

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE  
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# Genus *Culicoides* (Diptera-Ceratopogonidae) in Central Missouri

SPECIES; SEASONAL ABUNDANCE; ACTIVITY

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## SUMMARY

Twenty-one species, including three subspecies of the genus *Culicoides* were recorded in central Missouri from April, 1966 to July, 1967. New state records of *Culicoides* include the following 16 species and subspecies: *C. arboricola* Root and Hoffman, *C. baueri* Hoffman, *C. biguttatus* (Coquillett), *C. haematopotus* Malloch, *C. hinmani* Khalaf, *C. nanus* Root and Hoffman, *C. oklahomensis* Khalaf, *C. paraensis* (Goeldi), *C. piliferus* Root and Hoffman, *C. sanguisuga* (Coquillett), *C. scanloni* Wirth and Hubert, *C. spinosus* Root and Hoffman, *C. stellifer* (Coquillett), *C. travisi* Vargas, *C. variipennis variipennis* (Coquillett), *C. variipennis sonorensis* Wirth and Jones and *C. villosipennis* Root and Hoffman.

The remaining six species were previously recorded in Missouri. These included: *C. crepuscularis* Malloch, *C. guttipennis* (Coquillett), *C. multipunctatus* Malloch, *C. obsoletus* (Meigen), *C. variipennis australis* Wirth and Jones, and *C. venustus* Hoffman.

Eight species of *Culicoides* were recorded biting man in central Missouri. These included: *C. biguttatus*, *C. guttipennis*, *C. haematopotus*, *C. obsoletus*, *C. piliferus*, *C. sanguisuga*, *C. scanloni*, and *C. variipennis*. In addition, the following species have been recorded biting man in the United States: *C. crepuscularis*, *C. hinmani*, *C. paraensis*, *C. spinosus*, and *C. travisi*.

Description of habitats, seasonal abundance data, and biting records on man are also presented along with a key to the adult female of species included.

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## SPECIES; SEASONAL ABUNDANCE; ACTIVITY

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### INTRODUCTION

Many species of *Culicoides* are considered notorious pests of man throughout this country. Because of their minute size *Culicoides* are often overlooked, or their annoyance is blamed on larger blood suckers such as mosquitoes. These biting midges are usually crepuscular in habit. Consequently, reduced visibility combined with their small size has earned them an appropriate name, "no-sees-ums."

Major efforts have been undertaken in several states to increase our knowledge of *Culicoides*. However, little information has been available on the *Culicoides* of Missouri. Adams (1940) collected two species, *Culicoides crepuscularis* Malloch and *C. variipennis* (Coquillett) from light traps operated in Jackson County. Foote and Pratt (1954) listed *C. guttipennis* (Coquillett) and *C. obsoletus* (Meigen) taken from Missouri. Wirth and Jones (1957) recorded *C. variipennis australis* Wirth and Jones, from Booneslick Salt Spring in Howard County. Stone *et al.* (1965) listed *C. multipunctatus* Malloch and *C. venustus* Hoffman as being recorded from Missouri.

In addition to their biting, *Culicoides* have also been shown to be vectors of certain viral, protozoan and filarial diseases. Fallis and Bennett (1961a) list many of these diseases, their distribution and *Culicoides* vectors. Among these, *Culicoides variipennis*, a proven biological vector of bluetongue virus of sheep, is considered to be of economic importance to agriculture in the sheep-producing states of the west. Of particular importance today is the possible role of *Culicoides* in arbovirus transmission. Karstad *et al.* (1957) isolated eastern encephalitis virus from unidentified *Culicoides* specimens in Georgia. Also, Venezuelan encephalitis was isolated from *Culicoides* during an outbreak involving both man and horses in Ecuador.

Since no major work with *Culicoides* has been attempted in Missouri and because these flies constitute a potential health problem as vectors of disease of

both man and domestic animals, this study was undertaken. The objectives included: (1) to determine the species composition; (2) to determine their seasonal abundance; and (3) to establish bite records on man by *Culicoides* in the study area. This area was restricted to Boone, Howard, and Morgan counties.

## MATERIALS AND METHODS

Various methods were used to collect both larvae and adults in the field. Four 110-volt light traps were operated in Columbia residential areas from April 26 to September 30, 1966, and from April 12 to July 1, 1967. Material was collected dry. Two other 110-volt light traps were operated in the vicinity of Gravois Mills in Morgan County from April 2 to June 26, 1967. Material was collected in 50 percent ethyl alcohol. This proved to be the most desirable method of collecting *Culicoides* in light traps because of their rapidity in drying out. Light trap 5 was located adjacent to the Lake-of-the-Ozarks in a forested area. Light trap 6 was situated at the edge of a flat open area adjacent to Gravois Creek and surrounded by forest. The trap was operated on a farm containing both cattle and chickens.

Emergence cages patterned after Dove *et al.* (1932) were used in various types of habitats. Collections were made at weekly intervals and then each cage was moved to a position adjacent to that of the week before. The following week each cage was returned to the position it was in two weeks earlier. At all sites the emergence cage(s) were positioned in the area(s) of greatest probable concentration of immature forms of *Culicoides*. This was determined either by observation or results from previous studies.

Qualitative sampling at various habitats was also undertaken. Small samples from tree holes, the edges of creeks, ponds and pools, a salt spring, cottonwood tree sap flows, and piles of leaf litter were returned to the lab. The immatures included were allowed to develop.

Quantitative samples of larvae were collected at two sites from June, 1966, to June, 1967. One location was at Booneslick Salt Spring in Howard County. At this site a series of moderately saline springs provided the water source. Larval samples were taken at this location from two places due to seasonal differences in current, algal development and possible mineral content of the water itself. The second location was a polluted effluent area adjacent to a sewage lagoon. At this site, samples were taken in the immediate area of emergence cage one. All larval samples were taken at weekly or biweekly intervals using a 6 inch by 6 inch Eckman dredge and a white plastic dish pan. Material was transferred from the dish pan to one gallon jars and returned to the lab. Larvae were removed from these samples by means of a high density solution using the magnesium sulfate method of Anderson (1959).

## MORPHOLOGY

The genus *Culicoides* is characterized by the presence in the female of strong, well-developed mouthparts, and 15-segmented antennae. Two prominent sensory pits are located immediately behind the head on the anterior surface of the mesonotum. The tarsal claws are equal, small, and simple in both sexes with the empodium vestigial or small. The costa extends to about the mid-length of the wing. Sclerotized radial branches of the wing form two slightly unequal cells, the first radial cell narrowly elongate and the second much wider and slightly longer. Also, the second radial cell is not definitely square at the distal end (Figure 1).\* Macrotrichia are usually abundant.

Due to the small size of *Culicoides* and the closely related species involved, many of the diagnostic characters essential for identification require slide-mounted specimens. As a result, coloration and over-all size of the specimen are often obscured. For this reason, many taxonomic characters previously used by other workers are briefly defined in the following paragraphs. These characters are for female specimens only and have been used in the following keys and descriptions.

### Head

**Eye Separation.** The degree of compound eye separation is usually constant for a given species. Separation may vary from contiguous to widely separated.

**Antennal Ratio.** The antennal ratio (AR) is determined by combining the length of the last five antennal segments and dividing by the combined lengths of the previous eight antennal segments. The scape and pedicel are not included in this ratio.

**Sensillar Pattern.** Situated on the distal tip of individual antennal segments 3 through 15, in varying combinations, are small oval spots with dense tufts of hair (Figure 2). These sensillar tufts or olfactory pits occur in various patterns depending upon the species and are generally constant for a given species. Often these sensillar tufts are not in a direct line along the length of the antenna. Consequently, close observation of both antennae of a given specimen is necessary. In the species descriptions, parentheses around an antennal segment number indicate the sensory tuft may or may not be present on that segment. Jamnback (1965) associated host preference with the number of these sensillar tufts on the antenna. He suggested that species with higher numbers of these olfactory pits are primarily ornithophilic whereas species with fewer pits are primarily mammalophilic.

**Maxillary Palp.** The maxillary palp (Figure 3) is five-segmented with the first segment reduced and the third segment slightly to greatly swollen in comparison to the other four segments. The third segment contains a sensory pit whose location, size, and depth vary to some extent from one species to another.

\* See Appendix, beginning on page 25, for all Figures.

By measuring the greatest length of the third segment and dividing by its greatest width a useful ratio ( $L/W$ ) is obtained. Jamnback (1965) used three sets of ratio values to establish the degree of swelling in the third maxillary segment. For constancy these values are followed in this work.  $L/W$  ratio values of more than 3.00 indicate the segment is slightly swollen;  $L/W$  values of 2.50 to 3.00 indicate it is moderately swollen;  $L/W$  values of less than 2.50 indicate the third segment of the maxillary palp is greatly swollen.

**Head to Proboscis Ratio.** The head to proboscis ( $H/P$ ) ratio is obtained by measuring the distance between the center of the median hair socket (Figure 3) and the center of the tormae. This value is the head length. The distance from the center of the tormae to the tip of the labrum-epipharynx is the length of the proboscis.

**Mandibular Teeth.** The number of mandibular teeth has been found to be a useful taxonomic character in separating closely-related species.

### Thorax

**Legs.** The presence or absence of distinct pale bands on the femora and tibiae is a useful character in species identification. Also, the number of spines on the hind tibial comb (Figure 4) and their relative lengths are constant for most species.

**Wing.** There is an abundance of microtrichia on the wings, usually evenly distributed. In many instances, species can be distinguished on the basis of resulting light and dark areas on the wing. The Tillyard modification of the Comstock-Needham system of wing venation is used in this work. The anterior branches are  $M_1$  and  $M_2$  and the posterior branches are  $M_{3+4}$  and  $Cu_1$ . Figure 1 defines these cell and vein locations.

### Abdomen

**Spermathecae.** The spermathecal system of *Culicoides* consists of sclerotized and unsclerotized parts. Figure 5 illustrates such a representative system. The number of visible sclerotized spermathecae may vary from none to three in local species. One species, *Culicoides multipunctatus* Malloch, lacks a sclerotized spermathecal system altogether. Other species possess only a single large one while some species may have three. The latter situation results from an expanded rudimentary spermatheca. In addition to their presence or absence and number, the size of the spermathecae in relation to each other is an important character. These relative size variations may vary from equal to subequal or they may be completely unequal to each other.

**KEY TO CENTRAL MISSOURI SPECIES OF ADULT  
FEMALE *CULICOIDES***

1. Second radial cell of wing included partially or entirely  
within a light spot (Figures 19, 25, 31) .....2  
Second radial cell of wing entirely within a dark spot  
(Figures 10,11 ) .....8
2. Spermathecae unequal or very unequal with neck absent  
(Figures 44, 46) or very short parallel sided (Figure 40) .....3  
Spermathecae equal or subequal; neck either long  
parallel sided or short, strongly tapered (Figures 34, 37, 39, 48) .....4
3. Proximal antennal segments very short, antennal ratio  
1.89 (n=1); sensillar pattern 3, 5, 7, 9-15; faint wing  
pattern as shown in Figure 22 ..... *piliferus* (p. 16)  
Sensillar pattern 3, 5, 7, 9, 11-15; antennal ratio 1.45  
(n=1). Wing as shown in Figure 24 ..... *scanloni* (p. 18)
4. Compound eyes separated .....5  
Compound eyes contiguous .....6
5. Sensillar pattern, 3, 11-15; lacking a sclerotized ring ..... *spinus* (p. 18)  
Sensillar pattern 3(4)5(6)7(8)9(10)11-15;  
sclerotized ring present ..... *biguttatus* (p. 10)
6. Vein Cu<sub>1</sub> in light area for entire length; legs with  
distinct proximal pale bands on all tibiae;  
Spermathecae as shown in Figure 51 ..... *venustus* (p. 22)  
Vein Cu<sub>1</sub> in dark area (Figure 23); legs with indistinct  
pale bands; Spermathecae as shown in Figures 41, 45 .....7
7. Wing vein M<sub>3+4</sub> with fewer than 8 macrotrichia; cell M<sub>4</sub>  
with fewer than 4 macrotrichia excluding  
border of wing ..... *sanguisuga* (p. 16)  
Wing vein M<sub>3+4</sub> with more than 8 macrotrichia; cell M<sub>4</sub>  
with more than 4 macrotrichia excluding  
border of wing ..... *obsoletus* (p. 16)
8. Wings with pattern of two pale spots or less  
(Figures 12, 17) .....9  
Wings with pattern of more than two pale spots  
(Figures 18, 26) .....10
9. Spermathecae unsclerotized (not visible); antennal ratio  
0.85-1.01; mandible with 10-13 teeth ..... *multipunctatus* (p. 15)  
Spermathecae sclerotized with bluntly tapered necks  
(Figure 35); antennal ratio 1.00-1.16; mandible  
with 15-17 teeth ..... *biguttatus* (p. 10)

10. Only one spermatheca present (Figures 36, 50) ..... 11  
 Two or more spermathecae present ..... 12
11. Spermatheca large, subelliptical; legs indistinctly banded;  
 wing pattern shown in Figure 13 ..... *crepuscularis* (p. 11)  
 Spermatheca C- or U-shaped; legs distinctly banded; wing  
 pattern shown in Figures 28, 29, 30 ..... *variipennis* (p. 20)
12. Wing without discal pale spots; sensillar pattern 3-15  
 (Figures 18, 27) ..... 13  
 Wing with discal pale spots; sensillar pattern different ..... 14
13. Legs with distinct pale bands; proboscis short, H/P ratio  
 1.79-2.13; Mandible with 11-13 teeth ..... *nanus* (p. 15)  
 Legs with indistinct pale bands; proboscis moderately long,  
 H/P ratio 1.22 (1.10-1.34); Mandible with 13-17  
 teeth; Spermathecae as shown in Figure 49 ..... *travisi* (p. 19)
14. Pale spot absent on  $M_2$  vein of wing (Figure 16) ..... 15  
 Pale spot present on  $M_2$  vein of wing (Figure 14) ..... 17
15. Two distinct pale spots in  $M_1$  cell; sensillar pattern  
 3, 5, 7, 9, 11-15; spermathecae as shown in  
 Figure 39 ..... *binmani* (p. 15)  
 Three or four distinct pale spots in  $M_1$  cell; sensillar  
 pattern 3, 8-10 ..... 16
16. Hind tibial comb with 4 spines; four distinct pale spots  
 in  $R_5$  cell (Figure 21); spermathecae as shown  
 in Figure 43 ..... *paraensis* (p. 16)  
 Hind tibial comb with 5 spines; only three distinct  
 pale spots present in  $R_5$  cell (Figure 26) ..... *stellifer* (p. 18)
17. Distal pale spots in cells  $R_5$ ,  $M_1$ ,  $M_2$ ,  $M_4$  and vannal  
 cell all touching or very closely bordering wing  
 margin; pale spot over r-m cross-vein of wing  
 not extending basad of vein (Figure 15);  
 Spermathecae as shown in Figure 38 ..... *haematopotus* (p. 14)  
 Distal pale spots in cells  $R_5$ ,  $M_1$  and  $M_2$  cells of  
 wing not touching wing margin ..... 18
18. Pale spot on  $M_1$  vein of wing absent;  
 sensillar pattern 3-10 ..... *baueri* (p. 10)  
 Distinct pale spot present on  $M_1$  vein;  
 sensillar pattern different ..... 19
19. Wing with pale spot over r-m cross-vein small, not  
 extending below  $M_{1+2}$  vein (Figure 32);  
 Spermathecae as shown in Figure 5 ..... *villosipennis* (p. 23)  
 Wing with pale spot over r-m cross-vein  
 extending below  $M_{1+2}$  vein ..... 20

20. Wing with  $Cu_1$  vein entirely in dark area ..... *guttipennis* (p. 12)  
 Wing with  $Cu_1$  vein in pale area for all or part of  
 its length (Figure 20); Spermathecae as shown in Figures 33, 42 ..... 21
21. Hind femur dark to tip ..... *oklabomensis* (p. 16)  
 Prominent subapical pale band  
 present on hind femur ..... *arboricola* (p. 10)

### *Culicoides arboricola* Root and Hoffman

This species was collected commonly from wet tree holes in central Missouri. *C. arboricola* was collected in light traps from May 4 to September 14, 1966, in Columbia. During 1967, this species was first recorded from a light trap April 28 in Morgan County. Collections of *C. arboricola* were still being taken June 25 when operation of all light traps was discontinued. On June 12, 1967, 689 *C. arboricola* were collected from light trap 6. This was the largest collection of this species during the period from April 1 through June 25, 1967. The following dates and numbers indicated nights of relatively high activity of this species: May 29 (222), June 10 (284), June 11 (189), June 15 (542), June 17 (137), and June 20 (193). All of these collections were obtained from light trap 6 which was located near a chicken coop. No records are known of *C. arboricola* biting man.

### *Culicoides baueri* Hoffman

One female was captured in an emergence cage over a permanent marshy area during the week of August 29 to September 5, 1966. One male *C. baueri* was taken the same way from the edge of a back water isolated pool along Gravois Creek in Morgan County during the week April 28 to May 5, 1967. The water source at both locations came from underground fresh water springs. *C. baueri* was collected in light traps from May 25 to September 1, 1966, in Columbia. During the first half of 1967, this species was collected from April 30 to June 28 in Boone and Morgan Counties. *C. baueri* was never collected in large or moderate numbers. On June 10, 1967, eight specimens were obtained from light trap 6 in Morgan County. Other dates showing comparatively high collections were: May 18 (4), May 28 (7) and June 9 (4). These collections were obtained from light trap 6 during 1967. The feeding habits of *C. baueri* are not known.

### *Culicoides biguttatus* (Coquillett)

A temporary pool created by the construction of a sewage lagoon unit was the only location from which *C. biguttatus* was recorded emerging. *C. biguttatus* was recorded in light traps from May 22 to July 3, 1966, in Columbia. In 1967,

this species was first recorded May 10 at light trap 6 in Morgan County. One female *C. biguttatus* was recorded biting man May 26, 1967, adjacent to a chicken coop in Morgan County.

### *Culicoides crepuscularis* Malloch

This species has a very wide range of breeding habitats. Here in central Missouri, this species was recovered from sewage lagoon effluent areas, edges of temporary and permanent ponds, a roadside drainage ditch in a forested area, the edge of a sand bank of an isolated pool and spring seepage areas.

*C. crepuscularis* was first recorded emerging April 5, 1967, from a habitat sample collected March 24, 1967. April 6, 1967, several dozen *C. crepuscularis* pupae were collected from sewage lagoon effluent trickling through a residential area in Sturgeon, Mo. From the limited sample collected it appeared a large emergence of this species had begun or was about to occur. The latest recorded emergence of *C. crepuscularis* was obtained from a permanent marshy area during the week of October 17 to 24, 1966. Only one significant adult emergence of *C. crepuscularis* was recorded from a temporary pool site during the week of June 6 to 13 with 16 specimens captured. The following week 84 specimens were recorded, yielding the highest emergence for the year. These emergence figures were obtained from a 4 square foot recovery cage. From April 10 to June 19, 1967, this site yielded nearly identical initial and peak emergence dates. From June 5 to 12 initial emergence of 79 specimens was recorded while the following week 250 *C. crepuscularis* were collected. However, the emergence cage was removed June 19, 1967, and further data were not obtained at that location.

The peak emergence date for the second generation at the permanent marshy area in Columbia was incomplete since sampling at this site was terminated June 26, 1967 (Figure 6). Also, lack of data during July at this location further interfered with determining the emergence time span for this generation.

The apparent peak of the second generation at the sewage effluent site (Figure 7) occurred between July 13 and 20. During the week of July 20 to 27 a tremendous decline in adult emergence occurred. This appeared to coincide with an increase in the water level at the pool which amounted to an approximate 2 to 4 inch increase. During the process of larval sampling and direct observation at this location, it became apparent that larval abundance declined appreciably with increased water depth.

Areas yielding the greatest number of larvae and, especially, pupae were located in exposed or nearly exposed mud flats. These areas were either surrounded by water or at the edge of the polluted pool. Therefore, the decline of adult emergence indicated by the emergence traps during that period was believed caused by larval migration to shallower areas and not by a reduction of adult emergence. The water level increased again at this location during the early part of October, 1966. The emergence cages remained within the same limited area regardless of water level changes; it is believed the larvae of this species again

migrated to shallower areas. As a result, subsequent emergence was not recorded at this location.

*C. crepuscularis* was recorded in Columbia light traps from May 18 to September 11, 1966. Peak emergence during this period occurred between June 24 and 29 when 91 specimens were collected. With the exception of June 22, 1966, when 38 specimens were collected, the remainder of the period yielded low collections of from one to five *C. crepuscularis*.

In Morgan County at light trap 6, this species was among the first to be collected. The first specimen was taken April 4, 1967. Table 1 summarizes the light trap data of *C. crepuscularis* from April 1 to June 26, 1967.

Three separate weeks of high collections from the light traps in Boone and Morgan Counties corresponded closely with emergence cage data obtained in Boone County. The overwintering generation of *C. crepuscularis* showed a peak emergence between April 17 and 24, 1967, in Boone County. The first peak collection of this species at light trap 6 occurred sometime during the preceding week. However, the maximum north-south distance between two of these sites was approximately 61 miles, the north-south distance from Sturgeon to light trap 6 in Morgan County. This could account for some variation in peak emergence dates.

The next peak collection obtained from light traps occurred during the week of May 9 to 15. Again, this coincided within a week of emergence cage data. The third peak recorded from light trap 6 occurred during the week of June 6 to 12 in Morgan County. However, light trap collections of this species peaked during the week of June 13 to 19 in the Columbia area. This corresponded to emergence peaks at the temporary pool and the polluted effluent sites.

The data obtained from emergence cages, light traps, and random sampling indicated *C. crepuscularis* appeared in central Missouri in early April and continued emerging until at least mid-October. From three to five generations of this species are believed to occur in central Missouri with the last generation overwintering at least in some part as larvae.

Although quite abundant, this species has not been recorded biting man in central Missouri. Edmunds and Keener (1954) reported this species was a serious biting pest of man in western Nebraska. Snow *et al.* (1957) reported *C. crepuscularis* biting man on five occasions from April 30 to October 16, 1952, in Tennessee.

### *Culicoides guttipennis* (Coquillett)

This species was the most common tree-hole-breeding *Culicoides* collected in central Missouri. *C. guttipennis* was also obtained from a dog's water bowl which contained an accumulation of leaves. It was found in association with *C. arboricola*, *C. nanus*, and *C. villosipennis* in various tree holes in Boone and Morgan counties. Wet tree hole samples taken on March 24, 1967, yielded emerging *C.*

TABLE 1. -ADULT C. CREPUSCULARIS COLLECTED BY LIGHT TRAP FROM APRIL 1 TO JUNE 26, 1967, BOONE AND MORGAN COUNTIES

Week	Locations 1-4 Columbia, Boone County	Location 5 Lake of the Ozarks Morgan County	Location 6 Farm, Gravois Creek Valley, Morgan County
4/1-6	0	0	2
4/7-10	0	0	8
4/11-17	1	2	170
4/18-24	0	1	9
4/25-5/1	0	1	151
5/2-8	0	2	13
5/9-15	3	3	237
5/16-22	2	1	20
5/23-29	13	2	94
5/30-6/5	1	2	28
6/6-12	21	8	391
6/13-19	40	0	117
6/20-26	22	1	97

*guttipennis* adults between April 5 and 15, 1967. The latest emergence of this species occurred when eight adults were obtained in mid-November, 1966, from an October 19 tree hole sample. *C. guttipennis* was recorded from June 13 to September 25, 1966, in Columbia light traps. Only seven specimens were obtained during that period. This species was collected in moderate numbers from light trap 6 in Morgan County from April 29 to June 25, 1967, when sampling was discontinued. During this period of time, the peak activity for *C. guttipennis* was June 12 when 194 specimens were collected in one night from light trap 6. Other collections of relatively high numbers were May 29 (175), June 8 (64), June 9 (127), June 11 (104), June 15 (64), and June 20 (67). On the basis of these data, it is believed the species emerges from early April until frost in central Missouri.

*C. guttipennis* has been collected frequently biting man at dusk in central Missouri with from one to 40 specimens biting in less than one hour. Interestingly this species was the predominant biter on both May 18 and May 26, 1967, in the vicinity of light trap 6. However, light trap collections on these same dates at this site yielded zero and 6 specimens, respectively. On June 9, 1967, no *C. guttipennis* were recorded biting man at dusk at this site, yet 127 specimens were collected from the light trap. Variations in activity between dusk and dawn apparently were quite pronounced.

### *Culicoides haematopotus* Malloch

This species was collected from many habitats during the 1966-67 period in central Missouri. These included sewage lagoon effluent areas, the edges of temporary and permanent ponds, a forest pool filled with leaves, a sand bank of an isolated pool adjacent to a creek, a spring seepage site and an overflow isolated pool adjacent to a spring-fed creek. None of the sampled habitats yielded many *C. haematopotus*. The highest emergence of this species occurred at the temporary pool site from June 12 to 19, 1967, when 15 specimens were collected from a 4 square foot area.

*C. haematopotus* specimens were recorded emerging from a sand bank sample of an isolated pool between April 4 and 5, 1967. The sample was collected March 24 of that year. The latest record of this species was the week of September 26 to October 3, 1966, when three females were captured in the permanent marshy area from an emergence cage. This species was collected from May 6 to September 25, 1966, in Columbia light traps. During this time, collection of *C. haematopotus* was grouped into three rather distinct periods. These included: The last 10 days in May when nine specimens were collected, the first 20 days in July when 19 specimens were collected and the first 13 days of September when seven specimens were collected. In addition, the last five days of May, 1967, at light trap 6 yielded the highest collection period at that location from April 1 to June 25, 1967.

In Morgan County, the first collection of *C. haematopodus* occurred April 16, 1967. Light trap five, like the Columbia light traps, yielded low but constant numbers of *C. haematopodus* ranging from one to five specimens per night. At light trap 6, *C. haematopodus* was most abundant from May 27 to May 29. At a peak on May 29, 103 specimens were collected while May 27 and 28 yielded 49 and 35 specimens, respectively. Other relatively high collections were May 10 (61), June 9 (75), June 10 (28), and June 12 (30).

Snow *et al.* (1957) collected 116 *C. haematopodus* in light traps from April 30 to October 16, 1952.

On the basis of the information above, at least three generations of *C. haematopodus* are believed to occur in central Missouri.

Two female *C. haematopodus* were recorded biting man on both May 18 and 26, 1967, in Morgan County. One female was also recorded biting man in a forested area in Boone County on June 12, 1967. All bites were experienced at dusk. Several authors, including Malloch (1915), Edmunds and Keener (1954), and Snow *et al.* (1957) have reported this species biting man in small numbers.

### *Culicoides hinmani* Khalaf

This species was rarely collected in central Missouri from June 4 to September 1, 1966, with only 13 specimens obtained from light traps. *C. hinmani* was not recorded biting man in central Missouri. However, Snow (1955) reported *C. hinmani* as a diurnal biter being most active in the afternoon hours, and frequently feeding into the twilight period. Snow *et al.* (1957) recorded *C. hinmani* frequently biting man, with 538 records taken between July 23 and October 18 of one year.

### *Culicoides multipunctatus* Malloch

One male was obtained from a sand bank at the edge of a shaded isolated pool. *C. multipunctatus* was rarely collected in central Missouri in light traps from July 23 to September 5, 1966, or on April 28, or May 28, 1967. Altogether only 10 specimens were obtained. This species was not recorded biting man in central Missouri.

### *Culicoides nanus* Root and Hoffman

*C. nanus* is a tree hole breeding *Culicoides*. Larvae of this species were collected March 29, 1966, along with *C. guttipennis* and reared in the laboratory. All emerged by the first week of April, 1966. September 14 was the latest record for *C. nanus* from a light trap. Specimens were obtained from tree hole samples, light traps, and a yellow porch light. *C. nanus* is less abundant than either *C. guttipennis* or *C. arboricola* in central Missouri on the basis of adults emerging from tree hole samples taken during the period of study. No records of this species biting man are known.

### *Culicoides obsoletus* (Meigen)

One female *C. obsoletus* was captured in an emergence cage covering a thick accumulation of leaf litter in a roadside drainage ditch in Morgan County. From the numbers of *obsoletus* group specimens examined, there were relatively few *C. obsoletus* compared to *C. sanguisuga* specimens. Only random series were taken from collections of specimens originally identified as *C. sanguisuga*. The two species cannot be distinguished unless mounted on slides. *C. obsoletus* was recorded in city light traps on June 13 and 20, 1966. *C. obsoletus* was also recorded from April 16 to June 24, 1967, at light traps 5 and 6 in Morgan County. This species was recorded biting man along with *C. sanguisuga* May 8, 1967, in Boone County and the early morning hours of June 9, 1967, in Morgan County.

### *Culicoides oklahomensis* Khalaf

Only one male from light trap 6 was identified from slide mounted material. No bite records for this species are known.

### *Culicoides paraensis* (Goeldi)

This species was collected from cottonwood tree sap flows in central Missouri. Snow *et al.* (1957) found this species breeding only in moist tree cavities. Snow and Pickard (1958) collected *paraensis* from the ooze of a white oak tree in Alabama. Specimens were obtained as larvae August 8, 1966. Emergence occurred between August 22 and 30, 1966. April 17, 1967, a sample containing larvae was collected from a second cottonwood tree. Emergence from this sample occurred between April 28 and 29, 1967. *Paraensis* was neither collected from light traps nor recorded biting man in central Missouri. However, Snow *et al.* (1957) reported *C. paraensis* was the most widespread and annoying species attacking man during the daylight hours in Tennessee.

### *Culicoides piliferus* Root and Hoffman

Only two female *C. piliferus* were collected. The first was taken from a Columbia light trap June 16, 1966. The other specimen was recorded biting man May 8, 1967, in Boone County. The bite occurred in a forested area at dusk.

### *Culicoides sanguisuga* (Coquillett)

This species was recorded emerging in small numbers from thick accumulations of leaf litter. These sites were common in roadside drainage ditches in forested areas. Emergence from recovery cages during the period of April 6 to June 26, 1967, was greatest during the week of June 5 to 12 (Table 2). Ten *C. sanguisuga* were collected from a one square foot area during that week in Boone County. The other cage at the Ashland Wildlife Area yielded six *C. sanguisuga*

TABLE 2. -EMERGENCE AND LIGHT TRAP DATA FOR ADULT *C. SANGUISUGA* (COQUILLET) FROM APRIL 1 TO JUNE 26, 1967,  
BOONE AND MORGAN COUNTIES

Ashland (a) Boone County Emergence Cages		LOCATION Massey's (a) Morgan County Emergence Cages		Light traps, Morgan County Collections		
Week	Emergence	Week	Emergence	Week	Trap 5	Trap 6
4/6-10/67	0	4/6-10/67	0	4/6-10/67	1	1
4/10-17/67	0	4/10-17/67	1	4/11-17/67	4	15
4/17-28/67	1	4/17-24/67	1	4/18-24/67	11	51
4/28-5/5/67	0	4/24-5/1/67	0	4/25-5/1/67	46	500
5/5-12/67	0	5/1-8/67	2	5/2-8/67	141	386
5/12-19/67	0	5/8-15/67	3	5/9-15/67	227	1038
5/19-26/67	1	5/15-22/67	0	5/16-22/67	188	929
5/26-6/2/67	--(b)	5/22-29/67	1	5/23-29/67	49	1106
6/2-9/67	5(c)	5/29-6/5/67	0	5/30-6/5/67	22	156
6/9-16/67	3(c)	6/5-12/67	16	6/6-12/67	174	3070
6/16-26/67	1(d)	6/12-19/67	4	6/13-19/67	401	1718
		6/19-26/67	1	6/20-26/67	103	1820

(a) Two one square foot emergence cages

(b) Data lost due to heavy rains

(c) Data from only one cage

(d) Cages were vandalized

for that week. On Lake Road 5-16 of the Lake of the Ozarks, one emergence cage yielded five *C. sanguisuga* per square foot for the week of June 2 to 9, 1967.

*C. sanguisuga* was recorded from April 30 to July 10, 1966, in Boone County. In Morgan County, this species was first recorded at both light traps 5 and 6 April 9, 1967. From April 9 to June 25, 1967; 10,803 *C. sanguisuga*, including a few *C. obsoletus*, were collected in those two light traps. During the week June 6 to 12, 1967; 3,070 specimens were taken from the two light traps (Table 2). This constituted the peak activity for *C. sanguisuga* from April 1 to June 25, 1967, in Morgan County. Light trap 5 yielded the following maximum collections: May 10 (181), May 18 (142), June 10 (98), and June 18 (210). Light trap 6 yielded relatively high collections as follows: May 10 (405), May 22 (527), May 29 (580), June 10 (642), June 11 (652), June 12 (1176), June 15 (573), June 16 (442), June 23 (496), and June 25 (529).

*C. sanguisuga* was reported by Arthur Massey, the operator of light trap 5, to have declined rapidly in numbers biting man around the first of July, 1966. During 1967, however, he reported that biting activity continued until about the first week of August, 1967. This prolonged activity over the previous year was believed caused by relatively lower temperatures and more abundant moisture during June and July, 1967.

This species was undoubtedly the greatest pest *Culicoides* found in central Missouri during the course of the investigation. Many instances were recorded of *sanguisuga* biting man. Bite counts exceeding 12 per minute were obtained frequently in both Boone and Morgan Counties. Biting occurred at all hours of the day; however, major activity occurred at dusk and again for a short period at dawn.

#### *Culicoides scanloni* Wirth and Hubert

Only seven specimens were recorded from light trap 6 from May 10 to May 26, 1967. One record of *C. scanloni* biting man was obtained May 26, 1967. This occurred adjacent to a chicken coop in Morgan County at dusk.

#### *Culicoides spinosus* Root and Hoffman

This species was collected only from light traps in Columbia from May 29 to June 29, 1966. *spinosus* was first recorded on May 15, 1967, from light trap 6 in Morgan County. One female was collected July 9, 1967, from a suburban Columbia light trap. This species was never collected in large numbers during the period of study. *C. spinosus* was not recorded biting man in central Missouri. However, it was reported to be a diurnal biter in Tennessee, feeding on both man and horses (Snow *et al.*, 1957).

#### *Culicoides stellifer* (Coquillett)

This species was collected in muck saturated from spring seepage water, in mud at the edge of a temporary pool, and in a sand bank of an isolated pool

adjacent to a creek. *C. stellifer* was collected emerging from the recovery cage at the permanent marsh site in Columbia between August 22 and October 3, 1966. Emergence the following year from this site was first recorded the week of May 8 to 15. Emergence continued until the week ending June 12, 1967. The highest emergence recorded at this location during 1967 occurred from May 29 to June 5, when 42 specimens were collected from a 4 square foot area.

Collection of *C. stellifer* at the temporary pool was irregular during 1966. This was believed due primarily to the dry conditions which developed during July and August of that year. Since this site was dependent on runoff from rainfall, the area was dry for several intervals during the summer of 1966. Thirty *C. stellifer* was the highest emergence recorded at that location. This occurred from August 1 to 8, 1966, within a 4 square foot area.

*C. stellifer* was collected in Columbia light traps from May 23 to September 26, 1966. The highest number obtained occurred June 20 when 69 specimens were captured. Other 1966 high collections from Columbia light traps were: June 15-16 (27), June 19 (21), June 22 (45), and June 24 to 29 (61). Peak activity recorded by the Columbia light traps occurred during the last half of June, 1966. *C. stellifer* was first recorded from a Columbia light trap on May 8, 1967. However, no further collections were taken until May 18.

Relatively large numbers of *C. stellifer* were collected at light trap 6 while light trap five yielded only 11 specimens from April 1 to June 25, 1967. The highest number of *C. stellifer* collected at light trap 6 during this period was 1,943 specimens the night of May 29, 1967. Other nights yielding high collections at this location were: June 8 (620), June 9 (1,042), June 12 (1,371), June 15 (1,238), June 16 (765), June 17 (591), June 18 (462), and June 23 (622).

*C. stellifer* is the most abundant *Culicoides* species attracted to lights in central Missouri. It was the predominant *Culicoides* in five of the six light traps operated during this period of study. *C. stellifer* was not recorded biting man in central Missouri.

### *Culicoides travisi* Vargas

This species was obtained from a temporary pool supplied by runoff water from rainfall. Another location contained spring seepage water which saturated the soil throughout the year. The species is common in central Missouri. Emergence records from the temporary pool showed *C. travisi* emerging between May 15 and 29, 1967. At the spring seepage area, *C. travisi* was recorded emerging between May 29 and June 5, 1967. Emergence was slight at both locations. During 1966, *C. travisi* was collected from light traps in Columbia from May 22 to September 17. In 1967, this species was first collected on April 15 in Morgan County. It was abundant in the Columbia light traps on June 16 when 17 females were collected. Other dates yielded relatively high collections as follows: June 3 (13), June 14 (11), June 15 (12), and June 20 (17).

*C. travisi* was not recorded biting man in central Missouri. Snow *et al.* (1957) recorded it biting man in considerable numbers in the Tennessee Valley.

### *Culicoides variipennis* (Coquillett)

In 1957, Wirth and Jones proposed five new subspecies of *C. variipennis*. Ecological and distributional data were presented along with morphological characteristics. Three of these subspecies collected in central Missouri were identified by W. W. Wirth as *C. v. variipennis*, *C. v. sonorensis* and *C. v. australis*.

Table 3 summarizes the morphological variations recorded for series of these subspecies collected from two habitats and one light trap in central Missouri. Specimens from the Sturgeon and light trap 6 sites were relatively constant for the morphological characters. However, it was interesting to note two distinct morphological forms were recorded from the Sturgeon site. Eight of the 12 females in the sampled series were *C. v. variipennis* while the remaining four showed *C. v. sonorensis* characteristics.

The light trap 6 specimens showed typical *C. v. variipennis* characteristics. However, specimens examined from the Booneslick Salt Spring showed greater variation in these same characteristics. In addition, considerable size variations were recorded as evidenced by the greater extremes in wing lengths. The overwintering generation specimens were all very large with wing lengths exceeding 2.00 mm. During the following months, however, most specimens showed a definite size reduction. This phenomenon also was observed at the Sturgeon site in *C. variipennis* and *C. crepuscularis* adults during the period of study.

These size variations may have resulted from one or more factors including: (1) a prolonged growth period for overwintering larvae resulting in larger adults; (2) intraspecific competition; and/or (3) interspecific competition. At the salt spring site, *variipennis* was the predominant animal macro-organism as evidenced by the large larval concentrations which at times exceeded 20,000 per square foot.

Wirth and Jones (1957) recorded *C. v. australis* from saline habitats throughout the Mississippi Valley and the Gulf Coastal Plain. Atchley (1967) examined more than 50 specimens from an extremely saline lake in New Mexico. He stated *C. v. sonorensis* was the only form present and not *C. v. australis* as would be expected. From this and other data presented in his paper, Atchley considers *C. v. australis* to be a synonym of *C. v. sonorensis*.

*C. variipennis* was reared from swine polluted puddles, sewage lagoon effluent areas, and a salt spring in central Missouri. Figure 8 presents the initial and peak emergence dates of adult *C. variipennis* at the sewage effluent site in Sturgeon. Initial emergence of the overwintering generation was recorded between April 13 and 17. Peak emergence followed between April 24 and May 1. Initial emergence of the first generation occurred between June 5 and June 12. Peak emergence was recorded between June 12 and 19. However, sampling procedures were terminated June 19, 1967. Consequently, it can not be determined if this period was actually the peak for the first generation.

TABLE 3. -MORPHOLOGICAL VARIATIONS IN SUBSPECIES OF *C. VARIIPENNIS* COLLECTED FROM THREE HABITATS/LOCATIONS IN CENTRAL MISSOURI

Location and Expected Sub- Species on Basis of Habitat	Subspecies Recorded	Sensillar Pattern	Third Maxillary Palp L/W Ratio		Wing Length	
			Mean	Range	Mean	Range
<u>Booneslick Salt Spring australis</u>		3-10(n=5)	2.70	2.33-3.18(n=5)	1.83mm	1.21-2.16mm (n=3)
		3,6-10(n=1)	--	--	1.60mm(n=1)	
		3,7-10(n=2)	2.77	2.63-2.90(n=2)	2.13mm(n=1)	
		3,8-10(n=1)	3.00(n=1)		--	--
<u>Sturgeon Sewage effluent sonorensis</u>	<u>sonorensis</u>	3,7-10(n=4)	2.60	2.29-3.20(n=4)	1.44mm	1.31-1.60mm (n=4)
	<u>variipennis</u>	3,8-10(n=8)	3.41	3.15-3.65(n=8)	1.60mm	1.60-1.65mm (n=4)
<u>Light trap Six-farm, creek valley</u>	<u>variipennis</u>	3,8-10(n=7)	3.35	3.08-3.75(n=8)	1.64mm	1.49-1.78mm (n=8)

The initial emergence of the second generation was recorded between June 29 and July 6. Peak emergence followed between July 27 and August 3, 1966. This was the highest emergence during the entire year, amounting to 9,344 *variipennis* collected from the two 4 square foot emergence cages. An appreciable decrease in adult emergence was recorded the preceding week of July 20 to 27, and this was discussed in the seasonal abundance of *C. crepuscularis*.

The remainder of the fall period produced irregular emergence of adult *C. variipennis*. As mentioned in the seasonal abundance of *C. crepuscularis*, the variation in water level was believed responsible for this decrease in emergence.

Figure 9 presents the recorded initial and peak densities of larvae at the Booneslick Salt Spring. The overwintering larvae of this species were not sampled until February 14 at this site. However, the following weeks from March 24 to April 24 showed a continued decline in larval numbers. These lower larval densities corresponded to the Sturgeon site (Figure 8). No data were obtained from the Booneslick site during the mid weeks in June, 1966. Sometime during that period the first generation larvae were believed to have reached peak abundance. Additional peaks in larval populations were recorded on July 29, September 1, September 28, and November 22, 1966, above the bridge where the current is slight to absent. Below the bridge where the current was relatively strong three peaks were recorded. One occurred on September 1, the second on October 12, and the third on November 22. On March 17, 1966, pupae of *variipennis* were observed in great numbers along the banks of Booneslick Salt Spring. Adults also were observed emerging at that time. In addition, females of this species were observed resting or ovipositing along the margins of Salt Creek at Booneslick as late as November 22, 1966.

This species was one of the earliest to appear in the spring in central Missouri. *C. variipennis* was recorded at light trap 6 from April 4 to June 25, 1967, when sampling was discontinued. During this period of time the highest collection of *C. variipennis* occurred May 29 when 379 specimens were taken. Other nights with relatively high collections were: May 22 (46), May 27 (72), June 9 (44), June 10 (55), June 11 (44), June 23 (56), and June 24 (59). *C. variipennis* was recorded emerging from early April until mid-October. On the basis of the data above it is believed this species has from three to five generations per year in central Missouri.

This species was recorded biting man on several occasions in central Missouri. In no instance, however was *variipennis* recorded biting man in significant numbers except within the immediate vicinity of Booneslick Salt Spring. Jones (1959) reported that *variipennis* showed a preference for cattle, sheep and then man.

### *Culicoides venustus* Hoffman

Only 3 specimens were collected on June 19 and 20 and August 15 during 1966 from one city light trap. *C. venustus* was collected in moderate numbers

from light trap 6 in 1967. The earliest light trap record of *C. venustus* was May 4. Collections of this species continued up to June 25 when the operation of the light traps was discontinued. During this time, May 29 yielded the largest number of *C. venustus* with 209 specimens collected. Other high collections were May 27 (34), May 28 (33), and June 1 (42). No records of this species biting man are known.

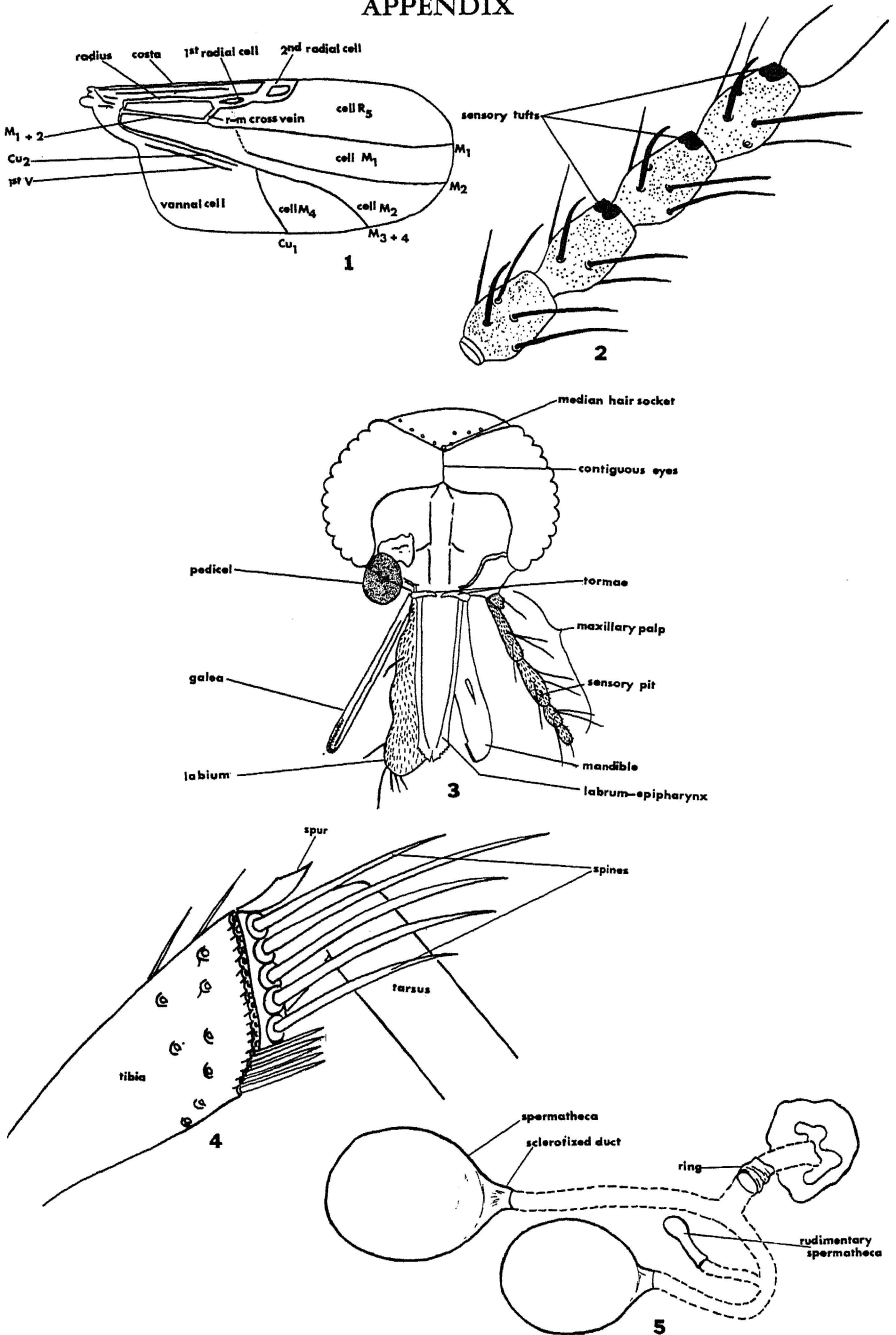
#### *Culicoides villosipennis* Root and Hoffman

This species was taken in moderate numbers at light trap 6. Light trap 5 obtained only 5 specimens from June 1 to 19, 1967. The earliest record obtained from a light trap was May 22, 1967. One female *C. villosipennis* emerged April 6, 1967, from a wet black walnut tree hole sample taken March 24, 1967, in Boone County. Collections were still being taken of this species when light trapping was discontinued. Light trap 6 yielded 65 females on June 23, 1967. Other nights with relatively high collections were: June 10 (39) and June 12 (64). No records of this species biting man are known.

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APPENDIX



Figures 1-5. Morphology of *Culicoides* showing diagnostic characters of: (1) wing; (2) antennal segments 7 through 10; (3) head; (4) tibia; (5) spermathecae.

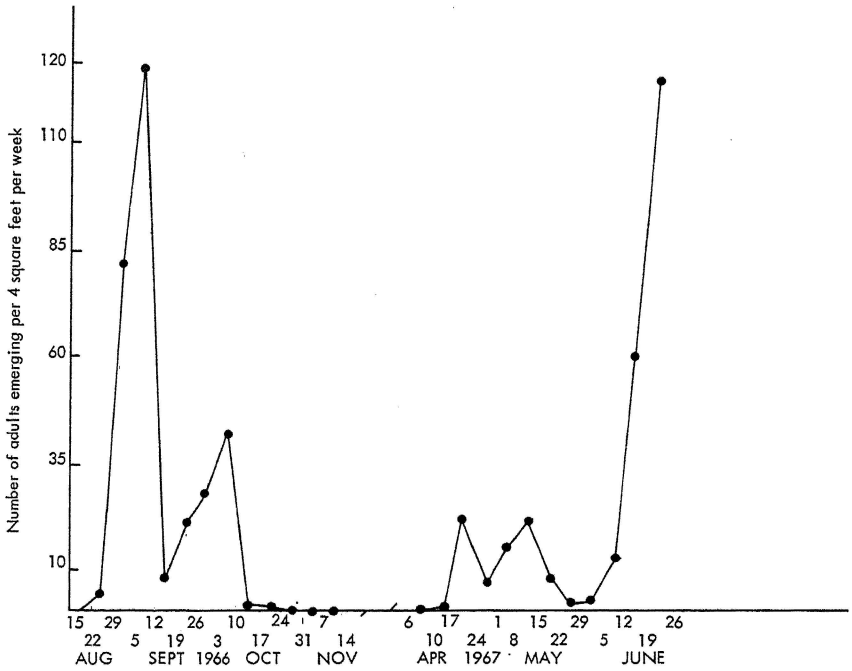


Figure 6. Emergence of adult *C. crepuscularis* from the permanent marshy site in Columbia, Missouri.

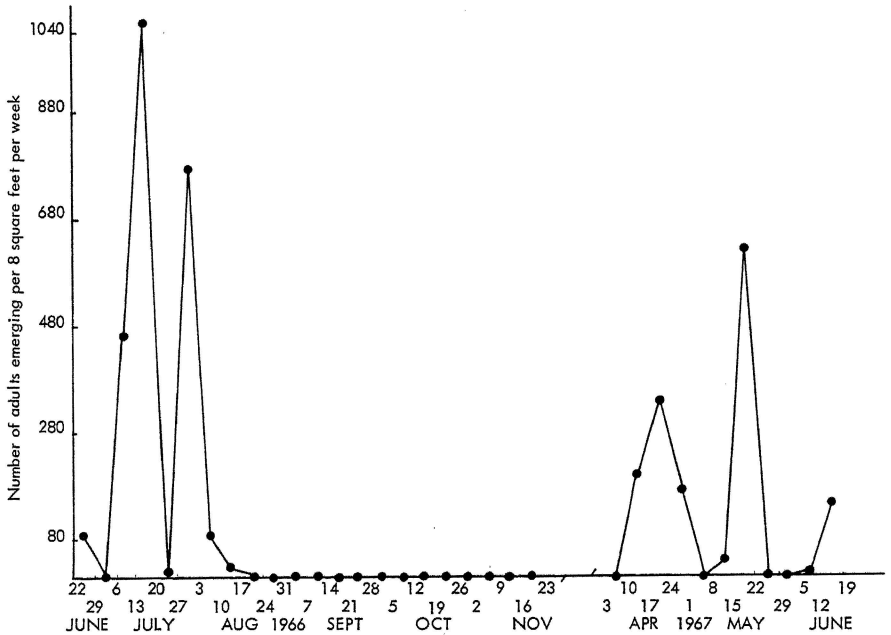


Figure 7. Emergence of adult *C. crepuscularis* from a sewage effluent site in Sturgeon, Missouri.

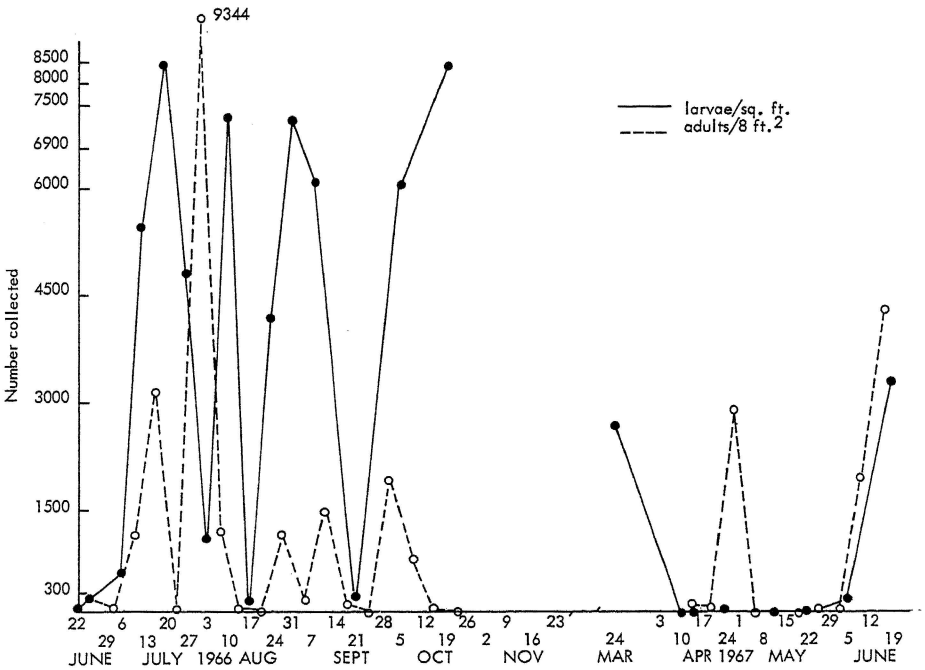


Figure 8. Emergence of adult *C. variipennis* compared with larval abundance from a sewage effluent site in Sturgeon, Missouri.

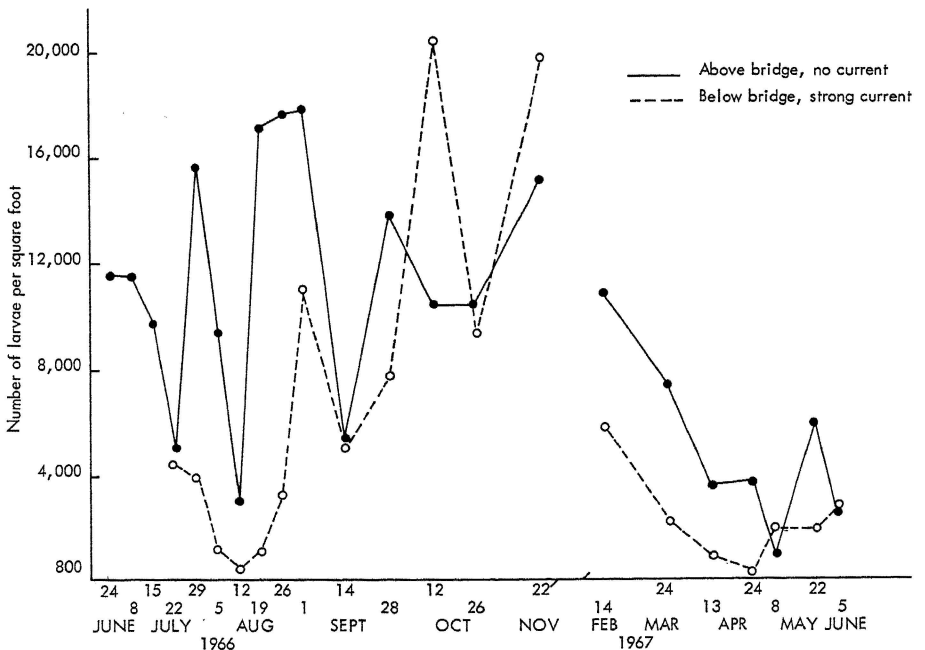
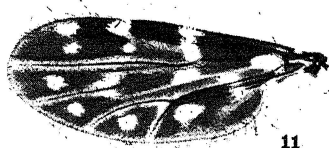


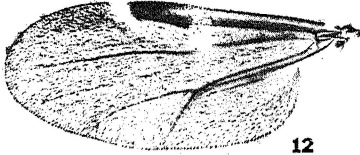
Figure 9. Larval abundance of *C. variipennis* from Booneslick Salt Spring in Howard County, Missouri.



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11



12



13



14



15



16



17



18



19

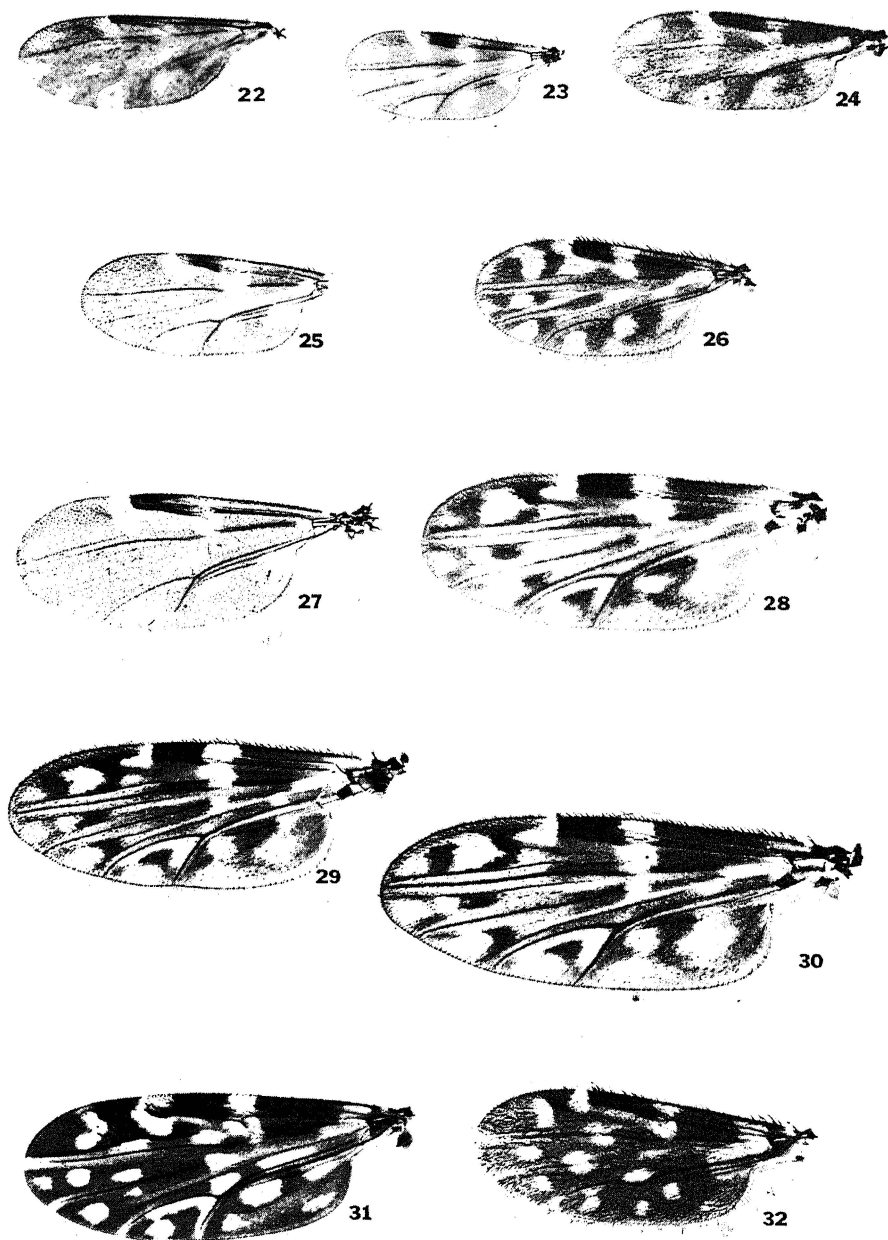


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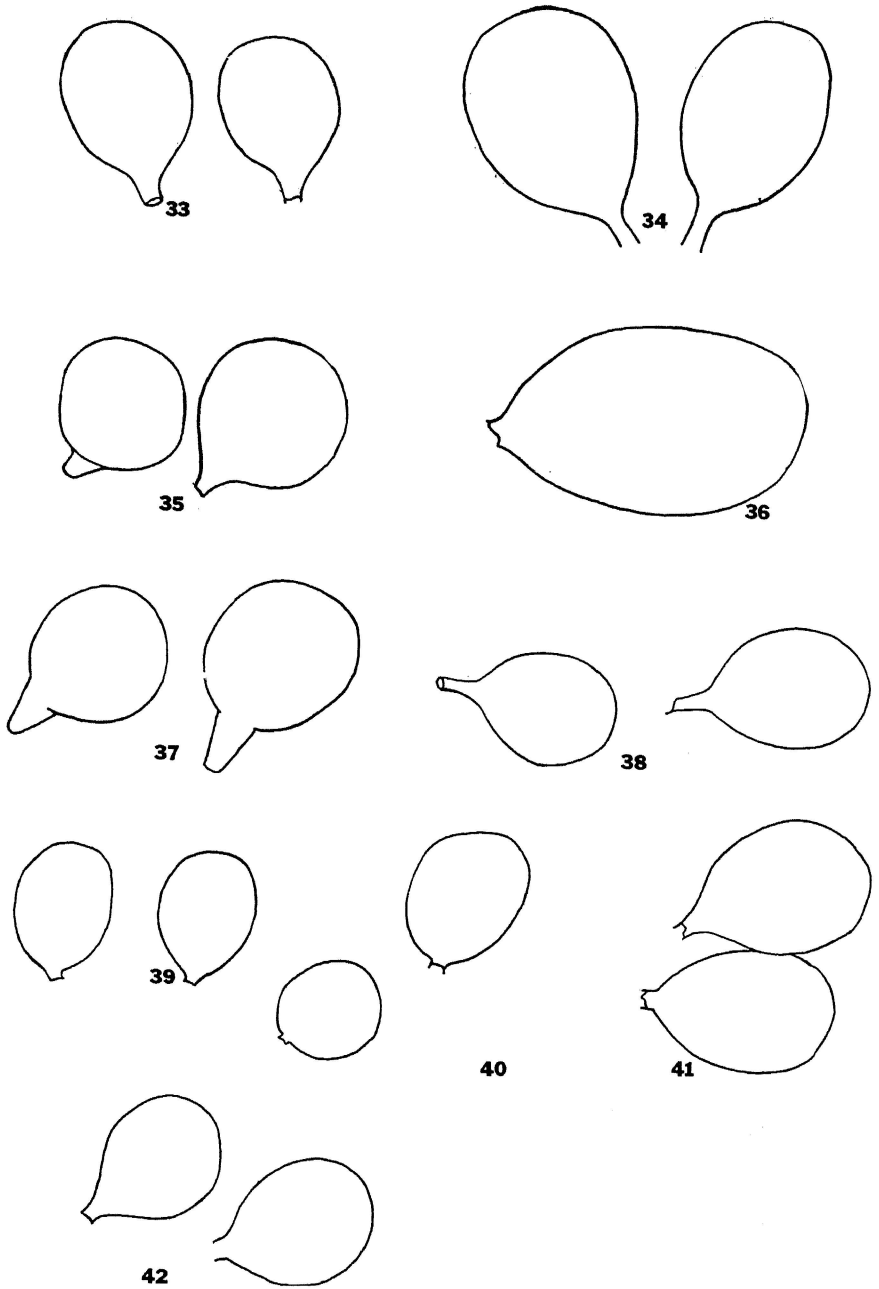


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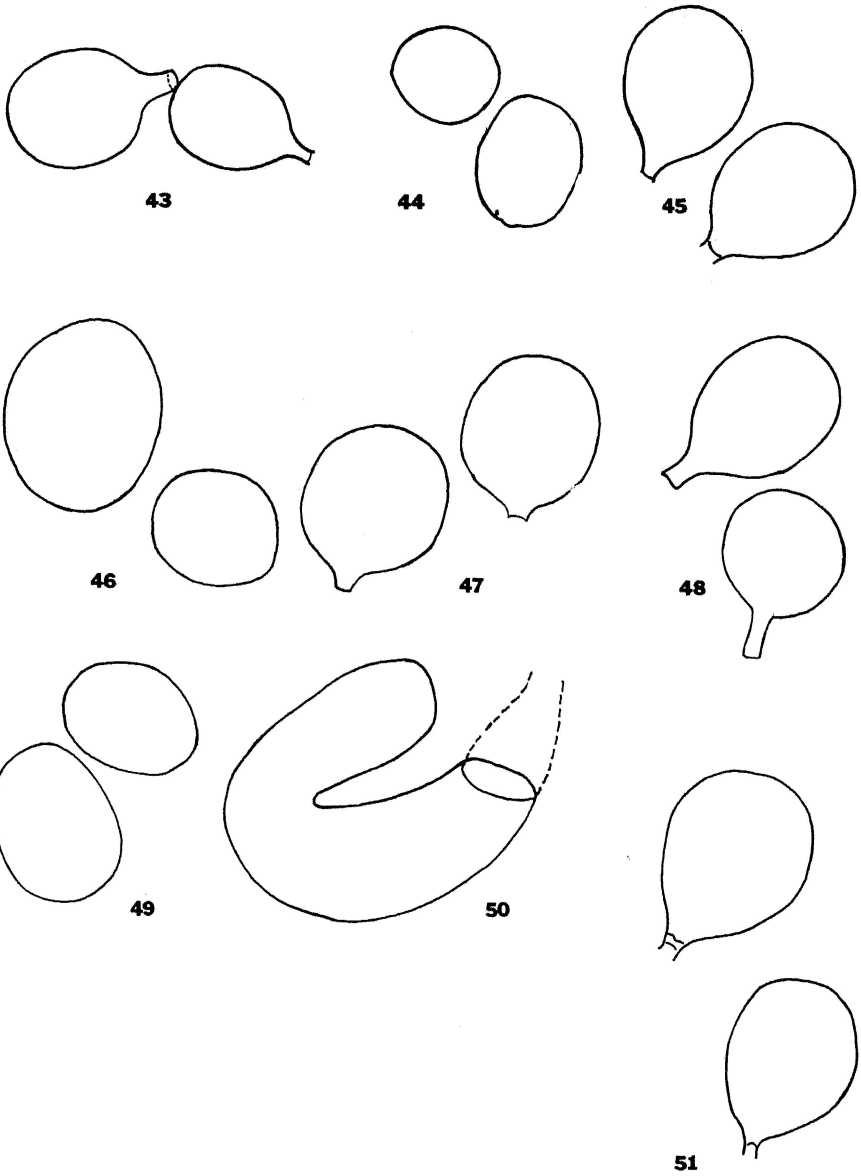
Figures 10-21. Wing patterns of *Culicoides*: (10) *arboricola*; (11) *baueri*; (12) *biguttatus*; (13) *crepuscularis*; (14) *guttipennis*; (15) *haematopotus*; (16) *hinmani*; (17) *multipunctatus*; (18) *nanus*; (19) *obsoletus*; (20) *oklahomensis*; (21) *paraensis*.



Figures 22-32. *Wing patterns of Culicoides*: (22) *piliferus*; (23) *sanguisuga*; (24) *scanloni*; (25) *spinosus*; (26) *stellifer*; (27) *travisi*; (28) *variipennis australis*; (29) *variipennis sonorensis*; (30) *variipennis variipennis*; (31) *venustus*; (32) *villosipennis*.



Figures 33-42. *Spermathecae* of *Culicoides*: (33) *arboricola*; (34) *baueri*; (35) *biguttatus*; (36) *crepuscularis*; (37) *guttipennis*; (38) *haematopotus*; (39) *hinmani*; (40) *nanus*; (41) *obsoletus*; (42) *oklahomensis*.



Figures 43-51. *Spermathecae* of *Culicoides*: (43) *paraensis*; (44) *piliferus*; (45) *sanguisuga*; (46) *scanloni*; (47) *spinosus*; (48) *stellifer*; (49) *travisi*; (50) *varripennis*; (51) *venustus*.

TABLE 4--LIST OF SPECIES OF CULICOIDES OCCURRING IN CENTRAL MISSOURI

<u>Culicoides arboricola</u>	Root and Hoffman
<u>Culicoides baueri</u>	Hoffman
<u>Culicoides biguttatus</u>	(Coquillett)
<u>Culicoides crepuscularis</u>	Malloch
<u>Culicoides guttipennis</u>	(Coquillett)
<u>Culicoides hinmani</u>	Khalaf
<u>Culicoides multipunctatus</u>	Malloch
<u>Culicoides nanus</u>	Root and Hoffman
<u>Culicoides obsoletus</u>	(Meigen)
<u>Culicoides oklahomensis</u>	Khalaf
<u>Culicoides paraensis</u>	(Goeldi)
<u>Culicoides piliferus</u>	Root and Hoffman
<u>Culicoides sanguisuga</u>	(Coquillett)
<u>Culicoides scanloni</u>	Wirth and Hubert
<u>Culicoides spinosus</u>	Root and Hoffman
<u>Culicoides stellifer</u>	(Coquillett)
<u>Culicoides travisi</u>	Vargas
<u>Culicoides variipennis australis</u>	Wirth and Jones
<u>Culicoides variipennis variipennis</u>	(Coquillett)
<u>Culicoides variipennis sonorensis</u>	Wirth and Jones
<u>Culicoides venustus</u>	Hoffman
<u>Culicoides villosipennis</u>	Root and Hoffman