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THE EGG OF *WYEOMYIA SMITHII* (COQUILLET) AND A REVIEW OF KNOWLEDGE OF THE EGGS OF THE SABETHINI

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The egg of *Wyeomyia smithii* was first described by Smith (1902): "The eggs are chestnut brown in color, somewhat chunky, bean-shaped, the ends somewhat pointed, the inner margin nearly straight. There is no evident sculpture; yet when first mounted and examined under the microscope, there seems to be a somewhat irregular tessellated reticulation that disappears later, when the shells become more transparent."

Price (1958a) extended this description: "The individual chestnut-brown egg is provided with a longitudinal hydrophobic area along the slightly concave surface, which represents the ventral side of the developing embryo. This enables the majority of the eggs to float ventral side up at the water surface and often to gather together in loose aggregations. Once an egg is pressed below the water surface, it sinks to the bottom, a thin film of air being revealed as a silvery region on the ventral surface. A definite chorionic sculp-

turing, present along this ventral region and inconspicuous on the other more dorsal portions of the egg, may well contribute to the ability of the egg to float."

An opportunity to observe the eggs of this species was presented when Dr. T. J. Zavortink collected larvae from *Sarracenia* in Ohio and Michigan and brought them to Los Angeles for rearing. Adult females were given a water bowl lined with paper towelling for egg deposition. When the bowl was later examined, most of the eggs were on the water surface while a few were on the moist paper, as was true with Price (1958a) and Wallis and Frempong-Boadu (1967). The eggs (Fig. 1a, c), as noted by Price, appeared to have an upper, hydrophobic face and a lower, more or less hydrophilic surface. The egg thus floats with the upper, non-wettable face exposed to the air. As Price noted, if the egg is submerged in water the upper face is not wetted but is enclosed in a film of air, owing to the hydrophobic

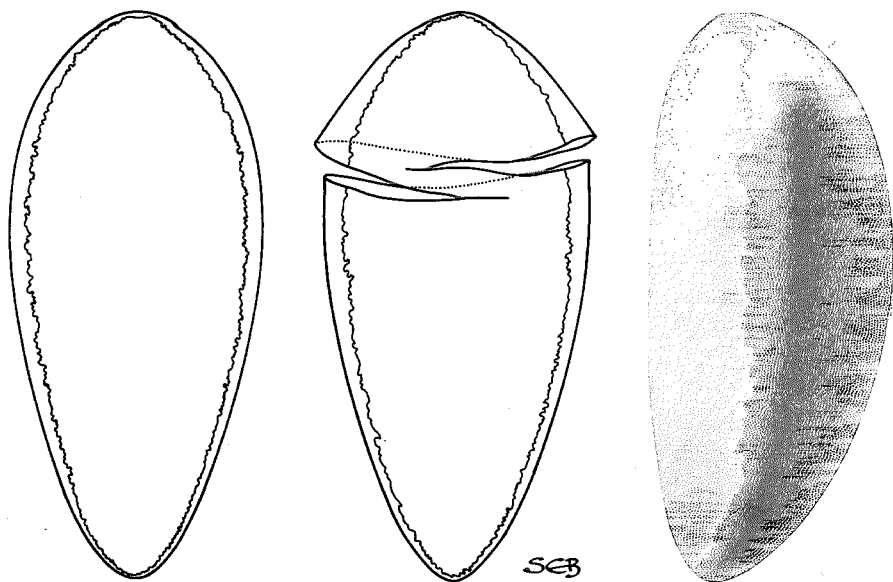


FIG. 1.—Egg stage of *Wyeomyia smithii*; a. upper surface; b. upper surface of hatched egg; c. lateral view.

nature of the upper surface. The air film may not, however, be large enough to buoy up the egg sufficiently to return it to the surface.

Eggs which are brought into contact with a hydrophilic surface, such as moist absorbent paper, may come to lie with a trapped film of air between the upper, hydrophobic surface and the paper; a continuous sheet of moisture covering the outer, hydrophilic surface of the eggs and the surrounding paper surface. When eggs thus come to lie just above the meniscus they are not easily dislodged. Eggs therefore tend to become concentrated near the meniscus much in the same fashion as aedine eggs, but for different reasons. This tendency may account for the observations of Smith: "Eggs were laid in leaves as yet perfectly dry; at the bottom and at the sides; singly or in little groups. . . . Of the old leaves many become imperfect in late fall and any

puncture or decay allowing the water to escape, would of course mean the death of the larvae. So the new leaves are selected and in them many more eggs were found than in the others."

It seems quite unlikely that eggs would be laid in perfectly dry leaves; if they were, it seems even less likely that they would survive since the eggs of all mosquitoes must absorb substantial amounts of water for development to occur. Eggs of all species of mosquitoes are laid either on water or on a very moist substrate. In the case of *W. smithii* there is no indication that the egg can diapause or withstand any degree of drying. Wallis and Frempong-Boadu (1967) say: ". . . in our colonies eggs were predominantly oviposited on the water surface. From here they floated to the water's edge and stuck to the sides of the container as the water level diminished. These eggs as well as those removed from the water surface

after being allowed to dry were not viable when subsequently submerged in water." The egg of *W. smithii* is obviously adapted for floating on water and the observations of Price and those of Wallis and Frempong-Boadu support the idea that eggs are laid on the water. It is likely that the young pitchers in which Smith found most of the eggs also held small amounts of fluid on which the eggs were laid.

Price (1958b) mentions the unusual method of hatching in this species: "The eggs float in such a manner that the ventral side of the embryo is uppermost. . . . The egg burster splits the dorsal surface of the egg approximately one-fourth of the way from the anterior end and the cap opens along a spiral line. The larva rears itself into the water from the dorsal side." This curious spiral rupture is shown in Figure 1b.

REVIEW OF STUDIES OF SABETHINE EGGS

Maorigoeldia. The eggs of *M. argyropus*, the only included species, according to Graham (1929) are laid singly by females standing on the surface of the water. The egg is said to have a roughened covering which traps a film of air around the egg and contributes to its buoyancy. The film of air imparts a lavender hue to the egg. When the roughened covering is lost as sometimes happens when the eggs are agitated, the eggs become brownish and no longer float. When the larva hatches, a split forms which runs the full length of the egg along the lateral margin.

Tripteroides. Baisas and Ubaldo-Pagayon (1952) illustrate two types of eggs which are thought to be those of *Tripteroides* species; one is thought to be the egg of *T. microcala*. Thurman (1959) describes *Tripteroides* eggs as "elongated; bearing minute protuberances . . . laid singly on the surface of the water." It seems likely that this description is based on the illustrations of Baisas and Ubaldo-Pagayon. Yamada (1917) described the egg of *T. bambusa* as follows: The eggs are spindle-shaped, dark colored and very

small: 0.5 mm in length, 0.2 mm in diameter. The surface of the egg shell is covered with many large and small air sacs which are arranged rather regularly to form a net pattern. The large air sacs make up the net, the meshes of the net are filled with many small air sacs.¹ The eggs were laid individually on the surface of the water.

Both *T. microcala* and *T. bambusa* are in the subgenus *Tripteroides*. No eggs have been described in the subgenera *Rachisoura* or *Rachionotomyia*.

Trichoprosopon. There is a great deal of confusion concerning the eggs of *T. digitatum*. According to Lutz (1903), Arnett (1949), and Galindo *et al.* (1951), the eggs are laid singly, while according to Theobald (1910), Howard *et al.* (1913, 1915), Pawan (1922), Bates (1949), and Aitken *et al.* (1968) the eggs are laid in rafts. Since related species are known to lay their eggs singly it seems likely that the confusion arises from misidentification.

Howard *et al.* (1913) pointed out that *T. digitatum* is the only sabethine known to lay its eggs in rafts. They note that the raft is clearly different from those of other raft-laying mosquitoes since it is flat, not curved. Pawan (1922) describes how the female of this species forms the raft, holding it with her mid-legs during the process. He noted that the eggs had rather sharp ventral tips and the raft sank down in the water so that the bottom third of each egg was submerged. The photographs by Aitken *et al.* (1968) show the loosely organized nature of the rafts. The eggs are placed so far apart that air cannot be trapped between the eggs, and the buoyancy of the raft is due only to the buoyancy of the individual eggs. In other raft layers the eggs are packed tightly together so that the interstices hold a great deal of air; this contributes greatly to the

¹ The reference apparently is to the reticulation of the chorion. The translation was graciously supplied by Dr. Takeshi Miura of the University of California Mosquito Control Research Laboratory, Fresno.

buoyancy of the raft. The ventral ends of such eggs are very blunt and the raft floats on the surface of the water with only the ventralmost tip of each egg submerged. Pawan describes the difference in texture between the smooth, presumably hydrophilic, ventral third and the tuberculate, presumably hydrophobic, dorsal $\frac{2}{3}$ of the egg of *Trichoprosopon*. This differentiation of the surface of the egg is clearly shown in the photographs of Aitken *et al.* It is clear from the description and figures of Pawan that at hatching the egg does not open by a simple circular tear as is customary with other raft layers. Aitken *et al.* remark that ovipositing females characteristically "stand guard" for about a day over their clutches of eggs as if they were incubating them. Pawan, on the other hand, noted that it was common for the female to remain on the water surface for two or three hours after oviposition, either close to or away from the egg raft.

Trichoprosopon compressum, like *T. digitatum*, is in the subgenus *Trichoprosopon*. Busck (1908) described the egg as having hair fringes which helped it to remain afloat by spreading its weight over a larger area of surface film. "The eggs are laid singly on the surface of the water. They are elliptical, black, with four longitudinal fringes of short white hairs from tip to tip." If the hairs were wetted by agitation of the water the eggs were submerged but hatched nevertheless.

Galindo *et al.* (1951) examined the eggs of *T. magnum* of the subgenus *Ctenogoeldia*. "The eggs are elongate and are laid singly. They are not resistant to drying . . ." and hatch within 2 to 3 days even if only moist.

Forattini *et al.* (1963) described the egg of *T. pallidiventer*, of the subgenus *Runchomyia*, which was laid singly and displayed no surface features except for reticulations and bosses. Eggs of the subgenera *Limamyia*, *Vonplessenia*, *Shannoniani*, and *Isotomyia* have not been described.

Wyeomyia. Aside from *W. smithii* the only egg descriptions in this genus are those of Busck (1908) which presumably

pertain to *W. pseudopecten* and *W. ulcoma*. "The eggs which are black, smooth and elliptical, are laid singly, but in large numbers, in the uppermost, just-opening and yet dry flower sheath [of *Heliconia* where they await rain for their development]."

Galindo (1958) mentions that the eggs of *Sabethes chloropterus* are very similar to those of "several species of *Wyeomyia*. This comment probably applies to *Wyeomyia mitchellii* and *W. scotinomus*, among others, since it was earlier noted (Galinc *et al.*, 1951) that females of these species laid eggs in the laboratory, from which larvae were reared.

These descriptions pertain to the subgenera *Wyeomyia* (*smithii*, *mitchellii*, *scotinomus*) and *Dendromyia* (*pseudopecten*, *ulcoma*). No eggs have been described of the subgenera *Nunezi*, *Cruzmyia*, *Davismyia*, *Menolepis*, and *Antunesmyia*.

Phoniomyia. The eggs of *P. palma* and *P. davisii* have been described by Forattini *et al.* (1963). It would appear that they are laid singly and are without prominent surface features except for reticulation.

Limatus. According to Peryassú (1908) the eggs of *L. durhamii* are laid singly or in small groups. Peryassú's illustration of the egg shows no prominent surface features.

Sabethes. The eggs of *Sabethes chloropterus* have been described by Galinc (1958): "The eggs of *Sabethes chloropterus* are peculiarly rhomboid in shape thus differing markedly from the known eggs of members of the tribe Culicini. . . . It is interesting to note that eggs of this species are very similar to those of at least two species of typical *Sabethes* namely, *S. cyaneus* and *S. tarsopus*, as well as to those of several species of *Wyeomyia*. However, they are strikingly different from the known eggs of *Trichoprosopon* (*digitatum*, *compressum*, *longipes*, *magnus* etc.), thus corroborating the close affinity that exists between *Wyeomyia* and *Sabethes*, through such an intermediate group

as the subgenus *Davismyia*, and the wide divergence which evidently exists between these two genera and the more primitive sabethine genus *Trichoprosopon*." It is noted that the eggs do not diapause and cannot withstand drying. The extraordinary egg-laying behavior of this species was described in an earlier paper (Galindo, 1957); the female "shoots" her eggs through small holes in bamboo with such force that the eggs are capable of traveling as far as 10 cm in a horizontal direction.

The mentioned species are in the subgenera *Sabethes* and *Sabethoides*. Eggs of the subgenus *Sabethinus* have not been described.

Malaya. Eggs of this genus have not been described but Hopkins (1952) states: "Dr. Haddow has bred . . . (*M. taeniarostris*) . . . from dry material collected from plant axils, which indicates that the egg is resistant to drying."

Topomyia. No eggs have been described from this genus.

CONCLUSION. It is apparent that most sabethine eggs are laid singly and ordinarily they are not capable of diapausing or withstanding drying. They generally have no prominent surface features such as the floats of *Anopheles* or *Orthopodomyia* although less conspicuous surface features as are illustrated for *Wyeomyia smithii* may be present. One sabethine, *Trichoprosopon digitatum*, forms egg rafts but these are quite different from the usual type of egg raft produced by culicine mosquitoes.

In the cases which are known sabethine eggs do not hatch by rupture along a simple circular split as is customary in culicine mosquitoes. This characteristic deserves further study in the eggs of all groups of mosquitoes.

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FIFTEEN SPECIES OF MOSQUITOES AS POTENTIAL HOSTS OF A MERMITHID NEMATODE *ROMANOMERMIS* SP.¹

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The species of mermithid nematodes reported from mosquitoes of the Nearctic Region vary in their degree of host specificity. *Agamomermis culicis* Stiles appears to be host specific for *Aedes sollicitans* (Walker) (Petersen *et al.*, 1967), and *Paramermis canadensis* Steiner appears to be highly specific for *Aedes vexans* (Meigen) (Hearle, 1926); both these mermithid species seem to complete their parasitic stage only in adult mosquitoes. However, most other mermithids that have been reported from North American mosquitoes restrict their development to the larval stages of the host and appear to be less host specific than those maturing in adult mosquitoes. Stabler (1952) reported finding larvae of a species of *Aedes* and two species of *Culex* parasitized by an undescribed mermithid, and Welch (1960) reported that *Hydromermis churchillensis* Welch parasitized larvae of at least three species of mosquitoes though at least three other species seemed to be resistant. Also, an undescribed species of *Romanomermis* in Louisiana was observed parasitizing larvae of at least 13 species of mosquitoes in nature and 32 species in the laboratory

(Petersen *et al.*, 1968). Since the distribution of this *Romanomermis* sp. is apparently somewhat restricted because it prevents pupation and thus cannot be disseminated by the host, tests were made to evaluate 15 mosquito species as potential hosts.

MATERIALS AND METHODS. First instar larvae of the selected mosquito species were exposed to the newly hatched preparasitic juvenile nematodes in the laboratory. However, the preliminary tests indicated that it would be difficult to predict the degree of infection that would result. We therefore included a control species (one known to be a suitable host) which could be used to determine the potential infectivity of the preparasitic nematodes and would also allow us to make a direct comparison between the two species. Though *Culex pipiens quinquefasciatus* Say and *Culiseta inornata* (Williston) are not known natural hosts of the parasite, they were used as the control species because both are susceptible to the nematode and are readily available from laboratory colonies.

The tests were made as follows: Whenever possible, 200 first instar larvae of both the test and the control species were placed in a common container with 50 ml. of water and an unknown quantity of pre-

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