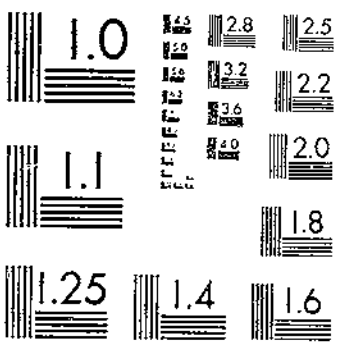
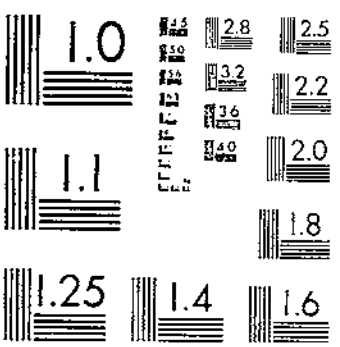
START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

THE NORTH AMERICAN SPECIES OF FORCIPOMYIA, SUBGENUS EUPROJOANNISIA (DIPTERA: CERATOPOGONIDAE)

by
PAUL G. BYSTRAK AND WILLIS W. WIRTH

UNITED STATES DEPARTMENT OF AGRICULTURE

TECHNICAL BULLETIN NUMBER 1591

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

ACKNOWLEDGMENTS

An effort of this complexity would be impossible without continuous and willing support from a wide variety of sources. Thanks are due Donald W. Webb of the Illinois Natural History Survey, Urbana, Ill., for the loan of the type of *Forcipomyia hirtipennis* (Malloch). H. J. Remm of Tartu University, Estonian SSR, provided European specimens. We are grateful to John A. Davidson, William L. Grogan, Jr., and Donald H. Messersmith of the University of Maryland for many helpful suggestions.

CONTENTS

On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

This publication was prepared by the Science and Education Administration's Agricultural Research staff, which was formerly the Agricultural Research Service.

Washington, D.C. Issued December 1978

THE NORTH AMERICAN SPECIES OF FORCIPOMYIA, SUBGENUS EUPROJOANNISIA (DIPTERA: CERATOPOGONIDAE)

By PAUL G. BYSTRAK and WILLIS W. WIRTH [1]

ABSTRACT

Biting midges of the genus *Forcipomyia*, subgenus *Euprojoannisia*, are important pollinators of cacao (*Theobroma cacao* L.) and other tropical crops. Their role as pollinators in North America and other temperate regions has not been determined and needs study. A short review is given here of the mechanism of cacao pollination by *Forcipomyia* midges. A taxonomic revision is made of the 14 known North American species of this subgenus, with detailed descriptions, illustrations, and notes on biology of all stages. Six species are described as new—*canadensis*, *dowi*, *fuscicalcarata*, *navaiae*, *pechumani*, and *unica*. *Forcipomyia turfacea* Kieffer 1925 is synonymized with *F. hirtipennis* (Malloch, 1915) (NEW SYNONYMY). Larvae of *Euprojoannisia* species are usually found in semiaquatic habitats, such as algae-covered rocks or mud, wet moss or leaves, mats of decaying aquatic vegetation, and leaf axils of water-holding plants.

INTRODUCTION

The genus *Euprojoannisia* was described by Brèthes (*1914*) [2] in the family Cecidomyiidae for a single Argentine species, *E. platensis* Brèthes. This species was poorly understood until 1975, when Wirth and Cavalieri reexamined the holotype and confirmed its taxonomic position in the family Ceratopogonidae in the group of species we are revising here.

The genus *Euforcipomyia* was proposed by Malloch (*1915*) to include those forcipomyiine midges with the hindbasitarsus at least 1.5 times the length of the second tarsomere. He designated as type-species *E. hirtipennis* Malloch, represented by a single female. Edwards (*1924*) united *Euforcipomyia* with the genus *Apelma* Kieffer, known from the male only, since both have long first tarsomeres. In 1926, Edwards suppressed both genera and created a "Group C" in the genus *Forcipomyia* Meigen, basing it on the hindtarsal ratio and including *F. crassipes* (Winnertz, *1852*) and *F. titillans* (Winnertz, *1852*). This arrangement was not widely adopted, and Mayer (*1933*) used *Apelma* as the subgeneric name. Johannsen (*1943*, *1952*) used the name *Euforcipomyia* for the subgenus and included in it seven North American species. Wirth (*1952*) noted that *Apelma* Kieffer is a junior homonym of *Apelma* Billberg (Coleoptera) and also accepted *Euforcipomyia* as a valid subgenus. He described an additional new variety, *F. calcarata* var. *sonora* from California.

The late L. G. Saunders (*1956a*) in his classic article on the classification of the genus

[1] Respectively, Plant Protection Section, Maryland Department of Agriculture, Annapolis 21401, and Systematic Entomology Laboratory, Science and Education Administration, c/o U.S. National Museum, Washington, D.C. 20560.

[2] The year in italic after the authors' names indicates the reference in Literature Cited, p. 49.

Forcipomyia, was the first to bring some order into this diverse group. Using characters of all stages (fig. 1), he described eight subgenera of *Forcipomyia,* but he did not recognize *Euforcipomyia* because the type-species was of "uncertain identity." Instead he proposed the subgenus *Proforcipomyia* to include the members of this group, with type-species *F. wirthi,* new species. He used the material Wirth (*1952*) had mistakenly called *F. calcarata* (Coquillett), but which differed considerably from Coquillett's holotype. In addition, Saunders described three new neotropical species, *F. bromeliae, spatulifera,* and *longispina.* In 1959, he described *F. mortuifolii, setigera,* and *falcifera* in the subgenus *Proforcipomyia* as three new neotropical species that may be of economic importance in cacao pollination. Saunders' work in this subgenus was characterized by using larvae as the diagnostic stage and by a particular insistence on detail and excellence, which unfortunately has not been equaled since.

H. J. Remm of Tartu University in the Estonian SSR has been the primary European worker in this subgenus. He (*1960*) described *F. subsaltans* from Estonia, and later he (*1961*) followed Wirth and included it in the subgenus *Euforcipomyia,* along with the European species *F. alacris* (Winnertz, *1852*), *titillans,* and *turfacea* Kieffer (*1924*). Remm (*1966*) recorded these species except *F. subsaltans* from Lithuania, and in addition he described a new species, *F. borealis,* which he tentatively placed in the subgenus *Warmkea.* He (*1967*) moved *F. crassipes* to *Forcipomyia* (*Forcipomyia*) and accepted *Proforcipomyia* as the appropriate name for the subgenus.

Wirth (*1965*) in the catalog of North American Diptera utilized Saunders' approach and recognized two subgenera, *Euforcipomyia,* including only *F. hirtipennis,* and *Proforcipomyia,* including the North American species *F. calcarata, indecora, sonora* (elevated to species status), *titillans,* and *wirthi.* In his oriental catalog, Wirth (*1973*) used the subgenus *Proforcipomyia* for seven oriental species. In his neotropical catalog, however, he (*1974*) switched to the name *Euforcipomyia* for the 10 known neotropical species of the subgenus. To compound the confusion, Wirth and Cavalieri (*1975*) confirmed that the type-species of *Euprojoannisia* Brèthes (*1914*) was a *Forcipomyia* of the subgenus *Euforcipomyia,* antedating Malloch's name and making it a junior synonym of *Euprojoannisia.*

Under the "Fifty Year Rule," as stated by the International Commission (*1961*) in Article 23b of the International Code of Zoological Nomenclature, as amended by the Monaco Congress of 1972, and published by the Commission (*1974*) in the Bulletin of Zoological Nomenclature in amended Articles 23a, b, and 79, a case could possibly be made for conserving either *Euforcipomyia* or *Proforcipomyia* based on current general use of a junior synonym for an important economic group of animals. However, since both junior synonyms have been in recent use a comparable number of times and in comparable economic literature, there is no prima facie case for either name. Moreover, under the current application of Article 79 the recent use of the senior synonym *Euprojoannisia* by Wirth and Cavalieri and others seriously weakens any case that might be made for using the plenary powers to conserve either of the junior synonyms. Under these circumstances we believe it preferable to observe the law of priority and to apply the name *Euprojoannisia* for this subgenus of biting midges.

Through the courtesy of the Illinois Natural History Survey we have critically examined Malloch's holotype of *F. hirtipennis.* We believe the males, which match it, to be identical with males of *F. turfacea* Kieffer, making the European species a junior synonym (NEW SYNONYMY). *F. hirtipennis* is a valid species and definitely belongs in the subgenus *Euprojoannisia.*

ECONOMIC IMPORTANCE

The subgenus *Euprojoannisia* is of considerable economic importance because several tropical species are the major pollinators of cacao (*Theobroma cacao* L.). This situation was

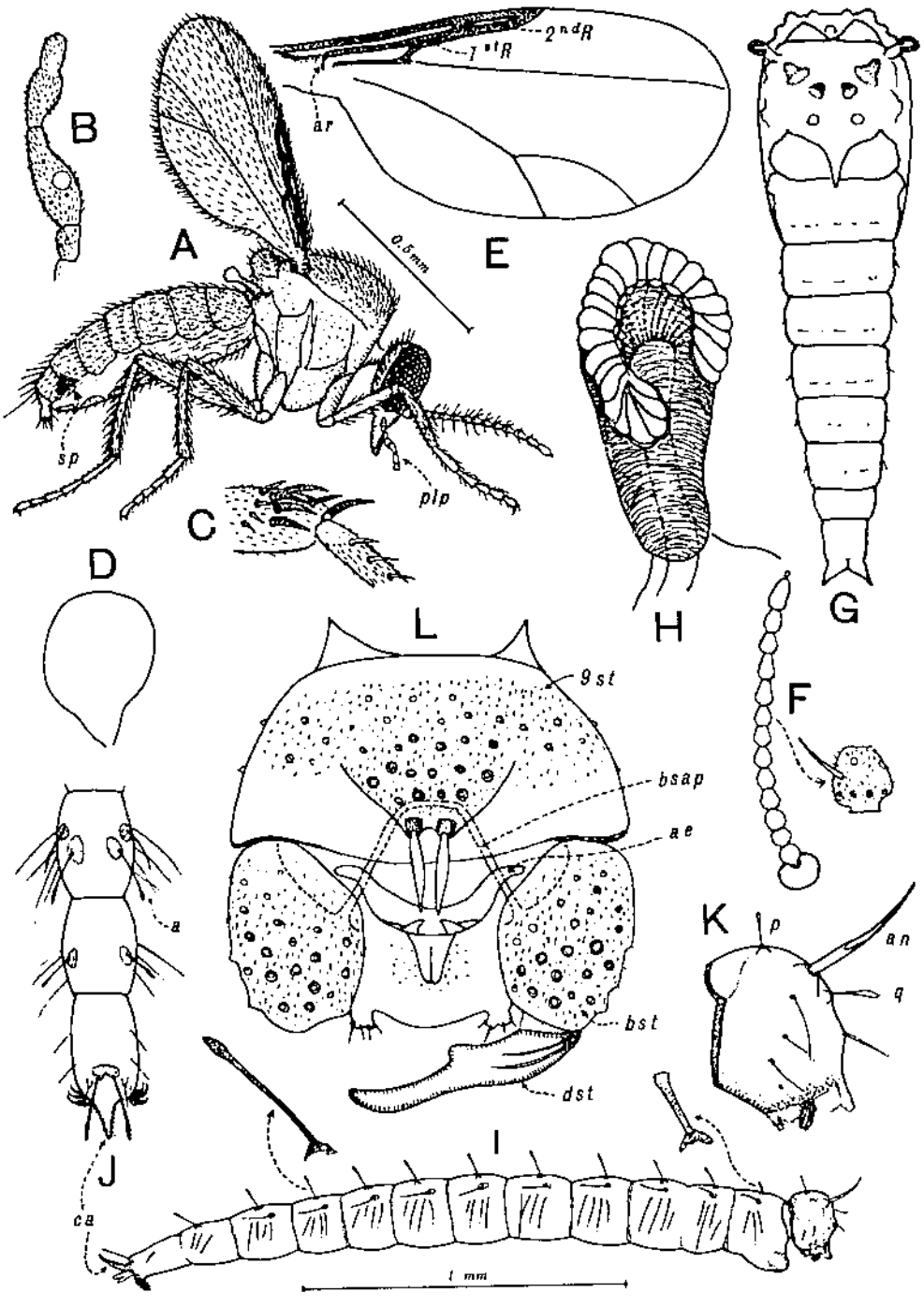


FIGURE 1.—*Forcipomyia* (*Euprojoannisia*) *mortuifolii* Saunders (from Saunders, *1959*), illustrating general appearance and taxonomic characters of the subgenus *Euprojoannisia*: *A*, Female habitus, lateral view; *B*, female palpus; *C*, female prothoracic tibial comb; *D*, female spermatheca; *E*, female wing venation; *F*, female antenna; *G*, pupa, dorsal view; *H*, pupal respiratory horn; *I*, larva, lateral view; *J*, last three segments of larva, dorsal view; *K*, larval head, lateral view; *L*, male genitalia, ventral view. (*a*, seta *a*; *ae*, aedeagus; *an*, antenna; *ar*, basal arculus; *bsap*, basistylar apodeme; *bst*, basistyle; *ca*, cauda; *dst*, dististyle; *p*, seta *p*; *plp*, palpus; *q*, seta *q*; 1st *R*, first radial cell; 2nd *R*, second radial cell; *sp*, spermatheca; 9 *st*, 9th sternum)

studied by Billes (*1941*), Posnette (*1944*), and Macfie (*1944*); more recently by Saunders (*1956b, 1959*), Soria (*1971, 1973*), Winder and Silva (*1972*), Soria and Wirth (*1974, 1976*), and Winder (*1977*) in the New World; Posnette (*1950*), Gerrard (*1966*), Dessart (*1961, 1962*), and Kaufmann (*1974, 1975a, 1975b, 1975c*) in Africa; Soetardi (*1950*) and Soerjobroto (*1967*) in Indonesia; and Barroga (*1961, 1964, 1965*) in the Philippines. Members of this subgenus accomplished virtually all pollination except accidental pollination, and a lack of these flies was believed to be the major cause for poor productivity of cacao in certain areas. *Forcipomyia* midges have also been involved in pollinating Pará rubber (*Hevea brasiliensis* (Willd. ex A. Juss.) Muell.-Arg.) (Warmke, *1951, 1952*; Wirth, *1956*).

CACAO POLLINATION

Information on the mechanism of cacao pollination can be found in McGregor (*1976*) and also in "Insect Pollination of Crops" by Free (*1970*) and "Pests of Cocoa" by Entwistle (*1972*).

The pollination biology of cacao differs from locality to locality. In West Africa much of the cacao is the Amelonado strain, which is self-fertile and no cross-pollination is required. But in most of the rest of the world the cacao varieties are self-sterile and require cross-pollination. Billes (*1941*) experimentally disproved that wind or water could serve to cross-pollinate cacao and narrowed the search to an insect pollinator. Cope (*1940*) indicated that a winged pollinator must exist to account for setting on self-sterile cacao trees. Billes (*1941*) first called attention to the ceratopogonid midges, which he considered to be the most important cross-pollinators in Trinidad. Specimens collected by Posnette in Trinidad were identified by Macfie (*1944*) as two species of *Forcipomyia: F.* (*Euprojoannisia*) *quasiingrami* Macfie and *F.* (*Thyridomyia*) *nana* (Macfie). Posnette (*1950*) reported that three species of *Forcipomyia* were responsible for pollinating cacao in Ghana.

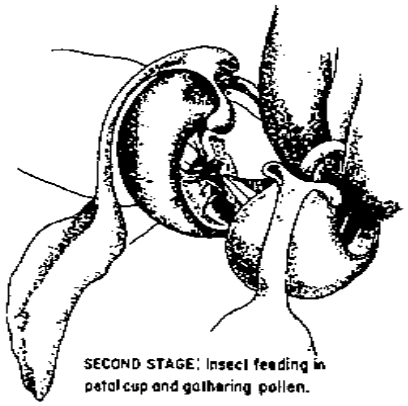
Cacao flowers (fig. 2) are produced in clusters directly from old wood of the main stem or older branches of the cacao tree at points that originally were leaf axils. Each flower has five petals enclosed within five larger sepals, which are its most conspicuous part. The petals are white and each has two prominent purple guidelines. The superior ovary contains five carpels, each with numerous ovules that develop into the seeds of commerce. The single style divides into five stigmas. It is surrounded by an inner circle of five stamens, each with four anthers, and an outer circle of five staminodes, which are united at the base. The filaments of the stamens bend outward so that the anthers lie within the pouched parts of the petals, and the erect-pointed staminodes form a barrier around the style (Free, *1970*).

According to McGregor (*1976*), cacao flowers have numerous microscopic nectaries on the pedicels, sepals, ovaries, guidelines of the petals, and the staminodes. They secrete nectar, which has an odor that attracts various insects. The flower opens about dawn and the anthers dehisce just before sunrise. The stigma is usually pollinated 2 to 3 hours later, but it is receptive from sunrise to sunset of the day of opening. The stigma is receptive to pollen along its entire length and not just at the tip. If the flower is not pollinated, it is usually shed the following day.

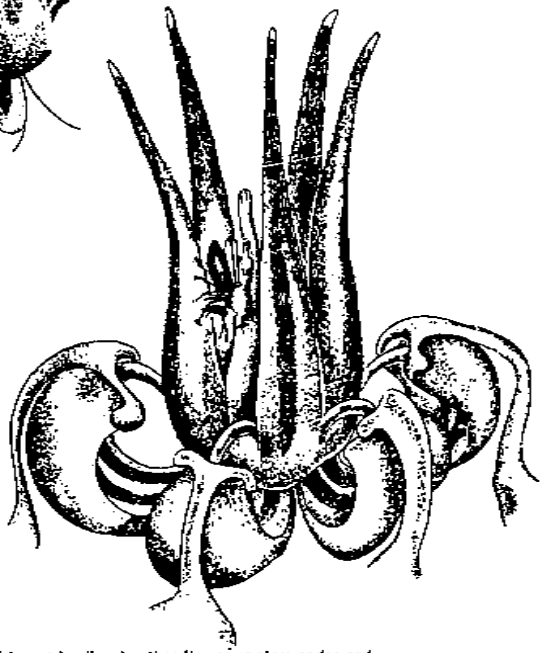
The mechanism of cacao pollination is not completely known and probably differs with the prevalent kind of insect that visits the flowers. According to Posnette (*1950*) and Entwistle (*1972*), the presence of characteristic "balls" or clusters of pollen on cacao stigmas is the most reliable indication that the flower has been pollinated. These balls are formed almost entirely by the activities of ceratopogonid midges, mostly *Forcipomyia* spp. (fig. 2). The midge usually alights on a staminode and while walking up the inner side brushes its thorax against the stigma or style so that any pollen that the midge has already acquired is removed either as a ball or as a smear on the flower. The pollen is acquired by the midge when, after this, the fly enters the petal hood following the pigmented guidelines so that at the apex of the

FLOWER CUSHION

FIRST STAGE: Insect feeding on staminodes.



SECOND STAGE: Insect feeding in petal cup and gathering pollen.



THIRD STAGE: Insect feeding in other flower on staminodes and spreading pollen on pistil

FIGURE 2.—Cacao pollination (from Saunders, *1956b*).

hood the bristles and hairs of the thorax collect a ball of the slightly sticky pollen from the anther. Pollination is effected when the midge flies to another flower and walks up its staminodes.

Cacao flowers are so constructed that pollination and especially cross-pollination is rather easy for tiny midges, but it is very difficult to shake or blow pollen directly from the anthers onto the style. Flowers are effectively pollinated when they bear more than about 35 pollen grains on the style or stigma (Kaufmann, *1975c*). According to Kaufmann, males of *F.* (*F.*) *squamipennis* Ingram and Macfie may effectively pollinate cacao flowers by "filament pollination" as opposed to the normal "style pollination."

Most pollination of cacao in Ghana takes place in the first 2 or 3 hours after dawn, with a second much smaller peak during the afternoon, and little pollination at night. A heavy rainfall in the early morning will nearly eliminate pollination for the day, but afternoon rains have little effect.

In Ghana the proportion of flowers pollinated during the flowering season of cacao is relatively small, only 2 to 5 percent. Of these, a considerable number will fail to set, owing to incompatible pollen, or because the pollen being deposited is too late to check the abscission mechanism of the flower. Early in the season for about a month, very little setting takes place despite a large number of flowers, but whether this is due to lack of pollinating insects or to the physiological condition of the tree is not known. Toward the end of the season, in July and August, there are fewer flowers, but they stay on the tree longer and the amount of pollination increases, with the result that pollination and setting may approach 50 to 75 percent. Thus, a large part of the main crop is formed well past the maximum flowering season of the trees. The distance over which cross-pollination will occur has not been determined, although it is important to know how close to self-sterile clones one should plant compatible pollinator trees (Sumner, *1962*; Leston, *1970*).

The earlier accounts of cacao pollination credited some of the pollination to various insects found in the cacao flowers, such as ants, aphids, thrips, and wild bees, in addition to the ceratopogonid midges. Most of the studies previously cited here showed that usually the most important, if not the only pollinators, were midges of the family Ceratopogonidae. Species of the subgenus *Euprojoannisia* were repeatedly reported to be the most important of the pollinators present.

Kaufmann (*1973a*) reported that in Ghana the psyllid leafhopper *Tyora tessmani* Aulmann, in addition to being a serious pest on cacao, may act as a pollinator when the wandering nymphs bearing bushy tails of waxy threads crawl into the flowers and from flower to flower and are transported from tree to tree by the wind. Kaufmann (*1973b*) also reported effective pollination of cacao in the dry season by cecidomyiid midges. She attributed a maximum of 60 percent of effectively pollinated flowers in December at the height of the wet season to ceratopogonid pollination. But pollination by ceratopogonids dropped to 6.5 percent in March in the dry season, when she found as much as 10 percent of the flowers to be pollinated by Cecidomyiidae.

In Bahia, Brazil, Soria and Wirth (*1974*) reported from the examination of more than 327,000 cacao flowers that although several species of ceratopogonids were found in the flowers, only those flowers in which species of *Euprojoannisia* were seen were effectively pollinated. They explained that the space between the staminodes and the stigma is large enough for only midges of this subgenus to pass through, resulting in a massive deposit of pollen grains on the stigma. Winder (*1977*) reported a much wider variety of ceratopogonids and other small Diptera found in cacao flowers in Bahia and concluded that these also might be responsible for varying amounts of pollination. He supported Soria and Wirth in indicating the distinct connection between species of *Euprojoannisia* and effective pollination. Most of the species of *Dasyhelea*, *Culicoides*, and *Forcipomyia* of other subgenera, as well as the Cecidomyiidae listed by Winder, are in the same size range as *Euprojoannisia* and thus indicate their suitability as pollinators with respect to body size.

BIOLOGY

Very little is known of the life histories or immature stages (fig. 3) of the North American species of *Euprojoannisia*. The larvae are found in semiaquatic habitats, and the adults do not stray far from such habitats. For example, *F. wirthi* Saunders larvae were collected in great numbers from the algae growing on the rocks at the outer edges of a mineral spring, where they apparently fed on diatoms and other algae (Wirth, *1952*; Saunders, *1956a*). The larvae of *F. canadensis*, new species, have been collected three times from wet moss in Canada and once from mud and sedges along a stream at 10,000-foot elevation in Colorado. Another example was the collection of *F. sonora* Wirth pupae from decaying mats of *Scirpus olneyi* A. Gray in Death Valley, Calif. Adults presumably visit flowers like their neotropical relatives. *F. sonora* has repeatedly been collected from celery blossoms in Utah, and *F. blantoni* Soria and Bystrak was collected from the flowers of elder (*Sambucus simpsonii* Rehd.) (Caprifoliaceae) in Florida.

PROCEDURES

The terminology used here follows Wirth (*1952*). Measurements were obtained according to Chan and LeRoux (*1965*). A representative sample of each species was selected for complete measurement, and the data are presented in the descriptions either as raw values or as ratios, with the mean value first, followed in parentheses by the range of values and the number of specimens examined. A comparison of the values of the more useful characters is given in figure 4.

Several special terms and techniques require further clarification. Body length is taken on whole mounted specimens only and is the distance from the anterior edge of the eyes to the tip of the abdomen. Wing and costal length are measured from the basal arculus to their respective distal ends. Wing width is taken at the widest point. The costal length divided by the wing length gives the costal ratio (CR). Palpal ratio (PR) is the length of the third palpal segment divided by its greatest width. Palpal proportions (PP) are the relative lengths of each palpal segment, not including the first, which is usually impossible to measure. Antennal proportions (AP) are the relative lengths of each antennal flagellomere (for convenience and in accordance with most previous works, hereafter referred to as flagellar segments, although their lack of true segmentation is recognized). The antennal ratio (AR) is obtained by dividing the combined length of the five distal segments in females (four distal segments in males) by the combined length of the remaining proximal flagellar segments. The antennal length is obtained by adding the individual lengths of all flagellar segments and therefore represents a minimum value. All proportions given can be converted to millimeters by multiplying by 0.0022. The flagellar pit is in the pedicel in which the flagellum articulates.

The tarsal ratio (TR) is the length of the first tarsomere divided by the length of the second tarsomere. In the males the hindbasitarsus is considered normal if its greatest width is less than the width of the adjacent end of the tibia, although it may be incrassate. Spermatheca length includes the neck if present and, along with the greatest width, is given in millimeters. Spermathecae are considered "equal" if they are within 0.001 mm of the same dimensions. They are "unequal" if the smaller is no longer than the width of the larger. They are considered "subequal" if they are between these extremes. Colors used refer to phenol-balsam slide-mounted specimens viewed in transmitted light and not to living colors except as noted.

The numerical data collected are of descriptive rather than discriminative value and consequently have not been included in a summarizing table. With few exceptions, no species can be separated based on measurable characters, as shown in figure 4, in which size is graphed to indicate the degree of overlapping to be found within the group. The ratios par-

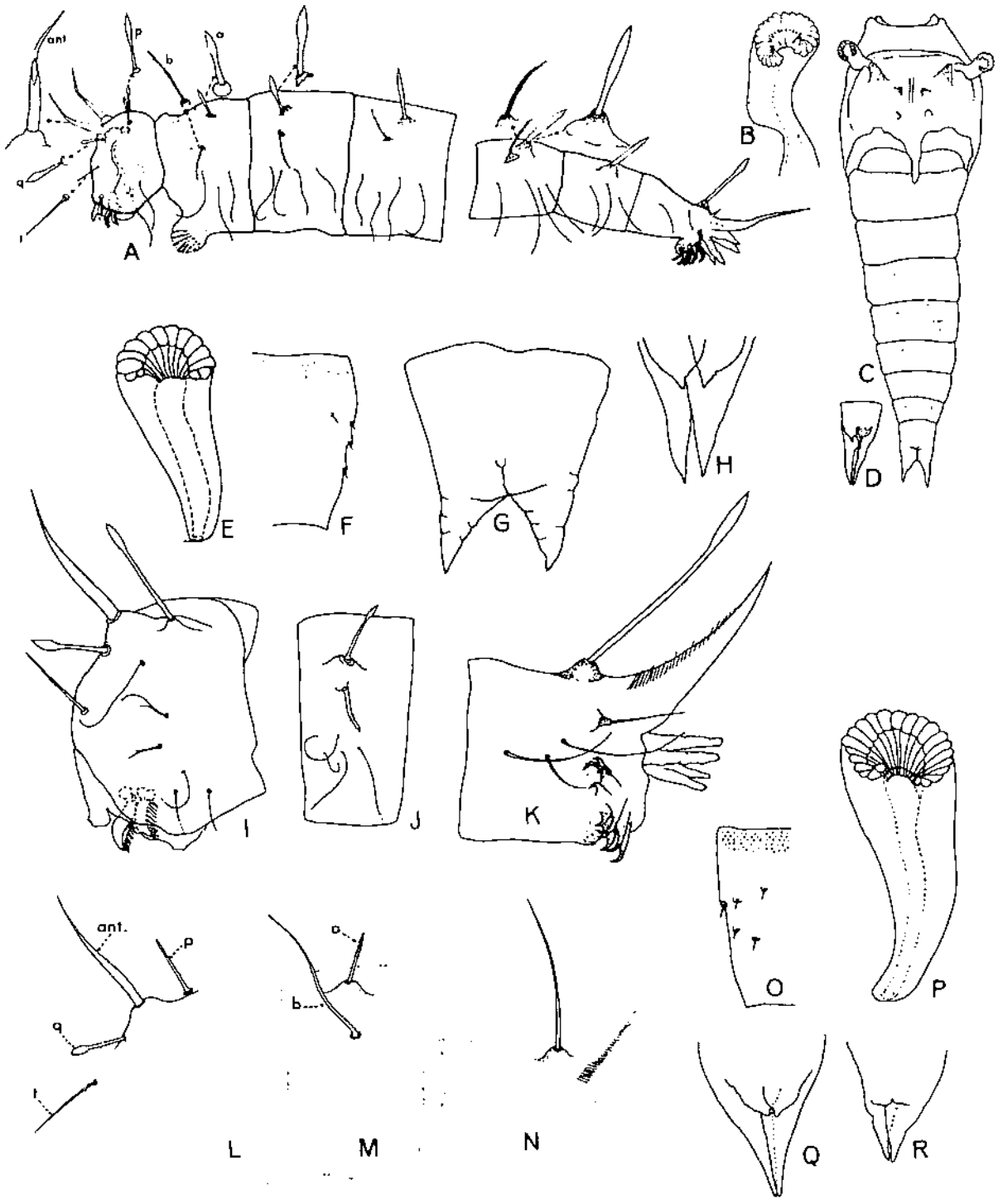


FIGURE 3.—Larvae and pupae of *Forcipomyia* (*Euprojoannisia*) spp.: *A–D, blantoni*; *E–K, canadensis*; *L–R, sonora*. *A*, Anterior and posterior parts of larva, with named setae and antenna as indicated; *B*, *E*, *P*, pupal respiratory horn; *C*, female pupa; *D*, *H*, *Q*, posterior segments of male pupa; *F*, *O*, pupal body segment; *G*, *R*, posterior body segments of female pupa; *I*, *L*, larval head; *J*, *M*, larval body segment; *K*, *N*, larval caudal segment. (*a*, seta *a*; *ant*, antenna; *b*, seta *b*; *p*, seta *p*; *q*, seta *q*; *t*, seta *t*)

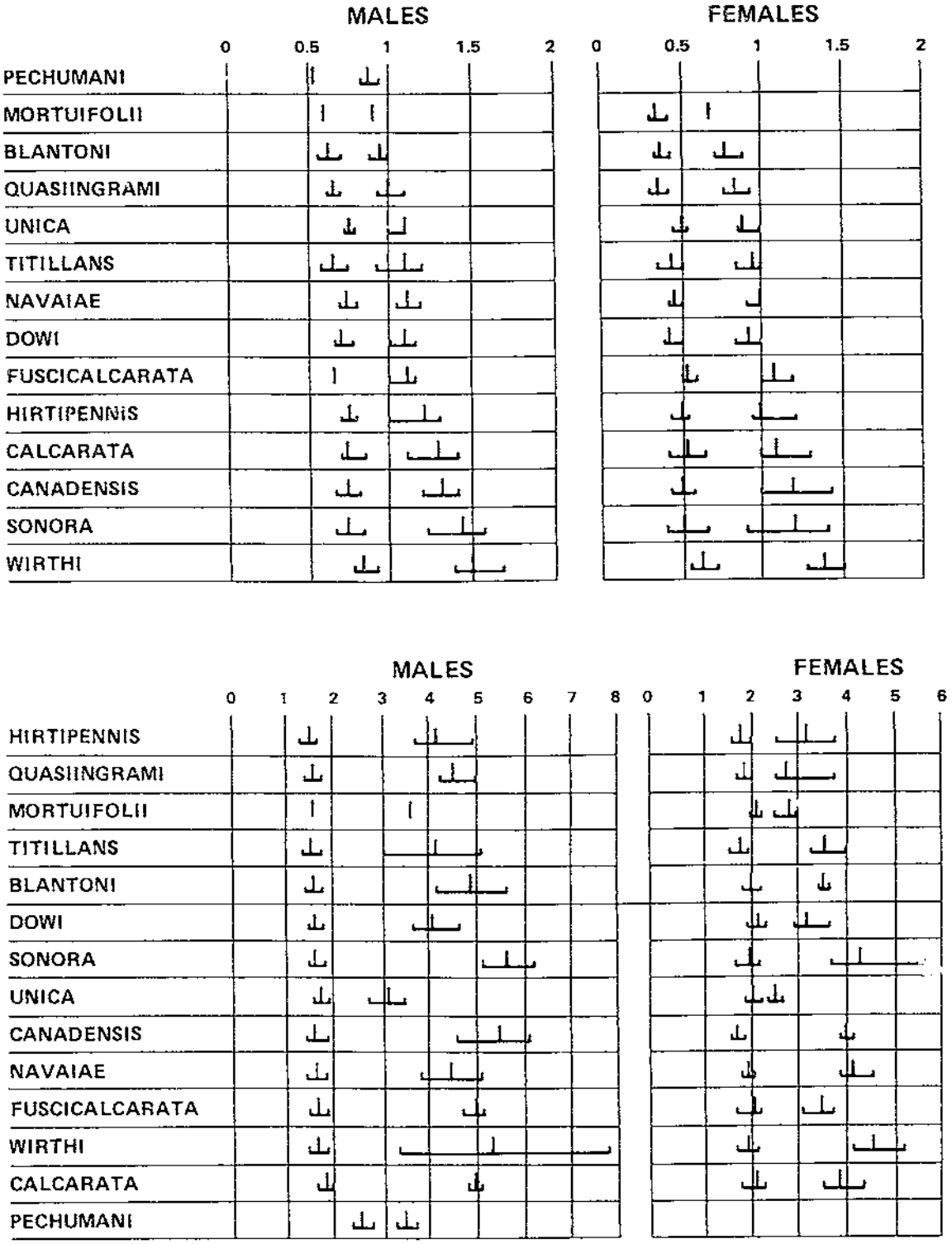


FIGURE 4.—*Forcipomyia* spp.: *Above*, comparison of antennal (left) and wing (right) lengths, in millimeters, *below*, comparison of metathoracic tarsal (left) and palpal (right) ratios. [Vertical bar, mean values; horizontal bar, range of variation]

ticularly are more useful on the subgeneric than on the specific level and are given as ranges in the subgeneric diagnosis.

Although some alcohol-preserved and pinned specimens were used, most of the specimens examined in this study were slide mounted as proposed by Wirth and Marston (*1968*). Holotypes were deposited in the U.S. National Museum in Washington, D.C. Paratypes when available will be deposited in the British Museum (Natural History), London; California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa; and Florida State Collection of Arthropods, Gainesville.

The subgenus *Euprojoannisia* has been particularly troublesome taxonomically. For example, Wirth and Messersmith (*1977*) listed 12 synonyms for the widespread African species *Forcipomyia psilonota* (Kieffer). Under the name *Forcipomyia ingrami* Carter, this species has erroneously been reported from all tropical parts of the world, including southern Florida. For this reason we have illustrated the diagnostic male genitalia of *F. psilonota* (fig. 11, *O*) for comparison with related American species.

Owing to lack of larvae, we could not use Saunders' approach based on larval characters for most of the species. He (*1959*) commented that females are "most difficult to identify" and he noted that even Macfie was "unable to sort them out." Saunders believed males to be more useful, "but they can rarely be associated with females of the same species except by rearing." He declined to describe species with females only. In life, the species must sort themselves by odors, behavioral patterns, or ecological barriers, because physical differences are seldom obvious. To see nearly identical adults that have been reared from obviously different larvae is dismaying. The presence of a double row of dorsal abdominal glands and the vast array of antennal sensilla lends credence to the idea of chemosensory association.

In this study, emphasis was first given to larval characters in the few species available. In the adults, the most useful characters were those least subject to variation from poor mounting. For the males, these are the hind-basitarsus, the basistylar apodeme, the dististyle, and the aedeagus, in that order. For the females, the spermathecae were best, followed by overall size and color, the third palpal segment, and the frontal sclerite. Matching sexes was best done by cross-matching localities, but color and size, especially absolute length of basitarsi, were also useful characters.

SUBGENUS EUPROJOANNISIA BRETHES

Euprojoannisia Brèthes, 1914: 155. Type-species, *Euprojoannisia platensis* Brèthes (orig. desig.).

Forcipomyia, subgenus *Euprojoannisia* Brèthes; Wirth and Cavalieri, 1975: 125 (synonym: *Euforcipomyia* Malloch; combination).

Euforcipomyia Malloch, 1915: 312. Type-species, *Euforcipomyia hirtipennis* Malloch (orig. desig.).

Forcipomyia, subgenus *Euforcipomyia* Malloch; Johannsen, 1943: 778 (combination); Wirth, 1952: 143; Johannsen, 1952: 156; Saunders, 1956a: 662; Remm, 1961: 178; Wirth, 1974: 4.

Forcipomyia, subgenus *Proforcipomyia* Saunders, 1956a: 662. Type-species, *Forcipomyia wirthi* Saunders (orig. desig.); Saunders, 1959: 33; Remm, 1966: 56; Remm, 1967: 5; Wirth, 1973: 355.

Diagnosis.—The following subgeneric descriptions are taken from Saunders (*1956a*) with amplification. They have been expanded to include most of the characters that all members of the group under consideration have in common. They will also apply to neotropical and palaearctic species for which specimens are available or adequate descriptions have been published.

Larva.—Generally elongate and colorless, except for sclerotized head and, frequently, scattered reddish pigmentation spots, apparently in fat bodies. Head semihypognathous; in profile with two flat regions or concavities, one anterior to *q* hairs, the other anterior to *t* hairs; labrum extended to short proboscis. Mandible with medial right angle twist and scooplike distal part. Head with *p* and *q* hairs, body with *a* hairs variable with the species; of useful taxonomic value. Prothoracic pseudopod normally a single spinose mound; may be tipped

with hook-bearing papillae. Anal pseudopod a simple ridge with two anteriorly directed rows of hooks. Cauda tapered to point, generally long, with fringe of setae.

Pupa.—Simple, without unusual processes, colors, or shapes; rarely retaining larval exuviae. Prothoracic horns with apical, nearly complete circle of spiracular papillae. Male sexual processes dorsal.

Adult.—Unmarked gray-brown or yellow-brown, moderately hairy, small midges; normally without distinctive color patterns, setae, scales, or other features.

Head: Eyes bare, black, contiguous or very narrowly separated; occiput with semierect coarse setae. Mandible without teeth in males and some females; most females with very fine sclerotized teeth along distolateral half. Maxilla of female with small, widely spaced, sclerotized teeth. Labrum tapered, blunt ended, with lateral fringe. First palpal segment generally small and indistinct; third segment elongate and slender, swollen midway and bearing sensory pit of variable size and shape but always with capitate sensilla; fourth and fifth segments approximately equal in length and normally incompletely fused. Male PR ranging from 2.60 to 7.83; female PR ranging from 2.18 to 5.30. Pedicel of antenna darker than 13-segmented flagellum. Basal flagellar segments of female spherical to stout vasiform, with short coarse verticils and variable number and arrangement of transparent sensilla of several types. Basal flagellar segments of male roughly spherical, becoming narrower and oblique distally, bearing long plume hairs and one to six small transparent sensilla. Distal segments of three types: Segments 12 and 13 elongate (12 about twice as long as 13 and about one-sixth total flagellar length), with verticils, scattered shorter setae, and scattered transparent sensilla; segment 14 with short verticils and numerous sensilla; segment 15 with numerous sensilla and often swollen. Plume extending distally to base of 14th segment. Both sexes with terminal apical papilla, which is normally bifid. AR from 0.78 to 1.16.

Thorax: First tarsomere always longer than second; in males metathoracic basitarsus variable and of useful taxonomic value. Male metathoracic TR from 1.39 to 3.08; female metathoracic TR from 1.58 to 2.27. Prothoracic tibial comb consisting of heavy setae in variable numbers and arrangement; of taxonomic value. Mesothoracic tibial comb a single row of long coarse setae. Metathoracic tibial comb in two rows, distal row with four to seven stout setae, proximal row with about twice as many shorter, thinner setae. Prothoracic and metathoracic tibia with stout spur. Claws equal, more strongly curved in females than in males; stout and simple in females, slender and bifid in males. Wing densely covered with both microtrichia and slender dark macrotrichia; first radial cell usually open on females and always obliterated on males, second always open in both sexes. CR from 0.38 to 0.60.

Abdomen: Spermathecae variable, usually two and subequal, but may be two equal or unequal, or one. Subgenital sclerotization of female not usually visible. Basistylar apodemes of male joined by arch of variable shape; of considerable taxonomic value. Parameres usually not present; vestigial when present and not visible under most circumstances. Aedeagus darkly sclerotized and gently arched with horizontal valve, or lightly sclerotized and roughly triangular plate with vertical excision; normally with lateral flanges.

KEYS TO NORTH AMERICAN SPECIES OF EUPROJOANNISIA

Adults

1.	Females	2
—	Males	14

FEMALES

2.	One spermatheca present	*unica*, n. sp.
—	Two spermathecae present	3

3. Spermathecae greatly unequal 4
— Spermathecae equal or slightly unequal 6
4. Small spermatheca hyaline (unpigmented) ..... *dowi*, n. sp.
— Small spermatheca pigmented 5
5. Distal edge of ninth sternum with deep V-shaped concavity; frontal sclerite with slight medial bulge; mandibular teeth extremely fine ..... *fuscicalcarata*, n. sp.
— Distal edge of eighth sternum with shallow, rounded concavity; frontal sclerite with pointed medial projection; mandibular teeth conspicuous ..... *calcarata* (Coquillett)
6. Mandible without teeth ..... *hirtipennis* (Malloch)
— Mandible with teeth 7
7. Spermathecae slightly unequal, larger one with minute knobs around base of neck ..... *blantoni* Soria and Bystrak
— Spermathecae equal or slightly unequal, neck without knobs 8
8. Spermathecae equal 9
— Spermathecae slightly unequal 11
9. Distal edge of eighth sternum with deep V-shaped concavity edged with clear flaps over gonopore; northeastern distribution ..... *titillans* (Winnertz)
— Distal edge of eighth sternum with shallow concavity 10
10. Small, yellow-brown, sparsely hairy species with two yellow stripes on mesonotum; Florida only ..... *navaiae*, n. sp.
— Large, dark, very hairy species; western distribution ..... *wirthi* Saunders
11. Spermathecae slightly unequal; palpus short and stout; Florida and tropical distribution 12
— Spermathecae more nearly equal; palpus elongate and slender; western distribution 13
12. Smaller spermatheca with clear punctations; basal antennal segments spherical to stout vasiform ..... *quasiingrami* Macfie
— Both spermathecae darkly sclerotized, smaller without clear punctations; basal antennal segments ellipsoid to spherical ..... *mortuifolii* Saunders
13. Distal edge of eighth sternum with slight concavity; second tarsal ratio larger than third ..... *canadensis*, n. sp.
— Distal edge of eighth sternum with deep concavity; second tarsal ratio smaller than third ..... *sonora* Wirth

MALES

14 (1). Hindbasitarsus as wide or wider than adjacent end of tibia 15
— Hindbasitarsus narrower than adjacent end of tibia 22
15. Parameres sclerotized and conspicuous ..... *pechumani*, n. sp.
— Parameres absent or hyaline and difficult to see 16
16. Basistylar apodemes joined at about 60° angle ..... *calcarata* (Coquillett) (part)
— Basistylar apodemes joined in rounded arch 17
17. Aedeagus a triangular plate; three proximal hindtarsomes brown ..... *fuscicalcarata*, n. sp.
— Aedeagus arched; hindbasitarsus pale or brown 18
18. Basistylar apodemes joined in sharply rounded arch; no visible parameres 19
— Basistylar apodemes joined in broad arch; parameres hyaline plates, faintly visible; hindbasitarsus not infuscated 20
19. Aedeagus a high arch, deeper than wide; hindbasitarsus not infuscated ..... *calcarata* (Coquillett) (part)
— Aedeagus a low arch, wider than deep; hindbasitarsus brown ..... *quasiingrami* Macfie
20. Aedeagus high arched, about as high as wide ..... *wirthi* Saunders
— Aedeagus low arched, about twice as wide as long 21
21. Parameres large, occupying most of space between apodemes, longer than aedeagus ..... *sonora* Wirth
— Parameres small, not longer than aedeagus ..... *canadensis*, n. sp.

22. Ninth sternum with mesal mound bearing two stout spines; dististyle with mesal process ..... *mortuifolii* Saunders
— Ninth sternum without mound; dististyle simple 23
23. Basistylar apodemes joined by straight bar 24
— Basistylar apodemes joined in rounded arch or acute angle 25
24. Apodemes flared distally; distal edge of ninth sternum with deep concavity; aedeagus a triangle on arch; Florida distribution ..... *unica*, n. sp.
— Apodemes forked distally; ninth sternum with concavity; aedeagus a broad, scooplike structure; holarctic distribution ..... *hirtipennis* (Malloch)
25. Apodemes joined at acute angle 26
— Apodemes joined in rounded arch 27
26. Aedeagus a strongly sclerotized arch ..... *navaiae*, n. sp.
— Aedeagus a lightly sclerotized triangular plate ..... *dowi*, n. sp.
27. Aedeagus a strongly sclerotized, boxlike arch; holarctic distribution ..... *titillans* (Winnertz)
— Aedeagus a gently curved, lightly sclerotized arch; Southeastern States and neotropical distribution ..... *blantoni* Soria and Bystrak

Known Immature Stages

1. Larvae 2
— Pupae 5
2. *q* hair a very tiny peg; *a* hair peglike ..... *wirthi* Saunders
— *q* hair hastate, spear shaped; *a* hair various 3
3. *p* hair a simple peg, half length of antenna; *a* hair identical but fringed ..... *sonora* Wirth
— *p* hair hastate; *a* hair various 4
4. *p* hair about third length of antenna; *a* hair of prothoracic a simple club; *a* hairs of body with blade part very small ..... *mortuifolii* Saunders
— *p* hair more than half length of antenna; *a* hairs hastate, with blade less than fourth of total length ..... *canadensis*, n. sp.
5 (1). Retains larval exuviae 6
— Sheds larval exuviae 7
6. Respiratory horn with 22 or more spiracular papillae; terminal processes appressed ..... *sonora* Wirth
— Respiratory horn with 14 or fewer spiracular papillae; terminal processes divergent ..... *canadensis*, n. sp.
7. Thorax with two pairs of conspicuous pointed tubercles; tropical Florida and neotropical distribution ..... *mortuifolii* Saunders
— Thorax with only minute setigerous tubercles; western North America ..... *wirthi* Saunders

DESCRIPTIONS OF FORCIPOMYIA (EUPROJOANNISIA) SPECIES

1. *blantoni* Soria and Bystrak

(Figs. 3, *A–D*, 5)

Forcipomyia (*Euforcipomyia*) *blantoni* Soria and Bystrak, 1975: 3 (Brazil; all stages; figs.).

Forcipomyia (*Euprojoannisia*) sp. 1; Soria et al., 1976: 103 (Ecuador; habits; cacao pollination).

Diagnosis.—Male can be recognized by its normal hindbasitarsus; broad, flat, slightly arched aedeagus with vertical sclerotized cleft; and distally flared basistylar apodemes joined by broad arch. Female has two unequal spermathecae, larger of which is distinctly pyriform in shape with minute knobs around base of neck.

Female.—Wing length 0.80 (0.74–0.87, n = 9) mm; width 0.34 (0.32–0.39, n = 9) mm. Antennal length 0.41 (0.38–0.46, n = 9) mm.

Head: Brown, with decumbent setae. Eyes black, narrowly separated. Frontal sclerite (fig. 5, *E*) with strongly sclerotized, gently arched mark and large triangular projection. Mouth parts light brown; mandible with many sclerotized teeth. Palpus (fig. 5, *C*) light brown; third segment short and stout with lightly sclerotized

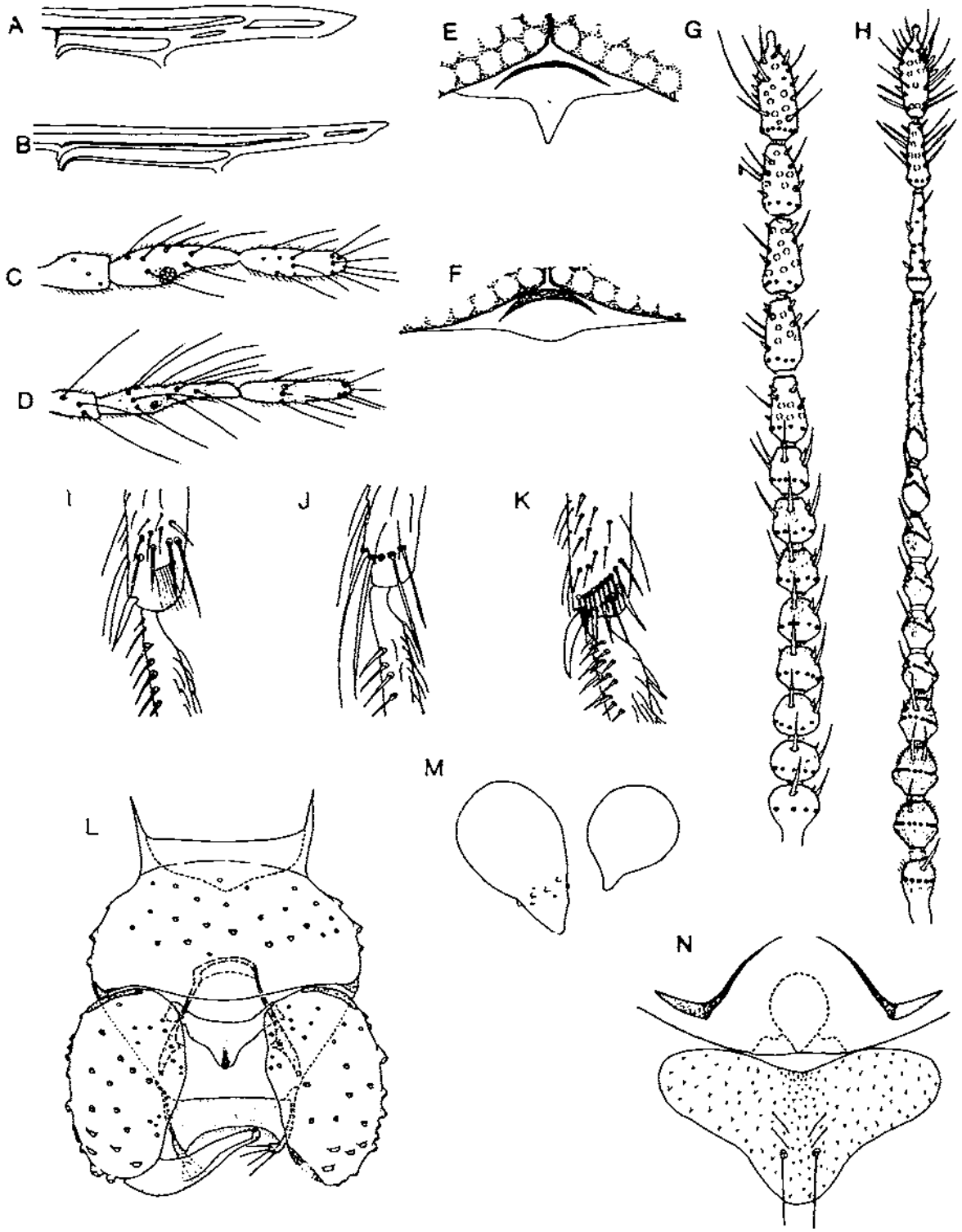


FIGURE 5.—*Forcipomyia blantoni* Soria and Bystrak: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, male frontal sclerite; *G*, female flagellum; *H*, male flagellum; *I*, female foretibial comb; *J*, female midtibial comb; *K*, female hindtibial comb; *L*, male genitalia; *M*, spermathecae; *N*, female genitalia.

shallow pit containing 10–12 capitate sensilla; PR 3.34 (3.11–3.44, n = 9); PP 13–29–16–20. Antenna (fig. 5, *G*) light brown; segments 3–10 nearly spherical, with coarse verticils and clear sensilla, including some arranged in pairs of large slender one and small peglike one; segments 11–15 longer, tapered, with verticils and many clear sensilla of various types; segment 15 with medial seta and apical papilla; AP 14–10–10–11–11–11–11–11–16–18–17–17–25; AR 1.0 (0.93–1.10, n = 9).

Thorax: Mesonotum shining brown, pleuron and scutellum yellow brown. Scutellum and lateral edges of mesonotum with contiguous row of larger than average setae. Foretibial comb (fig. 5, *I*) with two rows of stout, dark setae; midtibial and hindtibial combs (fig. 5, *J–K*) normal. Prothoracic TR 2.30 (2.08–2.36, n = 9); mesothoracic TR 1.83 (1.66–1.93, n = 9); metathoracic TR 1.93 (1.82–2.19, n = 9). Wing with dense covering of dark, semierect macrotrichia; first radial cell very narrow, second long and wide (fig. 5, *A*); CR 0.55 (0.50–0.60, n = 9). Halter brown.

Abdomen: Brown, with small brown pigment spots. Two unequal spermathecae (fig. 5, *M*), darkly sclerotized; the larger pyriform, with small knobs around base of neck, averaging 0.077 by 0.050 mm; the smaller spherical with distinct neck, averaging 0.060 by 0.041 mm (n = 9). Distal edge of ninth sternum (fig. 5, *N*) transverse, internal apodemes gently rounded.

Male.—Wing length 0.95 (0.87–1.00, n = 10) mm; width 0.29 (0.26–0.32, n = 10) mm. Antennal length 0.61 (0.57–0.68, n = 8) mm.

Head: Brown, with semierect setae. Frontal sclerite (fig. 5, *F*) with medial triangular projection and dark, arched, sclerotized mark. Mouth parts light brown. Palpus (fig. 5, *D*) light brown; third segment long and narrow, with small, shallow, unsclerotized pit containing a few capitate sensilla; PR 4.83 (4.29–5.67, n = 9); PP 16–33–17–10. Antenna (fig. 5, *H*) light brown, with dense, light-brown plume; pedicel brown; segments 3–11 vasiform, becoming narrower and oblique distally, with pair of long sensilla; segments 12 and 13 long, narrow, with scattered coarse setae and clear sensilla; segments 14 and 15 densely covered with clear sensilla; segment 15 without verticils and with apical papilla; AP 15–15–15–13–13–13–13–13–13–15–51–33–20–29; AR 0.95 (0.90–1.00, n = 9).

Thorax: Colors as in female. Prothoracic TR 1.98 (1.86–2.40, n = 10); mesothoracic TR 1.51 (1.23–1.67, n = 9); metathoracic TR 1.66 (1.56–1.77, n = 10). Hindbasitarsus normal. Wing covered with fine decumbent macrotrichia; first radial cell obliterated, second nearly closed (fig. 5, *B*); CR 0.48 (0.41–0.52, n = 10). Halter brown.

Abdomen: Brown, with scattered setae. Genitalia as in figure 5, *L*. Basistyle 1.7 times as long as wide and 1.2 times as long as dististyle; dististyle tapered, with darker, slight hook at tip. Aedeagus a broad, lightly sclerotized arch with darkly sclerotized vertical cleft. Basistylar apodemes flared distally and joined by broad arch. Parameres absent.

Larva (fig. 3, *A*).—Length (4th instar) 2.87 (2.39–3.16, n = 12) mm. Body elongated and tapered. General color milky, some specimens bearing reddish pigmentation on dorsal surface of first three segments. Head small, sclerotized, scalloped in profile; *p* and *q* hairs stout and hastate, *t* hair simple. Antenna long, bent posteriorly from about the middle. Eyes large and conspicuous. Prothoracic pseudopod a simple mound covered with small hooks. Body with *a* hairs stout and hastate, on darkened tubercles; *b* (?) hairs dark, fringed, arising from small tubercles; missing on precaudal and caudal segments. Each segment, except prothoracic, precaudal, and caudal, bearing four long, simple lateral setae. Cauda long and slender, without fringe. Anal blood gills bifid, stout.

Pupa (fig. 3, *C*).—Length, male 2.08 (1.90–2.29, n = 7) mm; female 1.99 (1.84–2.16, n = 8) mm. Larval exuviae not retained. Generally light gray brown, without any conspicuous features. Thorax with three pairs of tubercles, anterior large and knobby, posterior small, simple mounds. Prothoracic horn (fig. 3, *B*) large with long connecting stem, averaging 0.14 (0.13–0.15, n = 14) mm long, with mediposterior heel and about 26 spiracular papillae. Terminal processes slightly divergent, longer in males. Male sexual processes (fig. 3, *D*) dorsal.

Distribution.—Circum Caribbean, from Vir-

ginia in North America south to at least central Brazil in South America.

Types.—Holotype, male, reared in laboratory from wild female collected by S. Soria at Ilheus (Centro de Pesquisas do Cacau), Bahia, Brazil, 7 Aug. 1973. Allotype, female, parent of holotype. Four males, five females, five larvae, and five pupae from same lot of progeny were designated as paratypes.

Specimens Examined.—ALABAMA: Wilson Dam, 17 May 1954, W. E. Snow, 1 male. FLORIDA: Alachua Co., Gainesville, May–Aug. 1967, F. S. Blanton, UV (ultraviolet) light, 21 males, 38 females. Baker Co., Glen St. Mary, 11 June 1957, E. W. Holder, Jr., car window, 1 male, 1 female. Dade Co., Homestead, 9 Sept. 1968, R. M. Baranowski, UV trap, 2 males, 3 females; Miami, 1944, W. W. Wirth, light trap, 1 male; 31 Aug. 1966, J. C. Buff, light trap, 2 females; Orchid Jungle, May–June 1969, R. M. Baranowski, UV trap, 4 males, 2 females. Escambia Co., Molino, 12 Aug. 1969, F. S. Blanton, UV trap, 4 males. Gilchrist Co., no locality, 3 July 1960, G. Hicks, 1 female. Hardee Co., Wachula, 13 June 1960, W. Jernigan, 1 male. Highlands Co., Archbold Biological Station, 23 Mar. 1970, S. W. Frost, on flowers of *Sambucus simpsoni*, 4 females; Sebring, Highland Hammock St. Park, 15 Apr. 1970, W. W. Wirth, light trap, 2 males. Hillsborough Co., Tampa, Mar. 1967, Taylor coll., 1 female. Indian River Co., Vero Beach, Apr. 1956–Jan., Nov. 1957, Oct. 1958, Feb., Mar., Apr. 1959, Jan., Apr. May, Dec. 1960, Ent. Res. Center, light trap, 11 males, 36 females. Jefferson Co., Monticello, Oct. 1969, W. H. Whitcomb, UV trap, 1 male, 2 females. Leon Co., Tallahassee, May 1970, F. S. Blanton, UV trap, 2 males. Liberty Co., Torreya St. Park, 30 June 1957, F. S. Blanton, 3 females; 4 July 1965, H. V. Weems, 1 female. Marion Co., Juniper Springs, 28 Apr. 1970, W. W. Wirth, 2 females. Orange Co., Lake Magnolia Park, 6 Aug. 1970, E. Irons, UV trap, 1 male, 1 female. Putnam Co., Lons Lake, Sept. 1971, F. S. Blanton, UV trap, 1 male, 13 females. MISSISSIPPI: Harrison Co., Gulfport, 1 Aug. 1968, R. E. Woodruff, UV trap, 1 female. SOUTH CAROLINA: Charleston, Sept. 1969, W. B. Ezell, light trap, 3 males, 1 female. VIRGINIA: Fairfax Co., Falls Church, June–Aug. 1958, W. W. Wirth, light trap, 1 male, 3 females.

Discussion.—*F. blantoni* is one of the most important pollinators of cacao in Brazil and Ecuador (Soria and Wirth, *1974;* Soria et al., *1976*). In Florida it has been collected from the blossoms of elder.

2. *calcarata* (Coquillett)

(Figs. 6, 11, *P*)

Ceratopogon calcaratus Coquillett, 1905: 64 (male; Mexico); Kieffer, 1906: 50 (in list).

Forcipomyia (Euforcipomyia) calcarata (Coquillett); Johannsen, 1943: 778 (combination); Johannsen, 1952: 158 (in key); Wirth, 1952: 143 (misidentification); Wirth, 1965: 124 (distribution).

Diagnosis.—Very common, large, darkly pigmented species. Male with basistyle slender and curved; aedeagus a high rounded, darkly sclerotized arch; basistylar apodemes unbranched and joined in gently rounded arch; hindbasitarsus slightly swollen. Female with one large and one small darkly sclerotized spermathecae and shallow concavity in distal edge of eighth sternum.

Female.—Wing length 1.1 (1.0–1.3, n = 11) mm; width 0.47 (0.42–0.52, n = 11) mm. Antennal length 0.54 (0.49–0.67, n = 11) mm.

Head: Head and antennal pedicel brown. Eyes black and contiguous. Frontal sclerite (fig. 6, *F*) relatively indistinct, with medial projection. Mouth parts light brown; mandible (fig. 6, *E*) with numerous conspicuous teeth. Palpus (fig. 6, *C*) light brown; third segment swollen, with large (0.013 mm average diameter), deep, round pit containing 13–15 short-stemmed, bulbous sensilla; fourth and fifth palpal segments partly fused, fourth twice length of fifth and slightly thicker; PR 3.78 (3.36–4.29, n = 11); PP 19–42–22–11. Antennal segments (fig. 6, *H*) light brown; 3–10 vasiform, longer than wide; 11–15 longer, tapered, with numerous sensilla; apical papilla and medial seta on segment 15; AP 18–13–15–15–16–15–16–16–21–21–21–21–31; AR 0.92 (0.86–0.97, n = 11).

Thorax: Mesonotum and postscutellum shining brown, scutellum and pleural region yellow brown, legs dark yellow. Thorax with many fine setae and row of large coarse setae along

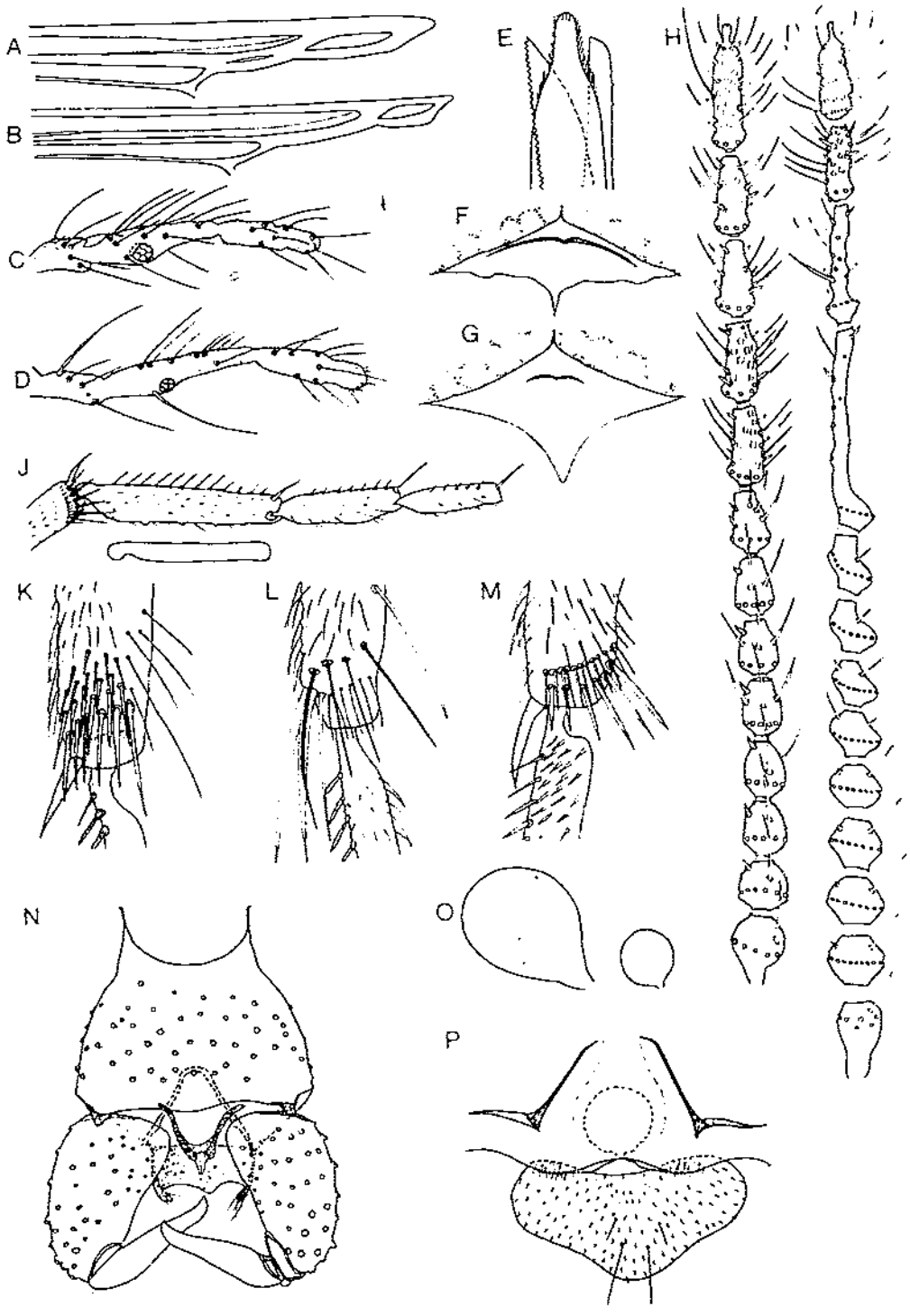


FIGURE 6.—*Forcipomyia calcarata* (Coquillett): *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female mandible, labrum, and maxilla; *F*, female frontal sclerite; *G*, male frontal sclerite; *H*, female flagellum; *I*, male flagellum; *J*, male hindtarsus, with midbasitarsus for comparison; *K*, female foretibial comb; *L*, female midtibial comb; *M*, female hindtibial comb; *N*, male genitalia; *O*, spermathecae; *P*, female genitalia.

pleural edge of mesonotum, connected with similar row across scutellum. Tibial combs as illustrated (fig. 6, *K–M*). Prothoracic TR 2.14 (1.95–2.25, n = 11); mesothoracic TR 1.85 (1.67–2.14, n = 11); metathoracic TR 2.09 (1.93–2.27, n = 11). Wing sparsely covered with coarse macrotrichia; first radial cell narrowly open, second large, long, narrow (fig. 6, *A*); CR 0.53 (0.50–0.55, n = 11). Halter usually translucent brown, occasionally black.

Abdomen: Brown or yellow brown, with dense layer of red particles internally and numerous fine yellow setae externally. Two unequal spermathecae (fig. 6, *O*), both ovoid, with short necks and darkly sclerotized; the larger with clear punctations and averaging 0.067 by 0.047 mm; the smaller 0.025 by 0.022 mm (n = 11). Distal edge of eight sternum (fig. 6, *P*) with shallow concavity.

Male.—Wing length 1.3 (1.1–1.4, n = 10) mm; width 0.37 (0.32–0.39, n = 11) mm. Antennal length 0.73 (0.72–0.85, n = 10) mm.

Head: Dark brown, with coarse hooked setae on vertex. Frontal sclerite indistinct (fig. 6, *G*). Mouth parts and antenna light brown, antenna bearing thick yellow plume reaching to 14th segment. Palpus (fig. 6, *D*) light brown; third segment slender, very elongate, with small deep pit; fourth and fifth segments as in female; PR 4.93 (4.44–5.22, n = 10); PP 20–45–23–11. Flagellar pit round and striated. Antennal segments (fig. 6, *I*) 4–11 roughly spherical, becoming oblique and narrow distally; segments 12 and 13 elongate, with numerous widely scattered sensilla, segment 12 twice as long as 13; segments 14 and 15 slightly swollen, with numerous fine sensilla and terminal papilla; AP 28–19–18–18–17–17–18–19–20–72–42–30–36; AR 1.0 (0.98–1.1, n = 10).

Thorax: As in female, with usual sexual differences. Prothoracic TR 1.92 (1.76–2.09, n = 11); mesothoracic TR 1.45 (1.37–1.50, n = 11); metathoracic TR 1.81 (1.69–1.91, n = 11). Hindbasitarsus not darkened, swollen, twice as wide as midbasitarsus and as wide or wider than adjacent end of hindtibia (fig. 6, *J*). Wing sparsely covered with prostrate macrotrichia; first radial cell obliterated, second short and relatively wide (fig. 6, *B*); CR 0.47 (0.45–0.49, n = 10). Halter brown.

Abdomen: As in female, with usual differences. Genitalia as in figure 6, *N*. Basistyle long and slender, curved, with numerous large coarse setae, about half as wide as long; dististyle hooked distally, 0.8 as long as basistyle. Aedeagus darkly sclerotized, high arched, 0.75 as long as wide, with lighter vertical valves. Basistylar apodeme unbranched, with slight flange distally and joined in arch varying from acutely angled (fig. 11, *P*) to gently rounded (fig. 6, *N*). Parameres flat, platelike, when present, but usually not visible.

Distribution.—Florida, Mexico, South Caroline, Virginia.

Type.—Holotype, male, on pin with genitalia mounted on slide, Frontera, Tabasco, Mexico, 19 Feb., C. H. T. Townsend (USNM type No. 8368).

Specimens Examined.—FLORIDA: Alachua Co., Gainesville, Apr.–July 1967, F. S. Blanton, light trap, 31 males, 59 females; 18 Nov. 1969, F. W. Mead, light trap, 1 male. Baker Co., Macclenny, July 1971, F. S. Blanton, UV trap. Collier Co., Collier Seminole St. Park, 17 May 1973, W. W. Wirth, light trap, 1 male, 7 females. Dade Co., Miami, 1943–44, W. W. Wirth, light trap, 3 males; 17 Feb. 1961, A. S. Mills, light trap, 1 female. Gilchrist Co., Suwanee River, June 1962, G. K. Hicks, 1 female. Hardee Co., Ona, July 1970, E. Irons, light trap, 7 males, 11 females; Wauchula, 13 June 1960, W. Jernigan, light trap, 1 male. Indian River Co., Fellsmere, 17 Mar. 1956, Ent. Res. Center, light trap, 4 males, 2 females; Vero Beach, Nov. 1957, W. L. Bidlingmayer, 4 males, 4 females; July–Aug. 1958, Apr., Aug. 1959, Jan., Mar., Apr., May, Dec. 1960, Apr. 1961, Ent. Res. Center, light trap, 16 males, 21 females. Lee Co., Sanibel Island, 30 July 1962, F. S. Blanton, light trap, 1 female; 11 May 1973, W. W. Wirth, light trap, 1 female. Monroe Co., Everglades State Park, 24 July 1962, F. S. Blanton, light trap, 2 females. Orange Co., Lake Magnolia Park, 6 Aug. 1970, E. Irons, UV trap, 1 male, 6 females; Rock Springs, 15 Dec. 1951, M. E. McDuffie, emergence trap, 1 male. Putnam Co., Lons Lake, Sept. 1971, F. S. Blanton, UV trap, 1 male, 7 females; Red Water Lake, 27 May 1967, F. S. Blanton, 1 male, 8 females. Sarasota Co., Myakka River St. Park,

21 May 1973, W. W. Wirth, light trap, 16 males, 8 females. St. Lucie Co., Fort Pierce, Mar. 1956, St. Bd. Health, light trap, 5 males, 6 females. SOUTH CAROLINA: Charleston, Aug. 1975, D. L. Kline, emergence trap, dredge spoil island, 2 males, 2 females. VIRGINIA: Fairfax Co., Falls Church, 8 July 1950, 28 Sept. 1960, W. W. Wirth, 2 males.

MEXICO: Quintana Roo, Cancun, 22 Apr. 1974, D. Pletsch, light trap, 1 male.

Discussion.—In the holotype of *F. calcarata* (fig. 11, *P*), the basistylar apodemes form an acute angle instead of a gentle arch. In our Florida populations, about 10 to 20 percent of the males had the arch forming an acute angle; the series varied toward the more prevalent gently rounded extreme shown in figure 6, *N*. The immature stages and life history of this species are unknown.

3. *canadensis*, new species

(Figs. 3, *E–K*, 7)

Diagnosis.—Larvae can be identified by presence of hastate *p*, *q*, and *a* hairs, all of which are shorter than antenna. Pupal horn is symmetrical and tapered, with 10 to 14 spiracular papillae. Males have hindbasitarsus as wide as tibia, semicircular aedeagus, and basistylar apodemes joined in rounded arch bearing small, hyaline parameres. Females have slightly subequal spermathecae, mandibular teeth, shallow depression on distal edge of eighth sternum, and second TR larger than third.

Female.—Wing length 1.20 (0.97–1.40, n = 5) mm; width 0.49 (0.45–0.55, n = 4) mm. Antennal length 0.50 (0.46–0.53, n = 5) mm.

Head: Dark brown, with slender, semierect setae on vertex. Eyes black, narrowly separated. Frontal sclerite (fig. 7, *E*) with long slender medial projection. Palpus (fig. 7, *C*) brown, long, and slender; third segment with deep, sclerotized pit; fourth and fifth segments nearly fused; PR 3.98 (3.80–4.10, n = 5); PP 20–38–24–12. Antenna (fig. 7, *F*) brown; basal segments stout vasiform, with two very long clear sensilla; distal segments elongate vasiform, with relatively few clear sensilla; terminal papilla bifid; AP 17–13–13–14–14–14–14–15–20–21–20–21–28; AR 0.97 (0.93–1.00, n = 5).

Thorax: Dark brown, scutellum and pleuron slightly lighter. Foretibial comb (fig. 7, *H*) with five slender setae; hindtibial comb (fig. 7, *I*) normal. Legs gray brown. Prothoracic TR 2.07 (1.95–2.22, n = 5); mesothoracic TR 1.94 (1.89–2.00, n = 4); metathoracic TR 1.73 (1.67–1.79, n = 5). Wing with dense covering of slender, medium gray macrotrichia; first radial cell nearly closed, second short (fig. 7, *A*); CR 0.49 (0.48–0.50, n = 5). Halter brown (chalky white in life).

Abdomen: Brown, dorsal glands present. Two subequal subspherical spermathecae (fig. 7, *K*), darkly sclerotized with distinct necks; the larger averaging 0.093 by 0.081 mm; the smaller 0.085 by 0.064 mm (n = 5). Distal edge of eighth sternum (fig. 7, *L*) with ventral V-shaped depression anterior to slight concavity.

Male.—Wing length 1.3 (1.2–1.4, n = 4) mm; width 0.42 mm. Antennal length 0.76 (0.72–0.77, n = 4) mm.

Head: Brown, with coarse setae. Palpus (fig. 7, *D*) long and slender; third segment cylindrical, pit shallow and bearing two or three protruding bulbous sensilla; fourth and fifth segments practically fused; PR 5.38 (4.50–6.14, n = 4); PP 21–44–25–12. Antenna (fig. 7, *G*) brown, with light-brown plume; basal segments subspherical, smaller and oblique distally, with one or two long sensilla; segments 7–10 apparently fused; segment 12 elongate, about one-fifth length of antenna; segment 13 similar but half as long; segments 14 and 15 with dense covering of clear sensilla; segment 15 bearing bifid or trifid apical papilla; AP 30–19–18–17–16–16–18–19–19–65–37–26–38; AR 0.97 (0.95–1.00, n = 4).

Thorax: As in female, with usual differences. Prothoracic TR 1.99 (1.95–2.05, n = 4); mesothoracic TR 1.68 (1.60–1.80, n = 4); metathoracic TR 1.70 (1.64–187, n = 4). Hindbasitarsus as wide as adjacent end of tibia. Wing with sparse covering of macrotrichia; first radial cell obliterated, second narrow (fig. 7, *B*); CR 0.43 (0.39–0.46, n = 4). Halter brown.

Abdomen: Brown, densely covered with setae. Genitalia as in figure 7, *K*. Basistyle 1.6 times as long as wide; dististyle thick and blunt ended, 0.8 times as long as basistyle. Aedeagus

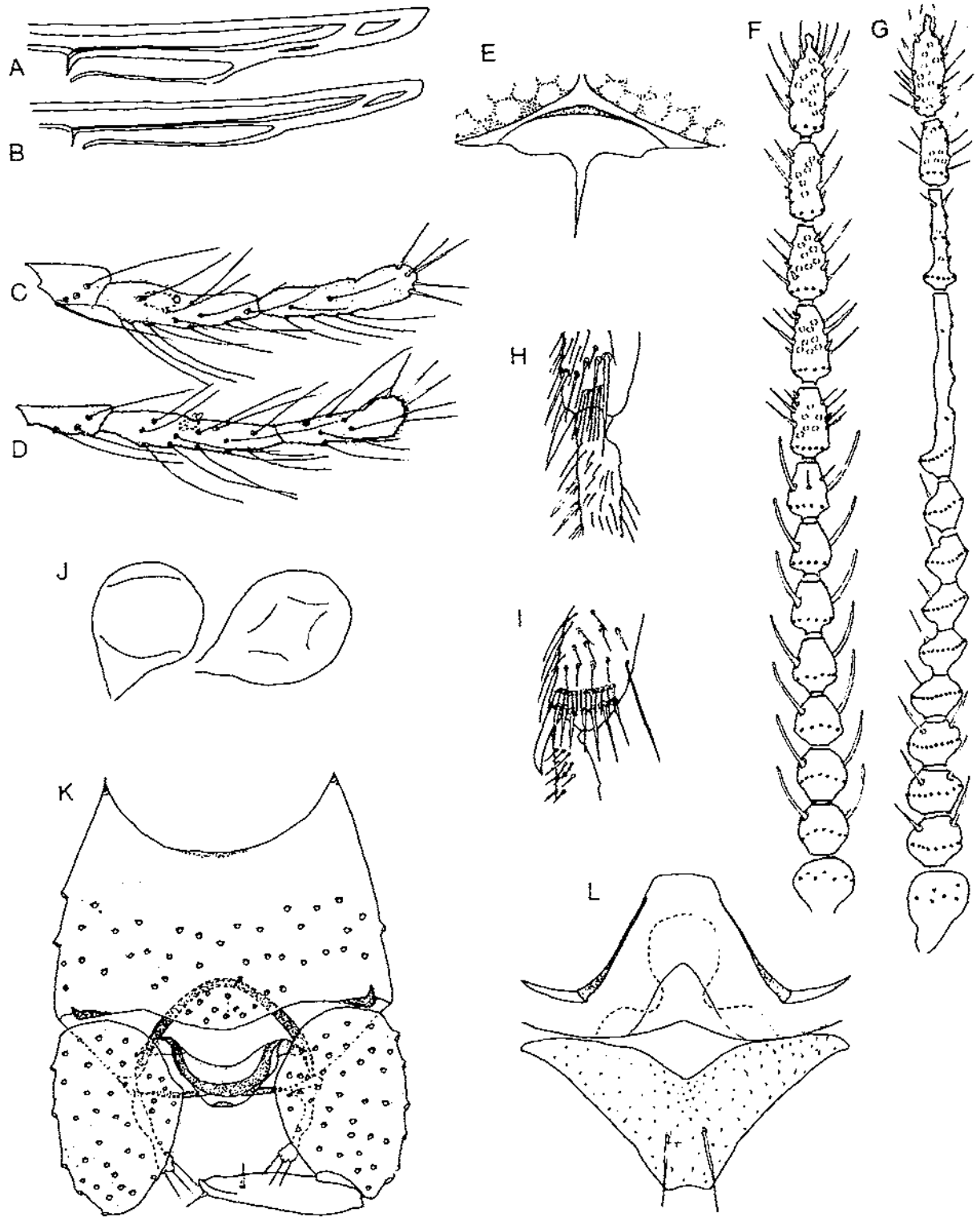


FIGURE 7.—*Forcipomyia canadensis*, new species: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, female flagellum; *G*, male flagellum; *H*, female foretibial comb; *I*, male hindtibial comb; *J*, spermathecae; *K*, male genitalia; *L*, female genitalia.

a low arch, somewhat derby hat shaped, lightly sclerotized, with lateral flanges. Basistylar apodemes joined in rounded arch, from which two small hyaline parameres arise. Parameres not longer than aedeagus. Distal edge of ninth sternum with large concavity; distal edge of ninth tergum sclerotized.

Larva (fig. 3, *I–K*).—Length 2.9 (2.6–3.2, n = 4) mm. Head strongly sclerotized, blackish; remainder with strong red-brown pigmentation, fading and broken toward cauda. On head, *q* hair half spear shaped, about half length of antenna; *p* hair hastate, about as long as antenna. Prothoracic pseudopod a simple, spinose cushion. Posterior pseudopod normal. Body with *a* hairs hastate (fig. 3, *J*); *b* hairs peglike, slightly shorter than *a* hairs. Precaudal *a* hair (fig. 3, *K*) hastate, longer than cauda; subcaudal *b* hair rapierlike. Cauda with fringe. Anal blood gills slender, elongate, bifid.

Pupa (fig. 3, *E–H*).—Length, female 2.9 (2.6–3.2, n = 3) mm; greatest width 0.9 mm. Retains larval exuviae. Body segments (fig. 3, *F*) completely unadorned, without significant tubercles or setae; mottled with color of larva. Respiratory horn (fig. 3, *E*) 0.1 mm long (n = 3), tapered, symmetrical, with 10–14 spiracular papillae. Terminal processes of male (fig. 3, *H*) longer than in female (fig. 3, *G*), both slightly divergent.

Distribution.—Western North America.

Types.—Holotype, male, allotype, female, Echo Lake, Saskatchewan, Sept. 1956, L. G. Saunders, from wet moss (Type No. 72220, USNM). Paratypes, 9 males, 14 females, 36 larvae, 9 pupae, as follows:

ALASKA: Palmer, 7 July 1964, K. M. Sommerman, jeep trap, 1 male. COLORADO: Rio Grande Co., South Fork, 10,000-foot elevation, 2 June 1972, W. W. Wirth, pupa collected from soft mud and sedges at brook margin, 1 male with larval and pupal exuviae. WASHINGTON: Olympic Nat. Park, Elwha River, 6 July 1968, W. W. Wirth, boggy forest, 1 male.

BRITISH COLUMBIA: Nanaimo, July 1926, L. G. Saunders, 2 males, 1 larva, 1 pupa. SASKATCHEWAN: Same data as holotype, 1 male, 9 females, 32 larvae, 2 pupae. Pike Lake, Oct. 1957, L. G. Saunders, from wet moss, 3 males, 5 females, 3 larvae, 6 pupae.

Discussion.—The specific name is taken from the predominantly Canadian distribution of this species. *F. canadensis* inhabits wet situations at high altitudes or latitudes, where the larvae live in moss or other vegetation. Although the larvae and pupae are easily identified, the adults are practically indistinguishable from those of *F. sonora* and *wirthi*. The male hindbasitarsus of *F. canadensis*, however, is noticeably broader than in the two related species, with the ventral spines especially well developed.

4. *dowi*, new species

(Fig. 8)

Diagnosis.—Male can be recognized by its normal hindbasitarsus; lightly sclerotized, platelike aedeagus with darkly sclerotized vertical cleft; and basistylar apodemes flaring from acute and obsolescent angle of fusion. Female has one normal spermatheca and one small clear round spermatheca. Both sexes are densely pigmented in abdomen and scutellum with red or dark-brown particles.

Female.—Wing length 0.95 (0.84–1.00, n = 10) mm; width 0.40 (0.35–0.42, n = 10) mm. Antennal length 0.47 (0.44–0.50, n = 11) mm.

Head: Brown, with semierect coarse setae. Eyes black, narrowly separated. Frontal sclerite (fig. 8, *E*) with long medial projection. Mouth parts yellow brown; mandible with many fine teeth. Palpus (fig. 8, *C*) light brown; third segment stout, with large sensory pit containing 12 capitate sensilla, and located proximad of midlength of segment; fourth and fifth segments fused, fourth part almost twice as long as fifth; PR 3.15 (2.73–3.56, n = 10); PP 15–31–17–10. Antenna (fig. 8, *F*), except pedicel, light brown; segments 3–10 globular, with scattered clear sensilla; segments 11–15 longer, tapered, densely covered with clear sensilla; terminal segment bearing apical papilla; AP 15–11–12–13–13–13–13–14–18–20–20–20–28; AR 0.98 (0.91–1.00, n = 10).

Thorax: Entirely yellow brown. Legs paler, covered with fine yellow setae. Hindtibial comb (fig. 8, *J*) in 2 rows, distal with 6 stout setae, proximal with 10–12 shorter, finer setae; midtibial comb (fig. 8, *I*) with single row of long, light-colored setae; foretibial comb (fig. 8, *H*) in 3 rows of 5, 5, and 3 setae with distal being

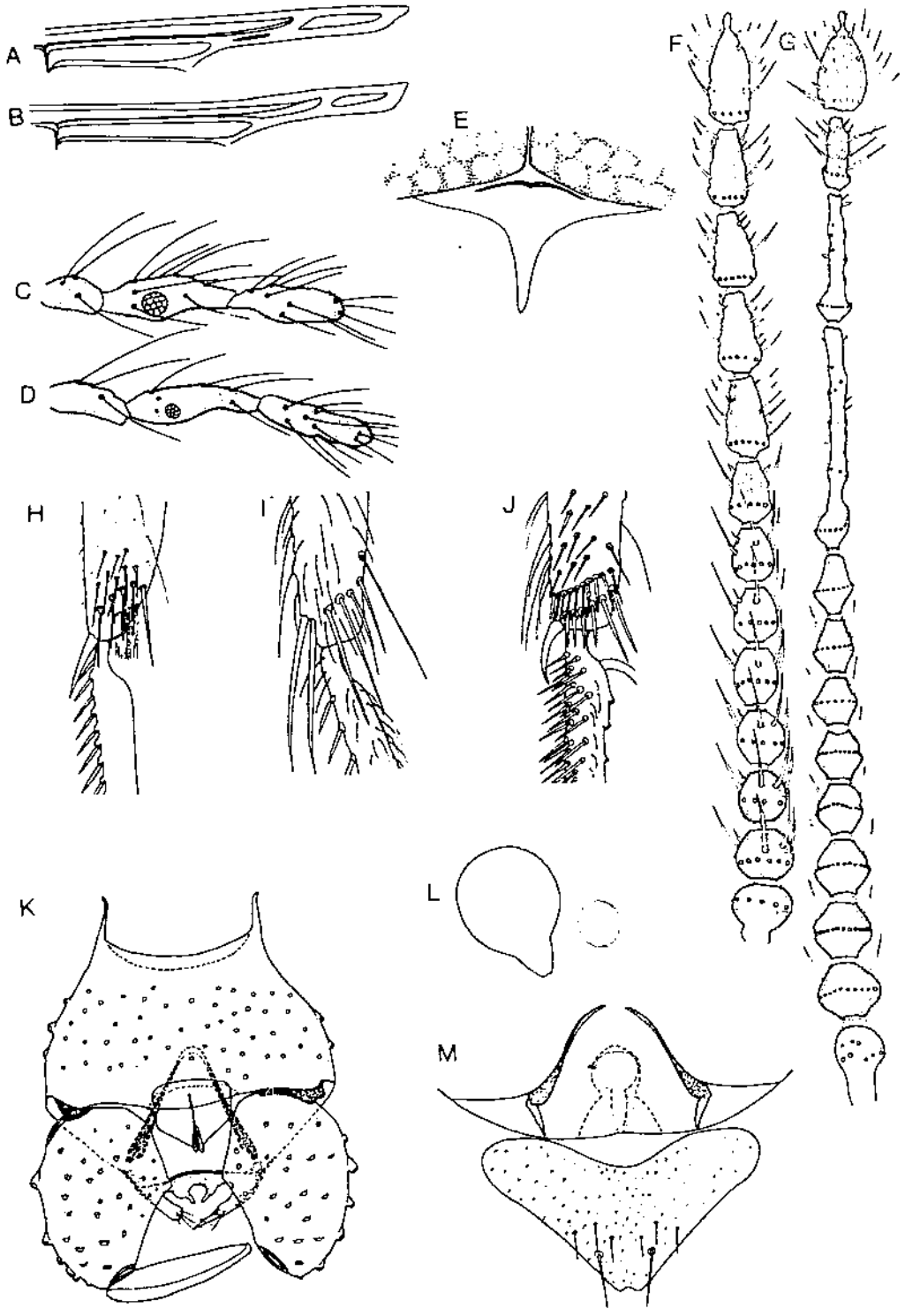


FIGURE 8.—*Forcipomyia dowi*, new species: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, female flagellum; *G*, male flagellum; *H*, female foretibial comb; *I*, female midtibial comb; *J*, female hindtibial comb; *K*, male genitalia; *L*, spermathecae; *M*, female genitalia.

longest. Prothoracic TR 2.07 (1.88–2.31, n = 10); mesothoracic TR 1.95 (1.81–2.12, n = 10); metathoracic TR 2.01 (1.91–2.11, n = 10). Wing densely covered with fine macrotrichia; first radial cell open but very narrow, second long, wider, lanceolate (fig. 8, *A*); CR 0.53 (0.50–0.58, n = 10). Halter black, stem ribbed medially.

Abdomen: Yellow brown, with red particles and fine yellow setae. Two very unequal spermathecae (fig. 8, *L*); the larger ovoid, darkly sclerotized, with neck, averaging 0.067 by 0.047 mm (n = 9); the smaller spherical, clear, without neck, averaging 0.025 mm in diameter (n = 10). Distal edge of eighth sternum (fig. 8, *M*) flat, internal apodemes rounded, anal cone slightly concave distally.

Male.—Wing length 1.1 (1.0–1.2, n = 10) mm; width 0.33 (0.32–0.39, n = 10) mm. Antennal length 0.70 (0.66–0.77, n = 10) mm.

Head: Shining dark brown, antenna (except pedicel), palpus, and mouth parts lighter flat brown. Third palpal segment (fig. 8, *D*) elongate, with small, shallow, round pit containing seven to eight capitate sensilla; fourth and fifth segments partly fused, fourth almost twice length of fifth; PR 4.12 (3.67–4.71, n = 9); PP 17–36–19–10. Antennal segments (fig. 8, *G*) 3–10 broadly ovoid, becoming narrower distally, bearing dense light-brown plume reaching to 14th segment; segments 12 and 13 elongate, 12 almost twice length of 13; both with slender verticils, scattered coarse setae, and numerous clear sensilla; segment 14 tapered, with numerous clear sensilla and verticils; segment 15 similar but swollen, without verticils, half as wide as long and with apical papilla; flagellar pit striated: AP 29–17–17–16–15–15–14–16–17–62–37–23–32; AR 0.99 (0.93–1.10, n = 10).

Thorax: Mesonotum and postscutellum shining brown; scutellum and pleural region lighter and more yellow; legs lighter than pleuron. Prothoracic TR 2.04 (1.90–2.22, n = 10); mesothoracic TR 1.66 (1.57–1.76, n = 10); metathoracic TR 1.68 (1.54–1.81, n = 10). Hindbasitarsus slightly wider than midbasitarsus, but narrower than adjacent end of tibia. Wing covered with fine macrotrichia; first radial cell obliterated, second narrow but open (fig. 8, *B*). Halter black, stem ribbed mesally.

Abdomen: Dark reddish brown, mottled with red and brown particles. Genitalia as in figure 8, *K*. Basistyle stout, about 1.5 times as long as wide; basistylar apodemes flaring distally from acute and obsolescent angle of fusion. Aedeagus a broad, lightly sclerotized, roughly square plate with darkly sclerotized, longitudinal cleft. Parameres absent.

Distribution.—Florida, Mexico.

Types.—Holotype, male, on slide, Vero Beach, Indian River Co., Fla., Nov. 1957, W. L. Bidlingmayer (USNM type No. 72218). Allotype female, same data. Paratypes, 23 males, 26 females, as follows:

FLORIDA: Collier Co., Collier Seminole St. Park, 17 May 1973, W. W. Wirth, light trap, 1 female. Indian River Co., Vero Beach, Nov. 1957, W. L. Bidlingmayer, 14 males, 20 females; Jan.–Apr. 1959, Ent. Res. Center, light trap, 3 males, 2 females.

MEXICO: Quintana Roo, Cancun, 22 Apr. 1974, D. Pletsch, 6 males, 3 females.

Discussion.—It is with great pleasure that we name this species in honor of Mark I. Dow in recognition of his contributions to the study of the family Ceratopogonidae. We have been greatly inspired by his professional manner and consistent attention to detail.

Nothing is known of the life history of this species. The male genitalia of *F. dowi* resemble those of the neotropical *F. bromeliae* Saunders in the shape of the aedeagus, but the basistylar apodemes form a broad arch to a transverse bar in *F. bromeliae*. The male hindbasitarsus of *F. bromeliae* is also pale and slender. The female spermathecae of *F. bromeliae* are subequal and subspherical, with distinct, stout necks often bearing a ring of minute knobs.

5. *fuscicalcarata*, new species

(Fig. 9)

Diagnosis.—Male can be recognized by its enlarged and darkened first three hindtarsomeres; broad, lightly sclerotized, triangular aedeagus; and basistylar apodemes joined in broad, rounded arch. Female is difficult to separate from *F. calcarata*, but small spermatheca is smaller than in *F. calcarata* and eighth sternum has deeper V-shaped concavity.

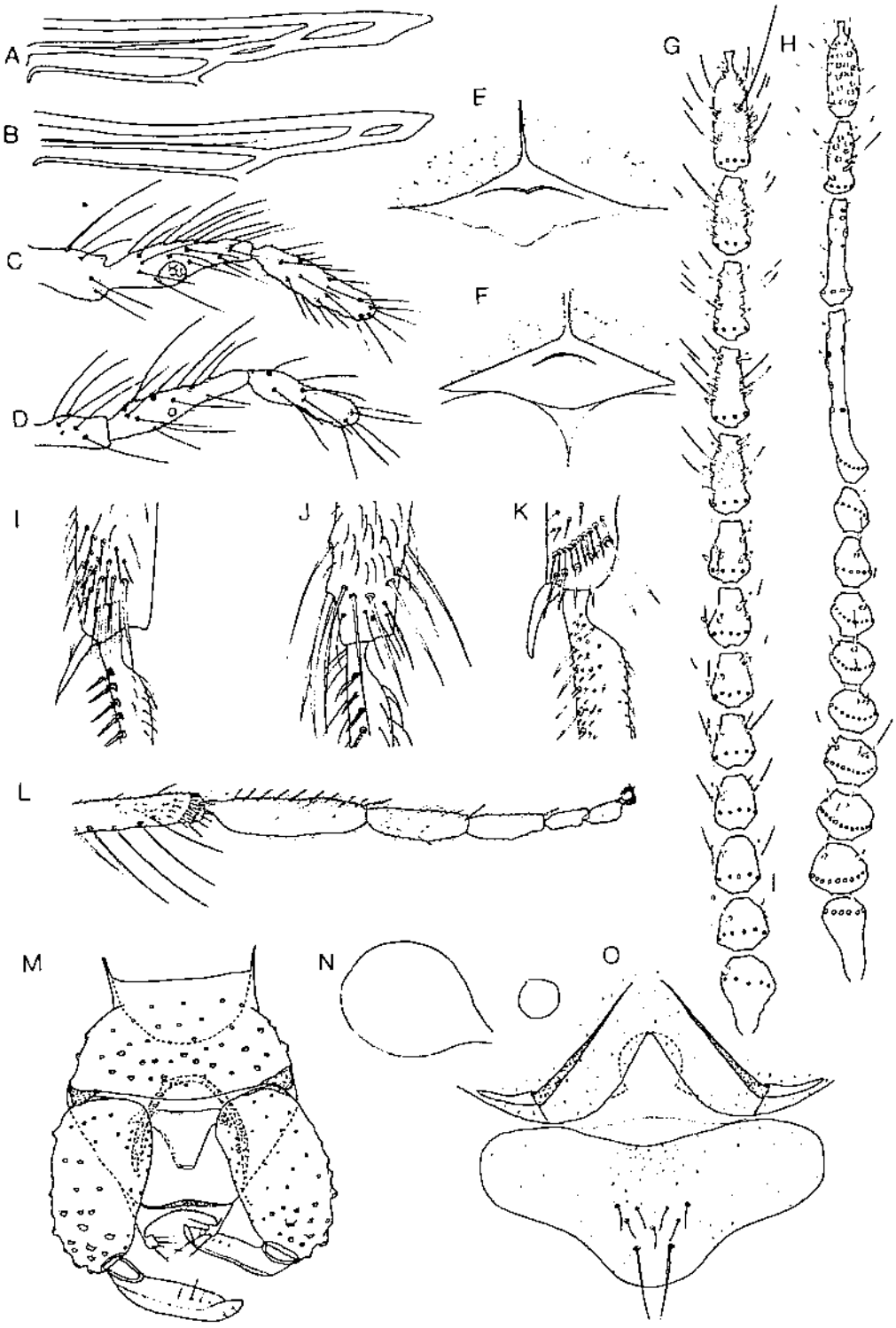


FIGURE 9.—*Forcipomyia fuscicalcarata*, new species: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; C, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, male frontal sclerite; *G*, female flagellum; *H*, male flagellum; *I*, female foretibial comb; *J*, female midtibial comb; *K*, female hindtibial comb; *L*, male hindtarsus; *M*, male genitalia; *N*, spermathecae; *O*, female genitalia.

Female.—Wing length 1.1 (1.0–1.2, n = 10) mm; width 0.43 (0.35–0.52, n = 10) mm. Antennal length 0.53 (0.50–0.56, n = 9) mm.

Head: Brown, with coarse setae on vertex. Eyes black, narrowly separated. Frontal sclerite (fig. 9, *E*) with flattened medial mound. Mouth parts yellow brown; mandibular teeth extremely fine, may not be visible at ×400. Palpus (fig. 9, *C*) yellow brown; third segment elongate, swollen medially, with large deep pit containing numerous capitate sensilla; fourth and fifth segments fused, fourth about twice length of fifth; PR 3.45 (3.09–3.67, n = 7); PP 20–38–21–11. Antenna (fig. 9, *G*) light brown; segments 3–10 ovoid, tapered, about as wide as long, bearing five or six clear sensilla per segment; segments 11–15 longer, tapering distally, with numerous clear sensilla; segment 15 bearing apical papilla and mesal spine; AP 18–13–14–15–15–15–15–16–21–21–20–20–31; AR 0.93 (0.87–0.99, n = 9).

Thorax: Mesonotum and postscutellum dark brown. Scutellum and pleural region light brown. Scutellum and mesonotum with scattered light-brown setae. Legs yellow brown. Tibial combs as figured (9, *I–K*). Prothoracic TR 2.11 (1.85–2.28, n = 10); mesothoracic TR 1.80 (1.75–1.87, n = 10); metathoracic TR 2.03 (1.74–2.21, n = 10). Prothoracic tarsal spines 15–7–5–5–1; mesothoracic tarsal spines 11–5–5–0–0; metathoracic tarsal spines 15–8–5–5–1. Wing densely covered with long yellow macrotrichia; first radial cell very narrow or close, second short and wide (fig. 9, *A*); CR 0.53 (0.50–0.56, n = 10). Halter brown.

Abdomen: Brown, with numerous light-brown setae and conspicuous dorsal glands. Subgenital sclerotization indistinct. Two unequal brownish spermathecae (fig. 9, *N*), the larger pyriform, averaging 0.066 by 0.049 mm and bearing clear punctations; the smaller spherical, averaging 0.020 mm in diameter. Distal edge of eighth sternum (fig. 9, *O*) with V-shaped concavity; internal apodemes sclerotized and straight, parallel to edges of concavity.

Male.—Wing length 1.1 (1.0–1.1, n = 4) mm; width 0.31 (0.29–0.32, n = 4) mm. Antennal length 0.64 mm.

Head: Brown, with dense setae. Eyes black, narrowly separated. Frontal sclerite (fig. 9, *F*) without distinct projection. Mouth parts and palpus yellow brown. Palpus (fig. 9, *D*) with third segment elongate, slender, with small unsclerotized shallow pit; fourth and fifth segments fused, fourth portion longer than fifth; PR 4.96 (4.75–5.13, n = 4); PP 19–40–19–11. Antenna (fig. 9, *H*) light brown, with dense plume of light-brown setae reaching to 14th segment; pedicel dark brown; flagellar pit circular and striated; segments 3–11 ovoid, becoming oblique and narrower distally, bearing several small clear sensilla; segments 12 and 13 elongate, bearing, in addition to verticils, scattered coarse setae and several clear sensilla; segment 15 with thick apical papilla; AP 26–16–14–14–14–14–13–15–16–50–35–23–29; AR 0.98 (n = 1).

Thorax: Color as in female. Prothoracic TR 2.09 (2.05–2.15, n = 4); mesothoracic TR 1.78 (1.73–1.86, n = 4); metathoracic TR 1.73 (1.69–1.88, n = 4). Hindbasitarsus greatly enlarged, wider than adjacent end of tibia, and from 2.2 to 2.5 times wider than midbasitarsus. First three hindtarsomeres brown, darker than remainder of leg (fig. 9, *L*). Wing covered with long coarse macrotrichia; first radial cell obliterated, second short and obovate (fig. 9, *B*); CR 0.47 (0.45–0.50, n = 4). Halter brown.

Abdomen: Terga dark brown; first three sterna pale, remainder dark brown. Genitalia as in figure 9, *M*. Basistyle slender, about twice as long as wide, and 1.25 times longer than dististyle; dististyle thick, with lateral fold terminating in slight hook. Aedeagus a lightly sclerotized, triangular plate. Basistylar apodemes joined in broadly rounded arch; flared distally with slight dorsal projection. Distal edge of ninth tergum sclerotized.

Distribution.—Florida.

Types.—Holotype, male, on slide, Chantilly Acres, Gainesville, Alachua Co., Fla., 8 May 1967, F. S. Blanton, light trap (Type No. 72219, USNM). Allotype, female, same data, but collected 12 May 1967. Paratypes, 7 males, 14 females, as follows:

FLORIDA: Alachua Co., Gainesville, Chantilly Acres, May 1967, F. S. Blanton, light trap, 2 females. Dade Co., Homestead, 9 Sept. 1968, R. M. Baranowski, UV trap, 2 males, 4 females; Miami, 1944, W. W. Wirth, light trap, 1 male; Orchid Jungle, May–June 1969, R. M. Bara-

nowski, UV trap, 1 male, 2 females; Ross and Costello Hammock, 21 Oct. 1964, R. M. Baranowski, UV trap, 1 female. Highlands Co., Archbold Biol. Sta., Lake Placid, 1–7 May 1964, R. W. Hodges, 1 female. Lee Co., Sanibel Island, 30 Dec. 1962, F. S. Blanton, 1 female. Leon Co., Tallahassee, Mar. 1960, M. A. Kohn, at light, 1 male. Monroe Co., Big Pine Key, 10 Apr. 1970, W. W. Wirth, light trap, 1 female. Orange Co., Orlando, 19 July 1969, light trap, 2 females.

Discussion.—This species is close to *F. calcarata*, and although the males show strong differences, the females cannot easily be separated. The frontal sclerite is the most consistently useful structure for separating the two. This species is named in reference to the dusky or darker color of the first three hindtarsomeres of the male. The life history of *F. fuscicalcarata* is unknown.

A male paratype from Miami is a gynandromorph, with well-developed spermathecae, but otherwise with male features. It is interesting that the spermathecae of this individual are subequal.

6. *hirtipennis* (Malloch)

(Fig. 10)

Euforcipomyia hirtipennis Malloch, 1915: 313 (female; Illinois); Edwards, 1924: 190 (notes); Saunders, 1925: 268 (notes).

Forcipomyia (Group C) *hirtipennis* (Malloch); Edwards, 1926: 397 (combination).

Forcipomyia (*Euforcipomyia*) *hirtipennis* (Malloch); Johannsen, 1943: 778 (status; distribution); Johannsen, 1952: 158 (in key); Saunders, 1956a: 662 (identity uncertain); Wirth, 1965: 124 (distribution).

Forcipomyia turfacea Kieffer, 1924: 148 (Estonia); Remm, 1961: 178 (diagnosis; figs. male genitalia, antenna, female wing, tibial comb). NEW SYNONYMY.

Diagnosis.—Male with normal hindbasitarsus and with square-based basistylar apodemes branched distally; aedeagus large, arched, lightly sclerotized, with large horizontal valve. Female without mandibular teeth, only species in North America with this character.

Female.—Wing length 1.0 (0.94–1.20, n = 15) mm; width 0.45 (0.39–0.52, n = 15) mm. Antennal length 0.50 (0.47–0.55, n = 15) mm.

Head: Yellow brown, with heavy, anteriorly directed setae; mouth parts and antenna, with exception of torus, slightly paler. Frontal sclerite (fig. 10, *E*) with mesal projection, about as long as wide. Mandible without distinct teeth. Third segment of palpus (fig. 10, *C*) stout, tapering distally, with distinct small round sensory pit containing capitate sensilla; PR 3.18 (2.50–3.75, n = 15); PP 14–30–15–11. Proximal eight antennal segments (fig. 10, *G*) short and stout, 0.75 as wide as long, stout vasiform in shape, tapering slightly distally, each with three to five long and one to three short clear sensilla; distal five segments about same width but longer, more tapered, with dense covering of clear sensilla; segment 15 more swollen with bifid apical papilla; AP 16–13–14–16–15–15–15–15–21–21–20–19–27; AR 0.91 (0.78–0.98, n = 15).

Thorax: Mesonotum dark brown with pale-brown posteriorly directed, semierect setae. Scutellum slightly lighter in color with larger, erect, light-brown setae. Postscutellum similar in color to mesonotum but without setae. Legs yellow brown, without noticeable pattern; covered with numerous fine yellow setae and scattered longer yellow setae, especially on tibia and tarsus. Foretibia with irregular comb and slightly smaller spine (fig. 10, *K*); midtibial comb with 4 setae, alternately long and short (fig. 10, *L*); hindtibial comb with double row, proximal row with 8–10 fine setae, distal row with 5–6 coarse setae and elongated curved spine (fig. 10, *M*). Prothoracic TR 1.91 (1.60–2.29, n = 15); mesothoracic TR 1.82 (1.71–2.00, n = 15); metathoracic TR 1.73 (1.58–2.00, n = 15). Empodium large, well developed (fig. 10, *J*). Wing densely covered with microtrichia (fig. 10, *I*), and uniformly covered with slender, prostrate, pale macrotrichia; macrotrichia of costal margin thicker and darker; first radial cell narrow, second wider (fig. 10, *A*); CR 0.47 (0.44–0.56, n = 15). Halter translucent brown.

Abdomen: Yellow brown, slightly darker dorsally, covered with slender yellow setae. Gland spots present. Two spermathecae (fig. 10, *O*), subequal, darkly sclerotized, with short necks; averaging 0.083 by 0.054 mm and 0.072 by 0.049 mm (n = 15). Subgenital sclerotization indistinct (fig. 10, *P*).

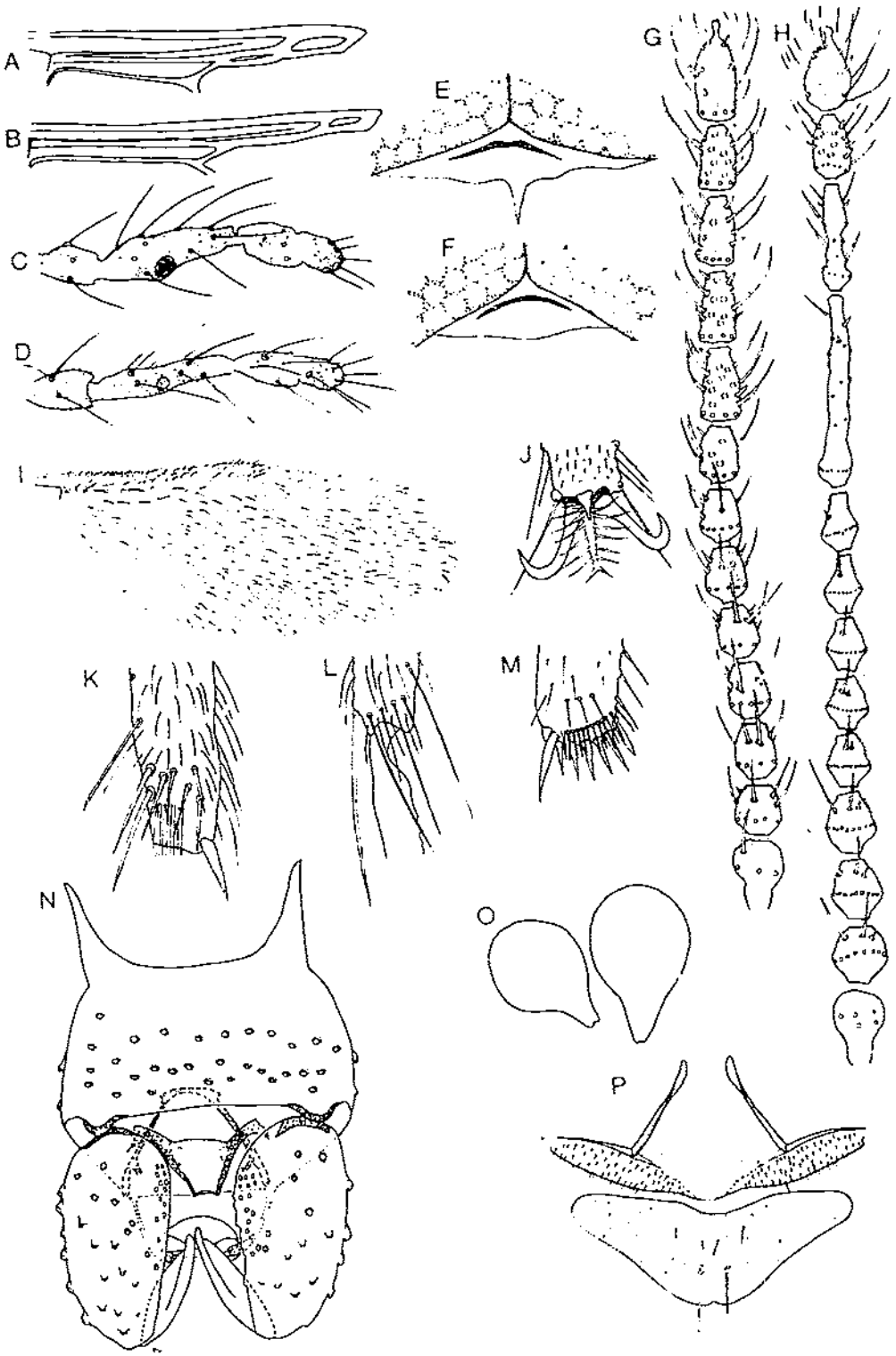


FIGURE 10.—*Forcipomyia hirtipennis* (Malloch): *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, male frontal sclerite; *G*, female flagellum; *H*, male flagellum; *I*, female wing; *J*, female claw and empodium; *K*, female foretibial comb; *L*, female midtibial comb; *M*, female hindtibial comb; *N*, male genitalia; *O*, spermathecae; *P*, female genitalia.

Male.—Wing length 1.2 (1.0–1.3, n = 10) mm; width 0.36 (0.32–0.39, n = 10) mm. Antennal length 0.74 (0.70–0.77, n = 10) mm.

Head: Light brown, with setae on vertex and around basal antennal segment. Palpus (fig. 10, *D*) light brown; third segment long and narrow with small round pit about midlength; PR 4.24 (3.75–5.00, n = 10); PP 18–34–16–11. Antennal segment 3 elongated; segments 4–11 globular, about as wide as long but becoming narrower distally; segment 12 greatly elongated, narrow, with numerous fine sensilla; segment 13 similar but half as long; segments 14 and 15 stouter, shorter, with dense covering of sensilla; segment 15 without verticils and bearing apical papilla; plume dense, yellow brown, reaching to 14th segment (fig. 10, *H*); AP 28–19–18–18–17–17–17–18–19–69–37–22–29; AR 0.93 (0.86–1.00, n = 10).

Thorax: As in female, with usual differences. Prothoracic TR 1.79 (1.55–2.17, n = 10); mesothoracic TR 1.38 (1.30–1.50, n = 10); metathoracic TR 1.47 (1.39–1.54, n = 9). Wing as in female but slightly longer and narrower, with first radial cell obliterated and second small (fig. 10, *B*); CR 0.45 (0.42–0.47, n = 10). Halter light brown.

Abdomen: As in female, but with usual differences (fig. 10, *N*). Basistyle about twice as long as wide, with numerous stout setae; dististyle stout and tapering, 0.75 length of basistyle, with fold along lateral edge. Aedeagus large, with lightly sclerotized arched base and lighter horizontal valve. Basistylar apodemes joined by broad flat bar; branched distally, strongly sclerotized.

Distribution.—Holarctic, recorded from northern Europe and northern North America; reaching southward in the mountains.

Types.—Holotype, female, of *F. hirtipennis*, slide mounted, Urbana, Ill., 15 June 1915, J. R. Malloch, from a window sill (Ill. Nat. Hist. Survey collection). Kieffer's type of *F. turfacea* presumed lost.

Specimens Examined.—ALASKA: Anchorage, 5 Aug. 1964, K. Sommerman, jeep trap, 1 female; Alaska Highway, Anchorage to Girdwood, June–July 1964, K. Sommerman, jeep trap, 9 females; Anchorage-Seward Highway, 6 Aug. 1964, K. Sommerman, jeep trap, 1 male; Kenai Peninsula, Johnson Lake, 19 July 1965, K. Sommerman, jeep trap, 2 males, 1 female; Johnson Lake to Kasilof, 19 July 1965, K. Sommerman, jeep trap, 2 males; Palmer, July 1963, 21 July 1964, 10 Aug. 1964, K. Sommerman, jeep trap, 1 male, 4 females; Palmer to Anchorage Highway, 21 July 1964, K. Sommerman, jeep trap, 4 males; Seward Highway, Bird Creek to Anchorage, 2 Aug. 1964, K. Sommerman, jeep trap, 2 males, 9 females; Seward Highway to Anchorage, 6 Aug. 1964, K. Sommerman, jeep trap, 1 male; Valdez, 1 Aug. 1949, R. W. Williams, 1 male. CONNECTICUT: Middlesex Co., Millington, East Haddom, Aug. 1976, T. H. G. Aitken, light trap, 1 male. MAINE: Penobscot Co., Old Town, Lake Pushaw, 1 Aug. 1966, W. W. Wirth, at light, 1 male; Orono, 7 July 1965, 12 July 1968, K. E. Olson, hovering over pine log, 5 females. MARYLAND: Montgomery Co., Colesville, 21 Apr. 1977, W. W. Wirth, light trap, 50 males, 10 females; Forest Glen, 19 Apr. 1968, W. W. Wirth, light trap, 1 female. MASSACHUSETTS: Barnstable Co., Centerville, 8 July 1959, D. B. Smith, light trap, 1 male. NEW YORK: Cattaraugus Co., Allegany State Park, 28 May 1963, W. W. Wirth, mossy woods, 2 females; sphagnum bog, 1 male, 4 females. Chautauqua Co., Sinclairville, 31 May 1963, W. W. Wirth, muddy brook, 1 female. Essex Co., Newcomb, Lake Harris, 19 Aug. 1972, L. Knutson, malaise trap, 1 male. Lewis Co., Whetstone Gulf, 20 June 1963, W. W. Wirth, 1 male, 3 females. Monroe Co., Braddock Bay, 12 June 1963, W. W. Wirth, near marsh, 1 male. St. Lawrence Co., Cranberry Lake, 24 June 1963, W. W. Wirth, light trap, 2 males, 2 females; 25 June 1963, 1 male, 1 female; sphagnum bog, 26 June 1963, 1 female. Suffolk Co., Greenport, 25 May 1963, W. W. Wirth, pond margin, 1 male, 1 female. NORTH CAROLINA: Macon Co., Highlands, 25 June 1958, J. L. Laffoon, at light, 1 female; July 1965, P. M. Marsh, malaise trap, 3 males, 16 females. RHODE ISLAND: Washington Co., North Kingstown, July 1968, J. E. Tisdale, 1 female. TENNESSEE: Sevier Co., Gatlinburg, 15 June 1947, R. H. Whittaker, hemlock forest, 1 male. VIRGINIA: Augusta Co., Reddish Knob, 29 Aug. 1953, W. W. Wirth, 1 male. Rockbridge Co., Vesuvius, July 1960, D. H. Messersmith, light trap, 1 male. WASHINGTON: Whatcom

Co., Glacier, 4 June 1917, H. G. Dyar, 1 male. Seattle, May 1964, T. Kincaid, 1 male, 2 females. WEST VIRGINIA: Hardy Co., Lost River State Park, 8 July 1963, K. V. Krombein, tent trap, 2 males, 1 female.

BRITISH COLUMBIA: Cowichan Lake, 20 June 1964, J. A. Chapman, malaise trap, 1 male, 26 females. Ocean Falls, 11 July 1960, E. I. Schlinger, 1 female. QUEBEC: Chelsea, 26 May 1960, W. W. Wirth, 1 male. Meach Lake, 6 June 1960, W. W. Wirth, 1 male, 1 female. Old Chelsea, Summit King Mountain, 1,150 feet, malaise trap, 1 male, 2 females.

ESTONIA: Tartu, July 1960, H. J. Remm, 2 males, 1 female.

Discussion.—Since Malloch's specimen of *F. hirtipennis* has not heretofore been critically examined, the absence of mandibular teeth was never noted. The males that match it appear identical in all critical respects to the males of *F. turfacea* identified by Remm and to his illustration of the species (Remm, *1961*). One of the females identified by Remm as *F. turfacea* and now in the USNM collection is also without mandibular teeth. The two species appear to be synonymous and precedence lies with *F. hirtipennis*.

The size of specimens varies considerably, with the largest from Alaska and the smallest from the east coast. In addition, the aedeagus of the Alaskan specimens is less distinct, similar to that of *F. alacris* (Winnertz). *F. hirtipennis* is part of a complex of holarctic species, and much work needs to be done on their biology and immature stages to make the taxonomy more meaningful. Nothing is known of the life history of this species nor of its immature stages.

7. *mortuifolii* Saunders

(Figs. 1, 11, *A–N*)

Forcipomyia (*Proforcipomyia*) *mortuifolii* Saunders, 1959: 35 (all stages; Trinidad; figs.).

Diagnosis.—Very small, yellow-brown species. Male is unique in subgenus in having dististyle with distinct median tooth and hooklike tip and moundlike projection on ninth sternum bearing two large, stout spines. Female is best identified by very small size, oval basal antennal segments, and subequal, unadorned spermathecae.

Female.—Wing length 0.69 (n = 2) mm; width 0.27 (n = 2) mm. Antennal length 0.35 (0.33–0.36, n = 3) mm.

Head: Brown, with decumbent setae. Eyes black, narrowly contiguous. Frontal sclerite (fig. 11, *E*) indistinct, with medial projection. Mandible with fine teeth. Palpus (fig. 11, *C*) short and stout, yellow brown; third segment short and stout with large, shallow, unsclerotized, conical pit containing capitate sensilla; fourth and fifth segments incompletely fused, nearly equal; PR 2.65 (2.50–2.89, n = 3); PP 15–25–14–9. Antenna (fig. 11, *F*) yellow brown, pedicel darker; segments 3–5 flattened, elliptical, each with microtrichia, two clear sensilla longer than segment, one peglike sensillum, and long and short pair of sensilla; segments 6–10 subspherical, only sixth with microtrichia, all with preceding arrangement of sensilla; segments 11–15 longer, tapered, with numerous sensilla; segment 15 with large medial seta and enlarged apical papilla; AP 11–9–9–10–10–9–10–10–14–14–14–14–19; AR 0.97 (0.95–0.97, n = 3).

Thorax: Shining brown; legs and pleuron yellow brown. Foretibial comb (fig. 11, *H*) consisting of five setae longer than spur, sheltering tiny distal comb and preceded by four narrower, shorter setae (described by Saunders (*1959*) as setose, but this is apparently true only in newly emerged specimens); other tibial combs as illustrated (fig. 11, *I–J*). Prothoracic TR 2.13 (2.00–2.30, n = 3); mesothoracic TR 1.87 (1.83–1.92, n = 3); metathoracic TR 2.13 (2.00–2.30, n = 3). Wing with sparse covering of slender macrotrichia; first radial cell small, second long and narrow (fig. 11, *A*); CR 0.53 (0.52–0.55, n = 2). Halter light brown.

Abdomen: Yellow brown, with fine yellow setae. Two subequal sclerotized spherical spermathecae (fig. 11, *M*) with short necks; larger averaging 0.070 by 0.056 mm; the smaller 0.056 by 0.045 mm. Subgenital sclerotization and anal cone without special features (fig. 11, *N*).

Male.—Wing length 0.9 mm; width 0.3 mm. Antennal length 0.59 mm.

Head: As in female, with following differences: Mandible without teeth. Third palpal segment more slender with small, unsclerotized, shallow pit (fig. 11, *D*); PR 3.63; PP 16-29–17–10. Antenna (fig. 11, *G*) bearing sparse plume;

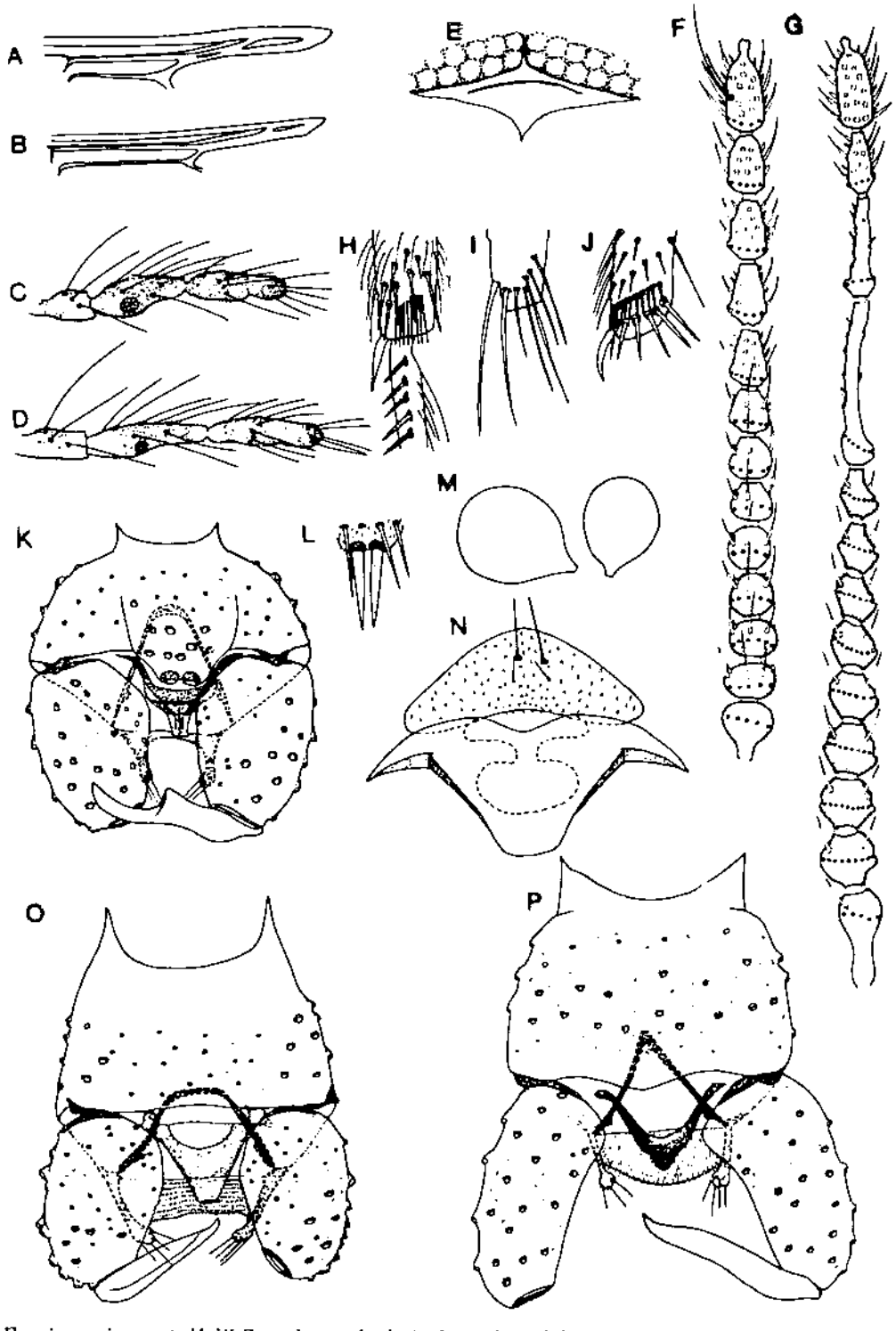


FIGURE 11.—*Forcipomyia mortuifolii* Saunders: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, female flagellum; *G*, male flagellum; *H*, female foretibial comb; *I*, female midtibial comb; *J*, female hindtibial comb; *K*, male genitalia; *L*, detail of medial mound of male ninth sternum with spines; *M*, spermathecae; *N*, female genitalia. *Forcipomyia psilonota* (Kieffer): *O*, Male genitalia. *Forcipomyia calcarata* (Coquillett): *P*, Male genitalia of holotype from Mexico.

segments 3–11 subspherical, becoming narrower and oblique distally, with microtrichia and two short slender sensilla per segment; segments 12 and 13 with peglike sensilla and scattered setae; segment 14 with numerous sensilla; segment 15 with no verticils, numerous sensilla, and apical papilla; AP 30–15–15–15–13–13–13–14–14–47–29–18–26; AR 0.84.

Thorax: As in female, with usual differences. Prothoracic TR 1.76; mesothoracic TR 1.67; metathoracic TR 1.58. Hindbasitarsus normal. Wing with sparse macrotrichia; first radial cell obliterated, second small (fig. 11, *B*); CR 0.48. Halter brown.

Abdomen: Light brown. Genitalia as in figure 11, *K*. Basistyle long and stout, 1.6 times longer than wide; dististyle with stout mesal tooth at midlength, tip long, slender, curved. Aedeagus complex; strongly sclerotized arch with two large vertical valves and two flanges near base of valves. Basistylar apodemes joined in broad arch, forked slightly near distal end. Ninth sternum with large medial mound (fig. 11, *L*) bearing many coarse setae and tipped with two large flattened spines with prominent basal tubercles.

Larva (fig. 1, *I*).—Length (4th instar) 2.3 mm. Reddish-brown pigment pattern throughout body, fading slightly posteriorly. Head dark, profile distinctly scalloped; *p* hairs fine, spear shaped; *q* hairs half-spear shaped, stouter (fig. 1, *K*). Body with *a* hairs spear shaped, with only slightly swollen tip; short, stout, and wedge shaped on prothorax (fig. 1, *I*); dorsolateral hairs short, stout, curved; four short fine lateral hairs on each segment. Prothoracic pseudopod a spinulose cushion. Cauda (fig. 1, *J*) short, attaining tips of last pair of *a* hairs, which have fused bases and are unusually short.

Pupa (fig. 1, *G*).—Length 1.8 mm. Pale yellowish throughout (exuviae). Three tubercles on median sclerite of cephalothorax, none on laterals. Thorax with two pairs of conspicuous pointed tubercles and one smaller, rounded, posterior pair. Prothoracic horn (fig. 1, *H*) without basal enlargement, bearing incomplete circlet of spiracular papillae, about 25 in lower palisade. Abdominal segments with only minute lateral setae; terminal processes divergent in both sexes (fig. 1, *G*).

Distribution. — Caribbean area, including south Florida.

Types.—Holotype, male, St. Augustine, Trinidad, West Indies, 10 Aug. 1957, L. G. Saunders, reared from rotting leaves in cacao plantation (Type No. 6729, Canadian National Collection, Ottawa). Paratypes, many, all stages.

Specimens Examined.—FLORIDA: Dade Co., Ross and Costello Hammock, Sept. 1970, R. M. Baranowski, light trap, 1 male, 3 females.

DOMINICA: Cabrit Swamp, 23 Feb. 1965, W. W. Wirth, 2 males. Clarke Hall, May–June, 1964, O. S. Flint, light trap, 3 males, 1 female; 2 Feb. 1965, W. W. Wirth, light trap, 1 male. Fond Figues River, 13 Mar. 1965, W. W. Wirth, light trap, 1 female. Pont Casse, Apr., June 1964, O. S. Flint, at light, 31 males, 19 females; 1.5 mi N Pont Casse, 12 Feb. 1965, W. W. Wirth, rain forest, 2 females. JAMAICA: Hardwar Gap, 20 Feb. 1969, W. W. Wirth, light trap, 6 males. PUERTO RICO: Maracao Forest Res., 10 Feb. 1961, A. B. Gurney, at light, 2 males. ST. LUCIA: 14 Apr. 1969, R. F. Darsie, at light, 1 male.

Discussion.—This unique tropical species is reported here for the first time from North America, where it is apparently limited to the subtropical area of extreme south Florida. The male, with its peculiar genitalia, cannot be confused with any other species; however, the female is best identified by association with the male. Saunders' (*1959*) excellent report gives considerable detail on both the life history and immature stages of this species based on observations in Trinidad. Our figure 1 is taken from Saunders' publication.

8. *navaiae*, new species

(Fig. 12)

Diagnosis.—Male can be identified by normal hindbasitarsus, strongly sclerotized, arched aedeagus, and basistylar apodemes flaring from acute and obsolescent angle of fusion. Female has two equal spermathecae, two longitudinal yellow stripes on mesonotum, and gonopore edges posteriorly directed and strongly sclerotized. Both sexes have reddish pigment spots in abdomen and scutellum.

Female.—Wing length 1.0 (0.9–1.0, n = 6)

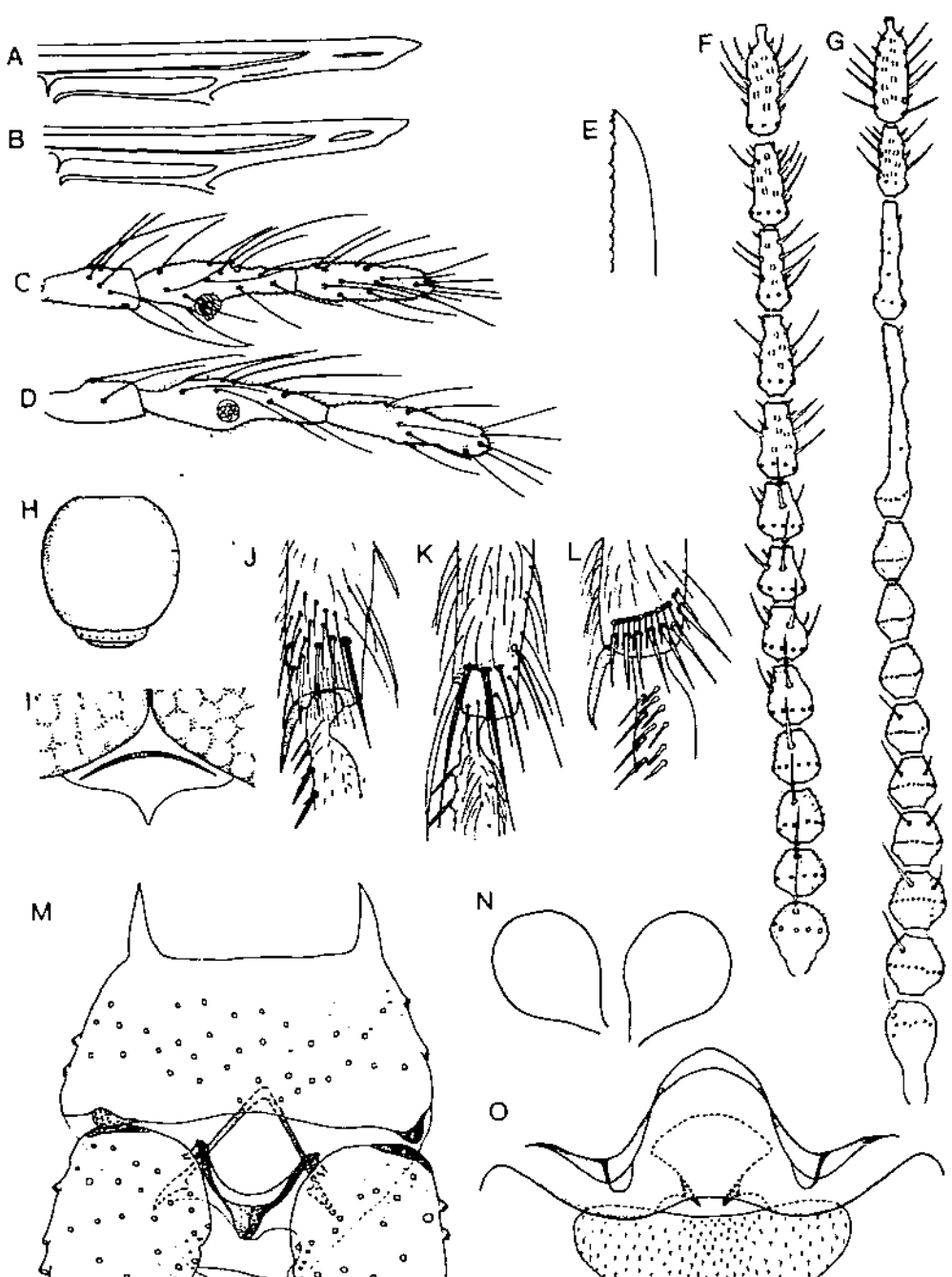


FIGURE 12.—*Forcipomyia navaiae*, new species: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, mandibular teeth of female; *F*, female flagellum; *G*, male flagellum; *H*, dorsal view of female mesonotum; *I*, female frontal sclerite; *J*, female foretibial comb; *K*, female midtibial comb; *L*, female hindtibial comb; *M*, male genitalia; *N*, spermathecae; *O*, female genitalia.

mm; width 0.40 (0.39–0.42, n = 6) mm. Antennal length 0.47 (0.44–0.50, n = 6) mm.

Head: Brown, bearing coarse setae. Eyes black, narrowly separated. Frontal sclerite (fig. 12, *I*) with blunt medial projection and large simple arched mark. Mouth parts yellow; mandible bearing coarse pointed teeth (fig. 12, *E*). Palpus (fig. 12, *C*) yellow; third segment slender, bearing huge (0.020 mm); shallow sensory pit with 9–11 protruding capitate sensilla; fourth and fifth segments fused; PR 4.07 (3.80–4.63, n = 6); PP 18–36–17–11. Antennal pedicel dark, without setae or microtrichia. Flagellum (fig. 12, *F*) yellow; antennal segments 3–10 vasiform, with stout verticils and four to eight sensilla; segments 11–14 longer and tapered, with stout verticils and numerous sensilla; segment 15 with verticils, sensilla, and bifid apical papilla; AP 16–12–13–14–14–13–13–14–18–20–19–19–27; AR 0.94 (0.86–1.00, n = 6).

Thorax: Mesonotum (fig. 12, *H*) brown, with two longitudinal yellow stripes. Scutellum and pleuron yellow, with occasional red pigment particles. Mesonotum densely covered with fine yellow setae. Postscutellum and mesoepisternum dark brown. Legs yellow. Prothoracic TR 2.16 (2.05–2.28, n = 6); mesothoracic TR 1.88 (1.75–2.06, n = 6); metathoracic TR 1.86 (1.80–1.96, n = 6). Foretibial comb (fig. 12, *J*) complex, consisting of large patch of setae, with distal ones longest; midtibial comb (fig. 12, *K*) a single row of long coarse setae; hindtibial comb (fig. 12, *L*) normal. Wing covered with short, coarse, dark, semierect macrotrichia; first radial cell closed, second nearly so (fig. 12, *A*); CR 0.49 (0.47–0.52, n = 6). Halter dark.

Abdomen: Yellow brown, densely covered with light-brown setae, longer on dorsal surface than on ventral surface. Medial glands present and conspicuous. Two equal spermathecae (fig. 12, *N*), ovoid with distinct necks, averaging 0.074 by 0.051 mm (n = 6). Distal edge of eighth sternum (fig. 12, *O*) with slight concavity; gonopore edges darkly sclerotized, projecting posteriorly, and sharply pointed; internal apodemes rounded anteriorly.

Male.—Wing length 1.09 (1.03–1.19, n = 6) mm; width 0.33 (0.32–0.36, n = 6) mm. Antennal length 0.71 (0.67–0.77, n = 6) mm.

Head: Shining brown, with decumbent setae. Eyes black, narrowly separated. Mouth parts yellow brown. Palpus (fig. 12, *D*) yellow brown, third segment with large, shallow, unsclerotized pit containing eight bulbous, stemmed sensilla; fourth and fifth segments fused; PR 4.48 (3.89–5.14, n = 7); PP 16–37–19–10. Antenna (fig. 12, *G*) light brown with dense plume; segments 3–11 subspherical, becoming narrower and oblique distally; segments 12 and 13 elongate, with several scattered setae and peglike sensilla; segment 14 with numerous long, pointed, and short peglike sensilla; segment 15 without verticils, bearing numerous sensilla of several types and apical papilla; AP 32–17–17–16–15–15–15–16–17–62–37–22–31; AR 0.92 (0.83–0.98, n = 6).

Thorax: Shining yellow brown, with yellow setae. Scutellum and pleuron lighter, with reddish pigment spots. Legs yellow. Prothoracic TR 2.09 (2.00–2.22, n = 7); mesothoracic TR 1.58 (1.42–1.65, n = 7); metathoracic TR 1.71 (1.65–1.87, n = 7). Hindbasitarsus only slightly wider than midbasitarsus and narrower than tibia. Wing with semierect, slender, brown macrotrichia; first radial cell obliterated, second open but small (fig. 12, *B*); CR 0.48 (0.46–0.58, n = 6). Halter black.

Abdomen: Brown, with very dense layer of reddish pigment spots. Genitalia as in figure 12, *M*. Basistyle short and stout, 1.6 times longer than wide; dististyle long and slender, tapering to slight hook. Aedeagus strongly sclerotized, arched, with lighter medial valve. Basistylar apodemes flared distally, about 60° angle between them; arising from obsolescent angle of fusion. Parameres absent.

Distribution.—Florida.

Types.—Holotype, male, allotype, female, on slides, Vero Beach, Indian River Co., Fla., Nov. 1957, W. L. Bidlingmayer (Type No. 72222, USNM). Paratypes, 13 males, 11 females, as follows:

FLORIDA: Dade Co., Miami, 31 Aug. 1966, H. C. Buff, light trap, 3 females. Hillsborough Co., Tampa, Mar. 1967, Taylor, light trap, 1 female. Indian River Co., Vero Beach, Nov. 1967, W. L. Bidlingmayer, 13 males, 5 females; Feb. 1959, 1 female.

Discussion.—This species is named in honor of Dr. Shahin Navai in recognition of her exacting, carefully detailed work on the genus *Culicoides* of Southwest Asia and in appreciа-

tion of her continuous advice and assistance during this study at the University of Maryland.

F. navaiae is very similar to *F. dowi* but has an arched aedeagus rather than a flat, platelike one, and the spermathecae differ greatly. Some specimens of both species share a peculiarity of the palpus in which there are two pits, a distal one containing a single bulbous sensillum and an adjacent proximal one containing five slightly smaller sensilla. This feature has not been assigned any taxonomic significance as the palpus is believed to be associated with food as opposed to species recognition.

9. *pechumani*, new species

(Fig. 13)

Diagnosis.—Male small, very dark, with conspicuous parameres, large arched aedeagus, and swollen hindbasitarsus. Female unknown.

Male.—Length 1.3 mm. Wing length 0.86 (0.81–0.94, n = 3) mm; width 0.27 (n = 3) mm. Antennal length 0.55 (n = 3) mm.

Head: Dark brown, with decumbent setae on vertex and around scape. Eyes black, narrowly separated. Frontal sclerite (fig. 13, *C*) with ventral sclerotization bearing flattened medial mound. Mouth part brown. Palpus (fig. 13, *B*) short, brown, with few setae; third segment stout, with small shallow pit containing six capitate sensilla; fourth and fifth segments fused, thickened, and approximately equal; PR 3.50 (3.43–3.52, n = 2); PP 12–24–12–10. Antenna (fig. 13, *E*) brown, with plume brown; flagellar pit (fig. 13, *M*) rugose and striated; segments 3–11 changing from subspherical proximally to vasiform distally, each with one to three stout sensilla; segment 12 elongate, pinched mesally, with numerous peglike and long slender sensilla; segment 15 without verticils, densely covered with peglike and long slender sensilla; apical papilla (fig. 13, *D*) bifid and bearing two structures probably sensory in nature; AP 21–14–14–13–12–12–13–14–14–47–28–19–26; AR 0.94 (0.88–0.97, n = 3).

Thorax: Shining dark brown, with numerous semierect setae. Tibial combs as illustrated (fig. 13, *F–H*). Prothoracic TR 2.58 (2.50–2.67, n = 3); mesothoracic TR 2.29 (2.08–2.50, n = 3); metathoracic TR 2.66 (2.47–2.86, n = 3). Hindbasitarsus (fig. 13, *I*) swollen, darkened, wider than tibia; bearing setal clusters, each consisting of two short basal and one long central seta (fig. 13, *J*). Claws bifid (fig. 13, *K*). Wing sparsely covered with dark macrotrichia; first radial cell obliterated, second open (fig. 13, *A*); CR 0.41 (0.40–0.42, n = 3). Halter brown.

Abdomen: Dark brown, with lighter pleuron. Dorsal glands present. Genitalia (fig. 13, *L*) very distinctive; dististyle long and slender, nearly as long as basistyle, bearing three evenly spaced clear sensory hairs, which appear identical in structure to those on antenna. Cerci large, darkly sclerotized. Aedeagus large, with broad, sclerotized arch supporting large, lightly sclerotized valve. Basistylar apodemes stout, flared distally, joined by heavy straight bar from which two large parameres extend caudad.

Distribution.—New York.

Types.—Holotype, male, on slide, Cranberry Lake, St. Lawrence Co., N.Y., 25 June 1963, W. W. Wirth, collected from alders and bunch grass on marshy lake margin (Type No. 72223, USNM). Paratypes, four males: Three same data as holotype; one male, Benson Mines, St. Lawrence Co., N.Y., 25 June 1963, W. W. Wirth, sweeping herbs under alders in mucky swamp area near beaver dam.

Discussion.—This species is named in honor of Dr. L. L. Pechuman of Cornell University, Ithaca, N.Y., in recognition of his lifelong dedication to the study of New York natural history, especially in the Diptera.

Remm (*1966*) described a species, *F. borealis*, which he tentatively placed in the subgenus *Warmkea*. He noted that it was unique to *Warmkea* in many ways and indicated his uncertainty as to its placement with a question mark after the subgeneric name. The genitalia of *F. borealis*, as figured in that report, very closely correspond to those of *F. pechumani*; however, the hindtarsi differ radically. The exact taxonomic status of these species is difficult to ascertain. They do not fit readily into any of the established subgenera, of which they are closest to *Euprojoannisia*. The females of *F. borealis* are definitely closest to *Euprojoannisia* also. Therefore, until the larvae are discovered, the present arrangement seems the most tenable in spite of the strain placed on the sub-

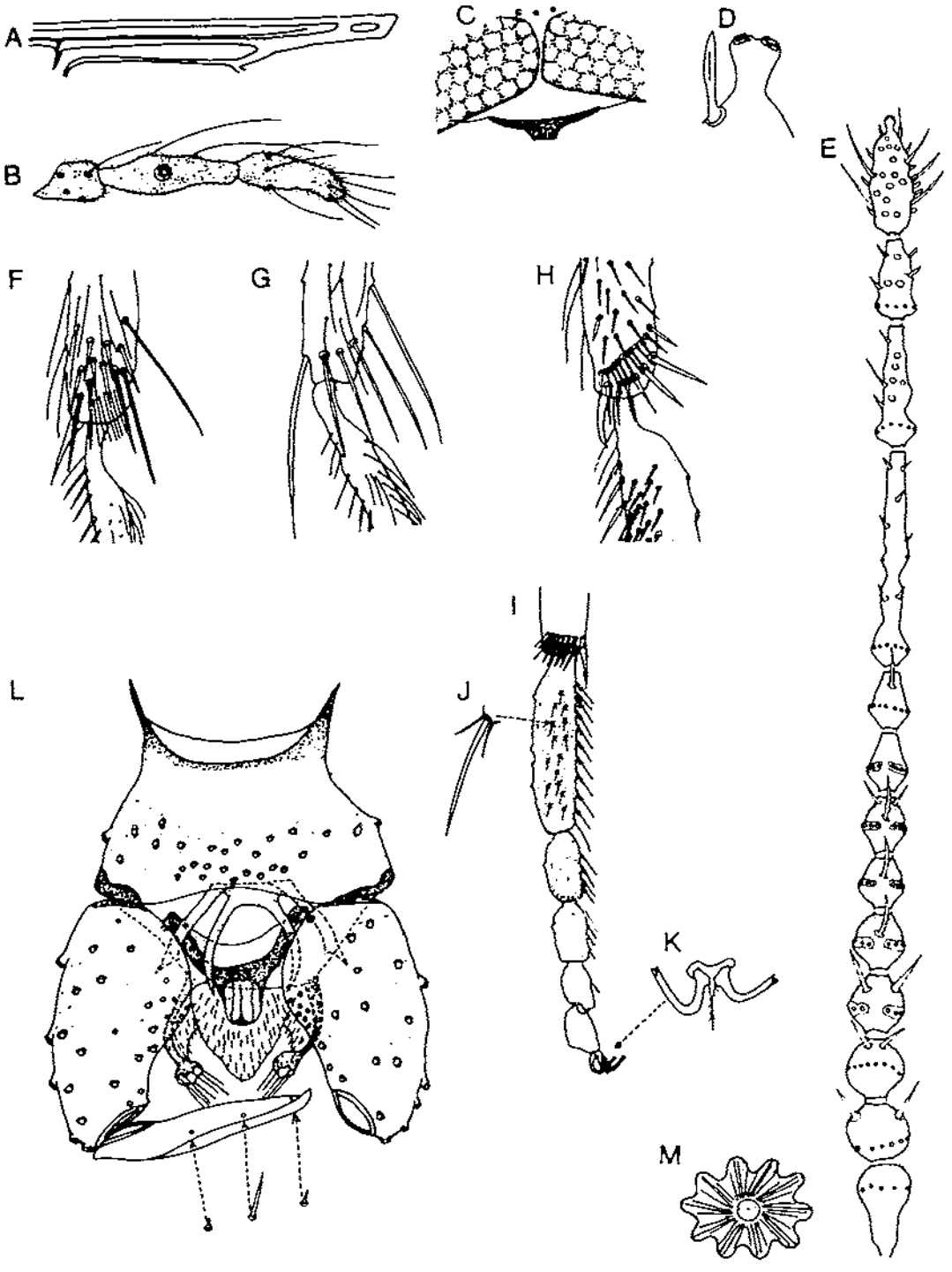


FIGURE 13.—*Forcipomyia pechumani*, new species, male: *A*, Anterior veins of wing; *B*, palpus; *C*, frontal sclerite; *D*, detail of apical papilla of antenna; *E*, flagellum; *F*, foretibial comb; *G*, midtibial comb; *H*, hindtibial comb; *I*, hindtarsus; *J*, detail of setal clusters; *K*, detail of claw and empodium; *L*, male genitalia; *M*, flagellar pit in pedicel.

generic definition by the peculiarities of the males.

10. *quasiingrami* Macfie

(Fig. 14)

Forcipomyia quasi-ingrami Macfie, 1939: 164 (male; Brazil; figs.).

Diagnosis.—Very small species. Male with enlarged, darkened hindbasitarsus; roughly semicircular, darkly sclerotized aedeagus; and broadly arched basistylar apodemes, branched distally. Female has subequal, nearly unequal, spermathecae, smaller of which bears clear punctations; very stout palpus; and stout, vasiform, basal antennal segments.

Female.—Wing length 0.84 (0.74–0.94, n = 8) mm; width 0.34 (0.29–0.42, n = 8) mm. Antennal length 0.39 (0.36–0.46, n = 8) mm.

Head: Brown, with decumbent setae on vertex. Eyes black, narrowly separated. Frontal sclerite (fig. 14, *F*) with sclerotized arched mark. Mouth parts light brown; mandible with unusually coarse teeth (fig. 14, *E*). Palpus (fig. 14, *C*) light brown; third segment short, swollen medially, with large, lightly sclerotized pit containing seven to nine capitate sensilla; fourth and fifth segments almost completely fused; PR 2.59 (2.50–2.75, n = 7); PP 14–27–16–9. Antenna (fig. 14, *H*) except pedicel light brown; segments 3–10 vasiform, nearly spherical, with coarse verticils and several clear sensilla per segment; segments 11–15 longer, tapered, with verticils and numerous clear sensilla of several types; segment 15 with apical bifid papilla and medial long seta; AP 13–10–10–11–11–10–11–11–16–17–17–16–24; AR 0.95 (0.89–1.00, n = 8).

Thorax: Mesonotum and postscutellum shining brown, with scattered fine brown setae on mesonotum; scutellum and pleural region yellow brown; legs yellow. Foretibial comb roughly triangular, two setae in proximal, four in middle, and five in distal row; only distolateralmost seta longer than tibial spur; all setae yellow (fig. 14, *J*); midtibial and hindtibial combs normal (fig. 14, *K–L*). Prothoracic TR 2.01 (1.73–2.25, n = 8); mesothoracic TR 1.65 (1.39–1.79, n = 8); metathoracic TR 1.81 (1.66–2.00, n = 8). Claws stout and short, strongly curved. Wing densely covered with relatively long, thin, brown macrotrichia; densest in region of second radial cell; first radial cell short and narrow, second longer and wider (fig. 14, *A*); CR 0.55 (0.52–0.58, n = 8). Halter brown.

Abdomen: Dull brown, with numerous fine yellow setae. Two subequal, subspherical, sclerotized spermathecae with short necks; smaller with clear punctations; the larger averaging 0.065 by 0.047 mm; the smaller 0.054 by 0.041 mm (n = 8) (fig. 14, *O*). Distal edge of eighth sternum with slight concavity; gonopore edged with slight sclerotization (fig. 14, *P*).

Male.—Wing length 1.00 (0.90–1.10, n = 8) mm; width 0.29 (0.26–0.32, n = 8) mm. Antennal length 0.65 (0.62–0.70, n = 7) mm.

Head: Brown, with decumbent setae on vertex. Mouth parts yellow. Palpus (fig. 14, *D*) yellow brown; third segment elongate with small round sensory pit; fourth and fifth partially fused: PR 4.57 (4.29–5.00, n = 7); PP 15–32–16–10. Antenna (fig. 14, *I*) brown, with dense brown plume; pedicel dark brown, flagellar pit circular and striated: segments 3–11 ovoid, becoming oblique and narrow distally; segments 12 and 13 elongate with slender verticils and scattered coarse setae and clear short sensilla; segment 14 with short verticils and numerous sensilla; segment 15 swollen, without verticils, bearing bifid apical papilla and numerous clear sensilla of several types; AP 26–16–16–15–14–15–15–16–16–56–34–21–30; AR 0.96 (0.93–0.99, n = 7).

Thorax: Color as in female. Prothoracic TR 1.84 (1.58–2.06, n = 8); mesothoracic TR 1.32 (1.10–1.50, n = 8); metathoracic TR 1.56 (1.46–1.75, n = 8). Anterior setae of forebasitarsus and midbasitarsus unusually short and stout, almost scalelike. Hindbasitarsus (fig. 14, *M*) darker than remainder of leg; swollen, wider than adjacent end of tibia, and twice as wide as midbasitarsus. Wing densely covered with brown, curved macrotrichia; first radial cell obliterated, second short and narrow (fig. 14, *B*); CR 0.47 (0.45–0.47, n = 7). Halter brown.

Abdomen: Terga dull brown, distal ends occluded with dark pigment spots; sterna clear or very light brown, distal ones darker. Basi-

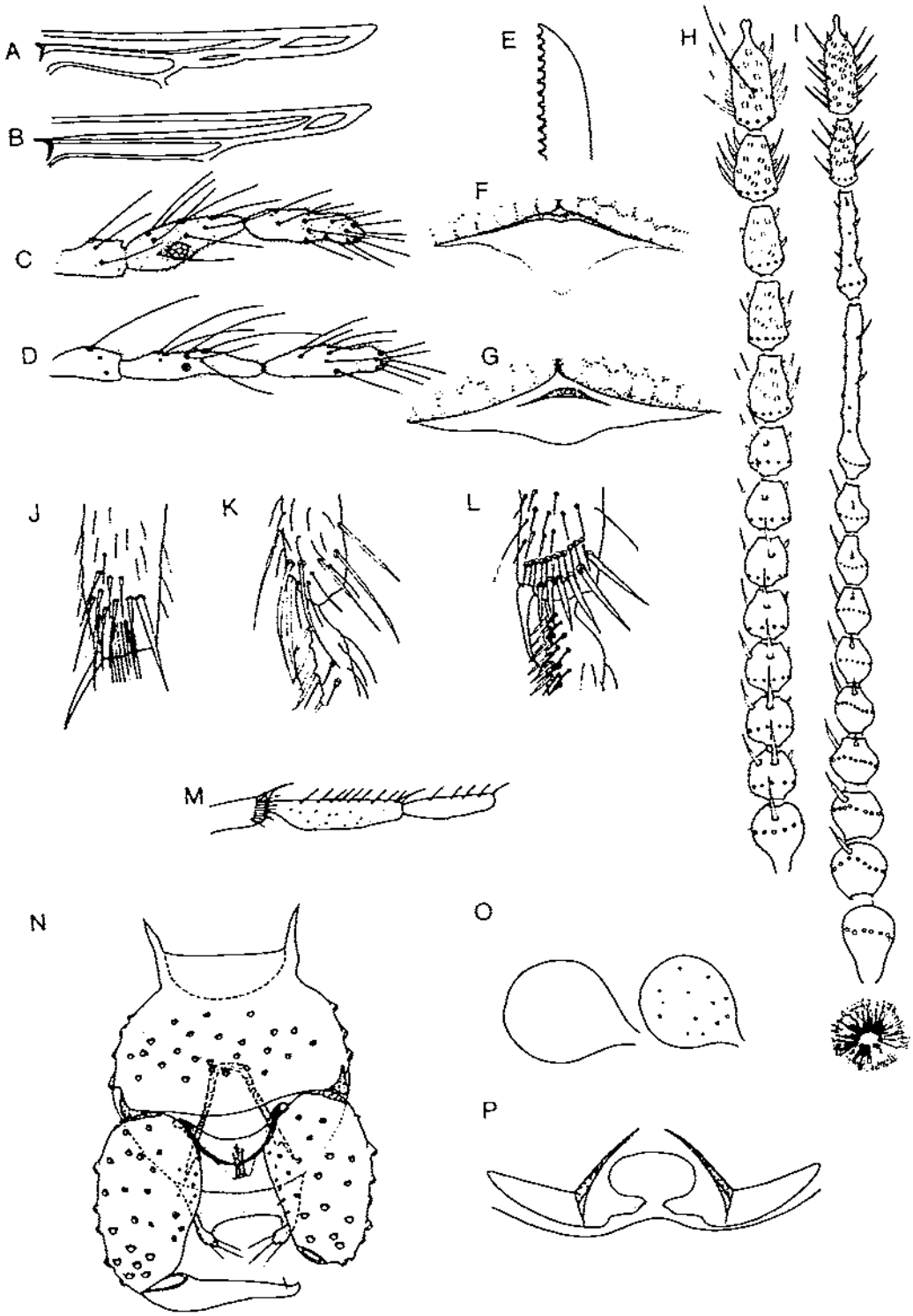


FIGURE 14.—*Forcipomyia quasiingrami* Macfie: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female mandibular teeth; *F*, female frontal sclerite; *G*, male frontal sclerite; *H*, female flagellum; *I*, male flagellum; *J*, female foretibial comb; *K*, female midtibial comb; *L*, female hindtibial comb; *M*, male first and second hindtarsomeres; *N*, male genitalia; *O*, spermathecae; *P*, female genitalia.

style long and slender, 1.75 times longer than wide and 1.25 times longer than dististyle. Aedeagus semicircular, darkly sclerotized along edges, with distinct tubular vertical valve. Basistylar apodemes joined in broadly rounded arch, forked distally with posteriorly directed branch. Parameres absent.

Distribution.—Neotropical, extending into Florida.

Types.—Holotype, male, Nova Teutonia, Santa Catarina, Brazil, 24 May 1937, F. Plaumann (deposited in British Museum (Nat. Hist.), London). No allotype or paratypes designated, although "*Forcipomyia* sp." on page 169 is probably, as Macfie (*1939*) mentioned, the female of the species.

Specimens Examined.—FLORIDA: Alachua Co., Gainesville, May, Sept. 1967, F. S. Blanton, light trap, 4 males, 6 females. Alachua Co., Island Grove, 1 Aug. 1967, F. S. Blanton, light trap, 1 female. Collier Co., Collier Seminole St. Park, 17 May 1973, W. W. Wirth, light trap, 2 females. Collier Co., Ochopee, Sept. 1971, F. S. Blanton, light trap, 1 male. Dade Co., Homestead, 9 Sept. 1968, R. M. Baranowski, UV trap, 2 males, 7 females. Dade Co., Miami, 28 Sept. 1960, P. E. Briggs, 1 male; 8 Aug. 1966, J. C. Buff, light trap, 1 male; 6 Aug. 1977, W. W. Wirth, light trap, 4 males, 3 females. Dade Co., Orchid Jungle, May–June 1969, R. M. Baranowski, UV trap, 2 females. Dade Co., Ross and Costello Hammock, 21 Oct. 1969, R. M. Baranowski, UV trap, 1 male, 1 female. Gulf Co., Beacon Hill, 15 Oct. 1970, F. S. Blanton, light trap, 1 male. Hardee Co., Ona, July 1970, E. Irons, light trap, 1 female. Jefferson Co., Monticello, Sept. 1969, W. H. Whitcomb, UV trap, 1 male, 4 females. Leon Co., Tallahassee, Mar. 1960, M. A. Kohn, at light, 1 male, 1 female; May 1970, F. S. Blanton, UV trap, 1 male, 2 females. Orange Co., Lake Magnolia Park, 6 Aug. 1970, E. Irons, UV trap, 1 male, 8 females. Orange Co., Rock Springs, 15 Dec. 1951, W. E. McDuffie, emergence trap, 2 males, 4 females; 21 Apr. 1970, W. W. Wirth, light trap, 1 male. Sarasota Co., Myakka River St. Park, 21 May 1973, W. W. Wirth, light trap, 13 females.

BRAZIL: Bahia, Itabuna, F1–10–07–04–72, J. A. Winder, 1 male. Santa Catarina, Nova Teutonia, Feb. 1971, F. Plaumann, 1 male (topotypic). DOMINICA: Cabrit Swamp, 23 Feb. 1965, W. W. Wirth, 2 males. Clarke Hall, 10 Apr. 1964, O. S. Flint, light trap, 1 male; 10 Sept. 1964, T. J. Spilman, light trap, 1 male; 24 Jan. 1965, W. W. Wirth, at mango flowers, 5 males; 28 Mar. 1965, W. W. Wirth, light trap, 1 male. Manets Gutter, 15 Mar. 1965, W. W. Wirth, light trap, 1 male. JAMAICA: Negril, Westmoreland Parish, 22 June 1970, E. G. Farnworth, light trap, 5 males. Runaway Bay, 16 Feb. 1969, W. W. Wirth, light trap, 2 males; 1 Mar. 1970, W. W. Wirth, malaise trap, 3 males. ST. LUCIA: Castries, Fairview, 14 Apr. 1959, R. Darsie, light trap, 4 males, 2 females.

Discussion.—This neotropical species is reported here for the first time from North America. It is sufficiently distinct that Macfie's meager description is adequate for positive identification. There is no indication that the female of the species has previously been described with some degree of certainty. The male of this species is similar to that of *F. blantoni*, differing in the presence of the swollen hindbasitarsus and the shape of the aedeagus. It is also like *F. calcarata*, but it is much smaller and has a more rounded apodeme arch, which is forked at the distal end. The female can readily be identified if mounted and cleared enough to show the distinctive genitalia or the clear punctations on the smaller spermatheca. Otherwise the female is best identified by association with the male. Nothing is known of the life history or the immature stages of this species. Wirth took males at mango flowers in Dominica.

11. *sonora* Wirth

(Figs. 3, *L–R*, 15)

Forcipomyia calcarata var. *sonora* Wirth, 1952: 145 (male; Calif.; figs.).

Forcipomyia (*Proforcipomyia*) *sonora* Wirth; Wirth, 1965: 125 (distribution).

Diagnosis.—Larvae can be identified by hastate *q* hairs and long, peglike *p* and *a* hairs. Pupae retain larval exuviae and have long cone-shaped pupal horn with 22 or more spiracular papillae. Male has hindbasitarsus as wide as tibia, aedeagus a derby-hat shaped plate, and

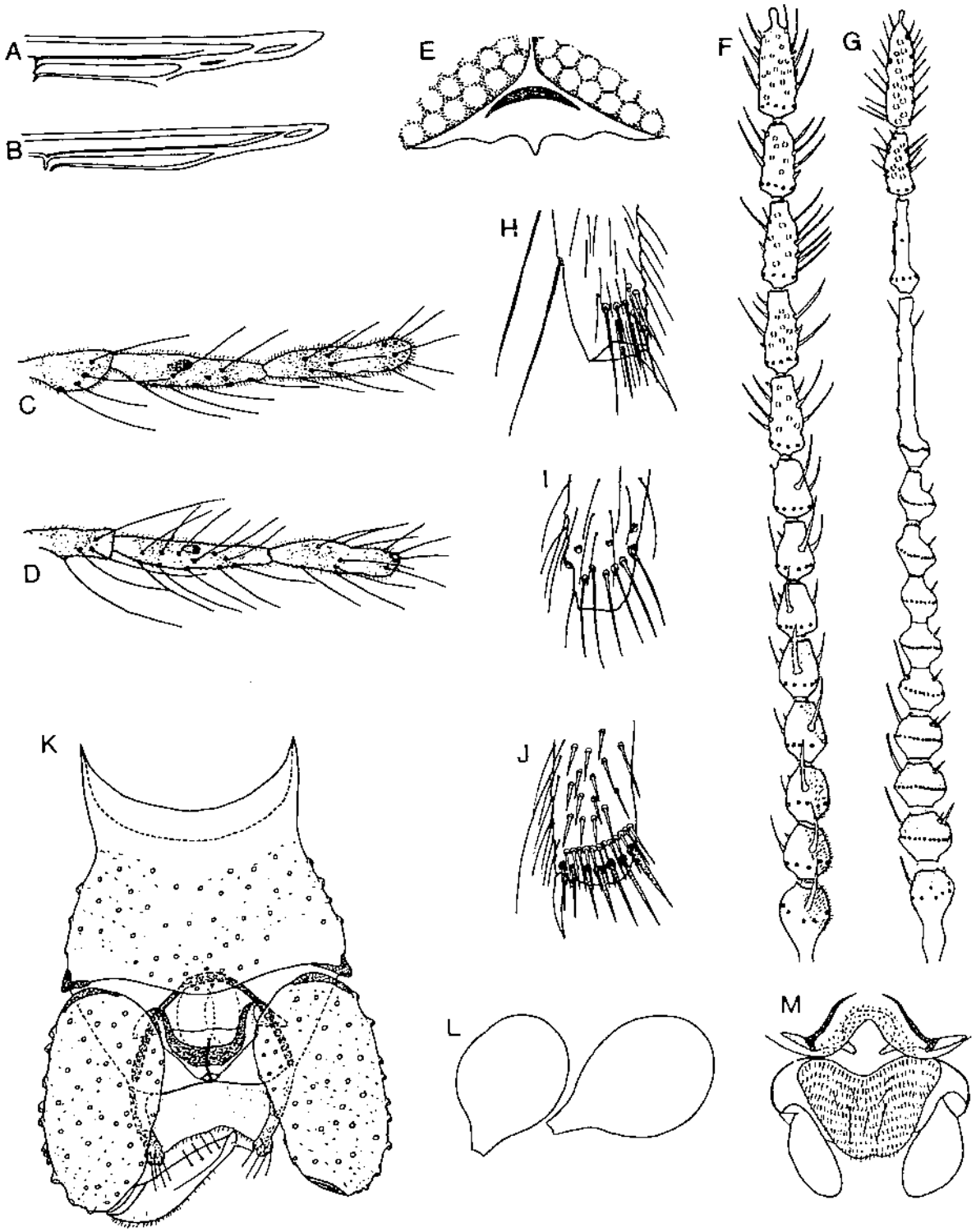


FIGURE 15.—*Forcipomyia sonora* Wirth: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, female flagellum; *G*, male flagellum; *H*, female foretibial comb; *I*, female midtibial comb; *J*, female hindtibial comb; *K*, male genitalia; *L*, spermathecae; *M*, female genitalia.

basistylar apodemes joined in simple semicircle and bearing large, oval, hyaline parameres. Female has subequal spermathecae, V-shaped concavity in distal edge of eighth sternum, and frontal sclerite with short medial projection.

Female.—Wing length 1.20 (0.90–1.40, n = 14) mm; width 0.50 (0.42–0.58, n = 14) mm. Antennal length 0.52 (0.43–0.58, n = 14) mm.

Head: Brown, with scattered erect setae. Eyes black, narrowly separated. Frontal sclerite (fig. 15, *E*) with crescent-shaped sclerotized mark and short medial projection. Mouth parts light brown; mandible with fine sclerotized teeth. Palpus (fig. 15, *C*) brown and slender; third segment slender, without pronounced enlargement, with deep, darkly sclerotized pit; fourth and fifth segments fused; PR 4.26 (3.44–5.71, n = 14); PP 14–31–20–11. Antenna (fig. 15, *F*) light brown; segments 3–10 stout vasiform, with dense verticils and two to four long sensilla per segment; segments 11–15 elongate, cylindrical, with verticils and many sensilla; segment 15 with apical papilla; AP 18–14–15–15–15–14–14–15–21–21–20–20–29; AR 0.92 (0.81–0.97, n = 14).

Thorax: Brown, with dull grayish pollen, pleuron and scutellum lighter; numerous setae present. Prothoracic TR 2.02 (1.85–2.33, n = 14); mesothoracic TR 1.89 (1.68–2.20, n = 13); metathoracic TR 1.89 (1.68–2.08, n = 14). Foretibial comb (fig. 15, *H*) consisting of single irregular row of setae shorter than tibial spur; midtibial comb (fig. 15, *I*) with relatively short setae; hindtibial comb (fig. 15, *J*) normal. Wing densely covered with slender macrotrichia; first radial cell nearly closed, second small (fig. 15, *A*); CR 0.48 (0.43–0.52, n = 15). Halter black.

Abdomen: Brown, with numerous coarse setae and double row of dorsal glands. Two subequal supermathecae (fig. 15, *L*), darkly sclerotized with short necks; the larger averaging 0.092 by 0.058 mm; the smaller 0.084 by 0.058 mm. Distal edge of eighth sternum with deep V-shaped concavity; subgenital sclerotization with protruding sclerotized points (fig. 15, *M*).

Male.—Wing length 1.47 (1.25–1.58, n = 8) mm; width 0.42 (0.38–0.45, n = 7) mm. Antennal length 0.76 (0.69–0.83, n = 8) mm.

Head: Brown, with coarse setae on vertex. Eyes narrowly separated. Frontal sclerite obovate. Palpus (fig. 15, *D*) brown, slender, elongate; third segment wth small deep pit; PR 5.71 (5.25–6.43, n = 7); PP 20–45–24–13. Antenna (fig. 15, *G*) brown; basal segments spherical, becoming more narrow and tapered distally; segments 7–9 apparently fused; segments 12 and 13 elongate, with verticils, scattered setae, and few sensilla; segment 15 without verticils, with many sensilla, and apical papilla; plume brown, reaching to 14th segment; AP 31–18–17–17–16–16–17–18–19–70–39–26–39; AR 1.1 (1.0–1.2, n = 8).

Thorax: Dark brown, pleuron and scutellum lighter. Prothoracic TR 1.88 (1.73–2.04, n = 8); mesothoracic TR 1.65 (1.55–1.79, n = 8); metathoracic TR 1.67 (1.59–1.81, n = 8). Hindbasitarsus as wide as adjacent end of tibia. Wing with dense covering of macrotrichia; first radial cell obliterated, second small (fig. 15, *B*); CR 0.47 (0.45–0.56, n = 7). Halter dark.

Abdomen: Brown, with brown setae. Genitalia as in figure 15, *K*. Basistyle 1.7 times as long as wide; dististyle stout. Aedeagus a low broad arch, somewhat indistinct, and shaped like a derby hat. Basistylar apodemes joined in rounded arch. Parameres large and obovate, hyaline but generally visible, occupying most of space between basistylar apodemes. Distal edge of ninth sternum convex; distal edge of ninth tergum sclerotized.

Larva.—No larvae have been collected, but one has been reconstructed as to salient features based on larval exuviae retained on a pupa. Head (fig. 3, *L*) sclerotized, with normal antenna and *t* hairs; with hastate *q* hairs and long, peglike *p* hairs. Prothoracic pseudopod a simple spinose cushion. Body with *a* hairs identical to *p* hairs, but slightly setose (fig. 3, *M*); also dark hair, possibly *c* or *d*, tapered and about four times longer than *a* hair, on each segment. Cauda (fig. 3, *N*) with slight fringe; large, erect pair of stout tapered hairs anterior to cauda.

Pupa.—Length, female 2.9 mm; width 0.9 mm. Retains larval exuviae. Pupal horn (fig. 3, *P*) long (0.13 mm), cone shaped, with 22 or more spiracular papillae. Abdominal segments (fig. 3, *O*) unadorned, with small setae along lateral edges. Terminal processes of male (fig. 3, *Q*) long and appressed; of female (fig. 3, *R*) shorter and appressed.

Distribution.—Western North America.

Types.—Holotype, male, on pin with slide-mounted genitalia, Palo Verde, Imperial Co., Calif., 7 Apr. 1949, W. W. Wirth (USNM Type No. 59923). Allotype, on slide, Fairbanks Springs, Nev., 21 Aug. 1949, C. B. and R. M. Philip (in USNM, along with many paratypes).

Specimens Examined.—ARIZONA: Cochise Co., Portal, Southwest Research Station, 4 June 1967, C. W. Sabrosky, light trap, 3 males, 8 females. Pima Co., Ajo, 1 Oct. 1962, W. F. Barr, light trap, 1 female. Pima Co., Pena Blanca, 10 mi W Nogales, 1 Aug. 1961, Werner, Nutting, and Johnson, light trap, 1 female. CALIFORNIA: Imperial Co., Imperial Dam, 28 June 1954, W. A. McDonald, at lights, 1 female. Imperial Co., Laguna Lake, 10 June 1962, J. N. Belkin, 2 males. Modoc Co., Adin, 7 Sept. 1965, M. S. Mulla, suction trap, 1 female. Mono Co., Mono Lake, 7 June 1948, W. W. Wirth, lake margin, 1 female. Riverside Co., Blythe, 20 July 1947, J. A. MacSwain, light trap, 1 female. Riverside Co., Mecca, 23 Sept. 1964, J. A. Foulk, light trap, 1 female. San Bernardino Co., Saratoga Springs, Death Valley, 28 July 1954, J. N. Belkin and W. A. MacDonald, 8 females; 19 Feb. 1955, J. N. Belkin, 4 pupae, 8 males, 6 females. COLORADO: Alamosa Co., Great Sand Dunes Nat. Mon., 25 Aug. 1968, F. G. Andrews, 1 male. NEVADA: Nye Co., Fairbanks Springs, Death Valley, 21 Aug. 1949, C. B. and R. N. Philip, light trap, 1 male, 1 female. Washoe Co., Reno, Sept. 1969, K. and T. Butler, 1 female. NEW MEXICO: San Miguel Co., Los Vegas, 3 Aug. (no year), H. S. Barber, 1 male. OREGON: Malheur Co., Vale, Little Valley, 19 June 1963, K. Goeden, light trap, 1 female. Tillamook Co., Tillamook, 16 Aug. 1963, K. Goeden, 1 female. Umatilla Co., Umatilla, 6 Sept. 1941, E. F. Knipling, 1 male. SOUTH DAKOTA: Union Co., Jefferson, 13 Aug. 1953, J. L. Laffoon, 1 male. TEXAS: Kerr Co., Kerrville, 21 Mar. 1955, W. W. Wirth, light trap, 3 males, 7 females. UTAH: Box Elder Co., Corinne, 1 Nov. 1949, G. F. Knowlton, at celery, 3 males. Box Elder Co., Tremonton, 27 Sept. 1953, 2 males, 1 female. Cache Co., Logan, Aug. 1953–July–Aug. 1955, June 1956, July 1957, Aug. 1958, G. F. Knowlton, at light, 1 female. Washington Co., St. George, Santa Clara River, 29 May 1974, W. L. Grogan, 2 males. WASHINGTON: Adams Co., Othello, 9 Aug. 1960, R. Harwood, trap in animal burrow, 2 males, 2 females. Lewis Co., Mt. Rainier Nat. Park, Box Canyon Creek, 22 June 1968, W. W. Wirth, 1 male.

BRITISH COLUMBIA: Cowichan Lake, 20 June 1964, J. A. Chapman, malaise trap, 1 male, 12 females.

Discussion.—Wirth (*1952*) originally described this species as a variety, but later he (*1965*) elevated it to species status. Subsequent identification of the pupa and larval exuviae has verified it as a distinct species, differing somewhat from *F. wirthi*, with which it is unquestionably closely allied. Adults of these two species and *F. canadensis* are very difficult to separate, although the larvae are quite distinct.

This species is an inhabitant of the arid lands of western North America. Pupae were collected by J. N. Belkin in Death Valley on February 19, 1955. He found them under a foot or more of rotting vegetation (*Scirpus olneyi* A. Gray) along the edge of a seepage pond. They were associated with *Uranotaenia anhydor* Dyar (Diptera: Culicidae) and *Corethrella laneana* Vargas (Diptera: Chaoboridae). Adults are most commonly taken from light traps, but they have been collected from animal burrows in Washington and on celery blossoms in Utah.

Those adults collected during the summer in the southern part of the range average about one-fourth smaller and have larger tarsal ratios and smaller antennal and palpal ratios than adults from the same localities taken in the spring.

12. *titillans* (Winnertz)

(Fig. 16)

Ceratopogon titillans Winnertz, 1852: 27 (female; Europe; fig. wing).

Euforcipomyia titillans (Winnertz); Edwards, 1924: 190 (combination).

Forcipomyia (Group C) *titillans* (Winnertz); Edwards, 1926: 397 (combination).

Forcipomyia (*Euforcipomyia*) *titillans* (Winnertz); Remm, 1961: 178 (notes; redescribed; figs.).

Forcipomyia (*Proforcipomyia*) *titillans* (Winnertz); Wirth, 1965: 125 (N. Amer. distribution).

Diagnosis.—Northeastern species. For male, normal hindbasitarsus, rounded, unforked, basi-

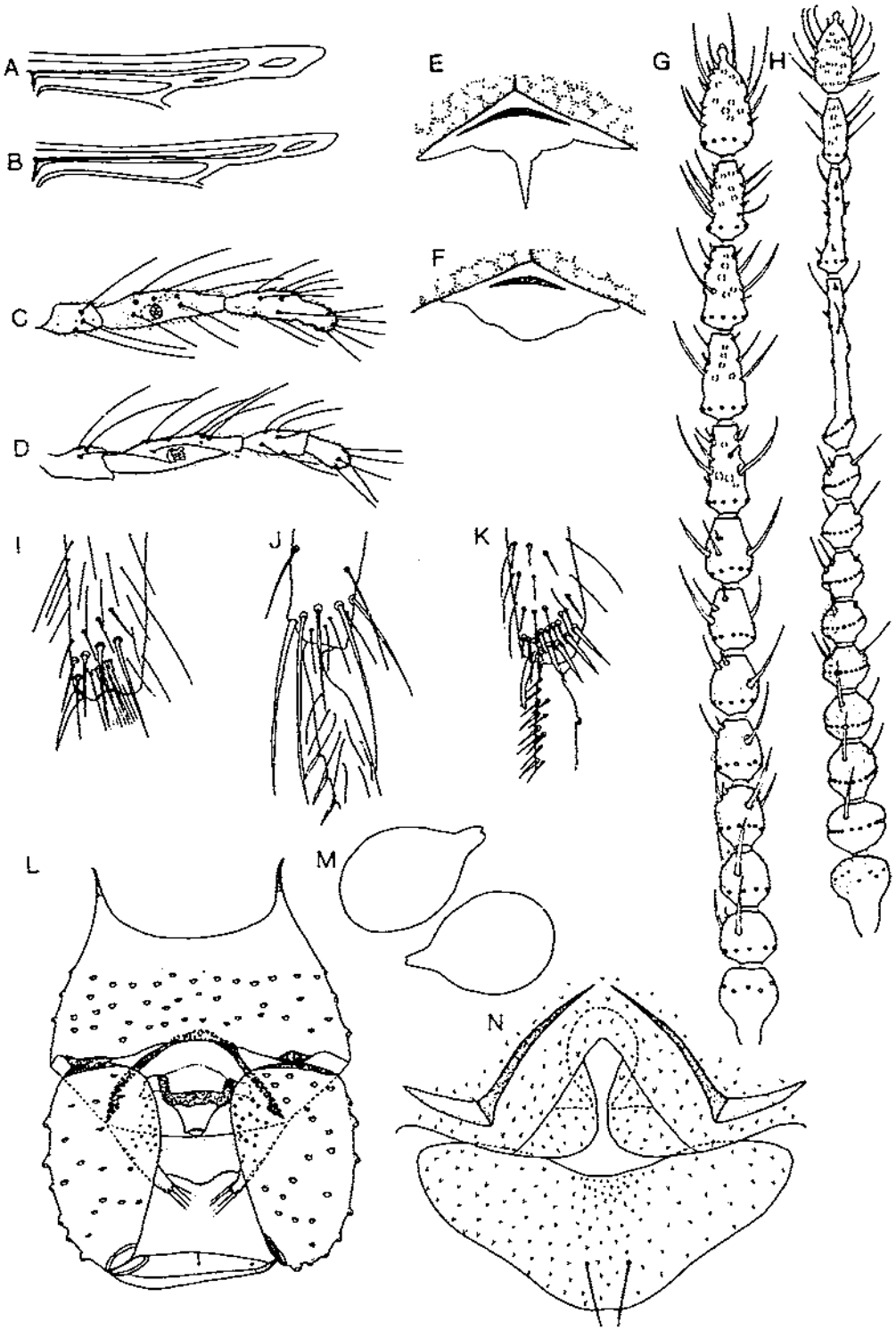


FIGURE 16.—*Forcipomyia titillans* (Winnertz): *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, male frontal sclerite; *G*, female flagellum; *H*, male flagellum; *I*, female foretibial comb; *J*, female midtibial comb; *K*, female hindtibial comb; *L*, male genitalia; *M*, spermathecae; *N*, female genitalia.

stylar apodemes joined by thicker arch, and square sclerotized aedeagus with large horizontal valve are distinctive. Female has equal spermathecae, and distal edge of eighth sternum has deep V-shaped concavity edged with clear flaps.

Female.—Wing length 0.99 (0.84–1.00, n = 10) mm; width 0.40 (0.32–0.45, n = 10) mm. Antennal length 0.47 (0.39–0.52, n = 10) mm.

Head: Eyes black, contiguous. Head, mouth parts, and pedicel dark brown; palpus and antenna lighter brown. Head with numerous semierect setae. Frontal sclerite (fig. 16, *E*) with medial pointed projection. Mandible with 18–25 fine, strongly sclerotized teeth. Palpus (fig. 16, *C*) with third segment elongate, with small unsclerotized deep round pit containing seven to nine capitate sensilla; fourth and fifth segments incompletely fused, fourth only slightly longer than fifth; PR 3.55 (3.33–4.00, n = 8); PP 15–30–15–12. Antennal segments (fig. 16, *G*) 3–10 globular, slightly tapered, about as wide as long, with dense verticils, and several clear sensilla per segment; segments 11–15 longer, more tapered, with numerous sensilla and terminal papilla; AP 16–12–12–14–14–13–14–15–19–19–18–18–27; AR 0.92 (0.89–0.96, n = 10).

Thorax: Uniformly shining dark brown, with pruinescence visible on some specimens. Slender small setae on mesonotum, long coarse setae on scutellum. Foretibial comb (fig. 16, *I*) with two rows of setae, four proximal, five distal; midtibial and hindtibial combs as illustrated (fig. 16, *J–K*). Legs yellow. Prothoracic TR 2.26 (2.06–2.46, n = 10); mesothoracic TR 1.94 (1.81–2.07, n = 10); metathoracic TR 1.75 (1.65–1.89, n = 10). Wing densely covered with slender prostrate setae; both radial cells open (fig. 16, *A*); CR 0.50 (0.46–0.53, n = 10). Halter translucent brown.

Abdomen: Yellow brown, pruinescent, with numerous slender setae; with two dorsal glands per segment. Spermathecae (fig. 16, *M*) darkly sclerotized, ovoid, with short necks; equal in size, averaging 0.079 by 0.056 mm. Distal edge of eighth sternum (fig. 16, *N*) with deep V-shaped concavity with clear flaps, apparently over gonopore.

Male.—Wing length 1.10 (0.90–1.20, n = 10) mm; width 0.34 (0.32–0.35, n = 10) mm. Antennal length 0.67 (0.59–0.73, n = 10) mm.

Head: As in female, with usual differences. Frontal sclerite (fig. 16, *F*) smoothly rounded medially. Third palpal segment (fig. 16, *D*) slender, with small shallow sensory pit containing four to five capitate sensilla; fourth and fifth segments poorly fused, fifth slightly shorter than fourth; PR 4.22 (3.10–5.14, n = 10); PP 15–32–16–11. Antenna (fig. 16, *H*) with segments 3–11 globular, tapering, and becoming narrower distally, with long yellow-brown plume and two to six sensilla per segment; segments 6–10 frequently fused; segments 12 and 13 slender, elongated, sparingly covered with coarse setae and short sensilla; segments 14 and 15 short, ovoid, slightly swollen, with numerous sensilla; segment 15 without verticils and bearing apical papilla; AP 26–17–16–16–15–15–15–16–16–57–35–22–30; AR 0.94 (0.88–1.00, n = 10).

Thorax: As in female, with usual differences. Prothoracic TR 2.09 (2.00–2.22, n = 9); mesothoracic TR 1.68 (1.50–1.79, n = 10); metathoracic TR 1.59 (1.47–1.72, n = 10). Hindbasitarsus normal. Wing like that of female but narrower; first radial cell obliterated, second narrowly open (fig. 16, *B*); CR 0.45 (0.39–0.53, n = 10). Halter translucent brown.

Abdomen: Brown, with numerous slender setae. Genitalia as in figure 16, *L*. Basistyle twice as long as wide; dististyle tapered with lateral fold terminating in slight darkened hook. Aedeagus with square, darkly sclerotized base, more than twice as broad as long, with lighter basal flanges; valves long, lightly sclerotized, and horizontal. Basistylar apodemes flared distally, joined by broader short arch. Parameres absent.

Distribution.—Europe, eastern Canada, and northeastern United States, reaching southward in the mountains.

Type.—Location of Winnertz' type not determined.

Specimens Examined. — CONNECTICUT: New London Co., Norwich, 9 June 1959, A. A. Hubert, light trap, 1 male. NEW YORK: Cattaraugus Co., Allegany St. Park, 28 May 1963, W. W. Wirth, 1 male. Chautauqua Co., South Dayton, marsh, 1 June 1963, W. W. Wirth, 1

female. Erie Co., East Concord Bog, maple swamp, 1 June 1963, W. W. Wirth, 1 male, 1 female. Essex Co., Newcomb, Lake Harris, 19 Aug. 1972, L. V. Knutson, malaise trap, 1 male. Franklin Co., Fish Creek Pond, 26 June 1963, W. W. Wirth, light trap, 1 female. Lewis Co., Brantingham, lake margin, 22 June 1963, W. W. Wirth, 1 female. Lewis Co., Whetstone Gulf, 20 June 1963, W. W. Wirth, 1 female. Monroe Co., Braddock Bay, near marsh, 12 June 1963, W. W. Wirth, 7 males, 2 females. Orleans Co., Albion, Burma Woods, 11 June 1963, W. W. Wirth, 10 males, 20 females. VIRGINIA: Fairfax Co., Falls Church, 23 May, 5 July, 8 Aug. 1958, W. W. Wirth, light trap, 1 male, 2 females. WEST VIRGINIA: Hardy Co., Lost River St. Park, 24 Sept. 1972, L. V. Knutson, malaise trap, 1 male, 3 females. Pocahontas Co., Cranberry Glades, 16 July 1955, W. W. Wirth, 1 female.

NOVA SCOTIA: Baddeck, Victoria, Aug. 1971, G. B. Fairchild, UV trap, 1 male. ONTARIO: Kemptville, 5 June 1960, W. W. Wirth, 1 female.

ESTONIA: Kahakula, 28 July 1966, H. J. Remm, 1 female. Lelle, 23 July 1960, H. J. Remm, 2 males, 2 females. Rannakula, Lulli Moor, 4 Aug. 1954, H. J. Remm, 1 male.

Discussion.—The European specimens provided by Remm and his figures thereof (Remm, *1961*) coincide very closely with the North American specimens, except that the basistylar apodemes of American specimens are more rounded.

The immature stages and life history of this species are not definitely known. *F. titillans* has generally been collected from wet habitats at high altitudes or latitudes. In Dr. Saunders' notes are illustrations of a larva, pupa, and male genitalia from a collection taken at Lake Abington, England, in October 1924 from a rotten log. The genitalia appear to be those of *F. titillans*. The larva and pupa would key to *F. canadensis* in our key, but they differ in that the *p* and *a* hairs are longer than the antenna (except on the prothorax); in *F. canadensis* they are shorter than the antenna. The pupal horn of the Lake Abington specimens is asymmetrical rather than symmetrical as in *F. canadensis*.

13. *unica*, new species

(Fig. 17)

Diagnosis.—Male can be identified by its normal hindbasitarsus, high-arched aedeagus with triangular valve, and basistylar apodemes joined by straight bar. Female is unique among known North American species in that it has only one spermatheca.

Female.—Wing length 0.93 (0.87–1.00, n = 8) mm; width 0.38 (0.36–0.42, n = 8) mm. Antennal length 0.50 (0.48–0.53, n = 8) mm.

Head: Brown, with decumbent setae. Eyes black, narrowly separated. Frontal sclerite (fig. 17, *E*) with medial pointed projection. Mouth parts light brown; mandible with many extremely fine teeth. Palpus (fig. 17, *C*) light brown, first and second segments lighter than remainder; segment 3 very short, stout, with large unsclerotized pit containing numerous capitate sensilla; fourth and fifth segments fused; PR 2.49 (2.18–2.60, n = 8); PP 16–27–17–9. Antenna (fig. 17, *G*), except pedicel, light brown; segments 3–10 rounded, tapered, becoming more slender and with more clear sensilla distally; segments 11–15 slender, tapered, bearing numerous clear sensilla; segment 15 with medial spine and apical papilla; AP 17–13–13–14–14–14–15–16–21–21–21–19–28; AR 0.96 (0.87–1.00, n = 8).

Thorax: Brown, lighter on pleuron and scutellum, with scattered fine brown setae. Scutellum and pleuron with brown pigment spots. Legs yellow brown. Foretibial comb (fig. 17, *J*) with four long setae, preceded by three rows of shorter setae; midtibial comb as illustrated (fig. 17, *K*); hindtibial comb with last two setae considerably longer than first four (fig. 17, *L*). All setae darker than tibial spurs. Prothoracic TR 2.19 (2.00–2.34, n = 8); mesothoracic TR 1.95 (1.88–2.06, n = 8); metathoracic TR 1.93 (1.80–2.20, n = 8). Wing covered with coarse, dark, semierect macrotrichia, considerably coarser and darker and erect in costal region; first radial cell narrow, second unusually long and wide (fig. 17, *A*); CR 0.54 (0.51–0.59, n = 8). Halter brown.

Abdomen: Brown, with scattered setae and brown pigment spots. Dorsal glands present. One spermatheca (fig. 17, *N*), pyriform, darkly

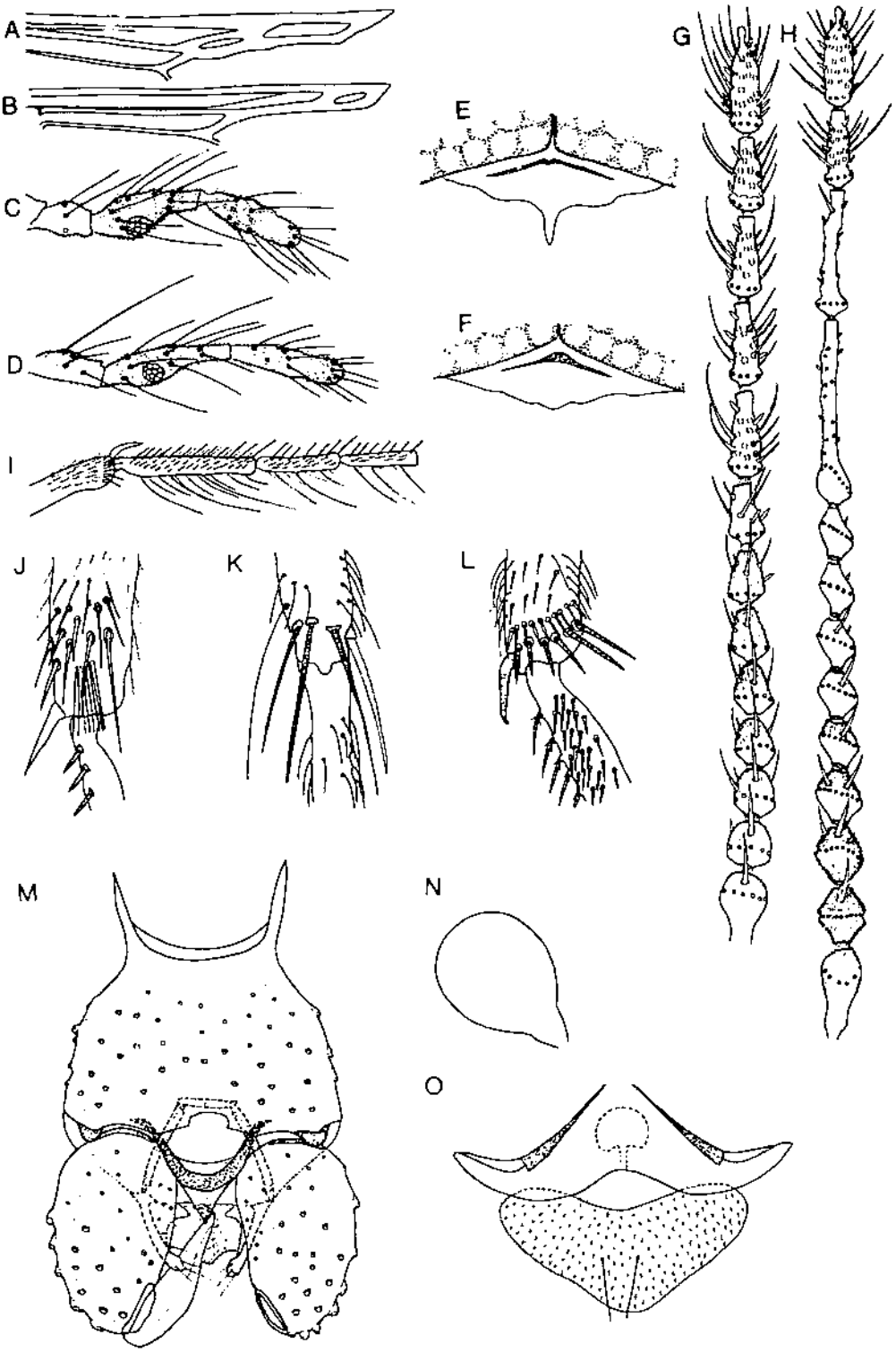


FIGURE 17.—*Forcipomyia unica*, new species: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, male frontal sclerite; *G*, female flagellum; *H*, male flagellum; *I*, male first three hindtarsomeres; *J*, female foretibial comb; *K*, female midtibial comb; *L*, female hindtibial comb; *M*, male genitalia; *N*, spermatheca; *O*, female genitalia.

sclerotized, averaging 0.072 by 0.049 mm. Distal edge of eighth sternum with slight concavity (fig. 17, *O*); subgenital sclerotization indistinct.

Male.—Wing length 1.1 (1.0–1.1, n = 6) mm; width 0.32 (0.29–0.36, n = 6) mm. Antennal length 0.74 (0.72–0.76, n = 6) mm.

Head: Brown, with decumbent setae. Eyes black; narrowly separated. Frontal sclerite (fig. 17, *F*) with slight medial mound. Mouth parts and palpus light brown. Third palpal segment (fig. 17, *D*) relatively short, stout, with large (0.009 mm) unsclerotized, shallow pit containing exposed capitate sensilla; fourth and fifth segments fused, somewhat swollen; PR 3.18 (2.60–3.55, n = 6); PP 17–31–17–10. Antennal pedicel brown, flagellar pit circular and striated; flagellum (fig. 17, *H*) light brown, with long, thick yellow plume; segments 2–11 stout, tapered, becoming narrower distally, with two to four small clear sensilla per segment; segments 12 and 13 elongated, with verticils, scattered coarse setae, and several clear sensilla; segment 15 without verticils, slightly swollen, and bearing apical papilla; AP 27–17–17–17–16–16–16–17–17–64–43–26–34; AR 1.00 (0.99–1.10, n = 6).

Thorax: Colors as in female. Prothoracic TR 2.12 (2.00–2.35, n = 6); mesothoracic TR 1.72 (1.63–1.89, n = 6); metathoracic TR 1.69 (1.64–1.82, n = 6). Hindbasitarsus normal. Wing lightly covered with coarse macrotrichia; first radial cell obliterated, second open (fig. 17, *B*); CR 0.49 (0.48–0.50, n = 6). Halter brown.

Abdomen: Brown, with layer of brown particles. Genitalia as in figure 17, *M*. Basistyle long, slender, 1.6 times longer than wide and 1.2 times longer than dististyle; dististyle slender, with slight hook at tip. Aedeagus high arched, with lightly sclerotized triangular valve and darkly sclerotized arch. Basistylar apodemes flared distally, joined by straight bar. Parameres absent.

Distribution.—Florida, Bahamas.

Types.—Holotype, male, allotype female, on slides, Chantilly Acres, Gainesville, Alachua Co., Fla., 10 May 1967, F. S. Blanton, light trap (Type No. 72225, USNM). Paratypes, 5 males, 56 females, as follows:

FLORIDA: Alachua Co., Gainesville, May–Sept. 1967, F. S. Blanton, light trap, 4 males, 41 females. Alachua Co., Island Grove, 13 June 1950, Jones, light trap, 1 male. Dade Co., Everglades Nat. Park, 24 Dec. 1962, F. S. Blanton, light trap, 1 female. Orange Co., Orlando, 19 July 1969, G. M. Stokes, light trap, 1 male, 11 females; 31 Aug. 1969, Greer coll., 1 female. Putnam Co., Red Water Lake, 27 May 1967, F. S. Blanton, light trap, 1 female. Sarasota Co., Myakka River St. Park, 21 May 1973, W. W. Wirth, light trap, 1 female.

BAHAMAS: New Providence, Coral Harbour, 23 Nov. 1968, G. M. Stokes, light trap, 2 males. North Bimini, Alice Town, 4 Feb. 1968, G. M. Stokes, light trap, 2 males, 1 female. South Bimini, May–June 1951, Cazier and Gertsch, 3 females; June 1951, Cazier and Vaurie, 2 females.

Discussion.—This species is superficially similar to the European species *F. alacris* (Winnertz), which also has the basistylar apodemes joined by a straight bar and a single spermatheca in the female. However, there are many strong differences, especially in the aedeagus and in size and color. In *F. alacris* the color is shining black, the male dististyle is much stouter distally, and the aedeagus has a much shorter and broader distal process. *F. unica* is unusually well defined, with several useful characters for both sexes and no confusing or transitional specimens. This makes it unique to the subgenus; hence the name. Nothing is known of the immature stages or life history.

Two other Old World species of *Euprojoannisia* are known whose females possess a single spermatheca: *F. vernocheti* Clastrier from Africa has the male dististyle characteristically expanded distally in a straplike structure. *F. fuscimana* (Kieffer) from the Australasian and oriental regions has the male aedeagus elongated and bearing distally a pair of slender, bladelike processes.

14. *wirthi* Saunders

(Fig. 18)

Forcipomyia (Euforcipomyia) calcarata (Coquillett); Wirth, 1952: 143 (misidentification; all stages; figs.; Calif.).

Forcipomyia (Proforcipomyia) wirthi Saunders, 1956a: 663 (all stages; Calif.; figs.).

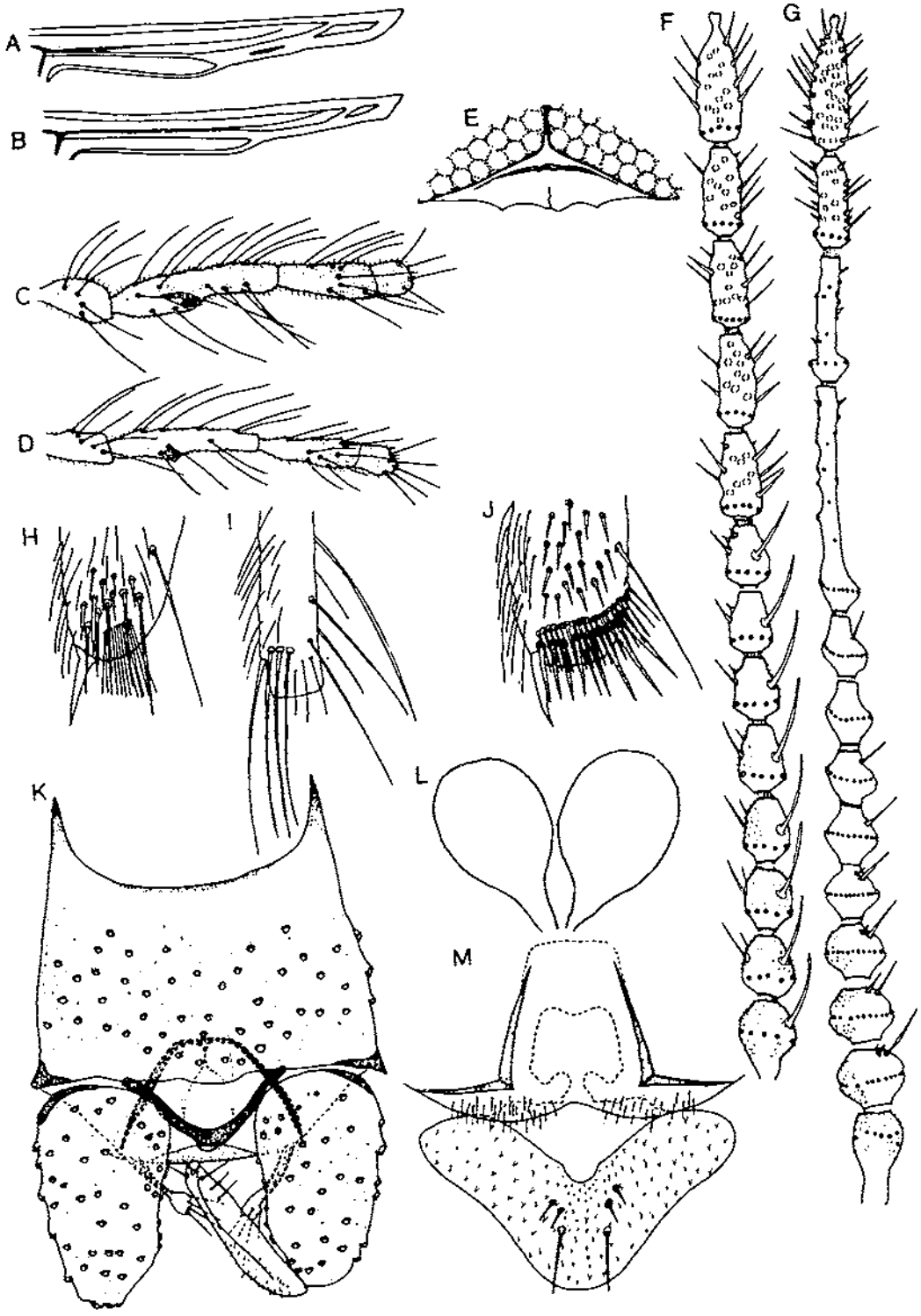


FIGURE 18.—*Forcipomyia wirthi* Saunders: *A*, Anterior veins of female wing; *B*, anterior veins of male wing; *C*, female palpus; *D*, male palpus; *E*, female frontal sclerite; *F*, female flagellum; *G*, male flagellum; *H*, female foretibial comb; *I*, female midtibial comb; *J*, female hindtibial comb; *K*, male genitalia; *L*, spermathecae; *M*, female genitalia.

Diagnosis.—Large, shining, dark-brown species. Larva can be identified by peglike *a* hairs, *p* hairs, and *q* hairs and very long, simple, lateral setae. Male can be identified by normal hindbasitarsus, arched, darkly sclerotized aedeagus, and basistylar apodemes joined in rounded arch with hyaline parameres. Female has two equal, ovoid, darkly sclerotized spermathecae with distinct necks and very deep, sclerotized palpal pit.

Female.—Length 1.90 (1.80–2.10, n = 3) mm. Wing length 1.40 (1.30–1.50, n = 5) mm; width 0.52 (0.48–0.55, n = 5) mm. Antennal length 0.61 (0.56–0.73, n = 5) mm.

Head: Completely dark brown, except for black, narrowly separated eyes. Frontal sclerite (fig. 18, *E*) bluntly rounded medially. Mandible with large, coarse teeth along distal half. Third palpal segment (fig. 18, *C*) long and slender with deep, ovoid, strongly sclerotized pit; fifth segment strikingly small; PR 4.53 (4.18–5.25, n = 4); PP 18–44–24–12. Antennal segments (fig. 18, *F*) 3–10 stout vasiform, with three clear sensilla per segment; segments 11–15 long, tapered, with numerous clear sensilla and terminal apical papilla; AP 21–15–16–15–16–16–16–16–27–28–27–25–34; AR 1.10 (0.97–1.20, n = 5).

Thorax: Shining dark brown throughout, with scattered fine yellow setae and double row of long brown setae around base of mesonotum and across scutellum. Tibial combs as illustrated (fig. 18, *H–J*). Prothoracic TR 2.01 (1.94–2.17, n = 5); mesothoracic TR 1.89 (1.77–1.96, n = 5); metathoracic TR 1.85 (1.72–2.06, n = 5). Wing covered with long coarse macrotrichia; first radial cell closed or narrowly open, second long and narrow (fig. 18, *A*); CR 0.48 (0.45–0.50, n = 4). Halter dark brown (creamy white in life; see Saunders (*1956a*)).

Abdomen: Brown, with short dark setae and double row of dorsal glands. Spermathecae (fig. 18, *L*) equal, ovoid, with long, distinct necks; averaging 0.103 by 0.058 mm. Anal cone with numerous fine setae and several medial large ones. Distal edge of eighth sternum (fig. 18, *M*) with slight concavity, internal apodemes almost parallel.

Male.—Length 2.2 (2.0–2.5, n = 4) mm. Wing length 1.5 (1.4–1.7, n = 4) mm; width 0.45 (0.42–0.48, n = 4) mm. Antennal length 0.83 (0.78–0.91, n = 4) mm.

Head: As in female, with usual differences. Third segment of palpus (fig. 18, *D*) long and slender, with small sclerotized pit; fourth and fifth segments incompletely fused; PR 5.36 (3.46–7.83, n = 3); PP 19–47–25–14. Antenna (fig. 18, *G*) with dense yellow-brown plume; basal segments more or less spherical, with one or two small clear sensilla per segment; segments 12 and 13 elongate, with scattered setae and clear sensilla; segment 14 shorter and stouter, with many sensilla; 15 swollen, with numerous sensilla and apical papilla; AP 32–20–19–18–17–17–17–19–20–75–45–31–40; AR 1.1 (1.0–1.2, n = 4).

Thorax: As in female, but with single row of large setae across scutellum. Prothoracic TR 1.92 (1.79–2.04, n = 4); mesothoracic TR 1.77 (1.62–2.11, n = 4); metathoracic TR 1.76 (1.62–1.91, n = 4). Hindbasitarsus wider than midbasitarsus, but narrower than adjacent end of tibia. Wing macrotrichia sparser and shorter than in female; first radial cell obliterated, second short and narrow (fig. 18, *B*); CR 0.44 (0.42–0.44, n = 4). Halter brown (creamy white in life; see Saunders (*1956a*)).

Abdomen: Similar to that of female, with usual differences. Genitalia as in figure 18, *K*. Basistyle nearly twice as long as wide; dististyle long and stout, with lateral fold, terminating in pointed tip. Aedeagus darkly sclerotized, high arched, about as long as wide. Basistylar apodemes joined in simple, semicircular arch bearing moderately large, obovate, hyaline parameres.

Larva.—Length (4th instar) 4.2 (3.8–4.7, n = 4) mm. Head strongly sclerotized, remainder essentially colorless except for reddish pigment spots in fat bodies; *q* hairs tiny pegs; *p* and *t* hairs longer, peglike; lateral setae slender, longer, and flexible. Body with *a* hairs like *p* hairs of head; lateral setae long and slender. Prothoracic pseudopod a simple mound with dense covering of minute setae; posterior pseudopod bearing 2 rows of anteriorly directed, erect hooks, anterior row with 10, posterior row with 8 longer ones. Cauda normal, with lateral fringe of long, coarse setae. Anal blood gills blunt, bifid, about half length of cauda.

Pupa.—Length, 2.71 mm; female 2.39 mm; width of both 0.75 mm. Light brown, generally unadorned. Respiratory horn symmetrical, stout, with broad base; narrower in female than in male, 0.079 mm long in both. Terminal processes of male long, appressed, accounting for most of difference in length between sexes; female processes blunt, divergent. Larval exuviae not retained.

Distribution.—California.

Types.—Holotype, female, Alum Rock State Park, San Jose, Santa Clara Co., Calif., 22 Feb. 1948, W. W. Wirth, reared from larvae around mineral spring (deposited in Canadian National Collection, Ottawa). Allotype, male, paratypes, same data, also in Canadian National Collection. Many paratypes, all stages, in USNM.

Specimens Examined.—CALIFORNIA: Monterey Co., Paraiso Hot Springs, 13 km SW Soledad, 31 Aug. 1975, P. H. Arnaud, Jr., 1 male, 1 female. Riverside Co., Agua Caliente Indian Reservation, Palm Canyon, 24 Feb. 1970, P. H. Arnaud, Jr., 3 females. Santa Clara Co., Alum Rock Park, data as above, 7 males, 7 females, many larvae, pupae. Siskiyou Co., Hornbrook, June 1948, R. Coleman, light trap, 1 male.

Discussion.—Wirth (*1952*) and Saunders (*1956a*) described this species in detail.

LITERATURE CITED

BARROGA, S. F.

1961. INSECTS ASSOCIATED WITH CACAO POLLINATION: A PROGRESS REPORT. Coffee and Cacao Jour. 4: 208, 219.

———

1964. PROGRESS REPORT ON THE STUDY OF INSECTS, PARTICULARLY MIDGES ASSOCIATED WITH POLLINATION OF THEOBROMA CACAO, APRIL, 1963. Philippine Jour. Plant Indus. 29: 123–133.

———

1965. PROGRESS REPORT ON THE STUDY OF INSECTS ASSOCIATED WITH POLLINATION OF THEOBROMA CACAO WITH SPECIAL EMPHASIS ON MIDGES. Philippine Jour. Agr. 27: 147–159.

BILLES, D. J.

1941. POLLINATION OF THEOBROMA CACAO L. IN TRINIDAD, B. W. I. Trop. Agr. (Trinidad) 18: 151–156.

BRETHES, J.

1914. DESCRIPTION DE SIX CECIDOMYIDAE (DIPT.) DE BUENOS AIRES. Buenos Aires Mus. Nac. de Hist. Nat. An. 26: 151–156.

CHAN, K. L., and LEROUX, E. J.

1965. DESCRIPTION OF FORCIPOMYIA (NEOFORCIPOMYIA) SP. N. AND REDESCRIPTION OF FORCIPOMYIA (NEOFORCIPOMYIA) EQUES (JOHANNSEN) (DIPTERA: CERATOPOGONIDAE), WITH AN ACCOUNT OF THE DIGESTIVE AND REPRODUCTIVE SYSTEMS. Phytoprotection 46: 74–104.

COPE, F. W.

1940. AGENTS OF POLLINATION IN CACAO. Imp. Col. Trop. Agr. [Trinidad], Cacao Res. Ann. Rpt. 1939: 13–19.

COQUILLETT, D. W.

1905. NEW NEMATOCEROUS DIPTERA FROM NORTH AMERICA. N.Y. Ent. Soc. Jour. 13: 56–69.

DESSART, P.

1961. CONTRIBUTION A L'ETUDE DES CERATOPOGONIDAE (DIPTERA). LES FORCIPOMYIA POLLINISATEURS DU CACAOYER. Bul. Agr. du Congo Belge 52: 525–540.

———

1962. CONTRIBUTION A L'ETUDE DES CERATOPOGONIDAE (DIPTERA). IV. LES FORCIPOMYIA POLLINISATEURS DU CACAOYER (2). Rev. de Zool. et de Bot. Africaines 65: 139–148.

EDWARDS, F. W.

1924. APELMA AND EUFORCIPOMYIA: SYNONYMICAL NOTES. Ent. Monthly Mag. 60: 190.

———

1926. ON THE BRITISH BITING MIDGES (DIPTERA: CERATOPOGONIDAE). Roy. Ent. Soc., London, Trans. 74: 389–462.

ENTWISTLE, P. F.

1972. PESTS OF COCOA. 779 pp. Longman Group Ltd., London.

FREE, J. B.

1970. INSECT POLLINATION OF CROPS. 544 pp. Academic Press, New York.

GERRARD, B. M.

1966. POLLINATION STUDIES. West African Cocoa Res. Inst. Rpt. 1963–65, pp. 46–47.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE.

1961. INTERNATIONAL CODE OF ZOOLOGICAL NOMENCLATURE ADOPTED BY THE XV INTERNATIONAL CONGRESS OF ZOOLOGY. 176 pp. Internatl. Trust for Zool. Nomencl., London.

———

1974. AMENDMENTS TO THE INTERNATIONAL CODE OF ZOOLOGICAL NOMENCLATURE ADOPTED SINCE THE XVI INTERNATIONAL CONGRESS OF ZOOLOGY, WASHINGTON, 1963. Bul. Zool. Nomencl. 31: 77–101.

JOHANNSEN, O. A.
1943. A GENERIC SYNOPSIS OF THE CERATOPOGONIDAE (HELEIDAE) OF THE AMERICAS, A BIBLIOGRAPHY, AND A LIST OF THE NORTH AMERICAN SPECIES. Ent. Soc. Amer. Ann. 36: 763–791.

———
1952. GUIDE TO THE INSECTS OF CONNECTICUT. PART IV. THE DIPTERA OR TRUE FLIES. FASC. 5. MIDGES AND GNATS. HELEIDAE (CERATOPOGONIDAE). Conn. State Geol. and Nat. Hist. Survey Bul. 80: 149–175.

KAUFMANN, T.
1973a. COCOA POLLINATION BY MALES OF FORCIPOMYIA SQUAMIPENNIS (DIPTERA: CERATOPOGONIDAE) IN GHANA. Trop. Agr. (Trinidid) 52: 71–74:

———
1973b. PRELIMINARY OBSERVATIONS ON CECIDOMYIID MIDGE AND ITS ROLE AS A COCOA POLLINATOR IN GHANA. Ghana Jour. Agr. Sci. 6: 193–198.

———
1974. BEHAVIORAL BIOLOGY OF A COCOA POLLINATOR, FORCIPOMYIA INORNATIPENNIS (DIPTERA: CERATOPOGONIDAE) IN GHANA. Kans. Ent. Soc. Jour. 47: 541–548.

———
1975a. STUDIES ON THE ECOLOGY AND BIOLOGY OF A COCOA POLLINATOR, FORCIPOMYIA SQUAMIPENNIS I. & M. (DIPTERA, CERATOPOGONIDAE) IN GHANA. Ent. Res. Bul. 65: 263–268.

———
1975b. ECOLOGY AND BEHAVIOR OF COCOA POLLINATING CERATOPOGONIDAE IN GHANA, W. AFRICA. Environ. Ent. 4: 347–351.

———
1975c. COCOA POLLINATION BY MALES OF FORCIPOMYIA SQUAMIPENNIS (DIPTERA: CERATOPOGONIDAE) IN GHANA. Trop. Agr. (Trinidad) 52: 71–74.

KIEFFER, J. J.
1906. DIPTERA. FAM. CHIRONOMIDAE. *In* Wytsman, P., ed., Genera Insectorum, fasc. 42, pp. 1–78, 4 pls. Bruxelles.

———
1924. CHIRONOMIDEN DER HOCHMOORE NORDEEUROPAS UND DES OSTLICHEN MITTELEUROPAS. Beitr. z. Kunde Estlands 10: 145–163.

LESTON, D.
1970. ENTOMOLOGY OF THE COCOA FARM. Ann. Rev. Ent. 15: 273–294.

MACFIE, J. W. S.
1939. A REPORT ON A COLLECTION OF BRAZILIAN CERATOPOGONIDAE (DIPT.). Rev. de Ent. 10: 137–219.

———
1944. CERATOPOGONIDAE COLLECTED IN TRINIDAD FROM CACAO FLOWERS. Ent. Res. Bul. 35: 297–300.

MCGREGOR, S. E.
1976. INSECT POLLINATION OF CULTIVATED CROP PLANTS. U.S. Dept. Agr. Handb. 496, 411 pp.

MALLOCH, J. R.
1915. SOME ADDITIONAL RECORDS OF CHIRONOMIDAE FOR ILLINOIS AND NOTES ON OTHER ILLINOIS DIPTERA. Ill. State Lab. Nat. Hist. Bul. 11: 305–363, 5 pls.

MAYER, K.
1933. DIE METAMORPHOSE VON FORCIPOMYIA (APELMA) COMIS JOHANNSEN (DIPT. CERATOPOG.) UND BESCHREIBUNG EINER UNBEKANNTEN APELMALARVE. Arch. f. Hydrobiol. Sup. Bd. 12: 224–238.

POSNETTE, A. F.
1944. POLLINATION OF CACAO IN TRINIDAD. Trop. Agr. (Trinidad) 21: 115–118.

———
1950. THE POLLINATION OF CACAO IN THE GOLD COAST. Hort. Sci. Jour. 45: 155–163.

REMM, H.
1960. THREE NEW SPECIES OF THE GENUS FORCIPOMYIA IN ESTONIA. [In Russian.] Eest. NSV Tead. Akad. Juures Asuva Lood. Seltsi Aast. 53: 188–194.

———
1961. A SURVEY OF THE SPECIES OF THE GENUS FORCIPOMYIA MEIGEN (DIPTERA, HELEIDAE) FROM ESTONIA. [In Russian, English summary.] Eest. NSV Tead. Akad. Juures Asuva Lood. Seltsi Aast. 54: 165–195.

———
1966. BITING MIDGES (DIPTERA, HELEIDAE) OF LITHUANIA. [In Russian.] Tartu Riikliku Ulikooli Toimetised 180: 53–71.

———
1967. ON THE FAUNA OF CERATOPOGONIDAE (DIPTERA) IN THE CAUCASUS. [In Russian.] Tartu Riikliku Ulikooli Toimetised 194: 3–37.

SAUNDERS, L. G.
1925. ON THE LIFE HISTORY, MORPHOLOGY AND SYSTEMATIC POSITION OF APELMA KIEFF. AND THYRIDOMYIA N. G. (DIPTERA, NEMAT. CERATOPOGONINAE). Parasitology 16: 252–277, 1 pl.

———
1956a. REVISION OF THE GENUS FORCIPOMYIA BASED ON CHARACTERS OF ALL STAGES (DIPTERA, CERATOPOGONIDAE). Canad. Jour. Zool. 34: 657–705.

———
1956b. CACAO POLLINATION IN COSTA RICA. 13 pp. Banco de Costa Rica, San Jose.

———
1959. METHODS FOR STUDYING FORCIPOMYIA MIDGES, WITH SPECIAL REFERENCE TO CACAO-POLLINATING SPECIES (DIPTERA, CERATOPOGONIDAE). Canad. Jour. Zool. 37: 33–51.

SOERJOBROTO, W.
1967. POLLINATION OF CACAO BY FORCIPOMYIA SPP. IN RELATION TO ENDRIN SPRAYING. Menara Perkebunan 36: 22–25.

SOETARDI, R. G.
1950. DE BE TEKENIS VAN INSECTEN BIJ DE BESTUIVING THEOBROMA CACAO L. Arch. v. Koffiecult. (Bogor, Indonesia) 17: 1–31.

SORIA, S. DE J.
1971. LA POLINIZACION DEL CACAO POR LAS MOSQUITAS FORCIPOMYIA SPP. (DIPTERA, CERATOPOGONIDAE) EN PALMIRA, COLOMBIA. Acta Agron. (Palmira) 21: 77–82.

———
1973. LOCAIS DE COLETA E DISTRIBUICAO DE FORCIPOMYIA (DIPTERA, CERATOPOGONIDAE) RELACIONADAS COM A FLORACAO E FRUCTIFACACAO DO CACAUEIRO NA BAHIA, BRASIL. Rev. Theobroma 3: 41–49.

——— and BYSTRAK, P. G.
1975. A NEW SPECIES OF FORCIPOMYIA (DIPTERA, CERATOPOGONIDAE) DESCRIBED IN ALL STAGES, WITH AN ACCOUNT OF ITS ROLE AS A CACAO POLLINATOR. Rev. Theobroma 5 (2): 3–11.

——— and WIRTH, W. W.
1974. IDENTIDADE E CARACTERIZACAO TAXONOMICA PRELIMINAR DAS MOSQUINHAS FORCIPOMYIA (DIPTERA, CERATOPOGONIDAE) ASSOCIADAS COM A POLINIZACAO DO CACAUEIRO NA BAHIA. Rev. Theobroma 4 (1): 3–12.

——— and WIRTH, W. W.
1976. CICLOS DE VIDA DOS POLINIZADORES DO CACAUEIRO FORCIPOMYIA SPP. (DIPTERA, CERATOPOGONIDAE) A ALGUMAS ANOTACOES SOBRE O COMPORTAMENTO DAS LARVAS NO LABORATORIO. Rev. Theobroma 5 (4): 3–22.

——— WIRTH, W. W., and FLORES-F., J. D.
1976. IDENTIDAD DE LAS MOSQUITAS FORCIPOMYIA SPP. (DIPTERA, CERATOPOGONIDAE) RELACIONADAS CON LA POLINIZACION DEL CACAOTERO EN ECUADOR (NOTA PRELIMINAR). Rev. Theobroma 6: 101–108.

SUMNER, H. M.
1962. POLLINATION. *In* Wills, J. B., ed., Agriculture and Land Use in Ghana, pp. 260–261. Oxford Univ. Press, London.

WARMKE, H. E.
1951. STUDIES ON POLLINATION OF HEVEA BRASILIENSIS IN PUERTO RICO. Science 113: 646–648.

———
1952. STUDIES ON NATURAL POLLINATION OF HEVEA BRASILIENSIS IN BRAZIL. Science 116: 474–475.

WINDER, J. A.
1977. FIELD OBSERVATIONS ON CERATOPOGONIDAE AND OTHER DIPTERA: NEMATOCERA ASSOCIATED WITH COCOA FLOWERS IN BRAZIL. Ent. Res. Bul. 67: 57–63.

——— and SILVA, P.
1972. CACAO POLLINATION: MICRODIPTERA OF CACAO PLANTATIONS AND SOME OF THEIR BREEDING PLACES. Ent. Res. Bul. 61: 651–655.

WINNERTZ, J.
1852. BEITRAG ZUR KENNTNISS DER GATTUNG CERATOPOGON MEIGEN. Linnaea Ent. 6: 1–80, 8 pls.

WIRTH, W. W.
1952. THE HELEIDAE OF CALIFORNIA. Calif. Univ. Pubs., Ent. 9: 95–266.

———
1956. THE HELEID MIDGES INVOLVED IN THE POLLINATION OF RUBBER TREES IN AMERICA. Wash. Ent. Soc. Proc. 58: 241–250.

———
1965. FAMILY CERATOPOGONIDAE (HELEIDAE). *In* Stone, A., Sabrosky, C. W., Wirth, W. W., et al., A Catalog of the Diptera of America North of Mexico, pp. 121–142. U.S. Dept. Agr. Agr. Handb. 276, 1696 pp.

———
1973. FAMILY CERATOPOGONIDAE (HELEIDAE). *In* Delfinado, M. D., and Hardy, D. E., eds., A Catalog of the Diptera of the Oriental Region, v. 1, pp. 346–388. Univ. Press, Honolulu.

———
1974. FAMILY CERATOPOGONIDAE. *In* Univ. Sao Paulo Mus. de Zool., A Catalogue of the Diptera of the Americas South of the United States, fasc. 14, pp. 1–89. Sao Paulo, Brazil.

——— and CAVALIERI, F.
1975. SOBRE LA IDENTIDAD DE EUPROJOANNISIA PLATENSIS BRETHES, 1914 (DIPTERA: CERATOPOGONIDAE). Neotropica 21: 125–126.

——— and MARSTON, N.
1968. A METHOD FOR MOUNTING SMALL INSECTS ON MICROSCOPE SLIDES IN CANADA BALSAM. Ent. Soc. Amer. Ann. 61: 783–784.

——— and MESSERSMITH, D. H.
1977. NOTES ON THE BITING MIDGES OF THE SEYCHELLES (DIPTERA: CERATOPOGONIDAE). Wash. Ent. Soc. Proc. 79: 293–308.

☆U.S. GOVERNMENT PRINTING OFFICE: 1978 O—269-626

END