OPERATIONAL AND SCIENTIFIC NOTES

POTENTIAL VECTORS OF *DIROFILARIA IMMITIS* IN SAN MATEO CO. CALIFORNIA

RENAN A. ACEVEDO[1]

Several mosquito species are considered potential vectors of canine heartworm, *Dirofilaria immitis* (Ludlam et al. 1970). Various species have been implicated in different geographical areas and the ability to support development of the parasite seems to vary among different strains of some species (Kartman 1953), which makes extrapolation of results from one area to another unreliable. Studies in California have shown development to infective stage in *Aedes sierrensis* (Ludlow) and a laboratory strain of *Ae. dorsalis* (Meigen) (Weinmann and Garcia 1974). The distribution and habits of *Ae. sierrensis* made it seem an important potential vector.

The most common criterion for assigning the role of vector is the development to infective stage of larvae experimentally ingested by mosquitoes. The ability to transmit infection to previously healthy dogs is sometimes also studied. The relevance of these laboratory procedures to the field situation is rarely assessed.

We have studied the development of *D. immitis* in wild-caught female mosquitoes. The low survival of these wild mosquitoes in the laboratory precluded a more complete analysis, but we feel that the results are worth reporting as the behavior of the insects is likely to be closer to that in natural conditions. We also obtained some information on the relative attraction of certain mosquitoes to dogs.

The study area was the community of La Honda, California, located in the Santa Cruz Mountains, south of San Francisco. Native vegetation was redwood and mixed hardwood forest, but there has been an extensive process of logging. Farming and ranching are some of the major land uses in the area. Climate is of the mediterranean type. Mean annual rainfall is 772.9 mm (max 167.9 in January, min 2.5 mm in July). Average monthly temperature ranges from 9.8°C in January to 16.9°C in July.

[1] Department of Medical Microbiology, School of Medicine, University of California, Davis, CA 95616.

Mosquitoes were collected from November 1979 to October 1980 in dry-ice baited CDC miniature light traps (Hausherr's Machine Works, Toms River, NJ) or in a dog baited trap. A caged dog was kept inside a tent from which mosquitoes were collected periodically. Collected mosquitoes were then initially transported to an insectary kept at 27–28°C and 85–90% RH. Later on they were maintained at 23°C and over 75% RH. Water and sugar were provided *ad libitum*, the sugar being removed 24 to 48 hours before a feeding attempt on a heartworm infected dog (approximately 11,000 microfilaria/ml). The fed mosquitoes were checked at least every 2 days after feeding, and those found dead were dissected. Malpighian tubules and proboscis were examined for developing nematodes. All worms were kept in 5% glycerol in 70% ethanol. Most mosquitoes were identified just before dissection. Representative specimens were sent to the Vector Biology and Control Section of the California Department of Health for confirmation of species identification.

RESULTS. Total number of mosquitoes collected as well as species composition of the catch differed among different traps. The total yield of station R was 73 *Culiseta incidens* (Thomson) and 1 *Ae. sierrensis* while station C-2 yielded 36 *Ae. increpitus* Dyar, 2 *Ae. sierrensis*, 1 *Cx. pipiens* Linn., 6 *Cs. incidens* and 2 *Cs. particeps* (Adams). Table 1 lists the entire catch of mosquitoes without regard to date or station. One mosquito identified by us as *Cx. peus* Speiser was later determined to be *Cx. thriambus* Dyar (first record for San Mateo County).

Table 1. Female mosquitoes trapped in La Honda, California.

Species	Dry ice	Dog or resting	Total
Ae. increpitus	39	16	55
Ae. sierrensis	6	6	12
Cs. incidens	132	12	144
Cs. inornata	8	—	8
Cs. particeps	2	1	3
Cx. peus-thriambus	2	1	3
Cx. pipiens	6	1	7
Cx. tarsalis	32	—	32
An. franciscanus	1	—	1
An. punctipennis	1	—	1

Tables 2 and 3 summarize the feeding success on the infected dog and the degree of development of the parasite in the different mosquitoes. Except for *Cx. pipiens, Cx. peus-thriambus* and *Cs. inornata,* between 1/2 and 3/4 of the tested mosquitoes fed on the infected dog. Infective stage larvae were found in the proboscis of *Ae. sierrensis* and *Cs. incidens* only. The highest feeding success was shown by *Ae. sierrensis* and *Cs. particeps,* and *Ae. sierrensis* allowed good development of *D. immitis.* However, the small sample size made this difference non-significant.

DISCUSSION. Twelve of the mosquito species listed by Ludlam et al. (1970) as vectors of *D. immitis* have been found in California (Bohart and Washino 1978). Weinmann and Garcia (1974) have added 2 new California species to the list: *D. immitis* developed to infective stage in *Ae. sierrensis* and *Ae. dorsalis.* Besides *Ae. sierrensis* we have found development to 2nd stage or beyond in the following new species: *Ae.*

Table 2. Feeding success of wild-caught mosquitoes and numbers infected after feeding on dog infected with *D. immitis.*

Species	Number fed/ number attempted	Number showing development of *D. immitis*	Percentage of fed
Ae. increpitus	16/28	4	25
Ae. sierrensis	5/7	3	60
Cs. incidens	28/51	8	29
Cs. inornata	1/4	0	—
Cs. particeps	4/6	1	25
Cx. peus-thriambus	0/2	0	—
Cx. pipiens	0/2	0	—
Cx. tarsalis	10/16	3	30
An. franciscanus	1/1	1	100

Table 3. Development of *D. immitis* in wild caught mosquitoes fed on infected dog.

No. days after feeding	Stage	Location	Mosquito species
1	microfilariae	gut	*Ae. increpitus*
2	microfilariae	gut, Malp. tubules	*Cs. incidens*
	microfilariae	Malp. tubules	*Cs. incidens*
	microfilariae	Malp. tubules	*Cs. incidens*
4	microfilariae	gut, Malp. tubules	*Cs. incidens**
	1st stage	Malp. tubules	*Ae. increpitus*
6	1st stage	Malp. tubules	*Ae. sierrensis*
7	microfilariae	Malp. tubules	*Cs. incidens**
8	1st, 2nd stage	Malp. tubules	*Ae. increpitus*
	1st stage	Malp. tubules	*Cs. incidens*
10	1st, 2nd stage	Malp. tubules	*Cx. tarsalis*
	1st, 2nd stage	Malp. tubules	*Cx. tarsalis*
	2nd stage	Malp. tubules	*Cs. particeps*
11	2nd (3rd?) stage	Malp. tubules	*Ae. sierrensis*
12	2nd stage	Malp. tubules	*Ae. increpitus*
14	2nd (3rd) stage	Malp. tubules	*Cx. tarsalis*
	2nd (3rd) stage	Malp. tubules	*An. franciscanus*
16	3rd stage	Malp. tubules	*Cs. incidens*
21	3rd stage	M. tubules, proboscis	*Cs. incidens*
	3rd stage	Proboscis	*Ae. sierrensis*

* Mosquitoes kept at lower temperature (about 20°C).

increpitus, Cs. incidens, Cs. particeps and *An. franciscanus* McCracken.

Culex tarsalis Coq. was relatively successful both in feeding on the dog and allowing parasite development. However, since this is primarily an ornithophilic species, it is not usually considered an important vector of heartworm (Bemrick and Sandholm 1966). *Culiseta incidens* on the other hand, could be involved as an intermediate host of this nematode: it is relatively abundant almost year round and is attracted to dogs and willing to feed on them. The latter factors could compensate for the relatively low percentage of fed mosquitoes which supported development of *D. immitis*. A study on mosquito host preference (Tempelis and Washino 1967) reported 56 *Cs. incidens* had fed on cattle and horses only. This study does not necessarily contradict our suggestion that *Cs. incidens* might play a role in *D. immitis* transmission, due to the relatively small sample sizes and different areas studies.

Aedes sierrensis appears to be the best potential vector among those studied. It is attracted to dogs, feeds readily on them and allows a good degree of development of the parasite. The distribution of this tree hole mosquito seems to roughly coincide with the published reports of the foci of heartworm transmission in the foothills of both the Sierra Nevada and coastal ranges in California (Hansen 1978).

ACKNOWLEDGMENTS. I wish to thank the La Honda Fire Brigade and all the people of La Honda for their cooperation and encouragement. I am also grateful to Dr. J. H. Theis, Department of Medical Microbiology, University of California, Davis for his continuing help and advice and Drs. J. F. Kraus, School of Public Health, University of California, Los Angeles and W. K. Longhurst, Department of Agronomy and Range Science, University of California, Davis for their review of the manuscript.

Lucia Hui, Vector Biology and Control Section, California Department of Health Services helped with the identification of the mosquitoes.

This research was partially funded by University of California, Faculty Research Award D670 and by School of Veterinary Medicine, Paulitz Estate Companion Animal Fund.

References Cited

Bemrick, W. J. and H. A. Sandholm. 1966. *Aedes vexans* and other potential mosquito vectors of *Dirofilaria immitis* in Minnesota. J. Parasitol. 52:762–767.

Bohart, R. M. and R. K. Washino. 1978. Mosquitoes of California. University of California. Div. Agricultural Sciences. Priced Publication Number 4084.

Hansen, C. P. 1978. The sudden rise of the dog heartworm (*Dirofilaria immitis* to a serious pest level in San Mateo County. Proc. Calif. Mosq. Vector Control Assoc. 46:15–16.

Kartman, L. 1953. Factors influencing infection of the mosquito with *Dirofilaria immitis* (Leidy, 1856) Exp. Parasitol. 2:27–78.

Ludlam, K. W., L. A. Jachowski and G. F. Otto. 1970. Potential vectors of *Dirofilaria immitis*. J. Am. Vet. Med. Assoc. 157:1354–1359.

Tempelis, C. H. and R. K. Washino. 1967. Host feeding patterns of *Culex tarsalis* in the Sacramento Valley, California, with notes on other species. J. Med. Entomol. 4:315–318.

Weinmann, C. J. and R. Garcia. 1974. Canine heartworm in California with observations on *Aedes sierrensis* as a potential vector. Calif. Vector Views 21:45–50.

CULISETA MELANURA IN NEWFOUNDLAND

LEWIS T. NIELSEN[1] AND JOSEPH E. MOKRY[2]

During May and June, 1981, we conducted an intensive mosquito survey on the Island of Newfoundland. During this survey several species previously unreported from the Island were found. Details on these and other species collected are now in press (Nielsen and Mokry 1982).

Of particular interest was the collection of *Culiseta melanura* (Coq.). A single larva of this species was collected on the Avalon Peninsula, 15 km SW of St. John's, V-28-81, and was

[1] Biology Department, University of Utah, Salt Lake City, Utah 84112.

[2] Research Unit on Vector Pathology (RUVP), Memorial University of Newfoundland, St. John's, Newfoundland, Canada A1C 5S7.