ATTACK RATE OF *CULEX TARSALIS* ON REPTILES, AMPHIBIANS AND SMALL MAMMALS [1]

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Thomas and co-authors (1) recently suggested that cold-blooded vertebrates may play a role in the overwintering and summer maintenance of western equine encephalitis (WEE) virus. Previous studies (2–7) have indicated that a variety of small mammals may also play some part in the maintenance of WEE and St. Louis encephalitis (SLE) viruses in nature. One obvious measure of the relative importance of these animals to the ecology of the viruses is the degree to which *Culex tarsalis,* the primary arthropod vector of these viruses in the Western United States, is attracted to and feeds on the various animal species. Dow, and co-authors (8) reported limited attractiveness for *C. tarsalis* of a small number of small mammals and cold-blooded vertebrates. The objective of this study was to extend these observations.

Methods. Poso Creek, a small stream about 12 miles N.E. of Bakersfield, was the area selected for field exposures of animals. A 350-yard stretch of the stream bank was selected for the experiment. In this area the stream, which is a drainage channel for clarified effluent from oil wells in the vicinity, has a moderately rapid central channel with a thick marginal growth of tules. There are numerous pools along the margin with emergent grasses which serve as excellent breeding places for culicine mosquitoes. Along the edge of these shallow waters there is a series of small cottonwood trees. Ten trap stations were located on the limbs of these trees, three in crotches of large shrubs and one in a dense cluster of tules.

The animals were collected locally, and each was exposed for one night in a small portable bait can trap described by Dow and co-authors (8). Insofar as possible, each animal was restrained, either within a nylon stocking or in small cages, before being placed in the trap. The baited traps were placed in the field in the later afternoon with the funnels oriented in line with prevailing air movements. The following morning the ends of the traps were plugged and the animals removed through the traps' sleeve opening. The bait cans were then taken to the field laboratory where the mosquitoes were chloroformed, identified, and their state of blood engorgement recorded.

Three different sets of controls were established. Prior to any animal exposures, traps containing 3 pound blocks of dry ice were placed overnight in 6 out of 14 sites to be used for the animal tests. The purpose of this run was to establish that there was a sufficient population of mosquitoes for the study, and to provide a base line measure of the variability of individual sites.

Two unbaited traps were included each test night with the animal exposures since it was observed early in the experiment that the smallest lizards attracted so few mosquitoes that some measure was needed of the chance entry of mosquitoes into traps.

As a third comparison, two 8-week-old leghorn chickens were exposed each night that other animals were exposed. These chickens were restrained in nylon stockings and placed in stations located at the upper and lower ends of the trapping-line.

The results of the dry ice run (Table 1) established the presence of a significant population of *C. tarsalis* in the Poso Creek

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TABLE 1.—Mosquitoes collected in 6 traps baited with dry ice, Kern County, 1960

Station	Total all species	Number of each species collected		
		Culex tarsalis	*Culex erythrothorax*	*Anopheles franciscanus*
1	409	402	5	2
2	267	246	21	1
3	962	887	72	3
4	632	485	141	6
5	389	364	22	3
6	236	194	33	9

area. As the different stations showed a nearly four-fold variation between the highest and the lowest numbers of trapped mosquitoes, the test animals were randomly placed in the different stations and, whenever enough animals of the different species were available, representatives of each species were exposed each night.

RESULTS AND DISCUSSION. A total of 88 animals representing 16 different species was exposed; 45 were reptiles (7 species), 17 were amphibians (2 species), and 26 were small mammals (7 species). Table 2 presents the mosquito collections obtained from the field exposures of these animals as well as for the control chickens and the unbaited traps. Every species attracted some *C. tarsalis;* some of the larger rodents attracted numbers similar to the chickens while the smaller lizards attracted an average of only one or two mosquitoes per night. The animals in each group are ordered according to their approximate average size and weight; thus, *Citellus beecheyi*, the largest of the mammals tested, is listed first in the mammal group. There is a fairly good correlation between the average number of mosquitoes attracted and

TABLE 2.—*Culex tarsalis* collected in traps baited with small mammals, reptiles, and amphibians as compared with chicken and unbaited trap controls, Kern County, 1960

Species	No of times species was exposed	Number collected	
		Average per run	Maximum and minimum in all runs
Mammals			
Citellus beecheyi (Beechey Ground Squirrel)	2	159.0	177–141
Citellus nelsoni (San Joaquin Antelope Squirrel)	2	153.0	193–111
Dipodomys heermanni (Heermann Kangaroo Rat)	8	65.1	103– 39
Dipodomys nitratoides (San Joaquin Kangaroo Rat)	4	50.5	89– 27
Peromyscus maniculatus (Deer Mouse)	6	53.3	109– 31
Perognathus inornatus (San Joaquin Pocket Mouse)	1	38.0	38
Mus musculus (House Mouse)	3	17.6	28– 5
Reptiles			
Coluber flagellum (Red Racer)	1	25.0	25
Lampropeltis getulus (King Snake)	1	8.0	8
Crotaphytus wislizenii (Leopard Lizard)	14	8.9	39– 0
Sceloporus occidentalis (Western Fence Lizard)	6	2.6	11– 0
Phrynosoma spp. (Horned Lizard)	9	1.8	8– 0
Cnemidophorus tigris (Western Whiptail)	11	0.5	4– 0
Uta stansburiana (Side-blotched Lizard)	3	1.7	5– 0
Amphibians			
Rana catesbeiana (Bullfrog)	7	28.0	65– 0
Bufo boreas (Western Toad)	10	15.4	64– 0
Chickens	15	214.0	496– 72
Unbaited traps	10	0.5	2– 0

the size of the animals within each group of animals tested; the larger lizards, such as *Crotaphytus wislizenii*, attracted four or more times as many mosquitoes as the smaller lizards, such as *Uta stansburiana*.

On the average the mammals were about five times as attractive to *C. tarsalis* as the cold-blooded vertebrates. *Rana catesbeiana* is about the same size as the large ground squirrel, *C. beecheyi*, while the smallest mouse, *Mus musculus*, is comparable in size and weight to *Sceloporus occidentalis* or *U. stansburiana*.

Table 3 presents the rates of engorgement of the attracted mosquitoes on each species. Of special significance is the rather consistently high percentage of feedings on reptiles which compares very closely to that on the chicken controls. While the chickens and reptiles were very easily restrained in nylon stockings, effective restraint of the mammals and amphibians was more difficult. Partly because of this, most of the mamals and amphibians had a lower engorgement rate in the mosquitoes they attracted; in fact, for survival of *Perognathus inornatus* and *Peromyscus maniculatus*, it was necessary to allow the animals considerable freedom in a wire mesh cage, and thus the mosquitoes probably had difficulty in feeding. When the mammals were well restrained, as in the case of *Citellus nelsoni*, the engorgement rate was comparable to that on the chicken controls, and this suggests that feeding would have been more frequent on the other mammals with adequate restraint. Although the amphibian group was not very well restrained, engorgement rates on these hosts were so low that there may have been a repellent factor which limited feeding. On at least two occasions, amphibians were restrained quite well and there was less than 25 percent engorgement.

TABLE 3.—Comparative engorgement rates of *C. tarsalis* mosquitoes collected by exposure of experimental hosts and comparison group, Kern County, 1960

Species	Total Number: Collected	Total Number: Blood engorged	Percent of attracted engorged
Mammals			
Citellus beecheyi (Beechey Ground Squirrel)	318	161	50
Citellus nelsoni (San Joaquin Antelope Squirrel)	306	253	83
Dipodomys heermanni (Heermann Kangaroo Rat)	520	326	63
Dipodomys nitratoides (San Joaquin Kangaroo Rat)	202	98	49
Peromyscus maniculatus (Deer Mouse)	320	20*	6*
Perognathus inornatus (San Joaquin Mouse)	38	0*	0
Mus musculus (House Mouse)	52	38	73
Reptiles			
Coluber flagellum (Red Racer)	25	23	92
Lampropeltis getulus (King Snake)	8	2	25
Crotaphytus wislizenii (Leopard Lizard)	120	108	90
Sceloporus occidentalis (Western Fence Lizard)	16	14	87
Phrynosoma spp. (Horned Lizard)	16	12	75
Cnemidophorus tigris (Western Whiptail)	6	4	67
Uta stansburiana (Side-blotched Lizard)	5	4	80
Amphibians			
Rana catesbeiana (Bullfrog)	196	47	25
Bufo boreas (Western Toad)	154	9	6
Chickens	3214	2957	92
Unbaited traps	5	0	0

* Very poor restraint of host may have influenced opportunity for feeding.

The animals tested normally are terrestrial or aquatic and would not be exposed to mosquitoes in trees or shrubs and above ground level. It was impractical to attempt exposures in the normal nocturnal habitats of these animals and the results probably are not a measure of their usual contact with vectors. It is suspected that the methods and locations of these tests increased exposure to vector attack.

Only *C. tarsalis* is referred to in the data presented in Tables 2 and 3. This species was the most abundant with all baits, and in the series of animal exposures it often was the only mosquito attracted. *Culex erythrothorax* was attracted in small numbers and fed on chickens, *Citellus beecheyi, Citellus nelsoni, Dipodomys heermanni, Dipodomys nitratoides, Peromyscus maniculatus, Mus musculus,* and *Sceloporus occidentalis.* This mosquito also was attracted to but did not feed on *Rana catesbeiana* and *Bufo boreas.*

These observations extend the known range of host species attractive to and fed on by *C. tarsalis.* The relatively low attractiveness of the several species of reptiles and amphibia, would indicate that they are less likely to serve as effective natural hosts of WEE and SLE viruses and sources of vector infection than are warm blooded hosts.

SUMMARY. *Culex tarsalis* was attracted to mosquito traps baited with 7 species of rodents, 7 species of reptiles and 2 species of amphibians. The number of *C. tarsalis* attracted was proportional to the size of the hosts within each major group. Rodents were more attractive than reptiles or amphibians, but less so than 8-week-old chickens or dry ice. A high proportion of mosquitoes fed on most hosts if the animals were adequately immobilized.

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OBSERVATIONS ON MOSQUITO FEEDING ACTIVITY ON THE FLOWER HEADS OF *EUPATORIUM* AND *SOLIDAGO* (COMPOSITAE)

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As pointed out by Bates (1949), it is assumed that in nature plant juices, particularly flowers, form the principal food of male mosquitoes and of females of species not known to suck blood. Early records of mosquitoes as flower visitors are summarized by Howard, Dyar, and Knab (1912). Subsequent records, e.g., Britten (1937) and Philip (1943), add little to the general fact that mosquitoes of both sexes