BLOOD-FEEDING OF *CULEX* MOSQUITOES IN AN URBAN ENVIRONMENT[1,2]

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ABSTRACT. The modified capillary tube precipitin test was used to identify blood meal sources of *Culex quinquefasciatus* emerging from sewage ditches in East Baton Rouge Parish, Louisiana. Canines were the primary hosts, but Passeriformes and humans were also suitable blood meal sources. The percentage of *Cx. quinquefasciatus* feeding on these 3 hosts fluctuated with the habitat and the season.

INTRODUCTION

Blood meal identifications determine host types and the vector potential of a species (Bruce-Chwatt and Gockel 1960, Nasci 1984, Irby and Apperson 1988). Enzootic and endemic transmission of pathogens is influenced by fluctuating mosquito feeding patterns (Edman et al. 1972). Local variations in blood-host preference have been attributed primarily to the relative density and availability of acceptable hosts (Tempelis and Washino 1962, Nasci 1985), but may be caused by seasonal shifts in host preference (Nasci 1984). Also, studies of blood-feeding patterns often provide biased results due to experimental design errors (Boreham 1975, Nasci 1984). These errors may be minimized by collecting over the entire season, in various habitats and with several trap types.

Culex quinquefasciatus Say has been shown to utilize a wide variety of blood hosts (Horsfall 1972, Edman et al. 1972, Irby and Apperson 1988). The threat of disease pathogen transmission in urban areas may increase as *Culex* encounter more humans and household pets. Unfortunately, few studies analyze mosquito blood-feeding patterns in areas of dense human populations, and no such studies have been conducted in Louisiana. The purpose of this project was threefold: 1) determine blood hosts of urban *Cx. quinquefasciatus* emerging from sewage ditches during the summer months, 2) explain host preference variations, and 3) speculate on the capacity of this mosquito to vector St. Louis encephalitis (SLE) virus and dog heartworm in urban East Baton Rouge Parish, Louisiana.

MATERIALS AND METHODS

Mosquitoes were collected from 2 urban study sites, referred to hereafter as Area A and Area B, located 14 km apart and within the city limits of Baton Rouge and Zachary, Louisiana, respectively. Both Areas A and B were populous neighborhoods containing sewage ditches and hardwood forests. The neighborhood in Area A consisted of single story brick homes bordering on hardwood forests. The neighborhood in Area B consisted of house trailers and single story homes located in or adjacent to hardwood forests or open grassy lots. Outdoor dog kennels (3 × 4 m) were present in homeowners' yards at both study sites and consisted of concrete floors and dog houses enclosed by fencing. The hardwood forests at both areas contained oak (*Quercus* sp.), beech (*Fagus* sp.), cypress (*Cupressus* sp.), hackberry (*Celtis* sp.) and a dense understory.

Twenty ovitraps baited with hay infusion (Reiter 1983), and 4 walk-in red boxes (1.9 × 1.9 × 1.3 m) (Meyer 1985), were used to collect blood-fed *Culex* near houses, outdoor dog kennels and hardwood forests. Ovitraps were operated biweekly from May 24 through July 29, 1987 and from August 26 through September 26, 1987 at Area A, and from August 1 through August 24, 1987 at Area B. The 20 ovitraps were set 25–50 m apart and arranged in 4 rows of 5 traps within the test areas. Red boxes were set between 10–50 m apart and were located adjacent to and within the hardwood forest at Area A only. They were sampled weekly from May 24 through October 15, 1987 using battery-powered aspirators (Meek et al. 1985).

All blood-fed *Culex* collected in the ovitraps and red boxes were brought to the laboratory and stored at −70°C. Samples were labeled according to the following criteria: collection date, collection site, method of capture (ovitrap or red box) and location of capture within the ovitrap pattern.

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Table 1. Blood meal sources of *Culex quinquefasciatus* collected by ovitraps near houses in 2 East Baton Rouge Parish, LA neighborhoods (June–September 1987).

Date	No. of collections and (mosquitoes)	Total % ± SE of blood meal sources			
		Dog	Human	Avian	Other
Area A					
Jun. 1–24	7 (139)	53.7 ± 2.4	11.9 ± 0.6	29.9 ± 1.0	4.5 ± 0.3
Jul. 1–29	7 (149)	75.2 ± 4.2	8.7 ± 0.4	12.8 ± 1.3	3.3 ± 0.3
Aug. 26–Sep. 26	8 (132)	78.8 ± 3.1	12.9 ± 0.6	6.0 ± 0.3	2.3 ± 0.2
Total	22 (420)	69.2 ± 1.9	11.1 ± 0.3	16.3 ± 0.7	3.4 ± 0.2
Area B					
Aug. 1–24	9 (94)	64.9 ± 3.4	14.9 ± 0.8	18.1 ± 1.0	2.1 ± 0.2

Blood meals were identified using the modified capillary tube precipitin test (Tempelis and Lofy 1963). Each blood-fed mosquito was tested with pooled antisera for general classes and then tested with specific antisera within each host class. The following antisera were used: human, dog, rat (*Sigmodon hispidus* Say and Ord), chicken [*Gallus gallus* (Linn.)], pigeon (*Columba livia* Gmelin), mourning dove [*Zenaida macroura* (Linn.)], house sparrow [*Passer domesticus* (Linn.)], cardinal [*Cardinalis cardinalis* (Linn.)], northern mockingbird [*Mimus polyglottos* (Linn.)] and the common grackle [*Quiscalus quiscula* (Linn.)]. Commercially available rabbit antisera[3,4] and bob white quail antisera were used in precipitin tests described by Tempelis and Reeves (1962) and Tempelis and Lofy (1963). Production of antisera in quail instead of larger-bodied chickens necessitated a reduction in the size of sera injections from 3.0 cc to 0.3 cc/injection. Three injections per quail were made, one day apart, into the wing vein. Daily blood samples were taken and titered beginning 10 days after the last injection. When homologous titers above 1:10,000 and heterologous titers below 1:1,000 were reached, quail were exsanguinated.

RESULTS

Blood-fed adult mosquito collections in Areas A and B yielded 1,263 *Culex* specimens, and, when analyzed, various feeding preferences were indicated depending on location and method of collection (Tables 1–4). Dogs were the hosts most frequently fed upon according to the samples of *Cx. quinquefasciatus* tested overall. The total percentage of mosquitoes collected in the neighborhood at Area A included 69.2% which fed on canines, 11.1% on humans, 16.3% on Passeriformes and 3.4% on undetermined hosts. The total percentage of blood-fed females collected in the neighborhood at Area B included 64.9% which fed on dogs, 14.9% on humans, 18.1% on Passeriformes and 2.1% on undetermined hosts (Table 1).

The avian feeding preference in the neighborhood at Area A was 29.9% in June but decreased to 12.8% during the July collection period and to 6.0% during August (Table 1). The decrease in avian feeding was accompanied by an increase in canine feeding from 53.7% in June to 75.2% in July to 78.8% in late August through September.

A substantial canine feeding preference was observed for *Culex* collected by ovitraps within 25 m of outdoor dog kennels (Table 2). The total percentage of blood-fed females captured near outdoor dogs at Area A included 98.8% which fed on canines and 1.2% on Passeriformes. No other hosts were utilized. All of the blood-fed mosquitoes collected near outdoor dogs at Area B had fed on canines. A total of 408 blood-fed mosquitoes at Area A and 96 at Area B were the highest numbers of blood-fed individuals collected for all the locations sampled.

Avian feeding preference reached its greatest incidence in the hardwood forests, but few blood-fed *Culex* (64 for Area A and 22 for Area B) were collected from this habitat (Table 3). The total percentage of blood-fed females collected by ovitraps within the hardwood forest at Area A included 31.3% which fed on canines, 15.6% on humans, 48.4% on Passeriformes and 4.7% on undetermined hosts. The total percentage of blood-fed individuals captured in the hardwood forest at Area B included 22.7% which fed on canines, 22.7% on humans, 45.5% on Passeriformes and 9.1% on undetermined hosts.

The hardwood forest at Area A was also sampled for adult mosquitoes using 4 resting stations (walk-in red boxes). A total of 159 blood-fed females were aspirated from the red boxes, of which 39.0% fed on canines, 29.6% on hu-

[3] Sigma Chemical Co., P.O. Box 14508, St. Louis, MO 63178.

[4] Mention of commercial products does not constitute a recommendation for use or endorsement for sale by Louisiana State University Agricultural Center.

Table 2. Blood meal sources of *Culex quinquefasciatus* collected by ovitraps adjacent to dog kennels in 2 East Baton Rouge Parish, LA neighborhoods (June–September 1987).

Date	No. of collections and (mosquitoes)	Total % ± SE of blood meal sources			
		Dog	Human	Avian	Other
Area A					
Jun. 1–24	7 (109)	96.3 ± 3.2	0	3.7 ± 0.3	0
Jul. 1–29	7 (78)	98.7 ± 3.2	0	1.7 ± 0.1	0
Aug. 26–Sep. 26	8 (221)	100.0 ± 7.2	0	0	0
Total	22 (408)	98.8 ± 3.3	0	1.2 ± 0.1	0
Area B					
Aug. 1–24	9 (96)	100.0 ± 3.8	0	0	0

Table 3. Blood meal sources of *Culex quinquefasciatus* collected by ovitraps in 2 East Baton Rouge Parish, LA hardwood forests (June–August 1987).

Date	No. of collections and (mosquitoes)	Total % ± SE of blood meal sources			
		Dog	Human	Avian	Other
Area A					
Jun. 1–24	7 (34)	29.4 ± 0.6	17.6 ± 0.3	52.9 ± 0.7	0
Jun. 1–24	7 (30)	33.3 ± 0.4	13.3 ± 0.3	43.3 ± 0.5	10.0 ± 0.2
Total	14 (64)	31.3 ± 0.3	15.6 ± 0.2	48.4 ± 0.4	4.7 ± 0.1
Area B					
Aug. 1–24	9 (22)	22.7 ± 0.4	22.7 ± 0.3	45.4 ± 0.7	9.1 ± 0.2

mans, 27.0% on Passeriformes and 4.4% on undetermined hosts (Table 4). No shifts in host utilization were evident over the course of the study for the blood-fed mosquitoes collected from the red boxes.

All blood-fed *Culex* testing positive for general class antisera also tested positive for specific antisera within each host class. No blood-fed *Culex* tested positive for more than one specific antiserum, and no mosquitoes tested positive for the columbiform, chicken or rat antisera.

DISCUSSION

Urban *Culex* host-feeding patterns varied over short distances with changes in collection methods and location which has been shown to occur with other mosquito species (Nasci 1984). From June to July and in September, a decrease in avian feeding preference was observed in the neighborhood at Area A (Table 1) and also noted in other studies on mosquito blood-feeding patterns (Edman 1971, Ritchie and Rowley 1981, Bertsch and Norment 1983). Decreased Passeriformes host utilization may have resulted from the removal of 5 multicompartment bird homes on July 15, 1987, thereby reducing the local bird population. These homes provided shelter for approximately 75 nesting purple martins. The homes were removed after the purple martins had departed and prior to the invasion by starlings and sparrows.

Increased avian feeding preference was observed in the hardwood forests (Table 3), indicating that Passeriformes were the most readily available hosts at this location. *Culex* collected from within the forest at Area B utilized Passeriformes as the primary host but fed on higher percentages of dogs and humans than the mosquitoes collected from within the forest at Area A. This observation may be attributed to the greater availability of dogs and humans within this location, whereas no dogs or humans resided within the nearby hardwood forest at Area A. Overall, the blood meal sources of *Culex* collected from Areas A and B were similar and may be attributed to consistent numbers of available avian and mammalian hosts in the 2 study sites.

Increased human feeding preference by *Cx. quinquefasciatus* was observed in the neighborhoods at Area A and B (Table 1), which coincides with increased human populations. However, despite being outnumbered by humans, dogs were the primary hosts within the neighborhood. *Culex* may have preferred dogs over humans because canines, especially those in kennels, were often outdoors from sunset to sunrise with little protection from the mosquitoes. Substantial canine host utilization occurred near outdoor dog kennels (Table 2), indicating that dogs were highly attractive and available for bloodmeals. These findings agree with those of Edman (1971) regarding increased mosquito feeding activity in areas with more available hosts.

Table 4. Blood meal sources of *Culex quinquefasciatus* collected from walk-in red boxes in Area A (forest) of East Baton Rouge Parish, LA (May–October 1987).

Date	No. of collections and (mosquitoes)	Total % blood meal sources			
		Dog	Human	Avian	Other
May 24–Jun. 24	5 (45)	33.3	33.3	29.8	4.4
Jul. 1–29	5 (32)	40.6	31.3	25.0	3.1
Aug. 1–24	4 (31)	41.9	25.8	25.8	6.5
Aug. 26–Sep. 26	5 (24)	41.7	20.8	33.3	4.2
Oct. 1–15	3 (27)	40.7	33.3	22.2	3.7
Total					
May. 24–Oct. 15	22 (159)	39.0	29.6	27.0	4.4
Standard errors:		0.5	0.4	0.4	0.1

Culex sampled from the red boxes, located in the hardwood forest at Area A, had fed on a higher percentage of dogs and humans and lower percentage of Passeriformes than the mosquitoes collected by ovitraps positioned in the same forest. The large red boxes were quite visible from within the neighborhood and may have attracted engorged females dispersing from homes and dog pens. Bidlingmayer and Hem (1980) found that visually conspicuous objects can serve as long-distance attractants to mosquitoes. The ovitraps were less visible than the red boxes and would have attracted fewer mosquitoes from the neighborhood. The result would be a lower percentage of the blood-fed *Culex* collected by ovitraps in the forest utilizing dog and human blood hosts. The low percentage of undetermined hosts may be attributed to low numbers of available hosts other than dogs, humans, and Passeriformes.

Blood meal sources which were not tested for but were observed at both study sites included cats, bats, squirrels, rabbits, raccoons, reptiles and amphibians. Irby and Apperson (1988) reported that 1.3% of *Cx. quinquefasciatus* had fed on reptiles/amphibians, indicating that they may be a suitable alternate host worthy of attention in future mosquito blood host studies.

Avian and human host utilization implicates *Cx. quinquefasciatus* in SLE transmission (Bertsch and Norment 1983). The high percentage of mosquitoes feeding on canines also implicates this mosquito in dog heartworm transmission, which has been shown to occur in laboratory and field studies (Villavaso and Steelman 1970).

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