NOCTURNAL BLOOD-FEEDING FROM PASTURED CALVES BY THE CERATOPOGONID MIDGE, *CULICOIDES VENUSTUS*, IN NEW YORK STATE[1]

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ABSTRACT. To confirm or refute nocturnal blood-feeding from cattle by *Culicoides venustus*, haematophagous insects attracted to pastured calves were sampled through 5 nights. Drop-trap and vacuum apsirator samples were taken at 30 min before and after sunset and at hourly intervals through the night until an hour after sunrise. Female *C. venustus* were consistently captured in drop-trap samples during darkness and sunrise twilight; only 1 specimen was captured during sunset twilight. Vacuum samples captured *C. venustus* sporadically during darkness. The data confirm that female *C. venustus* are primarily nocturnal in host-seeking and consistently utilize cattle as a blood meal source.

INTRODUCTION

Unlike the common muscoid flies associated with domestic livestock, many haematophagous Nematocera have received little attention relative to their veterinary importance (see Steelman 1976 for review). This condition is exemplified by biting midges of the genus *Culicoides* (Jones 1978), despite the acknowledged involvement of species as vectors of domestic-animal disease agents. Reported here is a study conducted to confirm or refute nocturnal blood-feeding from bovine hosts by *C. venustus* Hoffman, a biting midge widespread in eastern North America (Foote and Pratt 1954, Battle and Turner 1972). Current information concerning the blood feeding behavior of *C. venustus* is limited to the report by Schmidtmann et al. (1980). These authors captured a small number of specimens from calves and ponies, but only in the last sample taken during eve-

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ning twilight; they therefore speculated that the species may be nocturnal and, consequently, more active in blood-feeding from livestock than previously appreciated. Since 50 to 60% of the 2-plus million dairy cows, as well as most replacement heifers, in the Northeast dairy region spend 4 to 5 months grazing pasture forage, information concerning insect blood-feeding from pastured cattle is important in an economic context.

MATERIALS AND METHODS

Animals used to attract host-seeking *C. venustus* were a pair of Holstein heifer calves that ranged in weight from about 100 to 150 kg during study. On sample dates, both calves were tethered to stakes positioned 5.5 m apart under the cross-arm of a drop-trap support structure (Fig. 1). The support structure, which was positioned on open pasture, consisted of a telephone pole 6.1 m in length set 1 m into the ground, and a cross arm 4.9 m in length centered over the pole in a north-south axis. Drop-trap units (Fig. 1) were suspended from the distal ends of the cross-arm by a rope running through a pulley. The frame of the drop-trap unit was constructed from 20-mm PVC pipe, hexagonal in shape, and ca. 2.3 m in diameter and 2.4 m in height. The catch bag was made of fine-gauge (<60 mesh) nylon tricot and constructed to fit the interior of the frame, to which it was attached by elastic ties. A 914-mm zipper was inserted in one side of the bag.

Sampling was conducted through 5 nights in the summer of 1978. Dates reported represent calm nights when wind did not preclude biting midge host-seeking; sampling was started on additional dates, but terminated due to unstable weather. All observations were made at the same site in a 2-ha pasture approximately 5 km east of Ithaca, Tompkins County, New York. Sampling was initiated at 30 min before sunset, as calculated for Ithaca, New York at 42°27′ north latitude. Subsequent samples were taken at 30 min after sunset, which closely approximates the end of civil twilight at 42° north latitude during the summer months (Anonymous 1963), and thereafter at hourly intervals post-sunset until the hour after sunrise.

At each sample time, either 1 or 2 drop-trap units were released to enclose a calf tethered below. One calf was left exposed every other sample time for vacuum aspirator sampling. Once in place over a calf, the drop trap was undisturbed for 10 min, permitting blood-feeding insects to complete engorgement. The operator then entered the catch bag, closed the zipper, and collected all insects on the inside surface of the fabric with a portable vacuum aspirator. A catch bottle contained within the aspirator, and labeled as to date, time, and animal, served as a receptacle for each sample. Collection of insects was aided by the use of a head lamp covered with transparent red cellophane. After exiting the catch bag, the operator closed the zipper and immediately elevated the drop-trap unit to the cross arm. When elevated, the bottom of the catch bag was ca. 4 m above ground.

On alternate sample times, a series of vacuum aspirator samples was taken directly from the calf not enclosed by a drop-trap unit. Samples of 60 sec duration each were taken from 4 regions of host anatomy. These were: 1) the head and ears, including the inside and outside of the ear pinna; 2) the back, extending from the neck to the tailhead; 3) the belly, extending from the brisket to the teats; and 4) the legs, from about 18″ to the ground, inside and outside. Details of the vacuum aspirator and contained catch-bottle, which was replaced between samples, are described in Schmidtmann et al. (1980).

Female *C. venustus* were identified by their relatively large size, dark coloration and the pale spot covering part of the second radial cell of the wing, and rated as blood-fed or non-blood-fed by the presence of red blood in the gut. The numbers of specimens captured hourly were added across sample dates and con-

verted to "Williams' mean," defined as $\log_{10}(M_W+1) = \frac{\Sigma \log_{10}(n+)}{N}$, where n1, n2 ... nN represent numbers of specimens captured hourly in N nights of observation. Antilog (M_W-1) values represent the mean capture rate for each sample time. This procedure is useful for numerical catch data as it gives a strong measure of central tendency and accommodates zero values (Haddow 1960).

RESULTS

A total of 173 female *C. venustus,* 99 of which were blood fed, was captured in 94 drop-trap samples (Table 1). Capture rates ranged from 0 to 14 specimens ($\bar{x}$ = 1.8) per sample. No male *C. venustus* were captured. With the exception of a single female captured at 30 min before sunset, specimens were 1st captured at sample time −1; thereafter, *C. venustus* host-seeking activity was continuous through

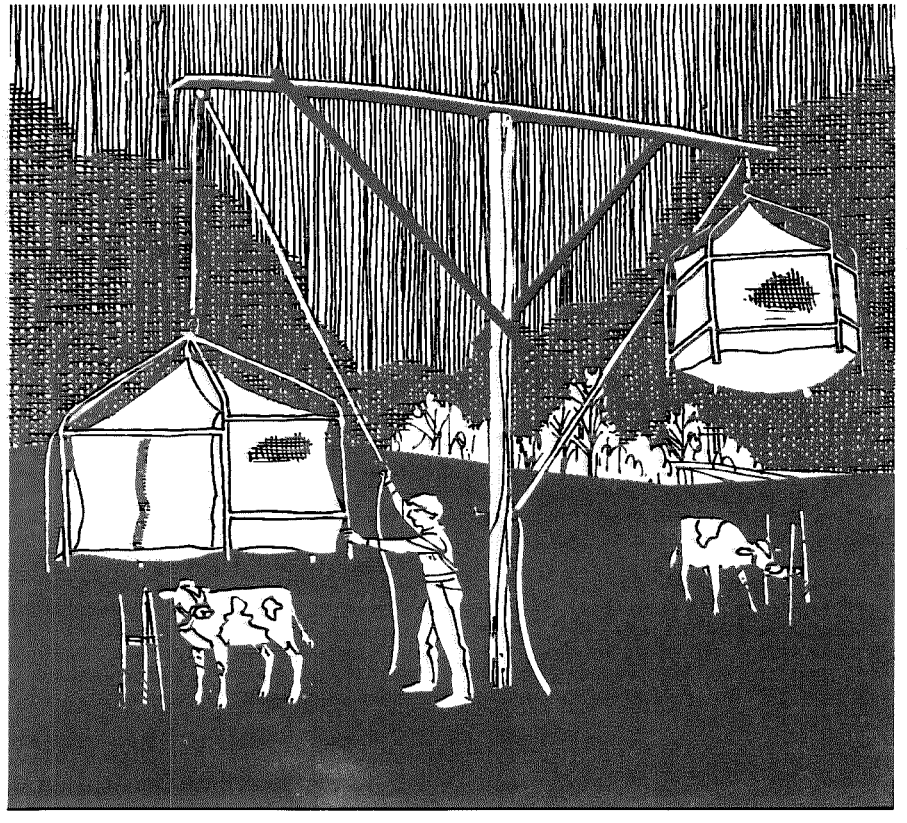

Fig. 1. Drop-trap sampling of *C. venustus* attracted to tethered calves.

Table 1. *Culicoides venustus* captured from tethered calves.

Date	No. female C. venustus captured/sample time											
	Sample times											
	+30	−30	−1	−2	−3	−4	−5	−6	−7	−8	−9	−10	−11
30–V–78	0[1]	0	1	0	2	4	0	2	0	1	0	3	0
	0/1	0/2	0/1	1/2	5/1	7/2	1/1	0/2	0/1	9/2	3/1	2/2	0/1
29–VI–78	0	0	8	4	3	1	10	6	0	1	5	—	—
	0/2	0/1	4/2	6/1	5/2	9/1	5/2	8/1	5/2	11/1	4/2	—	—
18–VII–78	0	0	2	0	5	7	1	0	1	2	0	1	0
	0/1	0/2	3/1	0/2	1/1	3/2	1/1	1/2	1/1	0/2	0/1	1/2	0/1
1–VIII–78	1	0	0	0	0	0	0	0	0	0	0	0	0
	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/1	0/2
5–IX–78	0	0	1	0	0	0	1	0	0	1	0	0	0
	0/1	0/2	0/1	0/2	0/1	0/2	3/1	0/2	0/1	0/2	0/1	0/2	0/1
Total	1	0	12	4	10	12	12	8	1	5	5	4	0
	0/7	0/8	7/7	7/8	11/7	19/8	10/7	9/8	6/7	20/8	7/7	3/7	0/5

[1] No. non-blood-fed specimens.
No. blood-fed specimens/No. drop-trap samples taken.

the night, averaging 2.6 specimens per sample through sample time −8. Host-seeking activity persisted through civil twilight before sunrise, and specimens were also captured post-sunrise at sample interval −10. No specimens were observed at hourly sample −11. Relative capture rates expressed as "Williams' mean" are presented in Fig. 2. Host-seeking activity was continuous through the night, with apparent peaks of activity occurring at sample intervals −4 and −8. Blood-fed females represented from 37 to 86% ($\bar{X}$ = 58%) of specimens captured per sample time during the hours of darkness (sample intervals −1 through −8). At least 1 *C. venustus* was captured in 41 of 48 drop-trap samples taken during the hours of darkness (excluding sample date 1-VIII when no specimens were captured after sunset).

A total of 13 *C. venustus* was captured in 48 vacuum samples taken from calves. One specimen was captured from the head region, 2 in two samples from the back, and 10, 8 in one sample, from the belly region.

DISCUSSION

As the northernmost species of the Neotropical subgenus Hoffmania (Fox 1948), *C. venustus* is found from the Mississippi River east to the Atlantic coastline and from the panhandle of Florida north to Ontario, Canada (Foote and Pratt 1954, Blanton and Wirth 1979). Our data demonstrate that female *C. venustus* consistently take blood from pastured calves during nocturnal periods. This confirms that cattle are acceptable as a blood-meal source and that female *C. venustus* seek blood nocturnally, as conjectured by Schmidtmann et al. (1980). It also illustrates that blood-feeding from pastured livestock may be common and widespread in the eastern U.S. The development of larval *C. venustus* in livestock hoofprints in wet pastures and mud along stream margins (see Blanton and Wirth 1979 for review), increases the probability that cattle in other areas also are exposed to *C. venustus* blood feeding. It is also notable that the distribution of pit sensilla on the antennae of female *C. venustus*, 3, 11–15, conforms to the pattern found in other large-mammal-feeding biting midges (Jamnback 1965).

The specific identity of blood in females captured in drop-trap samples was not determined. We are not aware, however, of behavior exhibited by blood-fed Nematocera, or of errors in our sampling procedure, that would result in females

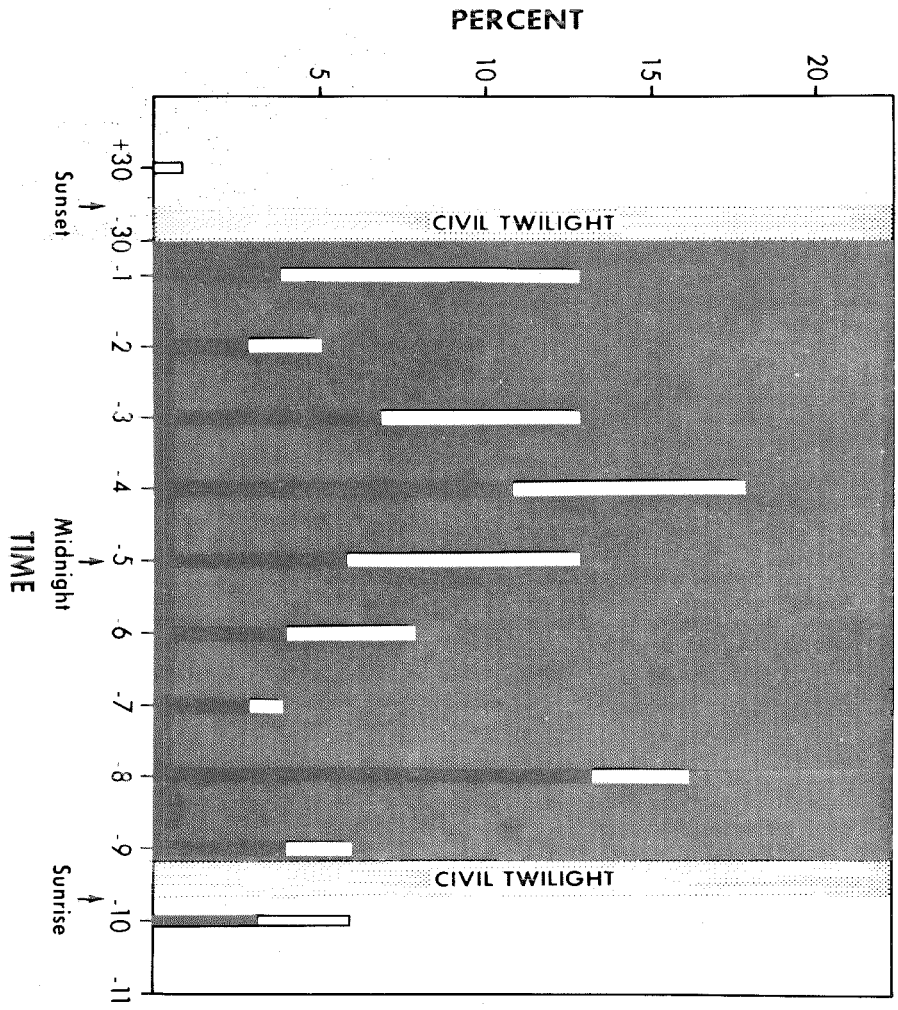

Fig. 2. Host-seeking activity of *C. venustus*. Data for each sample time calculated as Williams' mean and expressed as a percentage of the total catch. Dark bars represent the percentage of blood-fed females captured relative to non-blood-fed (white bar) per sample time. Sunrise and associated civil twilight varied through the summer, but was between sample times −9 and −10 on all sample dates.

recently blood-fed from one animal being captured consistently in a drop-trap unit in place over another animal 3 to 5 m distant. Further, Muller and Murray (1977) established by serologic tests that engorged *Culicoides* captured from sheep with a similar drop-trap contained sheep blood. The capture of *C. venustus* in vacuum samples taken directly from calves, though sporadic, also indicates that *C. venustus* females take blood from calves.

Many species of *Culicoides* seek blood meals during crepuscular periods, and some remain active into the night under favorable climatic conditions; a lesser number of species are strictly nocturnal (Kettle 1977). The near-total absence of *C. venustus* in evening twilight samples and the consistent capture of specimens through the night indicate that *C. venustus* host-seeking is primarily nocturnal. It is of interest that host-seeking activity also persisted through twilight at sunrise. A similar condition was reported for 2 African biting midges by Walker (1977), who suggested that the lack of evening activity presumably resulted from wind that prevented host-seeking flight. Since we collected many specimens of other *Culicoides* spp. during evening twilight (unpublished data), it appears that factors other than wind velocity were responsible for the paucity of *C. venustus* at bait animals.

The drop-trap sampling system used in this study is functionally similar to the trapping methods (closure traps) used to capture hostseeking *Culicoides* by Bennett (1960), Jones (1961), Hair and Turner (1968), Humphreys and Turner (1973), and Muller and Murray (1977). A primary limitation of our system was the physical size of the support structure, which restricted sampling mobility. Advantages of this method, as discussed by Jones (1978), are the unobstructed access of insects to selected bait animals, direct evidence of blood feeding, and acquisition of data relating host-exposure rates to periodic insect activity. The capture of *C. venustus* in 41 of 48 samples during the hours of darkness, which contrasts with capture of females in 3 of 16 comparable vacuum sample sequences, shows that drop-trap sampling is a sensitive method for estimating host-exposure rates at moderately low levels of insect attack.

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