

HOST-SEEKING ACTIVITY OF *CULICOIDES* SPP. (DIPTERA: CERATOPOGONIDAE) NEAR YANKEETOWN, FLORIDA¹

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ABSTRACT. The diel, seasonal, and lunar host-seeking periodicity of *Culicoides mississippiensis*, *C. floridensis*, *C. barbosai*, and *C. furens* was studied near Yankeetown, Florida. *Culicoides mississippiensis* was the only species active during all seasons. Significantly more ($P < 0.05$) individuals sought a blood meal when the moon was full than when the moon was in some other phase. *Culicoides floridensis*, the species with the shortest wing length, did not attack when the wind speed exceeded 9 km/h, and *C. mississippiensis*, the species with the greatest wing length, did not attack when the wind speed exceeded 17 km/h.

INTRODUCTION

Bloodsucking ceratopogonids often attack in large numbers and the victim is left with red wheals that may persist for several days. Linley and Davies (1971) estimated that most people will not tolerate more than 5 bites/hour for outdoor activities; a level which is easily exceeded at certain times.

Many species of ceratopogonids are abundant at dusk and dawn. Kettle and Linley (1969a, 1969b) determined that *Culicoides furens* (Poey) and *Culicoides barbosai* Wirth and Blanton displayed this pattern of activity in Jamaica. Foulk (1969) showed that *Culicoides variipennis* Coquillett was also most abundant at dusk and dawn in California, and Scholl et al. (1979) came to a similar conclusion for *Culicoides guttipennis* (Coquillett) in Wisconsin.

Some species do not exhibit crepuscular activity. *Culicoides paraensis* Goeldi is only active during the day in Wisconsin (Scholl et al. 1979), *Leptoconops knowltoni* Clastrier and Wirth has two diurnal peaks in California (Foulk 1969), and *Culicoides venustus* Hoffman is most abundant during the night in New York (Schmidtman et al. 1980).

Data on patterns of activity for ceratopogonids along the west coast of Florida have been obtained with a vehicle-mounted insect trap (Lillie et al. 1987) or light traps (Beck 1958, Khalaf 1969, Kline 1986). The objective of this study was to use a human subject to determine

the diel, seasonal, and lunar host-seeking periodicity of anthropophilic ceratopogonids near Yankeetown, Florida (29°2'N, 82°4'W).

MATERIALS AND METHODS

The diel cycle was divided into 20 periods, based upon times of sunrise, sunset, and civil twilight as obtained from the U.S. Naval Observatory (Bidlingmayer 1961, Barnard and Jones 1980, Lillie et al. 1987). Periods 1 through 10 represented the diurnal portion of the diel cycle, which began at sunrise and ended at sunset. Period 11, evening twilight, began at sunset and ended at evening civil twilight. The nocturnal portion of the diel cycle consisted of the time between evening civil twilight and morning civil twilight and was divided into eight equal periods, 12 through 19. Morning twilight was represented by period 20 which began at civil twilight and ended at sunrise. The duration of each period in the diurnal phase ranged from 62 to 84 min, twilight periods ranged from 52 to 60 min, and each period of the nocturnal phase ranged from 60 to 90 min during the 14-month study.

Sampling was carried out four times during each lunar cycle on the 1st day (± 1 d) of each quarter phase of the moon (i.e., new moon, first quarter moon, full moon, and last quarter moon) from May 26, 1983 to July 5, 1984 for a total of 56 days of sampling. A mouth aspirator was used to collect ceratopogonids from the forearm of a human host for 5 min during each period of the 24 h cycle. A light was operated during the collection process in periods 11 through 20. Biting midges attracted to other areas of the body were not collected. Personal insect repellents or insecticides were never used. A total of 1,120 samples was collected throughout the study.

All collections were stored in a styrofoam chest with dry ice for transport back to the laboratory in Gainesville, FL. The adult *Culicoides* were sorted, identified to species and sex, and stored in 75% ethanol for later reference.

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During this sampling program, environmental conditions were monitored. Temperature ($^{\circ}\text{C}$) and wet bulb depression were measured at the end of each period with a sling psychrometer. Light intensity was measured at the same time with an International Light[®] model IL710A Research Photometer. A weather station was set up at the research site to monitor wind speed and wind direction throughout the study.

All data were entered into the University of Florida computer system and analyzed with the general linear model analysis of variance (ANOVA) and Duncan's multiple range test of the Statistical Analysis System (SAS Institute 1982). The analysis included a comparison of the number of individuals of each species collected during different diel periods, phases of the moon, and seasons of the year. Distinction among the four seasons was based upon dates of the summer and winter solstices and the spring and fall equinoxes.

RESULTS AND DISCUSSION

Culicoides mississippiensis Hoffman, *C. floridensis* Beck, *C. barbosai*, and *C. furens* were collected during this study. The same species were obtained in a vehicle-mounted insect trap (Lillie et al. 1987) and modified New Jersey light traps (Kline 1986) in the same area. *Culicoides mississippiensis* was the most abundant ceratopogonid in all studies. Kline (1986) collected 17 additional species of *Culicoides*, but he was able to sample a greater diversity of habitats with light traps; the current study was limited to anthropophilic species.

Diel and seasonal host-seeking activity. *Culicoides mississippiensis* was present throughout the year (Figs. 1-4), but it was most abundant during the cooler months. This pattern of activity was also reported by Beck (1958), Khalaf (1969), and Kline (1986). The number of females attempting to engorge was greatest just before sunset in spring (Fig. 1) and fall (Fig. 3). As many as 190 specimens were collected from the forearm over a 5 min interval in late March. Individuals usually crawled over the skin for a brief period before attempting to insert their mouthparts. This crawling period provided an opportunity to collect most specimens before they had a chance to bite.

The attack activity of *C. mississippiensis* dropped sharply after sunset, but individuals continued to seek a bloodmeal throughout the

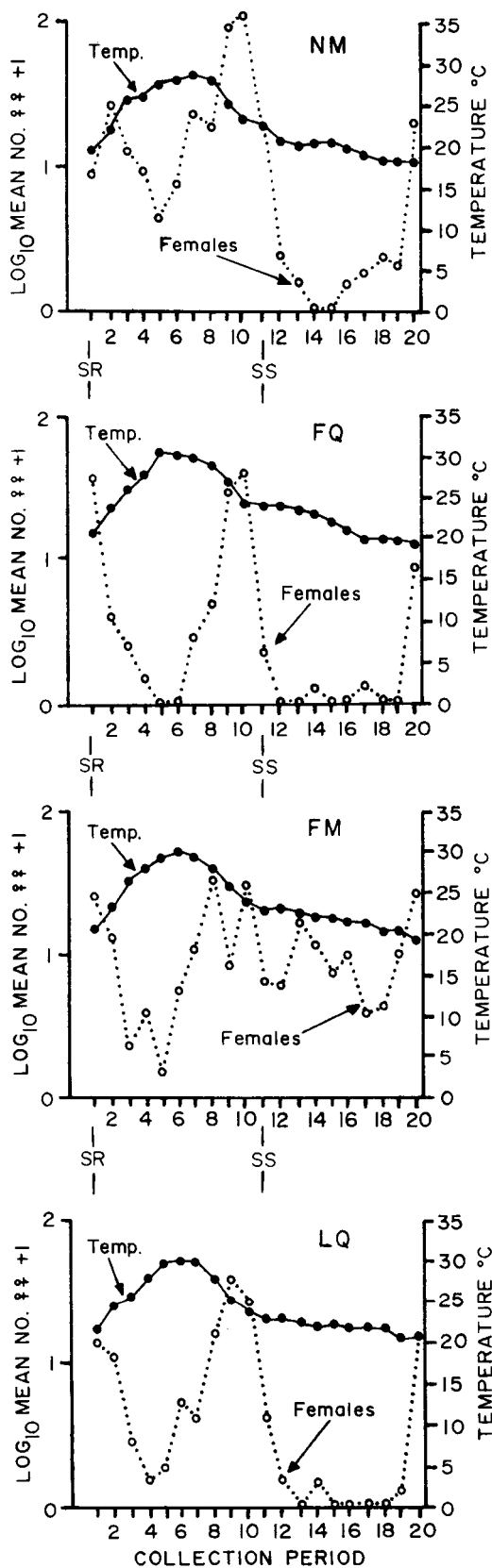


Fig. 1. Diel and lunar host-seeking periodicity of *Culicoides mississippiensis* during new (NM), first quarter (FQ), full moon (FM), and last quarter (LQ) phases of the moon in spring (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

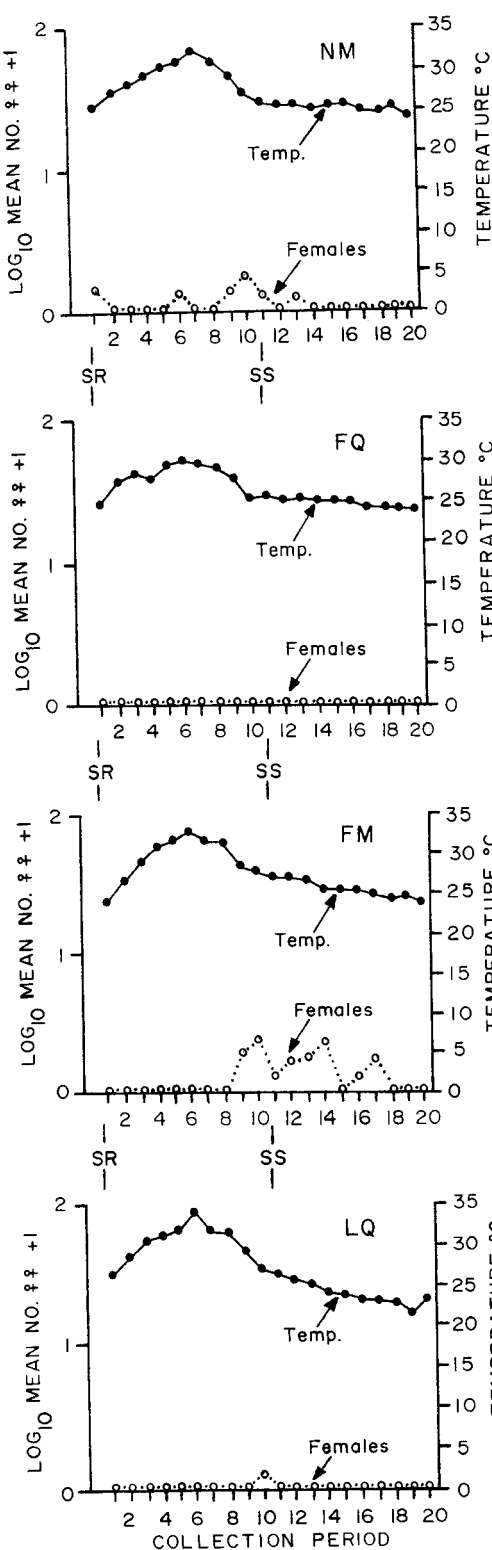


Fig. 2. Diel and lunar host-seeking periodicity of *Culicoides mississippiensis* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in summer (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

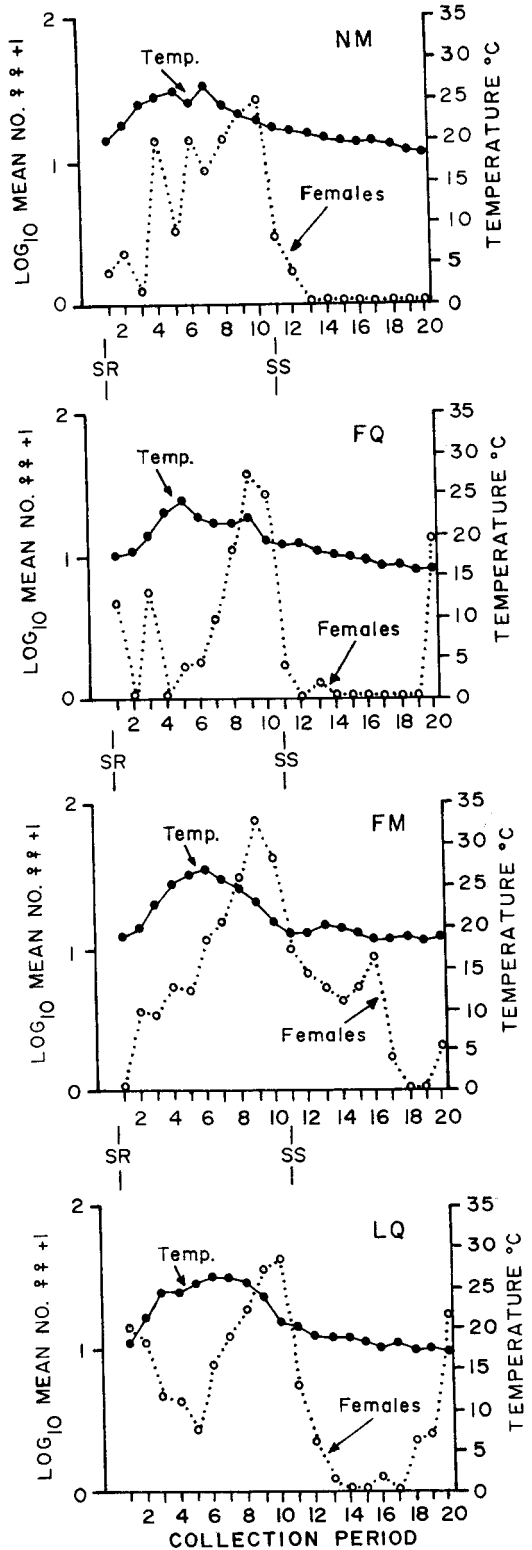
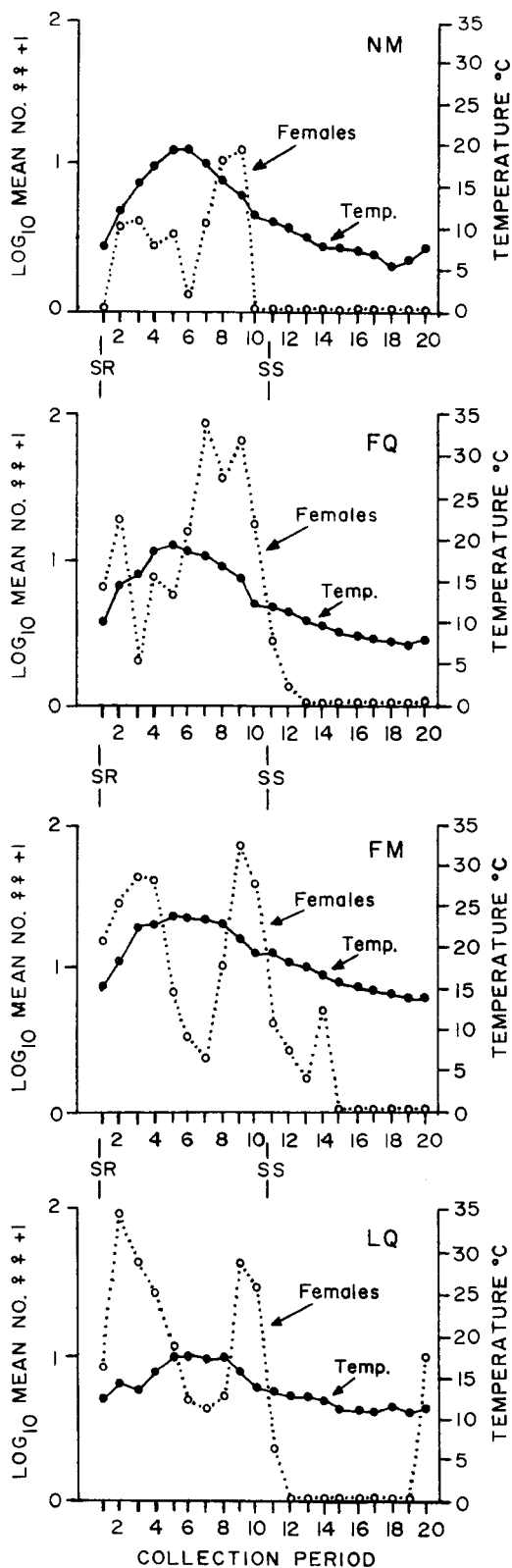


Fig. 3. Diel and lunar host-seeking periodicity of *Culicoides mississippiensis* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in fall (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.



night in spring (Fig. 1) and fall (Fig. 3). A second peak occurred during early morning hours. The increase began just before sunrise (period 20) and continued for 2-3 hours after that time during all seasons except summer (Fig. 2). Attack by this species persisted throughout daylight hours in spring (Fig. 1), fall (Fig. 3), and winter (Fig. 4). Only in summer was the host-seeking activity below the threshold, 5 bites/h (Linley and Davies 1971), for comfortable human activity during most of the diel cycle. The attack rate was also low during portions of the night in fall and winter.

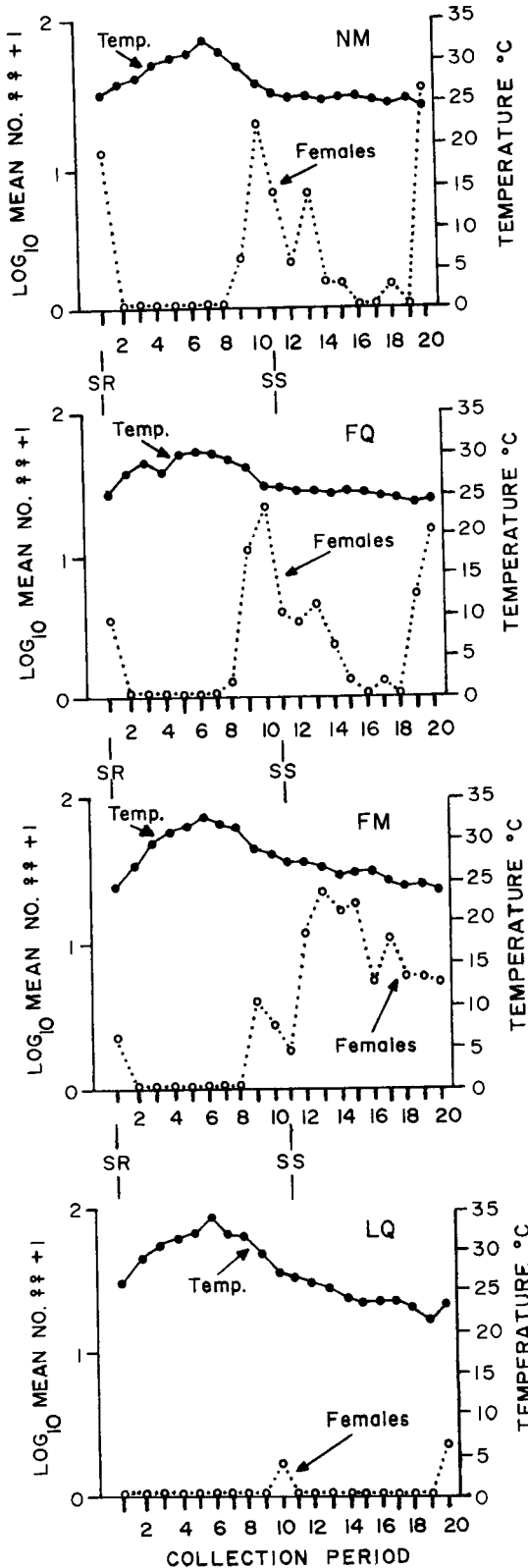
Culicoides floridensis was the next most abundant species in search of a human host. A total of 1,138 specimens was collected in spring, summer, and fall, but the majority (966) was obtained during the summer (Fig. 5). In prior light trap studies, activity ranged from April through October in the Yankeetown study area (Kline 1986) and from mid-May to early September in Highlands County, FL (Beck 1958). Data for spring and fall were not presented in the figures because too few specimens were obtained. This species is a vicious biter in the Yankeetown area; as many as 81 specimens were collected over a 5 min period.

Blanton and Wirth (1979) reported that *C. floridensis* attacked man during the daytime in Florida. In contrast to their report, attack during the day was rare near Yankeetown (Fig. 5). The number of host-seeking females declined to zero in the hour following sunrise and did not increase again until shortly before sunset.

Culicoides barbosai was active during all seasons except winter (Figs. 6-8). They often attempted to feed on the fingers and the palm of the hand. Kettle (1969a, 1969b) found that *C. barbosai* preferred to feed on the legs rather than the arms of a human host at night, but that was not examined in our study. The largest 5 min collection of this species contained 80 specimens. Host-seeking activity was greatest at dusk and dawn with the dawn peak being the more pronounced of the two (Figs. 6-8). The number of attacking midges of this species usually declined rapidly after sunrise; only during fall did the attack activity of *C. barbosai* persist beyond the middle of the day (Fig. 8).

Culicoides furens was absent from collections during most of the daylight hours (Fig. 9). Few specimens were obtained in spring and fall and

Fig. 4. Diel and lunar host-seeking periodicity of *Culicoides mississippiensis* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in winter (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.



these data are not illustrated. The abundance of this species relative to other ceratopogonids in the area was greater when collected in a vehicle-mounted insect trap (Lillie et al. 1987). This difference may have occurred because only a single host was used for all collections and the specific collection site never changed. The results may have been biased if the host or collection site was not favored by *C. furens*. Kettle (1969a, 1969b) reported that *C. furens* preferred to feed on the leg of a human rather than the arm. In this study, all samples were taken from the arm, approximately 1.2 m above ground level. Perhaps the lack of exposure to the preferred biting site, legs, decreased numbers collected from the human host in our study.

The diel periodicity of host-seeking specimens did not always agree with that of specimens collected in a vehicle-mounted insect trap (Lillie et al. 1987). It is likely that the two sampling methods procured different segments of populations of species active in the area. Individuals in search of a bloodmeal were collected in the aspirator after being attracted to a human host. In contrast, midges engaged in a variety of behaviors including search of mates, breeding sites, and food sources were collected in the vehicle-mounted insect trap. The most apparent difference was that the vehicle-mounted insect trap collected both sexes while only females were obtained with the aspirator. Bidlingmayer (1961) encountered similar disparities in the two sampling techniques.

Lunar host-seeking periodicity. The frequency of attack by individuals seeking a bloodmeal during the night was greatest when the moon was full. In some instances the number of specimens collected during full moon was approximately 100 times greater than when the moon was in some other phase. Kettle (1972) observed in Jamaica that the biting rates of *C. barbosa* and *C. furens* were maximal at new moon and not full moon. He speculated that the lunar effect was a result of tides influencing the time of emergence rather than nighttime illumination stimulating adult activity. We did not examine the influence of tides near Yankeetown.

Culicoides mississippiensis was collected in large numbers during daylight hours of all moon phases, but individuals remained active throughout the night only when the moon was full (Figs. 1-4). The moon had no influence,

Fig. 5. Diel and lunar host-seeking periodicity of *Culicoides floridensis* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in summer (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

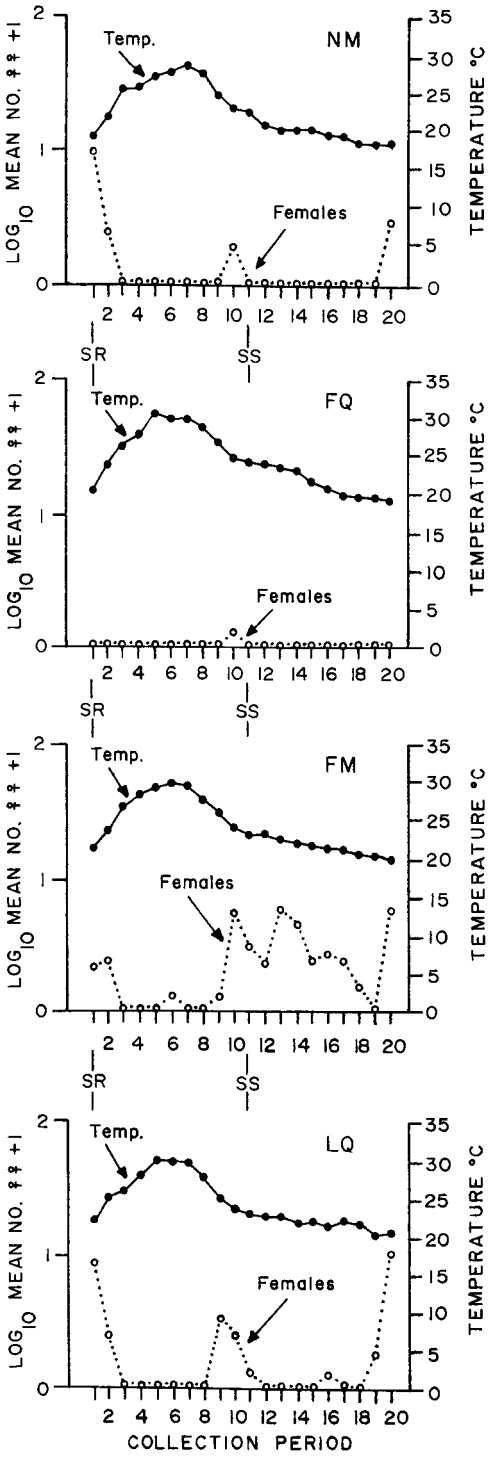


Fig. 6. Diel and lunar host-seeking periodicity of *Culicoides barbosai* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in spring (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

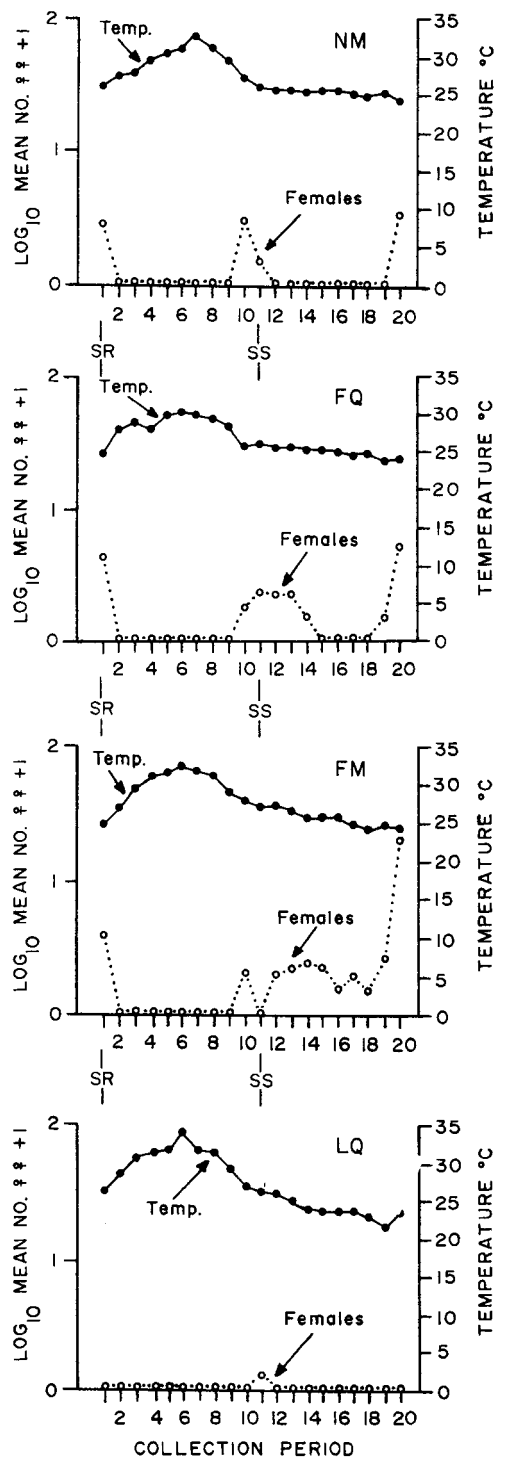


Fig. 7. Diel and lunar host-seeking periodicity of *Culicoides barbosai* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in summer (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

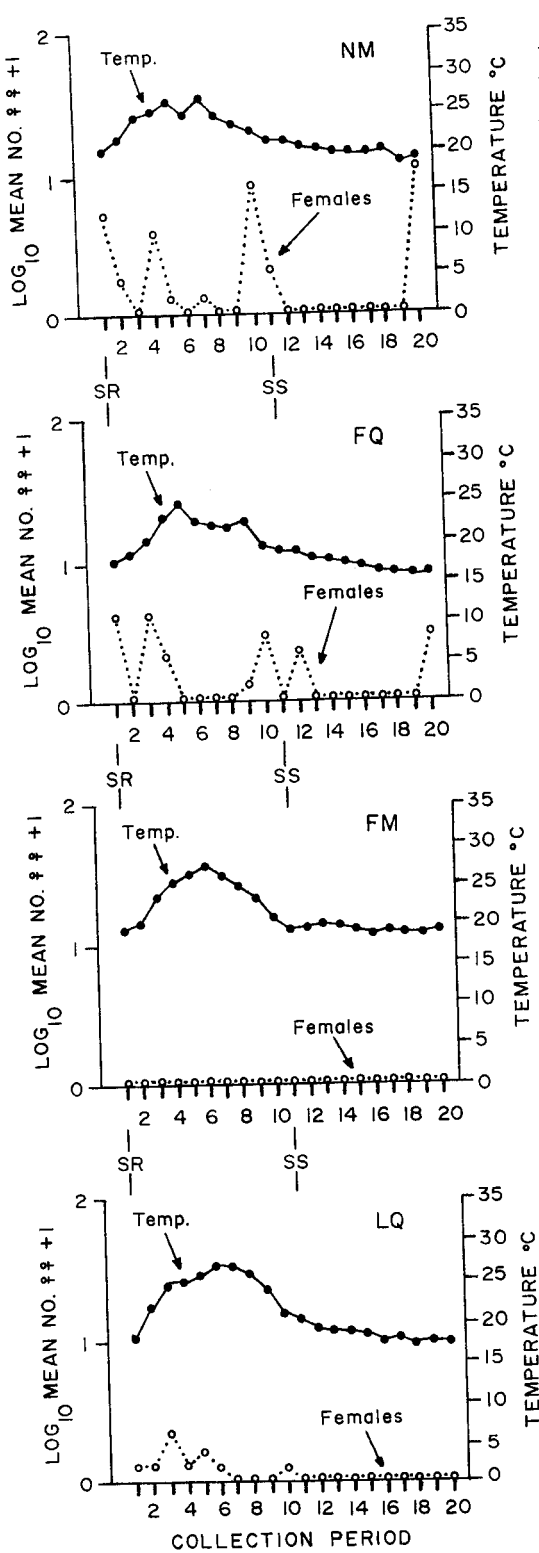


Fig. 8. Diel and lunar host-seeking periodicity of *Culicoides barbosai* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in fall (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

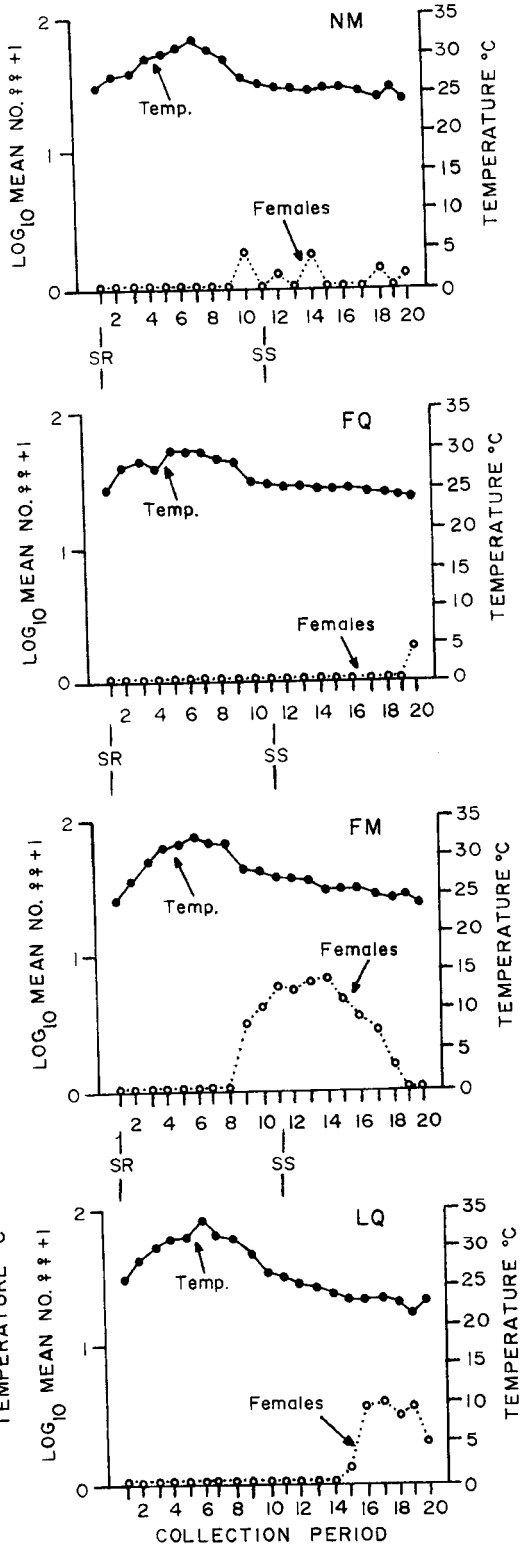


Fig. 9. Diel and lunar host-seeking periodicity of *Culicoides furens* during new (NM), first quarter (FQ), full (FM), and last quarter (LQ) phases of the moon in summer (SR = sunrise; SS = sunset). Each mean represents number of females attracted to forearm of a human host during 5-min per period.

however, during the winter when the average temperature was below 15°C (Fig. 4). Attack activity in that season declined to zero around period 15 and did not resume until sunrise.

Culicoides floridensis was inactive during the day, but showed increased activity during a full moon (Fig. 5). The difference was significant ($P < 0.05$) when compared with other phases. In contrast, *C. barbosai* collections while greatest when the moon was full, did not differ significantly ($P > 0.05$) from collections taken during other phases (Figs. 6–8). *Culicoides furens*, the least abundant host-seeking species, also showed increased activity during full moon (Fig. 9). It differed from the other species in that activity on full moon peaked during early periods of the night. Its activity during the last quarter phase was also distinct in that a peak in the level of activity was observed after moonrise (ca. period 16).

Meteorological conditions. The wind had a noticeable effect on attack activity of the four species. *Culicoides floridensis*, the species with the shortest wing length (Blanton and Wirth 1979), was the most sensitive. Host-seeking by this species did not occur when the wind speed was greater than 9 km/h. *Culicoides barbosai* and *C. furens*, which have longer wing lengths than *C. floridensis*, were absent from host-seeking collections when the wind speed was greater than 13 km/h. The threshold for *C. mississippiensis*, the species with the greatest wing length (Blanton and Wirth 1979), was 17 km/h. This phenomenon was also observed in collections obtained in a vehicle-mounted insect trap (Lillie et al. 1987).

Wind direction had no influence on the host-seeking activity of the four species at the collection site. Close proximity to a salt marsh with extensive *C. mississippiensis* and *C. furens* breeding sites may be the reason. However, an individual residing about 3.2 km from the collection site on the Gulf of Mexico stated that biting midges were not a problem when the wind was blowing inland from the Gulf, but the annoyance was extremely great when it was from the opposite direction. Studies were not performed to confirm this observation or to determine the species involved.

The temperature varied from -1.6 to 37.2°C during the study. *Culicoides mississippiensis* did not begin attacking the host until the temperature exceeded 14°C and the attack was most intense when the temperature was between 18 and 22°C. The other species did not attack until the temperature exceeded 16°C. *Culicoides floridensis* and *C. barbosai* preferred temperatures in the range of 25 to 28°C.

ACKNOWLEDGMENTS

We are grateful to D. D. Allen for his hospitality and cooperation during this study. E. C. Greiner (School of Veterinary Medicine, University of Florida) provided helpful comments and suggestions. We thank J. C. Lord for reviewing the manuscript. Ronald G. Marks (Biostatistics Unit, J. Hillis Miller Health Center, University of Florida) reviewed the research proposal and experimental design. A. J. Rahe (Statistician, USAF School of Aerospace Medicine) provided advice on statistical analysis. This work was supported by Federal Hatch Project ENY 2442 and is Florida Experiment Station Journal Series Number 8914.

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