

EGGS OF FLOODWATER MOSQUITOES. VII. SPECIES OF AEDES COMMON IN THE SOUTHEASTERN UNITED STATES (DIPTERA: CULICIDAE)^{1,2}

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ABSTRACT

Eggs of nine species of *Aedes* are described and illustrated. Material treated includes *A. aegypti*, *atropalpus*, *mitchellae*, *sollicitans*, *taeniorhynchus*, *cantator*, *atlanticus*, *infirmatus*, and *thibaulti*. These descriptions, together with those of seven other *Aedes* by Horsfall and Craig

(1956) and descriptions of seven *Psorophora* by Horsfall et al. (1952) should allow specific identification of almost all aedine eggs which might be encountered in the southeastern United States. Diagnostic features include size, shape, color, and details of chorionic sculpturing.

New approaches to problems of classification, bionomics and control of aedine mosquitoes have been provided by the recent development of techniques for species identification based on external morphology of the egg stage. Craig and Horsfall (1956) outline some of the kinds of information which can be obtained from eggs of Nearctic species of *Aedes* and *Psorophora*.

Structural characteristics of eggs provide significant information on the systematic relationships of aedine species (Craig 1956). In most cases, data from eggs confirm current systematic

arrangements. However, in a few instances, new categories or subgeneric shifts are indicated. For example, most earlier authors considered that *Aedes taeniorhynchus*, *sollicitans* and *mitchellae* (see egg descriptions below), together with *A. nigromaculis* (see Craig 1956), should be included in Group A of the subgenus *Ochlerotatus*. On the other hand, Ross (1947) placed these species in a separate subgenus, *Taeniorhynchus*, on the basis of female genitalia. Pratt (1956) followed Ross in this respect. Evidence afforded by characteristics of eggs validates the subgeneric status of *Taeniorhynchus*. The sculpturing of the chorion and the shape of whole eggs of species in this group are similar and distinctive. They actually resemble some *Finlaya* more than *Ochlerotatus* and the latter subgenus forms a much more uniform group if Group A is excluded.

¹Most of this work was done while the senior author was at the Medical Research Directorate, Chemical Warfare Laboratories, Army Chemical Center, Maryland. Part of the work was supported by a research grant from the U. S. Public Health Service.

²Accepted for publication April 6, 1959.

Recognition of eggs, when coupled with newer collection methods (Horsfall 1956), allows sanitarians and ecologists to conduct surveys of distribution and abundance of floodwater mosquitoes. Species of *Aedes* and *Psorophora* spend most of their lives in the egg. Therefore, surveys directed toward this dormant stage may be conducted during the fall and winter months when regulatory operations are inactive rather than during the short periods of larval or adult prevalence. At present, a number of organizations concerned with mosquito abatement are using data from egg surveys as a major factor in planning control activities. In the southeastern United States, investigators for the Tennessee Valley Authority make egg surveys to determine areas of maximum oviposition around the reservoirs and impounded waters.

Although the taxonomy of anopheline eggs has been well studied, eggs of culicine species have not received similar attention. This is one of a series of papers dealing with descriptions and illustrations of the eggs of the Nearctic aedine mosquitoes. Horsfall et al. (1952) first showed that eggs of seven species of *Psorophora* could be segregated on the specific level. Craig (1956) described eggs of 35 out of about 63 Nearctic *Aedes*, including representatives of all Nearctic subgenera and six of the seven groups of the largest subgenus, *Ochlerotatus*. Six of the nine species described herein were treated in that work. In order to make descriptions more readily available to field workers and to add additional species as they become available, descriptions of eggs of *Aedes* are being published on a regional basis. Horsfall and Craig (1956) described eggs of seven species of *Aedes* characteristic of the central United States. The present work continues this regional treatment. Papers on western and northern species are contemplated.

Approximately 20 species of *Aedes* are characteristic of the southeastern United States. Nine of these are described herein, including *Aedes aegypti*, *atropalpus*, *mitchellae*, *sollicitans*, *taeniorhynchus*, *cantator*, *atlanticus*, *infirmatus* and *thibaulti*. All of the species from Illinois described by Horsfall and Craig (1956) are also found in the southeastern states. These include *Aedes vexans*, *dupreei*, *canadensis*, *trivittatus*, *triseriatus*, *stimulans* and *sticticus*. *Aedes cinereus* was described by Craig (1956). Other forms which may be encountered in egg samples but which have not yet been described include *Aedes fulvus pallens* (not common), *A. grossbecki* (not common, egg probably resembles *A. stimulans*), *A. tormentor* (egg probably resembles *A. atlanticus*) and *A. canadensis mathesoni* (probably resembles *A. canadensis canadensis*).

METHODS

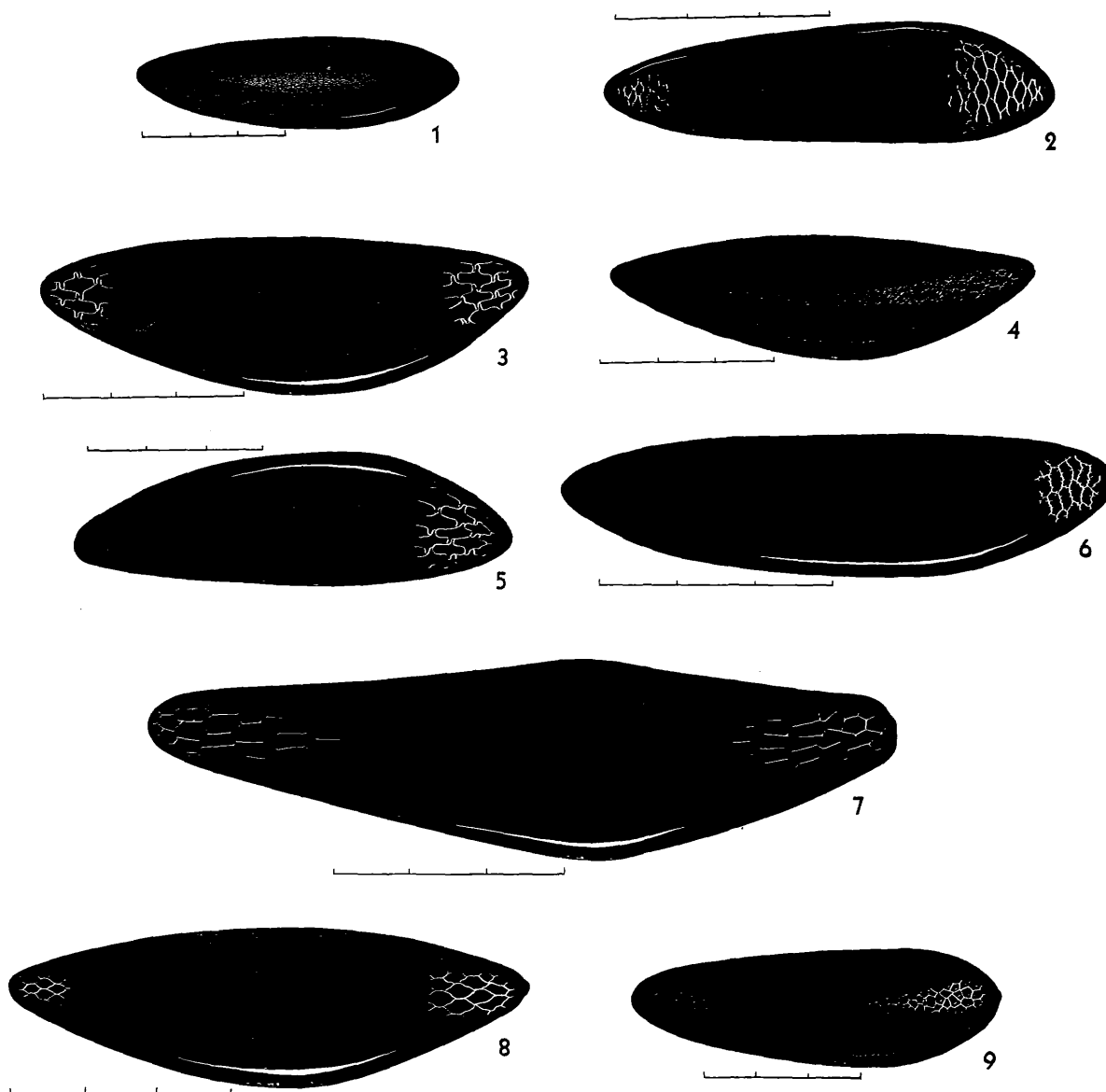
Eggs of the nine species to be described were obtained from several sources including: (a) ovi-

positions on moist cellucotton by individual wild-caught females, (b) screenings of soil samples from field oviposition sites, (c) ovipositions in cage colonies by *A. aegypti* and *A. atropalpus* and (d) dissection of dried, gravid females from museum collections. Where identity of the ovipositing female was questionable, as in the case of the *A. atlanticus-tormentor* complex, eggs were hatched, larvae were reared to adulthood and positive identification was made on the basis of the male genitalia. Permanent collections of whole eggs are stored in 10 percent formalin. Cleared fragments of chorion are preserved on slides. Reference collections are deposited at the University of Notre Dame and the University of Illinois.

Whole eggs are best identified by placing them in water over a nonreflective grey or black background and illuminating with an intense, sharply focused beam of white light. A stereoscopic dissecting microscope at magnifications greater than 100 diameters will usually reveal characters sufficient for specific segregation. Important characters revealed by this optical system include the shape, size and color of the whole egg, the nature of the exochorion and the grosser aspects of chorionic sculpturing. The illustrations of whole eggs on plate I were made with this optical system.

Measurements and drawings were taken from camera lucida projections of whole eggs with developed embryos. At least 30 eggs were used to calculate each mean dimension. Care must be taken in interpretation of size and shape for diagnostic purposes. Woke (1955) showed that *Aedes aegypti* would produce malformed and distorted eggs if females were forced to retain their eggs in the oviduct due to absence of a suitable oviposition site. Eggs of *Aedes vexans* collected at field oviposition sites show remarkable variability with respect to size and shape. Infertile eggs are particularly susceptible to distortion. All measurements were made on eggs from several females representing a single population. Biometric studies on geographic variation in size are needed before mean dimensions can have much taxonomic significance. Laboratory studies on the effect of nutrition on egg formation might indicate a further source of variation in size.

For positive identification, it may be necessary to examine finer details of chorionic sculpturing. The cellular reticulation of the chorion is produced by the imprint of the cells which comprise the ovarian follicle of the mother. Certain details of sculpturing are characteristic for each species and show little intraspecific variation, in contrast to the characters provided by size and shape of whole eggs. Craig (1955) described the method of choice for preparation of the chorion for microscopic examination. Egg shells are bleached and softened with hydrochloric acid and



EXPLANATION OF PLATE I

Lateral aspect of eggs of species of *Aedes* common in the Southeastern United States as seen in reflected light through a stereoscopic dissecting microscope. Anterior end is to the right. Dorsal surface toward top of page (except figs. 2, 5 with ventral surface toward top). Scale along ventral surface of each egg is 300μ . FIG. 1, *Aedes aegypti*; FIG. 2, *Aedes atropalpus*; FIG. 3, *Aedes mitchellae*; FIG. 4, *Aedes sollicitans*; FIG. 5, *Aedes taeniorhynchus*; FIG. 6, *Aedes cantator*; FIG. 7, *Aedes atlanticus*; FIG. 8, *Aedes infirmatus*; FIG. 9, *Aedes thibaulti*.

potassium chlorate. Shell fragments are then mounted flat as single sheets and viewed with the phase-contrast microscope. The photographs on plate II were made from such preparations.

Grateful acknowledgement is due to the many workers who furnished specimens for this study. Names of collectors are indicated at the end of each description. Eggs from sources marked GBC or WRH were collected by one of the authors.

***Aedes* (*Stegomyia*) *aegypti* (Linnaeus, 1762)**

Pl. I, fig. 1; Pl. II, fig. 1-3

Shape: Narrowly elongate ellipse; only slightly more crescentic ventrally than dorsally; greatest diameter at middle; slightly greater taper anteriorly, anterior pole more blunt.

Size: Length 581μ - 777μ , mean $682\mu \pm 8\mu$; dorsoventral diameter 171μ - 222μ , mean $195\mu \pm 3\mu$.

Color: Variable, brown to black with faint purple sheen.

Exochorion: Thick, translucent, adhesive, conspicuous; highly indicative of chorionic reticulation; intracellular spaces of reticulation with large air bubbles dorsally, smaller and more numerous bubbles ventrally (see de Buck 1938).

Chorion by reflected light: Reticulation inconspicuous, often visible only on dorsal side, differing markedly around circumference; dorsal cells only slightly longer than wide; ventral cells transversely elongate.

Chorion by transmitted light: Dorsal cells hexagonal, centrally depressed, axially oriented in the long axis of the egg; lateral cells with partial transverse elongation, rhomboidal; ventral cells transversely elongated, fusiform; margins of cells raised and jagged; surface of cells profusely and minutely rugose.

Remarks: The striking features of these eggs when mixed with others are (1) change in pattern of the reticulation around the circumference, (2) elliptical shape of the whole egg, (3) regular hexagonal reticulation on the dorsal surface. The shape of cells is similar to *A. atropalpus* but the wrinkled surface serves to separate it from that species. No morphological variation was discovered in eggs from laboratory colonies which originated from field populations in North and South America, Asia, and Africa.

Source: Fifteen laboratory strains from colonies which originated in various parts of the world including: Orlando, Fla. (C. N. Smith); Savannah, Ga. (H. F. Schoof); Trinidad, B. W. I. (R. W. Fay); Ilobi, Nigeria (R. Elliott); Newala, Tanganyika (J. D. Gillett); Saudi Arabia (P. C.

C. Garnham); Klang Island, Malaya (W. W. Macdonald); Manila, Philippine Islands (L. LaMotte). Some of these colonies originated from recent field collections while others had been maintained in the laboratory for up to 30 years.

Aedes (Finlaya) atropalpus (Coquillett, 1902)

Pl. I, fig. 2; Pl. II, fig. 4-6

Shape: Narrowly elongate ellipse; dorsal side distinctly flattened; greatest diameter at anterior third; both poles blunt.

Size: Length $443\mu-764\mu$, mean $631\mu\pm 20\mu$; dorsoventral diameter $158\mu-202\mu$, mean $182\mu\pm 14\mu$.

Color: Light tan to dark brown with purple cast.

Exochorion: Very thick, translucent, conspicuous, adhesive, difficult to remove.

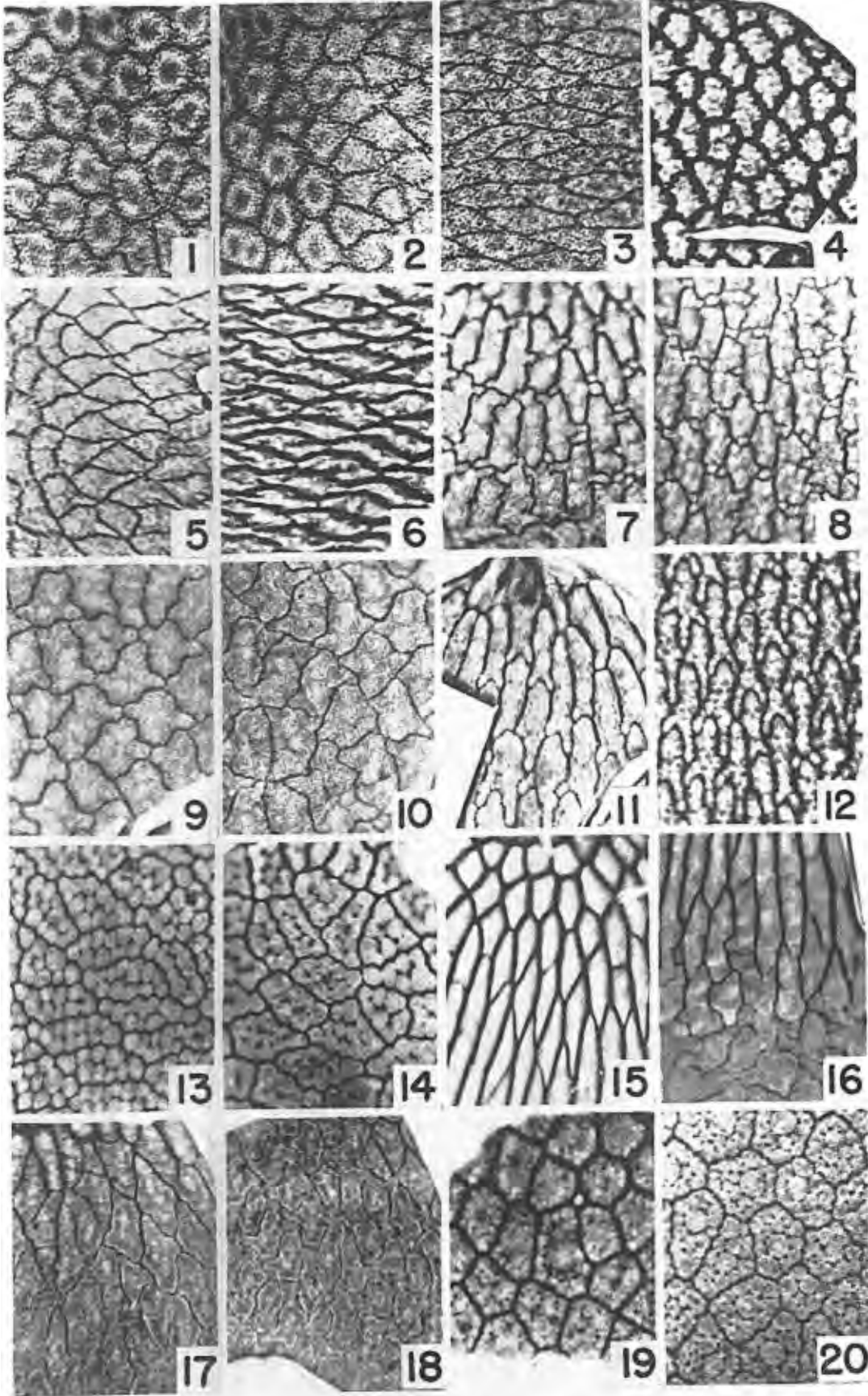
Chorion by reflected light: Reticulation prominent, always visible on entire egg, differing markedly around circumference; dorsal cells polygonal, only slightly longer than wide; ventral surface appearing transversely wrinkled.

Chorion by transmitted light: Pattern of reticulation similar to *A. aegypti*; dorsal cells axially oriented in the long axis of the egg, hexagonal, deeply depressed in center; lateral cells with partial transverse elongation, rhomboidal; ventral cells transversely elongate, fusiform, irregular, difficult to discern except as ridges; margins of cells thick, strongly raised and tortuous on dorsum, lower and straight on venter; surface of cells smooth, unmarked.

EXPLANATION OF PLATE II

Details of chorionic sculpturing of eggs of *Aedes* common in the Southeastern United States as photographed through a phase contrast microscope using high, dry objective and bright, medium phase contrast illumination. Anterior end is toward top of page.

Figure	Species	Area of egg
1	<i>A. aegypti</i>	Median, dorsal aspect
2	<i>A. aegypti</i>	Median, lateral aspect
3	<i>A. aegypti</i>	Median, ventral aspect
4	<i>A. atropalpus</i>	Median, dorsal aspect
5	<i>A. atropalpus</i>	Median, lateral aspect
6	<i>A. atropalpus</i>	Median, ventral aspect
7	<i>A. mitchellae</i>	Near anterior pole
8	<i>A. mitchellae</i>	Median
9	<i>A. sollicitans</i>	Anterior third
10	<i>A. sollicitans</i>	Median
11	<i>A. taeniorhynchus</i>	Anterior pole near micropyle
12	<i>A. taeniorhynchus</i>	Median
13	<i>A. cantator</i>	Median, ventral aspect
14	<i>A. cantator</i>	Median, dorsal aspect
15	<i>A. atlanticus</i>	Anterior pole near micropyle
16	<i>A. atlanticus</i>	Anterior third
17	<i>A. infirmatus</i>	Anterior pole near micropyle
18	<i>A. infirmatus</i>	Anterior third
19	<i>A. thibaulti</i>	Anterior pole near micropyle
20	<i>A. thibaulti</i>	Median



Remarks: The striking features of these eggs when mixed with others are (1) change in pattern around circumference, (2) very thick cell walls on dorsum. Although the pattern of the reticulation resembles *A. aegypti*, the smooth surface of the intracellular areas and the depth of the dorsal cells of *atropalpus* provide satisfactory characters for separation.

Source: Baltimore Co., Md. (GBC); Harford Co., Md. (GBC); laboratory colony, National Institutes of Health (P. A. Woke).

Aedes (Taeniorhynchus) mitchellae (Dyar, 1905)

Pl. I, fig. 3; Pl. II, fig. 7-8

Shape: Variable, elongate obovoid to broadly fusiform; ventral side broadly crescentic, dorsal side nearly straight to past middle third; similar to *A. sollicitans*.

Size: Length 659 μ -810 μ , mean 726 μ \pm 9 μ ; dorsoventral diameter 184 μ -259 μ , mean 222 μ \pm 5 μ .

Color: With exochorion intact, grayish cast; with exochorion removed, black and variably shiny.

Exochorion: Distinct, flaky, readily removed.

Chorion by reflected light: Reticulation of low relief, indistinctly linear in the long axis of the egg, especially evident at the poles.

Chorion by transmitted light: All cells two or more times as long as wide; each cell rectilinear, expanded as one or more small bud-like arms on each side; arms of each cell less than one-fourth as wide as lateral margin of entire cell; cells bounded laterally by nearly straight, raised margins; surface of cells smooth to faintly pitted with indistinct, irregular discs.

Remarks: The distinctive feature of these eggs when mixed with others is the linear appearance of the reticulation of the chorion, evident at the poles but obscure medially. These eggs are very similar to *A. sollicitans* and *A. taeniorhynchus* with respect to shape, size and color. They differ from *sollicitans* in the straighter lateral margins of the cells and from *taeniorhynchus* in having cells with lateral rather than caudal arms.

Source: Clay Co., Fla. (GBC).

Aedes (Taeniorhynchus) sollicitans

(Walker, 1856)

Pl. I, fig. 4; Pl. II, fig. 9-10

Shape: Variable, elongate obovoid to broadly fusiform; ventral side broadly crescentic, dorsal side nearly straight from anterior pole to past middle third; both ends with similar taper, the anterior end sometimes appearing somewhat nipple-like; greatest diameter extending from midsection to anterior third.

Size: Length 641 μ -786 μ , mean 729 μ \pm 17 μ ; dorsoventral diameter 196 μ -264 μ , mean 221 μ \pm 14 μ (eggs from Kent Co., Del.).

Color: With exochorion intact, grayish cast;

with exochorion removed, black and variably shiny, sometimes blue-black.

Exochorion: Distinct, flaky, readily removed.

Chorion by reflected light: Reticulation obscure or of low relief, composed of rounded cells, each of which is usually extended laterally as a bud-like arm on each side.

Chorion by transmitted light: Cells near midsection about as long as wide; cells near micropylar area somewhat longer than wide; cell margins sigmoid, slightly raised, without acute angles; bud-like lateral arms of each cell about one-third to one-fourth as wide as lateral margin of entire cell; surface of cells with minute, irregular furrows, appearing wrinkled but without punctation.

Remarks: The distinctive feature of these eggs when mixed with others is the cellular structure of the chorion as described above. These eggs are very similar to *A. mitchellae* and *A. taeniorhynchus* with respect to shape, size, and color. However, the cells of the chorion of *sollicitans* are broader in relation to length than are those of the other species. The lateral position of the arms differs from *taeniorhynchus* and the area occupied by the arms is greater than in *mitchellae*.

Source: Kent Co., Del. (GBC); Harford Co., Md. (GBC); Saline Co., Ill. (WRH); Chatham Co., Ga. (H. F. Schoof).

Aedes (Taeniorhynchus) taeniorhynchus

(Wiedemann, 1821)

Pl. I, fig. 5; Pl. II, fig. 11-12

Shape: Variable, elongate obovoid to broadly fusiform; ventral side broadly crescentic, dorsal side nearly straight; greatest diameter extending from midsection to anterior third; usually similar to *A. sollicitans*.

Size: Length 641 μ -804 μ , mean 746 μ \pm 7 μ ; dorsoventral diameter 205 μ -264 μ , mean 235 μ \pm 15 μ (eggs from Orange Co., Calif.).

Color: With exochorion intact, grayish cast; with exochorion removed, black and variably shiny.

Exochorion: Distinct, flaky, readily removed.

Chorion by reflected light: Reticulation obscure or of low relief, linear in the long axis of the egg.

Chorion by transmitted light: All cells at least three times as long as width at middle; cells roundedly polygonal with caudal and occasionally lateral bud-like arms; caudal arms elongate, up to one-half as long as entire cell; boundaries of contiguous cells generally appearing as irregular, punctate or chain-like walls; surface of cells divided into irregular sections or discs.

Remarks: The distinctive feature of these eggs when mixed with others is the linear appearance of the reticulation caused by the peculiar shape of the cells. These eggs are very similar to *A. sollicitans* and *A. mitchellae* with respect to

shape, size, and color. They differ in having cells with caudal rather than lateral arms.

Source: Orange Co., Calif. (J. G. Shanafelt); Chatham Co., Ga. (H. F. Schoof); Indian River Co., Fla. (GBC).

Aedes (Ochlerotatus) cantator (Coquillett, 1903)

Pl. I, fig. 6; Pl. II, fig. 13-14

Shape: Narrowly fusiform; greatest diameter at anterior third.

Size: Length 623μ - 837μ , mean $729\mu \pm 11\mu$; dorsoventral diameter 188μ - 230μ ; mean $206\mu \pm 4\mu$.

Color: Dark brown to tan.

Exochorion: Thin, variably adherent.

Chorion by reflected light: Reticulation distinct over entire surface, composed of polygonal cells of variable size and shape; long axis of cells oriented around circumference; surface of cells covered by several small craters.

Chorion by transmitted light: Cells transversely elongate, length about two times width, especially on dorsum; ventral cells with more irregular shape and arrangement; margins of cells composed of angular, raised, unbroken ridges; surface of cells divided into 6 to 12 rounded subdivisions separated by slight elevations.

Remarks: Distinctive features of these eggs when mixed with others are (1) transverse orientation of the subdivided cells comprising the reticulation and (2) slender profile of the whole egg.

Source: Kent Co., Del. (GBC); Harford Co., Md. (GBC).

Aedes (Ochlerotatus) atlanticus

Dyar and Knab, 1906

Pl. I, fig. 7; Pl. II, fig. 15-16

Shape: Elongate, unequally fusiform; ventral profile arched in midsection and extending in straight or slightly incurved lines to both blunt ends; dorsal profile extending from slightly arched midsection to each end as straight lines, sometimes appearing concave with a median convex swelling; lateral profile distinctly fusiform.

Size: Length 918μ - 1037μ , mean $972\mu \pm 9\mu$; dorsoventral diameter 248μ - 335μ , mean $288\mu \pm 5\mu$.

Color: Shiny blue-black.

Exochorion: Thin, readily detached.

Chorion by reflected light: Anterior and posterior fifths appearing coarsely sculptured with conspicuous, straight-sided, hexagonal cells; remainder of surface smooth or faintly reticulated.

Chorion by transmitted light: Cells near micropyle quadrate to pentagonal, only slightly longer than wide, bounded by straight, uniformly raised ridges; cells of anterior and posterior fifths 2 to 4 times as long as wide, quadrangular, all cell margins straight, angular, unbroken, but some parallelogrammatic cells having margins of shorter sides less conspicuously raised; pattern of

reticulation changing abruptly about one-fifth the distance medially from each pole, cells becoming faint and irregular, some having lateral bud-like arms similar to *A. sollicitans*; median cells not distinguishable, cell margins becoming progressively more sinuate, irregular and less strongly raised toward middle.

Remarks: Conspicuous features of these eggs when mixed with others are (1) extreme length (2) concave dorsal profile and (3) coarse reticulation at each end.

Source: Lauderdale Co., Ala. (WRH); Clay Co., Fla. (L. B. Alltop and D. L. Hayden).

Aedes (Ochlerotatus) infirmatus

Dyar and Knab, 1906

Pl. I, fig. 8; Pl. II, fig. 17-18

Shape: Fusiform; greatest diameter near middle; slightly more pointed posteriorly.

Size: Length 659μ - 788μ , mean $725\mu \pm 8\mu$; dorsoventral diameter 227μ - 259μ , mean $243\mu \pm 5\mu$.

Color: Satiny black.

Exochorion: Thin, loosely adherent.

Chorion by reflected light: Reticulation appearing as irregular, polygonal cells that are in low relief; pattern obscure medially.

Chorion by transmitted light: Cells near poles at least 2 times as long as wide, irregular shape; subterminal cells roundedly quadrangular, about 1.5 to 2 times as long as wide, usually with lateral sides bearing a bud-like projection; cell margins composed of low, sigmoid ridges which may be indistinct medially; surface of cells divided into smooth discs of variable size.

Remarks: The distinctive feature of these eggs when mixed with others is the fusiform shape. These eggs are very similar to *Aedes trivittatus* (cf. Horsfall and Craig 1956), to the extent that positive separation may be difficult. Eggs of *A. infirmatus* are slightly larger (mean length of *A. trivittatus* = $686\mu \pm 8\mu$, mean dorsoventral diameter = $211\mu \pm 2\mu$) but the range of measurements overlap. The shape of *A. infirmatus* is less narrowly fusiform and more plump, as indicated by the ratio of mean length to mean dorsoventral diameter (*A. infirmatus* = 2.98μ , *A. trivittatus* = 3.25μ). However, measurements of other populations of these species are needed to verify this difference. The two species have similar patterns of chorionic reticulation. However, the lateral bud-like arms on cells of *A. infirmatus* are never separated from the main body of the cell, in contrast to *A. trivittatus* where the arms sometimes appear as small, separate cells.

Source: Orange Co., Fla. (GBC).

Aedes (Ochlerotatus) thibaulti

Dyar and Knab, 1910

Pl. I, fig. 9; Pl. II, fig. 19-20

Shape: Narrowly obovate to trapezoidal; dorsal profile almost straight; ventral profile sharply

curved on anterior quarter, gently crescentic on posterior three-quarters; greatest diameter at anterior quarter; both ends blunt.

Size: Length 666μ – 804μ , mean $706\mu \pm 11\mu$; dorsoventral diameter 196μ to 273μ , mean $223\mu \pm 5\mu$.

Color: Dull black.

Exochorion: Thin, transparent, adherent.

Chorion by reflected light: Anterior reticulation composed of pentagonal (less commonly hexagonal) cells bounded by high, straight, conspicuous ridges; median and posterior reticulation less distinct, appearing as irregularly hexagonal cells bounded by lower, less conspicuous, undulating ridges; surface of each cell dominated by an enlarged median disc.

Chorion by transmitted light: Anterior pentagonal cells with irregular orientation, slightly longer than wide; surface of anterior cells subdivided into one or two large, central, circular discs surrounded by smaller, rounded subdivisions; walls of anterior cells heavy, straight or with slight irregularities; median hexagonal cells about as long as wide; surface of each median cell divided into 10 to 15 uniform, rounded to angular sections and one larger, central disc; walls of median cells of low, undulating ridges.

Remarks: Distinctive features of these eggs when mixed with others are (1) the humped appearance of the anterior ventral profile, (2) the heavy anterior reticulation of pentagonal cells

and (3) the enlarged central disc on the surface of the cells.

Source: Pulaski Co., Ill. (WRH).

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