OBSERVATIONS ON THE BREEDING HABITATS OF SOME *CULICOIDES* AND OTHER HELEIDAE IN THE PANAMA CANAL ZONE (DIPTERA)

SAMUEL G. BREELAND
Health Bureau, Canal Zone Government

In connection with biological studies on the salt marsh sand fly, *Culicoides furens* (Poey), in the Panama Canal Zone, a number of observations have been made on the breeding habitats of this and other species of *Culicoides* as well as members of several other genera of Heleidae. As pointed out by Forattini *et al.* (1957), and Wirth and Blanton (1959), there has been little work of this nature reported for the neotropical region. The only references known to the author which apply specifically to the Canal Zone are those of Carpenter (1951) and Woke (1954). In addition, Wirth and Blanton (1959) summarize in table form the known breeding places of Panama *Culicoides* as compiled from existing literature. It is the purpose of this paper to report observations on the breeding habitats of 14 species of Canal Zone *Culicoides*, 10 of which are additions to the list of species with recorded breeding habitats (*alahialinus, barbosai, debilipalpis* gr., *gorgasi, diabolicus, guyanensis, insignis, leopoldoi, paraensis,* and *wokei*), 2 which offer additional habitat knowledge (*hoffmani* and *reticulatus*), and 2 which corroborate existing knowledge (*furens* and *trinidadensis*). In addition, observations are given on the breeding places of representatives of 7 genera of heleids. Three of the heleid genera are represented by known species (*Forcipomyia raleighi* Macfie, *Helea fuscivenosa* (Lutz), and *Stil-*

obezzia antennalis (Coq.) and *S. coquilletti* K.), while the other 4 are represented by one or more unidentified species (*Atrichopogon, Bezzia, Dasyhelea,* and *Johannsenomyia*).

The data presented are, for the most part, based on 351 positive weekly emergence cage collections from 774 cage-weeks of operation in 144 different locations representing 8 habitats. The data were collected between July, 1958, and September, 1959. With few exceptions, observations were made on the Atlantic side of the isthmus on the east side of the Panama Canal in and near the mangrove swamps within close proximity to community housing areas.

METHODS

Emergence cages, modified from those of Dove *et al.* (1932) were utilized. These cages of two types, metal and wood, covered surface areas of 452 square inches and 484 square inches, respectively. The yield of the two types of cages was not significantly different in any of the habitats when tested side by side. The metal cages were made by transversely cutting 55 gallon shortening drums in half with an acetylene torch and welding a fruit jar cap, lip out, to the side of the container a few inches below the solid end. The area encompassed by the cap was previously cut with the torch. Two cages were constructed from a single drum. The wooden cages were made from discarded ammunition boxes by covering with tar paper and stripping heavy gauge sheet metal around the open end to facilitate implanting the cage. The jar cap was countersunk in a hole made with a keyhole saw. These cages were in position for varying lengths of time, the average being 6.8 weeks per location. Each Monday morning, the positively phototactic insects were removed from the collecting jars into vials of 70 percent alcohol. The heleids were subsequently identified and recorded. The cages were moved to new locations when it was believed the area had been adequately sampled. Unless otherwise noted, all data in this study are from this source. Ecological observations including measurements of salinity, soil temperatures, and pH were recorded from each type habitat studied; however, efforts to correlate the latter two environmental factors with breeding, either quantitatively or qualitatively, were fruitless, and results are not included in this study. Salinity of the water in each habitat was determined by means of a set of hydrometers.

OBSERVATIONS ON BREEDING HABITATS

The coastal areas at each entrance to the Panama Canal support extensive growths of mangrove swamp with associated tidal marshes. Since the majority of Canal Zone residents live near the coast, it is necessary in mosquito control activities that these areas be drained by a vast network of tidal ditches to reduce impounded rain waters. *Culicoides,* being semi-aquatic in the larval stages, are able to thrive in these moist, tide-bathed swamps, which, in spite of superficial similarity, exhibit a range of habitats which differ in their suitability for *Culicoides* breeding. Since control efforts are costly, it is desirable to know the preferred and tolerated habitats of a given species. The writer has classified breeding habitats into eight principal types, as follows.

Type 1. Black muck mangrove swamp, non-inundated.—Areas well removed from the ocean shore line with tidal ditches for drainage. Soil of the black muck type, rich in animal and vegetable matter, matted together with fine roots. Usually saturated with salt water, the source of which is seepage and spillage from ditches with the incoming high tides. Sometimes supersaturated (oozing to the step) in low areas and near ditches after highest tides; occasionally temporarily inundated at time of high tides coupled with heavy rains. Conspicuous vegetation completely dominated by mangrove trees (*Rhizophoro mangle* L.). Salinity, varying with amount of rainfall, ranges between 5.4 and 26.4 parts per thousand.

Type 2. Black muck mangrove swamp, inundated.—Areas near the ocean shore-

line, usually ditchless, exposed to frequent inundation by high tide water. Swamp floor of black muck soil as in type 1, above. When not actually inundated by sea water, the soil is saturated. Foliage more sparse than in type 1 habitat and soil temperatures a little higher.

Type 3. Coral sand mangrove swamp, non-inundated.—Areas near the ocean shore line which were at one time exposed to high tide inundation and were type 4 habitats, but which have been isolated from direct inundation by man-made obstructions, in most cases road banks. Sufficiently close to the ocean so that seepage, rather than inundation, is the source of the salt water environment. Usually not so well drained, resulting in more of a rain-tide mixture. Salinity, 16.5 to 31.5 parts per thousand.

Type 4. Coral sand mangrove, inundated.—Ditchless areas near the ocean shore line exposed to frequent inundation by high tide water. The soil more of a mixture of black muck and coral sand, the latter forming the top one-half inch or so of the swamp floor. Soil smooth with a lack of matted roots, less decaying matter than in black muck type. Inundating water is sea water.

Type 5. Mangrove tide ditch muck.—(A dry weather condition.) Many areas well removed from high tide inundation, receive sea water only in and near the drainage ditches as a result of high tide flow in the ditch channels. Thus, in dry weather, there is created a super-saturated oozing muck in the sides and bottoms of these ditches, fully exposed to the sun with little or no vegetation except algae. The soil temperatures are usually in the nineties, and the salt content is from 26.5 to 31.5 parts per thousand.

Type 6. Salt marsh.—Unshaded areas of low elevation characterized by a covering of grasses and sedges. Not much breeding except in and near drainage ditches traversing the area. The soil in these ditches is a grey or brown muck, saturated to super-saturated, exposed to sun and light. The salinity is from 15 to 26.5 parts per thousand.

Type 7. Fresh water mangrove swamp.—Areas adjacent to rivers or fresh water streams flowing through mangrove swamp or salt marsh. Tidal drainage ditches empty into these streams which carry the drainage water out to sea with the descending tide. For the most of their length these streams have insufficient effect to change the typical mangrove environment; however, certain topographic peculiarities may result in a predominantly fresh water habitat near these streams within the confines of an otherwise saline area. Except for salinity, the habitat is very similar to the salt water types, 1 through 5.

Type 8. Adjacent forests.—Forest areas adjacent to mangrove swamps. Characteristic vegetation includes the star apple (*Chrysophyllum*), wild fig (*Ficus*), almendro (*Dipteryx panamaensis*), maragua (*Poulsenia armata*), and many palms, aroids, heliconias, and lianas (Wirth and Blanton, 1959). Soil, at least in places, sufficiently moist for *Culicoides* breeding, usually saturated to inundated in rainy season, high in organic matter. A fresh water habitat.

ECOLOGICAL OBSERVATIONS

The distribution of the various species according to the type habitat in which they were found is given in Table 1. The relative reliability of a habitat association with a given species may be ascertained by the number of times the species was found in a particular habitat, the number being given in the table.

In a number of instances, two or more species were collected from the same cage at the same time, thereby establishing a tolerance for the same larval habitat. The associations so observed are listed under the discussions of the species, which follow:

Culicoides alahialinus Barbosa.—Collected 1 female from a cage placed on bank of Puerto Escondido River (type 7 habitat)

at margin of well-drained mangrove swamp, December 5, 1958. The soil was saturated from river seepage and rainfall. The adult was associated with *C. leopoldoi* and *Stilobezzia* sp.

Culicoides barbosai Wirth and Blanton.—Collected 74 specimens (32 males, 42 females) from 20 collections in 11 locations representing 5 salt habitats. Recovered from cages during each calendar month except May and July, but its presence in biting records during these months completes the year-round distribution. This species, while well distributed in coastal mangrove areas, seems to show preference for coral sand habitats (types 3 and 4) near the ocean shore line. Found in cage jars with *C. furens, Dasyhelea* sp., *Stilobezzia antennalis,* and *S. coquilletti;* reared from muck samples with *C. trinidadensis.*

Culicoides debilipalpis gr.—Collected 3 adult males from saturated, black muck mangrove in Galeta swamp, August 3, 1959, and another male from the same

TABLE 1.—Distribution of the Heleid species recovered from emergence cages in different habitat types

Species	Number of times collected	Number of different cage locations	Number of times collected species from each habitat type: Black muck mangrove, non-inundated by tide 1	Black muck mangrove, inundated by tide 2	Coral sand mangrove, non-inundated by tide 3	Coral sand mangrove, inundated by tide 4	Mangrove tide ditch muck 5	Salt marsh 6	Fresh water mangrove 7	Forest areas adjacent to mangrove 8
Culicoides										
alahialinus	1	1	—	—	—	—	—	—	1	—
barbosai	20	11	4	3	6	6	1	—	—	—
debilipalpis gr.	2	2	2	—	—	—	—	—	—	—
diabolicus	4	4	2	—	—	1	—	—	1	—
furens	239	66	184	13	29	4	2	7	—	—
gorgasi	3	3	3	—	—	—	—	—	—	—
guyanensis	1	1	1	—	—	—	—	—	—	—
hoffmani	4	1	4	—	—	—	—	—	—	—
insignis	2	2	—	—	—	—	—	—	—	2
leopoldoi	12	5	—	—	—	—	—	—	11	1
paraensis	1	1	—	—	—	—	—	—	—	1*
reticulatus	5	2	—	—	—	1†	—	—	—	4
trinidadensis	1	1	—	—	—	1	—	—	—	—
wokei	2	2	—	—	2	—	—	—	—	—
Atrichopogon sp.	3	3	2	1	—	—	—	—	—	—
Bezzia sp.	1	1	—	—	—	—	—	—	1	—
Dasyhelea sp.	27	19	20	2	—	—	5	—	—	—
Forcipomyia										
raleighi	3	2	—	—	—	—	—	—	3	—
sp.	5	4	4	—	—	—	1	—	—	—
Helea fuscivenosa	3	2	3	—	—	—	—	—	—	—
Johannsenomyia sp.	2	2	—	—	—	—	—	—	—	2‡
Stilobezzia										
antennalis	3	3	1	—	—	—	—	—	—	2
coquilletti	3	3	1	—	—	—	—	—	—	2
sp.	4	3	1	—	—	—	—	—	3	—

* Reared from tree-hole collected larvae.
† A crab hole was under the cage from which this collection was made.
‡ Margin of fresh water stream.

type habitat (type 1), but from a different location, September 14, 1959. Found in association with *C. furens*.

Culicoides diabolicus Hoffman.—This species is the most numerous in light trap collections, but its preferred breeding habitat has escaped detection. Five specimens (4 males, 1 female) were recovered from 3 habitats. The species was found in mangrove swamp (habitat types 1 and 4) and in a fresh water mangrove situation, along the bank of the Puerto Escondido River (type 7 habitat). The species was recovered during October, November, and December, 1958. Found associated with *C. furens* in the salt mangrove, and with *C. leopoldoi* and *C. insignis* in the fresh water situation.

Culicoides furens (Poey).—Collected hundreds of specimens from 239 cage collections representing 66 locations and all six of the salt water habitats. No specimens were recovered from fresh water habitats 7 and 8; however, many collections were made in areas of rather low (1.5 to 5.8 parts/1000) salt content. Widely distributed throughout the mucky salt water bathed coastal areas, year round. Reaches greatest abundance in mangrove swamp or marsh only partially shaded. Densest populations found in super-saturated muck of tide ditches with no standing water and partially or fully exposed to sunlight. Virtually absent in densely shaded mangrove. Collected in association with *C. barbosai, C. debilipalpis* gr., *C. diabolicus, C. gorgasi, C. guyanensis, C. trinidadensis, C. wokei, Dasyhelea* sp., *Atrichopogon* sp., *Forcipomyia* sp., and *Helea fuscivenosa*.

Culicoides gorgasi Wirth and Blanton.—Collected 3 females from 3 locations in a single habitat (type 1, black muck mangrove). Two specimens were taken in February from Galeta swamp cages, and 1 specimen in May from a Fort Randolph cage. Associated with *C. furens* and *Dasyhelea* sp.

Culicoides guyanensis Floch and Abonnenc.—Recovered 2 male specimens from a Galeta swamp cage, type 1 habitat (black muck mangrove) on April 20, 1959, along with 30 specimens of *C. furens*. This is the same cage, in the same location, from which a single specimen of *C. gorgasi* was taken on February 23, 1959.

Culicoides hoffmani Fox.—Five specimens (2 males, 3 females) recovered from a single location in black muck mangrove habitat (type 1) with from 1 to 2 inches of standing water. Cage operated in position for a period of 6 cage-weeks, October 21, 1958–December 5, 1958, near Rainbow City. *C. hoffmani* was recovered in this location to the exclusion of other species, although a subsequent study revealed no special habitat characteristics, except for standing water. Specimens of *C. furens* were recovered from a nearby cage in the same habitat. This species was reported from tree hole debris by Fox (1949).

Culicoides insignis Lutz.—Only 2 specimens of this species were recovered from emergence cages; a female from a rain saturated forest floor near Coco Solo Hospital, December 15, 1958, in association with *C. leopoldoi* and *C. diabolicus*, and a male from stagnant water over a manhole cover at Coco Solo Hospital on August 17, 1959. This species is reported by Wirth and Blanton (1959) as being abundant in the arid tropics cow pasture country, a condition which does not exist on the Atlantic side.

Culicoides leopoldoi Ortiz.—Collected 45 specimens (18 males, 27 females) from 12 collections in 5 locations, representing 2 fresh water habitats (types 7 and 8). This species was recovered frequently from cages along the bank of the Puerto Escondido River, a fresh water mangrove situation, during November, December, and January. Two males were taken from a cage in a saturated forest area near France Field on December 8, 1958. Collected in association with *C. diabolicus, C. alahialinus, C. insignis, Bezzia* sp., and *Stilobezzia* sp.

Culicoides paraensis (Goeldi).—One male emerged on September 8, 1958, from tree hole debris collected September 5, 1958.

Culicoides reticulatus Lutz.—Recovered 41 specimens (32 males, 9 females) from 5 collections in 2 locations representing 2

habitats. Four collections were from a saturated forest floor (type 8 habitat), and one collection, yielding a single specimen was from a type 4 (inundated coral sand mangrove) habitat, but this cage was placed over a crab hole which might have been the source of the specimen. This species has been previously reported from crab holes by Lutz (1913) and by Forattini (1957). Indications are that this is predominately a forest floor species in well saturated areas during wet weather. Collected July, August, and September, 1959. No associated species.

Culicoides trinidadensis Hoffman.—Two females emerged August 10, 1959, from soil samples taken from a type 4 habitat (non-inundated coral sand mangrove), July 27, 1959, on Largo Remo Island. Galeta Point light trap where large numbers of this species are taken is in close proximity. In association with *C. furens* and *C. barbosai.*

Culicoides wokei Fox.—Recovered 7 specimens (3 males, 4 females) from a coral sand mangrove habitat in Galeta swamp, October 13, 1958, and 11 specimens (5 males, 6 females) from the same type habitat (type 3) on Pina Guapa Island, off Galeta Point, August 17, 1959. In association with *C. furens.*

Atrichopogon sp.—Collected 7 specimens (5 males, 2 females) from 3 locations representing 2 mangrove swamp habitats. One male emerged along bank of tidal ditch in non-inundated mangrove (type 1), Coco Solo Swamp, February 9, 1959, and 2 females in a like habitat in Galeta swamp, March 9, 1959. Recovered 4 males from a cage in type 2 habitat (black muck mangrove, inundated) on August 4, 1958, in association with *C furens,* and *Dasyhelea* sp.

Bezzia sp.—Recovered 1 male specimen from the bank of Puerto Escondido River (type 7 habitat) November 28, 1958. In association with *C. leopoldoi.*

Dasyhelea sp.—Collected numerous specimens of several species from a variety of habitats. Well distributed in mangrove areas and quite often (18 of 27 collections) associated with *C. furens.* Reaches greatest abundance in super-saturated ditch muck and similar areas of swamp which are exposed to the sun and with little or no visible vegetation. Woke (1954) gives a more complete account of *Dasyhelea* breeding in the Canal Zone. In addition to *C. furens,* representatives of this genus were found in association with *C. barbosai, C. gorgasi, Atrichopogon* sp., and *Forcipomyia* sp. Woke (1954) reports the recovery of *Dasyhelea* larvae July through September. The writer has emergence cage records for each month except April, May, and June, normally the last three months of dry season.

Forcipomyia sp.—A total of 12 specimens (7 males, 5 females) was recovered from 4 collections in type 1 mangrove in 3 different swamps, Galeta, Coco Solo, and Margarita, in February, September, and December, respectively. Associated with *C. furens* in the Galeta collection. In February, 1959, numerous specimens were taken in association with a dense population of *Dasyhelea* in a single collection from the oozing muck of a tide ditch, open to the sun (type 5 habitat). Also present in this collection were *Stilobezzia antennalis* and *S. coquilletti.*

Forcipomyia raleighi McFie.—Collected a single female from the bank of Puerto Escondido River, January 6, 1959, with no associated heleids. Collected 6 males and 6 females from an emergence cage in fresh water pocket of mangrove swamp, January 6, 1959, and an additional male and 2 females, January 19, 1959. In each case, considerable decaying leaves were covered by the cage, ground moist, but not mucky.

Helea fuscivenosa (Lutz).—Collected a total of 7 specimens (4 males, 3 females) from 2 locations from a single (type 1) habitat. One female emerged along with several specimens of *C. furens,* from a cage near France Field, August 18, 1958. Three males, along with several specimens of *C. furens,* emerged from a Galeta mangrove swamp, August 9, 1959, followed by the recovery of 1 male and 2 females from the same cage, September 15, 1959.

Johannsenomyia sp.—Collected several specimens from two separate cages along

the margin of a narrow and shallow portion of the Majagual River near France Field, March 9, 1959. In association with *Stilobezzia antennalis,* and *S. coquilletti.* Area exposed to the sun.

Stilobezzia antennalis (Coq.) and *S. coquilletti* K.—These 2 species were found in relatively large numbers on the margin of shallow portion of the Majagual River near France Field, March 9, 1959. In association with each other and with a species of *Johannsenomyia,* and with *C. barbosai.* Woke (1954) reported *S. coquilletti* reared from larvae taken from algae and black muck from a shallow stream of fresh water flowing through tidal marsh, a situation not unlike that reported here. Also collected in association with *Forcipomyia* sp. in a collection from mangrove swamp near Rainbow City.

Stilobezzia sp.—Several specimens each, of two species, collected in association with *C. leopoldoi,* November 24, 1958, from bank of Puerto Escondido River (type 7 habitat). The same 2 unidentified species were collected from a different cage in the same habitat on December 5, and again on December 15, 1959. In association with *C. alahialinus* in the December 5, collection.

SUMMARY

Observations on the breeding places of 14 species of *Culicoides* and representatives of 7 other genera of Heleidae are recorded. Results are based on collections made between July, 1958, and September, 1959, in and near coastal mangrove areas of the Panama Canal Zone. In addition to habitat descriptions and listings, the larval associations and dates of occurrence are given for each species.

ACKNOWLEDGMENT

I wish to express my sincere thanks to Dr. W. W. Wirth of the U. S. National Museum for the identifications and verifications of the heleid species discussed in this paper.

References

CARPENTER, S. J. 1951. Studies of *Culicoides* in the Panama Canal Zone (Diptera, Heleidae). Mosquito News 11(4):202–208.

DOVE, W. E., HALL, D. G., and HULL, J. B. 1932. The salt marsh sandfly problem. Ann. Ent. Soc. Amer. 25:505–522.

FORATTINI, O. P., RABELLO, E. X., and PATTOLI, D. 1957. A brief note on breeding places of *Culicoides* in São Vicente, Brazil. Mosquito News 17(4):312–313.

FOX, I. 1949. Notes on Puerto Rican biting midges or *Culicoides* (Diptera: Ceratopogonidae). Bull. Brooklyn Ent. Soc. 44:29–34.

LUTZ, A. 1913. Contribuição para o estude das "Ceratopogoninas" hematofagus do Brasil (parte sistemática). Mem. Inst. Oswaldo Cruz. 5:45–73.

WIRTH, W. W., and BLANTON, F. S. 1959. Biting midges of the genus *Culicoides* from Panama (Diptera: Heleidae). Proc. U. S. Natl. Mus. 109: 237–482.

WOKE, P. A. 1954. Observations on Central American biting midges (Diptera, Heleidae). Ann. Ent. Soc. Amer. 47(1):61–74.