MOSQUITO GYNANDROMORPHS

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The purpose of this paper is to describe four mosquito gynandromorphs and to bring together other similar aberrant forms of Culicidae which have been recorded in the literature.

Two of the aberrations to be described were obtained while the writer was stationed at the Fourth Service Command Medical Laboratory, Fort McPherson, Atlanta, Georgia, in 1943. Both of these specimens were of *Culex salinarius* Coquillet and were submitted for identification from Camp Gordon, Georgia; both were collected in the same resting station (number 4). The writer is indebted to Dr. Alan Stone of the United States National Museum for the two gynandromorphs of *Orthopodomyia,* for normal specimens of *O. fascipes* (Coq.) for purposes of comparison, and for permission to prepare a slide of the gynandromorph of *Culex nigripalpus* Theob. previously described by Rings.

Warren and Hill (1947) indicated that of approximately 2 million adult mosquitoes identified at Fort McPherson from 1942 to 1946, only five gynandromorphs were noted. Descriptions of four of these have been published (Middlekauff, 1944; Rings, 1946; Warren and Hill, 1947) while one of the new gynandromorphs of *Culex salinarius* to be described here represents the specimen mentioned by Middlekauff as having been lost. Thus of the large number of mosquitoes identified at the Fourth Service Command Medical Laboratory only six gynandromorphs were observed. Although it is quite possible that some aberrant specimens were overlooked, the above ratio indicates the infrequent occurrence of sex mosaics in this family of insects.

The descriptions of the four aberrant specimens follow (only structures present on the specimens and recognizable as to sex are described). Both gynandromorphs of *Culex salinarius* were identified by color previous to being cleared in KOH and mounted in chloral gum medium.

Specimen 1. Gynandromorph of *Culex salinarius* Coq.: Camp Gordon, Georgia, May 27, 1943 (Fig. 4).—Antennae male; left palpus male (terminal segment missing); proboscis male; wings female; left fore tarsus with two small equal claws—one claw simple, the other with a tooth near the base (Fig. 7; predominantly female, though the presence of the tooth indicates a tendency towards maleness); right fore tarsus female; abdomen female; genitalia female, normal, all three spermathecae present (Fig. 5).

Specimen 2. Gynandromorph of *Culex salinarius* Coq.; Camp Gordon, Georgia, June 23, 1943 (Fig. 2).—Antennae male; palpi male, normal (terminal segment of right palpus missing); proboscis male; wings female; right fore tarsus female; abdomen female; genitalia female; normal, all three spermathecae present (Fig. 6).

Specimen 3. Gynandromorph of *Orthopodomyia signifera* (Coq.); Marianao, Cuba, 1936, Coll. H. P. Carr (Fig. 3).—Antennae male; palpi male; wings female; left fore tarsus male; right mid tarsus female; abdomen female; genitalia female, normal, three spermathecae present (Fig. 8).

Specimen 4. Gynandromorph of *Orthopodomyia fascipes* (Coq.); Tabernilla, Panama, August 14, 1908, Coll. A. H. Jennings (reared from larva collected in bamboo trap). (Fig. 1.)—Right antenna male-like in that the terminal two segments are elongated and each of the flagellar segments possesses long fibrillae. However, female structures are represented by the presence of sensilla on flagellar segments I to XI; left antenna female; palpi female-like but with an additional small segment at their apices (Fig. 9); right wing male-like, slightly shorter

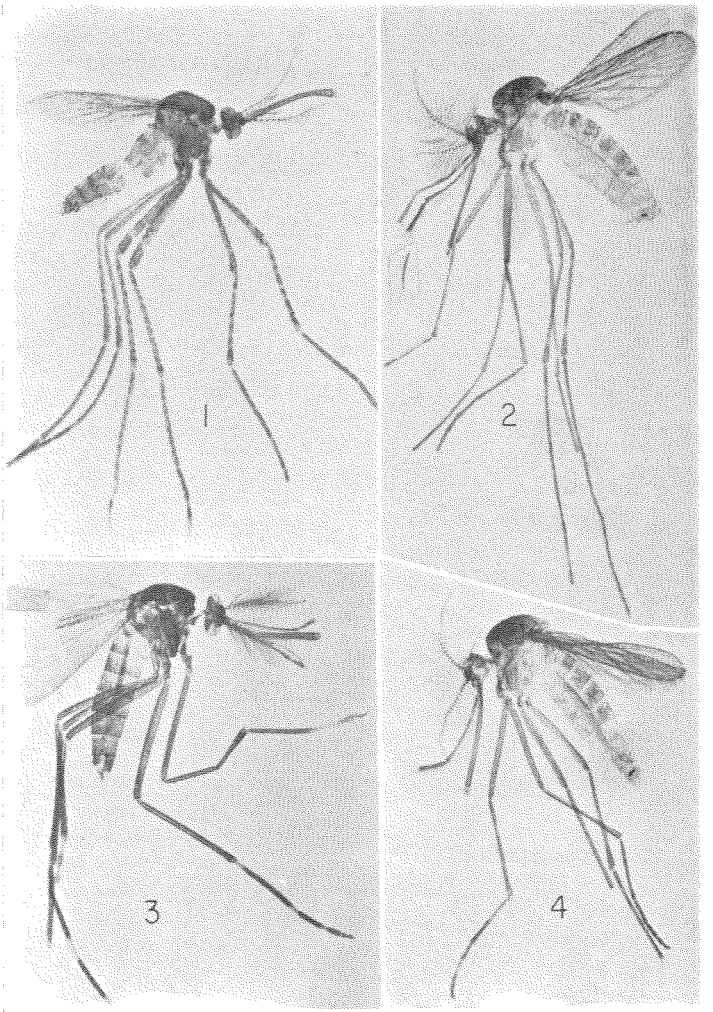
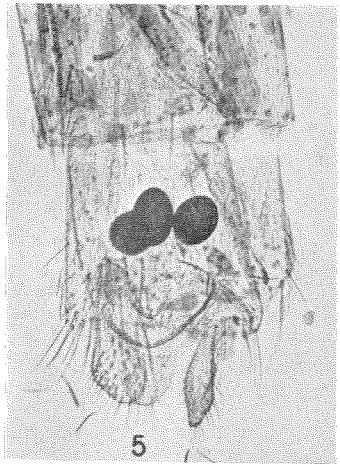
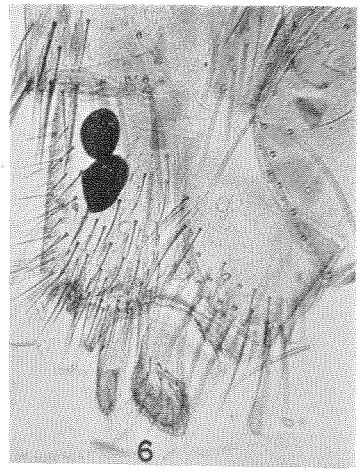
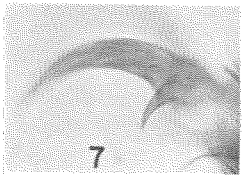


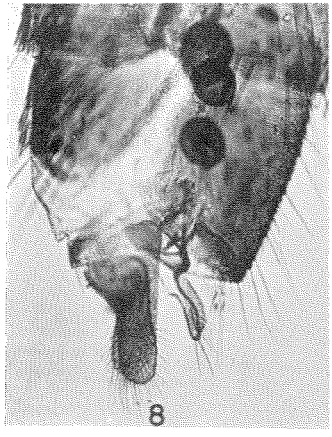
FIG. 1. Gynandromorph of *Orthopodomyia fascipes* (Coq.) × 4.3.
FIG. 2. Gynandromorph of *Culex salinarius* (Coq.) × 7.
FIG. 3. Gynandromorph of *Orthopodomyia signifera* (Coq.) × 7.
FIG. 4. Gynandromorph of *Culex salinarius* (Coq.) × 7.

(Photographs by Mr. Alan Wrigley, Microscopy and Photometry Section, Quartermaster Research and Development Laboratories)









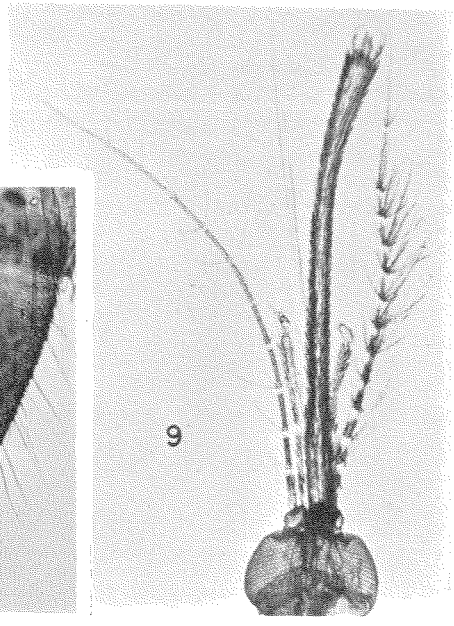


FIG. 5. Genitalia of gynandromorph in FIG. 4. × 94.
FIG. 6. Genitalia of gynandromorph in FIG. 2. × 94.
FIG. 7. Tarsal claw of left fore leg of gynandromorph in FIG. 4. × 426.
FIG. 8. Genitalia of gynandromorph in FIG. 3. × 94.
FIG. 9. Head of gynandromorph in FIG. 1. × 19.6.

(Photographs by Mr. Alan Wrigley)

and narrower than the left; left wing female; left fore tarsus male; right and left mid tarsi female; abdomen female; genitalia female, normal, three spermathecae present.

The other four mosaics described from material submitted to the Fourth Service Command Laboratory follow:

Gynandromorph of *Culex quinquefasciatus* Say, Camp Gordon, Augusta, Richmond County, Georgia, August 15, 1943: "Antennae and palpi as in male, normal. All tarsi are broken off. Genitalia as in female, spermathecae not visible." (Middlekauff, 1944).

Gynandromorph of *Culex pipiens-quinquefasciatus*, Camp Tyson, Paris, Henry County, Tennessee, September 1, 1943 (both *C. pipiens* and *C. quinquefasciatus* occur in this region and since the adult females are difficult to separate by color, both specific names are given).—"Right antenna, right palpus (apical segment broken off), right fore and left mid tarsi as in male, normal. Left antenna as in female but with some unusually long hairs; left palpus short as in female but distorted apically; left fore tarsus broken; right mid tarsus as in female, normal. Genitalia female, normal, with spermathecae." (Middlekauff, 1944.)

Gynandromorph of *Culex nigripalpus* Theobald, Hunter Field, Savannah, Georgia, September 28, 1945.—Taken in light trap. ". . . typical male antennae and palpi; the legs and wings were proportionately more slender, as in normal males, than analogous female structures. The genitalia, size and shape of the abdomen and abdominal scale pattern were characteristically female." (Rings, 1946.) Rings' description was based on an examination of an adult mounted on a triangular point. This specimen was cleared in KOH and mounted in chloral gum medium. Additional information concerning this aberrant is as follows: right fore tarsus male; left and right mid tarsi female; wings appear female; genitalia female, normal, three spermathecae present.

Gynandromorph of *Culex nigripalpus* Theobald, Fort Jackson, South Carolina, September 23, 1946.—Taken in light trap. "This specimen possesses antennae and palpi which are typical female and the abdomen and genitalia exhibit typical male characteristics." (Warren and Hill, 1947.)

The above eight gynandromorphs are deposited in the United States National Museum.

Felt (1904, pp. 467–468) described two gynandromorphs of the genus *Aedes* which apparently have been overlooked by earlier writers. These include a mosaic of *Aedes (Ochlerotatus) implacabilis* Walker (= *Culicada aberratus* Felt), and one of *Aedes (Ochlerotatus) pullatus* (Coquillet) (= *Culicada pullatus* Coq.). Carpenter (1948) described a gynandromorph of *Aedes canadensis* (Theob.). The records of other mosquito gynandromorphs are chiefly from Great Britain. Edwards (1917, pp. 216–217) described three gynandromorphs of *Aedes (Ochlerotatus) punctor* Kirby (= *Ochlerotatus nemorosus* Mg.). Shute (1926) described one mosaic also of *Aedes punctor*. Marshall (1938, pp. 312–313) reported three gynandromorphs, one each of *Aedes (Ochlerotatus) detritus* Haliday, *Culex pipiens* Linn. and *Culex molestus* Forskal. All of the above British records are reviewed by Marshall (1938, pp. 310–313). In addition to the foregoing records, Brelje (1923) gave a very complete description (both internal and external morphology) of a gynandromorph of *Aedes punctor* (= *A. meigenanus*); and Classey (1942) recorded a gynandromorph of *Theobaldia annulata* Schrank.

Very little is known about the behavior of mosquito gynandromorphs since they are, as a rule, noticed after the insects have been killed. Howard (1901, p. 37) recorded the observation of Dr. C. W. Stiles who in the summer of 1889, at "Leipsic" was bitten by a specimen of *Culex nemoralis* which succeeded in sucking blood, and which ". . . possessed male antennae." This convinced Stiles that ". . . either the males do occasionally bite or that occasionally females possess feath-

ered antennae." Edwards (1917) collected his "male" specimens while they were feeding on his hand and ankle. "A close examination later of the three specimens taken showed that none of them were normal males, but all three had one or more female characters on one or both sides of the body. It seems not improbable, therefore, that other male specimens of various mosquitoes which have occasionally been recorded as biting were really partly hermaphrodite." Of particular interest is the fact that one of Edwards' specimens lacked mandibles. Patton and Evans (1929) believed that the mandibles were unimportant in the piercing mechanism and Robinson (1939, p. 231) suggested that deficiency experiments should be performed as verification for Patton & Evans' suggestion. Since one of Edwards' gynandromorphs lacked mandibles but succeeded in sucking blood, the mandibles in this case were not necessary for piercing. Shute's (1926) gynandromorph was collected alive but he could not get it to take a blood meal, though the head was predominantly female and the abdomen, male.

Nothing is known of the sexual behavior of mosquito gynandromorphs but from observations on aberrations of this kind in other groups of insects one can speculate as to the behavior of these sex mosaics. It is generally accepted that insect sexual behavior is not under the influence of the gonads (Wigglesworth, 1939, p. 383). Morgan and Bridges (1919, pp. 22–23) described the courtship of Drosophila gynandromorphs; one specimen, male throughout except for female genitalia, was tested by Sturtevant and behaved as a male. Snyder (1946, p. 351) [1] recorded one case where a bilateral gynandromorph of Drosophila when placed with other flies of both sexes responded by vibrating the wing on the male side (i.e., male response) and extending the wing on the female side (i.e., female response). Whiting (1943, p. 238) tested five specimens of *Habrobracon juglandis* (Ashmead) which were masculine anteriorly and feminine posteriorly and found that they were indifferent to caterpillars (i.e., did not attempt to parasitize) but made ". . . vigorous attempts to mate with females, indicating the brain to be structurally male." Bates (1941, p. 170) concluded from his study of anopheline mosquitoes that the sexual behavior pattern is probably ". . . not dependent on the functioning of the primary sexual organs, . . ."

Roth (1948) showed that the sound produced by the female of *Aedes aegypti* (Linn.) is the external stimulus which attracts and induces the male to copulate. Certain sound frequencies, produced by tuning forks or an audio oscillator speaker, will induce the males of *aegypti* to give a typical mating response which is comparable to the copulating behavior with the female. This response of caged *aegypti* males induced by a sound stimulus can be broken down into four distinct behavior patterns as follows: (1) males which are at rest when exposed to a stimulating sound frequency take to *flight;* (2) after taking to flight the males are *attracted* to the sound source (e.g., tuning fork of 480 to 512 vps.); (3) once attracted the males seize and cling to the cloth of the cage (with their front and middle legs) near the sound source and their wings continue to vibrate, a behavior comparable to seizing the female in flight and therefore called the *seizing response;* (4) the fourth behavior pattern consists of flexing the abdomen ventrad so that the genitalia touch the cloth of the cage; this corresponds to the final stage in copulation when the male makes connection with the female and is called the *clasping response.* Males of *Culex pipiens* Linn., *Anopheles quadrimaculatus* Say and *Psorophora confinnis* Lynch-Arrib. when in a "mating-state" also give a mating response to sound but usually it is not as vigorous as that of *aegypti.*

It is likely that sexual mosaics in which the head is male and the abdomen female (Figs. 2–4) would react like a male and attempt to copulate with normal females though copulation would be unsuccessful

[1] A personal communication to Dr. L. H. Snyder from Prof. A. M. Winchester, Oklahoma Baptist University.

because of the lack of male genitalia. Whether or not a male-acting individual would succeed in seizing a partner would also depend upon the character of the last tarsal segments and claws of the front and/or middle legs since the female tarsi are not structurally suited for seizing and holding the male; the male tarsi of the front or middle legs, or both (depending upon the species) are suited for seizing and holding the female (see Roth, 1948). If the wings of the gynandromorph are female the sound produced by them in flight would no doubt fall within the spectrum which would attract, and therefore normal males would attempt to copulate with these gynandromorphs. An aberration in which the head is female and the remainder male probably would play the passive rôle of a female and would not attempt to mate with other females in spite of the presence of male genitalia. Such individuals with male wings and abdomen (but female heads) would produce a sound in flight which would fall outside the range which acts as a mating stimulus (the pitch of sound produced by a male in flight is higher than that produced by a female) for males and hence, theoretically, these individuals should not attract normal males. It is difficult to predict the mating behavior of a complete or partial bilateral gynandromorph (Fig. 1, and Felt's specimen of *A. implacabilis*) or of a form in which the structures are deformed or show characteristics of both sexes. Would an aberrant form in which one side (right or left) was male and the other female show a characteristic male mating response to a female or mechanically produced sound? If bilateral gynandromorphs behave in a manner similar to certain bilateral Drosophila gynandromorphs recorded in the literature, then the male side would behave as a male (i.e., give a seizing response) and the female side as a female. Since the female mosquito appears to be passive, except for flight, during mating, she would show no behavior indicative of a mating response. The male side of a bilateral mosquito gynandromorph could conceivably give a seizing response to stimulating sound frequencies, but whether or not the male would take to flight, be attracted and give a clasping response to these sounds (or to a female) remains to be shown from observations on living aberrants.

SUMMARY

Four new mosquito gynandromorphs are described. These include two specimens of *Culex salinarius* Coq., one specimen of *Orthopodomyia signifera* (Coq.) and one specimen of *Orthopodomyia fascipes* (Coq.). Other mosquito gynandromorphs from the literature are reviewed. Sex mosaics have been noted in the following species: *Aedes implacabilis* (Walker), *Aedes pullatus* Coq., *Aedes canadensis* (Theob.), *Aedes punctor* Kirby, *Aedes detritus* Haliday, *Culex pipiens* Say, *Culex quinquefasciatus-pipiens*, *Culex nigripalpus* Theob., *Culex molestus* Forskal, and *Theobaldia annulata* Schrank. The probable behavior of mosquito gynandromorphs is discussed.

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THE CALIFORNIA MEETINGS TO HAVE STATE, NATIONAL, AND INTERNATIONAL SIGNIFICANCE

The joint annual meeting of the American Mosquito Control Association and the California Mosquito Control Association will be held at Berkeley and Oakland, California, on February 6–9, 1949. The program will be truly international in scope with outstanding speakers from other countries, as well as from all parts of the United States. One day will be devoted to international, one day to national, and one day to local California topics.

The several phases of mosquito control, and the advances in knowledge made recently will be presented, including those in the fields of mosquito control engineering, entomology and chemistry.

Invitation to attend is extended to all interested. You may have your name placed on the list to receive a copy of the program when it is printed by writing to Mr. Harold F. Gray, Program Chairman, AMCA, 1-A Court House, Oakland, California.

The meeting will be followed by an inspection tour, February 10–15, of some of the work being accomplished in ridding California of the Mosquito Pest.