Journal of the American Mosquito Control Association, 12(2):310–311, 1996

UNUSUAL FEATURES OF PUPAL EXUVIAE NOTED IN THE *ANOPHELES QUADRIMACULATUS* COMPLEX (DIPTERA: CULICIDAE)

JOHN F. REINERT,[1] PAUL E. KAISER[2] AND JACK A. SEAWRIGHT[2]

ABSTRACT. Unusual features of the cephalothorax, observed in unmounted pupal exuviae, are reported for 3 of the 5 species of the Quadrimaculatus Complex of *Anopheles.*

Anopheles quadrimaculatus Say is currently recognized as a complex of 5 cryptic species designated A, B, C_1, C_2, and D (Kaiser et al. 1988a, 1988b; Lanzaro et al. 1988; Narang et al. 1989, 1990) based on the use of a variety of genetic techniques. While conducting a morphologic taxonomic study of this species complex some unusual features of the cephalothorax were observed in unmounted pupal exuviae. Because of the uniqueness of these features they are described here. However, complete descriptions and illustrations of the pupae and other life stages, along with synonymy, formal names of the letter-designated species, keys to life stages, bionomics, and distribution will be provided by the authors in an upcoming paper. All specimens used in this study were from individually reared adults with associated pupal and larval exuviae that were obtained from 128 isofemale broods. Each brood was initially identified by starch gel electrophoresis and many broods were subsequently identified by other genetic methods. Morphological terminology used follows Harbach and Knight (1980).

During eclosion the imago emerges through a middorsal split in the scutum of the pupal cephalothorax. This straight-lined split occurs along the dorsal ecdysial line located on the midline of the median keel and extends from the anterior margin of the scutum to the metanotum in most species of the family Culicidae. After the adult mosquito emerges the separated halves of the pupal scutum normally remain in a vertical position as the exuviae rests on the water surface; this is especially true in the genus *Anopheles.* The act of the imaginal mosquito emergence from the pupal exuviae has been previously described in detail by a number of investigators (e.g., Nuttall and Shipley 1901, Marshall and Staley 1932, Crawford 1938, Brumpt 1941, and Christophers 1960).

Pupal exuviae of species A and B of the Quadrimaculatus Complex exhibit the usual morphological condition for the genus *Anopheles* and the family Culicidae. In these 2 species the scutum is completely split to the metanotum and the resulting halves of the scutum remain vertical on either side of the dorsal ecdysial opening.

Species C_1 and C_2 have pupal exuviae that are markedly different from those of species A and B in that during eclosion the scutum does not completely split along the dorsal ecdysial line. In these 2 species the posterior portion of the scutum remains intact for the entire postscutal area of the cephalothorax; however, the 2 halves of the scutum remain vertical on either side of the anterior portion of the dorsal ecdysial opening. A similar condition may occur in *Anopheles maculipennis* Meigen as reported by Nuttall and Shipley (1901:456), "The dorsal slit, through which the insect issued, runs antero-posteriorly and is seen to be gaping, fusiform, and wider anteriorly at a point corresponding to that through which the bulk of the insect passed. The slit extends from a point corresponding to the anterior central margin of the imago's thorax, to a point corresponding to about the two hairs situated posteriorly to the respiratory trumpets . . . ." No material of *An. maculipennis* was available for study. After observing the condition in species C_1 and C_2, unmounted pupal exuviae of a number of species in several culicid genera (*Aedes, Anopheles, Culex, Psorophora, Toxorhynchites, Uranotaenia,* and *Wyeomyia*) were examined specifically for this feature, but all had the scutum completely split or had only an extremely narrow connected area at the posterior margin of the postscutal area.

Pupal exuviae of species D are completely split to the metanotum along the dorsal ecdysial line during eclosion, but they are unique in that the 2 halves of the scutum are bent at the juncture with the pupal mesothoracic wing and are projected laterally. This nearly horizontal position of the scutal halves gives the exuviae a very broad appearance when viewed from above as it rests on the water surface. In some culicids examined (e.g., *Aedes aegypti* (Linn.), *Aedes at-*

[1] Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0620.

[2] Medical and Veterinary Entomology Research Laboratory (MAVERL), Agriculture Research Service, U.S. Department of Agriculture, P.O. Box 14565, Gainesville, FL 32604-2565.

lanticus Dyar and Knab, *Aedes dupreei* (Coq.), *Aedes vexans* (Meigen), *Psorophora ciliata* (Fabr.), *Psorophora columbiae* (Dyar and Knab), *Psorophora ferox* (Von Humboldt), *Psorophora howardii* Coq., *Toxorhynchites rutilus rutilus* (Coq.), *Uranotaenia lowii* Theobald, and *Uranotaenia sapphirina* (Osten Sacken)) each separated half of the median keel, produced by the dorsal ecdysial opening, had the anterior portion (0.2–0.5) bent outward (25–80°) at the base of the median keel. This condition differs significantly from that found in species D. The dorsal apotome of species D is also unusual in that it possesses a well-developed median apical projection that is directed dorsally.

The significance of the unusual features observed in the pupal exuviae of species C_1, C_2, and D is unknown. The discovery of the unusual features reported here support the opinions expressed by Harrison and Peyton (1984) that the pupal stage offers good characters for separating species, especially in the genus *Anopheles*.

Appreciation is expressed to Gary A. Mount and Donald R. Barnard, MAVERL, for providing support and laboratory facilities to the senior author. Special thanks are given to E. L. Peyton (Walter Reed Biosystematics Unit, Smithsonian Institution, Washington, DC), Bruce A. Harrison (North Carolina Department of Environment, Health and Natural Resources, Winston–Salem, NC), and Ralph E. Harbach (The Natural History Museum, London, United Kingdom), for reviewing the manuscript.

REFERENCES CITED

Brumpt, E. 1941. Mecanisme d'eclosion des moustiques. Ann. Parasitol. Hum. Comp. 18:75–94.

Christophers, S. R. 1960. *Aedes aegypti* (L.), the yellow fever mosquito. Its life history, bionomics and structure. Cambridge Univ. Press. Cambridge, United Kingdom.

Crawford, R. 1938. Some anopheline pupae of Malaya with a note on pupal structure. Government Print. Office, Singapore.

Harbach, R. E. and K. L. Knight. 1980. Taxonomists' glossary of mosquito anatomy. Plexus Publ., Inc., Marlton, NJ.

Harrison, B. A. and E. L. Peyton. 1984. The value of the pupal stage to anopheline taxonomy, with notes on anomalous setae (Diptera: Culicidae). Mosq. Syst. 16:201–210.

Kaiser, P. E., S. E. Mitchell, G. C. Lanzaro and J. A. Seawright. 1988a. Hybridization of laboratory strains of sibling species A and B of *Anopheles quadrimaculatus*. J. Am. Mosq. Control Assoc. 4: 34–38.

Kaiser, P. E., S. K. Narang, J. A. Seawright and D. L. Kline. 1988b. A new member of the *Anopheles quadrimaculatus* complex, species C. J. Am. Mosq. Control Assoc. 4:494–499.

Lanzaro, G. C., S. K. Narang, S. E. Mitchell, P. E. Kaiser and J. A. Seawright. 1988. Hybrid male sterility in crosses between field and laboratory strains of *Anopheles quadrimaculatus* (Say) (Diptera: Culicidae). J. Med. Entomol. 25:248–255.

Marshall, J. F. and J. Staley. 1932. On the distribution of air in the oesophageal diverticula and intestine of mosquitoes. Its relation to emergence, feeding and hypopygial rotation. Parasitology 24:368–381.

Narang, S. K., P. E. Kaiser and J. A. Seawright. 1989. Identification of species D, a new member of the *Anopheles quadrimaculatus* species complex: a biochemical key. J. Am. Mosq. Control Assoc. 5:317–324.

Narang, S. K., J. A. Seawright and P. E. Kaiser. 1990. Evidence for microgeographic genetic subdivision of *Anopheles quadrimaculatus* species C. J. Am. Mosq. Control Assoc. 6:179–187.

Nuttall, G. H. F. and A. E. Shipley. 1901. Studies in relation to malaria II. The structure and biology of Anopheles (*Anopheles maculipennis*), III. The pupa. J. Hyg. 1:269–276, 451–484.