lowering the deet concentration to approximately 50%. It is likely that such reduction would bring savings in acquisition costs and increase user acceptability of the product, a serious problem among U.S. Army field personnel (Hooper and Wirtz 1983). By comparison it is useful to note that of over 250 deet formulations marketed by private industry, which has always been sensitive to consumer acceptability, only a few contain deet concentrations greater than 50% (United States Environmental Protection Agency 1980).

Further laboratory and field tests may be advisable against more deet tolerant species such as *Anopheles albimanus* Wied. before such a reduction is effected; however, if disease prevention is the purpose of utilizing insect repellents, greater overall use due to a more acceptable formulation may easily compensate for a slight reduction in the spectrum of efficacy.

References Cited

Buescher, M. D., L. C. Rutledge and R. A. Wirtz. 1982. Tests of commercial repellents on human skin against *Aedes aegypti*. Mosq. News 42:428–433.

Gilbert, I. H., H. K. Gouck and C. N. Smith. 1957. New insect repellent. Soap Chem. Spec. 33:115–117, 129–133.

Goldstein, A. 1964. Biostatistics, an introductory text. Macmillian Co., New York. 272 p.

Hooper, R. L. and R. A. Wirtz. 1983. Insect repellent used by troops in the field: Results of a questionnaire. Mil. Med. 148:34–38.

Rutledge, L. C., M. A. Moussa and C. J. Belletti. 1976. An *in vitro* blood-feeding system for quantitative testing of mosquito repellents. Mosq. News 36:283–293.

Schreck, C. E. 1977. Techniques for the evaluation of insect repellents: A critical review. Annu. Rev. Entomol. 22:101–119.

Shambaugh, G. F. and J. J. Pratt. 1959. Development of insect repellents for personal use. I. Diethyltoluamide. Pesticide Section Report No. 1. Chemical and Plastics Division, U. S. Army Quartermaster Research and Engineering Center, Natick, Massachusetts.

United States Environmental Protection Agency. 1980. Registrants with pesticide products containing the active ingredient *N,N*,diethyl-*m*-toluamide and other isomers. Washington, D.C. 146 p.

FIELD ISOLATIONS OF FILARIAL WORMS PRESUMED TO BE *DIROFILARIA IMMITIS* FROM MOSQUITOES IN KENTUCKY[1]

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Fifty-two species of mosquitoes have been recorded in Kentucky (Darsie and Ward 1981), and 29 of these species are known to occur in Calloway County (Courtney and Christensen 1982). Several species collected in Calloway County have been incriminated elsewhere as potential vectors of dog heartworm (*Dirofilaria immitis*) (Ludlam et al. 1970, Hu 1931); therefore, live trapping of mosquitoes for *D. immitis* isolation was done in 1981 as part of an attempt to determine which species might be natural vectors of dog heartworm in western Kentucky.

Calloway County is situated in the southwestern portion of Kentucky, and mosquitoes were collected on May 29 and 30, June 10, 16 and 24, and August 11, 13 and 19, with CO_2-baited CDC traps near the city of Murray. Trapping was done near a dog kennel that contained at least one dog with a microfilaremia of *D. immitis*. Collected mosquitoes were examined for filarial worm infections by previously described methods (Christensen and Andrews 1976).

A total of 1,871 adult females were collected comprising 14 species in 6 genera (Table 1). Of these, 1,544 were pooled by species in an attempt to isolate infective-stage *D. immitis*, but all pools were negative (Table 1).

Over half of the species collected in this study have been reported as potential vectors of *D. immitis* (Ludlam et al. 1970, Bemrick and Sandholm 1966, Christensen and Andrews 1976). But of 317 mosquitoes dissected in our study, only two were positive for filarial worms (Table 1). Twenty 2nd-stage juveniles were recovered

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Table 1. Mosquitoes dissected and (or) pooled for *Dirofilaria immitis* isolations.

Species	Total number pooled	Number of pools	Number dissected	Infected
Aedes canadensis			5	0
Aedes triseriatus			1	0
Aedes trivittatus			3	0
Aedes vexans	1214	13	117	0
Anopheles punctipennis	26	2	26	2 (7%)*
Coquillettidia perturbans			17	0
Culex erraticus	142	2	42	0
Culex pipiens	162	5	80	0
Culex restuans			3	0
Culex salinarius			2	0
Orthopodomyia signifera			1	0
Psorophora ciliata			2	0
Psorophora confinnis			6	0
Psorophora cyanescens			10	0

* Twenty second-stage juveniles were found in one specimen and twenty-eight in another specimen; both recoveries were from dissected mosquitoes.

from the Malpighian tubules of one *Anopheles punctipennis* (Say) and 28 2nd-stage juveniles from another specimen of the same species.

Laboratory studies have implicated *An. punctipennis* as a potential vector of dog heartworm in many areas of the country (Hu 1931, Phillips 1939, Yen 1938), and recently Buxton and Mullen (1980) recovered infective-stage juveniles from field-collected *An. punctipennis* that were assumed to be *D. immitis*. Regarding the circumstances under which mosquitoes were collected in our study, it is presumed that the 2nd-stage juveniles recovered were likely *D. immitis*. Collections were made in an area where there were infected dogs, and it is unlikely that the other two species of *Dirofilaria* (*D. striata* and *D. tenuis*) that utilize the Malpighian tubules of mosquitoes as developmental sites were involved. The main definitive hosts of *D. striata* and *D. tenuis* are bobcats (*Lynx rufus*) and raccoons (*Procyon lotor*), respectively, but signs were not evident that these hosts were present in the area where live trapping of mosquitoes was conducted; therefore, we believe *An. punctipennis* at least should be considered a potential natural vector of *D. immitis* in western Kentucky.

The predominant mosquito species collected was *Ae. vexans* (Meigen). As well as being a major pest species in most of the United States, *Ae. vexans* is a dominant species throughout the Tennessee Valley (Breeland et al. 1961). This mosquito species has long been considered a potential vector of dog heartworm (Hu 1931, Jankowski and Bickley 1976), and recently it was cited as the principal vector of *D. immitis* in Minnesota (Hendrix et al. 1980). Natural isolations of filarial worms, presumed to be *D. immitis*, from *Ae. vexans* have been reported by Bemrick and Sandholm (1966), Crans and Feldlaufer (1974), Magnarelli (1978), Todaro et al. (1977), and Buxton and Mullen (1980).

All of the 1,331 *Ae. vexans* examined in this study were negative for filarial parasites. Although we did not separate nulliparous from parous females in the 117 *Ae. vexans* dissected, and could not in the 1,214 individuals that were pooled, we believe that a representative number of older females was sampled. Mosquitoes were sampled over a significant period of time and 19% (22/117) of the *Ae. vexans* dissected were gravid. In addition, numerous eggs were present in the washings from all 13 pools examined; therefore, it is unlikely that we were examining only newly emerged cohorts. These data do not prove that *Ae. vexans* cannot function as a natural vector of *D. immitis* in our study area, but the evidence suggests that this species might not play a major role in the maintenance of *D. immitis* in Calloway County.

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.

Breeland, S. G., W. E. Snow and E. Pickard. 1961. Mosquitoes of the Tennessee Valley. J. Tenn. Acad. Sci. 36:249–319.

Buxton, A. and G. R. Mullen. 1980. Field isolations of *Dirofilaria* from mosquitoes in Alabama. J. Parasitol. 66:140–144.

Christensen, B. M. and W. N. Andrews. 1976. Natural infection of *Aedes trivittatus* (Coq.) with *Dirofilaria immitis* in central Iowa. J. Parasitol. 62:276–280.

Courtney, C. C. and B. M. Christensen. 1982. Diversity and seasonal abundance of mosquitoes (Diptera:Culicidae) in Calloway County, Kentucky. Trans. Ky. Acad. Sci. 43:55–59.

Crans, W. J. and M. F. Feldlaufer. 1974. The likely mosquito vectors of dog heartworm in a coastal area of southern New Jersey. Proc. Calif. Mosq. Control Assoc. 42:168.

Darsie, R. F., Jr. and R. A. Ward. 1981. Identification and geographical distribution of the mosquitoes of North America north of Mexico. Mosq. Syst. (Suppl. 1):1–313.

Hendrix, C. M., W. J. Bemrick and J. C. Schlotthauer. 1980. Natural transmission of *Dirofilaria immitis* by *Aedes vexans*. Am. J. Vet. Res. 41:1253–1255.

Hu, S. M. K. 1931. Studies on host-parasite relationships of *Dirofilaria immitis* Leidy and its culicine intermediate hosts. Am. J. Hyg. 14:614–629.

Jankowski, T. J. and W. E. Bickley. 1976. The mosquitoes *Aedes canadensis* and *A. vexans* as potential vectors of *Dirofilaria immitis* in Maryland. Ann. Entomol. Soc. Am. 69:781–783.

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

Magnarelli, L. A. 1978. Presumed *Dirofilaria immitis* infections in natural mosquito populations in Connecticut. J. Med. Entomol. 15:84–85.

Phillips, J. H. 1939. Studies on the transmission of *Dirofilaria immitis* in Massachusetts. Am. J. Hyg. 29:121–129.

Todaro, W. S., C. D. Morris and N. A. Heacock. 1977. *Dirofilaria immitis* and its potential mosquito vectors in central New York state. Am. J. Vet. Res. 38:1197–1200.

Yen, C. H. 1938. Studies on *Dirofilaria immitis* Leidy, with special references to the susceptibility of some Minnesota species of mosquitoes to the infection. J. Parasitol. 24:189–205.