong apical setae, one dorsal, one ventral, and eleven to thirteen smaller subapical setae, the basal half showing a lateral bulge and then narrowing to a short neck, the lateral margins distinct but merging with membrane of cowl. Cowl continuous with postgenital plate to about one-half the distance from the apex. Posterior sigma with posterolateral shoulders dilated. Insula bearing two groups of two to four submedian setae. Ninth tergite bilobed posteriorly, the lobes broadly rounded, each bearing seven to ten setae. Eighth sternite convex or very slightly emarginate apically.

Specimens examined: Chesterfield, Mass., 7 May 1963 (V. A. Nelson), 2; Kebler Pass, Colo. (M. E. Smith), 8; Location unknown, 4.

Discussion: Gjullin found four to six setae per lobe of the ninth tergite; I found seven to ten.

Aedes (Ochlerotatus) abserratus (Felt and Young), 1904.

Fig. 9.

Science, n. s. 20:312.

Description: Characters those of A. communis except as follows: Postgenital plate with ten to seventeen subapical setae. Lobes of ninth tergite each bearing six to twelve setae.

Specimens examined: Cape Cod, Mass., June, August 1939 (R. L. Armstrong), 3; Cape Cod, Mass., Spring 1939 (R. L. Armstrong), 2; Cape Cod, Mass., 1940 (R. L. Armstrong), 5.

Aedes (Ochlerotatus) canadensis (Theobald), 1908.

Fig. 9.

Mon. Culic. 2:3.

Reference: Ross (1947, fig. 167 A, B, C).

Description: Characters those of A. communis except as follows: Postgenital plate bearing thirteen to fifteen subapical setae. Lobes of ninth tergite each bearing four to six setae.

Specimens examined: Cape Cod, Mass., 1940 (R. L. Armstrong), 4; Concord, Mass., 29 April 19??. 4; Belchertown and Cushman, Mass., May, June 19??, 5.

Discussion: Ross illustrated the terminalia of this species but did not include a description.

Aedes (Ochlerotatus) cantator (Coquillett), 1903.

Fig. 9.

Can. Ent. 53:255.

Description: Characters those of A. communis except as follows: Postgenital plate bearing eight to ten subapical setae. Lobes of ninth tergite each bearing five to seven setae. Eighth sternite sometimes with a tiny median notch.

Specimens examined: Cape Cod, Mass., June, August, September 1939 (R. L. Armstrong), 8.

Aedes (Ochlerotatus) excrucians (Walker), 1856.

Fig. 9.

Ins. Saund., Dipt. p. 429.

Reference: Hara (1957, pl. 29).

Description: Characters those of A. communis except as follows: Postgenital plate bearing eighteen to twenty-four subapical setae. Eighth sternite slightly emarginate posteriorly.

Specimens examined: Maple Swamp, Flanders, N. Y., 19 June 1963 (R. G. Means), 8; Location unknown, 5.

Discussion: Hara counted eight to nine setae per lobe of the ninth tergite, which falls within my observed range of seven to ten.

Aedes (Ochlerotatus) fitchii (Felt and Young), 1904.

Fig. 9.

Science, n. s. 20:312.

Reference: Gjullin (1937, fig. 13).

Description: Characters those of A. communis except as follows: Postgenital plate bearing twelve to seventeen subapical setae. Lobes of ninth tergite each bearing ten to fourteen setae.

Specimens examined: Cape Cod, Mass., Spring 1939, 1940 (R. L. Armstrong), 4 (reared).

Discussion: Gjullin found six to nine setae per lobe of the ninth tergite; my range was ten to fourteen.

Aedes (Ochlerotatus) punctor (Kirby), 1837.

Fig. 9.

Richardson's Fauna Bor. Amer. 4:309.

Reference: Hara (1957, pl. 32).

Description: Characters those of A. communis except as follows: Lobes of ninth tergite each bearing four to six setae.

Specimens examined: Chesterfield, Mass., 13-19 May 1954, 6 (reared from larvae); Chesterfield, Mass., Summer 1963 (D. W. MacKenzie), 6 (reared from pupae).

Discussion: Hara found five setae on each posterior lobe of the ninth tergite, which falls within my observed range of four to six.

Aedes (Ochlerotatus) sticticus (Meigen), 1838.

Fig. 9.

Syst. Beschr. Zweifl. Ins. 7:1.

Reference: Hara (1957, pl. 31).

Description: Characters those of A. communis except as follows: Postgenital plate bearing seven to ten subapical setae.

Specimens examined: Northampton, Mass., May 1947 (M. E. Smith), 5.

Discussion: Hara counted six setae per lobe of the ninth tergite; I found a range of seven to ten.

Aedes (Ochlerotatus) stimulans (Walker), 1818.

Fig. 9.

List Dipt. Brit. Mus. 1:4.

Description: Characters those of A. communis except as follows: Postgenital plate bearing eight to ten subapical setae. Lobes of ninth tergite each bearing four to eight setae.

Specimens examined: Hadley, Mass., May 1960 (M. E. Smith), 40 (reared from pupae).

Aedes (Ochlerotatus) trivittatus (Coquillett), 1902.

Fig. 9.

J. N.Y. Ent. Soc. 10:193.

Description: Characters those of A. communis except as follows: Postgenital plate bearing five to eight subapical setae. Lobes of ninth tergite each bearing six to eight setae.

Specimens examined: Wakullah Springs, Fla., 1; Durham, N. C., Camp Butner, 22 July 1942, 1; Ft. Riley, Kansas, July, August 1948, 3.

Aedes (*Ochlerotatus*) *intrudens* Dyar, 1919.

Fig. 10 (Group).

Ins. Ins. Mens. 7:23.

Description: *Cerci* tapering to a rounded apex, bearing scales in addition to the setae. *Postgenital plate* emarginate apically, bearing two pairs of strong apical setae, one dorsal, one ventral, and eight to ten subapical setae, the basal half showing a lateral bulge and then narrowing to a short basal neck, the lateral margins distinct but merging with membrane of cowl. *Cowl* continuous with postgenital plate to about one-half the distance from the apex. *Posterior sigma* with lateral shoulders not dilated. *Insula* bearing two groups of two to three submedian setae. *Ninth tergite* bilobed posteriorly, the lobes broadly rounded, each bearing eight to eleven setae. *Eighth sternite* with posterior margin convex.

Specimens examined: Westhampton, Mass., April 1963 (V. A. Nelson), 1 (reared from larva); Cushman, Mass., May 1964 (V. A. Nelson), 5 (reared from larvae).

Aedes (Ochlerotatus) aurifer (Coquillett), 1903.

Fig. 10.

Can. Ent. 35:255.

Description: Characters those of A. intrudens except as follows: Postgenital plate bearing eleven to thirteen subapical setae. Lobes of ninth tergite each bearing eight to thirteen setae.

Specimens examined: Flanders, N.Y., 22 June 1963 (R. G. Means), 4; Dublin, N.H., 1,2 June 1951 (M. E. Smith), 12.

Aedes (Ochlerotatus) decticus Howard, Dyar, and Knab, 1917.

Fig. 10.

Carnegie Inst. Wash. Pub. 159. 4:737.

Reference: Smith (1952).

Description: Characters those of A. intrudens except as follows: Postgenital plate with eleven to thirteen subapical setae. Lobes of ninth tergite each bearing four to five setae. Eighth sternite sometimes with posterior margin very shallowly emarginate.

Specimens examined: Belchertown, Mass., 5 June 19?? (M. E. Smith), 6.

Discussion: Coher (in Smith, 1952) noted that the posterior lobes of the ninth tergite each bear no more than five setae, which was confirmed by my finding no more than four to five setae per lobe.

Aedes (Ochlerotatus) diantaeus Howard, Dyar, and Knab, 1917.

Fig. 10.

Carnegie Inst. Wash. Pub., 159. 4:758.

Reference: Smith (1952).

Description: Characters those of A. intrudens except as follows: Cerci without scales. Postgenital plate bearing thirteen to fifteen subapical setae. Lobes of ninth tergite each bearing seven to ten setae. Eighth sternite with a shallow flaring emargination posteriorly.

Specimens examined: Westhampton, Mass., 1 July 1953 (O. S. Flint), 3.

Discussion: Coher (in Smith, 1952) noted that the posterior lobes of the ninth tergite on each bear no less than seven nor more than twelve setae. My observed range was seven to ten.

Aedes (Ochlerotatus) dorsalis (Meigen), 1830.

Fig. 10.

Syst. Beschr. Zweifl. Ins. 6:242.

References: Gjullin (1937, fig. 1); Hara (1957, pl. 30).

Description: Characters those of A. intrudens except as follows: Postgenital plate bearing six to eight subapical setae. Lobes of ninth tergite each bearing four to seven setae. Eighth sternite emarginate posteriorly.

Specimens examined: Cape Cod, Mass., 25 July 1939 (R. L. Armstrong), 1; Boston, Mass., 30 July, 1; Brookline, Mass., 14 July, 1.

Discussion: Gjullin separated this species from the others of the subgenus Ochlerotatus by the shape of the basal half of the postgenital plate. I could not find a significant difference between the shape of the postgenital plate in dorsalis and that in the other species of the subgenus. Hara counted eight setae on each lobe of the ninth tergite; Gjullin and I found four to seven.

SUMMARY AND CONCLUSIONS

Of the twenty-three Aedes species included in this paper, the female terminalia of twelve have been described by previous workers, three have been illustrated but not described, and eight were studied for the first time. My observations of the previously studied species are generally in agreement with the findings of the earlier authors. I disagree with a statement by Hara concerning the North America form of A. vexans, and with certain details of Gerry's observations of A. sollicitans and A. taeniorhynchus.

A. mitchellae, A. trichurus, A. abserratus, A. cantator, A. stimulans, A. trivittatus, A. intrudens, and A. aurifer have not been previously examined for differences in the female terminalia and are described for the first time. A. mitchellae, and A. sollicitans exhibit overlapping characters and are difficult to separate. The terminalia of A. trichurus are distinct at both the subgeneric and species levels. The remaining six species, belonging to the subgenus Ochlerotatus, fall into two groups on the basis of the configuration of the posterior sigma. Of the characters under investigation, none were found reliable for species separation in this subgenus. The number of setae on the postgenital plate and on the lobes of the ninth tergite, though variable within each species (see table), were helpful.

As a result of this study, I have reached the following conclusions:

1. The female terminalia of the Aedes species studied exhibit characters that are significantly different at the subgeneric level.
2. In the subgenus Ochlerotatus there are few dependable characters for species differentiation.

3. Closely related species within a subgenus are not readily separated by female terminalia.

4. On the basis of present knowledge, female terminalia offer only limited use for species identification. They could be helpful in small local faunas where the species present belong to different subgenera or are distantly related species within a subgenus.

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EXPLANATION OF ILLUSTRATIONS

The illustrations in this paper are not drawn to scale but rather of sufficient size to show structural detail.

The positions of the structures shown are slightly reoriented to illustrate diagnostic characteristics. For example the cerci, which are normally roof-like in position, are drawn to show their full outlines.

Abbreviations
Figs. 1 - 3

C - Cercus

PGP - Postgenital plate

CL - Cowl

PS - Posterior sigma

AS - Anterior sigma

AM - Anal membrane

Figs. 2 - 10

A - genitalia in ventral view

B - ninth tergite

C - eighth sternite, posterior margin

Setae were omitted from the illustrations because their inclusion would serve no useful purpose. First, the arrangement of the setae on the structures does not form a species-diagnostic pattern. Second, the numbers of setae vary within a given species and overlap with other species. Setal count ranges are sometimes helpful (especially in local limited fauna) for separating species (see table), but this is better explained in the text

than in the figures.

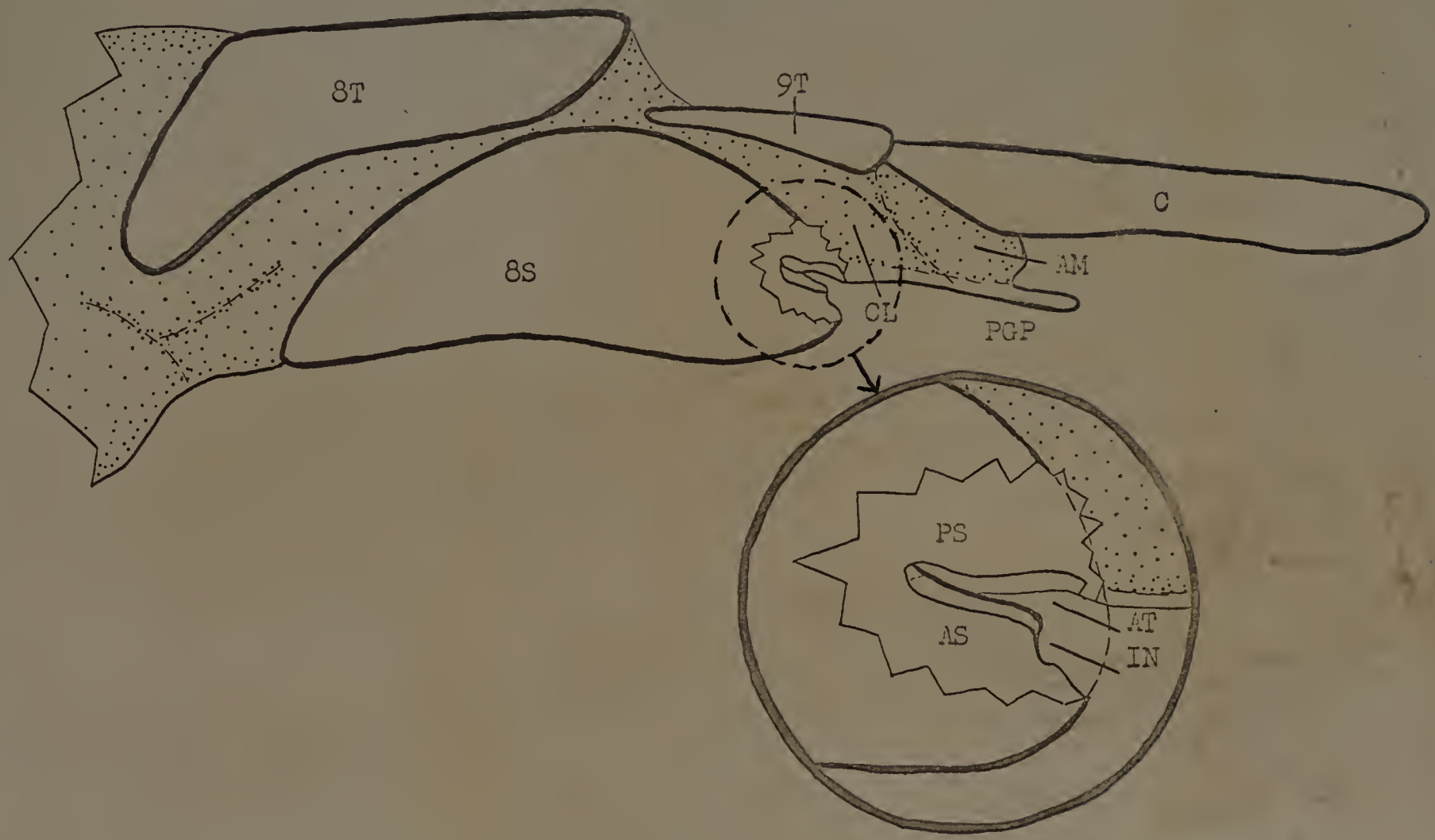
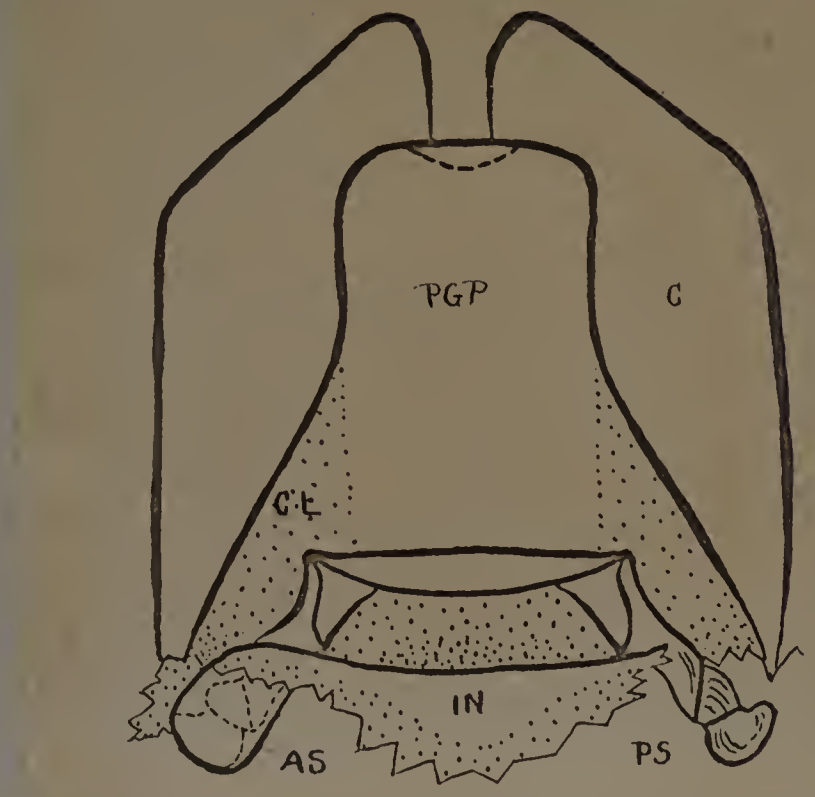


Fig. 1. Lateral view of female terminalia.

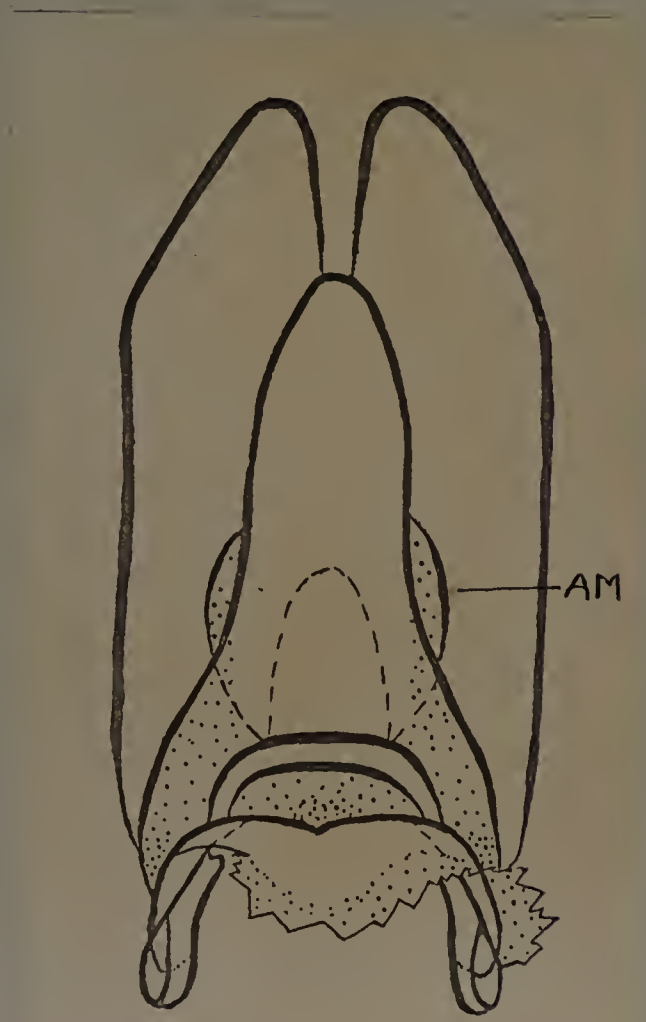


A

B

C

Fig. 2. Aedes atropalpus (Coquillett), 1902.



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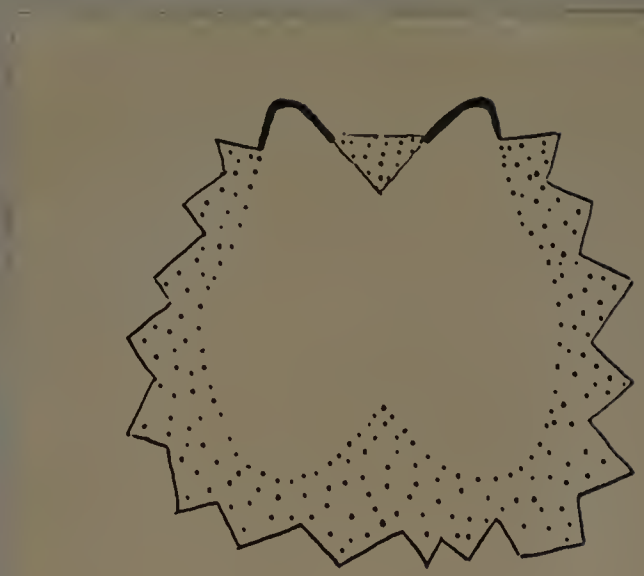

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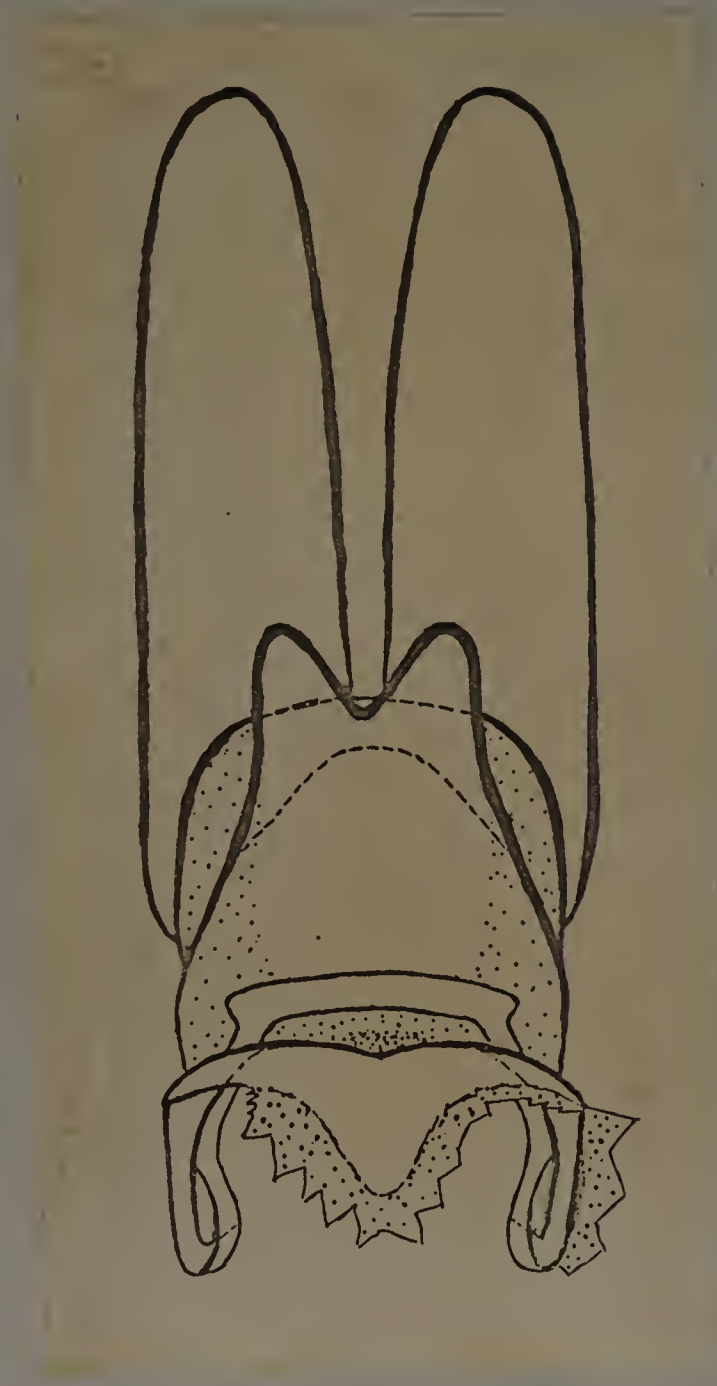
Fig. 3. Aedes triseriatus (Say), 1823.



A

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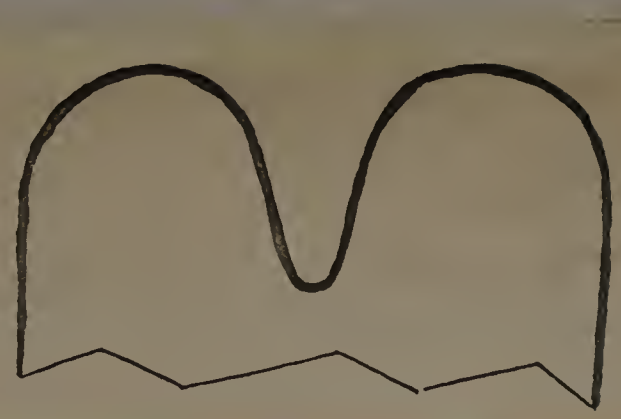

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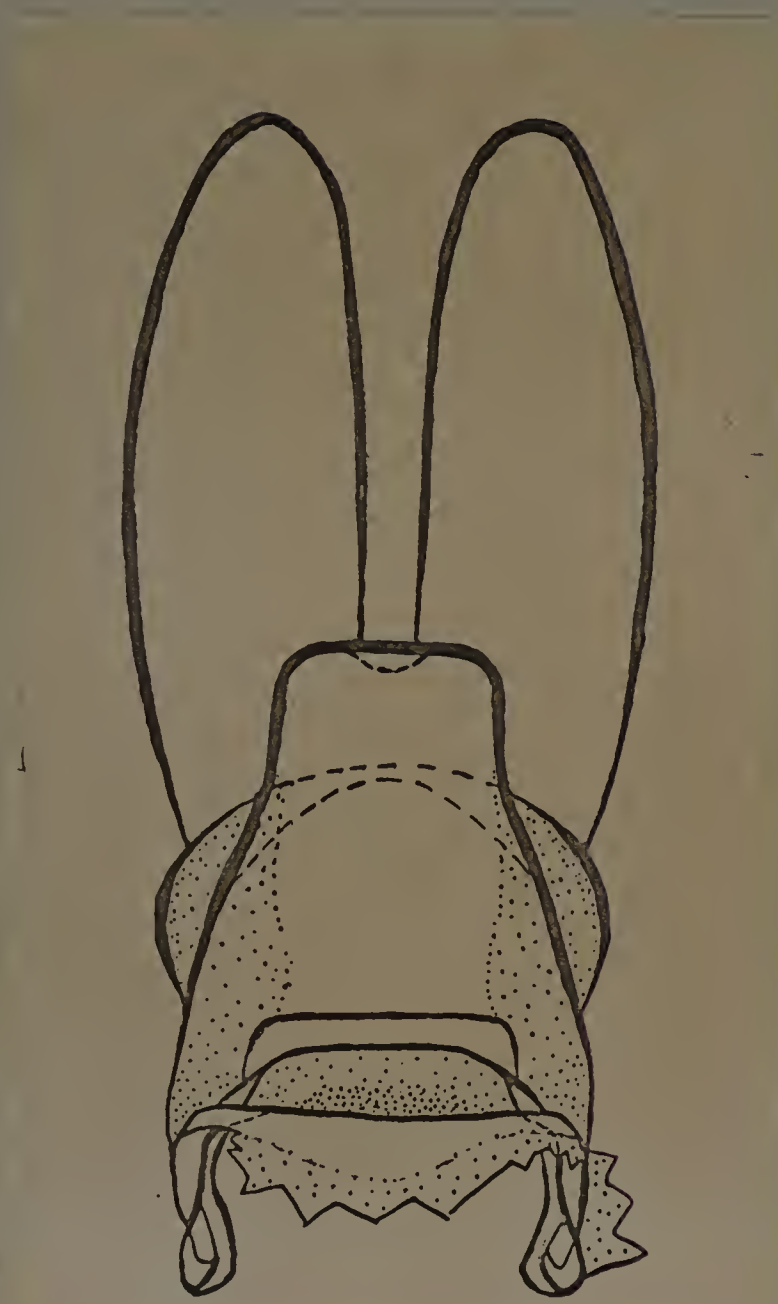
Fig. 4. Aedes vexans (Meigen), 1830.



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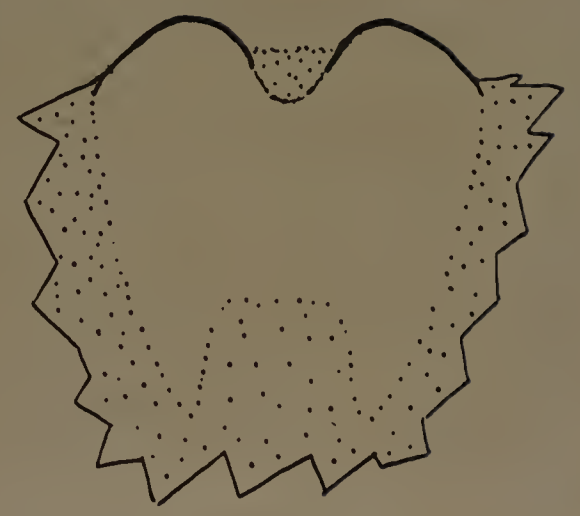

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Fig. 5. Aedes sollicitans (Walker), 1856, and A. mitchellae (Dyar), 1905.

A

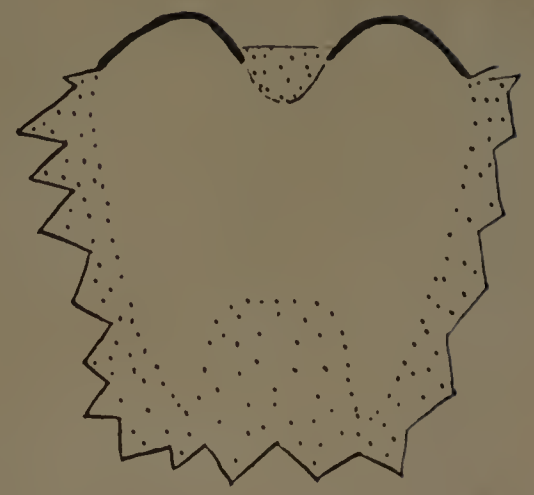

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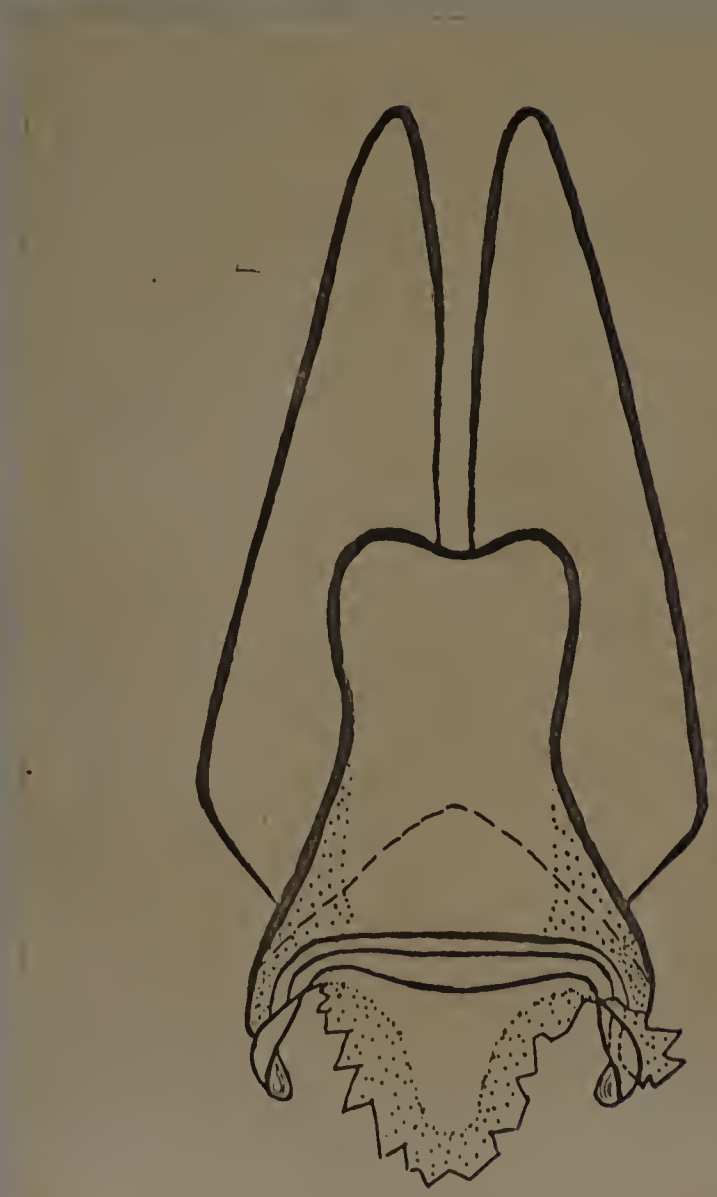
Fig. 6. Aedes taeniorhynchus (Wiedemann), 1821.



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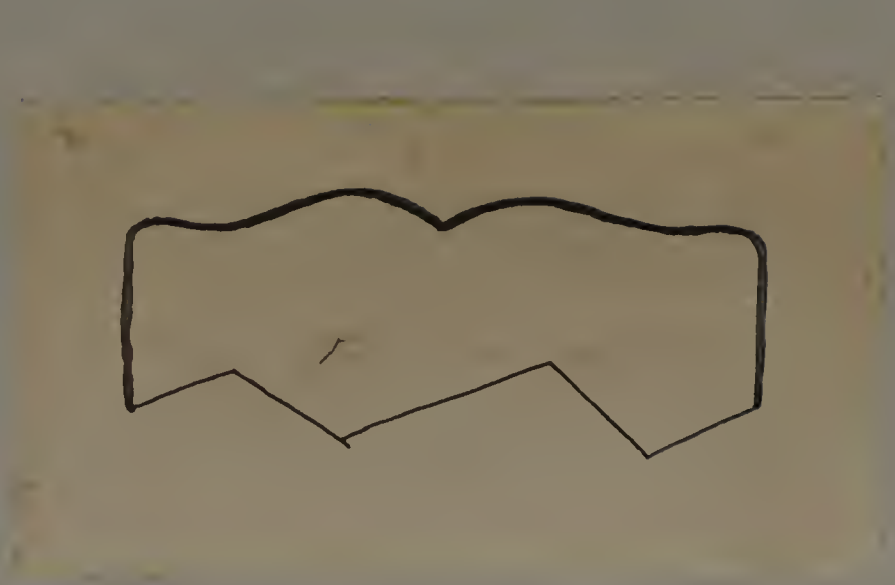

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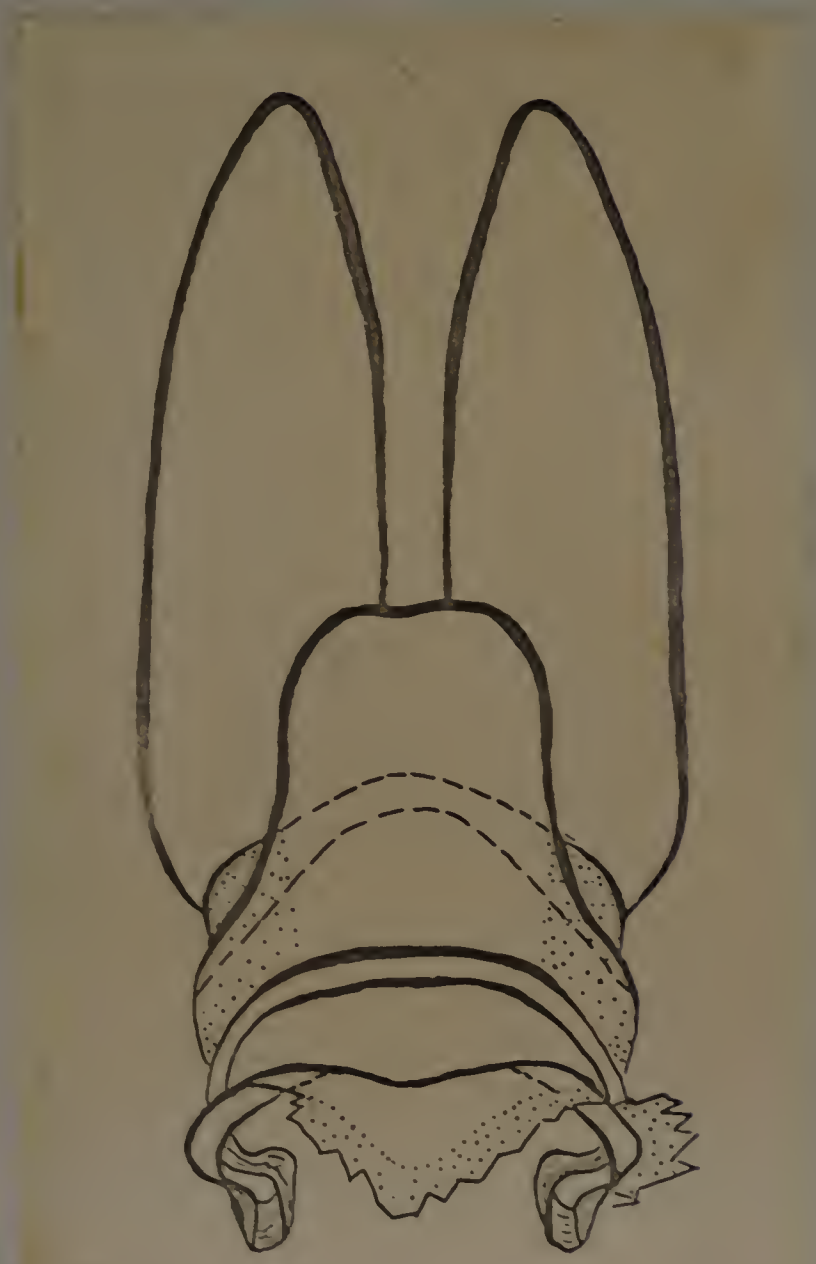
Fig. 7. Aedes cinereus Meigen, 1818.



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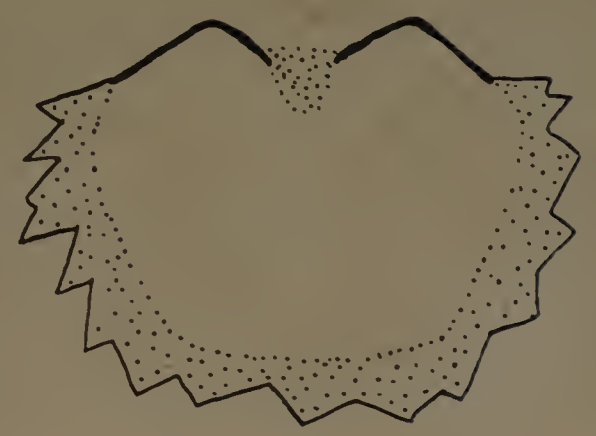

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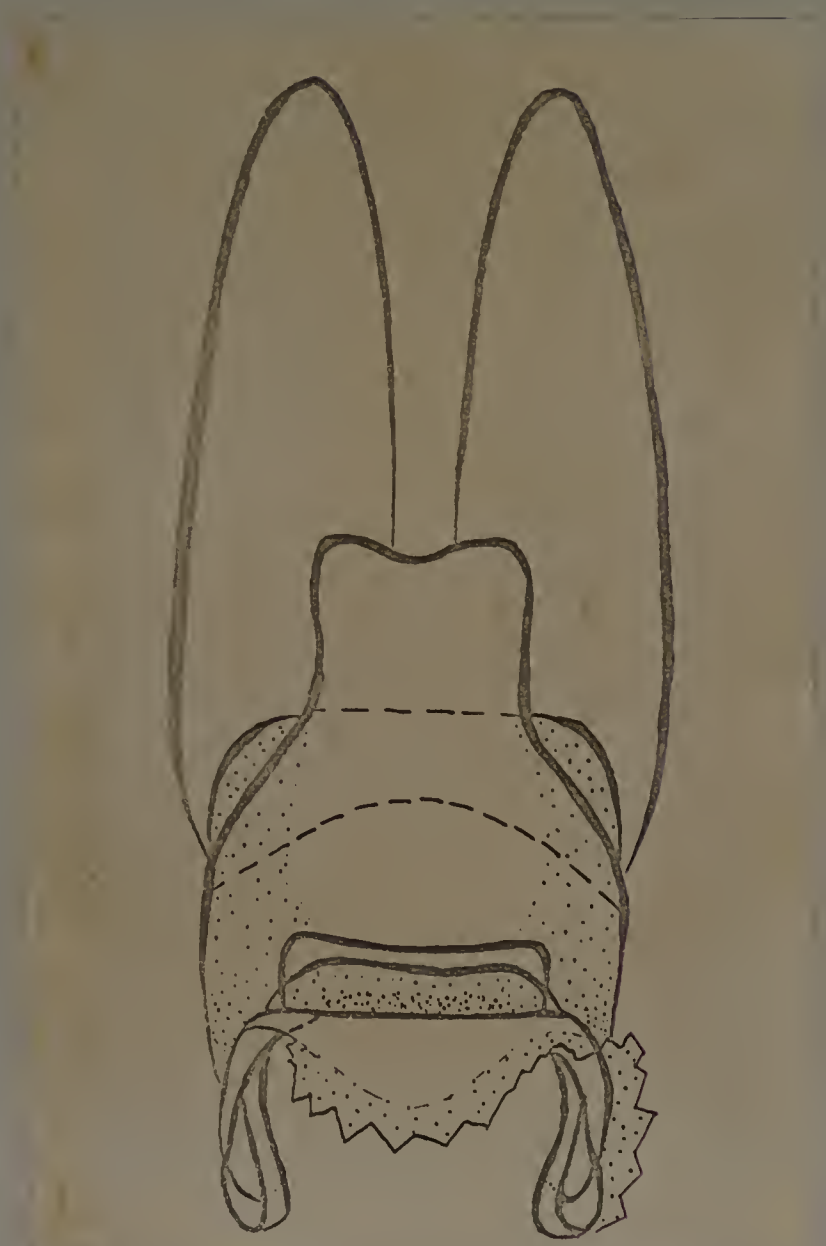
Fig. 8. Jadera trichurus (Dver), 1904.



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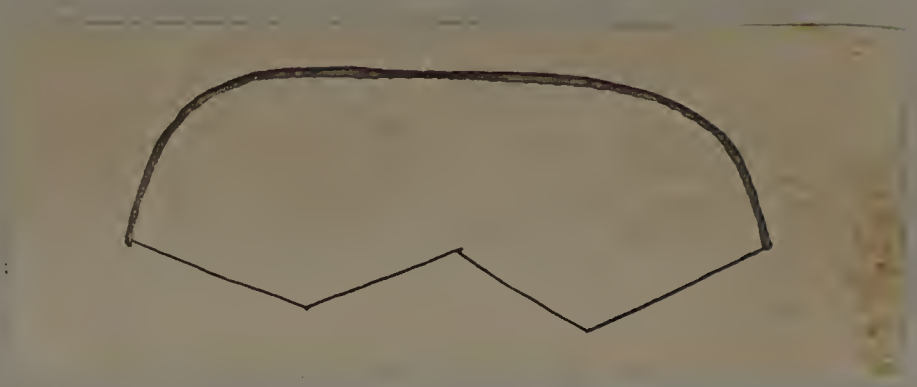
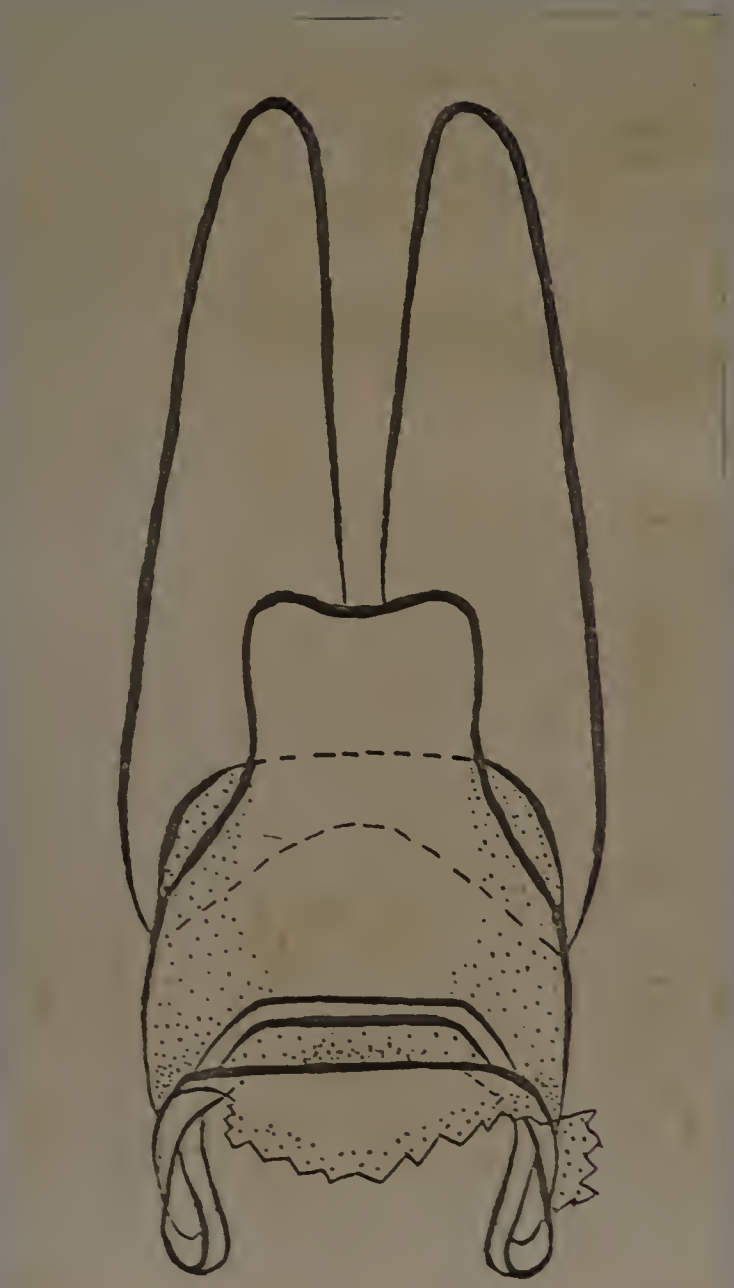


C

Fig. 2. Aedes communis Group.



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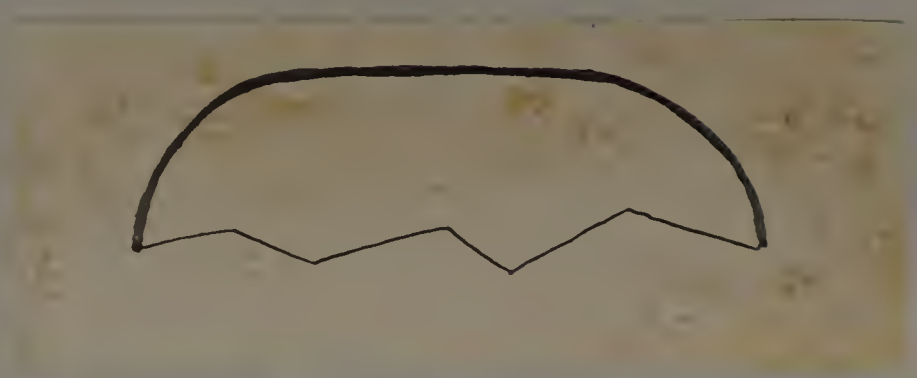

C

Fig. 10. Aedes intrudens Dyar.

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Approved by:

Marion E Smith

Graduate Committee

Date JUN 17 1964