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HOST-FEEDING BEHAVIOR OF THE HOUSE MOSQUITO *CULEX PIPIENS* IN NORTHWEST OHIO (DIPTERA: CULICIDAE)

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ABSTRACT

The human-biting behavior of *Culex pipiens* was investigated in northwest Ohio. The biting studies were conducted by exposing a human volunteer for 33 h at ground and 10-m height levels in a field area which contained sizeable populations of *C. pipiens*. No significant feeding on humans was noted and only a single specimen of *C. pipiens* was observed to attempt feeding. Concurrent light trap data revealed a definite stratification preference for *C. pipiens* at the 10-m height level. In the laboratory, caged *C. pipiens* were allowed to feed on humans (12-h period) with no positive results. Other caged specimens fed readily on a house sparrow.

In the United States, mosquitoes in the *Culex pipiens* complex are considered to be important vectors in promoting urban epidemics of St. Louis encephalitis (SLE). St. Louis encephalitis is undoubtedly the most important arthropod-borne virus in the U.S. Since its discovery in 1933, an estimated 10,000 cases and 1000 deaths have been attributed to the disease (Shroyer 1982). The disease exists primarily as an infection of birds transmitted by mosquitoes. Humans apparently acquire the infection from mosquitoes which have previously fed on infected birds. Human cases typically occur in late summer (CDC 1977). The *Culex pipiens* complex consists of *Culex pipiens pipiens* L. (northern house mosquito) and *Culex pipiens quinquefasciatus* Say (southern house mosquito); they are closely related and difficult to separate. One or both of these mosquito subspecies is found in every state (CDC 1977) with *C.p.pipiens* and *C.p.quinquefasciatus* being primarily found in the northern and southern United States respectively. House mosquitoes breed prolifically in artificial containers and may commonly be found in storm sewer catch basins, street gutters, rain barrels, tin cans, and other sources.

Numerous studies have been conducted on the *C. pipiens* complex to determine host-vector relationships and to subsequently better elucidate the epidemiological role of the mosquito with SLE. A great amount of variation in host preferences has been exhibited by this species. Reeves and Hammon (1944), Tempelis and Reeves (1964), Tempelis et al. (1967), Ekis (1971), Spielman (1971), and Magnarelli (1977) all provided evidence that members of the *C. pipiens* complex are primarily avian feeders. Tempelis (1975) concluded that *C.p.pipiens* prefers birds and *C.p.quinquefasciatus* feeds readily on both birds and mammals. Edman and Downe (1964) reported that *Culex pipiens* females in Kansas fed more commonly on cattle than birds. In Delaware, Murphey et al. (1967) stated that members of *C. pipiens* fed on seven species of small mammals. Ekis and Hagmann (1968) demonstrated differences between avian and mammalian preferences in different parts of a single state, New Jersey. It has even been suggested by Means (1968) that on Long Island, N.Y., there is an ornithophilic farm population and also a woodland population of *C. pipiens* that readily attacks humans. Tempelis and Reeves (1964) reported some feeding on humans by *C. pipiens* in Colorado and Illinois. Spielman (1971) reported a small number of human feedings by *C. pipiens* in Massachusetts. In his review of Thomas Monath's recent book *St. Louis Encephalitis*, Shroyer (1982) stated that omission of any discussion on host preferences of *C. pipiens* is annoying. Major outbreaks

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of SLE in the Great Lakes states have traditionally been attributed to *C. pipiens* transmission; however, significant human-biting has never been demonstrated in these areas. Shroyer further stated that this gap in our understanding of SLE transmission deserved mention.

The purpose of this study was to investigate the host-feeding behavior of *C.p.pipiens*, particularly on humans, in a Great Lakes area. The specific site chosen was Bowling Green, Ohio, which is located in the northwest corner of the state. In this area, *C. p. pipiens* is a very common mosquito species. Hereafter in this paper, *C. p. pipiens* will simply be referred to as *C. pipiens*.

MATERIALS AND METHODS

The study was conducted during August and early September of 1980 and 1981 in a field area located on the outer city limits of Bowling Green. The 0.4-ha study area consisted primarily of tall grasses with a 75-m row of mature elm trees bordering a portion of the field. The area was chosen because of the presence of numerous pools of shallow water which contained large populations of house mosquitoes. The biting studies were conducted by utilizing a human volunteer who was positioned within the elm tree area at both ground and 10-m height level. Biting studies were done at both ground and 10-m level to account for any vertical stratification preferences that might be displayed by *C. pipiens*. Illumination was provided by placing a small battery-operated light (containing two D-size batteries) directly above the human host. Host-seeking mosquitoes were collected by having the volunteer constantly expose his arm and subsequently aspirate any mosquitoes seeking a blood meal. The mosquitoes were not aspirated until they were actually seen probing into the host's arm. Host exposure times were set so as to provide a sampling of 1-h increments from 2100 to 0700 hrs. Some hours were repeated which resulted in 33 h (13 different nights) of field exposure under average climatic conditions. This included 7 h at ground level and 6 h at the 10-m level prior to 1200 hrs; 7 h of exposure at ground level and 13 at the 10-m level occurred after 1200 hrs. Since the purpose of this study was to evaluate host-feeding choices of *C. pipiens* and not to evaluate feeding frequency at different times, no attempt was made to insure that all hours were repeated the same number of times. For example, host exposure during the hours from 0100 to 0200 hrs. (10-m level) was repeated four times while some hours and elevations were not repeated at all. Mitchell and Rockett (1979) and Mitchell (1981) have shown that house mosquitoes display pronounced activity at certain times and elevations. Upon conclusion of a host exposure period, all aspirated individuals were taken to the laboratory for counting and identification.

As an aid in monitoring adult mosquito activity, light traps (CDC type) baited with CO_2 were twice utilized (early and late August, 1980) at ground level and the 10-m level. On two other nights in late August and early September, light traps were placed only at the 10-m level to monitor *C. pipiens* activity. The traps were placed within the row of elm trees bordering the study area and were used on nights when host exposure studies were also being conducted. The light traps were operated continuously from 2100 to 0700 hrs. Female mosquitoes which were caught in the light traps were taken to the laboratory for counting and identification. In addition to utilizing light traps as an aid in determining that a substantial number of *C. pipiens* was actually present within the study area during the human-biting exposure periods, breeding areas were also checked (weekly) for the presence of house mosquito larvae. Ordinarily, house mosquitoes migrate only short distances (CDC 1977).

To further evaluate the feeding behavior of *C. pipiens* females, larval specimens were collected in the study area and subsequently maintained in the laboratory until molting to adult had occurred. Approximately 72 h after molting to adult had occurred and ample time had been provided for sclerotization of the mouthparts, 40 females were placed in a screened cage (45 by 30 by 30 cm) containing a living but immobilized house sparrow (*Passer domesticus*). Another 40 females were placed in a separate cage which was similar to the bird cage but contained a one-way opening for the placement of a human arm. Both the sparrow and human arm were exposed to the mosquitoes for a total

uninterrupted period of 12 h at approximately 25°C. Since *C. pipiens* is normally active only at night (CDC 1977), the 12-h exposure period was done overnight. Upon conclusion of the exposure period, the mosquitoes (while still in their cage) were briefly chilled at 5°C to reduce mobility and the number of blood-fed (engorged) mosquitoes were subsequently counted.

RESULTS AND DISCUSSION

During the study, a total of 177 mosquitoes seeking a human blood meal were collected (Table 1). The vast majority (169 or 95.5%) were *Aedes vexans* (Meigen), the floodwater mosquito (Table 1). In the Bowling Green area, this mosquito and *C. pipiens* are widely acknowledged to be two of our most common mosquito species. Of the five remaining specimens, six (3.4%) were *Aedes dorsalis* (Meigen), one (0.56%) was *Anopheles punctipennis* (Say), and one (0.56%) was *Culex pipiens*. It should be mentioned that *A. dorsalis* and *A. punctipennis* are not commonly encountered mosquitoes in the Bowling Green area. For example, an independent 1980 city survey of adult mosquitoes present during the summer months included no *A. punctipennis* specimens and only 0.03% were *A. dorsalis*. *Culex pipiens* comprised 43% of the total collected. In our study, all mosquitoes seeking a blood meal were collected at ground level except for 16 specimens of *A. vexans*. One hundred and sixty-three mosquitoes (92% of the total) were collected prior to midnight and 157 of those were collected at ground level. The authors were surprised at the relatively low numbers of *A. vexans* mosquitoes found feeding on man after midnight; however, *A. vexans* has been reported to have peak activity periods. In Illinois, Horsefall et al. (1973) utilized time-segregative light traps and determined that during September, 80% of *A. vexans* were trapped before midnight. A similar situation may exist in northwest Ohio.

A total of 611 mosquitoes were collected in the CDC light traps which were placed at ground and 10-m levels for comparative purposes (Table 2). A total of 339 and 272 specimens were collected at the ground and 10-m levels respectively (Table 2). At ground level, 300 (88%) were *A. vexans* and 24 (7%) were *C. pipiens*. Repeating the procedure at the 10-m level resulted in 73 (27%) *A. vexans* and 197 (72%) *C. pipiens*. The additional two light traps which were simply placed at the 10-m level resulted in the trapping of 38 and 42 specimens of *C. pipiens* and five and four specimens of *A. vexans*. The preference of *C. pipiens* and *A. vexans* for high and low levels respectively closely conforms to previous studies by Mitchell and Rockett (1979) and Mitchell (1981). Utilizing a light trap capable of segregating mosquito collections according to a time interval on a single night, Mitchell (1981) also determined that *C. pipiens* populations found in northwest Ohio were most active after midnight and that the greatest number of specimens were collected between 0100 and 0200 hrs. and 0300 and 0400 hrs. The results were obtained from 21 trap-nights.

Table 1. Mosquitoes attempting to feed on humans.

Time of Collection	Elevation	*Aedes vexans*	*Aedes dorsalis*	*Culex pipiens*	*Anopheles punctipennis*
Pre-1200 hrs.	ground (7)[a]	149[b]	6	1	1
	10 (6)	6	0	0	0
Post-1200 hrs.	ground (7)	4	0	0	0
	10m (13)	10	0	0	0

[a]Indicates number of 1-h block repetitions. Repetitions were conducted so as to cover all hours (ground and 10-m levels) from 2100 to 0700 hrs. with some hours being repeated.
[b]Indicates number of individuals.

Table 2. Light trap collections of mosquitoes at two elevations.[a]

Elevation	Species	No. of Specimens
Ground	*Aedes vexans*	52
	Culex pipiens	11
	Aedes dorsalis	4
10 m	*A. vexans*	18
	C. pipiens	67
	Anopheles quadrimaculatus	1
Ground	*A. vexans*	248
	C. pipiens	13
	Psorophora columbiae	8
	A. quadrimaculatus	3
10 m	*A. vexans*	55
	C. pipiens	130
	P. columbiae	1

[a]All collections done in August 1980.

In the laboratory, no caged *C. pipiens* were observed to feed on humans during the 12-h exposure period. Engorgement was not noted in a single mosquito. Of the 40 mosquitoes placed in an alternate cage containing the house sparrow, 22 (55%) of the mosquitoes engorged.

The results of this study would indicate that *C. pipiens*, during the peak SLE season of late summer, either will not feed on humans or is not a significant human feeder in this geographical area. It is tempting to speculate that this mosquito does not commonly utilize humans as a host in other Great Lakes areas. Thirty-three hours of field exposure by a human in an area known to harbor large populations of house mosquitoes resulted in only one specimen of *C. pipiens* attempting to feed on him. It is also possible that the single specimen observed in the feeding position would have terminated probing prior to actual feeding. This single occurrence may simply have been an anomaly. It should be mentioned that the failure of *C. pipiens* to be a significant human feeder in this area would not completely negate the mosquito's public health importance and involvement in SLE transmission. If the mosquito can actively carry and transmit the virus to a host, even an infrequent human biter would be important. Also, since the SLE virus exists primarily as an infection of birds transmitted by ornithophilic mosquitoes such as *C. pipiens* (CDC 1977), the mosquito is important in promoting amplification of the virus within the bird population. Amplification within the bird population would facilitate transmission to humans by "opportunistic" (both bird- and mammal-feeding) mosquitoes.

Additional work is in progress to further delineate the feeding behavior and vector potential of *C. pipiens* in the northwest Ohio area.

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