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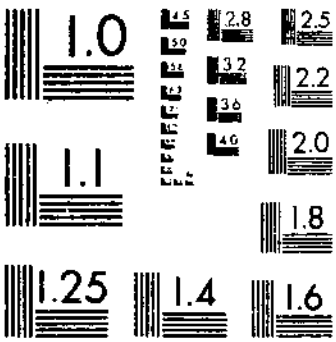

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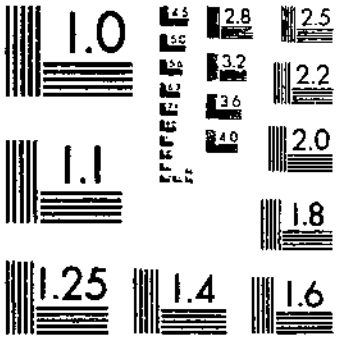

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THE WEST INDIAN SANDFLIES OF THE GENUS CULICOIDES

(Diptera: Ceratopogonidae)

By Willis W. Wirth and Franklin S. Blanton

Technical Bulletin No. 1474

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Our West Indian *Culicoides* collections, unless otherwise specified, have been deposited in the U.S. National Museum, Washington, D.C. Whenever possible we have deposited duplicate material in the collections of the British Museum (Natural History) in London, Institute of Jamaica in Kingston, University of Puerto Rico in Mayaguez and the School of Public Health in San Juan, American Museum of Natural History in New York, University of Florida and Florida State Collection of Arthropods in Gainesville, and the University of the West Indies in St. Augustine, Trinidad.

We have adapted many of the illustrations from our earlier publications. They have been drawn by the artists of the 406th Medical Laboratory, U.S. Army, in Tokyo, Japan, and by Thomas M. Evans, Linda Heath, and Niphan Ratanaworabhan of our staff. Original drawings for this bulletin were prepared by Gloria Gordon of our staff and the senior author. The wing photographs were made by Sally Craig of the Walter Reed Army Institute of Research, Washington, D.C., and Jack Scott of the Smithsonian Institution. To all these persons we extend our thanks.

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The West Indian Sandflies of the Genus Culicoides (Diptera: Ceratopogonidae)

By WILLIS W. WIRTH, *Systematic Entomology Laboratory, Northeastern Region, Agricultural Research Service*, and FRANKLIN S. BLANTON, *Department of Entomology, University of Florida*

The first species of *Culicoides* reported from the West Indies was described from the beaches of northern Cuba in 1851 by Felipe Poey, "the father of Cuban Zoology," as *Oecacta furens* (fig. 1). Poey noted the abundance and bloodsucking attacks of "el jejen" on the Cuban coasts and speculated that it must be breeding in the mangroves or marshes along the seashore.

In the English speaking islands of the Antilles these pests are known as "sandflies." Williston (*1896*) [1] described three species of *Culicoides* from Saint Vincent as *Ceratopogon maculithorax*, *C. decor*, and *C. phlebotomus*. H. H. Smith, who collected material for Williston, added the note on *C. phlebotomus:* "This is the common 'sand-fly' about the southern end of the island."

Coquillett (*1901*) described *Ceratopogon melleus* from Florida; this bloodsucking species is also a pest in the Bahamas. Little was added to our records of West Indian sandflies until Edwards (*1922*) described *Culicoides loughnani* and a variety *jamaicensis* from Jamaica. Hoffman (*1925*) reviewed the North American, Central American, and West Indian *Culicoides* and described *C. trinidadensis*.

In 1942 Fox began a concentrated study of the Caribbean *Culicoides* resulting in a long series of papers (Fox, *1942*, *1946*, *1947*, *1948*, *1949*, *1952a*, *1952b*, *1955a*, *1955b;* Fox and Hoffman, *1944;* Fox and Kohler, *1950;* Fox and Maldonado, *1958;* Fox and Garcia-Moll, *1961;* and Kohler and Fox, *1951*).

Beck (*1951*) began her study of Florida *Culicoides* with the description of a new species, *C. floridensis*, which also occurs in the Bahamas.

In a far-sighted and effective response to the difficult sandfly pest problem at resort hotel and beach areas on the north coast, the Jamaican Government established a Sandfly Research and Control Laboratory under the Ministry of Health at Montego Bay in 1959. Since then this laboratory has contributed immensely to our knowledge of the biology and control of West Indian

[1] The year in italic after the authors' names indicates the reference in Literature Cited, p. 86.

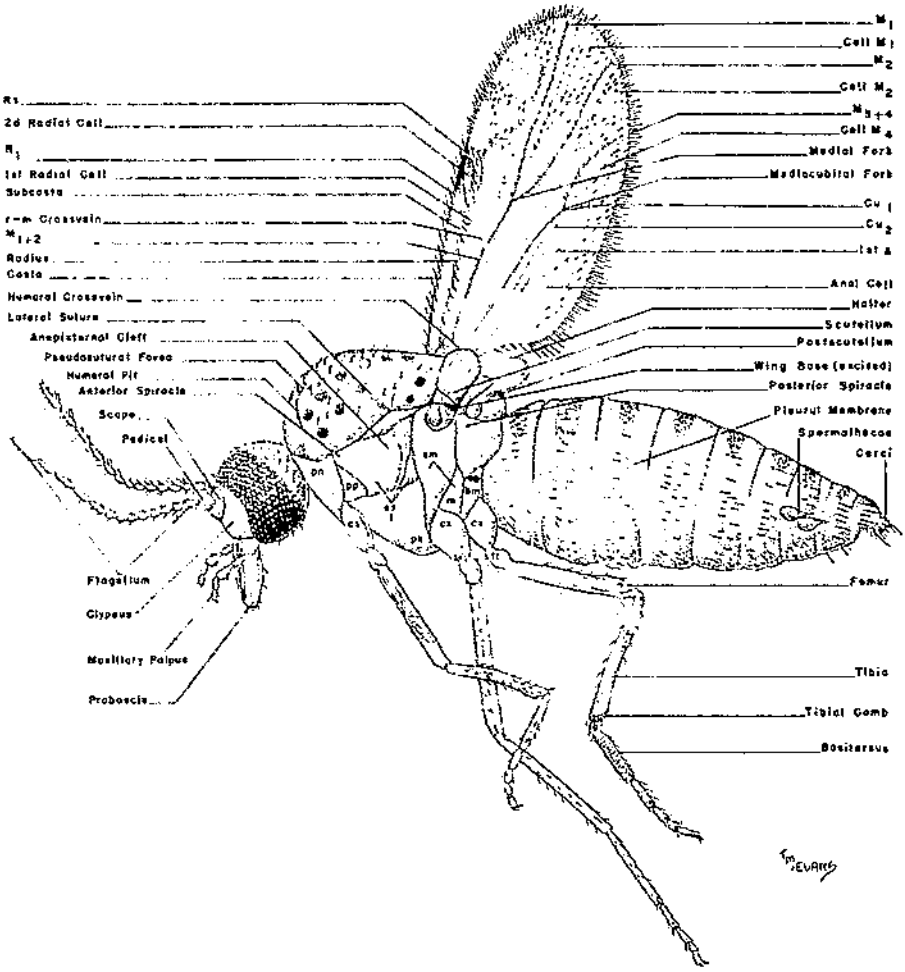

FIGURE 1.—*Culicoides furens*: Lateral view of female, left wing and right legs removed, with parts labeled (cx, coxa; em, epimeron; es, episternum; m, meron; pn, pronotum; pp, propleuron; px, precoxale; tr, trochanter).

sandflies, beginning with the work of D. S. Kettle and later that of J. R. Linley and John B. Davies (see Literature Cited for their contributions). A similar laboratory has been established on Grand Cayman Island and staffed by M. E. C. Giglioli and John E. Davies.

The Bahamian Government was never able to establish a coordinated laboratory such as these, but in the early 1930's it enlisted the help of J. G. Myers, a government entomologist, from Trinidad. Since 1950 it has relied heavily on the assistance of private entomologists from the United States, two of whom should be mentioned for their important work on the biology and control of Bahamas sandflies—Edwin A. Sea-

brook of the Palm Beach County, Fla., Mosquito Abatement District, and Glenn M. Stokes of New Orleans, La.

Setting the geographic limits of the West Indies is slightly arbitrary and controversial depending on the purposes of the study. Geological, biological, and political considerations result in different limits. For the purpose of this study, we have excluded Trinidad and Tobago from the West Indies because these islands have a sandfly fauna essentially the same as the adjacent Venezuelan mainland and because a review of their sandfly species is being reported elsewhere. We will refer occasionally to Trinidad as "West Indian" when a few Antillean species are found there but not on the South American mainland. Although the Dutch island of Aruba falls within the same category as Trinidad in being closely related to the Venezuelan mainland in its biogeography, we have included its only known *Culicoides* species in our review because it has been neglected in other reports. The Bermuda Islands share some *Culicoides* species with the Southeastern United States and only one with the West Indies. We are excluding them from our study and we refer the reader instead to the reports of Williams (*1956, 1957*) and Wirth and Williams (*1957*).

Regrettably our coverage of the West Indies has been extremely uneven, and today we know practically nothing of the *Culicoides* of the important islands of Cuba and Hispaniola and most of the islands of the Lesser Antilles except Dominica. Perhaps one of the major accomplishments of this bulletin will be to point out these gaps in our knowledge and to provide a tool for filling them in when field work can be done in these neglected areas.

ECONOMIC IMPORTANCE

Our knowledge of the biology and biting habits of *Culicoides* is still so fragmentary that we have scarcely any indication of their importance as vectors of pathogenic organisms, but their role is probably minor as compared with that of mosquitoes, fleas, lice, and ticks. However, *Culicoides* may have an important role in the transmission of some diseases, mainly as vectors of filarial worms (Sharp, *1927, 1928;* Steward, *1933;* Buckley, *1933, 1934, 1938;* Dampf, *1936;* Henrard and Peel, *1949;* Romaña and Wygodzinsky, *1950;* Chardrome and Peel, *1951;* Hopkins, *1952;* Hopkins and Nicholas, *1952;* Mirsa et al., *1952;* and Duke, *1954, 1956*). These species may also transmit certain groups of viruses such as bluetongue of sheep and cattle (du Toit, *1944;* Price and Hardy, *1954;* Foster et al., *1963;* Bowne et al., *1964, 1966*); horsesickness (du Toit, *1944*); buttonwillow virus (Reeves et al., *1970*); malarialike protozoa including *Haemoproteus* of birds (Fallis and Wood, *1957;* Fallis and Bennett, *1960, 1961*); *Leucocytozoon* of chickens (Akiba, *1960*); and *Hepatocystis* of monkeys (Garnham et al., *1961*).

By their annoying attacks in tremendous numbers, *Culicoides* species have gained notoriety as pests on beaches and in coastal swamps throughout the world. Recreation areas in the mountains also have their quota of these pestiferous species. In the West Indies the most widespread and troublesome pest is *C. furens*, which in some coastal areas is troublesome enough to retard the development of otherwise magnificent resorts (Myers, *1935;* Adamson, *1939;* Linley and Davies, *1971*). In special areas *C. phlebotomus*, *C. barbosai* Wirth and Blanton, and *C. melleus* are also a problem, along with another blood-sucking ceratopogonid, *Leptoconops bequaerti* (Kieffer) (Painter, *1927;* Linley and Davies, *1971*). Fourteen of the 24 West Indian species have been recorded as biting humans.

Linley and Davies (*1971*) reviewed the problem of sandflies versus tourism in the West Indies, summarized the biology of the most important species, and made recommendations for control. The main thrust of their entire article is toward ways of avoiding a sandfly problem whenever possible rather than trying to control an already existing one. They "advise that intending developers should fully investigate the sandfly situation before commencing their projects, since control measures forced upon them later may be very expensive."

Linley and Davies further stated: "One point that should not escape would-be developers is the following. In fast-growing areas, such as parts of Florida, small towns are often established in desirable areas, and combined interest ensures the necessary funds to deal with insects on a coordinated basis. An entirely different situation exists in a remote island locality. We saw instances of single hotels sited in complete isolation, literally surrounded by enormous swamps. The tourist in this situation is important only to the promoters, and they alone must bear the entire and frequently formidable cost of insect control."

ADULT MORPHOLOGY

The structure of *Culicoides* adults has been described by Carter et al. (*1920*), Jobling (*1928*), Tokunaga (*1937*), Gad (*1951*), Wirth (*1952a*), Wirth and Blanton (*1959*), Jamnback (*1965*), and Atchley (*1967, 1970*). In the following brief descriptions the most important characters used in *Culicoides* classification are defined.

Head.—The head is subspherical, with the anterior surface somewhat flattened and in line with the anterior surface of the proboscis. The compound eyes are large, reniform, and more or less contiguous above the bases of the antennae. They may be bare or with short pubescence between the ommatidial facets. The degree of eye separation or contact is often useful in distinguishing species. In the angle between the eyes on the frons is an interocular seta, and above this is often a transverse

suture that marks the separation of the frons and vertex.

The antenna has 15 divisions, termed segments in this bulletin for convenience, although it is recognized that the 13 divisions of the flagellum are not true segments in the morphological sense. The basal segment or scape is ringlike, incorporated in the head capsule, and hidden by the greatly enlarged pedicel. The first flagellar segment is slightly enlarged and always bears several small sensory pits each surrounded by minute setae. Some or all of the distal segments also bear these sensory tufts; their number, shape, and distribution are of great importance in classification. In the female the first eight flagellar segments are short and bear long verticils basally. The five distal segments are more elongated and without verticils. The ratio of the combined lengths of the five elongated distal segments divided by the combined lengths of segments 3–10 forms the antennal ratio (AR). In the male the pedicel is more enlarged than in the female, and the transition in lengths of the flagellar segments occurs between segments 12 and 13. Of segments 3–12, each has a whorl of greatly elongated, erectile verticils forming a sparse to dense plume.

The mouthparts are well developed, often as long as the head capsule itself, and stronger in the female than in the male. In females of most species they are fitted for piercing and bloodsucking. They consist of six slender, distally toothed blades of subequal lengths, including a strong upper labrum-epipharynx, a pair of maxillae, a pair of strongly toothed mandibles, and a median tubular hypopharynx. These parts are enclosed in a proboscis formed by the fleshy part of the labium. The relative length of the proboscis is of value in classification and is expressed as the proboscis/head ratio (P/H ratio), which is obtained by dividing the distance from the end of the labrum-epipharynx to the tormae by the distance from the latter to the interocular setal base. The maxillary palpus is five-segmented, and the third segment is somewhat swollen and on the distal part of the medioventral surface bears a specialized sensory pit or group of sensilla, which forms an important taxonomic character. The palpal ratio (PR) is the length of the third palpal segment divided by its greatest breadth.

Thorax.—The thorax is moderately broad and convex above, arched anteriorly, and projecting slightly over the head. Dorsally it bears a pair of small depressions behind the humeri, known as the humeral pits, which have been assumed to be sensory but whose exact function is obscure. In various species the disk of the mesonotum is ornamented with a distinctive pattern, best seen in fresh or dried specimens, but usually visible to some degree in slide-mounted material. The legs are slender without special armature, but the apex of the fore tibia bears a small spur and tuft of modified hairs, and the tip of the hind tibia bears an anterior spur and two transverse rows of modified spinose hairs. The "hind tibial comb" includes only the longer spines in the distal row

and is of some value in classification. The fourth tarsomere is usually cylindrical but in a few groups is cordiform. The claws are small and equal on all legs, simple in the female but divided at the apices in the male. The empodium is vestigial.

Wing.—The wings bear dense microtrichia, the size and pigmentation of which give rise to the characteristic pattern of dark or light spots, and more or less abundant macrotrichia or longer hairs. The color pattern of spots or bands is characteristic for each species and is of primary importance in classification; however, in some groups of species it is poorly developed or even absent. In the males the wing is longer and narrower than in the female, and the color pattern is less contrasting. The wing length is measured from the basal arculus to the wing tip. The costa usually extends to more than half the wing length. The costal ratio (CR) is the value obtained by dividing the length of the costa by the wing length. There are, with rare exceptions, two complete radial cells formed by the more heavily sclerotized radial branches; usually the second or distal one (2RC) is broader and longer than the first, which is often slitlike. We used the Tillyard modification of the Comstock-Needham system of wing venation, in which from front to back the branches of the anterior fork are called M1 and M2 and those of the posterior fork are M3+4 and Cu1. The color of the halter is also useful in species separation.

Abdomen.—The female abdomen is relatively stout and the apex somewhat tapered, with a pair of small rounded cerci visible below the ninth tergum. Internally the female possesses from one to three sclerotized spermathecae, which are usually oval to pyriform, with the slender bases of the ducts sclerotized for a short distance. The spermathecae are joined by hyaline ducts to a common duct, and at the juncture there is usually a small sclerotized ring. In most species with two sclerotized spermathecae there is also a small rudimentary third one. The number and shapes of the functional spermathecae and the presence or absence of a ring are important in classification. The length of the spermatheca is measured in the axis of the base of the duct and includes the sclerotized part of the duct.

The male abdomen is slender and bears the prominent genitalia terminally. These are of primary importance in group classification and species identification. The ninth segment is in the form of an irregular sclerotized ring consisting of the fused tergum and sternum. The ninth tergum forms an expanded plate, convex externally and hollowed out mesally, and bearing the anus flanked by a pair of membranous cerci on the ventromesal face. The hind corners of the ninth tergum are frequently expanded as a pair of apicolateral processes. The ninth sternum is much shorter than the tergum, usually with a caudomedian excavation on its hind margin, where the base of the aedeagus articulates at the lateral corners.

The forcepslike genital appendages or gonopods arise laterally at

the base of the tergum and are two-segmented. The enlarged basal segment or basistyle bears two internal processes at the base, a mesally directed ventral root and an anteriorly directed dorsal root, the latter articulating directly with the base of the paramere. The distal segment (dististyle or clasper) is setose and slightly swollen at the base, slender and nearly bare distally with an incurved point. When not extended, it is folded mesad across the mesal face of the ninth tergum. The aedeagus is usually a Y-shaped structure with a median process directed ventrocaudad, forming a sclerotized support on the ventral surface of the male genital duct.

The parameres are usually a pair of sclerotized internal rodlike sclerites, each with knobbed base and ventrally directed distal point. They are subject to great modifications in the shape and direction of the basal knob, the middle stem, or the distal point. In some groups of species the parameres may fuse mesally in part or completely in a platelike structure. Although morphologists suggest that it is more appropriate to use the term paramere for the primary gonopod, here called the basistyle and dististyle, and the term claspette for the internal sclerite, here called the paramere, we prefer to follow the traditional usage among ceratopogonid taxonomists.

BIOLOGY

Adult Food Habits and Autogeny

The males feed on nectar from flowering plants and females may increase longevity by doing so. Without sugar, laboratory-bred *C. barbosai* adults were all dead within 4 days, but with sugar available, males lived up to 13 days and females up to 17 days (Linley, *1966b*). In *C. obsoletus* (Meigen) females, longevity increased from 10 to 51 days in New York when they were fed sugar (Jamnback, *1961*).

Only *Culicoides* females take a blood meal. In most species a blood meal is required for egg maturation. In some species, which are autogenous, eggs may be matured on the first gonotrophic cycle without a blood meal. These flies obtain nutrition for egg development from fat bodies stored during the larval stages. Maturation of a second and subsequent egg batches in such species is dependent on a blood meal, and a meal is needed for each batch of eggs. Facultative autogeny takes place to a variable degree in *C. melleus* (Linley, *1969*), *C. furens* and *C. barbosai* (Linley, *1966b;* Linley et al., *1970b*), *C. sanguisuga* (Coquillett) (Jamnback, *1965*), *C. waringi* Lee and Reye and *C. mackerrasi* Lee and Reye (Dyce and Murray, *1967*), and other species.

Gluchova (*1958*) showed that the number of blood meals and ovarian cycles could be ascertained by the number of follicular relicts in the ovaries after oviposition. She identified up to four ovarian cycles in wild-

caught *C. grisescens* Edwards, but Lewis (*1958*) found more than one relict body difficult to observe in *C. furens* and *C. barbosai*. Some species with reduced mouthparts (low number of mandibular teeth) are not known to take a blood meal: *C. bambusicola* Lutz (Lee, *1968*), *C. circumscriptus* Kieffer (Gluchova, *1958*), *C. bermudensis* Williams (Williams, *1961*), and *C. dendrophilus* Amosova (Amosova, *1959*).

Linley et al. (*1970b*) found in Florida that *C. furens* females that were caught attempting to bite in nature were all parous (i.e., had relict ovariole dilations from previous ovipositions). They concluded that this species is probably 100 percent autogenous. They showed that *C. furens* exhibits a seasonal change in egg productivity of autogenous females in a population, varying from a minimum of 43 eggs per female in the smallest individuals (mean wing length 0.91 mm.) emerging in September to a maximum of 81 eggs deposited by larger females (wing length 1.15 mm.) emerging in March after developing in the cooler part of the year.

The adult feeding habits of the West Indian *Culicoides* can be summarized as follows:

Feeding on man.—*barbosai, floridensis, foxi* Ortiz, *furens, hoffmani* Fox, *insignis* Lutz, *loughnani, melleus, panamensis* Barbosa, *paraensis* (Goeldi), *phlebotomus, pusillus* Lutz, *trilineatus* Fox, and *trinidadensis*.

Feeding on horse, donkey, mule.—*arubae* Fox and Hoffman, *foxi, furens*, and *heliconiae* Fox and Hoffman.

Feeding on cattle.—*insignis*.

Feeding on bird.—*archboldi* Wirth and Blanton and *hoffmani*.

Hosts unknown.—*borinqueni* Fox and Hoffman, *bredini* Wirth and Blanton, *decor, dominicanus* Wirth and Blanton, *farri* Wirth and Blanton, *guadeloupensis* Floch and Abonnenc, and *jamaicensis*.

Mating Habits

Mating (Downes, *1955*) typically takes place in flight. The males form swarms and as the females fly through the swarms they are captured by the males. A few species will mate without swarming, with both sexes running or crawling around on the soil or vegetation near the potential larval habitat and mating on contact (Downes, *1958*). *C. melleus* is a West Indian species with this habit (Linley, *1969;* Wirth, personal observation). In some species both sexes are attracted to the adult host where the males mate with the females shortly after the latter have fed (i.e., *C. nubeculosus* (Meigen) in Russia and *C. utahensis* Fox in western North America).

While swarming the males bring the setae of the antennal plumes to an erect position (Downes, *1955, 1958*), where they serve in auditory recognition of the wing beat frequency of the female. At all other times they are folded. The mating posture (Pomerantzev, *1932*) is normally end to end facing in opposite directions with the male claspers pointing to the head of the female and the ventral parts of the genitalia

in contact. In *C. nubeculosus* this results in a 180° rotation of the male genitalia, but in most other species there is only a gentle torsion of the male abdomen.

Most species mate only once, but Jones (*1966*) found that *C. variipennis* (Coquillett) can mate repeatedly and stored sperm would last for up to three egg batches. Sperm is transferred to the female in a spermatophore in *C. nubeculosus* (Pomerantzev, *1932*) and in *C. melleus* (Linley and Adams, *1971*).

Oviposition

Females when not given a suitable choice of oviposition site may refuse to oviposit, but decapitation can remove this inhibition (Linley, *1965c*), and eggs may be deposited freely for experimental studies. Typically the eggs are laid within a week or 10 days after the females emerge in autogenous species or the same length of time after a blood meal. The eggs are small (0.25 mm. long) and banana shaped, white when newly laid and darkening to brown. They are deposited on a moist substrate and cannot survive prolonged drying. The eggs hatch in a few days (2–4 in *C. furens* and 5–7 in *C. barbosai;* Linley, *1966b*). The first-instar larva possesses a functional spine-bearing proleg.

Linley (*1965b*) found that *C. furens* and *C. barbosai* in Jamaica showed evidence (ovariole relicts) of ability to deposit one (autogenous) or two (second after a blood meal) batches of eggs. Jones (*1967*) found that *C. variipennis* females deposit an egg batch for each blood meal taken. A single female could live up to 44 days, deposit a maximum of 243 eggs in a batch, and lay up to 1,143 eggs in as many as seven egg batches during her lifespan.

Larval Habitats

Only the most important works on the life histories and larval habitats of the West Indian species will be mentioned, beginning with the early South American and Central American studies of Lutz (*1913*), Painter (*1927*), Fox (*1942*), Carpenter (*1951*), Woke (*1954*), and Forattini et al. (*1958*).

The most intensive study of breeding places of neotropical *Culicoides* was made by Williams (*1964*) in Trinidad. He reared 24 species from a wide variety of habitats, including sandy and muddy margins of streams and ditches with fresh and brackish water, pond and swamp margins, spring seep areas, discarded animal bedding, rain-soaked manure, decaying cacao pods, banana stalks, calabash fruits, and flowers of *Calathea*, *Heliconia*, and *Clusia*.

In the West Indies the only intensive studies of *Culicoides* biology were made in Jamaica by D. S. Kettle, J. R. Linley, and J. B. Davies, who have published a series of papers on larval habitats, biology, and immature stages. Their findings are reviewed here under each species in Descriptions of *Culicoides* Species.

The West Indies are particularly favorable for those *Culicoides* species that prefer coastal mangrove swamps and sandy beaches because of the many miles of shoreline, par-

ticularly in the small low islands of the Bahamas. Only the larger islands of the Greater Antilles and Lesser Antilles have area and elevation enough to create constantly wet environments suitable for the rain forest and cloud forest species that predominate on the neotropical mainland.

The preferred larval habitats of the West Indian *Culicoides* species are as follows:

(1) Sandy beaches and coastal lagoons—*melleus, phlebotomus*.

(2) Coastal mangrove swamps and salt marshes—*arubae, barbosai, furens, insignis, trinidadensis*.

(3) Wet soil and pond and stream margins, usually with organic matter—*foxi, insignis*.

(4) Rotting plant materials—*foxi, jamaicensis, loughnani, paraensis, pusillus*.

(5) Tree hole debris—*borinqueni, hoffmani, paraensis, trilineatus*.

(6) Leaf axils and bracts of water-holding plants—*decor* (inferred), *dominicanus* (inferred), *farri* (inferred), *heliconiae, panamensis*.

(7) Unknown—*archboldi, bredini, floridensis, guadeloupensis*.

CONTROL MEASURES

Literature on *Culicoides* control has been reviewed by Kettle (*1969a*) and Linley and Davies (*1971*).

Several workers have recommended control measures for *C. furens* using a system of dikes and pumps for water-level management and drying up or flooding potential larval breeding sites (see Hull and Dove (*1935*), Hull et al. (*1939, 1943*), Platts et al. (*1943*), Rogers (*1962*), MacLaren et al. (*1967*), and Linley and Davies (*1971*)).

Working in Jamaican mangrove swamps producing large numbers of *C. furens, C. barbosai,* and *C. insignis*, Davies (*1969*) found that *C. barbosai* preferred more heavily shaded habitats than the other two species. Clearing the mangroves and exposing the soil to full sunlight reduced the population of *C. barbosai* to a tenth of that in the control area but had little effect on *C. furens* and *C. insignis*.

Measures for treating the soil with insecticides to control *Culicoides* larvae have been proposed by Curran and Goulding (*1950*), Labreque and Goulding (*1954*), Jamnback et al. (*1958*), and Wall and Doane (*1965*). Use of insecticide sprays and fogs for outdoor control of *Culicoides* adults has been described by Madden et al. (*1946*), Glasgow and Collins (*1946*), and Bruce and Blakeslee (*1948*). Wire or plastic mesh screens have been only partially effective in preventing *Culicoides* from entering houses because of the small size of the insects (Porter, *1959*). Treating the screens with insecticide in kerosene proved helpful (Jamnback, *1963*).

With the recent concern about the long range environmental deterioration produced by massive applications or long continued usage of modern pesticides, advisory agencies

have become cautious about recommending chemical control except as a last resort. Emphasis is being placed on the need for research to develop biological and managemental solutions to sandfly problems.

GEOGRAPHICAL DISTRIBUTION

Hodge (*1954*) reviewed the Antillean geography and ecology. Woodring (*1954*) reported on the geological history of the Caribbean. Chace and Hobbs (*1969*) summarized the West Indian biogeography in a revision of the West Indian terrestrial and fresh-water decapod crustaceans. The maps of the West Indies and Dominica by Chace and Hobbs and the accompanying gazeteers are especially helpful and have been followed in our distribution lists.

The following tabulation summarizes our knowledge of the distribution of the West Indian *Culicoides*. The format has been adapted from a similar table by Chace and Hobbs. The maps in figures 2–6 illustrate some of these distributions.

The geographic distribution of the fauna is as follows:

- Antillean endemics (nine species):
  - Lesser Antilles (five species):
    - Dominica — *archboldi, bredini, dominicanus*
    - Guadeloupe — *guadeloupensis*
    - Dominica, Saint Lucia, and Saint Vincent—*decor*
  - Greater Antilles (two species):
    - Jamaica—*farri*
    - Jamaica and Puerto Rico —*borinqueni*
  - Lesser Antilles and Greater Antilles (two species):
    - Jamaica and Cayman Islands to Barbados and Trinidad—*hoffmani*
    - Puerto Rico to Barbados and Grenada—*trilineatus*
- Antillean fauna also represented on continental masses (15 species):
  - Lesser Antilles, Central America, and South America (one species):
    - *heliconiae*—Honduras to Brazil; Grenada
  - Lesser Antilles, North America, Central America, and South America (two species):
    - *arubae*—Texas to Colombia and Venezuela; Aruba
    - *paraensis* — Eastern United States to Argentina; Grenada
  - Greater Antilles, North America, Central America, and South America (three species):
    - *barbosai* — Florida to Panama and Ecuador; Bahamas, Cuba, Jamaica, Cayman Islands

jamaicensis—Mexico to Panama, Venezuela, and Trinidad; Bahamas, Cuba, Jamaica, Puerto Rico

panamensis—Mexico to Panama; Cuba, Jamaica, Cayman Islands

Greater Antilles and North America (one species):

loughnani — Florida, Texas; Bahamas, Cuba, Jamaica

Bahamas and North America (two species):

floridensis—Florida; Bahamas, Bermuda

melleus—Eastern United States (coastal); Bahamas

Lesser Antilles, Greater Antilles, Central America (and/or Mexico), and South America (four species):

foxi—Mexico to Argentina; Jamaica, Puerto Rico

phlebotomus—Mexico to Ecuador and Brazil; widespread in West Indies

pusillus—Mexico to Ecuador and Brazil; widespread in West Indies

trinidadensis—Nicaragua to Colombia and Trinidad; Bahamas, Cuba, Haiti

Lesser Antilles, Greater Antilles, North America, Central America, and South America (two species):

furens—Eastern United States to Brazil and Ecuador; widespread in West Indies

insignis—Florida to Argentina; widespread in West Indies

The geographic distribution of the *Culicoides* species is as follows: [2]

Antigua—*furens, hoffmani,* phlebotomus,* pusillus* *

Aruba—*arubae*

Bahamas—*barbosai, floridensis,* furens, jamaicensis, loughnani,* melleus,* trinidadensis*

Barbados—*furens, hoffmani,* paraensis, trilineatus*

Cayman Islands—*barbosai, furens, hoffmani,* insignis,* panamensis,* pusillus* *

Cuba—*barbosai, furens, insignis,* jamaicensis,* loughnani,* pusillus,* trinidadensis* *

Dominica—*archboldi, bredini, decor, dominicanus, furens, hoffmani,* insignis,* phlebotomus,* pusillus,* trilineatus* *

Dominican Republic—*furens, insignis,* phlebotomus*

Grenada — *heliconiae, paraensis, pusillus,* trilineatus* *

Guadeloupe—*furens, guadeloupensis*

Haiti—*furens, insignis, trinidadensis*

Jamaica — *barbosai, borinqueni, farri, foxi,* furens, hoffmani, insignis, jamaicensis, loughnani, panamensis,* phlebotomus,* pusillus*

[2] New records are marked with an asterisk.

Montserrat—*furens*

Puerto Rico—*borinqueni, foxi, furens, hoffmani, insignis, jamaicensis, phlebotomus, pusillus, trilineatus*

Saint Croix—*furens, hoffmani, jamaicensis, loughnani,* phlebotomus, trilineatus*

Saint John—*furens, insignis,* phlebotomus **

Saint Lucia—*decor, furens, hoffmani,* insignis,* phlebotomus,* pusillus,* trilineatus **

Saint Thomas—*furens,* trilineatus*

Saint Vincent—*decor, furens, phlebotomus*

Virgin Gorda—*furens **

According to Woodring (*1954*), large insular masses existed in the Caribbean during the Cretaceous and some persisted during the Eocene period. There is no geological evidence, however, of any continuous land bridges or evidence that any existing land masses were continuously in the Antilles back to the Eocene.

Eardley (*1954*) postulated that a belt of late Jurassic or Cretaceous orogeny branched eastward from Central America through the Greater Antilles and Lesser Antilles to Trinidad and Venezuela. This belt made a tight U-shaped pattern and marked two tectogenes, both formed in late Mesozoic and probably in succession one after the other. A third tectogene from Puerto Rico around the Lesser Antilles to the Leeward Islands formed in the Eocene and continues to the present. These orogenic belts were regions of subsidence, heavy sedimentation, igneous activity, and horizontal compression. At times they may have been seaways, at others, superior mountain systems.

Eardley believed the orogenic

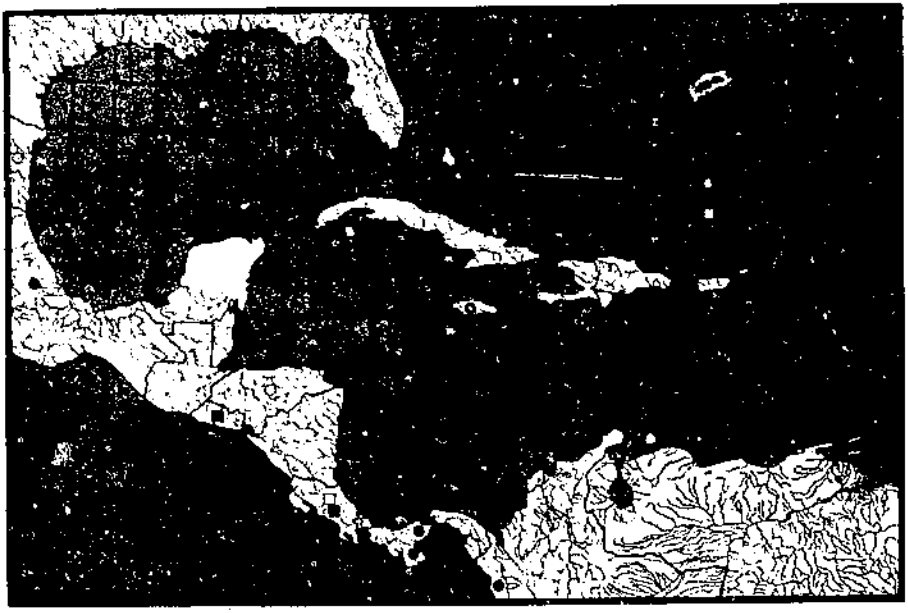

FIGURE 2.—Distribution of the *Culicoides nigrigenus* group in the Caribbean.

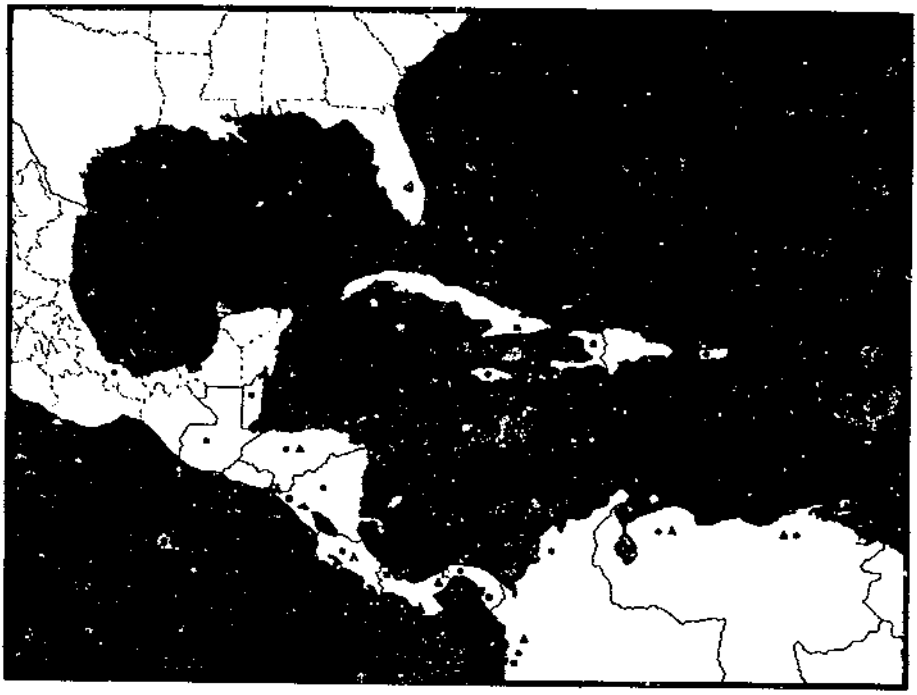

FIGURE 3.—Distribution of some *Culicoides* (*Hoffmania*) species in the Caribbean.

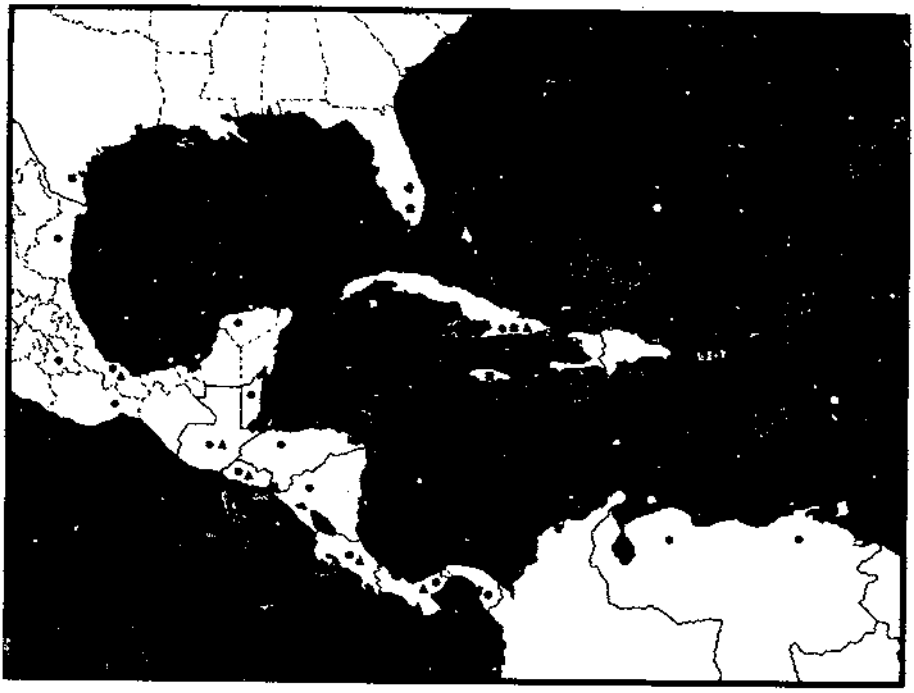

FIGURE 4.—Distribution of the subgenus *Drymodesmyia* in the Caribbean.

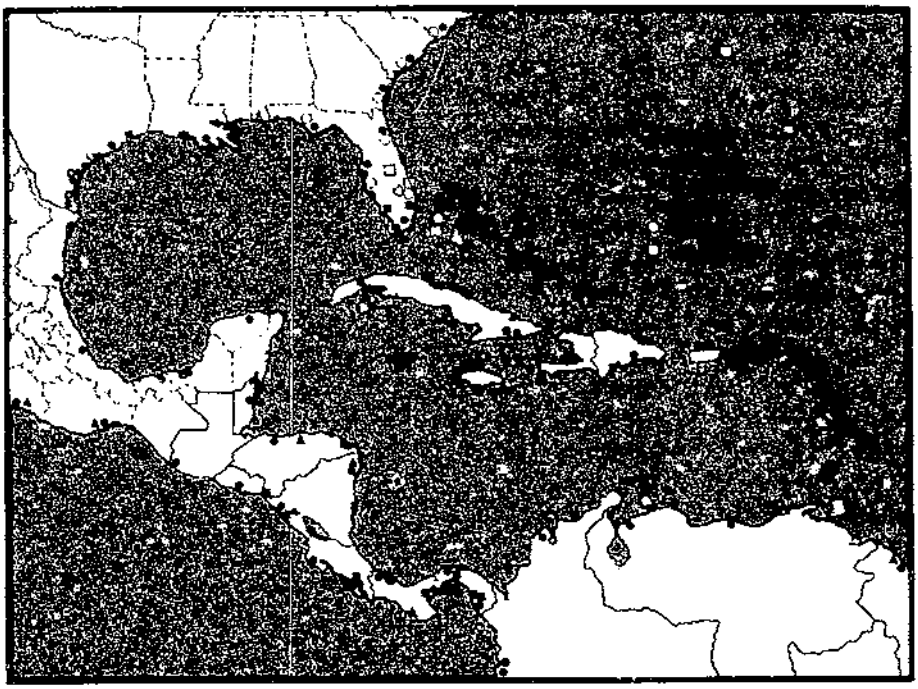

FIGURE 5.—Distribution of some *Culicoides* species in the Caribbean.

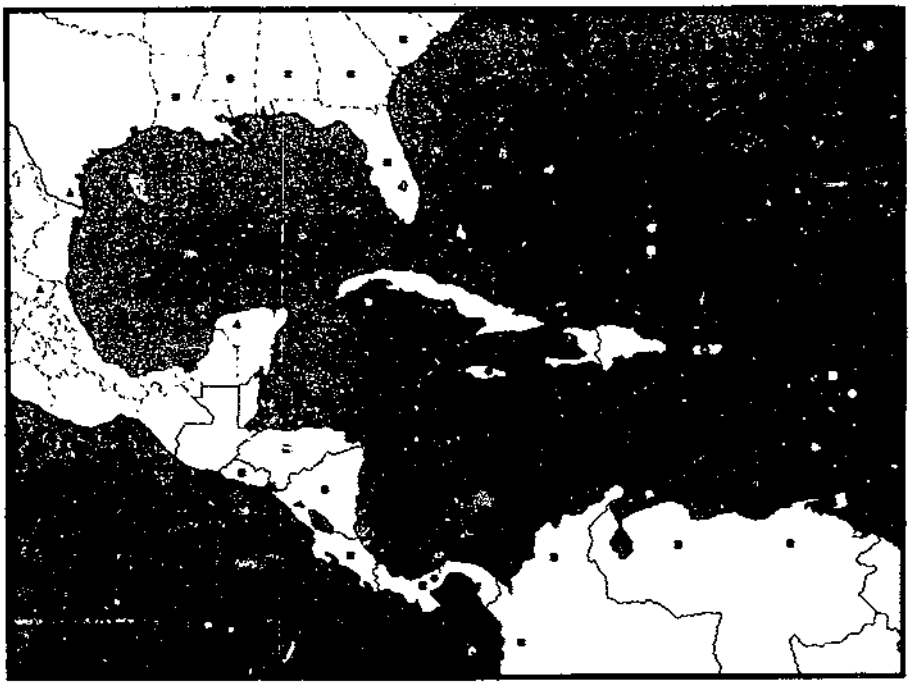

FIGURE 6.—Distribution of the *Culicoides debilipalpis* group in the Caribbean.

cycle generally consisted of (1) general epeirogenic uplift of a central region for a long time and the shedding from it of large amounts of debris to partly surrounding basins; (2) compressional deformation in the partly surrounding basins to form a belt of major orogeny; and (3) subsidence of the former region of uplift, with the creation of a basin having deep water in places. The marginal areas of the new basin soon became sites of heavy sedimentation. The Gulf of Mexico is believed to have begun to subside in the Permian period, the western Caribbean Basin to be due to Cretaceous and early Tertiary subsidence, and the eastern Caribbean Basin is thought to have resulted from middle and late Tertiary subsidence.

According to Chace and Hobbs (*1969*), most of the present islands of the Antilles are not known to be older than Oligocene or early Miocene. Consequently, the ancestors of the present fresh-water and terrestrial faunas on them could not have been established earlier.

Belkin (*1962*) believed that this "American Mediterranean" region has been an important center of evolution of new types of mosquitoes and probably other terrestrial and fresh-water organisms rather than a barrier to their dispersal. In the course of island formation through fragmentation of a land area, great environmental stress would be placed on surviving populations and these would be greatly reduced and isolated. Under these conditions there would be an ideal opportunity for quick fixation of new adaptive types. These would have a chance to become established and better adapted and they could then disperse when the isolated areas became approximated again with one or more of the adjoining continental masses. Limited hybridization would probably also occur when contact was reestablished and would contribute to further evolution. Belkin believed that this hypothesis helped to explain several controversial problems as enumerated below:

(1) The presence of equally primitive and distinct members of a phylad both in the Northern and Southern Hemispheres. Usually it is interpreted that the phylad originated in a continental area in one hemisphere and then dispersed to another. According to Belkin as exemplified by the subgenus *Ochlerotatus* of *Aedes*, the situation is easily explained if the phylad originated on an intercontinental island and dispersed to both hemispheres where taxa evolved independently. Bram (*1967*) reported that 47 of the 61 American species of the subgenus *Culex* (*Culex*) are found in the American Mediterranean, which apparently was their primary center of origin.

(2) The presence of annectant types on the larger islands and on the periphery of intercontinental areas. Belkin considered that these might represent relatively unsuccessful types evolved in isolation that had not been able to radiate and are confined to the immediate vicinity of their place of origin.

(3) The successive replacement of phylads during evolution of a minor

group. This could be accomplished by the origin of new dominant types in isolation of the intercontinental area and their subsequent invasions of continental areas.

The *Culicoides furens* group may illustrate Belkin's third type of situation. This coastal salt-marsh group comprises five species—*C. alahialinus* Barbosa, ranging from Panama to Ecuador; *C. barbosai* (West Indies distribution (p. 26)); *C. furens* (p. 43); *C. gorgasi* Wirth and Blanton, a Panama endemic; and *C. cancer* Hogue and Wirth, a Costa Rican crab-hole endemic. *C. furens* is by far the most dominant, wide-ranging, and successful species of this group (fig. 5) and may actually be a sister species of the similarly dominant *C. schultzei* (Enderlein) of the Ethiopian-Oriental fauna. Since no Afro-Asian species appears to be closely related to *C. schultzei*, it seems on morphological grounds that the origin of this species was with the American *C. furens* group. At the same time that *C. furens* was achieving dominance, it seems that *C. cancer* and *C. gorgasi* evolved as ecologically restricted endemics, and *C. barbosai* followed *C. furens* part way in the western Caribbean to Florida (fig. 5) with a much restricted ecological niche located a little closer to the actual seashore. *C. schultzei* evolved from this group and is even more fresh water tolerant than *C. furens*, breeding in a wide spectrum of wet soil habitats.

The West Indian *Culicoides* exhibit an unusual degree of endemism, possibly because of their low ecological valence in the sense of Belkin's second situation. Three of the nine endemic species belong to the *C. nigrigenus* group of the subgenus *Anilomyia*, a group of seven circum-Caribbean species that breed, so far as is known, in the leaf axils of bromeliads (fig. 2). This group has one widespread mainland species, *C. nigrigenus* Wirth and Blanton, ranging from Mexico to Colombia and Trinidad; two Lesser Antillean endemics, *C. decor* and *C. dominicanus*; *C. hayesi* Matta from Mexico and Honduras; *C. lutealaris* Wirth and Blanton and *C. chrysonotus* Wirth and Blanton from El Salvador, Costa Rica, and Panama; and *C. farri* endemic to Jamaica. We suspect that through isolation the Antillean endemics evolved from mainland ancestors, *C. decor* and *C. dominicanus* through Venezuelan stocks, with the ancestor of *C. farri* coming across the Nicaraguan Swell. Cuba and Hispaniola are terra incognita in this distribution pattern and should yield valuable collection data in this group especially. Absence of *Anilomyia* species in Puerto Rico, where many insect collections have been made, suggests that this group has invaded the Antilles independently from the west and from the southeast.

The subgenus *Drymodesmyia* contains two groups. The *C. copiosus* group contains 17 species that breed primarily in rotting cacti in the Southwestern United States and in Mexico, with a few species ranging through the West Indies to Florida and Puerto Rico and through Central America to Panama, Venezuela, and Trinidad. The three West Indian

species each have a different distribution pattern (fig. 4), indicating for each a different ancestral pathway to the islands. *C. jamaicensis* is widely distributed on the mainland from Mexico to Panama, Venezuela, and Trinidad and is found on the Greater Antilles and Bahamas. Its pathway was probably across the Nicaraguan Swell. *C. loughnani* is probably a Greater Antillean species that reinvaded the mainland through Florida and possibly followed the Gulf Coast to Texas. More collecting is necessary in Mexico to be sure it does not range through Yucatan to proximity with western Cuba. *C. panamensis* is a Central American species that has crossed the Nicaraguan Swell to Jamaica and the Cayman Islands. It is reasonable to deduce that *C. jamaicensis* evolved on the mainland and migrated to the Greater Antilles; *C. loughnani* probably traveled from the Antilles to the mainland; and the ancestral home of *C. panamensis* may have been either place, but more likely the mainland.

The second group of *Drymodesmyia* is the *C. daedalus* group, which contains two West Indian species breeding in tree holes, *C. borinqueni* and *C. bredini* (fig. 4). Both are West Indian endemics; *C. borinqueni* occurs in Jamaica and Puerto Rico and *C. bredini* only on Dominica. The former is closely related to *C. hinmani* Khalaf from the Southern United States, whereas the second has many similarities to *C. daedaloides* Wirth and Blanton from Panama. Evolutionary pathways are rather speculative in this group, but we would surmise that the ancestor of *C. hinmani*, *C. borinqueni*, and *C. bredini* came to the Greater Antilles across the Nicaraguan Swell from Central America, *C. bredini* evolved through isolation in the east, and *C. hinmani* developed similarly on the Florida mainland, leaving *C. borinqueni* in the Antillean heartland.

The distributional picture of West Indian species of the *C. debilipalpis* group is complex (fig. 6). *C. archboldi* is a Dominican endemic related to *C. eublepharus* Macfie. It probably came to the Lesser Antilles by way of Venezuela and Trinidad, where related species still occur. *C. guadeloupensis* and *C. trilineatus* are closely related West Indian endemics, the first species endemic to Guadeloupe Island and the second ranging from Puerto Rico through the Lesser Antilles to Grenada and Barbados. The most interesting distribution is shown by *C. hoffmani*, a West Indian endemic ranging from Jamaica and the Cayman Islands in the west to Barbados and Trinidad in the east. This species is closely related to *C. debilipalpis* Lutz, a widespread neotropical species ranging from Maryland to Florida and Texas in the United States and from Honduras in Central America to Trinidad and to Brazil and Argentina in South America (see Wirth and Blanton, *1971*). The closely related *C. eadsi* Wirth and Blanton is allopatric with *C. debilipalpis* in southern Texas and in Mexico, whereas in the West Indies *C. hoffmani* replaces it except in Trinidad where both species occur.

SYSTEMATIC ARRANGEMENT

Our systematic classification of the West Indian *Culicoides* (table 1) shows their arrangement in six subgenera and summarizes the mean values for certain numerical characters of the females. For greater convenience in using this bulletin, we have arranged the species descriptions and illustrations alphabetically without regard to natural classification.

TABLE 1.—*Systematic arrangement of West Indian species of* Culicoides *with mean values for certain numerical characters of females*

Subgenus and species	Wing length	Costal ratio	Antennal ratio	Antennal sensory pattern	Palpal ratio	Proboscis/head ratio
Subgenus *Hoffmania* Fox: *Mm.*						
foxi	1.21	0.68	1.10	3,11–15	3.2	1.15
heliconiae	1.66	.71	1.06	3,11–15	3.6	1.33
insignis	1.11	65	1.32	3,5,7,9,11–15	2.8	1.05
trinidadensis	1.12	.66	1.22	3,5,7,9,11–15	3.4	1.08
Subgenus *Anilomyia* Vargas:						
decor	1.20	.60	1.25	3,8,10–15	3.2	.85
dominicanus	1.22	.62	1.85	3–15	2.3	.75
farri	1.25	.60	1.35	3,10–15	2.0	.68
Subgenus *Avaritia* Fox:						
pusillus	.64	.53	1.18	3,13–15	2.6	1.08
Subgenus *Drymodesmyia* Vargas:						
borinqueni	1.05	.62	1.46	3,5,7,9,11–15	2.0	.62
bredini	1.00	.62	1.60	3,5,7,11–15	1.8	.80
jamaicensis	.97	.57	1.21	3–15	2.2	.95
loughnani	1.21	.55	1.17	3–15	2.4	.98
panamensis	.87	.55	1.12	3,11–15	2.0	.75
Subgenus *Oecacta* Poey:						
archboldi	.89	.74	1.70	3,11–14	2.3	.87
arubae	1.17	.52	.87	3–10	2.3	.90
barbosai	.88	.58	.93	3,7–10	2.2	.68
floridensis	.77	.65	1.21	None	2.0	.71
furens	.91	.58	1.28	3,7–10	2.4	.74
guadeloupensis	1.17	.67	1.65	(?)	1.4	(?)
hoffmani	.76	.59	.79	3,8–10	1.6	.70
melleus	1.05	.60	1.10	3,10–14	2.7	.63
paraensis	.78	.59	.77	3,8–10	2.1	.82
trilineatus	.97	.57	.86	3,6–10	2.6	.83
Subgenus *Macfiella* Fox:						
phlebotomus	1.03	.55	1.19	3,6–10	2.2	.83

KEY TO SPECIES

(mainly for females)

1. Second radial cell wholly or mainly included in a pale distal spot 2
— Second radial cell wholly included in a very dark spot 8
2. Base of cell M4 pale bordering veins M3 + 4 and Cu1 3
— Base of cell M4 and adjacent veins in a dark area 5
3. Cell M1 with two pale spots distal to the double spot straddling vein M2; small black spot present on vein R4 + 5 near end of 2RC; larger species, wing 1.21 mm. long ..... *foxi* Ortiz
— Cell M1 with only one pale spot distal to double spot straddling vein M2; no small black spot on vein R4 + 5 near end of 2RC; smaller species, wing 1.11 mm. long 4
4. Vein R4 + 5 blackened into adjacent distal pale area up to a point where vein turns abruptly forward to meet costa; mesonotum with prominent pattern; palpal segment 3 with definite, irregular, sensory pit ..... *insignis* Lutz
— Vein R4 + 5 not blackened into adjacent distal pale area; mesonotum without prominent pattern; palpal segment 3 without sensory pit but with sensilla scattered on surface ..... *trinidadensis* Hoffman
5. Apices of veins M1 and M2 pale at wing margin; palpal segment 3 long and slender, without sensory pit, sensilla scattered on surface; large blackish species, wing 1.66 mm. long; legs mostly blackish ..... *heliconiae* Fox and Hoffman
— Apices of veins M1 and M2 dark at wing margin; palpal segment 3 with definite round sensory pit; smaller yellowish species, wing 1.11–1.25 mm. long; legs extensively yellowish with blackish knee spots 6
6. Hind femur pale, a conspicuous dark band only on midportion (AR 1.25; antennal sensory pattern 3,8,10–15; spermathecae large and unequal) *decor* (Williston)
— Hind femur dark, with only a subapical pale band 7
7. AR 1.35; antennal sensory pattern 3,10–15; spermathecae small and subequal ..... *farri* Wirth and Blanton
— AR 1.85; antennal sensory pattern 3–15; spermathecae moderately small and slightly unequal ..... *dominicanus* Wirth and Blanton
8. Pale spots at periphery of wing faint or absent 9
— Pale spots at periphery of wing well defined 12
9. Small blackish species, wing 0.64 mm. long; wing without macrotrichia; 2RC short, as broad as long, CR 0.53; third palpal segment with small, round, deep sensory pit ..... *pusillus* Lutz
— Larger yellowish or brown species, wing 0.90–1.05 mm. long; wing with abundant macrotrichia; 2RC longer, CR 0.60–0.74; third palpal segment with scattered sensilla, irregular pit, or shallow round pit 10
10. Pale yellowish species; two spermathecae present 11
— Dull brownish species; one spermatheca present (antennal sensory pattern 3,11–14; AR 1.70; third palpal segment with irregular pit) *archboldi* Wirth and Blanton
11. Mesonotum yellow with pale grayish pollinosity; third palpal segment with sensilla scattered on surface; spermathecae heavily sclerotized dark brown; antennal sensory pattern 3,10–14 ..... *melleus* (Coquillett)
— Mesonotum shining yellow; third palpal segment with definite round pit; spermathecae pale yellowish, lightly sclerotized; antennal sensoria indistinguishable ..... *floridensis* Beck

12. Wing with a pale spot straddling midportion of vein M2, or veins M1 and M2 entirely pale margined, including this area 13
— Wing with no pale spot straddling vein M2, this vein usually dark to apex 19
13. Wing with pale markings extensive, interconnected, the veins including Cu1 pale margined along nearly their entire length 14
— Wing with pale markings less extensive, veins not pale margined except at apices 15
14. Mesonotum dark brown with narrow whitish longitudinal lines; cell R5 with two pale areas between end of costa and wing tip; spermathecae elongate, sacklike; halter knob pale ..... *loughnani* Edwards
— Mesonotum with pattern of punctiform brown dots; cell R5 with three pale areas between end of costa and wing tip; spermathecae short, ovoid; halter knob dark ..... *arubae* Fox and Hoffman
15. Vein M1 with pale spot straddling basal portion or lying immediately anterior to it near base 16
— Vein M1 without pale spot straddling basal portion or lying immediately anterior to it near base 17
16. Vein M1 with pale spot straddling basal portion; anal cell with two pale spots in distal portion; spermathecae oval without sclerotized necks. *jamaicensis* Edwards
— Vein M1 with basal pale spot confined to anterior side of vein; anal cell with one pale spot in distal portion; spermathecae unequal, retort shaped, with long necks arising obliquely ..... *panamensis* Barbosa
17. Mesonotum uniformly grayish-green pellinose; third palpal segment without sensory pit, sensilla scattered on surface of segment ..... *phlebotomus* (Williston)
— Mesonotum yellowish with dark-brown pattern; third palpal segment with small, round sensory pit 18
18. Wing veins M3 + 4 and Cu1 with apices pale at wing margin; antennal sensory pattern 3,5,7,9,11–15; halter deeply infuscated; male aedeagus with basal arch to 0.42 of total length, basal arms stouter; parameres shorter and more abruptly tapered on main portion ..... *borinqueni* Fox and Hoffman
— Wing veins M3 + 4 and Cu1 dark at wing margin; antennal sensory pattern 3,5,7,11–15; halter pale to slightly infuscated; aedeagus with basal arch to half of total length, basal arms slender; parameres longer and gradually tapering distally ..... *bredini* Wirth and Blanton
19. Cell M1 with three pale spots; cell R5 with two pale spots in distal half 20
— Cell M1 with two pale spots; cell R5 with one pale spot in distal half 21
20. Anal cell with one pale spot in distal portion; mesonotum without pattern of punctiform dots; cell R5 with apical pale spot small and round *paracensis* (Goeldi)
— Anal cell with two pale spots in distal portion; mesonotum with pattern of punctiform brown dots; cell R5 with apical pale spot obliquely hourglass shaped, subapical pale spot small and rounded ..... *furens* (Poey)
21. Cell M2 with one pale spot distal to level of mediocubital fork, not counting any spot lying immediately anterior to base of fork 22
— Cell M2 with two pale spots lying distal to level of mediocubital fork (anal cell with two distal pale spots; mesonotum with pattern of punctiform brown dots) ..... *barbosai* Wirth and Blanton
22. One spermatheca present; third palpal segment with irregular sensory pit; distal five antennal segments elongate ..... *guadeloupensis* Floch and Abonnenc
— Two spermathecae present; third palpal segment with definite round pit; distal antennal segments not elongate 23

23. Smaller species, wing 0.76 mm. long; macrotrichia scanty, mostly confined to distal half of wing; third palpal segment broad, PR 1.6 ..... *hoffmani* Fox
— Larger species, wing 0.97 mm. long; macrotrichia abundant, extending to base of wing; third palpal segment long and slender, PR 2.6 ..... *trilineatus* Fox

DESCRIPTIONS OF CULICOIDES SPECIES

Culicoides archboldi Wirth and Blanton

(Figs. 6 and 7)

Culicoides archboldi Wirth and Blanton, 1970a, p. 39 (male, female; Dominica; illus.).

Female.—Wing length 0.89 mm. Head: Eyes (fig. 7, *a*) narrowly separated, with long interfacetal pubescence. Antenna (fig. 7, *b*) with lengths of flagellar segments in proportion of 30–20–20–20–20–20–21–23–55–55–55–60–70; AR 1.70; five distal segments greatly elongated; sensory pattern 3,11–14. Third palpal segment (fig. 7, *c*) short and moderately swollen, with an open sensory area in an irregular concavity on distal half; PR 2.3. Proboscis moderately long, P/H ratio 0.87; mandible with 18–20 teeth.

Thorax: Uniformly dull dark brown; mesonotum without prominent pattern. Legs (fig. 7, *f*) brown; knee spots blackish; all tibiae with faint narrow basal pale bands; tibial comb with four spines, the one nearest the spur longest.

Wing (fig. 7, *d*): Dark brown without prominent pattern; radial cells, margins of veins, and an indistinct area midway on anterior margin of cell R5 darker brown; a small pale spot present at anterior margin of cell R5 just past tip of

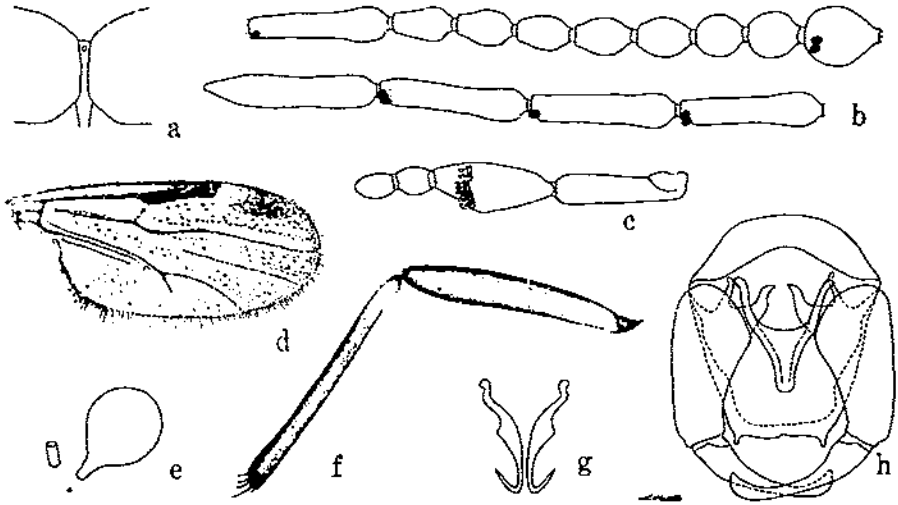

FIGURE 7.—*Culicoides archboldi: a*, Female eye separation; *b*, female antenna; *c*, female palpus; *d*, female wing; *e*, spermatheca; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

costa. Macrotrichia long and coarse, relatively sparse but covering most of wing except in radial field; CR 0.74; 2RC with moderately broad lumen. Halter brownish.

Abdomen: Dark brown. Spermatheca (fig. 7, *e*) single, short, oval, with long slender neck; measuring 0.053 by 0.035 mm.; sclerotized ring present.

Male Genitalia (fig. 7, *h*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering, with small, slender, apicolateral processes, caudal margin between them nearly straight. Basistyle with ventral root "foot-shaped," but posterior "heel" not well developed, dorsal root slender; dististyle slender and curved to bent pointed tip. Aedeagus with basal arch extending to half of total length, basal arms curved; distal portion tapering to rather stout, rounded, simple tip. Parameres (fig. 7, *g*) separate; each with small basal knob, proximal portion slender, with distinct dorsal swelling at midlength, without ventral lobe; distal portion slender and bent ventrocephalad, tapering to blunt-pointed tip.

Distribution.—Dominica (fig. 6).

Types.—Holotype, female, allotype, male, Clarke Hall, Dominica, 21–29 April 1964, O. S. Flint, light trap (USNM 70640).

West Indian Records.—

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, at light, 2 males, 6 females; same, 18 October 1966, E. L. Todd, 9 females; Clarke Hall Estate, April, May 1964, O. S. Flint, light trap, 14 males, 36 females; same, August 1964, T. J. Spilman, light trap, 28 males, 10 females; same, January-March 1965, Wirth, light trap, 1 male, 13 females; same, 21 January 1965, Wirth, malaise trap, 1 male; same, 30 March 1966, R. J. Gagne, at light, 1 female; d'Leau Gommier, 17 March 1956, J. F. G. Clarke, at light, 24 males, 95 females; Fond Figues River, 20 January, 9 February 1965, Wirth, light trap, 5 males, 7 females; Grand Bay, 13 March 1964, D. F. Bray, at light, 3 females; La Plaine, 17 February 1964, Bray, at light, 1 female; Layou River mouth, 15, 20 January 1965, Wirth, light trap, 5 females; Macoucheri, river mouth, 14 January 1965, Wirth, 10 females; Manets Gutter, 5 March 1965, Wirth, light trap, 1 male; Pont Casse, 22 June 1965, T. H. G. Aitken, chick-baited trap, 6 females; same, May-June 1964, O. S. Flint, at light, 5 males, 20 females; same, January 1965, Wirth, at light, 2 males, 6 females; Portsmouth, 24 June 1965, Aitken, chick-baited trap, 1 female; South Chiltern Estate, 20 February 1965, Wirth, light trap, 1 female; Trafalgar Hydro Plant, 10 May 1968, P. C. Drummond, light trap, 2 females.[3]

Discussion.—This species was dedicated to John Archbold in appreciation of his support of the Biological Survey of Dominica and his keen interest in the scientific exploration of the island.

[3] Throughout this bulletin all information pertaining to distribution records is given essentially as it appeared on the insect labels.

C. archboldi is probably most closely related to *C. eublepharus* among the neotropical species. Points of similarity include the narrowly separated, hairy eyes; long distal antennal segments and sensory pattern 3,11–14; single spermatheca; and general structure of the male genitalia, especially the shape of the parameres. However, *C. eublepharus* redescribed by Wirth and Blanton, *1959, p. 424*, under the name *C. transferrans* (Ortiz) has a distinct wing pattern and a definite, round palpal pit.

Larval Habitat.—Unknown.

Biting Habits.—The species was collected twice by Dr. Aitken at a chick-baited trap and it is probably ornithophilic.

Culicoides arubae Fox and Hoffman

(Figs. 5, 8, and 30)

Culicoides arubae Fox and Hoffman, 1944, p. 109 (male, female; Aruba I.; fig. wing).—Barbosa, 1947, p. 11 (distribution; fig. palpus, male genitalia).—Ortiz and Mirsa, 1952, p. 269 (redescribed; Venezuela; illus.).—Jones and Wirth, 1958, p. 86 (larval habitat; Texas).—Wirth and Blanton, 1959, p. 464 (redescribed; Panama; illus.).—Jones, 1961a, p. 702 (larval habitat; Texas).—Jones, 1961b, p. 742 (pupa, in key).

Culicoides sp. 1, Fox, 1942, p. 420 (pupa; Dutch West Indies; from crab holes; illus.).

Female.—Wing length 1.17 mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 8, *a*) with lengths of flagellar segments in proportion of 22–13–13–13–13–12–12–11–15–15–16–17–32; AR 0.87; sensory pattern 3–10. Palpal segments (fig. 8, *e*) with lengths in proportion of 15–30–48–11–11; PR 2.3; third segment with broad, shallow sensory pit. Proboscis long, P/H ratio 0.90; mandible with 14–16 teeth.

Thorax: Dark brown; mesonotum (fig. 8, *c*) densely pale grayish pruinose with median and sublateral vittae indistinctly yellowish-brown fumose; pattern of numerous punctiform brown dots at seta bases; scutellum dark brown in middle, pale on sides. Legs dark brown with distinct annulations; knees narrowly pale, then narrow blackish rings succeeded by narrow pale rings on each side on femora and tibiae; femora narrowly pale at bases; fore femur with narrow pale ring at midlength; tibial comb (fig. 8, *d*) with seven to eight spines, the one nearest the spur longest.

Wing (fig. 8, *b*; 30, *i*): Pattern as figured; membrane milky white, with limited dark-gray markings, giving appearance of blackish spots on whitish ground; 2RC blackish; veins pale margined; cell R5 with a large pale spot surrounding a small black spot behind 2RC, a broad, V-shaped mark and a small distal round pale spot in apex of cell; cells M1 and M2 with three small round pale spots past level of forks; two pale spots in cell M4 and two in distal portion of anal cell; base of wing extensively pale. Macrotrichia sparse but well distributed over wing including anal cell; CR 0.52; 2RC with distinct lumen. Halter knob infuscated.

Abdomen: Dark brown. Sperma-

thecae (fig. 8, *f*) two (occasionally three, as figured) plus rudimentary third and sclerotized ring; functional ones slightly unequal, ovoid, measuring 0.043 by 0.038 mm. and 0.038 by 0.029 mm.; without sclerotized necks.

Male Genitalia (fig. 8, *h*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering with large triangular apicolateral processes and deep caudomedian notch. Basistyle with dorsal and ventral roots simple, slender; dististyle nearly straight, tapering to slender, bent, pointed tip. Aedeagus broad and stout, basal arch extending to half of total length; distal portion with broad truncate tip. Parameres (fig. 8, *g*) separate;

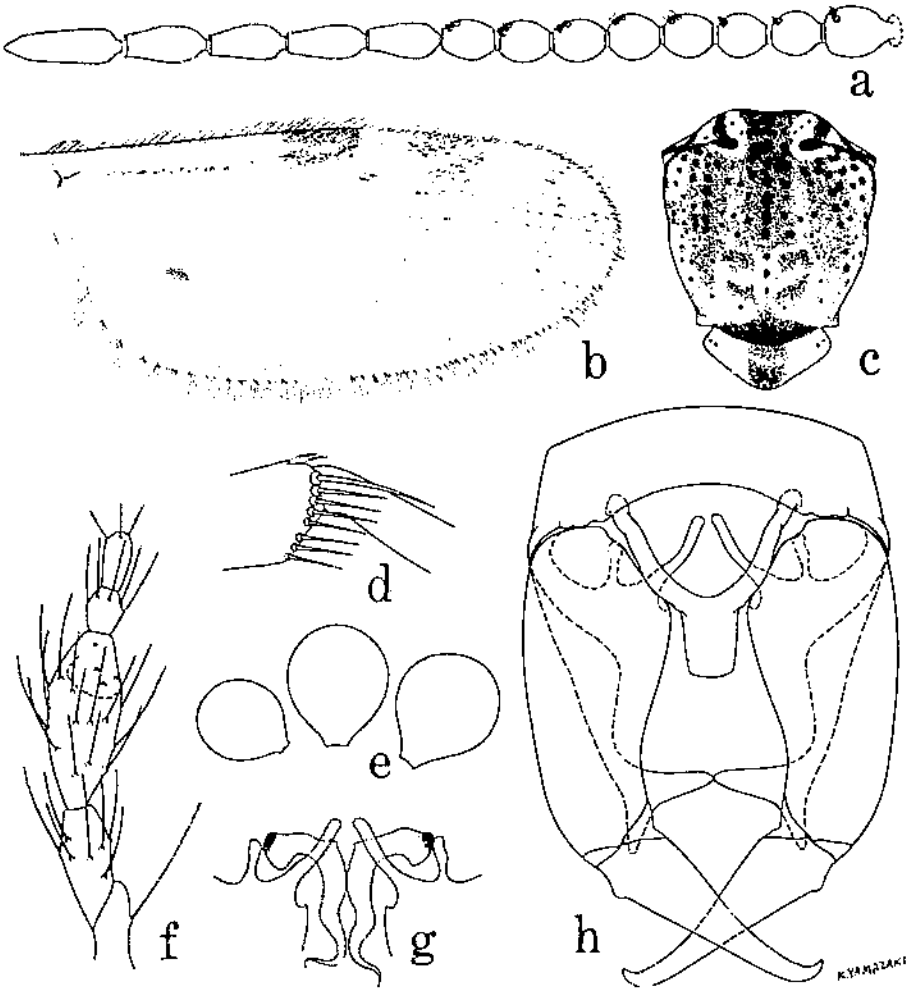

FIGURE 8.—*Culicoides orubae*: *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, female palpus; *f*, spermatheca; *g*, male parameres; *h*, male genitalia, parameres removed.

each with large, laterally directed basal arm bearing a lateral knob; main body short, slightly crooked, tapering to simple, ventrally bent, distal filament.

Distribution.—Aruba I., Colombia, Panama, Texas, Venezuela (fig. 5).

Type.—Holotype, female, Aruba I., Netherlands Antilles, August-September 1929, W. A. Hoffman (University of Puerto Rico collection).

West Indian Records.—

ARUBA ISLAND: Holotype female, allotype male, one paratype male, data as above (Fox and Hoffman, *1944*).

Discussion.—The correct systematic position of *C. arubae* is not readily apparent. It is similar in wing pattern, the punctiform mesonotal pattern, and presence of frontal tubercles to *C. variipennis*, the North American member of the subgenus *Monoculicoides* that shares its coastal habitat with *C. arubae* in Texas. *C. arubae* differs from *C. variipennis*, however, in number of spermathecae and in the separate male parameres, two important subgeneric characters excluding *C. arubae* from *Monoculicoides* and bringing it within our concept of the subgenus *Oecacta*. This species is included in the West Indies list because it occurs on the island of Aruba off the coast of Venezuela (fig. 5).

Larval Habitat.—The type series was reared by Hoffman from crab holes on Aruba Island. Jones and Wirth (*1958*) and Jones (*1961a*) reared *C. arubae* from the margins of salt-water pools in pickleweed and grassy salt marshes and a nonvegetated fresh-water slough in the Aransas National Wildlife Refuge, Aransas County, Tex., where associated *Culicoides* taxa were *C. bermudensis* and *C. variipennis australis* Wirth and Jones.

Biting Habits.—Wirth and Blanton (*1959*) reported *C. arubae* taken from the ear of a mule, Corozal, C.Z., Panama.

Culicoides barbosai Wirth and Blanton

(Figs. 5, 9, and 30)

Culicoides barbosai Wirth and Blanton, 1956c, p. 161 (male, female; Panama, Florida, Bahamas, Ecuador; illus.).—Lewis, 1958, p. 721 (Jamaica; internal anatomy; illus.).—Wirth and Blanton, 1959, p. 400 (redescribed; illus.).—Davies, 1964, p. 33 (biology; Jamaica).—Linley, 1965a, p. 58 (pupa; Jamaica; illus.).—Linley, 1966b, p. 1 (ovarian cycle; Jamaica).—Linley and Davies, 1971, p. 264 (biology and control; Florida, West Indies).

Female.—Wing length 0.88 mm.

Head: Eyes (fig. 9, *d*) nearly contiguous, bare. Antenna (fig. 9, *a*) with lengths of flagellar segments in proportion of 18–13–13–13–13–13–13–13–15–18–20–20–28; AR 0.93; sensory pattern 3,7–10. Palpal segments (fig. 9, *c*) with lengths in proportion of 7–17–21–8–8; PR 2.2; third segment moderately swollen, with a small deep sensory pit. Proboscis moderately short, P/H ratio 0.68; mandible with 16 teeth.

Thorax: Mesonotum (fig. 9, *e*) pruinose gray with pattern of dark-brown punctiform dots at bases of

mesonotal hairs, these dots irregularly fused in some areas, principally in two sublateral, longitudinal bands; scutellum narrowly dark in middle, yellowish on sides. Legs (fig. 9, *g*) dark brown; knee spots blackish; all femora with subapical, all tibiae with subbasal, and hind tibia with apical, narrow pale rings; tibial comb with four spines, the one nearest the spur longest.

Wing (figs. 9, *b*; 30, *a*): Pattern as figured, 2RC dark to tip; large yellowish anterior spots at wing base and over r-m crossvein; two longitudinally elongate poststigmatic pale spots in cell R5 narrowly fused to form an hourglass-shaped spot; distal pale spot in cell R5 large, rounded, and broadly meeting anterior wing margin; two pale spots in cell M1, the proximal one streak-like and lying adjacent to vein M2, the distal one usually connected by a narrow pale line to wing margin; veins M1 and M2 very faintly pale margined on distal halves; a pale line running through cell M2 to pale spot at apex of cell; large pale spot in cell M4; two pale spots, more or less coalesced, in distal part of anal cell. Macrotrichia numerous on distal

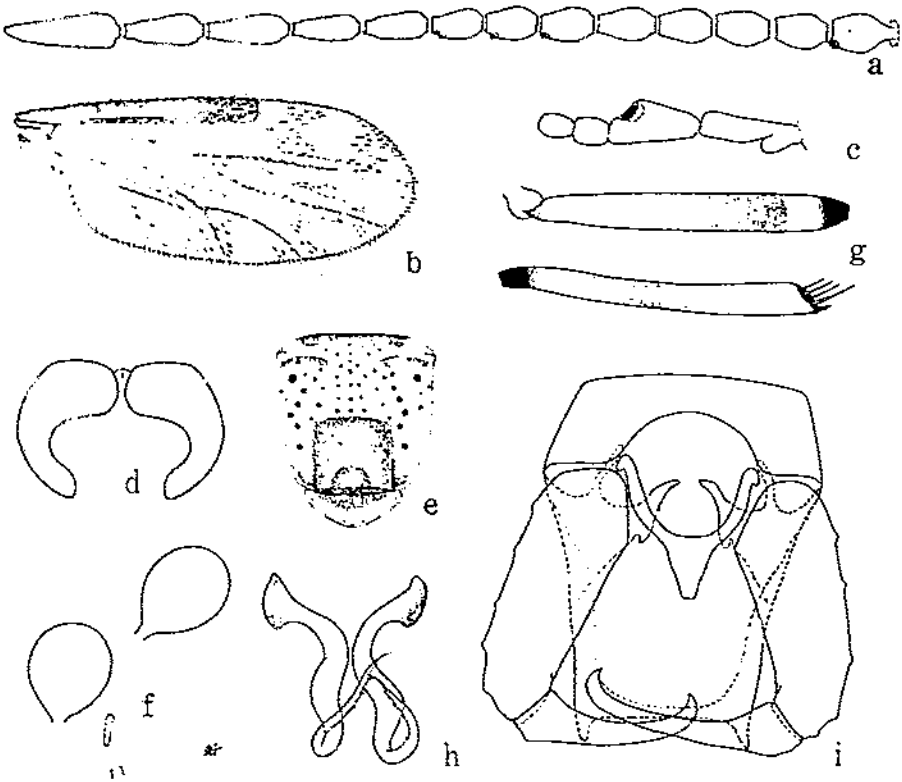

FIGURE 9.—*Culicoides barbosai*: *a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, female eye separation; *e*, thoracic pattern; *f*, spermathecae; *g*, hind femur and tibia; *h*, male parameres; *i*, male genitalia, parameres removed.

half of wing and a few in anal cell; CR 0.58. Halter dark.

Abdomen: Dark brown, cerci pale. Spermathecae (fig. 9, *f*) two plus sclerotized ring and rudimentary third; spermathecae ovoid with short, slender necks; subequal, each measuring 0.045 by 0.030 mm.

Male Genitalia (fig. 9, *i*).—Ninth sternum with broad caudomedian excavation, ventral membrane not spiculate; ninth tergum long, apicolateral processes moderately long and slender. Basistyle with slender, "foot-shaped" ventral root, dorsal root slender; dististyle long and slender, with bent apex. Aedeagus with basal arch extending to 0.7 of total length, basal arms slender and slightly curved, distal portion tapered to slender, rounded point with an indistinct lateral pair of pointed hyaline processes near juncture with arch. Parameres (fig. 9, *h*) separate; each with strongly sclerotized basal knob, stem slender and curved near base, distal portion gradually more swollen, with a distinct low ventral lobe, then distally becoming quite slender, tapering to a fine point with a few minute lateral fringing spines.

Distribution.—Bahamas, Cayman Islands, Costa Rica, Cuba, Ecuador, Florida, Jamaica, Panama (fig. 5).

Type.—Holotype, female, Mojinga Swamp, Panama Canal Zone, January 1953, F. S. Blanton, light trap (USNM 63157).

West Indian Records.—

BAHAMAS: Abaco, Marsh Harbour, 13 April 1968, G. M. Stokes, light trap, 4 females; Grand Cay, November 1957, R. Arundel, annoying man, 7 females; same, 25 January 1969, Stokes, biting man, 10 females; Grand Turk Island, May 1968, M. E. C. Giglioli, 2 females; Nassau, no date, Bishop, No. 14902, 30 females; New Providence Island, Coral Harbour, 24 November 1968, Stokes, biting man, 5 females; North Bimini Island, Paradise Point, 30 November 1968, Stokes, light trap, 2 females; South Bimini Island, June-July 1951, M. Cazier, C. and P. Vaurie, Berlese trap, 1 male, 3 females (AMNH); same, 1 December 1968, Stokes, biting man, 1 female.

CAYMAN ISLANDS: No locality, November 1967, M. E. C. Giglioli, 1 female; Driftwood Village, 1 January 1970, J. E. Davies, light trap, 4 females.

CUBA: Guantanamo Bay, 21 February 1962, E. R. Turner, light trap, 1 male, 3 females; same, 3 September 1964, T. S. Joscy, light, 1 female; same, February-April 1970, J. E. Tisdale, light trap, 1,000's.

JAMAICA: Reading, 4 miles east Montego Bay, reared from larvae (Linley, *1965a;* Davies, *1967*).—Portland Ridge, PWD Fish Lodge, Clarendon Parish, 21 August 1967, E. G. Farnworth, biting man, 17 females.

Discussion.—A complete review of our current knowledge of the biology and control of *C. barbosai* was published by Linley and Davies (*1971*). This species can readily be distinguished from *C. furens*, with which it is usually found, by the lack

of the small round pale spot in the middle of wing cell R5.

Larval Habitat.—Breeland (*1960*) reared *C. barbosai* numerous times in Panama from coastal mangrove areas where it showed a preference for coral sand habitats near the ocean shoreline. Linley (*1965a*) described the pupa reared from the banks of a small spit projecting into a mangrove swamp at Reading, near Montego Bay, Jamaica. Larvae were found in yellow mud, drier than that yielding *C. insignis*, more toward the landward side of the spit. *C. furens* was also found breeding at this spot. Davies (*1967*) reported that *C. barbosai* in Jamaica is almost entirely confined to the tidal waters of the seaward edge of mangrove swamps and is most numerous in the red mangrove habitat (*Rhizophora mangle* L.). The emergence rate is inversely proportional to the mean tides, and outbreaks may be expected in April-May and October-November when the sea levels are minimal. *C. barbosai* habitats are generally at about 0.2 of a foot lower level than those of *C. furens*.

Biting Habits.—Studies on the biting habits of *C. barbosai* in Jamaica were reported by Kettle and Linley (*1969a*). This species was found to prefer the arm to the leg when biting humans. Kettle (*1969b*) found that biting activity was crepuscular and nocturnal with a peak at dawn. He (*1969c*) reported that moderately high windspeed (above 3 m.p.h.) reduced the biting rate.

Culicoides borinqueni Fox and Hoffman

(Figs. 4, 10, and 30)

Culicoides borinqueni Fox and Hoffman. 1944, p. 110 (male, female; Puerto Rico; fig. wing).—Fox, 1946, p. 252 (Puerto Rico).—Fox, 1949, p. 30 (redescribed; Puerto Rico; illus.).—Fox and Kohler, 1950, p. 342 (Puerto Rico).—Fox and Maldonado, 1953, p. 165 (Puerto Rico).—Linley, 1965a, p. 58 (pupa; Jamaica; illus.).

Culicoides species 2.—Fox, 1942, p. 417 (pupa; Puerto Rico; illus.).

Female.—Wing length 1.05 mm.

Head: Eyes (fig. 10, *c*) contiguous, bare. Antenna (fig. 10, *a*) with lengths of flagellar segments in proportion of 25–20–20–20–20–20–20–20–42–42–50–50–58; AR 1.46; five distal segments elongated; sensory pattern 3,5,7,9,11–15. Third palpal segment (fig. 10, *d*) broad, PR 2.0; sensory pit round, shallow. Proboscis short, P/H ratio 0.62; mandible with 12–15 minute teeth.

Thorax: Golden brown pollinose on scutellum and disk of mesonotum; pleuron and margins of mesonotum dark brown. Legs (fig. 10, *f*) dark brown; knees with prominent broad yellowish bands covering apices of femora and bases of tibiae on all legs; knee spot blackish on fore leg only; tip of hind tibia broadly pale; tibial comb with four spines, the one nearest the spur longest.

Wing (figs. 10, *b*; 30, *b*): Pattern as figured; 2RC dark to tip; wing deeply infuscated due to coarse microtrichia; with prominent pattern of discrete small whitish spots arranged as for *C. bredini*, but the distal pale spot in cell R5 usually more ob-

liquely oriented with anterior end directed somewhat distad, anal cell with two well-separated distal pale spots; apices of veins M3+4 and Cu1 pale at wing margin in addition to pale apices of veins M1 and M2. Macrotrichia numerous, extending to base of wing except in radial field; CR 0.62; 2RC with broad lumen. Halter infuscated.

Abdomen: Dark brown. Spermatheeae (fig. 10, *e*) two plus rudimentary third and short sclerotized ring; functional ones oval with short necks; subequal, each measuring 0.045 by 0.032 mm.

Male Genitalia (fig. 10, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering, with long, slender, pointed, apicolateral processes, caudal margin between them straight. Basistyle moderately stout with simple, slender ventral and dorsal roots; dististyle slender and nearly straight, with bent, pointed tip. Aedeagus with basal arch extending to 0.42 of total length, basal arms moderately slender and curved; distal portion moderately slender with simple rounded tip. Parameres (fig. 10, *g*) separate; each with slender, moderately long, basal process bearing a well-developed lateral knob; stem moderately stout at base, rapidly tapering at about midlength to slender, ventrally bent, simple filamentous tip.

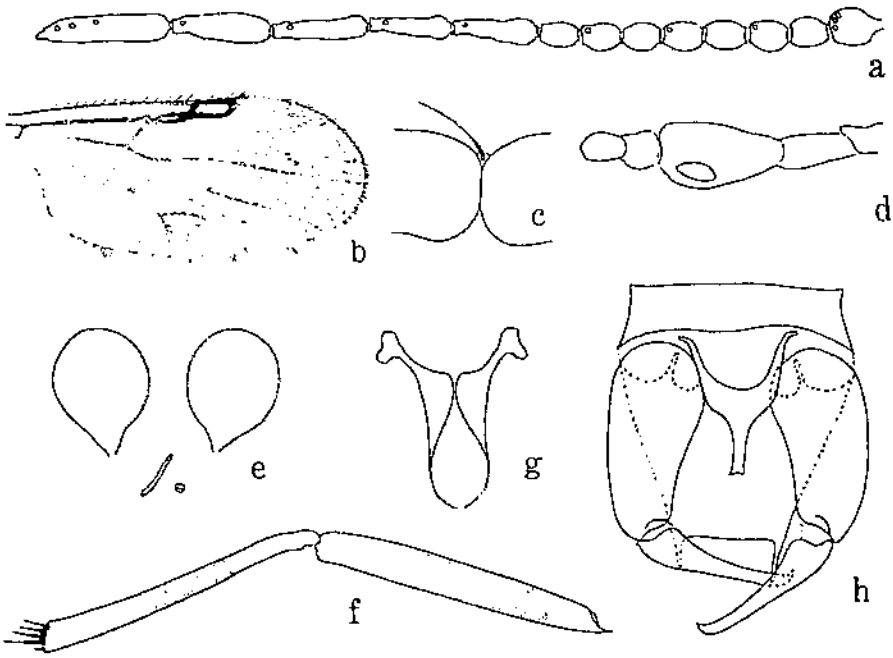

FIGURE 10.—*Culicoides borinquem:* *a*, Female antenna; *b*, female wing; *c*, female eye separation; *d*, female palpus; *e*, spermatheeae; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

Distribution.—Jamaica, Puerto Rico (fig. 4).

Types.—Holotype, female, allotype, male, two female paratypes, bred from a tree hole, Palmas Abajo, Puerto Rico, February 1931 (University of Puerto Rico collection).

West Indian Records.—

JAMAICA: Brandon Hill, Montego Bay, reared from tree holes; Ewarton, St. Catherine Parish, at light (Linley, *1965a*).—Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 1 female; Bath Fountain, St. Thomas Parish, 18 May 1970, Farnworth, light trap, 3 females; Hardwar Gap, Hollywell, Portland Parish, 16 June 1970, Farnworth, light trap, 3 males, 20 females; same, Institute of Jamaica cabin, 3,750 ft., 16 June 1970, Farnworth, light trap, 1 female; same, 20 February 1969, W. W. Wirth, light trap, 1 female; Negril, Westmoreland Parish, 20 November 1968, R. E. Woodruff, light trap in tropical hammock, 1 female; Reach, 2 mi. w. Manchioneal, Portland Parish, 24 November 1968, Woodruff, light trap, 1 female; Runaway Bay, St. Ann Parish, February 1969, Wirth, light trap, 3 females; Worthy Park, St. Catherine Parish, 11 November 1968, Woodruff, light trap, 2 females.

PUERTO RICO: Guyanilla, March 1949, Fox, reared from tree hole, 1 male, 1 female (Wirth and Hubert, *1960*).—Palmas Abajo, February 1931 (Fox and Hoffman, *1944*, types).—Carolina, 20 September 1949, I. Fox, reared from tree hole, 1 male; Fajardo, 1 July 1952, F. S. Blanton, light trap, 1 female.

Discussion.—*C. borinqueni* is very similar and closely related to *C. bredini* from Dominica but can be distinguished by the presence of the pale apices of wing veins M3+4 and Cu1, the presence of a sensory pit on antennal segment 9 as well as on 3,5,7,11–15, darker halteres, a shorter and stouter basal arch on the aedeagus, and a shorter and more abruptly tapering main body on the parameres.

Larval Habitat.—The type series was reared from a tree hole in Puerto Rico (Fox, *1942*; Fox and Hoffman, *1944*). Linley (*1965a*) reared *C. borinqueni* from tree holes in Jamaica, in one of which it was associated with *C. hoffmani*.

Biting Habits.—Unknown.

Culicoides bredini Wirth and Blanton

(Figs. 4 and 11)

Culicoides bredini Wirth and Blanton, 1970a, p. 41 (male, female; Dominica; illus.).

Female.—Wing length 1 mm.

Head: Eyes (fig. 11, *a*) contiguous, bare. Antenna (fig. 11, *c*) with lengths of flagellar segments in proportion of 28–20–20–20–20–20–21–22–47–50–52–52–73; AR 1.60; five distal segments elongated; sensory pattern 3,5,7,11–15. Third palpal segment (fig. 11, *b*) broad; PR 1.8; sensory pit round, shallow. Proboscis moderately long, P/H ratio 0.80; mandible with 12 minute teeth.

Thorax: Golden brown above on scutum and scutellum; humeri and lower pleuron dark brown. Legs (fig. 11, *f*) dark brown; knees with

prominent broad pale area covering apices of femora and bases of tibiae on all legs, knee spot blackish on fore leg only; tip of hind tibia narrowly pale; tibial comb with four spines, the one nearest the spur longest.

Wing (fig. 11, *d*): Dark gray due to coarse microtrichia, with prominent pattern of discrete small white spots; pale spot over r-m crossvein extending to costal margin; two poststigmatic pale spots in cell R5 small, round and separate, the hind one lying slightly proximad of the other; distal pale spot in cell R5 small and round, lying near apex of cell but well removed from margin; cell M1 with two pale spots, the proximal one broadly extending over base of vein M2 into cell M2; the latter with pale spot lying behind medial fork, another in front of mediocubital fork, and a small round pale spot near wing margin; cell M4 with a large pale spot in distal portion; anal cell with a double (sometimes divided) pale spot in distal portion; apices of veins M1 and M2 with a pale spot at wing margin. Macrotrichia long and coarse, moderately sparse, a few extending to base of wing except in radial field; CR 0.62; 2RC with broad lumen. Halter yellowish, base of knob slightly infuscated.

Abdomen: Dark brown. Spermathecae (fig. 11, *e*) two plus a rudimentary third and a long, slender, sclerotized ring; functional ones oval with short necks; subequal, each measuring 0.065 by 0.043 mm.

Male Genitalia (fig. 11, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering with long, slender, pointed, apicolateral processes, caudal margin between them straight. Basistyle moderately stout

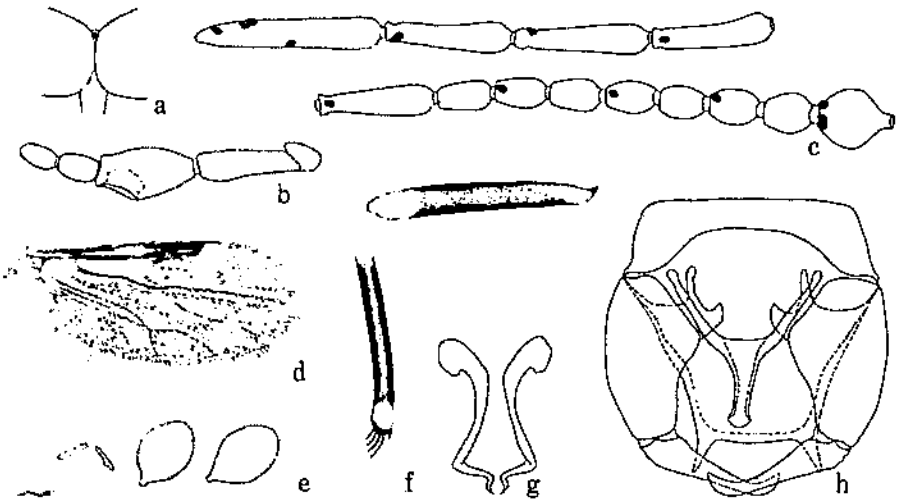

FIGURE 11.—*Culicoides bredini*: *a*, Female eye separation; *b*, female palpus; *c*, female antenna; *d*, female wing; *e*, spermathecae; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

with short, broad, ventral root and slender dorsal root; dististyle slender and nearly straight, with bent, pointed tip. Aedeagus with basal arch extending to half of total length, basal arms slender and slightly curved; distal portion slender with slightly flaring, rounded, simple tip. Parameres (fig. 11, *g*) separate; each with well-developed, lobate, laterally directed basal knob; main portion slender, curved, without ventral lobe, abruptly bent twice near apex and tapering to slender, pointed tip without fringing spines.

Distribution.—Dominica (fig. 4).

Types.—Holotype, female, allotype, male, paratypes, 44 males, 114 females, Clarke Hall, Dominica, 28 March 1965, W. W. Wirth, light trap (USNM 70641).

West Indian Records.—

DOMINICA: Antrim Estate, 1,000 ft., 15 March 1956, J. F. G. Clarke, 1 female; Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 2 males; Clarke Hall, May-June 1964, O. S. Flint, light trap, 3 males, 4 females; same, July-September 1964, T. J. Spilman, light trap, 7 males, 40 females; same, October 1964, P. J. Spangler, at light, 1 male; same, January-March 1965, Wirth, light trap, 17 males, 33 females; d'Leau Gommier, 17 March 1956, Clarke, at light, 5 males, 11 females; Fond Figues River, 13 March 1965, Wirth, light trap, 2 females; Macoucheri, 5 March 1965, Wirth, at light, 2 females; Manets Gutter, 15 March 1965, Wirth, 1 male, 4 females; Pont Casse, May-June 1964, Flint, at light, 6 males, 7 females; South Chiltern Estate, 10 February 1965, Wirth, light trap, 2 males, 10 females.

Discussion.—This species was named for J. Bruce Bredin in appreciation of his interest in, and support of, the Biological Survey of Dominica.

C. bredini has a wing pattern very similar to that of *C. daedaloides* from Panama. In the latter species, however, the distal pale spot in cell R5 is transverse and meets the anterior wing margin. *C. daedaloides* also has no pale spot lying in front of the mediocubital fork, and the distal pale spot in cell M2 meets the wing margin. In addition, the antennal sensory pattern of *C. daedaloides* is 3,8–10, the mesonotum bears a prominent pattern of pale patches, and the male parameres are shaped differently.

C. borinqueni from Jamaica and Puerto Rico is also similar to *C. bredini*, but differs in having the apices of the veins M3+4 and Cu1 pale at the wing margin, the halteres deeply infuscated, the antennal sensory pattern 3,5,7,9,11–15, the male aedeagus with a shorter basal arch and stouter basal arms, and the parameres shorter and more abruptly tapering in midportion.

Larval Habitat.—Unknown.

Biting Habits.—Unknown.

Culicoides decor (Williston) (Figs. 2 and 12)

Ceratopogon decor Williston, 1896, p. 281 (female; Saint Vincent, W.I.; fig. wing).

Culicoides decor (Williston).—Johannsen, 1943, p. 779 (combination).—Wirth and Blanton, 1956d, p. 227 (notes on type; comparison).—Forattini, 1957,

p. 265 (notes, comparison; fig. wing). —Wirth and Blanton, 1970b, p. 145 (redescribed; distribution; illus.).

Female.—Wing length 1.20 mm. Head: Eyes (fig. 12, *c*) narrowly separated, bare. Antenna (fig. 12, *a*) with lengths of flagellar segments in proportion of 36–25–25–24–24–23–23–24–45–48–50–50–76; AR 1.25; sensory pattern 3,8,10–15. Palpal segments (fig. 12, *b*) with lengths in proportion of 20–40–70–20–27; PR 3.2; third segment long, slightly swollen distally, with a large, deep, round pit opening by a slightly smaller pore. Proboscis moderately long, P/H ratio 0.85; mandible with 15 teeth.

Thorax: Yellowish brown; mesonotum with dense grayish pollen, humeral pits and anterior margin between them dark brown; mesonotum with numerous erect yellowish hairs; pleuron dark brown below. Legs (fig. 12, *e*) yellowish, knee

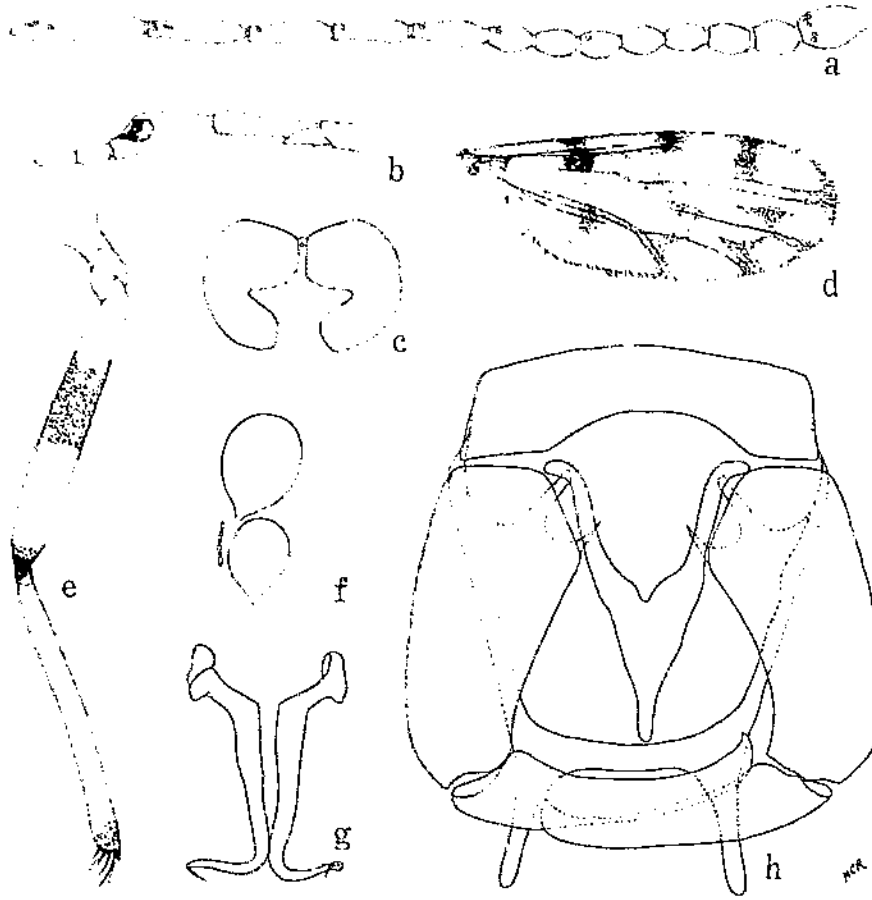

FIGURE 12.—*Culicoides decor*: *a*, Female antenna; *b*, female palpus; *c*, female eye separation; *d*, female wing; *e*, hind femur and tibia; *f*, spermathecae; *g*, male parameres; *h*, male genitalia, parameres removed.

spots blackish; proximal 0.6 of femora and distal 0.6 of tibiae on fore legs and midlegs brownish, hind femur with prominent dark-brown band in midportion, and hind tibia with narrow apex brown; tibial comb with four spines, the one nearest the spur longest.

Wing (fig. 12, *d*): Pattern as figured; distal 0.6 of 2RC in a pale area; pale areas large, leaving the dark areas forming a narrow zigzag pattern; CR 0.60; radial cells both elongate, with broad lumens. Macrotrichia numerous, extending to base of wing in anal cell. Halter pale.

Abdomen: Yellowish, becoming brownish distally. Spermathecae (fig. 12, *f*) two, rudimentary third present, sclerotized ring absent; functional ones large and ovoid, with short, slender necks; unequal, measuring 0.130 by 0.090 mm. and 0.102 by 0.068 mm.

Male Genitalia (fig. 12, *h*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately long and tapering, with long, slender, apicolateral processes. Aedeagus with basal arch extending to nearly half of total length, basal arms slender and curved; distal portion tapering to long, slender, median point. Parameres (fig. 12, *g*) separate; each with slender anterolateral process; main portion long and straight, tapering to slender simple tip abruptly bent laterad and ventrad.

Distribution.—Dominica, Saint Lucia, Saint Vincent (fig. 2).

Types.—Three female syntypes, Saint Vincent, H. H. Smith collector (British Museum (Natural History), London).

West Indian Records.—

DOMINICA: Clarke Hall, April-June 1964, O. S. Flint, light trap, 8 males, 22 females; same, July-August 1964, T. J. Spilman, light trap, 18 males, 24 females; same, January-March 1965, W. W. Wirth, light trap, 40 males, 50 females; Layou River mouth, 20 January 1965, Wirth, at light, 3 females; Macoucheri, 12 February 1965, Wirth, at light, 3 females; South Chiltern Estate, 19 February 1965, Wirth, light trap, 2 females (Wirth and Blanton, *1970b*).

SAINT LUCIA: Castries, Fairview, 14 April 1959, R. Darsie, light trap, 1 male; Gros Islet, Yacht Club, 27 October 1967, J. B. Davies, at light, 1 female; Saint Lucia Beach Hotel, 27 October 1967, Davies, at light, 1 female (Wirth and Blanton, *1970b*).

Discussion.—The *C. nigrigenus* group was reviewed by Wirth and Blanton (*1970b*), who found it to be circum-Caribbean in distribution (fig. 2). Three of the seven known species occur in the West Indies and are not found elsewhere. Of these, *C. farri* is endemic to Jamaica, *C. dominicanus* is endemic to Dominica, and *C. decor* is known to occur on three islands of the Lesser Antilles.

C. decor is distinguished from the other species of the *C. nigrigenus* group of the subgenus *Anilomyia* by its extensively pale hind femur with only midportion dark, its large spermathecae, moderately long proximal antennal segments, and antennal sensory pattern, 3,8,10–15. Two

other species of this group have been reared from wet debris held in leaf axils of bromeliads in Trinidad and Mexico. Williams' (*1964*) record of *C. decor* reared from a bromeliad in Trinidad was a misidentification of *C. nigrigenus* (Wirth and Blanton, *1970b*).

Larval Habitat.—Unknown.

Biting Habits.—Unknown.

Culicoides dominicanus Wirth and Blanton

(Figs. 2 and 13)

Culicoides dominicanus Wirth and Blanton, 1970b, p. 146 (male, female; Dominica; illus.).

Female.—Wing length 1.22 mm.

Head: Eyes (fig. 13, *c*) narrowly separated, bare. Antenna (fig. 13, *a*) with lengths of flagellar segments in proportion of 32–20–20–20–20–20–20–20–50–56–60–60–92; AR 1.85; sensory pattern 3–15. Palpal segments (fig. 13, *b*) with lengths in proportion of 15–40–52–17–17; PR 2.3; third segment swollen distally, with a large, round, deep sensory pit. Proboscis moderately long, P/H ratio 0.75; mandible with 15 teeth.

Thorax: Yellowish brown, mesonotum yellowish pollinose, dark brown on anterior margin; pleuron dark brown below; mesonotum with abundant yellowish hairs. Legs (fig. 13, *e*) brownish; knee spots blackish; fore femur and midfemur with subapical, and fore tibia and midtibia with basal, broad yellowish bands; hind femur dark brown with broad subapical yellowish ring, hind tibia yellowish except at extreme tip; tibial comb with four spines, the second from the spur longest.

Wing (fig. 13, *d*): Pattern as figured, as in *C. decor;* CR 0.62. Macrotrichia numerous, extending to base of wing in anal cell. Halter pale.

Abdomen: Yellowish, becoming brownish distally. Spermathecae (fig. 13, *f*) two, ovoid with short slender necks; moderately small, slightly unequal, measuring 0.080 by 0.058 mm. and 0.072 by 0.055 mm.; rudimentary third spermatheca present, sclerotized ring absent.

Male Genitalia (fig. 13, *h*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering, with moderately long, slender, diverging apicolateral processes. Aedeagus with basal arch extending to more than half of total length, rather angulate mesad, basal arms moderately stout and slightly bent; distal portion tapering to long slender median point. Parameres (fig. 13, *g*) separate; each with short anterolateral arm; midportion straight and moderately swollen at base, tapering distally to slender simple tip abruptly bent laterad and ventrad.

Distribution.—Dominica (fig. 2).

Types.—Holotype, female, allotype, male, 0.3 mi. e. Pont Casse, Dominica, 6 May 1964, O. S. Flint, at light (USNM 70653).

West Indian Records.—

DOMINICA: Castle Bruce Junction, 21 March 1956, J. F. G. Clarke, 4 males; d'Leau Gommier, 17 March 1956, Clarke, at light, 5 males, 2 females; Point Lolo, 25 January

1965, W. W. Wirth, at light, 3 females; Pont Casse, June 1964, O. S. Flint, at light, 41 males, 15 females; same, 12 March 1965, Wirth, light trap, 9 males, 8 females; South Chiltern Estate, 19 February 1965, Wirth, light trap, 4 males, 9 females (Wirth and Blanton, *1970b*).

Discussion.—This species is very similar to *C. decor*, which also occurs in Dominica (fig. 2), but can be distinguished from that species by the more extensive dark bands on the hind femur, by the sensory pattern 3–15 on the antenna, and by the much shorter proximal antennal segments, with AR 1.85. On Dominica the endemic species *C. dominicanus* is found only at the higher elevations, whereas the more widespread *C. decor* is restricted to lowland habitats.

Larval Habitat.—Unknown.

Biting Habits.—Unknown.

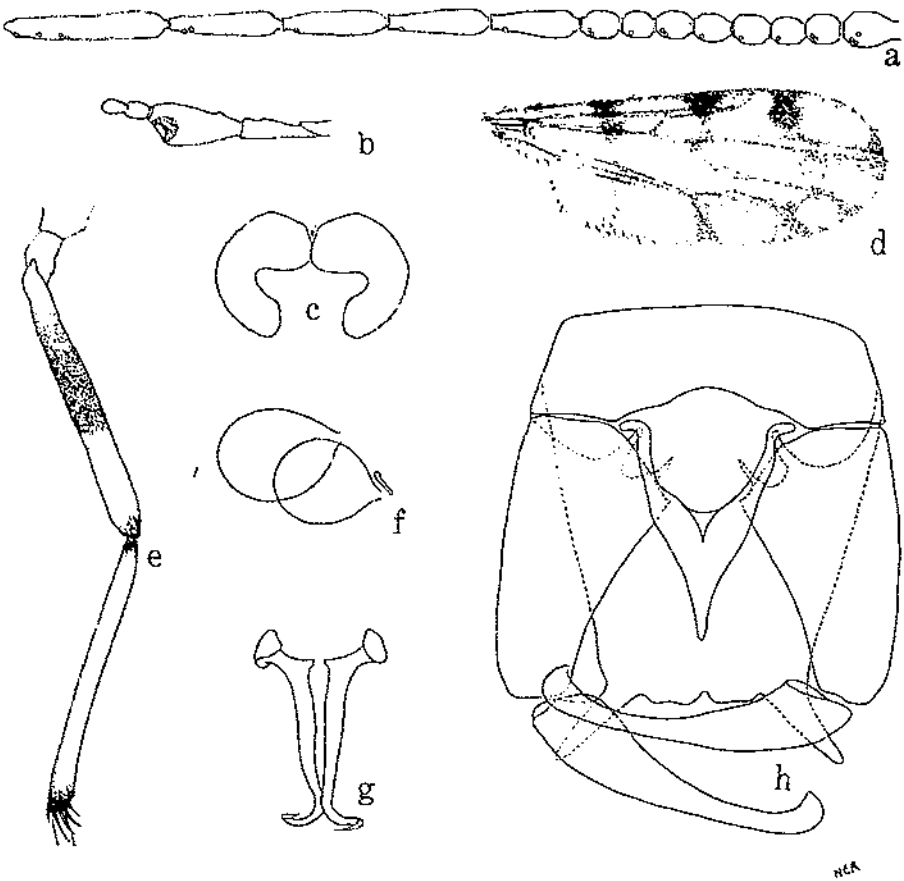

FIGURE 13.—*Culicoides dominicanus: a*, Female antenna; *b*, female palpus; *c*, female eye separation; *d*, female wing; *e*, hind femur and tibia; *f*, spermathecae; *g*, male parameres; *h*, male genitalia, parameres removed.

Culicoides farri Wirth and Blanton

(Figs. 2 and 14)

Culicoides farri Wirth and Blanton, 1970b, p. 148 (male, female; Jamaica; illus.).

Female.—Wing length 1.25 mm. Head: Eyes (fig. 14, *c*) narrowly separated, bare. Antenna (fig. 14, *a*) with lengths of flagellar segments in proportion of 32–22–22–22–22–22–23–24–45–45–50–54–70; AR 1.35; sensory pattern 3,10–15. Palpal segments (fig. 14, *b*) with lengths in proportion of 15–30–46–15–18; PR 2.0; third segment short and broad, with a large, round, moderately deep sensory pit. Proboscis moderately short, P/H ratio 0.68; mandible with 13 teeth.

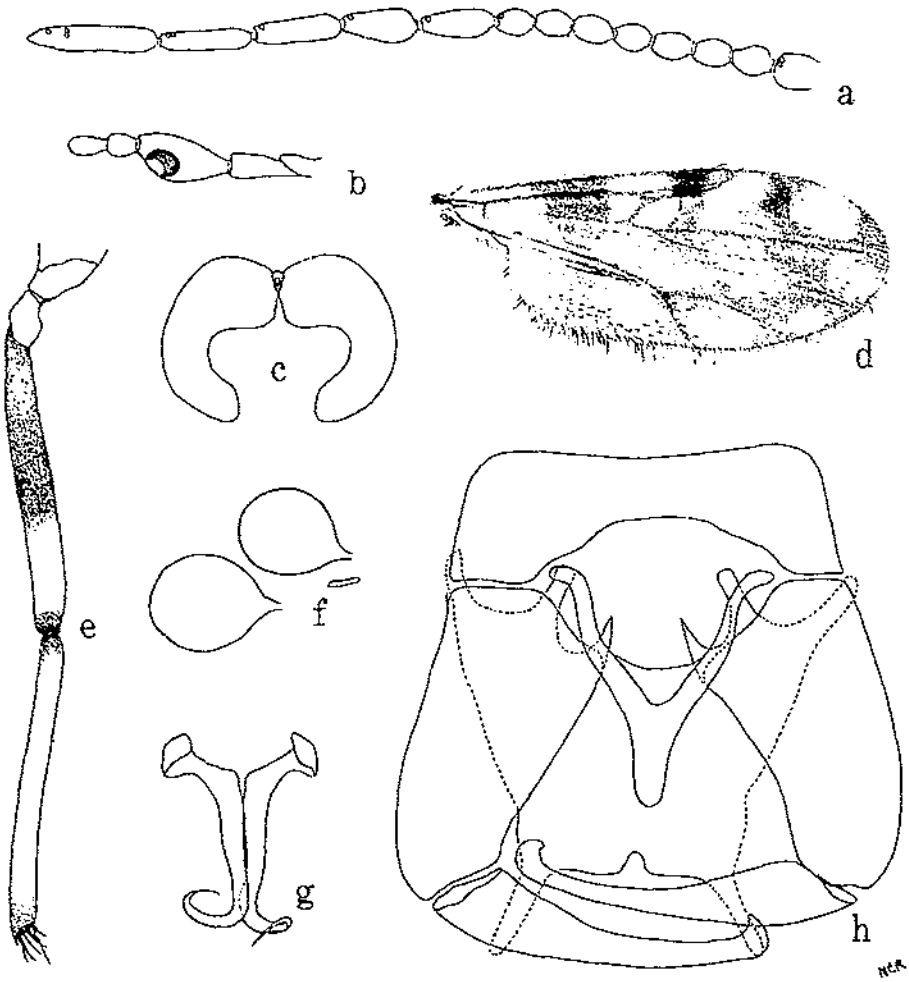

FIGURE 14.—*Culicoides farri*: *a*, Female antenna; *b*, female palpus; *c*, female eye separation; *d*, female wing; *e*, hind femur and tibia; *f*, spermathecae; *g*, male parameres; *h*, male genitalia, parameres removed.

Thorax: Yellowish brown, pleuron and anterior and lateral margins of mesonotum dark brown. Legs (fig. 14, *e*) brownish; knee spots blackish; fore femur and midfemur with subapical, and fore tibia and midtibia with basal, broad yellowish bands; hind femur dark brown with broad subapical pale band, hind tibia yellowish except dark brown at extreme tip; tibial comb with four spines, the one nearest the spur longest.

Wing (fig. 14, *d*): Pattern as figured, as in *C. decor;* CR 0.60. Macrotrichia numerous, extending to base of wing in anal cell. Halter pale.

Abdomen: Yellowish, becoming brownish distally. Spermathecae (fig. 14, *f*) ovoid with long slender necks; small and slightly unequal, measuring 0.064 by 0.046 mm. and 0.058 by 0.042 mm.; rudimentary spermatheca present, sclerotized ring absent.

Male Genitalia (fig. 14, *h*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering, with long, slender, divergent, apicolateral processes. Aedeagus with basal arch extending to not quite half of total length, basal arms slender and curved; distal portion tapering to moderately slender, bluntly pointed tip. Parameres (fig. 14, *g*) each with moderately long anterolateral arm; midportion straight and moderately stout, tapering to slender, simple tip, abruptly bent laterad and ventrad.

Distribution.—Jamaica (fig. 2).

Type.—Holotype, female, Jamaica, Portland Parish, Hardwar Gap, Institute of Jamaica Cabin, 20 February 1969, W. W. Wirth, light trap (USNM 70654).

West Indian Records.—

JAMAICA: Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 1 female; Hardwar Gap, same data as type, allotype, male, 1 male, 2 female paratypes; same, Hollywell Forest Camp, 16 June 1970, Farnworth, light trap, 1 male, 15 females; Worthy Park, St. Catherine Parish, 20 March 1970, Farnworth, light trap, 1 male, 4 females.

Discussion.—This endemic Jamaican representative of the Caribbean *C. nigrigenus* group (fig. 2) can be recognized by the dark proximal half of the hind femur, by the relatively long proximal antennal segments (AR 1.35), and by the antennal sensory pattern 3,10–15.

Larval Habitat.—Unknown.

Biting Habits.—Unknown.

Culicoides floridensis Beck

(Figs. 5, 15, and 30)

Culicoides floridensis Beck, 1951, p. 135 (male, female; Florida; fig. male genitalia).—Beck, 1956, p. 134 (Florida).—Williams, 1956, p. 299 (Bermuda; in key).—Williams, 1957, p. 66 (Bermuda).—Wirth and Williams, 1957, p. 12 (Bermuda; notes).—Beck, 1958, p. 9 (Florida).—Linley, 1970, p. 1016 (pupa; Florida).

Female.—Wing length 0.77 mm.

Head: Eyes (fig. 15, *d*) narrowly separated, bare. Antenna (fig. 15, *a*) with lengths of flagellar segments in proportion of 25–15–15–16–16–17–17–18–26–29–33–34–47; AR 1.21; sensoria not distinguishable. Palpal

segments (fig. 15, *c*) with lengths in proportion of 10–20–28–13–13; PR 2.0; third segment short, slightly swollen, with round, shallow sensory pit. Proboscis moderately short, P/H ratio 0.71; mandible with 14 teeth.

Thorax: Pale yellowish, subshining in dry specimens. Legs (fig. 15, *f*) pale yellowish; tibial comb with four spines, the one nearest the spur longest.

Wing (figs. 15, *b*; 30, *k*): Pale yellowish gray, without markings. Macrotrichia sparse, confined to apex of wing; CR 0.65; 2RC slitlike. Halter pale.

Abdomen: Pale yellowish. Spermathecae (fig. 15, *e*) two plus long slender ring, rudimentary third spermatheca not visible; functional spermathecae pale yellowish, elongate oval, tapering to long slender necks; subequal, each measuring 0.046 by 0.025 mm. including the neck.

Male Genitalia (fig. 15, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering, with short, pointed, apicolateral processes. Basistyle slender, ventral and dorsal roots slender, simple; dististyle long and slender, with bent, pointed tip. Aedeagus with basal arch rounded, extending to nearly half of total length, basal arms slender, slightly curved; distal portion tapering to slender, simple tip. Parameres (fig. 15, *g*) separate; each with distinct basal knob; stem moderately slender, with well-developed ventral lobe distally; distal portion beyond lobe slender, bent ventrad, tapering to

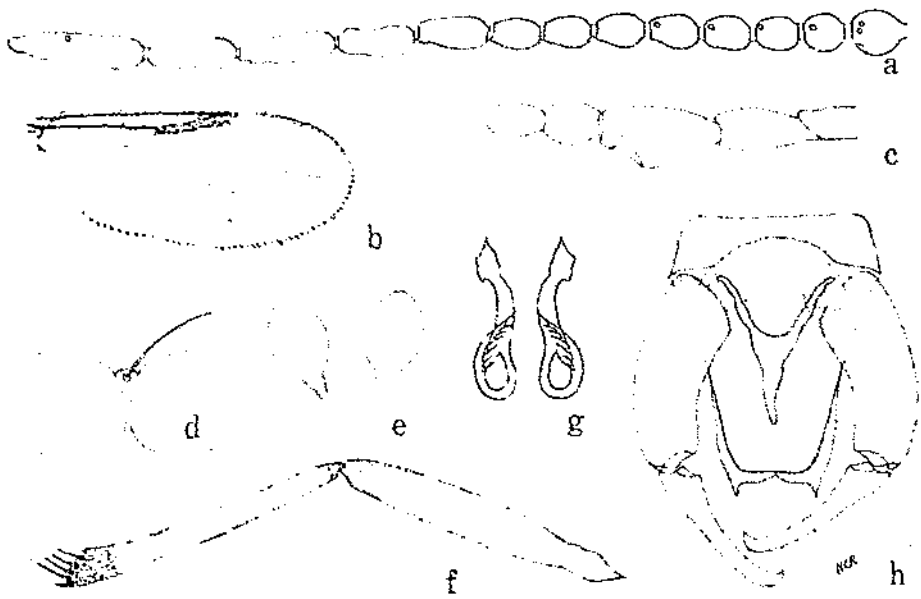

FIGURE 15.—*Culicoides floridensis*: *a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, female eye separation; *e*, spermathecae; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

slender point, and bearing lateral fringing spines.

Distribution.—Bahamas, Bermuda, Florida (fig. 5).

Types.—Holotype, male, allotype, female, Englewood, Sarasota County, Fla., in light trap (USNM 60924).

West Indian Records.—

BAHAMAS: South Bimini, June, July 1951, M. Cazier, C. and P. Vaurie, 1 male, 1 female (AMNH).

Discussion.—*C. floridensis* is a peripheral element in the West Indian *Culicoides* fauna (fig. 5), occupying only the island nearest to the Florida mainland, where it is abundant in its own restricted area. It can be distinguished from *C. melleus*, which it closely resembles, by its shining yellowish integument, more slender habitus, definite round palpal pit, lightly sclerotized spermathecae, and male genitalia with long tapering ninth tergum, distally slender aedeagus, and parameres with a ventral lobe and distal fringing spines.

Larval Habitat.—Linley (*1970*) described the pupa, which he reared in the laboratory on a nematode diet from eggs obtained by decapitating blood-fed wild females.

Biting Habits.—*C. floridensis* is a vicious biter in Florida, attacking man in the daytime (Linley, *1970*).

Culicoides foxi Ortiz

(Figs. 3 and 16)

Culicoides foxi Ortiz, 1950, p. 461 (male; Puerto Rico; *guttatus* (Coquillett) of Fox, 1949).—Ortiz, 1951b, p. 4 (male, female; Venezuela; illus.).—Fox, 1952a, p. 888 (Puerto Rico).—Wirth and Blanton, 1956a, p. 309 (redescribed; distribution; illus.).—Forattini, 1957, p. 205 (redescribed; distribution; illus.).—Wirth and Blanton, 1959, p. 293 (redescribed; Panama distribution; illus.).—Fox and Garcia-Moll, 1961, p. 120 (Puerto Rico).

Culicoides guttatus (Coquillett), misidentification.—Fox 1949, p. 31 (Puerto Rico; fig. wing, spermathecae, male genitalia).—Wolcott, 1951, p. 426 (Puerto Rico).

Female.—Wing length 1.21 mm.

Head: Eyes contiguous, bare. Antenna (fig. 16, *a*) with lengths of flagellar segments in proportion of 22 – 17 – 17 – 18 – 18 – 18 – 18 – 20 – 25–26–30–32–38; AR 1.10; sensory pattern 3, 11–15. Palpal segments (fig. 16, *f*) with lengths in proportion of 10–25–38–20–14; PR 3.2; third segment with broad, shallow sensory pit. Proboscis long, P/H ratio 1.15; mandible with 16 teeth.

Thorax: Dark brown; mesonotum (fig. 16, *c*) with prominent pattern, yellowish in center with two distinct, sublateral, blackish, longitudinal vittae. Legs brown with distinct pale bands at midlength and narrow blackish rings before apices on fore femur and midfemur, fore knee and midknee narrowly pale; hind tibia with basal and apical pale bands; tibial comb (fig. 16, *d*) with six spines, second from the spur longest.

Wing (fig. 16, *b*): Pattern as figured; 2RC pale on distal portion, but with small blackish spot just behind apex; r-m crossvein blackish; two pale spots in cell M1 past the pale spot straddling middle of vein M2. Macrotrichia sparse near distal wing margin; CR 0.68. Halter knob deeply infuscated.

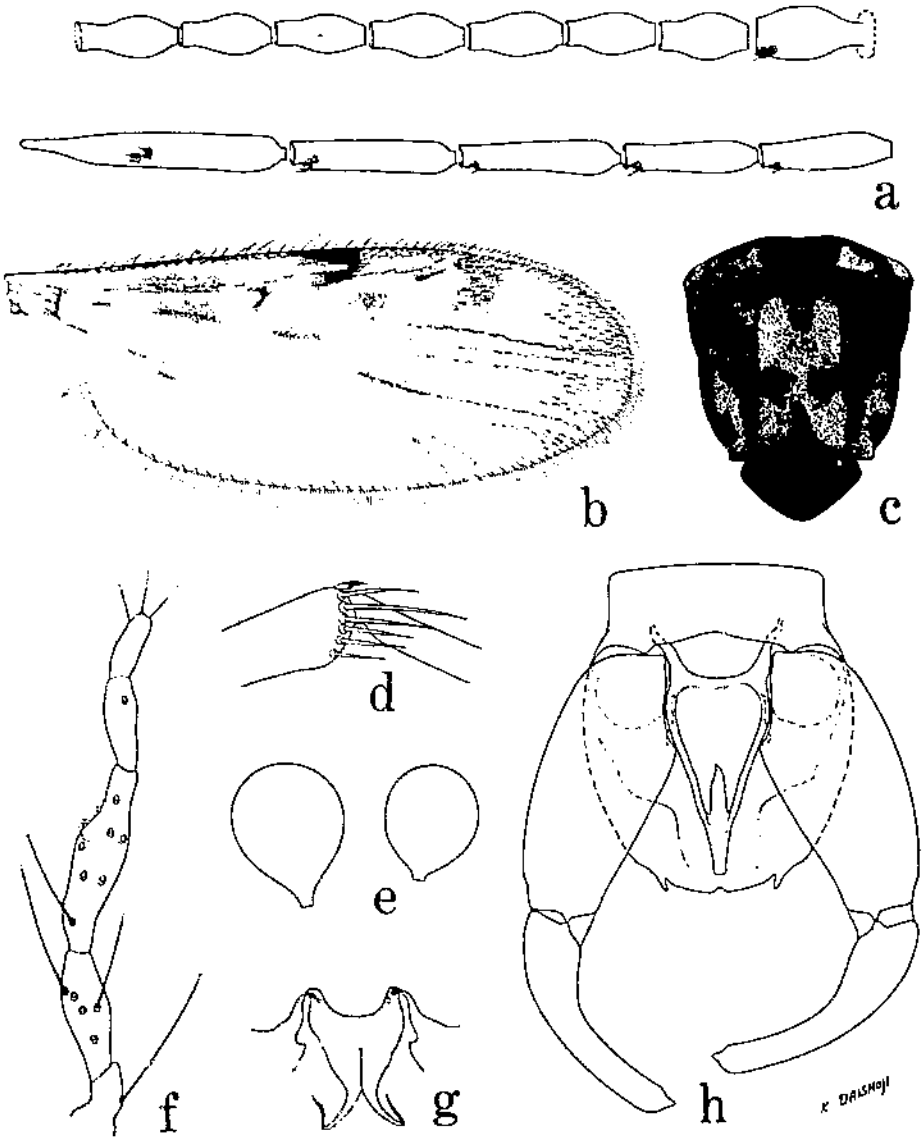

FIGURE 16.—*Culicoides foxi:* *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermathecae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

Abdomen: Blackish, cerci pale. Spermathecae (fig. 16, *e*) two plus rudimentary third and sclerotized ring; functional ones ovoid, tapering to short slender necks; unequal, measuring 0.063 by 0.049 mm. and 0.053 by 0.043 mm.

Male Genitalia (fig. 16, *h*).—Ninth sternum with shallow caudomedian excavation, ventral mem-

brane not spiculate; ninth tergum rounded, with small apicolateral processes widely spaced. Aedeagus elongate, sides convexly swollen, apex truncate rather than with papilliform tip. Parameres (fig. 16, *g*) fused on proximal fourth, apices with minute fringing hairs.

Distribution.—Mexico through Central America and South America to Colombia and Argentina; West Indies (Jamaica, Puerto Rico); Trinidad (fig. 3).

Type.—Holotype, male, Camp Tortuguero, Puerto Rico (University of Puerto Rico collection).

West Indian Records.—

JAMAICA: Bath, St. Thomas Parish, 19 July 1961, Maldonado and Farr, at light, 2 females; Delvey, St. Thomas Parish, 4 December 1962, T. H. G. Aitken, from donkey-baited trap, 1 female; 2 mi. w. Manchioneal, Green Hills, Portland Parish, 24 November 1968, R. E. Woodruff, light trap, 1 male; Mandeville, Manchester Parish, 4 April 1970, E. G. Farnworth, light trap, 2 females; Milk River Bath, Clarendon Parish, 19 November 1968, Woodruff, light trap, 1 female; Negril, Westmoreland Parish, 20 November 1968, Woodruff, light trap, 5 males, 10 females; Runaway Bay, St. Ann Parish, 16–28 February 1969, W. W. Wirth, light trap, 3 males, 3 females; Spanish Town, St. Catherine Parish, 28 May 1970, Farnworth, light trap, 1 female, Worthy Park Estate, St. Catherine Parish, 16 November 1968, Woodruff, light trap, 1 female; same, March–June 1970, Farnworth, light trap, 1,000's.

PUERTO RICO: Camp Tortuguero (Fox, *1949;* Wolcott, *1951;* type of *foxi*).—Henry Barracks (Fox, *1952a*).—Isla Verde Int. Airport (Fox and Garcia-Moll, *1961*).—Mayaguez (Wirth and Blanton, *1956a*).—Fort Buchanan, 26 June 1952, F. S. Blanton, light trap, 1 female; Mayaguez, 9 January 1969, Walker and Drummond, light trap, 2 females.

Discussion.—In 1950 Ortiz gave the name *Culicoides foxi* n. sp. to a male specimen from Camp Tortuguero, Puerto Rico. It had been misidentified and figured by Fox (*1949*) as *C. guttatus* (Coquillett). In 1951 Ortiz redescribed *C. foxi* from Caracas, Venezuela, and he invalidly designated types from that country. The type locality was erroneously given as Venezuela by Fox (*1955a*) and Wirth and Blanton (*1956a*, *1959*).

Larval Habitat.—Williams (*1964*) reared *C. foxi* in Trinidad from sunny and shaded stream and ditch margins, from rain-soaked horse and cow manure, and from rotting cacao pods.

Biting Habits.—Wirth and Blanton (*1959*) reported *C. foxi* from a horse-baited trap in Panama and from an animal-baited trap in Brazil. It has been taken biting man in Trinidad.

Culicoides furens (Poey)

(Figs. 1, 5, 17, and 30)

Oecata furens Poey, 1851, p. 236 (female; Cuba; fig. habitus, wing, head, antenna, mouthparts).—Townsend, 1893, p. 381 (Jamaica).—Cockerell, 1894, p.

419 (Jamaica).—Pratt, 1907, p. 28 (Cuba, Montserrat).—Johnson, 1919, p. 422 (Jamaica).—Stephens, 1923, p. 368 (Cuba).

Culicoides furens (Poey).—Lutz, 1912, p. 16 (combination).—Root, 1922, p. 396 (Puerto Rico).—Hoffman, 1925, p. 287 (redescribed; Cuba, Puerto Rico, Ba-

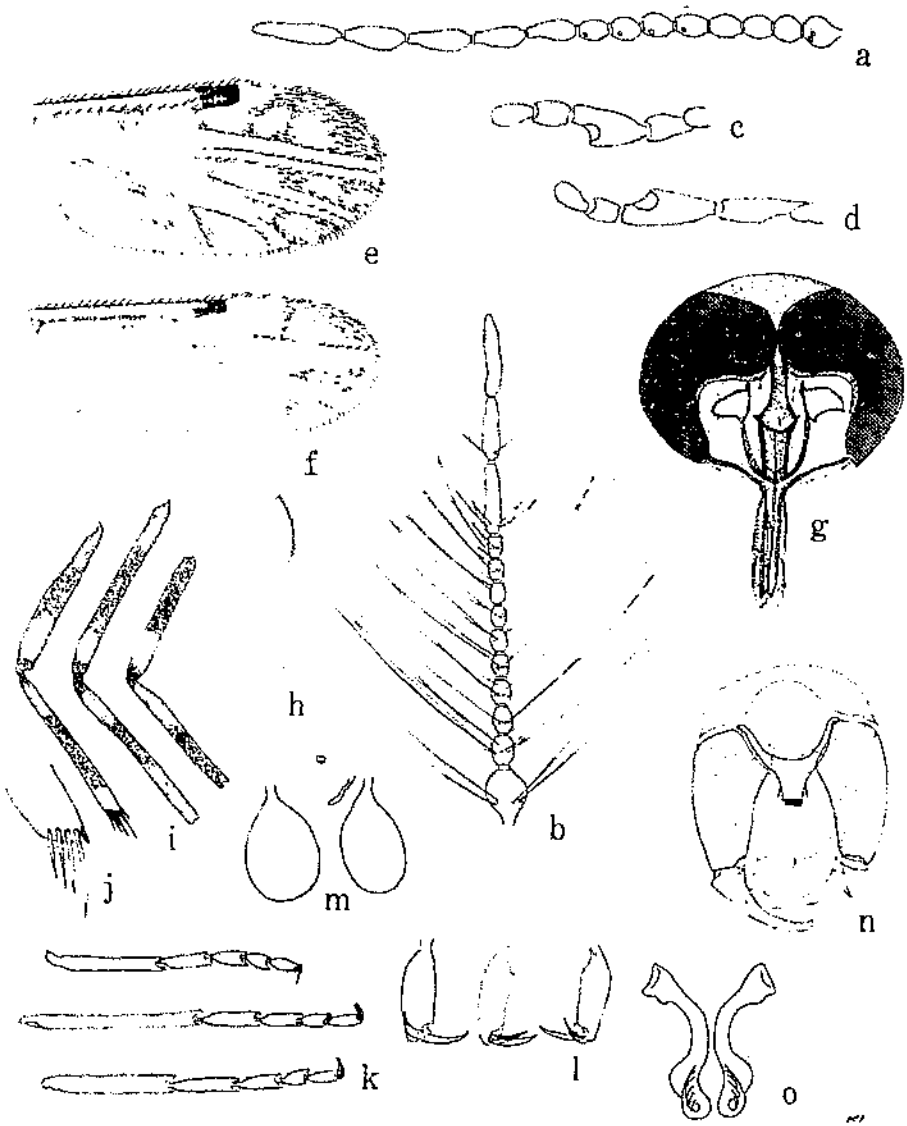

FIGURE 17.—*Culicoides furens:* *a*, Female antenna; *b*, male antenna; *c* and *d*, female palpi; *e*, female wing; *f*, male wing; *g*, female head; *h*, female mandible; *i*, femora and tibiae, left to right, of hind, middle, and fore legs; *j*, tibial comb; *k*, tarsi, top to bottom, of fore, middle, and hind legs; *l*, fifth tarsomere and claws, left to right, of fore, middle, and hind legs; *m*, spermathecae; *n*, male genitalia, parameres removed; *o*, male parameres.

hamas; illus.).—Wolcott, 1927, p. 312 (Haiti).—Myers, 1932, p. 1 (Bahamas).—Buckley, 1933, p. 257 (Saint Vincent).—Van Volkenberg, 1935, p. 17 (Puerto Rico).—Wolcott, 1936, p. 325 (Puerto Rico).—Macfie, 1937, p. 10 (male, female redescribed; Trinidad; synonyms; *dovei, maculithorax*).—Root and Hoffman, 1937, p. 162 (redescribed; U.S. records; fig. male genitalia).—Wolcott, 1941, p. 109 (Puerto Rico).—Fox, 1942, p. 418 (pupa; Puerto Rico; illus.).—Beatty, 1944, p. 144 (Saint Croix).—Barretto, 1944, p. 89 (male; Brazil; illus.).—Fox, 1946, p. 255 (Saint John, Dominican Republic).—Barbosa, 1947, p. 15 (notes; distibution; fig. male genitalia).—Floch and Abonnenc, 1950, p. 1 (Guadeloupe).—Fox and Kohler, 1950, p. 342 (Puerto Rico).—Wolcott, 1951, p. 425 (Puerto Rico, economic notes).—Kohler and Fox, 1951, p. 113 (Puerto Rico).—Wirth, 1952b, p. 91 (larva, pupa; Florida; illus.).—Fox and Maldonado, 1953, p. 165 (Puerto Rico).—Foote and Pratt, 1954, p. 21 (redescribed; distribution; illus.).—Ortiz and Leon, 1954, p. 572 (female; Ecuador; fig. wing, palpus).—Wirth and Blanton, 1956c, p. 159 (redescribed; distribution; illus.).—Lewis, 1958, p. 721 (Jamaica; internal anatomy; illus.).—Wirth and Blanton, 1959, p. 404 (redescribed; Panama distribution; illus.).—Fox and Garcia-Moll, 1961, p. 120 (Puerto Rico).—Jones, 1961b, p. 739 (pupa; illus.).—Bidlingmayer, 1961, p. 149 (Florida; adult biology).—Davies, 1964, p. 33 (Jamaica; biology).—Linley and Kettle, 1964, p. 129 (larva, pupa; Jamaica).—Linley, 1966a, p. 385 (Jamaica; biology; immature stages).—Linley, 1966b, p. 1 (Jamaica; ovarian cycle).—Linley and Davies, 1971, p. 264 (biology and control).

Cemtopogon maculithorax Williston, 1896, p. 277 (female; Saint Vincent; fig. wing).

Culicoides maculithorax (Williston).—Kieffer, 1906, p. 54 (combination).—Loughnan, 1921, p. 202 (Jamaica).—Edwards, 1922, p. 164 (Jamaica).

Culicoides dovei Hall, 1932, p. 88 (male, female; Georgia; fig. male genitalia).

Female.—Wing length 0.91 mm.

Head: Eyes (fig. 17, *g*) narrowly separated, bare. Antenna (fig. 17, *a*) with lengths of flagellar segments in proportion of 16–12–12–12–12–12–12–12–20–22–24–25–35; AR 1.28; sensory pattern 3,7–10. Palpal segments (fig. 17, *c* and *d*) with lengths in proportion of 11–24–28–10–13; PR 2.4; third segment slightly swollen, with small, shallow sensory pit. Proboscis moderately short, P/H ratio 0.74; mandible (fig. 17, *h*) with 15 teeth.

Thorax: Dark brown; mesonotum pollinose grayish, with prominent pattern of numerous scattered punctiform brown dots at seta bases; scutellum brown in middle, grayish pruinose on sides. Legs (fig. 17, *i*, *k*, *l*) brown; knee spots blackish; femora pale at bases, femora with subapical, tibiae with subbasal, and hind tibia with apical, narrow pale rings; tibial comb (fig. 17, *j*) with four spines, the one nearest the spur longest.

Wing (figs. 17, *e*; 30, *g*): Pattern as figured; 2RC blackish; pale spot over r-m crossvein large; cell R5 with three small, round, poststigmatic pale spots in a triangle, the two next to 2RC more or less fused, and a large, oblique, double spot broadly meeting wing margin in distal part of cell; cell M1 with three pale spots, the distal one located at the wing margin; vein M1 pale margined from apex nearly to its base, veins M2 and M3+4 pale margined

on distal portions; cell M2 with pale streak in basal portion and a wider spot behind medial fork, two pale spots lying past level of mediocubital fork; cell M4 with large pale spot; anal cell with pale area at base and two pale spots in distal portion. Macrotrichia moderately numerous on distal half of wing and in anal cell; CR 0.58. Halter pale.

Abdomen: Dark brown. Spermatheeae (fig. 17, *m*) two plus rudimentary third and sclerotized ring; ovoid with long slender necks; subequal, each measuring 0.057 by 0.037 mm.

Male Genitalia (fig. 17, *n*).—Ninth sternum with broad, deep, caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering with unusually long, slender, divergent, pointed, apicolateral processes. Basistyle with "foot-shaped" ventral root, posterior heel short, anterior toe long, dorsal root slender; dististyle slender, slightly curved, with bent pointed tip. Aedeagus with broad, rounded basal arch extending to about half of total length; basal arms slender; distal portion relatively short and stout, the apex of two types—in one the very slender, median, distally striate tip flanked by a prominent pair of lateral points of about the same length; in the other type the lateral points apparently lacking and the striated median tip broader. Parameres (fig. 17, *o*) separate; each with large basal knob, stem moderately stout and curved, bearing an extremely large ventral lobe; distal portion tapering to fine point and bearing about five strong, lateral, fringing spines.

Distribution.—Atlantic and Gulf coasts of the United States from Massachusetts to Florida and Texas; Caribbean and Atlantic coasts of Mexico, Central America, and West Indies to Brazil; Pacific coast from Mexico to Ecuador (fig. 5).

Types.—Existence of types of *C. furens* unknown; described from north coast of Cuba, probably Havana. Holotype female of *Ceratopogon maculithorax*, Saint Vincent (British Museum (Nat. Hist.), London). Holotype male of *dovei*, Brunswick, Ga. (USNM 43972, but missing from the USNM collection).

West Indian Records.—

ANTIGUA: No locality or date, Nos. 878, 879, A. H. Jennings, 32 females (Wirth and Blanton, *1956c*). —Fitches Creek, 22 September 1965, Martinez and Guerra, biting man 6 PM, 3 females; Jolly Beach Hotel, 2 November 1967, J. B. Davies, biting man, 2 females; Prickly Pear I., 6 April 1958, J. F. G. Clarke, light trap, 1 female.

BAHAMAS: Abaco I., Marsh Harbour, 13 April 1968, G. M. Stokes, light trap, 1 male, 1 female; Andros I., Driggs Hill near South Bight, 27 April 1953, E. Hayden and L. Giovannoli, 3 females (AMNH); Andros I., April 1966, H. J. Bowen, biting man, 2 females; Bimini, 25 January 1968, Stokes, light trap, 1 male, 2 females; Cat I., Bennetts Harbour, 24 March 1953, Giovannoli, 17 females (AMNH); Eleuthera I., James Cistern, 1 April 1953, Hayden and Giovannoli, 12 females (AMNH); Exuma Cays, Darby I.,

18 January 1953, Hayden and Giovannoli, 15 females (AMNH); same, Warderick Wells Cay, 10 January 1953, Hayden, 1 female (AMNH); Mayaguana I., near Abraham Bay, 3 March 1953, Hayden, 1 female (AMNH); New Providence I., Nassau, 3 June 1943, D. G. Hall, 6 females; same, 3 January 1953, Hayden, 1 female (AMNH); North Bimini, Alice Town, 4 February 1968, Stokes, 1 male, 2 females; North Bimini, Paradise Point, 18 February 1968, Stokes, light trap, 2 females; South Bimini, May, July 1951, C. and P. Vaurie, M. Cazier, and W. Gertsch, 3 males, 5 females (AMNH); Turks and Caicos I., cays 3.5 mi. sw. North Caicos I., 3 February 1953, Hayden, Giovannoli, and Rabb, 13 females (AMNH).

BARBADOS: No locality or date, No. 853, A. H. Jennings, 10 females.

CAYMAN ISLANDS: Grand Cayman, Red Bay, 11 August 1969, J. E. Davies, light trap, 1,000's; Grand Cayman, South Sound, 16 February 1970, Davies, emergence trap, 100 specimens.

CUBA: No locality, types of *furens* (Poey, *1851*).—Cardenas, June, E. A. Schwarz (Pratt, *1907*; Hoffman, *1925*).—Guantanamo Bay, February-April 1970, J. E. Tisdale, light trap, 1,000's; same, 21 February 1962, E. R. Turner, light trap, 6 males, 4 females; same, 3 September 1964, T. S. Josey, light, 2 males, 1 female; Havana, no date, J. R. Taylor, 7 females; Isle of Pines, Columbia, no date or collector stated, 7 females; La Victoria, Camaguey Prov., 3 July 1957, J. U. McGuire, 1 female.

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 10 males, 10 females; Clarke Hall Estate, January-March 1965, Wirth, light trap, 10 males, 12 females; Grande Savane, 1 February 1965, Wirth, 1 female; Layou River mouth, 20 January 1965, Wirth, 5 females; same, 6 February 1965, Wirth, reared margin lagoon, 4 males, 1 female; Macoucheri, 12, 14 February 1965, Wirth, at light, 1 male, seashore, 1 female; Portsmouth, 4 March 1964, D. F. Bray, 7 females.

DOMINICAN REPUBLIC: San Lorenzo, 14 May 1941, Dr. Mazzotti, biting man, 1 female (Fox, *1946*).

JAMAICA: Palisadoes, Port Maria (Townsend, *1898*).—No locality (Edwards, *1922*).—Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 10 females; Baths, St. Thomas Parish, 19 July 1961, Maldonado and Farr, 2 females; Burat Hill, Trelawny Parish, 16 May 1967, R. E. Woodruff, light trap, 1 male; Duckenfield, St. Thomas Parish, 4 December 1962, T. H. G. Aitken, donkey trap, 2 females; Duncans, Trelawny Parish, 25 February 1958, D. J. Lewis, 8 females; Falmouth, Trelawny Parish, 1 March 1969, W. W. Wirth, bay shore, 4 females; Kingston, no date, No. 875, A. H. Jennings, 4 females; Milk River Bath, Clarendon Parish, 11 November 1958, Aitken, 8 females; same, 19 November 1968, Woodruff, light trap, 100 females; same, 11 March 1970, Wirth and Farr, biting man 6 PM, 10 females; Mitchell Town, Clarendon Parish, 12 November

1958, Aitken, 29 females; Montego Bay, St. James Parish, 22 June 1957, M. V. King, 5 females; Morant Bay, St. Thomas Parish, 6 February 1937, Chapin and Blackwelder, 1 female; Negril, Westmoreland Parish, 20 November 1968, Woodruff, light trap, 200 males and females; same, 22 June 1970, Farnworth, light trap, 1,000's; Portland Ridge, PWD Fish Lodge, 21 August 1969, Farnworth, biting man, 1 female; Runaway Bay, St. Ann Parish, February 1969, Wirth, light trap, 10 males, 20 females; Spanish Town, St. Catherine Parish, 2 February 1937, Chapin and Blackwelder, 1 female; same, 28 May 1970, F rnworth, light trap, 20 females; T ckenham Park, St. Catherine Parish, 28 April 1970, Farnworth, light trap, 1,000's; Winchester, St. Thomas Parish, 7 December 1962, Aitken, donkey trap, 2 females.

MONTSERRAT: No locality (Pratt, *1907*).

PUERTO RICO: Aguirre, August 1921, F. M. Root (Hoffman, *1925*).—Isla Verde Int. Airport, 1958–60 (Fox and Garcia-Moll, *1961*).—Rio Piedras, July and September 1921, Root (Hoffman, *1925*). —San Juan (Fox, *1942*).—Camp Tortuguero, 24 June 1952, F. S. Blanton, light trap, 11 females; Fajardo, 1 July 1952, Blanton, light trap, 5 females; Fort Buchanan, 26 June 1952, Blanton, light trap, 3 females; Guanica, 22 June 1952, Blanton, light trap, 5 females; Las Palmas, 20 March 1970, G. M. Stokes, light trap, 3 males, 2 females; San Juan, 8 January 1969, Walker and Drummond, light trap, 10 females.

SAINT CROIX: Krause Lagoon, June 1938, H. A. Beatty, 18 females; Salt River, September 1938, Beatty, 8 females; Tagus, June 1938, Beatty, 2 females.

SAINT JOHN: Cruz Bay, 9 September 1937, 3 females (Fox, *1946*). —No locality, August-October 1961, R. W. Williams, light trap and emergence traps, 15 males, 30 females; Francis Bay, 25 March 1958, J. F. G. Clarke, at light, 9 females.

SAINT LUCIA: Grand Anse, 20 July 1964, R. Martinez, biting man, 1 female; Gros Islet, Yacht Club light, 25 October 1967, J. B. Davies, 1 female; Vilou Estate near Micoud, 28 July 1964, Martinez, biting man, 7 females.

SAINT THOMAS: No locality, 28 November 1957, R. Delgado, biting man, 1 female.

SAINT VINCENT: No locality or date, types of *Ceratopogon maculithorax* Williston (*1896*).

VIRGIN GORDA: North Beach, 23 March 1970, G. M. Stokes, biting man, 10 females.

Discussion.—A full discussion of the taxonomy and distribution of this species was presented by Wirth and Blanton (*1956c; 1959*). The extensive West Indian literature on the species is listed in the synonymy given on the preceding pages.

Larval Habitat.—Myers' (*1935*) account of the larval habitat of *C. furens* in the Bahamas was the first detailed study in the West Indies, and its accuracy and definition, borne out by more recent investigations, warrant repetition:

"In the Bahamas and probably elsewhere the ideal breeding-places for *Culicoides furens* are areas of waterlogged sand mixed with humus, not subject to actual flooding by any except unusually high tides, and more or less covered with a growth of mangroves. But even in such localities the sand-flies by no means breed evenly over the whole extent. A typical sand-fly swamp or 'swash,' as it is called in the Bahamas, may be described as follows from a New Providence example: the sandy, or in places rocky, beach is backed closely by a sea-dune, often of considerable width and clothed with sea-oats (*Uniola*), coco-plum (*Chrysobalanus Icaco*) and low scrub. At some distance inland is a line of rock outcrops. Between these two ridges lies the swamp, into which extend the branches of a narrow arm of the sea, a creek in the original sense of the word. The margin of the swamp is everywhere clearly defined by distinct zones of vegetation. The lower portion, about the arms of the creek, is covered almost uniformly with common stilt mangroves (*Rhizophora mangle*). The upper portions and the margins are clothed with almost pure stands of low black mangrove (*Avicennia nitida*). While the muddy sand between the *Rhizophora* bushes is invariably bare, that among the *Avicennia* shrubs is often covered, though not densely, with the low reddish herbaceous plant, *Salicornia perennis*. On the extreme edge of the swamp, at the foot of the sea-dune and of the landward rock outcrop, is a thin line of other vegetation, chiefly white mangrove (*Laguncularia racemosa*) and buttonwood (*Conocarpus erecta*) with denser beds of *Salicornia* and of the much greener sampire (*Philoxerus vermicularis*). Occasional patches of the salt-marsh grass, *Sporobolus virginicus*, also occur here. The distribution of these different vegetation zones depends upon distance from tidal influence. In the upper part of the swamp are frequent and extensive patches of bare soil. The soil of the whole area is permanently water-logged, while that in the immediate vicinity of the creek is flooded by every tide. The proportion of humus in the sand decreases as one approaches the mouth of the creek, where the sand is pure and almost white.

"In the swamp thus briefly characterised, sand-flies (*C. furens*) breed in greatest abundance about the meeting-place of the common mangrove (*Rhizophora*) and the black mangrove (*Avicennia*) patches, and to a greater extent in the shade of the former than of the latter. They breed also, right up to the edge of the swamp, in the shade of white mangroves (*Laguncularia*), of sampire (*Philoxerus*) of the grass, *Sporobolus virginicus*.

"I was able to find none in precisely similar soil in the shade of *Salicornia*, nor in the bare patches. Neither does the sand-fly breed in the lower part of the common mangrove zone, where every tide covers the surface with several inches of water. To sum up, we may state that for breeding in numbers sand-flies

(*Culicoides furens*) require (a) sand with a proportion of humus, permanently waterlogged with salt or brackish water, but not flooded, and (b) shade. It would be presumptuous to assert that odd sand-flies do not breed where some or even all of these conditions are lacking, but we are concerned here with main sources of infestation."

Painter (*1927*) reared *C. furens* from sand and mud near a tidal canal in Honduras. Carpenter (*1951*), Woke (*1954*), and Blanton et al. (*1955*) reported *C. furens* as a severe pest in Panama, breeding in the Farfan Swamp near Fort Kobbe, C.Z. They devised a system of tidal gates to keep the swamp flooded with fresh water from rainfall. Control was good until the gates deteriorated. Breeland (*1960*) reared this species in Panama from numerous collections from a wide variety of salt-water habitats and found it to be most abundant in mangrove swamps or marshes that were only partially shaded. The densest populations were found in supersaturated muck of tide ditches with no standing water and partial to full exposure to sunlight. This species was virtually absent in densely shaded mangrove swamps. Williams (*1964*) reared *C. furens* in Trinidad not only from tidal and brackish habitats but also from the margin of a fresh-water stream miles from the seacoast.

Linley and Kettle (*1964*) described the larva and pupa of *C. furens*, taken at Greenwood, east of Montego Bay, Jamaica. The breeding site was the shaded banks of two ponds, situated close to the sea, which contained considerable sea water even though they were not connected directly to the sea. Williams (*1962*), working on Saint John, compared emergence trap catches from ordinary tidal mangrove swamps (Type I) with those from vegetated margins of brackish ponds receiving some water by seepage from the sea, but with higher levels from periods of heavy rainfall (Type II). Type I habitats produced a nearly constant, moderate emergence of adults, whereas type II habitats produced larger numbers beginning with the flooding of such ponds by rainfall and increasing until about a week after the mud was exposed by drying of the ponds.

Linley (*1966a*) and Davies (*1967*) trapped *C. furens* in Jamaica in the Bogue Swamps east of Montego Bay in emergence cages along transects crossing various vegetation zones and tide levels. They generally found *C. furens* breeding in those parts of the swamp occupied by white or black mangroves (*Laguncularia* and *Avicennia*) at a slightly higher level (0.2 foot) than *C. barbosai*. Its emergence was hardly affected by general water levels, but unlike that of *C. barbosai*, the emergence of *C. furens* was greatly inhibited by high amplitude tides. For this reason the abundance of *C. furens* is unlikely to show much seasonal variation in Jamaica, but it is more abundant on a biweekly cycle during neap tides than during spring tides.

Using emergence traps, Linley et al. (*1970a*) compared the seasonal

emergence of *C. furens* in Florida from three habitat types—tidal ditches, brackish pools, and impoundments. Compared with the other two habitats, impoundments produced relatively few adults early in the year (March to June), but thereafter the rate of emergence in impoundments increased and during the cold months (September to March) exceeded that in the other two habitats.

Linley (*1968, 1969*) described techniques for colonizing *C. furens* in Florida and included notes on behavior under laboratory conditions. Earlier he (*1966a*) reported on the behavior, habitat preferences, and food preferences of larvae collected in Jamaica and reared in the laboratory. In alternate periods the larvae exhibited two types of activity—(1) burrowing through the soil, presumably foraging for food, and (2) inactively lying at the soil surface to secure a better supply of oxygen. Just prior to pupation the larvae migrate some distance to drier soil where contact with air can be made more easily by the pupa.

Biting Habits.—Kettle (*1969b*) found biting activity of *C. furens* in Jamaica to be crepuscular and nocturnal with a peak at dawn and irregular outbursts through the night. He (*1969c*) found that moderately high windspeed (above 3 m.p.h.) decreased the biting rate. Kettle and Linley (*1969b*) found that this species preferred to bite the legs rather than the arms of humans.

This species is rather exceptional among *Culicoides* species in its habit of freely entering houses and other buildings in search of a blood meal (Myers, *1935;* Adamson, *1939;* Porter, *1959*). Wire screens at windows and doors are only partially effective in keeping them out, but spraying or painting the screens with kerosene to which suitable insecticide has been added is an effective repellent.

Flight Range.—Williams (*1962*) found on Saint John in the Virgin Islands that adults of *C. furens* may be carried by prevailing winds for more than 4 miles over mountains 1,200 feet high. Breeland and Smith (*1962*) reported that *C. furens* in Panama was carried downwind a distance of about 2 miles. It seems likely that windborne *C. furens* may disperse from 3 to 4 miles from their breeding places, whereas upwind dispersal may be limited to several hundred yards. The reliability of prevailing winds or trade winds may be an important factor in planning control measures for this species (Linley and Davies, *1971*).

Culicoides guadeloupensis Floch and Abonnenc

(Fig. 6)

Culicoides guadeloupensis Floch and Abonnenc, 1950, p. 2 (female; Guadeloupe I.; fig. wing, palpus, head, eyes, legs, spermatheca, pharynx).

Female.—Wing length 1.17 mm.

Head: Eyes with short interfacetal hairs. Antenna with five distal segments elongate, 11 longer than 9 and 10 combined; AR 1.65. Palpal segments with lengths in proportion of 19–52–57–24–33; third segment

stout, with a large irregular shallow pit on distal portion; PR 1.4.

Thorax: No data given.

Wing: Wing pattern similar to that of *C. trilineatus* Fox; cell R5 with a single, oblique, poststigmatic pale spot and a transverse pale spot in distal portion; cell M1 with two pale spots; cell M2 with a pale spot behind medial fork, one in front of mediocubital fork, and one in distal portion of cell at wing margin; a small pale spot in cell M4; anal cell with a single pale spot in distal portion; vein M1 narrowly pale bordered on distal half. Macrotrichia abundant over entire wing; CR 0.67.

Abdomen: One spermatheca present, subspherical, with a moderately long, slender neck; measuring 0.064 by 0.055 mm.

Male Genitalia.—Male unknown.

Distribution.—Guadeloupe (fig. 6).

Type.—Known only from the holotype female, collected St.-Claude, Guadeloupe, 1944–5, R. Chassignet (slide No. 1944, in coll. Inst. Pasteur de la Guyane, Cayenne).

West Indian Records.—None.

Discussion.—The previous description was taken from Floch and Abonnenc (*1950*). The wing pattern of *C. guadeloupensis* is practically indistinguishable from that of *C. trilineatus*, but the hairy eyes, the presence of only one spermatheca, and the markedly elongate distal antennal segments provide means for readily distinguishing *C. guadeloupensis*.

Larval Habitat.—Unknown.

Biting Habits.—Unknown.

Culicoides heliconiae Fox and Hoffman

(Figs. 3 and 18)

Culicoides heliconiae Fox and Hoffman, 1944, p. 108 (female; Venezuela; fig. wing).—Fox, 1948, p. 22 (male, female; fig. palpus, aedeagus, parameres).—Wirth and Blanton, 1956e, p. 95 (redescribed; synonym: *rozeboomi;* illus.).—Wirth and Blanton, 1959, p. 274 (redescribed; Panama records; illus.).—Williams, 1964, p. 463 (Trinidad; larval habitats).—Wirth and Blanton, 1968, p. 205 (redescribed; illus.).—Wirth et al., 1968, p. 132 (Panama; reared from *Heliconia*).

Culicoides rozeboomi Barbosa, 1947, p. 26 (male, female; Trinidad; illus.).

Female.—Wing length 1.66 mm.

Head: Eyes contiguous, bare. Antenna (fig. 18, *a*) with lengths of flagellar segments in proportion of 60–50–50–50–50–50–50–50–65–66–80–83–108; AR 1.06; sensory pattern 3,11–15. Palpal segments (fig. 18, *f*) with lengths in proportion of 20–120–140–60–56; PR 3.6; third segment spindle shaped, with sensilla scattered on surface. Proboscis long, P/H ratio 1.33; mandible with 23 teeth.

Thorax: Blackish; mesonotum (fig. 18, *c*) with large median area and other smaller areas dark pruinose gray, lateral margins and a sublateral pair of short bands velvety black; humeri whitish. Legs blackish; midknee narrowly pale on each side of joint; fore femur with subapical, fore tibia with subbasal, and hind tibia with basal and apical, narrow pale rings; tibial comb (fig. 18, *d*) with six spines, second from spur longest.

Wing (fig. 18, *b*): Pattern as figured; 2RC with apex included in a pale spot; base of cell M4 dark where it borders bases of veins M3 +4 and Cu1; pale spot present in cell R5 anterior to base of vein M1; apices of veins M1, M2, M3+4, and Cu1 with pale spot at wing margin. Macrotrichia sparse on distal half of wing and extending nearly to base of anal cell; CR 0.71. Halter pale.

Abdomen: Blackish, cerci yellowish. Spermathecae (fig. 18, *e*) two plus rudimentary third and sclero-

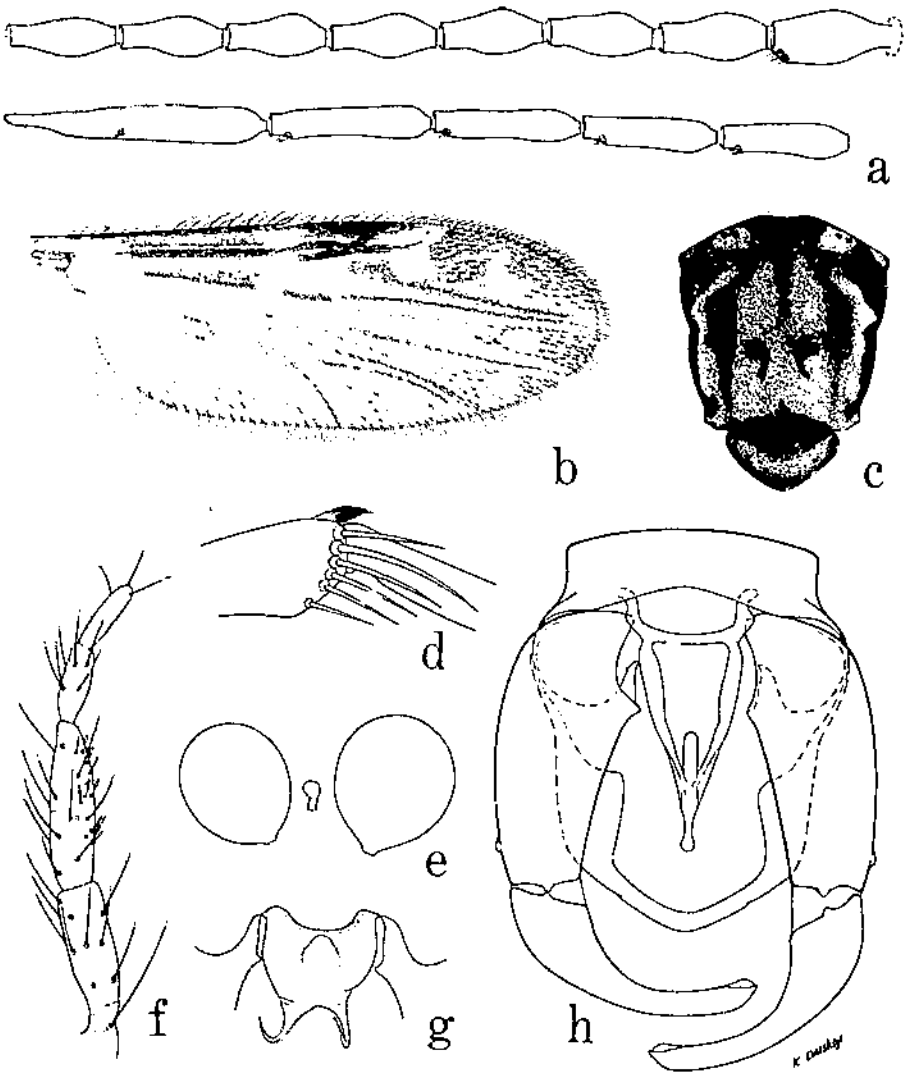

FIGURE 18.—*Culicoides heliconiae*: *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermathecae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

tized ring; functional ones ovoid with short slender necks; unequal, measuring 0.065 by 0.053 mm. and 0.051 by 0.042 mm.

Male Genitalia (fig. 18, *h*).—Ninth tergum with caudomedian margin slightly produced in a rounded process, sometimes slightly bilobed, apicolateral processes absent. Aedeagus narrow with short basal arch, anterior margin with distinct sclerotized band; distal portion with internal sclerotized anterior projection and round terminal papilla. Parameres (fig. 18, *g*) fused on proximal portion for about a third of total length, fused portion slightly broader than long, terminal filaments slender with fine fringing hairs distally.

Distribution.—Brazil, Colombia, Costa Rica, Grenada, Honduras, Panama, Trinidad, Venezuela (fig. 3).

Types.—Holotype, female, allotype, male, and one female paratype, Maracay, Venezuela, 2 August 1927, with cast pupal skins, reared from bromeliads (University of Puerto Rico collection).

West Indian Records.—

GRENADA: Lake Grand Etang, 2 mi. w., 4–8 August 1963, O. S. Flint, 1 female (Wirth and Blanton, *1968*).

Discussion.—This large blackish species is distinguished by its slender, spindle-shaped third palpal segment with scattered sensilla, its prominent wing pattern with an isolated pale spot at the base of cell R5, anterior to the base of vein M1, and with the base of cell M4 not pale margined, its pale-colored midknee, and its hind femur which lacks a subapical pale band.

Larval Habitat.—The type series was reared from bromeliads in Venezuela. Aitken (*1957*) reared this species from *Heliconia* bracts in Trinidad; Williams (*1964*) reared it in Trinidad from banana stump, *Heliconia* bracts, bamboo internode, and *Calathea* flowers; and Wirth et al. (*1968*) reared it from *Heliconia* bracts in Panama.

Biting Habits.—Carpenter (*1951*) and Wirth and Blanton (*1959*) found *C. heliconiae* abundant in collections from stable traps in Panama, and the latter concluded that the species must be strongly attracted to horses.

Culicoides hoffmani Fox (Figs. 6 and 19)

Culicoides hoffmani Fox, 1946, p. 251 (female; Trinidad; biting man; fig. wing, mesonotal pattern).—Fox, 1949, p. 29 (male, female; Puerto Rico; reared, tree hole; fig. palpus, spermathecae, male genitalia).—Fox and Kohler, 1950, p. 342 (Puerto Rico).—Fox and Maldonado, 1953, p. 165 (Puerto Rico).—Wirth and Blanton, 1956b, p. 189 (redescribed; distribution; illus).—Linley and Kettle, 1964, p. 129 (larva, pupa; Jamaica; illus.).—Linley, 1965a, p. 57 (Jamaica; reared from tree hole).—Wirth and Blanton, 1971, p. 36 (notes; separation from *debilipalpis* and *eadsi*).

Female.—Wing length 0.76 mm.

Head: Eyes moderately separated, with longer interfacetal hairs than in *C. debilipalpis*. Antenna (fig. 19, *a*) with lengths of flagellar segments in proportion of 14–11–13–15–15–14–14–15–14–14–15–15–25; AR 0.79; sensory pattern 3,8–10. Palpal segments (fig. 19, *c*) with lengths in

proportion of 6–11–19–6–7; PR 1.6; third segment short and swollen, with a moderately large and deep sensory pit. Proboscis moderately short, P/H ratio 0.70; mandible with 14 teeth.

Thorax: Dark brown; mesonotum (fig. 19, *f*) with a sublateral pair of darker brown patches widest at midlength. Legs dark brown; fore femur and midfemur with subapical, all tibiae with subbasal, and hind tibia with apical, narrow, pale rings; tibial comb (fig. 19, *e*) with four spines, the one nearest the spur longest.

Wing (fig. 19, *b*): Pattern as figured; 2RC dark to apex; pale spot over r-m crossvein small; cell R5 with three pale spots, the poststigmatic pair separate, small and round, the posterior one located nearly directly behind the other, distal pale spot not reaching anterior wing margin, transversely oval; cell M1 with two pale spots; cell M2 with pale spot at basal arculus, pale spot behind medial fork, but none in front of mediocubital fork; only one pale spot in distal portion of cell M2, located at wing margin; cell M4 with

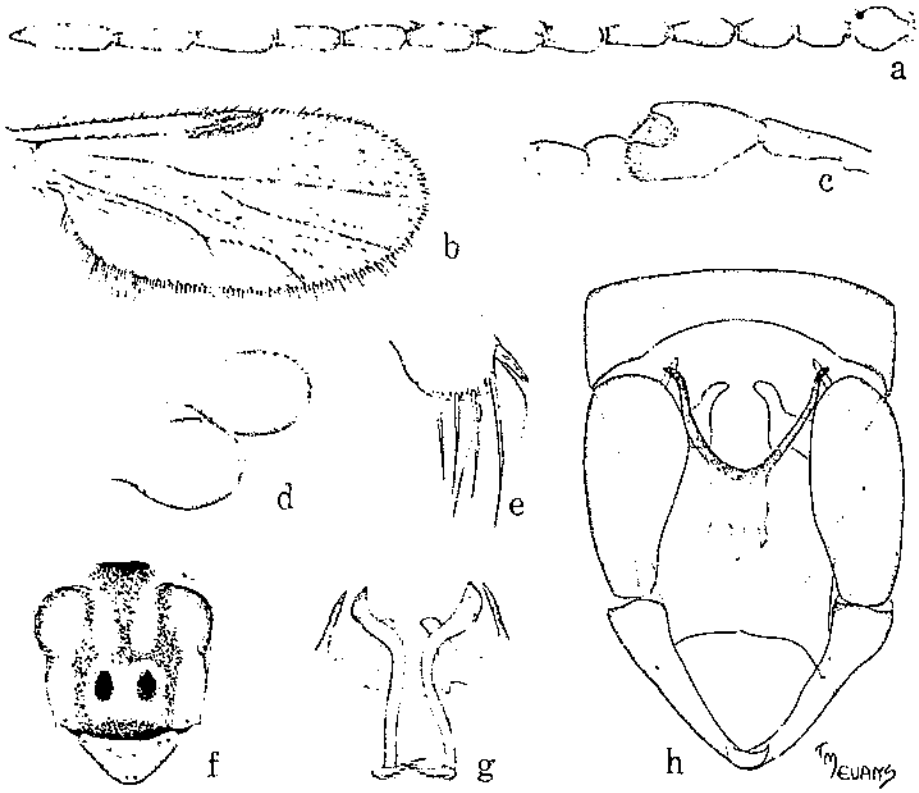

FIGURE 19.—*Culicoides hoffmani: a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, spermathecae; *e*, tibial comb; *f*, thoracic pattern; *g*, male parameres; *h*, male genitalia, parameres removed.

round pale spot in distal portion; anal cell with one pale spot in distal portion. Macrotrichia moderately sparse, usually confined to distal half of wing, rarely extending to base of cell M2; CR 0.59. Halter slightly infuscated, flat end of knob whitish.

Abdomen: Dark brown. Spermathecae (fig. 19, *d*) two plus rudimentary third and sclerotized ring; oval with long slender necks; slightly unequal, measuring 0.048 by 0.034 mm. and 0.043 by 0.031 mm.

Male Genitalia (fig. 19, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering, with large, triangular, apicolateral processes. Basistyle with ventral root "foot-shaped," posterior heel poorly developed, dorsal root slender; dististyle slender and nearly straight with hooked tip. Aedeagus with basal arch rounded, extending to slightly more than half of total length, basal arms slender and curved; distal portion broadly expanded and well sclerotized, with three strongly sclerotized distal points. Parameres (fig. 19, *g*) separate; each with basal knob, stem slender, midportion sinuate, no trace of ventral lobe; distal portion tapering to ventromesally bent distal point with lateral fringe of fine hairs.

Distribution.—Antigua, Barbados, Cayman Islands, Dominica, Jamaica, Saint Croix, Saint Lucia, Trinidad (fig. 6).

Types.—Holotype, female, paratype, female, Camuto Village, Trinidad, 11 April 1941, biting man (University of Puerto Rico collection).

West Indian Records.—

ANTIGUA: Wallings Dam near Sweets Village, 15 September 1965, R. Martinez, biting man 3 PM, 1 female.

BARBADOS: No locality or date, No. 830, A. H. Jennings, 2 females.

CAYMAN ISLANDS: No locality, June 1970, J. E. Davies, 2 females; Grand Cayman, Southwest Point, 3 November 1969, Davies, light trap, 1 female.

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 1 female; Carholme Estate, 7 February 1965, Wirth, sweeping, 2 males; Clarke Hall, January-March 1965, Wirth, light trap, 1 male, 9 females; d'Leau Gommier, 17 March 1956, J. F. G. Clarke, at light, 1 male; South Chiltern Estate, 20 February 1965, Wirth, light trap, 1 female.

JAMAICA: Brandon Hill, Montego Bay, reared from tree hole, larvae (Linley and Kettle, *1964;* Linley *1965a*).—Caymans Estate, 9 June 1962, A. Ventura, chicken-baited trap, 1 female; Worthy Park Estate, St. Catherine Parish, 11 November 1968, R. E. Woodruff, light trap, 1 female.

PUERTO RICO: Carolina, Guyanilla, I. Fox, reared, tree hole (Wirth and Blanton, *1956b*).—Mameyes, I. Fox, reared, tree hole (Fox, *1949*).—Mayaguez (Fox and Maldonado, *1953*).—San Juan, Fort Buchanan, Fort Bundy, Henry Barracks (Fox and Kohler, *1950*).

SAINT CROIX: No locality, August 1935, H. A. Beatty, 6 females (Wirth and Blanton, *1956b*).

SAINT LUCIA: Barre de l'Isle, Government Teak Nursery, 14 July 1964, R. Martinez, biting man 3:15 PM, 1 female; Saint Lucia Beach Hotel, 27 October 1967, J. B. Davies, at light, 2 males, 1 female; Vilon Estate near Micoud, 28 July 1964, Martinez, biting man 5 PM, 1 female.

Discussion.—The separation of *C. hoffmani* from the very similar allopatric species, *C. debilipalpis* and *C. eadsi*, was discussed by Wirth and Blanton (*1971*). *C. debilipalpis*, which occurs in the Southeastern United States from Maryland to Florida and Louisiana, in Central America and South America from Honduras to Trinidad, Brazil, and Argentina, has the third palpal segment longer and more slender with a small, deeper sensory pit. In addition, the wing of *C. debilipalpis* is hairier and the poststigmatic pale spots are more obliquely oriented, the spermathecae are more unequal in size, the male aedeagus has a slender, simple tip, and the parameres have a distinct ventral lobe. *C. eadsi* occurs from Texas to Mexico and is distinguished by a third palpal segment resembling that of *C. debilipalpis*, wing pattern like that of *C. hoffmani*, male aedeagus like that of *C. hoffmani*, but parameres with a distinct ventral lobe like those of *C. debilipalpis*. The distribution of these closely related species is shown in figure 6.

Larval Habitat.—Linley and Kettle (*1964*) described the tree hole habitat where they found larvae of *C. hoffmani*. The tree holes contained plant debris of a coarse crumblike texture and sometimes a layer of standing water on top. Larvae could be seen swimming near the surface and adhering to the walls of the hole just below the waterline. These authors described the larvae and pupae. The larvae are easily recognized by the presence of strongly developed perianal bristles on the caudal end. Larvae of *C. borinqueni*, which occurred in one of the same tree holes, could be distinguished from *C. hoffmani* by the lack of perianal bristles. The respiratory horn of the pupa bears coarse scales in midportion. It has seven to 11 distal and three to four lateral papillae. It is much longer and more slender than the respiratory horn of *C. borinqueni*. Larvae of *C. hoffmani* feed on protozoa and rotifers (Linley, *1965a*).

Biting Habits.—*C. hoffmani* was collected while biting man in Trinidad (holotype) and on Saint Lucia and Antigua. It was taken once in a chicken-baited trap in Jamaica.

Culicoides insignis Lutz

(Figs. 20 and 30)

Culicoides insignis Lutz, 1913, p. 50 (male, female, pupa; Brazil; fig. wing).—Costa Lima, 1937, p. 415 (fig. palpus).—Floch and Abonnenc, 1942, p. 1 (French Guiana; fig. wing, palpus).—Barbosa, 1947, p. 20 (notes on genitalia of male in Lutz collection; fig. male genitalia from Brazil).—Fox, 1948, p. 25 (notes on female characters).—Barbosa, 1952, p. 16 (Brazil; notes on Lutz collection).—Wirth and Blanton, 1956a, p. 319 (redescribed; Lutz syntypes restudied; male lectotype designated; synonyms: *inamollae*, *painteri*; distribution; illus.).—Wirth and Blanton, 1959, p. 285 (redescribed; Panama distribution;

illus.).—Fox and Garcia-Moll, 1961, p. 120 (Puerto Rico).—Williams, 1964, p. 463 (larval habitat; Trinidad).—Linley, 1965a, p. 57 (pupa; Jamaica; illus.).

Culicoides inamollae Fox and Hoffman, 1944, p. 110 (male, female; Puerto Rico; fig. wing).—Fox, 1948, p. 25 (distribution; fig. palpus, male genitalia).—Fox and Kohler, 1950, p. 342

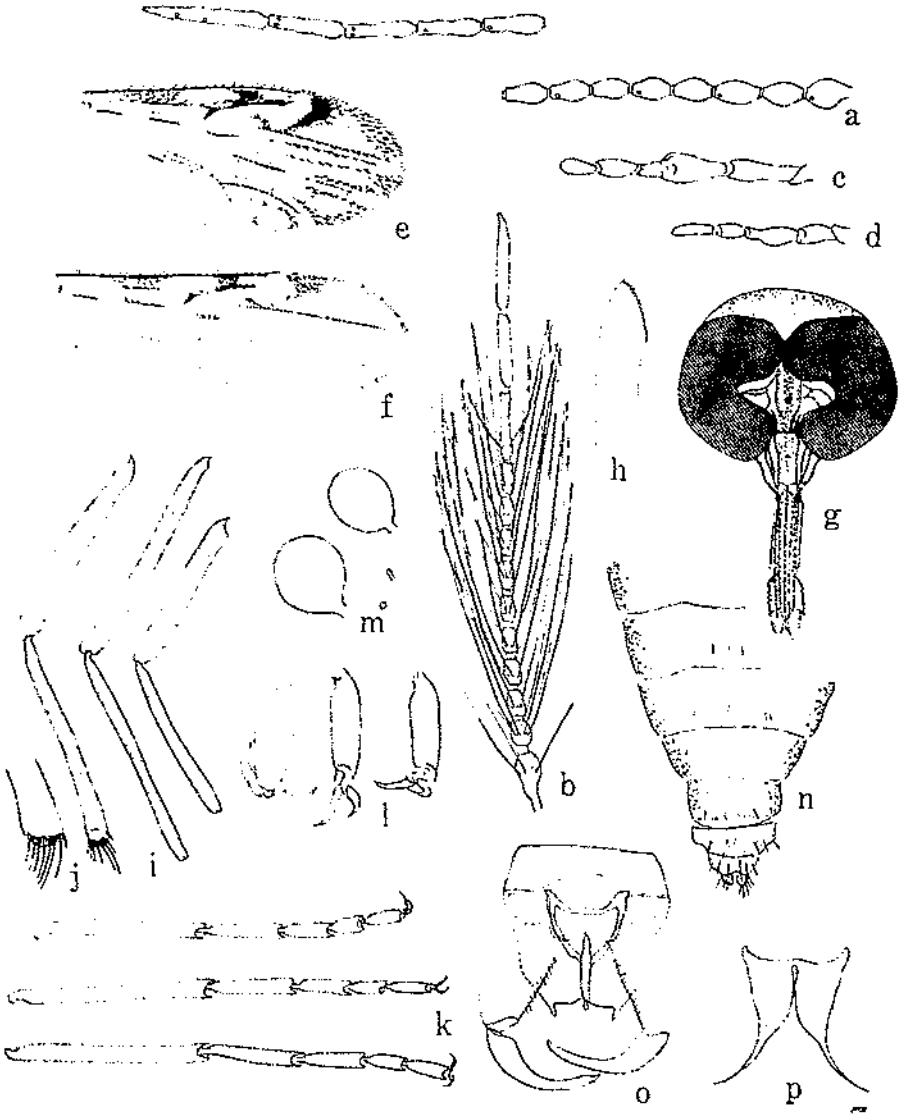

FIGURE 20.—*Culicoides insignis: a*, Female antenna; *b*, male antenna; *c*, female palpus; *d*, male palpus; *e*, female wing; *f*, male wing; *g*, female head; *h*, female mandible; *i*, femur and tibia, left to right, of hind, middle, and fore legs; *j*, tibial comb; *k*, tarsi, top to bottom, of fore, middle, and hind legs; *l*, fifth tarsomere and claws, left to right of fore, middle, and hind legs; *m*, spermathecae; *n*, female abdomen; *o*, male genitalia, parameres removed; *p*, male parameres.

(Puerto Rico).—Kohler and Fox, 1951, p. 113 (Puerto Rico).—Wolcott, 1951, p. 426 (Puerto Rico).—Fox, 1952a, p. 888 (Puerto Rico).—Fox and Maldonado, 1953, p. 165 (Puerto Rico).

Culicoides painteri Fox, 1946, p. 257 (female; Honduras; fig. wing).

Culicoides oliveri Fox and Hoffman, 1944, p. 108 (in part, male only, misidentified; Haiti).

Female.—Wing length 1.11 mm.

Head (fig. 20, *g*): Eyes contiguous, bare. Antenna (fig. 20, *a*) with lengths of flagellar segments in proportion of 20–14–14–14–14–14–14–15–24–25–26–29–44; AR 1.32; sensory pattern 3,5,7,9,11–15. Palpal segments (fig. 20, *c*) with lengths in proportion of 9–23–33–13–17; PR 2.8; third segment moderately swollen, with broad, shallow, somewhat subdivided sensory pit. Proboscis long, P/H ratio 1.05; mandible (fig. 20, *h*) with 21 teeth.

Thorax: Dark brown; mesonotum yellowish in center, with two darker sublateral vittae. Legs (fig. 20, *i*, *k*, *l*) dark brown with pale rings on fore knees and midknees and at base and apex of hind tibia; tibial comb (fig. 20, *j*) with six spines, second from spur longest.

Wing (fig. 20, *e*; 30, *l*): Pattern as figured; 2RC included in distal pale spot, but a prominent blackish line following vein R4+5 to the point where it turns abruptly forward to meet costa; crossvein r-m dark on anterior end; pale spot straddling midportion of vein M2; distal pale spot in cell R5 transverse, more or less emarginate on distal side; only one pale spot in distal portion of cell M1; cell M2 with pale streak at base, irregular pale area between medial and mediocubital forks, and two pale spots in distal portion; cell M4 with prominent pale lines bordering posterior side of vein M3+4 and distal side of vein Cu1, and a round pale spot in distal portion of cell connected narrowly to pale line along vein M3+4; anal cell with pale area at base and two pale spots in distal portion; apices of veins M1, M2, M3+4, and Cu1 with pale spot at wing margin. Macrotrichia sparse on distal half of wing and in anal cell; CR 0.65; 2RC elongate with broad lumen. Halter infuscated.

Abdomen: Blackish, cerci paler. Spermathecae (fig. 20, *m*) two plus rudimentary third and sclerotized ring; functional ones subspherical to ovoid with short slender necks; unequal, measuring 0.063 by 0.049 mm. and 0.052 by 0.041 mm.

Male Genitalia (fig. 20, *o*).—Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum rounded distally, with small, widely separated, apicolateral processes, caudal margin between them transverse. Basistyle with strong spinose setae on mesal margin, ventral and dorsal roots short; dististyle curved, with slender, bluntly rounded tip. Aedeagus with basal arch short, extending to a sixth of total length, anterior margin with sclerotized thickening; distal portion with internal, anteriorly directed, sclerotized point and slender apex with round terminal papilla. Parameres (fig. 20, *p*) connected at bases by a short sclerotized loop; each with

short, stout main body and slender, ventrally directed filiform tip with apex bare (West Indies and South America) or with minute fringing hairs (Central America).

Distribution.—Florida, Mexico, Central America, South America south to Brazil and Argentina, West Indies, Trinidad.

Types.—Lectotype, male, of *insignis* (designated by Wirth and Blanton, *1956a*), from Lutz collection, locality not stated, Instituto Oswaldo Cruz collection, Rio de Janeiro, Brazil. Types of *inamollae*, holotype, female, allotype, male, and two female paratypes, Mayaguez, Puerto Rico, 7 October 1935, G. S. Tulloch, light trap (University of Puerto Rico collection). Holotype, female, of *painteri*, paratype female, Puerta Castilla, Honduras, 20, 29 April 1926, R. H. Painter (University of Puerto Rico collection).

West Indian Records.—

CAYMAN ISLANDS: Grand Cayman, Red Bay, 5 December 1969, J. E. Davies, light trap, 50 males, females.

CUBA: Guantanamo Bay, 22 February 1962, E. R. Turner, light trap, 1 male; La Victoria, Camaguey Prov., 3 July 1957, J. U. McGuire, 6 males, 8 females.

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 3 males, 3 females; same, 18 October 1966, E. L. Todd, 1 female; Clarke Hall Estate, January-March 1965, Wirth, light trap, 30 males, 15 females; Layou River mouth, 20 January 1965, Wirth, at light, 8 females.

DOMINICAN REPUBLIC: Rio Camu, 10 km. ne. Jarabacoa, 12 June 1969, Flint and Gomez, 1 female.

JAMAICA: Reading, 4 mi. e. Montego Bay, reared from larvae (Linley, *1965a*).—Bath, St. Thomas Parish, February 1937, Chapin and Blackwelder, 5 females; Bluefields and Calder Estates, Westmoreland Parish, 8 December 1969, E. G. Farnworth, light trap, 1 female; Kingston, 29 January 1937, Chapin and Blackwelder, 1 female; Mandeville, Manchester Parish, 4 April 1970, Farnworth, light trap, 2 females; Negril, Westmoreland Parish, 20 November 1968, 22 June 1970, Farnworth, light trap, 500 approx.; Runaway Bay, St. Ann Parish, February 1969, W. W. Wirth, 6 males, 11 females; Santa Cruz, 24 February 1937, Chapin and Blackwelder, 1 male, 8 females; Spanish Town, St. Catherine Parish, 3 February 1937, Chapin and Blackwelder, 1 male, 8 females; same, 28 May 1970, Farnworth, light trap, 100's; Twickenham Park, St. Catherine Parish, 28 April 1970, Farnworth, light trap, 1,000's; Worthy Park Estate, St. Catherine Parish, 17 November 1968, R. E. Woodruff, light trap, 1 female; same, March-June, 1970, Farnworth, light trap, 1,000's.

PUERTO RICO: Henry Barracks (Fox, *1952a*).—Isla Verde Int. Airport, 1958–60 (Fox and Garcia-Moll, *1961*).—Mayaguez, 7 October 1935, G. S. Tulloch (Fox and Hoffman, *1944*, types of *inamollae*).—Bosque de Luquillo, 19 January 1969, Walker and Drummond, light trap, 1 female; Camp Tortuguero, 24 June 1952, F. S. Blanton, light trap, 10 females; Caroline, 20 July 1948,

H. D. Pratt, light trap, 4 males, 6 females; Fajardo, 1 July 1952, Blanton, light trap, 2 females; Fort Buchanan, 26 June 1952, Blanton, light trap, 1 female; Guajatara, 3 July 1952, Blanton, light trap, 1 female; Henry Barracks, 21 June 1952, Blanton, light trap, 4 females; Mayaguez, 9 January 1969, Walker and Drummond, light trap, 2 females; Rio Piedras, 24 August 1961, Flint and Spangler, light trap, 1 male.

SAINT JOHN: No locality, September 1961, R. W. Williams, emergence trap, 10 males, 15 females; Cancel Bay Plantation, August 1961, Williams, emergence trap, 1 male; Rendevous Bay, August 1961, Williams, emergence trap, 1 male.

SAINT LUCIA: Castries, Fairview, 14 April 1959, R. Darsie, light trap, 1 male; Cul de Sac Rd. at MP 9, 29 July 1963, Flint and Cadet, 1 female; Gros Islet, Yacht Club light, 26 October 1967, J. B. Davies, 1 male; Union Agr. Sta., 28 July 1963, O. S. Flint, 1 female.

Discussion.—The females of *C. insignis* are readily distinguished from other members of the subgenus *Hoffmania* in the Caribbean by the wing markings, with only one pale spot in cell M1 past the pale spot straddling vein M2, a dark r-m crossvein, and a dark line following vein R4+5 into the pale spot at the tip of 2RC to the point where the vein turns abruptly forward toward the costa.

Larval Habitat.—Fox (*1952a*) first characterized this species as a cow pasture species, writing that it "occurs abundantly around cattle and breeds in their pasturelands, hence it may feed on them." He also remarked that it "breeds in pasturelands and sugarcane fields." Wirth and Blanton (*1959*) reported it as being abundant in the muddy cow pastures in Panama.

Lutz (*1913*) originally reared *C. insignis* from mangrove swamps in Brazil. Fox and Hoffman (*1944*) were presumably led in part by the supposed differences in the larval habitat of *C. inamollae* in Puerto Rican cow pastures to describe it as a distinct species. But Linley (*1965a*) and Davies (*1967*) in Jamaica reared *C. insignis* from both types of habitats and intermediate ones as well. They reared it from extremely glutinous black mud that was shaded by red and black mangroves and periodically covered by tidal sea water. They also reared it from the margins of drainage ditches, which flowed from the sugarcane fields into the mangrove swamps, and from the waterlogged clay soil of the canefields themselves.

Biting Habits.—In Trinidad (Aitken, *1957*) and in Jamaica (Davies, *1967*) *C. insignis* is essentially a zoophilic species, biting man occasionally but not in sufficient numbers to be a nuisance.

Culicoides jamaicensis Edwards

(Figs. 4, 21, and 30)

Culicoides loughnani var. *jamaicensis* Edwards, 1922, p. 165 (female; Jamaica; fig. wing).—Hoffman, 1925, p. 283 (Panama).—Barbosa, 1947, p. 21 (Jamaica, Saint Croix; fig. male genitalia).

Culicoides loughnani jamaicensis Edwards.—Fox, 1949, p. 32 (Puerto Rico; fig. palpus, mesonotum, male genitalia).—Fox and Kohler, 1950, p. 342 (Puerto Rico).—Kohler and Fox, 1951, p. 113 (Puerto Rico).—Fox, 1952a, p. 888 (Puerto Rico).—Fox and Maldonado, 1953, p. 165 (Puerto Rico).

Culicoides jamaicensis Edwards.—Wirth, 1955, p. 112 (Guatemala; fig. male genitalia).—Wirth and Blanton, 1959, p. 339 (redescribed; Panama distribution; illus.).—Wirth and Hubert, 1960, p. 649 (Bahamas, Mexico; fig. wing).

Female.—Wing length 0.97 mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 21, *a*) with lengths of flagellar segments in proportion of 16–10–11–12–12–13–14–14–20–21–21–22–30; AR 1.21; sensory pattern 3–15. Palpal segments (fig. 21, *b*) with lengths in proportion of 10–20–37–10–10; PR 2.2; third segment large and swollen to apex, with a large, deep sensory pit opening by a small distal pore. Proboscis long, P/H ratio 0.95; mandible with 15 teeth.

Thorax: Dark brown; mesonotum (fig. 21, *e*) dark pruinose gray, with three broad dark-brown bands bordered by conspicuous narrow whitish lines. Legs dark brown; femora pale at bases, femora with subapical and tibiae with subbasal, narrow pale rings; tibial comb (fig. 21, *d*) with four spines, the second from spur longest.

Wing (fig. 21, *c*; 30, *d*): Pattern as figured; 2RC dark to tip; pale spot over r-m crossvein small; cell R5 with four pale spots arranged in a rhomboid, the proximal and distal pairs each sometimes fused into oblique double spots, the anterior

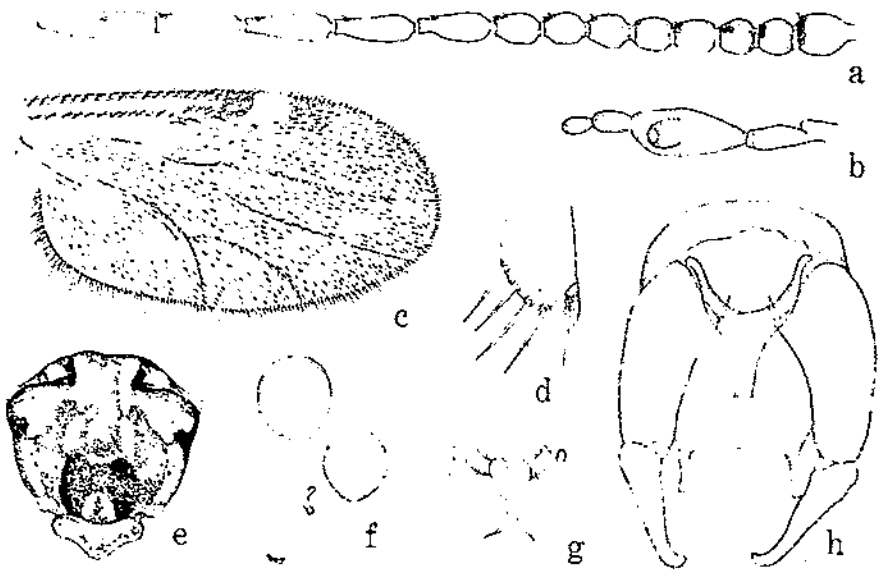

FIGURE 21.—*Culicoides jamaicensis:* *a*, Female antenna; *b*, female palpus; *c*, female wing; *d*, tibial comb; *e*, thoracic pattern; *f*, spermathecae; *g*, male parameres; *h*, male genitalia, parameres removed.

portions of which lie at anterior wing margin; small double pale spots present straddling base of vein M1 and midportion of vein M2; one pale spot in distal portion of cell M1, far from wing margin; cell M2 with pale spot near basal arculus, one lying in front of mediocubital fork, and one far from wing margin in apex of cell; cell M4 with large pale spot broadest along posterior margin of vein M3+4; anal cell with one pale spot near base and two in distal portion; a pale spot straddling midportion of mediocubital stem; pale spots at wing margin at apices of veins M1, M2, and M3+4. Macrotrichia long and numerous, covering entire wing; CR 0.57. Halter pale.

Abdomen: Dark brown. Spermatheeae (fig. 21, *f*) two plus rudimentary third and sclerotized ring; functional ones oval without sclerotized necks; unequal, measuring 0.046 by 0.037 mm. and 0.037 by 0.031 mm.

Male Genitalia (fig. 21, *h*).—Ninth sternum with scarcely perceptible caudomedian excavation, ventral membrane not spiculate; ninth tergum tapered, with extremely long and slender apicolateral processes. Basistyle with ventral and dorsal roots short and slender; dististyle short and tapered to slender, hooked apex. Aedeagus with rounded basal arch extending to nearly half of total length, basal arms stout and curved; distal portion stout and tapered to rather broad, truncated tip. Parameres (fig. 21, *g*) separate; each with stout basolateral arm; stem short, swollen bulbously at base, tapering rapidly to slender simple tip abruptly bent ventrolaterad.

Distribution.—Mexico to Panama, Venezuela, Bahamas, Greater Antilles, Trinidad (fig. 4).

Types.—Syntypes, 2 females, Kingston, Jamaica, W. F. M. Loughnan (British Museum (Nat. Hist.), London).

West Indian Records.—

BAHAMAS: Rum Cay near Port Nelson, 16 March 1953, E. B. Hayden, 1 male (AMNH) (Wirth and Hubert, *1960*).—South Bimini, June 1951, M. Cazier and C. Vaurie, 1 male, 1 female (AMNH).

CUBA: Guantanamo Bay, September 1964, U.S. Navy, light trap, 1 male, 4 females.

JAMAICA: Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 10 females; Caymans Estate, St. Catherine Parish, 17 November 1968, S. A. Apegi, light trap, 1 male, 1 female; Gordon Town, St. Andrew Parish, 1 February 1937, Chapin and Blackwelder, 1 female; Negril, Westmoreland Parish, 20 November 1968, R. E. Woodruff, light trap, 1 male, 1 female; Troy, Manchester Parish, 16 February 1937, Chapin and Blackwelder, 1 female; Twickenham Park, St. Catherine Parish, 26 March 1970, Farnworth, light trap, 1 female; Worthy Park Estate, St. Catherine Parish, 17 November 1968, Woodruff, light trap, 1 female.

PUERTO RICO: Henry Barracks (Fox and Kohler, *1950;* Kohler and Fox, *1951;* Fox, *1952a;* Fox and Maldonado, *1953*).—Sabana Seca,

22 August 1948, I. Fox, light trap, 1 male, 1 female (Fox, *1949*).—Amelia, Juana Diaz, 4–10 May 1949, I. Fox, light trap, 3 males, 3 females; Guanico, 22 June 1952, F. S. Blanton, light trap, 18 females; Losey Field, 23 June 1952, Blanton, light trap, 1 female; Salinas, 20 June 1952, Blanton, light trap, 2 females.

Discussion.—*C. jamaicensis* belongs to the *C. copiosus* group of the subgenus *Drymodesmyia*, which was revised by Wirth and Hubert (*1960*). This group consists of small species with hairy wings, the wing pattern usually characterized by pale spots straddling the midportions of veins M1 and M2, and the female palpus with the third segment greatly swollen and bearing a deep sensory pit usually opening by a smaller pore. The species within this group are most readily distinguished by details of the wing pattern in cell R5 and the anal cell and by the shape of the spermatheeae.

Larval Habitat.—Most of the species of *Drymodesmyia* breed in rotting stems of various species of cacti in Mexico and the Southwestern United States, where the most speciation has occurred. *C. jamaicensis* is atypical in its habits, not having been found in cacti. Hoffman (*1925*) reported that it was reared from a rotting calabash (fruit of *Crescentia cujete* L.) in Panama. Wirth and Hubert (*1960*) reported a rearing from the stem of decaying papaya in Mexico, and Williams (*1964*) reared it from a decaying calabash in Trinidad.

Biting Habits.—Unknown.

Culicoides loughnani Edwards

(Figs. 4, 22, and 30)

Culicoides loughnani Edwards, 1922, p. 165 (female; Jamaica; fig. wing).—Beck, 1952, p. 104 (male; Florida).—Foote and Pratt, 1954, p. 26 (redescribed; distribution; illus.).—Jones and Wirth, 1958, p. 89 (Texas).—Wirth and Hubert, 1960, p. 649 (redescribed; distribution; illus.).—Jones, 1962, p. 721 (Texas; in cacti).—Dyce, 1969, p. 644 (redescribed; Australia; biology, in cacti).

Female.—Wing length 1.21 mm.

Head: Eyes (fig. 22, *d*) moderately separated, bare. Antenna (fig. 22, *a*) with lengths of flagellar segments in proportion of 20–14–16–16–17–17–17–17–27–29–30–32–38; AR 1.17; sensory pattern 3–15. Palpal segments (fig. 22, *c*) with lengths in proportion of 10–24–46–12–13; PR 2.4; third segment moderately swollen to tip, with deep sensory pit tapering to slightly smaller pore. Proboscis moderately long, P/H ratio 0.98; mandible with 16 teeth.

Thorax: Dark brown, almost blackish; mesonotum with three dark longitudinal vittae separated by narrow whitish lines. Legs (fig. 22, *f*) pale; knee spots and tip of hind tibia prominently blackish; narrow pale rings subapically on all femora and subbasally on all tibiae, femora slightly infuscated in broad median portions; tibial comb with four spines, second from spur longest.

Wing (fig. 22, *b*; 30, *e*): Pattern as figured; two very dark anterior spots, one over 2RC and second at middle of anterior margin of cell

R5; pale markings extensive and interconnected; veins M1, M2, and M3+4 all pale margined nearly to bases, apex of vein Cu1 dark; distal pale spot in cell R5 double, broadly extending to anterior wing margin; pale spot in distal portion of cell M2 reaching wing margin but distal pale spot in cell M1 not; distal pale spot in anal cell double due to fusion of two spots, continuous with pale area at base of cell. Macrotrichia long and numerous, extending to base of wing; CR 0.55; 2RC short and broad, with distinct lumen. Halter pale.

Abdomen: Pale yellowish above. Spermatheeae (fig. 22, *e*) two plus rudimentary third and sclerotized ring; elongate saclike, slightly unequal, measuring 0.076 by 0.032 mm. and 0.069 by 0.021 mm., openings to ducts wide, necks not present.

Male Genitalia (fig. 22, *h*).—Ninth sternum without caudomedian excavation, ventral membrane not spiculate; ninth tergum with apicolateral processes long and slender, tapering to pointed tips. Basistyle with ventral root slender, dorsal root longer and blunt; dististyle nearly straight basally, tapering to slender, slightly hooked tip. Aedeagus with basal arch extending to 0.4 of total length, basal arms short and straight; distal portion stout, gradually tapering to broad, truncated tip. Parameres (fig. 22, *g*) separate; each with short, stout, basolateral arm; stem swollen for a short distance at base, tapering in straight midportion, twisted lateroventrally

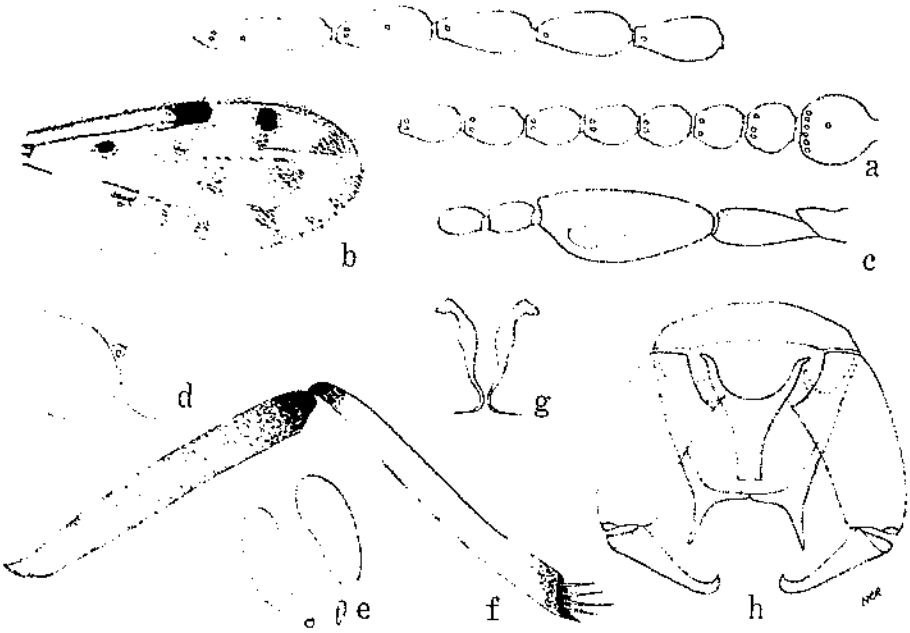

FIGURE 22.—*Culicoides loughnani: a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, female eye separation; *e*, spermatheeae; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

distad with slender, simple tip.

Distribution.—Bahamas, Cuba, Florida, Jamaica, Texas; Australia (introduced accidentally) (fig. 4).

Types.—Two syntype females, Kingston, Jamaica, Major W. F. M. Loughnan (British Museum (Nat. Hist.), London).

West Indian Records.—

BAHAMAS: Great Harbour Cay, Airport Well, 22 December 1968, G. M. Stokes, light trap, 1 female.

CUBA: Guantanamo Bay, 21 February 1962, E. R. Turner, light trap, 1 female; same, September 1964, U.S. Navy, light trap, 1 male, 1 female; same, 8–19 February 1965, U.S. Navy, light trap, 3 males, 1 female.

JAMAICA: Kingston, W. F. M. Loughnan, 2 females (Edwards, *1922*, syntypes).—No locality, December 1933, Dr. Kumm, 1 female (Fox, *1946*).—Hardwar Gap, Hollywell Forest Camp, Portland Parish, 16 June 1970, E. G. Farnworth, light trap, 1 female; Milk River Bath, Clarendon Parish, 19 November 1968, R. E. Woodruff, light trap, 1 female; Palisadoes, 15 June 1963, E. F. Legner, emerged from decaying barrel cactus, 6 males.

Discussion.—This species is easily recognized by the very extensive pale markings on the wings and legs and by the characteristic elongate, saclike spermathecae. The Saint Croix record published by Wirth and Hubert (*1960*) was in error; the specimen in the USNM is a male of *C. jamaicensis* Edwards.

Larval Habitat.—Jones (*1962*) reared *C. loughnani* from rotting cacti in Texas. Dyce (*1969*) reared this species from rotting stems of *Opuntia* in Australia and concluded that it was introduced into that country from the Americas with cacti infected with rot organisms during the program for biological control of the prickly pear.

Biting Habits.—Edwards (*1922*) reported that according to Major Loughnan this species was common in Jamaica, biting all through the afternoon, being most active toward sunset. Dyce (*1969*) failed to get reared females to feed on the arm of man in the laboratory.

Culicoides melleus (Coquillett)

(Figs. 5, 23, and 30)

Ceratopogon melleus Coquillett, 1901, p. 604 (female; Florida).

Culicoides melleus (Coquillett).—Kieffer, 1906, p. 54 (combination).—Hoffman, 1925, p. 278 (female; Maryland).—Wirth, 1952b, p. 94 (larva, pupa; Florida; illus.).—Foote and Pratt, 1954, p. 27 (redescribed; distribution; illus.).—Jamnback et al., 1958, p. 64 (New York; biology and control; illus.; larva, pupa).—Jamnback and Wall 1959, p. 85 (New York; larval habits).—Jones, 1961b, p. 735 (pupa; illus.).—Jamnback, 1965, p. 79 (redescribed, all stages; New York; illus.).—Linley, 1969, p. 709 (habits; Florida).—Linley and Adams, 1971, p. 427 (spermatophore formation).

Female.—Wing length 1.05 mm.

Head: Eyes (fig. 23, *d*) narrowly separated, bare. Antenna (fig. 23, *a*) with lengths of flagellar segments in proportion of 25–20–20–20–20–20–20–20–30–30–33–38–50; AR 1.10; sensory pattern 3,10–14. Palpal segments (fig. 23, *c*) with lengths in proportion of 12–25–44–18–15; PR 2.7;

third segment short and only slightly swollen, palpal pit absent, sensilla scattered on surface of segment. Proboscis short, P/H ratio 0.63; mandible with 12 teeth.

Thorax: Uniformly pale yellowish, in dry specimens with pale grayish pollinosity. Legs (fig. 23, *f*) pale straw yellowish; tibial comb with four spines, second from spur longest.

Wing (fig. 23, *b*; 30, *j*): Pale yellowish gray, without markings. Macrotrichia moderately numerous, well distributed, extending nearly to base of anal cell; CR 0.60; 2RC short with narrow lumen. Halter pale.

Abdomen: Pale yellowish. Spermathecae (fig. 23, *e*) two plus rudimentary third, sclerotized ring absent; spermathecae highly sclerotized, dark brown, short ovoid with short slender necks; subequal, each measuring 0.065 by 0.050 mm.

Male Genitalia (fig. 23, *h*).—Ninth sternum narrow, with moderately broad and deep caudomedian excavation, ventral membrane not spiculate; ninth tergum short, subapically narrowed, apicolateral processes greatly enlarged, divergent, protruding caudolaterad as a pair of prominent, bluntly rounded, digitiform lobes, the caudal margin between them transverse. Basistyle with ventral and dorsal roots short, simple, and pointed; dististyle swollen at extreme base, abruptly

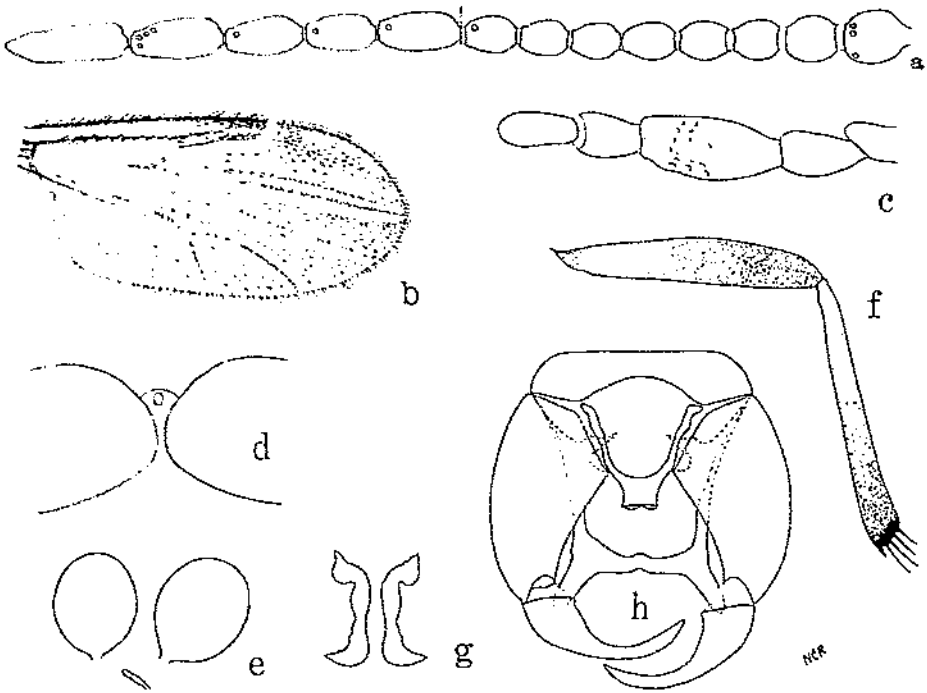

FIGURE 23.—*Culicoides melleus*: *a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, female eye separation; *e*, spermathecae; *f*, hind femur and tibia; *g*, male parameres; *h*, male genitalia, parameres removed.

narrowed at midlength and markedly curving to slender, pointed tip. Aedeagus with basal arch extending to two-thirds of total length, basal arms slender, nearly straight; distal portion broad and stout, broader than long, with truncated tip bent ventrally. Parameres (fig. 23, *g*) separate, short and stout; each with large basal knob bearing a distinct anterior process, stem stout, nearly straight, parallel sided, tip slightly expanded and abruptly bent ventrolaterad in a short, sharp point.

Distribution.—Bahamas, United States (Atlantic and Gulf coasts from Maine to Louisiana) (fig. 5).

Type.—Holotype, female, Lake Worth, Fla., Mrs. A. T. Slosson (USNM 5474).

West Indian Records.—

BAHAMAS: Abaco I., Marsh Harbour, 13 April 1968, G. M. Stokes, light trap, 10 females; Andros I., October 1967, Stokes, light trap, 5 females; Andros I., Driggs Hill near South Bight, 27 April 1953, Hayden and Giovannoli, 1 female (AMNH); Grand Cay, 22 January 1969, Stokes, light trap, 1 female; Great Harbour Cay, 22 December 1968, Stokes, light trap, 4 males; North Bimini, Alice Town, 4 February 1968, Stokes, light trap, 2 females; North Bimini, April, December 1968, Stokes, light trap, 1 male, 32 females; North Bimini, Paradise Point, 30 November 1968, Stokes, light trap, 2 females; Rum Cay near Port Nelson, 16 March 1953, Hayden, 1 female (AMNH); South Bimini, June 1951, M. Cazier, C. and P. Vaurie, 2 females (AMNH).

Discussion.—This species takes its name from its uniformly honey-colored appearance, which resembles no other West Indian species. *C. floridensis* is a similarly pale yellow, unmarked species but can be distinguished by its shinier mesonotum, slender body, almost complete lack of macrotrichia on the wings, pale spermathecae, slender palpus with a definite round pit, and less massive development of the male genitalia.

Larval Habitat.—Jamnback and Wall (*1959*) and Jamnback (*1965*) found *C. melleus* on Long Island, N.Y., breeding in intertidal sand, usually on beaches in bays or inlets where the larvae were not exposed to prolonged or heavy wave action. Goulding et al. (*1958*) reported this same habitat in Florida.

Biting Habits.—*C. melleus* is a serious biting pest of man on sandy beaches from New England to Florida and the Bahamas (Beck, *1952;* Goulding et al., *1958;* Foote and Pratt, *1954;* Jamnback et al., *1958;* Jamnback, *1965;* and Wall and Doane, *1965*).

Biological Notes.—Linley (*1969*) reported that in Florida *C. melleus* is autogenous. This species mates soon after emergence from the pupa, without the need for flight or swarm formation. Wirth (personal observation, *1951*) observed mating pairs of *C. melleus* running around on algae-covered rocks at the mouth of the Boynton Canal near Lake Worth, Fla. Linley and Adams (*1971*) found that the male of *C. melleus* transfers sperm by means of a spermatophore that lies held in his genitalia, with a long neck protruding into the

common spermatheeal duct of the female.

Culicoides panamensis Barbosa

(Figs. 4, 24, and 30)

Culicoides panamensis Barbosa, 1947, p. 22 (male, female; Panama; fig. palpus, male genitalia).—Wirth, 1955, p. 114 (notes: Guatemala; fig. palpus, male genitalia; synonym: *alambiculorum*).—Wirth and Blanton, 1959, p. 334 (redescribed; Panama distribution; illus.).

Culicoides alambiculorum Macfie, 1948, p. 81 (female; Mexico; fig. wing).

Female.—Wing length 0.87 mm. Head: Eyes narrowly separated, bare. Antenna (fig. 24, *a*) with lengths of flagellar segments in pro-

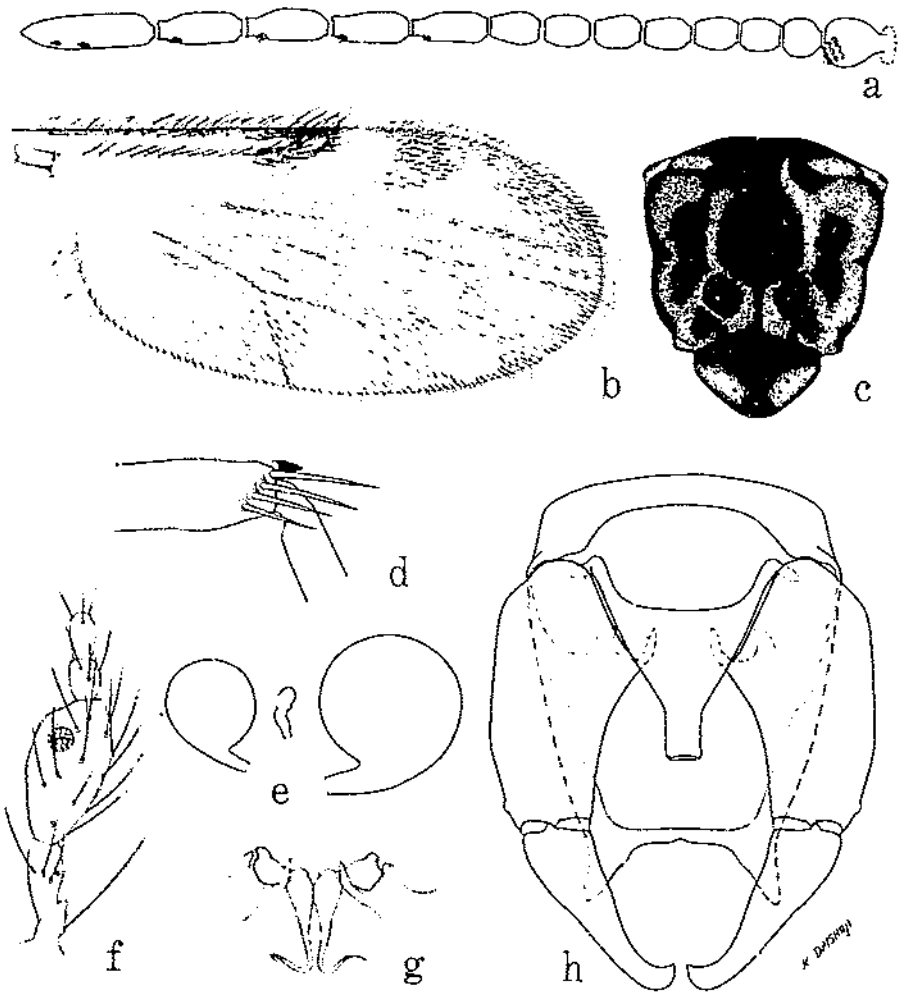

FIGURE 24.—*Culicoides panamensis:* *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e* spermatheeae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

portion of 16–10–10–11–11–11–11–12–18–18–19–20–28; AR 1.12; sensory pattern 3,11–15. Palpal segments (fig. 24, *f*) with lengths in proportion of 7–12–30–10–10; PR 2.0; third segment greatly swollen, with a deep, large pit opening through a small pore. Proboscis moderately long, P/H ratio 0.75; mandible with 10 nearly vestigial teeth.

Thorax: Dark brown; mesonotum (fig. 24, *c*) grayish-brown pruinose with three dark-brown longitudinal bands. Legs dark brown; fore femur and midfemur with subapical and all tibiae with subbasal, narrow pale rings; tibial comb (fig. 24, *d*) with four spines, the one nearest the spur longest.

Wing (fig. 24, *b*; 30, *c*): Pattern as figured; 2RC dark to tip; pale spot over r-m crossvein small; poststigmatic pale spot in cell R5 extending slightly caudad behind 2RC; distal pale spot in cell R5 rounded, not meeting wing margin; vein M1 with small pale spot straddling it near its base, sometimes this spot reduced to anterior portion lying on anterior side of vein; cell M1 with one pale spot in distal portion not reaching wing margin; pale spot straddling midportion of vein M2; cell M2 with pale area in base forming pale spots behind medial fork and in front of mediocubital fork, and one pale spot in distal portion of cell at wing margin; cell M4 with large pale spot across midportion; anal cell with pale area at base and one pale spot in distal portion; apices of veins M1, M2, M3+4, and Cu1 dark. Macrotrichia long and abundant, extending nearly to base of wing; CR 0.55. Halter pale.

Abdomen: Brownish. Spermathecae (fig. 24, *e*) two plus rudimentary third and sclerotized ring; functional ones retort shaped, unequal, measuring 0.048 by 0.046 mm. and 0.035 by 0.028 mm., the necks oblique and relatively long.

Male Genitalia (fig. 24, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering with long, stout, slightly flaring, apicolateral processes. Basistyle with ventral root slender and simple, dorsal root short and stout; dististyle short with stout base and hooked tip. Aedeagus stocky, with basal arch extending to only a fourth of total length; basal arms nearly straight; distal portion tapering to moderately slender, simple process with truncated tip. Parameres (fig. 24, *g*) separate, small and slender; each with large laterally directed basal knob, base of straight portion of stem bulbously swollen, gradually narrowed to simple, filiform, ventrally bent tip.

Distribution.—Cayman Islands, Costa Rica, Cuba, El Salvador, Guatemala, Jamaica, Mexico, Panama (fig. 4).

Type.—Holotype, male, Barro Colorado Island, C.Z., from flowers of *Heliconia mariae* (USNM 54360).

West Indian Records.—

CAYMAN ISLANDS: Grand Cayman, June 1970, J. E. Davies, 1 female.

CUBA: Guantanamo Bay, 21 February 1962, E. R. Turner, light trap, 1 female.

JAMAICA: Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 1 female; Hardwar Gap, Inst. Jamaica cabin, Portland Parish, 20 February 1969, W. W. Wirth, light trap, 1 male, 7 females; 2 mi. w. Manchioneal, Green Hills, Portland Parish, 24 November 1968, R. E. Woodruff, light trap, 10 females.

Discussion.—This species has a wing pattern similar to that of its relative, *C. jamaicensis*, but it has only one pale spot in the distal portion of the anal cell and the pale spot typically straddling the base of vein M1 has present only the portion lying on the anterior side of the vein; the retort-shaped spermathecae are quite distinctive.

Larval Habitat.—Wirth and Blanton (*1959*) reported a rearing by J. Zetek in Panama from flowers of *Heliconia mariae* Hooker-F., the beefsteak *Heliconia*.

Biting Habits.—Wirth (*1955*) reported this species feeding on horses and mules in Guatemala.

Culicoides paraensis (Goeldi)

(Figs. 25 and 30)

Haematomyidium paraenses Goeldi, 1905, p. 137 (female; Brazil; fig. female, wing).

Culicoides paraensis (Goeldi).—Lutz, 1913, p. 55 (male, female; Brazil; fig. wing; combination).—Floch and Abonnenc, 1942, p. 4 (French Guiana; illus. wing).—Barretto, 1944, p. 92 (male; Brazil; fig. wing, genitalia).—Ortiz, 1951a, p. 574 (redescribed; Venezuela; illus).—Tucker, 1952, p. 349 (Barbados).—Fox, 1955a, p. 250 (synonymy).—Wirth and Blanton, 1959, p. 440 (redescribed; Panama; illus.).

Culicoides undecimpunctatus Kieffer, 1917, p. 307 (female; Argentina).

Female.—Wing length 0.78 mm.

Head: Eyes broadly separated, bare. Antenna (fig. 25, *a*) with lengths of flagellar segments in proportion of 15–11–12–14–14–14–14–15–15–16–16–16–25; AR 0.77; sensory pattern 3,8–10. Palpal segments (fig. 25, *f*) with lengths in proportion of 8–17–20–7–10; PR 2.1; third segment slightly swollen with small, deep sensory pit. Proboscis moderately long, P/H ratio 0.82; mandible with 14 teeth.

Thorax: Dark brown; mesonotum (fig. 25, *c*) with dark grayish pollinosity, three somewhat prominent, longitudinal vittae anteriorly, the lateral ones widening at sutural level. Legs dark brown; fore femur and midfemur with subapical, all tibiae with subbasal, and hind tibia with apical, narrow, pale rings; tibial comb (fig. 25, *d*) with four spines, the second from the spur longest.

Wing (fig. 25, *b*): Pattern as figured; 2RC dark; pale spot over r-m crossvein narrow, extending to costal margin; cell R5 with four small round pale spots, the two poststigmatic pale spots well separated, the posterior one located slightly proximad of the other, the third spot larger and located subapically in cell, the fourth small and located at extreme apex; cell M1 with three small pale spots; cell M2 with pale spot at basal arculus, a pale spot lying behind medial fork and one in front of mediocubital fork, and one spot in distal part of cell, lying at wing margin; cell M4 with small round pale spot near wing

margin; anal cell with one pale spot in distal portion; apices of veins M1, M2, M3+4, and Cu1 dark. Macrotrichia sparse on distal half of wing, a few in base of cell M2 and in anal cell; CR 0.59; 2RC with distinct lumen. Halter pale, base of knob brownish.

Abdomen: Dark brown. Spermathecae (fig. 25, *e*) two with rudimentary third and sclerotized ring; functional ones ovoid with long

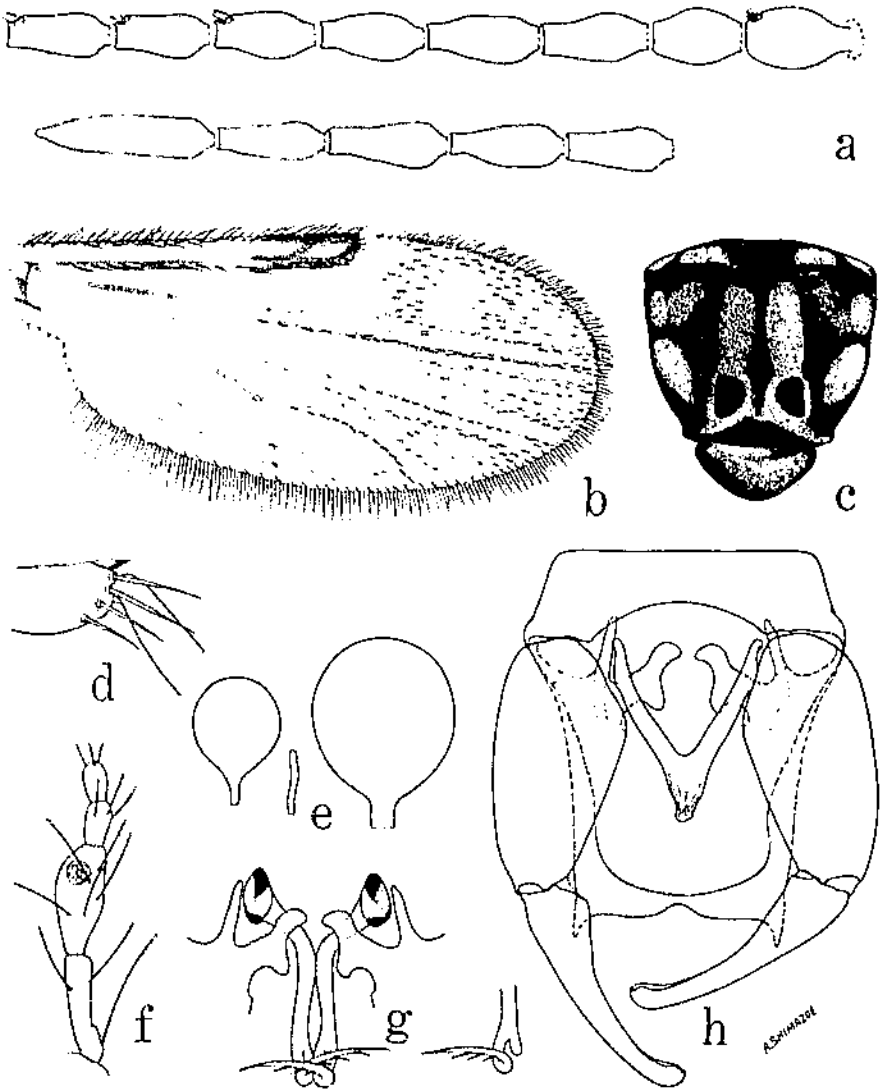

FIGURE 25.—*Culicoides paracensis*: *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermathecae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

slender necks; unequal, measuring 0.057 by 0.037 mm. and 0.048 by 0.029 mm.

Male Genitalia (fig. 25, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering with short, pointed, widely separated, apicolateral processes. Basistyle with ventral root "foot-shaped," ankle slender and posterior heel well developed, dorsal root slender; dististyle slender and curved with bent tip. Aedeagus V-shaped, basal arch extending to two-thirds of total length, basal arms nearly straight; distal portion with simple rounded tip. Parameres (fig. 25, *g*) separate; each with large basal knob; stem slender, bent at some distance from base, midportion straight with a well-developed ventral lobe, distal portion abruptly bent and tapered to a fine point with lateral fringe of fine spines.

Distribution.—Widely distributed in Eastern United States, Mexico, Central America, South America south to Argentina and Bolivia; West Indies (Grenada).

Types.—Syntypes, Belém, Pará, Brazil, E. Goeldi (according to Goeldi (*1905, p. 139*), syntypes were deposited in the British Museum (Nat. Hist.), London).

West Indian Records.—

GRENADA: Boulogne Estate, 8 December 1968, P. Bacon, biting man on cocoa propagating station, 50 females; Greenville, 14 December 1941, E. M. McCallan, biting man, 14 females.

Discussion.—*C. paraensis* is nearly identical to *C. debilipalpis*, except for the presence of the additional pale spots near the wing margin in the apices of cells R5 and M1, the pale spot present anterior to the mediocubital fork, and small differences in the proportions of the third palpal segment and the shape of the sensory pit. The two species share the tree hole habitat and much of the same geographic range.

Larval Habitat.—Snow et al. (*1957*) and Smith (*1965*) found this species breeding in tree hole debris in Florida and Tennessee, Breeland (*1960*) reared it from tree hole debris in Panama, and Williams (*1964*) reared it from rotting cacao pods and a rotting calabash in Trinidad.

Biting Habits.—This species was reported biting man in Panama (Woke, *1954;* Wirth and Blanton, *1959*), Guatemala (Wirth, *1955*), Brazil (Lutz, *1918;* Forattini, *1957*), and Argentina (Romaña and Wygodzinsky, *1950*). Snow et al. (*1957, 1958*) and Hair and Turner (*1968*) reported it as a troublesome, biting pest of man in the Southeastern United States. It is a forest species with daytime biting habits.

Culicoides phlebotomus (Williston)

(Figs. 5 and 26)

Ceratopogon phlebotomus Williston, 1896, p. 281 (female; Saint Vincent; fig. wing, palpus).

Culicoides phlebotomus (Williston).—Kieffer, 1906, p. 55 (combination).—Hoffman, 1925, p. 285 (female; Puerto Rico; fig. wing).—Painter, 1927, p. 253 (Honduras; biology).—Ciferri, 1929,

p. 520 (Dominican Republic).—Fox, 1942, p. 419 (pupa; Virgin Islands; illus.).—Ortiz and Mirsa, 1952, p. 275 (redescribed; Venezuela; illus.).—Wirth and Blanton, 1953, p. 114 (redescribed; illus.; synonym: *amazonius*).—Forattini, 1957, p. 455 (redescribed; illus.).—Wirth and Blanton, 1959, p. 469 (redescribed; Panama distribution; illus.).—Fox and Garcia-Moll, 1961, p. 120 (Puerto Rico).

Culicoides amazonius Macfie, 1935, p. 52 (male, female; Brazil; fig. male genitalia).

Female.—Wing length 1.03 mm. Head: Eyes contiguous, bare. Antenna (fig. 26, *a*) with lengths of flagellar segments in proportion of 16–11–11–12–12–11–11–11–16–18–20–21–38; AR 1.19; sensory pattern

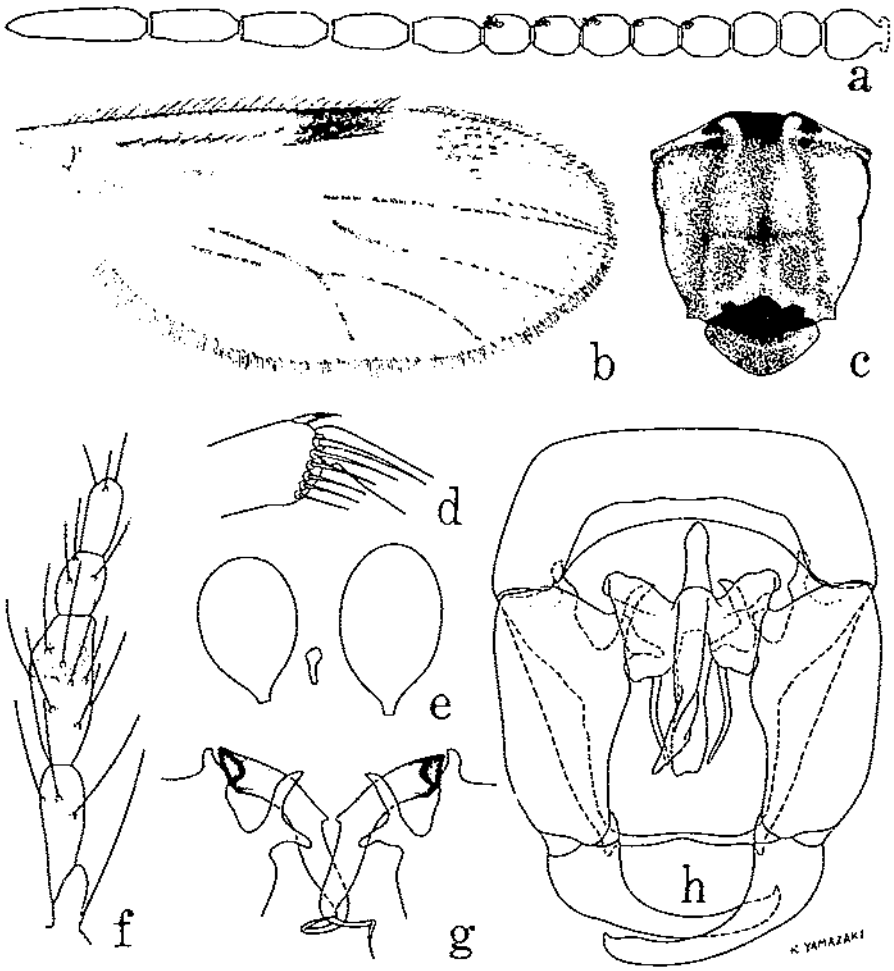

FIGURE 26.—*Culicoides phlebotomus: a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermathecae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

3,6–10. Palpal segments (fig. 26, *f*) with lengths in proportion of 13–24–26–10–13; PR 2.2; third segment slightly swollen, short, with a large, irregular, open sensory area.

Thorax: Dark brown with dense grayish pollen; mesonotum (fig. 26, *c*) densely grayish, blue-green pollinose, without prominent pattern. Legs yellowish brown, without distinctive bands; tibial comb (fig. 26, *d*) with seven spines, the one nearest the spur longest; fourth tarsomeres cordiform.

Wing (fig. 26, *b*): Pattern as figured; color smoky brownish with distinct white spots; 2RC blackish, veins surrounding it greatly thickened, cell itself with narrow lumen; cell R5 with four pale spots, three forming a triangle in poststigmatic area, the distal fourth spot large and usually broadly attaining anterior wing margin; one pale spot in cell M1 located far from wing margin, pale spot present straddling midportion of vein M2; cell M2 with one distal pale spot located far from wing margin; cell M4 with small round pale spot in center of cell; anal cell with one pale spot in distal portion and a pale streak near base; cell M2 with pale spot lying behind medial fork and one lying in front of mediocubital fork; a pale spot lying just distad of basal arculus in cell M2, and one lying over base of mediocubital stem. Macrotrichia sparse on distal fourth of wing; CR 0.55. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 26, *e*) two plus rudimentary third and sclerotized ring; functional ones ovoid with short necks; unequal, measuring 0.058 by 0.043 mm. and 0.048 by 0.041 mm.

Male Genitalia (fig. 26, *h*).—Ninth sternum with broad, moderately deep caudomedian excavation, ventral membrane not spiculate; ninth tergum broad, short, and tapering to small apicolateral processes. Basistyle with ventral root "foot-shaped," with narrow ankle and heel nearly as long as the anterior toe, dorsal root slender; dististyle greatly curved from near base with slender pointed tip. Aedeagus with a stout transverse bridge bearing a posteroventral, curved, pointed hook from midportion; a long, nearly straight, dorsal, rodlike process passing dorsal side of midportion of basal bridge, the pointed anterior end extending well proximad of the bridge, the broad, rounded, flattened, posterior end only slightly longer than the anterior hook. Parameres (fig. 26, *g*) separate; each with large, laterally directed, basal knob, main body nearly straight with a small, pointed tubercle on mesal side near base; gradually tapered and distally curved ventrad in a filiform simple tip.

Distribution. — Widespread on coastal beaches in Neotropical Region from Mexico to Ecuador and Brazil, throughout West Indies (fig. 5).

Types.—Four female syntypes of *C. phlebotomus*, Saint Vincent (British Museum (Nat. Hist.), London). Syntypes of *amazonius*, 12 males, 82 females, Tutoia, Brazil, Dr. E. M. Lourie (also in British Museum).

West Indian Records.—

ANTIGUA: Halfmoon Bay, 30 September 1965, R. Martinez, biting man, 4 females; Jolly Beach Hotel, 2 November 1967, J. B. Davies, biting man, 2 females.

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 3 females; Calibishie, 27 February 1965, Wirth, seashore, 1 female; Clarke Hall, January-February 1965, Wirth, light trap, 2 females; Grande Savane, 20 March 1965, Wirth, lagoon margin, 4 females; Layou River mouth, 6 February 1965, Wirth, reared, tidal lagoon, 20 males, 20 females; Macoucheri, 14 February 1965, Wirth, seashore, 1 female; Mero, 14 January 1965, Wirth, seashore, 4 females.

JAMAICA: Negril, Westmoreland Parish, 20 November 1968, R. E. Woodruff, light trap, 1 male, 1 female; same, 22 June 1970, E. G. Farnworth, light trap, 1 female.

PUERTO RICO: Fort Buchanan, May 1951, I. Fox, 1 female; Isla Verde Int. Airport, 1958–60 (Fox and Garcia-Moll, *1961*).—Mameyes, 11 November 1922, G. N. Wolcott, biting man at beach (Hoffman, *1925*).—Pt. Cangrejos, on beach (Wolcott, *1951*).—Guanica, 22 June 1952, F. S. Blanton, light trap, 10 females; Las Palmas, 20 March 1970, G. M. Stokes, light trap, 1 female.

SAINT CROIX: Cotton Valley, 8 September 1937, W. A Hoffman and H. A. Beatty, several females, pupae (Fox, *1942*; Fox, *1946*).

SAINT JOHN: No locality, November 1959, R. W. Williams, emergence trap, 9 males, 6 females; Cancel Bay Plantation, 7 September 1961, Williams, emergence trap, 1 female; Francis Bay, 25 March 1957, J. F. G. Clarke, at light, 1 male, 1 female; Lameshur Bay, 15–18 September 1961, Williams, emergence trap, 1 female; Trunk Bay, September-October 1961, Williams, light trap, 1 male, 2 females.

SAINT LUCIA: Gros Islet, 27 October 1967, J. B. Davies, 1 male; Reduit Beach, 16 July 1964, R. Martinez, biting man, 2 females.

SAINT VINCENT: No locality, type series (Williston, *1896*).

Discussion.—The cordiform fourth tarsomeres and the peculiar structure of the male aedeagus place *C. phlebotomus* in the subgenus *Macfiella*. The Panama species *C. willistoni* Wirth and Blanton is similar but can be distinguished by its mesonotal pattern of small brown punctiform dots.

Larval Habitat.—Painter (*1927*) reared this species from wet low depressions behind a sandy beach in Honduras, receiving sea water by seepage at high tide. Williams (*1964*) reared it in Trinidad from the sandy margin of tidal streams, open to the sun, with little or no vegetation. We reared it at Fort Kobbe, Panama, from the sandy margin of a lagoon just back of the beach, and the *Dominica* specimens from Grande Savane and the Layou River mouth came from just such a habitat.

Biting Habits.—Williston (*1896*) recorded the notes of H. H. Smith, who collected the type series on Saint Vincent: "This is the common 'sand-fly' about the southern end of the island, but is not very trouble-

some. Bites late in the afternoon, before sunset; sometimes during the heat of the day". Wolcott (*1951*) noted that this species is called "las plagas o jején" in Puerto Rico. It was taken frequently biting man on the sand beaches in Trinidad. Adamson (*1930*) reported that in Trinidad on most sea beaches, including some of the best for bathing, this species bites viciously at almost any hour of the day except when sufficient wind makes it inactive.

Culicoides pusillus Lutz (Figs. 27 and 30)

Culicoides pusillus Lutz, 1913, p. 52 (male, female; Brazil; fig. wing).—Macfie, 1938, p. 165 (Trinidad; fig. male genitalia).—Barbosa, 1947, p. 25 (Panama, Jamaica).—Ortiz and Mirsa, 1951, p. 603 (redescribed; Venezuela; illus.).—Fox, 1952a, p. 888 (Puerto Rico).—Wirth and Blanton, 1959, p. 292 (redescribed; Panama; illus.).—Fox and Garcia-Moll, 1961, p. 120 (Puerto Rico).

Female.—Wing length 0.64 mm.

Head: Eyes contiguous, with long interfacetal hairs. Antenna (fig. 27, *a*) with flagellar segments in proportion of 11–6–6–7–7–7–7–7–11–11–13–13–20; AR 1.18; sensory pattern 3,13–15. Palpal segments (fig. 27, *f*) with lengths in proportion of 5–17–19–8–8; PR 2.6; third segment slightly swollen, with small, deep sensory pit. Proboscis long, P/H ratio 1.08; mandible with 14 teeth.

Thorax: Blackish; mesonotum (fig. 27, *c*) densely bluish to greenish-gray pruinose, with two narrow, longitudinal, sublateral, black vittae. Legs pale brown; knee spots blackish; fore femur and midfemur with subapical, all tibiae with subbasal, and hind tibia with apical, broad, pale bands; tibial comb (fig. 27, *d*) with five spines, the one nearest the spur longest.

Wing (fig. 27, *b*; 30, *f*): Pattern as figured; large quadrate pale spots at anterior margin over r-m cross-vein and past end of 2RC, remainder of wing without distinct pale spots, but obscurely paler between the veins. Macrotrichia absent; CR 0.53; 2RC short. Halter pale.

Abdomen: Pale brown. Spermathecae (fig. 27, *e*) two, slightly ovoid, with short slender necks; subequal, each measuring 0.043 by 0.031 mm.

Male Genitalia (fig. 27, *h*).—Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum short, with two broadly rounded, caudolateral lobes, apicolateral processes absent. Basistyle with dorsal and ventral roots short and slender, subequal; dististyle with enlarged, rounded tip. Aedeagus with main body triangular, basal arch low and rounded, extending to about a fourth of total length; distal portion slender with rounded apex, a distinct internal, basally projecting, sclerotized peg present. Parameres (fig. 27, *g*) separate; each with slender anterolateral arm, main body stout at very base, tapering and becoming slender distally, with simple filamentous tip curving ventrally.

Distribution.—Widespread in Neotropical Region from Mexico to Brazil and Ecuador and throughout West Indies.

Types.—Syntypes of both sexes, Manguinhos, Rio de Janeiro, Brazil,

Lutz collection (Instituteo Oswaldo Cruz, Rio de Janeiro).

West Indian Records.—

ANTIGUA: No. 892, no other data, A. H. Jennings, 1 female.

CAYMAN ISLANDS: Grand Cayman, Smith Road Swamp, 1 December 1969, J. E. Davis, light trap, 2 females.

CUBA: Camaguey, 3 December 1957, J. U. McGuire, on grass, 3 females; Guantanamo, February-April 1970, J. E. Tisdale, light trap, 10 females.

DOMINICA: Cabrit Swamp, 23 February 1965, W. W. Wirth, light trap, 4 females; Clarke Hall Estate, 21–29 April 1964, O. S. Flint, light trap, 13 males, 30 females; same, August 1964, T. J. Spilman, light trap, 11 males, 15 females; same, January-March 1965, Wirth, light

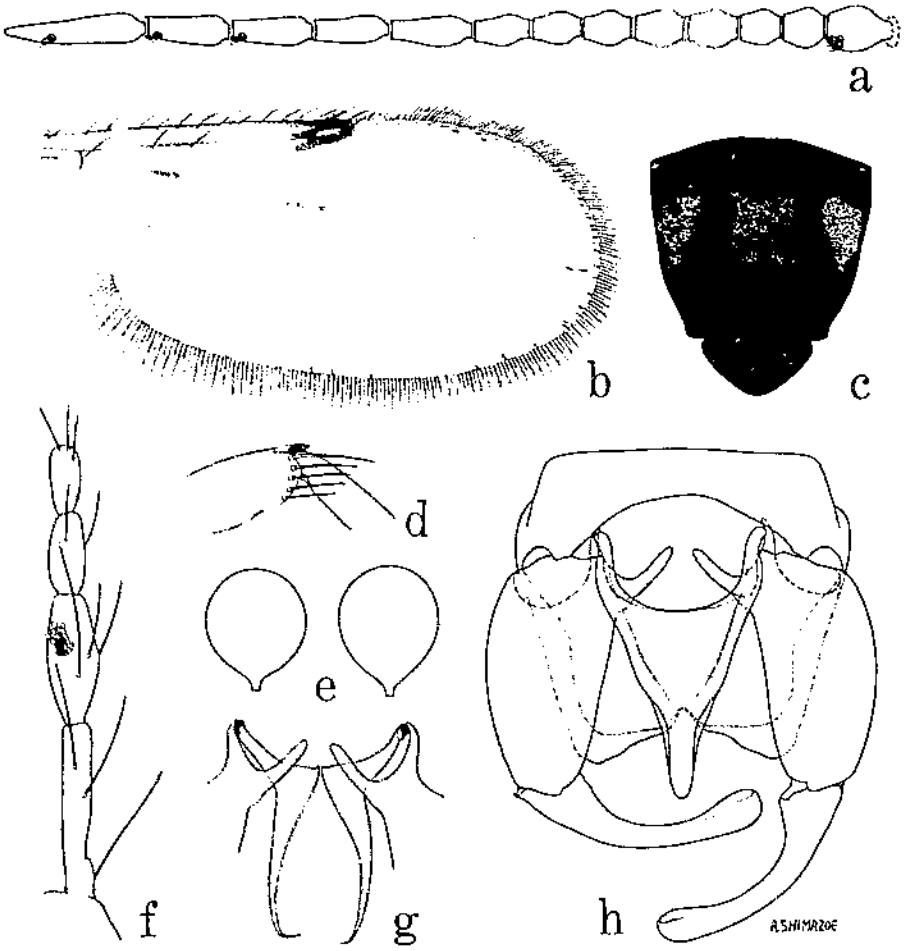

FIGURE 27.—*Culicoides pusillus*: *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermatheca; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

trap, 10 males, 10 females; same, 24 January 1965, Wirth, at mango flowers, 3 males; Layou River mouth, January-February 1965, Wirth, at light, 1 male, 2 females; Pont Casse, June 1964, Flint, light trap, 1 female; Sylvania, 23 January 1965, Wirth, light trap, 1 female.

GRENADA: Balthazar, 7 August 1963, O. S. Flint, 4 females.

JAMAICA: No locality (Barbosa, *1947*).—Annottto Bay, St. Mary Parish, 25 February 1969, W. W. Wirth, swept from marsh, 1 female; Askenish, near Dolphin Head, Hanover Parish, 20 June 1970, E. G. Farnworth, light trap, 50 females; Gordon Town, St. Andrew Parish, 1 February 1937, Chapin and Blackwelder, 1 female; Negril, Westmoreland Parish, 22 June 1970, Farnworth, light trap, 100 specimens; Negril, Crystal Waters, 20 November 1968, R. E. Woodruff, light trap, 10 males, 10 females; Runaway Bay, St. Ann Parish, February 1969, Wirth, light trap, 5 males, 10 females; Trinity Ville, St. Thomas Parish, 28 February 1937, Chapin and Blackwelder, 5 females; Twickenham Park, St. Catherine Parish, 28 April 1970, Farnworth, light trap, 500 specimens; Worthy Park Estate, St. Catherine Parish, 17 November 1968, Woodruff, light trap, 300 specimens; same, March-June 1970, Farnworth, 500 specimens.

PUERTO RICO: Henry Barracks (Fox, *1952a*).—Isla Verde Int. Airport (Fox and Garcia-Moll, *1961*). —Ramey Field, July 1958, L. T. Sanders, 2 females.

SAINT LUCIA: Castries, Fairview, 14 April 1959, R. Darsie, light trap, 7 males, 5 females; Cul de Sac Road at MP 9, 29 July 1963, Flint and Cadet, 1 male.

Discussion.—Its small size, short costa, poorly marked bluish-black mesonotum, characteristic antennal sensory pattern, bare wing without marginal pale spots, and short, bilobed ninth tergum without apicolateral processes characterize *C. pusillus* as a member of the subgenus *Avaritia*. *C. pusilloides* Wirth and Blanton from Central America is similar but can be distinguished by its more distinct wing pattern with marginal pale spots, its pale distal portion of 2RC, its antennal sensory pattern, 3,12–15, its only weakly bilobed male ninth tergum, and its much shorter male aedeagus with convex lateral margins.

Larval Habitat.—Williams (*1964*) reared *C. pusillus* from a wide variety of habitats in Trinidad, including a bamboo internode, banana stalks and bracts, rotting cacao pods, the edge of a drainage ditch, macerated coconut fiber animal bedding, horse and cow manure, bracts of *Heliconia*, and a rotting calabash.

Biting Habits.—This species was taken several times biting man in Trinidad (Adamson, *1939;* Aitken, in litt.).

Culicoides trilineatus Fox (Figs. 6 and 28)

Culicoides trilineatus Fox, 1946, p. 250 (female; Saint Thomas; biting man; fig. mesonotum, wing).—Fox, 1949, p. 30 (male, female; Puerto Rico; reared, tree hole; illus.).—Wirth and Blanton.

1956b, p. 189 (redescribed; illus.; distribution).—Forattini, 1957, p. 389 (redescribed; illus.; distribution).

Female.—Wing length 0.97 mm. Head: Eyes narrowly separated, bare. Antenna (fig. 28, *a*) with lengths of flagellar segments in proportion of 19–15–15–17–17–15–15–15–17–18–19–20–33; AR 0.86; sensory pattern 3,6–10. Palpal segments (fig. 28, *c*) with lengths in proportion of 13–24–30–10–12; PR 2.6; third segment moderately swollen toward tip, with moderately small, round, moderately deep sensory pit. Proboscis moderately long, P/H ratio 0.83; mandible with 18 teeth.

Thorax: Dark brown; mesonotum (fig. 28, *f*) grayish brown with three prominent dark-brown longitudinal lines connected posteriorly by a transverse line just in front of prescutellar depression, and dark brown along sides. Legs brown; fore knees and midknees dark with narrow pale rings on each side of joint; hind tibia with pale band at base and apex; tibial comb (fig. 28, *d*) with four spines, the second from the spur longest.

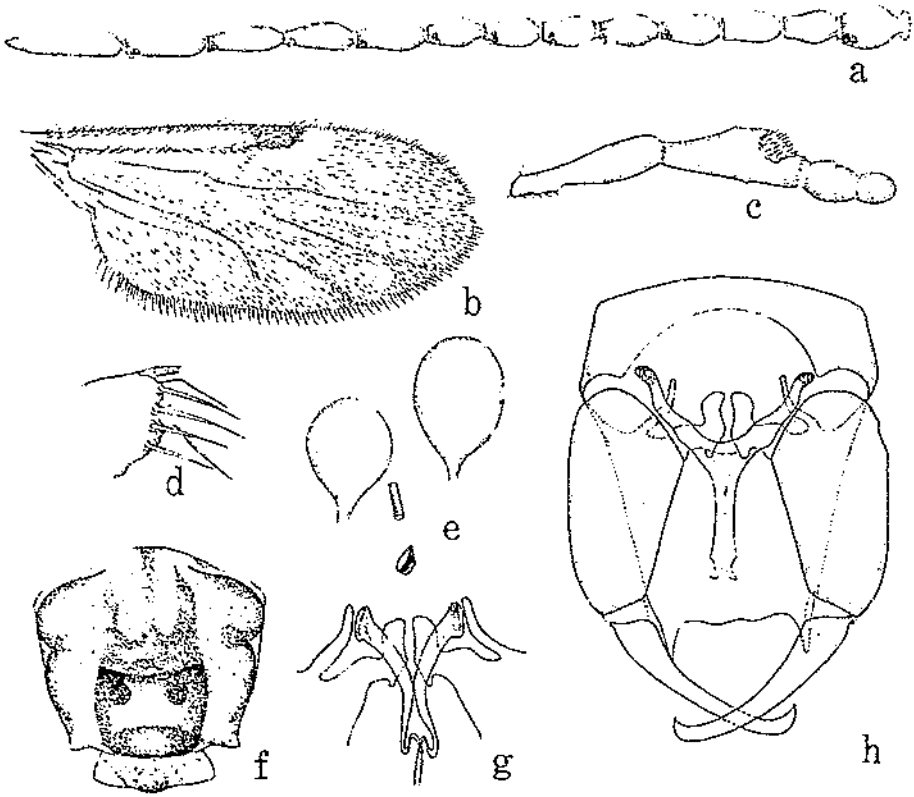

FIGURE 28.—*Culicoides trilineatus*: *a*, Female antenna; *b*, female wing; *c*, female palpus; *d*, tibial comb; *e*, spermathecae; *f*, thoracic pattern; *g*, male parameres; *h*, male genitalia, paramere removed.

Wing (fig. 28, *b*): Pattern as figured; 2RC dark to tip; pale spot over r-m crossvein small, extending to costal margin; cell R5 with three pale spots, two small poststigmatic spots, sometimes coalesced, the posterior one located slightly proximad of anterior one, distal spot small and transverse; cell M1 with two small pale spots, the proximal one sometimes scarcely discernible; cell M2 with pale spot at basal arculus, a pale spot behind medial fork, no pale spot lying ahead of mediocubital fork, and a small pale spot in distal part of cell; cell M4 with large round pale spot near posterior margin; anal cell with one pale spot in distal portion. Macrotrichia long, coarse, and abundant, extending to base of wing in cell M2 and anal cell; CR 0.57; 2RC with narrow lumen. Halter deeply infuscated.

Abdomen: Dark brown. Spermatheeae (fig. 28, *e*) two plus rudimentary third and sclerotized ring; functional ones ovoid with long, slender necks; subequal, each measuring 0.056 by 0.039 mm.

Male Genitalia (fig. 28, *h*).—Ninth sternum with broad, deep, caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering, with moderately long, pointed, apicolateral processes, margin between them transverse. Basistyle with ventral root "foot-shaped," the anterior toe stout, dorsal root slender; dististyle long and slender, slightly curved, with bent, pointed tip. Aedeagus with rounded basal arch extending to 0.4 of total length, basal arms slender and curved; distal portion long and slender, distally parallel sided, apex deeply bifid into two sharp, slender, appressed points. Parameres (fig. 28, *g*) separate; each with inconspicuous basal knob, basal portion only slightly swollen, curved gently toward midportion and tapering to slender, simple, filamentous tips bent abruptly ventral.

Distribution.—Barbados, Dominica, Grenada, Puerto Rico, Saint Croix, Saint Lucia (fig. 6), Saint Thomas.

Types.—Holotype, female, paratype, female, Red Hook, Saint Thomas, 11 September 1937, biting in afternoon (University of Puerto Rico collection).

West Indian Records.—

BARBADOS: No locality, No. 861, A. J. Jennings (Wirth and Blanton, *1956b*).

DOMINICA: Clarke Hall Estate, April-June 1964, O. S. Flint, light trap, 2 males, 8 females; same, July-September 1964, T. J. Spilman, light trap, 8 males, 25 females; same, October 1964, P. J. Spangler, light trap, 1 male, 3 females; same, January-March 1965, W. W. Wirth, light trap, 5 males, 5 females; Pont Casse, 15 June 1964, Flint, at light, 1 female.

GRENADA: Balthazar, 7 August 1963, O. S. Flint, 1 female.

PUERTO RICO: Henry Barracks (Fox, *1952a*); Isla Verde Int. Airport (Fox and Garcia-Moll, *1961*); Luquillo, reared from tree hole debris (Fox, *1949;* Wolcott, *1951*).

SAINT CROIX: No locality, May-August 1935, June 1938, H. A. Beatty, 33 females; Diamond School, September 1938, Beatty, 4

females; Salt River, September 1938, Beatty, 15 females; Tagus Pond, May 1936, June 1938, Beatty, 11 females; "Valley of jungles and stream," 1 mile from seacoast, May 1935, Beatty, 1 female (Wirth and Blanton, *1956b*).

SAINT LUCIA: Gros Islet, Yacht Club light, 26 October 1967, J. B. Davies, 1 female.

SAINT THOMAS: Red Hook (Fox, *1946*, types).

Discussion.—*C. trilineatus* belongs to the *C. debilipalpis* group. It can be readily distinguished from other species in the group by its coarsely hairy wings with reduced wing spots, its distinctive mesonotal pattern, its antennal sensory pattern 3,6–10, and its characteristic male aedeagus and parameres.

Larval Habitat.—Fox (*1949*) reported this species breeding in tree hole debris in Puerto Rico.

Biting Habits.—*C. trilineatus* has been recorded once biting man on Saint Thomas in the afternoon.

Culicoides trinidadensis Hoffman

(Figs. 3 and 29)

Culicoides trinidadensis Hoffman, 1925, p. 286 (female; Trinidad; fig. wing).—Fox, 1946, p. 356 (Trinidad).—Fox, 1948, p. 23 (fig. palpus).—Wirth and Blanton, 1956a, p. 324 (redescribed; distribution; illus.; synonyms: *oliveri, diminutus*).—Forattini, 1957, p. 231 (redescribed; illus.).—Wirth and Blanton, 1959, p. 297 (redescribed; Panama distribution; illus.).

Culicoides oliveri Fox and Hoffman, 1944, p. 108 (Haiti; male, female; fig. male genitalia).

Culicoides wokei Barbosa, 1947, p. 28 (preoccupied by *C. wokei* Fox; that portion of type series collected by Woke; male, female; Panama; fig. palpus, male genitalia).

Culicoides diminutus Barbosa, 1951, p. 163 (new name for *wokei* Barbosa).

Female.—Wing length 1.12 mm.

Head: Eyes contiguous, bare. Antenna (fig. 29, *a*) with lengths of flagellar segments in proportion of 23 – 15 – 15 – 15 – 15 – 15 – 15 – 16 – 27–29–32–33–43; AR 1.22; sensory pattern 3,5,7,9,11–15. Palpal segments (fig. 29, *f*) with lengths in proportion of 10–27–45–15–18; PR 3.4; third segment without sensory pit, sensilla scattered on surface. Proboscis long, P/H ratio 1.08; mandible with 17 teeth.

Thorax: Dull brown; mesonotum (fig. 29, *c*) without prominent pattern. Legs dark brown; a trace of pale spots on fore knees and mid-knees; pale bands at base and apex of hind tibia; tibial comb (fig. 29, *d*) with five spines, second from spur longest.

Wing (fig. 29, *b*): Pattern as figured; 2RC with apex in a pale spot, vein R4+5 not darkened past dark area over base of cell; wing grayish brown with pattern of small, dull, grayish-white spots; crossvein r-m dark on anterior end; cell M1 with only one pale spot distal to pale spot straddling vein M2. Macrotrichia sparse, covering distal half of wing; CR 0.66; 2RC with distinct lumen. Halter infuscated.

Abdomen: Blackish, cerci paler. Spermathecae (fig. 29, *e*) two plus rudimentary third and sclerotized ring; functional ones subspherical with short necks; subequal, each measuring 0.058 by 0.046 mm.

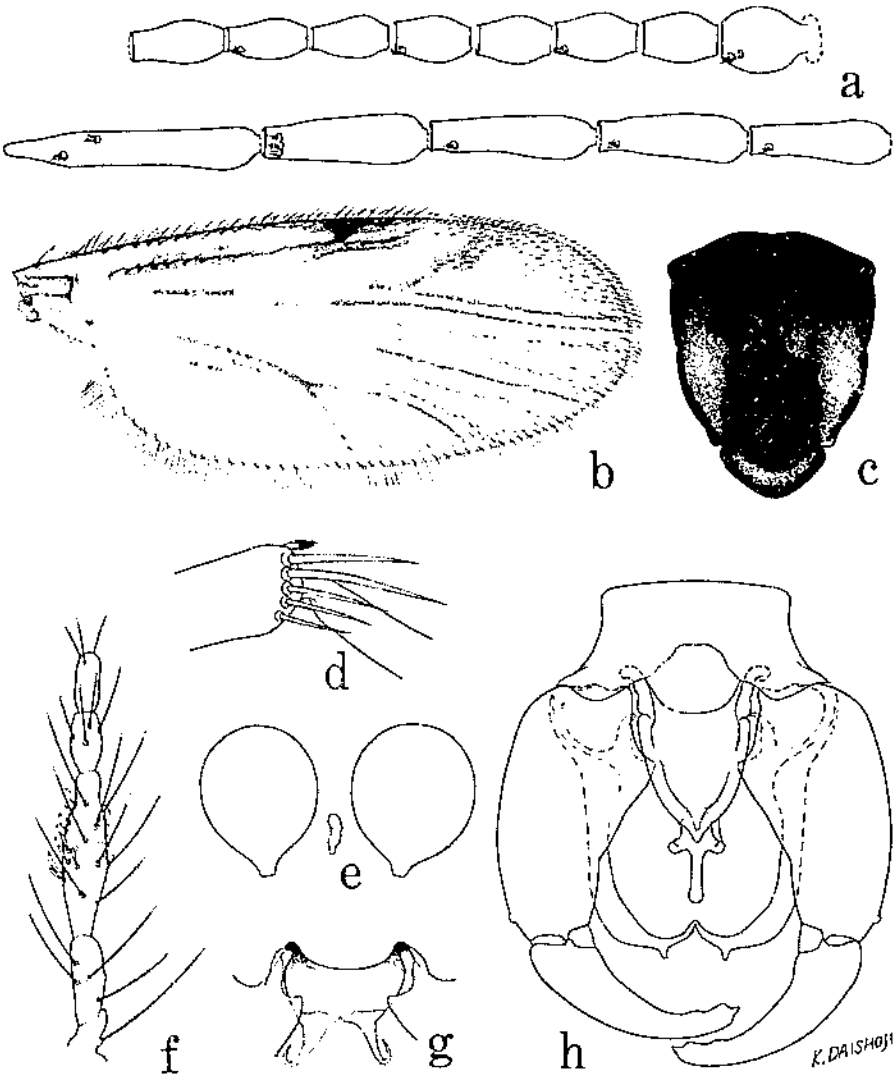

FIGURE 29.—*Culicoides trinidadensis:* *a*, Female antenna; *b*, female wing; *c*, thoracic pattern; *d*, tibial comb; *e*, spermathecae; *f*, female palpus; *g*, male parameres; *h*, male genitalia, parameres removed.

Male Genitalia (fig. 29, *h*).—Ninth sternum with narrow, moderately deep, caudomedian excavation; ninth tergum with distinct caudomedian cleft and small, submedian, apicolateral processes. Aedeagus stout, basal arch extending to only a fifth of total length; distal portion with a pair of characteristic subapical projections extending ventrolaterad, in ventral view resembling a fleur-de-lis. Parameres (fig. 29, *g*) fused on basal halves in a basal plate twice as broad as long, apices short and slender, without fringing hairs.

Distribution.—Bahamas, Colombia, Cuba, Haiti, Nicaragua, Panama, Trinidad (fig. 3).

Types.—Holotype, female, of *trinidadensis*, Caronia River, Port of Spain, Trinidad, 14 June 1906, F. W. Urich (USNM 27272). Holotype, female, of *oliveri*, Mariana, Haiti, 7 December 1925 (University of Puerto Rico collection). Lectotype, male, of *wokei*, designated by Wirth and Blanton (*1956a*), Balboa, C.Z., 29 July 1942, P. A. Woke No. 1027 (USNM 59363).

West Indian Records.—

BAHAMAS: Abaco I., April 1968, G. M. Stokes, light trap, 3 females; Andros I., Driggs Hill near South Bight, 27 April 1953, Hayden and Giovannoli, 4 females (AMNH) (Wirth and Blanton, *1956a*).—Cat I., Bennetts Harbour, 24 March 1953, L. Giovannoli, 2 females (AMNH); Grand Cay, 22 January 1969, Stokes, light trap, 2 females; Great Harbour Cay, 22 December 1968, Stokes, light trap, 1 male, 5 females.

CUBA: Guantanamo Bay, February-April 1970, J. E. Tisdale, light trap, 5 females.

HAITI: Mariana, 7 December 1925, "biting viciously in sun," 1 female (Fox and Hoffman, *1944*, holotype of *oliveri*; Wirth and Blanton, *1956a*).

Discussion.—This species greatly resembles the Brazilian species, *C. maruim* Lutz, with its unmarked mesonotum wing pattern with dark r-m crossvein, undarkened vein R4+5 and only one distal pale spot in cell M1, dark halter, and third palpal segment with scattered sensilla. *C. maruim* is paler with a more yellowish wing, lacks the sensoria on antennal segments 3, 7, and 9, the male aedeagus lacks the fleur-de-lis-like apex, and the parameres are fused only a short distance at bases and taper more gradually to stouter, bare apices.

Larval Habitat.—Woke (*1954*) reared *C. trinidadensis* from a tidal salt marsh near mangroves in Panama. Breeland (*1960*) reared it in Panama from a coral sand mangrove habitat inundated frequently by high tidewater.

Biting Habits.—This species was reported as a biting pest in Trinidad by Myers (*1935*), but Adamson (*1939*) and Aitken (*1957*) believed that this record probably should be referred to *C. diabolicus*, *C. foxi*, or *C. insignis*. Woke (*1954*) reported it biting man in Panama, and the Haitian types of *C. oliveri* were taken biting man viciously in the sun.

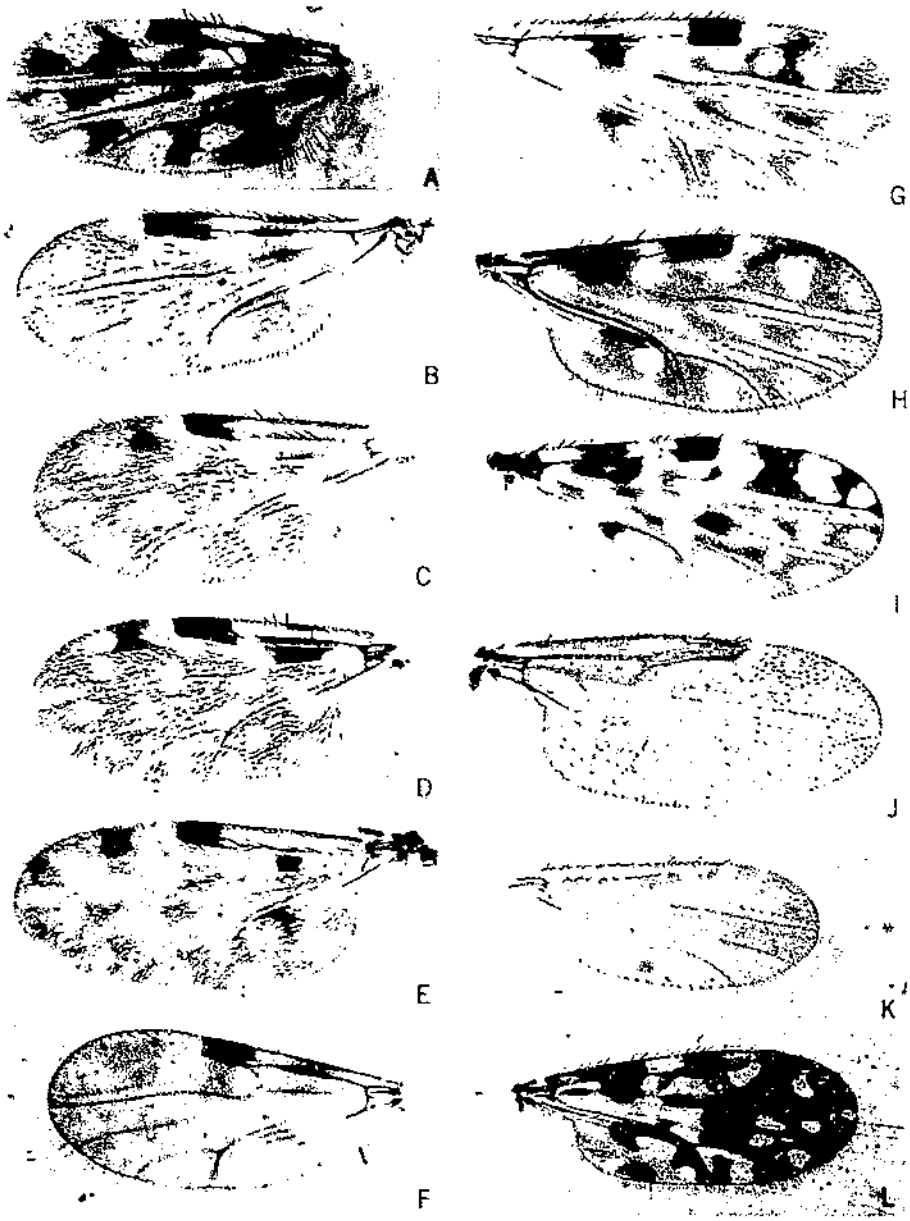

FIGURE 30.—*Culicoides* spp., female wings: *a*, *C. barbosai*; *b*, *borinqueni*; *c*, *panamensis*; *d*, *jamaicensis*; *e*, *loughnani*; *f*, *pusillus*; *g*, *furens*; *h*, *paraensis*; *i*, *arubae*; *j*, *melleus*; *k*, *floridensis*; *l*, *insignis*.

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