

## VERTICAL ACTIVITIES AND HOST PREFERENCES OF SEVERAL *CULICOIDES* SPECIES IN A SOUTHWESTERN VIRGINIA FOREST<sup>1</sup>

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**ABSTRACT.** Traps baited with domestic mammals and birds were placed at various elevations in the forest canopy to determine whether or not *Culicoides* host preference was affected by vertical distribution and the size of mammalian or avian hosts. Eight species of biting midges were collected during the study and their known host preference was correlated with the above factors.

These studies indicate that some *Culicoides* species tend to feed near ground level while others feed at higher elevations. This tendency might often reflect host availability rather than host preference. For some species, host size is a more important factor in host preference than whether it is a bird or mammal.

Little is known of the host preference of many species of *Culicoides* which feed on animals other than man. Some are generally considered ornithophilic and others mammalophilic. This raises some interesting questions. Assuming that both bird and mammal hosts are readily available, does a species which feeds in the forest canopy really prefer birds to mammals, or is it because there are more birds than mammals to be found at these higher elevations? Conversely, does a species which feeds at ground level really prefer mammals to birds, or is it because there are more and larger mammals than birds at ground level?

Several studies on the vertical abundance and distribution of insects have been made, but only a few of them have included information on *Culicoides*. The methods used for collecting species of this group at different heights have included: (1) airplanes (Glick 1939); (2) light traps (Williams 1955); (3) adhesive paper traps (Carpenter 1951); (4) sticky panels (Bidlelmayer 1961); (5) human bait (Snow 1955, Service 1969); and animal bait (Bennett 1960, Fallis and Bennett 1961, Humphreys and Turner 1973).

Bennett (1960) and Fallis and Bennett (1961) were the first to make extensive use of animals as bait for collecting *Culicoides*. They hoisted several species of birds into trees at heights up to 7.63 m for 20-30 minute exposure times. After the birds were brought down, they were covered with a trap from which *Culicoides* were then collected. Humphreys (1969), using techniques similar to those of Fallis and Bennett (1961), placed both birds (turkeys) and mammals (rabbits) at ground level and at 7.63 m. He found *Culicoides sanguisuga* (Coquillett) to be active at both levels. However, since the peak seasonal activity had already occurred by the time his studies were initiated, only small numbers of *Culicoides* were collected.

Jamnback (1965) proposed a theory that host preference was correlated with the abundance of sensory pits on the antennae. He stated that the antennae of ornithophilic species had more antennomeres with olfactory pits than did mammalophilic species. Six species were listed as being known to prefer large mammals. They were: *C. furens* (Pocock), *C. hollensis* (Melandier and Brues), *C. melleus* (Coquillett), *C. obsoletus* (Meigen), *C. variipennis* (Coquillett), and *C. sanguisuga*. Six other species were known to prefer birds. They were: *C. crepuscularis* Malloch, *C. downesi* Wirth and Hubert, *C. haematopotus* Malloch, *C. scanloni* Wirth and Hubert, *C. sphagnumensis* Williams, and *C. silobezzioides* Foote and Pratt. According to this theory, six additional species were listed

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which could be expected to prefer mammals. They were: *C. bickleyi* Wirth and Hubert, *C. chiopterus* (Meigen), *C. jammbacki* Wirth and Hubert, *C. spinosus* Root and Hoffman, *C. stellifer* (Coquillett), and *C. venustus* Hoffman. Also, nine species would be expected to prefer birds. These were: *C. arboricola* Root and Hoffman, *C. baueri* Hoffman, *C. biguttatus* (Coquillett), *C. guttipennis* (Coquillett), *C. niger* Root and Hoffman, *C. piliferus* Root and Hoffman, *C. pseudopiliferus* Wirth and Hubert, *C. travisi* Vargas, and *C. villosipennis* Root and Hoffman.

The following is a report of experiments to answer the above questions and to determine host preferences of several *Culicoides* species and their activity patterns at various levels in a southwestern Virginia forest.

**MATERIALS AND METHODS.** The collections were made in the Jefferson National Forest in Giles County, Virginia between July 10 and September 24, 1969. There were 18 trap-nights spaced at an average of 4.5 days apart.

Animal-baited traps as described by Turner (1972) were used to permit unattended all-night collecting of *Culicoides*. Traps were constructed for use with a large goat (50 kg.), small goat (34 kg.), large turkey (6.4 kg.), small turkey (3.6 kg.), and large rabbit (3.6 kg.). Test animals were kept in wire restraining cages over which the traps were placed. All traps were of the same basic design, with only dimensional changes being made to accommodate the size and shapes of the test animals.

Female *Culicoides* entered the traps through vertical slits in the sides. After taking a blood meal, the midges climbed up the front of the traps and entered the collecting funnels which were directed toward the prevailing light (i.e., setting or rising sun). From the collecting funnels they fell into collecting jars filled with alcohol.

On each trap night, three rabbits and three turkeys were placed in the traps at approximately 2 hours before sunset. Traps containing a rabbit and a turkey were hoisted consecutively into a large poplar

tree to elevations of 15.25 and 7.63 m by means of ropes and pulleys. A second rabbit and turkey were then hoisted up the opposite side of the same tree in like manner but in alternate order. A third rabbit and turkey were placed on opposite sides at the base of the tree. Thus, a rabbit and turkey were on opposite sides of the tree at 15.25, 7.63 m and ground level. The traps were oriented with guy ropes so that the collecting funnels would face the prevailing light. Relative positions of the test animals were reversed on successive trap nights. Each trap night was terminated at 2 hours after sunrise of the next morning.

On 10 of the test nights, the traps were brought down at 3:00 a.m., the collecting jars changed, and the traps hoisted back into the tree and reoriented toward the rising sun for the morning collection.

During 15 of the nights, a trap containing a small goat (34 kg.) was placed at the edge of a clearing 7.63 m from the base of the trap tree to provide an additional index on *Culicoides* activity. On 3 of the nights, a large goat (50 kg.) and a large turkey (6.4 kg.) were placed along a straight line at 7.63 m intervals from the small goat. On one occasion the small goat trap was used without the goat to determine if *Culicoides* would be attracted to the traps alone.

All specimens were sorted and identified in the laboratory. All of the *C. obsoletus* group specimens were considered to be *C. sanguisuga*. Specimens which could not be positively identified in alcohol were mounted on slides for identification. The identification of several species was confirmed by Dr. W. W. Wirth of the U. S. National Museum.

Paired t-tests were used in analyzing the number of *C. sanguisuga* and *C. arboricola* collected by the rabbit vs. the turkey traps at the three elevation levels. None of the other species were collected in numbers adequate for statistical analysis.

**RESULTS.** Eight species of *Culicoides* were collected from the animal traps (Table 3). Each species will be discussed separately as follows:

TABLE 1.—*C. sanguisuga* collected at ground level from animal-baited traps. Giles County, Va. 1969.

| Hosts                  | Trap nights | No. collected |                |
|------------------------|-------------|---------------|----------------|
|                        |             | Total         | No./trap night |
| Large goat (50 kg.)    | 3           | 1,822         | 607.3          |
| Small goat (34 kg.)    | 15          | 3,327         | 221.8          |
| Large turkey (6.4 kg.) | 3           | 235           | 78.3           |
| Small turkey (3.6 kg.) | 18          | 298           | 16.6           |
| Rabbit (3.6 kg.)       | 18          | 163           | 9.1            |

*C. sanguisuga* has been reported to be primarily mammalophilic, especially on large mammals (Jamnback 1965), and in this study the largest number of specimens were collected from traps at the ground level. The relative attraction of *C. sanguisuga* to the animal traps at ground level is shown in Table 1. Although the results could not be analyzed statistically due to the small number of trap nights of certain hosts, it appears that this species of *Culicoides* is attracted to a host in direct proportion to its size. This confirms similar results obtained by Humphreys and Turner (1973) using "Bennett type" animal-bait traps.

The results as shown in Table 2 indicate that *C. sanguisuga* is much more active at

the ground level than at any other elevation in the forest canopy. At the 15.25 m elevation, the small turkeys were significantly more attractive to this species than the rabbit. It should be pointed out that although the two hosts were the same weight (3.6 kg.), the small turkeys were more bulky than the rabbits.

*C. arboricola* is a tree hole species thought to be primarily ornithophilic (Jamnback 1965). This species was not collected at the ground level; however, an increasingly greater number were collected at the higher elevations (Table 2). There was little difference in the number collected from the rabbits and from the small turkeys; however, significantly more were found to be engorged on the turkeys than on the rabbits at 15.25 m.

The following species were collected in small numbers (Table 3):

*C. paraensis* is possibly mammalophilic, although its host preference is not well known. It has been reported from man (Snow 1955, Hair and Turner 1968), rabbits (Humphreys 1969), and from poultry (Messersmith 1965). According to Jamnback (1965), it would be expected to be mammalophilic since it has only 4 antennomeres with sensory pits. In this study, 20 specimens were collected from the small turkeys while only 4 were collected from the rabbits. Nine specimens were collected from the small goat. This species was

TABLE 2.—Total *C. sanguisuga* and *C. arboricola* collected during 18 trap nights from animal-baited traps suspended at different elevations in the forest canopy. Giles County, Va. 1969.

|                      | Ground level |        | 7.63m  |                   | 15.25m            |                   |
|----------------------|--------------|--------|--------|-------------------|-------------------|-------------------|
|                      | Rabbit       | Turkey | Rabbit | Turkey            | Rabbit            | Turkey            |
| <i>C. sanguisuga</i> |              |        |        |                   |                   |                   |
| Total No.            | 163          | 298    | 55     | 55                | 33                | 74                |
| No./night            | 9.1          | 16.5   | 3.1    | 3.1               | 1.8 <sup>a</sup>  | 4.1 <sup>a</sup>  |
| % engorged/night     | 6.8          | 6.0    | 9.1    | 5.5               | 6.3               | 6.6               |
| <i>C. arboricola</i> |              |        |        |                   |                   |                   |
| Total No.            | 0            | 0      | 6      | 4                 | 28                | 42                |
| No./night            | 0            | 0      | 0.3    | 0.2               | 1.6               | 2.3               |
| % engorged/night     | 0            | 0      | 0      | 27.3 <sup>b</sup> | 10.7 <sup>c</sup> | 60.0 <sup>c</sup> |

<sup>a</sup> Significant at 5% level (Paired t-test).

<sup>b</sup> Only 1 engorged specimen.

<sup>c</sup> Significant at 5% level (Paired t-test).

TABLE 3.—*Culicoides* spp. collected from animal-baited traps during 1969 host preference and vertical activity studies.

|                                | Ground level |            |              | Ground level |              | 7.63m     |              | 15.25m          |                 |
|--------------------------------|--------------|------------|--------------|--------------|--------------|-----------|--------------|-----------------|-----------------|
|                                | Large goat   | Small goat | Large turkey | Rabbit       | Small turkey | Rabbit    | Small turkey | Rabbit          | Small turkey    |
|                                | 3 Nights     | 15 Nights  | 3 Nights     | 17 Nights    | 18 Nights    | 17 Nights | 18 Nights    | 17 Nights       | 17 Nights       |
| <i>sanguisuga</i>              | 1,822        | 3,327      | 235          | 163          | 298          | 55        | 55           | 33 <sup>a</sup> | 74 <sup>a</sup> |
| <i>arboricola</i>              | 0            | 1          | 0            | 0            | 0            | 6         | 4            | 28 <sup>b</sup> | 42 <sup>b</sup> |
| <i>paraensis</i>               | 0            | 9          | 0            | 1            | 3            | 0         | 4            | 3               | 13              |
| <i>guttipennis</i>             | 2            | 7          | 1            | 0            | 0            | 0         | 1            | 7               | 8               |
| <i>scanloni</i> <sup>c</sup>   | 0            | 0          | 0            | 0            | 0            | 0         | 3            | 1               | 8               |
| <i>mulrennani</i> <sup>e</sup> | 1            | 3          | 3            | 0            | 0            | 1         | 0            | 0               | 0               |
| <i>piliferus</i>               | 0            | 0          | 0            | 0            | 0            | 0         | 0            | 0               | 3               |
| <i>hinmani</i>                 | 0            | 0          | 0            | 0            | 0            | 0         | 0            | 0               | 1               |

<sup>a</sup> Significant at the 5% level (Paired t-test).

<sup>b</sup> Significant at the 5% level for % engorgement (Rabbit=10.7%; Turkey=60.0%).

<sup>c</sup> Collected for the first time in Giles County, Virginia.

collected at all elevations in the canopy, but most of them (16 out of 24) were collected at 15.25 m.

Jannback (1965) suggested that *C. guttipennis* may be primarily ornithophilic because of its preference for the forest canopy, and its sensillar pattern which has nine antennomeres with sensillae. In these collections, there was little difference between the number collected from the rabbits (7 specimens) as compared with the small turkeys (9 specimens). The literature reports tend to confirm these latter results since this species was reported in large numbers from poultry (Messersmith 1965), and from mammals (Pratt 1907, Malloch 1915, Snow *et al.*, 1957; Murray 1957, Hair and Turner, 1968, and Humphreys 1969).

*C. scanloni* is a ground breeding species thought to be primarily ornithophilic. It was reported taken from poultry by Jannback (1965) and by Messersmith (1965). Only 12 specimens were collected in this study and all but one were collected from the small turkeys. It was not collected at the ground elevation and all but three specimens came from the 15.25 m elevation.

*C. mulrennani* has been reported as being a pest of man at Cranberry Glades, West Virginia (Battle and Turner 1971).

Eight specimens were collected in this study, and all but one were collected from the goats and large turkey. One specimen was collected from a rabbit at 7.63 m.

*C. piliferus* host preference is also not well known. Jannback (1965) suggested that this ground breeding species is probably ornithophilic. It has been reported from poultry (Messersmith 1965, Humphreys 1969), and from mammals (Wirth and Hubert 1962, Humphreys 1969). Only three specimens were collected in this study and these came from the small turkeys at 15.25 m.

*C. hinmani* Khalaf is a tree hole breeding species. It has been collected from man and other mammals (Hair and Turner 1968), but a few have been reported from poultry (Messersmith 1965). The single specimen collected during this study was taken from a turkey at 15.25 m.

CONCLUSIONS. More specimens of *C. sanguisuga* were collected at ground level than at either the 7.63 or 15.25 m elevation in the tree. Since this species is considered to be mammalophilic, it was most interesting to find that significantly more specimens were collected at the 15.25 m canopy elevation from the small turkeys than from the rabbits. More were also collected from the small turkeys than from the rabbits at ground level, but the difference was not

statistically significant. In general, however, *C. sanguisuga* tended to prefer larger animals, whether they be mammals or birds.

Two major factors emerged from this study as being important in determining a *Culicoides* blood meal. The first factor is the normal vertical flight activity of the species; whether it be located at ground level or in the higher elevations in the forest canopy. The second factor is the size or bulkiness of the host; whether it be bird or mammal.

A species that feeds in the upper forest canopy will presumably find more birds than mammals as potential hosts. It is our opinion that this reflects host availability rather than host preference. Of course, it may also be argued that an ornithophilic species feeds in the upper canopy because of the presence of a greater abundance of avian hosts. However, when rabbits were introduced into this elevation, many so-called ornithophilic species were also attracted to these mammalian hosts.

It is possible that the differences in elevation at which particular *Culicoides* species typically feed and the sizes of their potential hosts are more important in determining host preference than whether the hosts are birds or mammals.

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