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HOST PREFERENCE OF MOSQUITOES IN BERNALILLO COUNTY, NEW MEXICO[1,2]

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ABSTRACT. Host preference of mosquitoes was determined using animal-baited traps. Hosts used in the study were cattle, chickens, dogs, and horses. Ten mosquito species representing 4 genera were collected from the animal-baited traps. *Aedes vexans, Aedes dorsalis, Culex quinquefasciatus, Culex tarsalis,* and *Culiseta inornata* were used as indicator species for data analysis. Greater numbers of *Ae. vexans, Ae. dorsalis,* and *Cs. inornata* were collected from cattle and horses than from chickens or dogs. In addition, engorgement rates were higher on mammals than on chickens. Engorgement and attraction data for *Cx. quinquefasciatus* suggested a preference for chickens and dogs over cattle and horses. A slight preference for chickens and dogs was seen with *Cx. tarsalis,* but the degree of host preference of *Cx. tarsalis* was less than that in either *Ae. vexans* or *Cx. quinquefasciatus.*

INTRODUCTION

Host preference is an important aspect of arthropod-borne diseases. Determining the host preference of mosquitoes can aid in understanding the transmission of diseases within a geographical area (Defoliart et al. 1987). Mosquito host preference varies among geographical strains of the same mosquito species. In addition, host preference studies have led to potential mosquito control strategies (Kuntz et al. 1982).

Bertsch and Norment (1983), using the capillary precipitin method, determined the sources of blood meals from field-collected *Culex quinquefasciatus* Say in Mississippi. Their study showed a preference for avian hosts. Other researchers (Jones et al. 1977, Kuntz et al. 1982, McCreadie et al. 1984) have used animal-baited traps to study mosquito host preference.

Most studies using animal-baited traps have determined the mosquito species attracted to a single host species within a region. Dog-baited traps were used to find species composition and abundance in Indiana (Pinger 1985), Tennessee (Hribar and Gerhardt 1986), and Louisiana (Villavaso and Steelman 1970a, 1970b). Jones et al. (1977) used horse-baited traps to identify potential vectors of Venezuelan equine encephalitis (VEE) in the southwestern United States. Horses also were used to identify potential vectors of Potomac horse fever in Maryland (Fletcher et al. 1988). McCreadie et al. (1984) used cattle-baited traps to determine the biting flies and mosquitoes attacking cattle in Canada.

Studies in the USA comparing relative attraction of multiple host species in traps are limited. In a Texas rice-growing area, Kuntz et al. (1982) used multiple, paired host species to determine that cattle and horses were the preferred hosts for *Psorophora columbiae* (Dyar and Knab).

The only previous study concerning host preference in New Mexico was conducted by Jones et al. (1977), who identified the biting flies and mosquitoes that attack horses. The presence of mosquito-borne diseases such as canine heartworm disease (Pfaffenberger and Fawcett 1983) and western equine encephalitis (WEE) (Clark et al. 1986) suggests that host preference research is needed in New Mexico.

In our study, traps baited with chickens, a cow, a dog, and a horse were used to determine the host preference of mosquitoes in north-central New Mexico. The study design allowed mosquitoes to choose from 4 host species and evaluated preferred domestic hosts, potential vectors of diseases of domestic animals, and relative host utilization of several mosquito species.

MATERIALS AND METHODS

Study sites: Mosquito trapping was conducted at 2 sites in the Rio Grande Valley in Bernalillo Co., New Mexico. The south valley site (site 1) was an agricultural area consisting of small, irrigated farms and pastures. In addition, a dairy operation was located 1.2 km north and a small dog kennel was located 0.4 km west of the site. No domestic animals were present in the pasture during trapping.

The north valley site (site 2) was 24.2 km north of site 1. Trapping was conducted on fenced property between an irrigation canal and a pasture. The area directly east consisted of mixed hardwood tree species and other vegetation. In comparison to site 1, fewer domestic livestock were present in the surrounding area and no domestic animals were present in the immediate trapping area.

Traps: Stable traps, 1.22 × 2.20 × 1.68 m, were

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constructed of standard aluminum screen (7 × 6 mesh/cm) and square steel tubing (1.9 cm). The basic design of the traps was similar to that used by Roberts (1965); however, the sides were modified, with openings (1.3–1.9 cm) running the length of the traps at heights of 22.9, 77.7, and 121.9 cm from ground level. These openings could be closed easily to prevent mosquitoes from entering or leaving traps. Nylon netting was placed behind each door to minimize mosquito loss when animals were removed. Traps were placed 8 m apart and appropriate animal restraints were used to restrict animal movement within traps.

Design: Trapping was conducted monthly from June through September at both sites. Each trapping period consisted of 4 consecutive nights at each site. Using a random number table, relative locations of animals were assigned for each trapping night. Because of the individualized animal restraining modifications and possible residual host odor, traps were rotated daily to assigned animal locations. Also, traps were washed out daily with tap water to minimize residual odor.

Animals used in the study were a cow (270 kg), a horse (290 kg), a dog (20 kg), and 6 chickens (3 kg). Animals were placed in their respective cages at 1900 h; once all animals were in place, side slots were opened, allowing host-seeking mosquitoes access to bait animals. Side slots were closed at 0700 h the following morning and traps were left undisturbed for an additional 30 min, allowing any unfed mosquitoes the opportunity to engorge. Mosquitoes then were collected with a battery-powered aspirator (Meek et al. 1985) and identified according to Darsie and Ward (1981). Engorgement was determined by the expansion and coloration of engorged mosquitoes (Edman and Kale 1971). Partially engorged individuals were classified as engorged.

Data analysis was based on the number of mosquitoes attracted and number of engorged mosquitoes collected from the various hosts by site and year. The chi-square likelihood ratio statistic was used to compare utilization of each animal by selected mosquito species. The chi-square test for equal attraction or engorgement was rejected at $P < 0.01$.

RESULTS AND DISCUSSION

Ten mosquito species representing 4 genera were collected: *Aedes vexans* (Meigen) (n = 22,886), *Aedes dorsalis* (Meigen) (n = 1,326) *Aedes nigromaculis* (Ludlow) (n = 597), *Aedes melanimon* Dyar (n = 244), *Cx. quinquefasciatus* (n = 2,896), *Culex tarsalis* Coq. (n = 1,051), *Culex erythrothorax* Dyar (n = 1), *Culiseta inornata* Williston (n = 144), *Anopheles freeborni* Aitkin (n = 6), and *Anopheles franciscanus* McCracken (n = 1). *Aedes vexans, Ae. dorsalis, Cx. quinquefasciatus, Cx. tarsalis,* and *Cs. inornata* were the most abundant species in their respective genera and were used as indicator species for data analysis. Site differences within year for number of mosquitoes collected were not statistically significant (χ^2 = 6.48, P = 0.09), but there were differences between years (χ^2 = 336, $P < 0.0001$). This year difference was detected because of the large number (and therefore high power of the test) of mosquitoes in the study. Although the year difference was detected, trends for host use were the same over years, so data were pooled for final analysis.

Data summaries (Tables 1–5) showed similar seasonal distributions for *Aedes* and *Culex* indicator species, with low numbers of mosquitoes collected in June and September, and higher abundance in July and August. *Culiseta inornata* catches were lowest in July, but due to the small number collected, this may not have shown the actual seasonal distribution. Peak catches occurred in August for all 5 species.

Total numbers collected, engorgement percentage, and proportion of engorged mosquitoes showed preferences for either large or small animal hosts. Significant differences were observed in host preference parameters for attraction (χ^2 = 7,514, $P < 0.0001$) and engorgement (χ^2 = 4,470, $P < 0.001$).

Aedes vexans: Collection numbers, percentage of engorgement, and the proportion of engorged *Ae. vexans* collected from each host showed that this species preferred cattle and horses over chickens and dogs (Table 1). For all monthly trapping periods, the cow and horse attracted almost the same numbers of mosquitoes, and both hosts consistently attracted more than 3-fold as many mosquitoes as the dog or chickens. Ninety-seven percent of all *Ae. vexans* collected from both the horse and cow were engorged, versus engorgement rates of 78% for the dog and 34% for the chickens. The proportion of engorged mosquitoes collected from the large animal hosts was similar, with 0.43 collected from the horse and 0.46 collected from the cow. Small animal hosts were less utilized, with 8% of engorged mosquitoes collected from the dog and 3% from chickens. These results agree with studies on wild-collected *Ae. vexans* in Florida (Edman 1971) and Indiana (Nasci 1984). Both authors found that larger mammals served as primary blood sources for *Ae. vexans.* However, Edman (1971) suggested that blood meal sources are closely related to the availability of hosts within an area. Although less than 10% of *Ae. vexans* were collected on the dog, the high engorgement rate suggests that although dogs may not be the preferred host, they are utilized. Although chickens attracted many *Ae. vexans,* percent engorgement was greatly reduced.

Aedes dorsalis: Although this species was less abundant, host preference data (Table 2) were very similar to data for *Ae. vexans.* Again, large animal hosts were preferred, and nearly all *Ae. dorsalis* collected from large animals were engorged (97 and 94% from the horse and cow, respectively),

Table 1. Seasonal abundance, number engorged (%), and proportion of engorged *Aedes vexans* collected from animal-baited traps in Bernalillo Co., New Mexico.

	Horse		Cow		Dog		Chicken		Total	
	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)
June	300	292 (97)	584	565 (97)	71	59 (83)	47	17 (36)	1,002	933 (93)
July	3,667	3,604 (98)	3,835	3,762 (98)	1,019	794 (78)	983	349 (35)	9,504	8,509 (90)
Aug.	4,172	4,114 (98)	4,336	4,259 (98)	670	564 (84)	437	130 (30)	9,615	9,067 (85)
Sept.	1,202	1,088 (91)	1,126	1,009 (90)	323	209 (65)	114	44 (38)	2,765	2,350 (85)
Total	9,341	9,098 (97)	9,881	9,595 (97)	2,083	1,626 (78)	1,581	540 (34)	22,886	20,859 (91)
Proportion engorged		0.43		0.46		0.08		0.03		1.00

whereas lower engorgement rates were observed on the dog (78%) and chickens (39%). The proportion of engorged mosquitoes showed a greater utilization of the horse (0.52) over the cow (0.37).

Culex quinquefasciatus: More *Cx. quinquefasciatus* were consistently attracted to small animal than to large animal hosts (Table 3). The dog attracted more mosquitoes than the chickens, but the engorgement rate was highest on chickens (88%). The proportion of engorged *Cx. quinquefasciatus* was practically the reverse of results recorded with *Aedes* species, with most of the engorged mosquitoes collected from the small animal hosts. The largest proportion engorged on chickens (0.49), followed by the dog (0.38), cow (0.10), and horse (0.02). This preference for chickens agrees with a study by Bertsch and Norment (1983) with *Cx. quinquefasciatus* in Mississippi. They found that 60–70% of wild, bloodfed *Cx. quinquefasciatus* had fed on birds. However, Edman (1974), using blood meal analysis of wild mosquitoes, concluded that *Cx. quinquefasciatus* were general feeders in Florida. He again suggested that blood meal sources varied with available hosts within an area. However, if this were the case in Bernalillo Co. one would expect more *Cx. quinquefasciatus* collected from the cow or horse than was observed.

Culex tarsalis: Host preference of *Cx. tarsalis* varied more than with *Aedes* species or *Cx. quinquefasciatus* (Table 4). In general, *Cx. tarsalis* appeared to prefer the small animals over the large animals, but the degree of preference was smaller than with *Cx. quinquefasciatus*. Although greater numbers were attracted to the dog (348) and chickens (346) than to the cow (226) and horse (131), engorgement rates of *Cx. tarsalis* on the different hosts were similar, ranging from 76% on both the horse and cow to 88% on the chickens. Proportions of engorged mosquitoes were greatest with the chickens and dog. It appears that although this species shows differences in attraction to various hosts, host preference is not sufficient to prevent engorge-

Table 2. Seasonal abundance, number engorged (%), and proportion of engorged *Aedes dorsalis* collected from animal-baited traps in Bernalillo Co., New Mexico.

	Horse		Cow		Dog		Chicken		Total	
	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)
June	13	12 (92)	36	33 (92)	7	2 (29)	6	1 (17)	62	48 (77)
July	17	17 (100)	11	11 (100)	4	4 (100)	0	0	32	32 (100)
Aug.	571	556 (97)	383	365 (95)	127	102 (80)	84	17 (20)	1,165	1,040 (89)
Sept.	31	26 (84)	29	21 (72)	3	3 (100)	4	1 (25)	67	51 (76)
Total	632	611 (97)	459	430 (94)	141	111 (78)	94	19 (39)	1,326	1,171 (88)
Proportion engorged		0.52		0.37		0.09		0.02		1.00

Table 3. Seasonal abundance, number engorged (%), and proportion of engorged *Culex quinquefasciatus* collected from animal-baited traps in Bernalillo Co., New Mexico.

	Horse		Cow		Dog		Chicken		Total	
	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)
June	3	1 (33)	17	6 (35)	19	6 (32)	15	14 (93)	54	27 (50)
July	47	14 (30)	123	62 (50)	296	174 (59)	309	285 (92)	775	535 (69)
Aug.	94	30 (32)	226	113 (50)	665	472 (71)	604	520 (86)	1,589	1,135 (71)
Sept.	20	2 (10)	70	15 (21)	225	80 (36)	160	143 (89)	475	240 (51)
Total	164	47 (29)	436	196 (45)	1,205	732 (61)	1,088	962 (88)	2,893	1,937 (67)
Proportion engorged		0.02		0.10		0.38		0.49		1.00

ment. Our results agree with a study by Hayes et al. (1973) on wild-collected *Cx. tarsalis* in Texas. They found that 30–40% of *Cx. tarsalis* had fed on chickens but feeding preference was highly variable.

Culiseta inornata: This species showed a distinct preference for the large animal hosts, with 91 and 44 of the total 144 mosquitoes collected from the cow and horse, respectively (Table 5). In addition, all *Cs. inornata* taken from large animal hosts had engorged.

This study showed that dogs were fed upon by *Ae. vexans, Ae. dorsalis, Cx. quinquefasciatus,* and *Cx. tarsalis.* A previous study on potential mosquito vectors of canine heartworm, *Dirofilaria immitis* (Leidy), in Bernalillo Co. showed that *Ae. vexans* has the greatest vector efficiency, *Ae. dorsalis* can support development of infective *D. immitis,* and *Cx. quinquefasciatus* and *Cx. tarsalis* are generally of minor importance (Loftin et al. 1995). In the present study, dogs were fed upon more frequently by *Ae. vexans* than by *Cx. quinquefasciatus* or *Cx. tarsalis,* but a lower proportion of the *Ae. vexans* population fed on the dog. Haddock (1987) suggests that heartworm transmission is facilitated by high mosquito populations. However, the observed host preference coupled with Edman's (1971, 1974) theory that mosquito host preference is influenced by the available hosts suggests that the relative availability of large domestic hosts within an area may influence *Ae. vexans* feeding on dogs.

We consistently saw reduced attraction and engorgement of selected *Aedes* species on chickens. Two possible explanations exist. Edman and Kale (1971) and Edman et al. (1974) suggest that host defensive behavior reduces engorgement. However, this does not seem to be the case in our study because *Culex* species had high engorgement rates on chickens. Specific cues such as host odor may help mosquitoes distinguish mammalian from avian hosts. Gillies (1980) suggested that host odors and other factors are more powerful than carbon dioxide at close and moderate ranges. Probably the best

Table 4. Seasonal abundance, number engorged (%), and proportion of engorged *Culex tarsalis* collected from animal-baited traps in Bernalillo Co., New Mexico.

	Horse		Cow		Dog		Chicken		Total	
	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)
June	20	12 (60)	32	21 (65)	49	37 (76)	52	48 (92)	153	118 (77)
July	51	43 (84)	88	69 (78)	141	126 (89)	128	115 (90)	408	353 (86)
Aug.	59	44 (75)	96	75 (78)	139	125 (90)	155	130 (84)	449	374 (83)
Sept.	1	0	10	7 (70)	19	14 (74)	11	11 (100)	41	32 (78)
Total	131	99 (76)	226	172 (76)	348	302 (87)	346	304 (88)	1,051	877 (83)
Proportion engorged		0.11		0.20		0.34		0.35		1.00

Table 5. Seasonal abundance, number engorged (%), and proportion of engorged *Culiseta inornata* collected from animal-baited traps in Bernalillo Co., New Mexico.

	Horse		Cow		Dog		Chicken		Total	
	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)	No. collected	No. engorged (%)
June	8	8 (100)	28	28 (100)	0	0	0	0	38	37 (97)
July	1	1 (100)	1	1 (100)	0	0	0	0	2	2 (100)
Aug.	32	32 (100)	56	56 (100)	3	1 (33)	3	0	94	89 (94)
Sept.	3	3 (100)	6	6 (100)	0	0	1	1 (100)	10	10 (100)
Total	44	44 (100)	91	91 (100)	5	2 (4)	4	1 (25)	144	138 (96)
Proportion engorged		0.32		0.65		0.01		0.01		1.00

explanation is that chickens are simply not attractive to the selected *Aedes* species.

Feeding of *Cx. tarsalis* and, to a lesser extent, *Cx. quinquefasciatus,* on both birds and mammals was observed. Results suggest that both *Cx. quinquefasciatus* and *Cx. tarsalis* display host preference characteristics that could favor transmission of endemic WEE, as suggested by Hayes et al. (1973).

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