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Dirofilaria immitis in Coyotes and Foxes in Missouri

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ABSTRACT: Wild canid carcasses were obtained during the 1986–1987 and 1987–1988 trapping seasons in Missouri. Hearts and lungs from 293 coyotes (*Canis latrans*), 85 red foxes (*Vulpes vulpes*) and 70 gray foxes (*Urocyon cinereoargenteus*) were examined for *Dirofilaria immitis*. Age of hosts was determined by radiographic and histologic techniques. Nineteen coyotes (7%) had from 1 to 100 *D. immitis* and five red foxes (6%) had from 1 to 7 *D. immitis*, whereas gray foxes had none. This study indicates that heartworm prevalence differs by wild canid species within the same area and during the same time period.

Key words: *Dirofilaria immitis*, heartworm, coyotes, red foxes, gray foxes, *Canis latrans*, *Vulpes vulpes*, *Urocyon cinereoargenteus*, survey.

Although records of *Dirofilaria immitis* (Nematoda: Filarioidea) in wild canids are extensive, few studies have used both large samples of animals and data from multiple years to compare interspecific variation in prevalences (King and Bohning, 1984). Prevalence of infection may vary with geographic location, habitat, densities of mosquito vectors and definitive hosts, and climatic conditions. Our objectives were to determine the prevalence of heartworm in coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) from Missouri and to compare the reservoir potential of these wild canids.

Wild canid carcasses were collected during two trapping seasons, December 1986 to January 1987 and December 1987 through February 1988. Through cooperation of the Missouri Department of Conservation, carcasses were obtained from hunters, trappers, and fur buyers in 31 counties or county groups representing each of the six zoogeographic areas of Missouri (USA). During the 1986–1987 trapping season, 114 carcasses were obtained (66 coyotes, 26 red foxes and 22 gray foxes) and during the 1987–1988 season, 334 wild canid carcasses (227 coyotes, 59 red foxes, and 48 gray foxes) for a total of 448 carcasses (293 coyotes, 85 red foxes and 70 gray foxes).

After the heart and lungs were removed from all carcasses, the right side of the heart was opened and pulmonary arteries dissected to examine for *D. immitis*. If heartworms were found in the heart, the chest cavity also was examined for *D. immitis* that may have been released when the heart and lungs were removed. Due to poor preservation of most carcasses, blood was not tested for microfilariae. Heartworms were preserved in 2% formalin. Measurements and the appearance of the posterior end were used to determine sex and maturity. Representative specimens were deposited in the U.S. National Parasite Collection (Animal Parasitology Institute, USDA, Building 1180 BARC-East, Beltsville, Maryland 20705, USA; Accession Numbers 81211 to 81212).

Host age was determined by radiographic and histologic examination of canine tooth development. To differentiate juveniles from adults, one tooth from each canid was used for radiographic determination of pulp cavity size (Matson and Matson, 1981; Kuehn and Berg, 1983). Teeth from adults and those of questionable age were sectioned and aged by counting the cementum rings (Matson's, Box 308, Milltown, Montana 59851, USA). Chi square tests (Daniel, 1983) were used in statistical analyses.

Nineteen of 293 (7%) coyotes, 5 of 85 (6%) red foxes and 0 of 70 gray foxes were infected with *D. immitis*. At a 95% confidence level, prevalence differed significantly between gray foxes and coyotes (χ^2

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= 4.85), gray and red foxes ($\chi^2 = 4.38$), but not between red foxes and coyotes ($\chi^2 = 0.084$).

Heartworm infection in coyotes was found most frequently in adult animals. During the first season, 2 of 66 (3%) coyotes were infected. Both were adults (1- and 8-yr-old) with mature infections of three heartworms each. During the second season, 17 of 227 (8%) coyotes were infected, with intensities of 13.2 ± 5.7. Four of 112 (4%) young of the year were infected. Two of 43 (5%) 1-yr-old coyotes were infected. The highest prevalence was in 2-yr-old coyotes with 7 of 57 (12%) being infected. The coyotes with the highest intensities, 53 and 100 heartworms, were both 2 yr of age. The oldest infected coyote was 9 yr of age, but two other 9-yr-old animals and a 10- and 11-yr-old were not infected. Nine of 147 (6%) male and 10 of 146 (7%) female coyotes were infected. Seven of the 19 heartworm infections in coyotes were mature and consisted of both sexes; therefore, 2% of 293 coyotes could have had patent infections.

All red foxes infected with *D. immitis* were <2-yr-old. During the first season, 2 of 26 (8%) red foxes were infected; both were immature foxes with two and seven immature heartworms. In the second season, 3 of 59 (5%) red foxes were infected with one, one and four *D. immitis*. Two of 37 (5%) young of the year and 1 of 14 (7%) 1-yr-old animals were infected. Four of 46 (9%) males and 1 of 39 (3%) females were infected. Two of the five infections consisted of both sexes. These had only immature heartworms so that none of the red foxes could have had patent infections. Neither 22 gray foxes the first season nor 48 gray foxes the second season were infected with *D. immitis*.

Prevalence of *D. immitis* varies geographically, temporally and by host species. In the midwestern United States, prevalence in coyotes ranges from 1 of 8 (13%) in Indiana (Kazacos and Edberg, 1979), 39 of 443 (9%) in Nebraska (Pappas and Lunzman, 1985), 9 of 111 (8%) in Kansas (Graham, 1975), 8 of 220 (4%) in Iowa (Franson et al., 1976) to 8 of 1,530 (<1%) in Kansas (Gier and Ameel, 1959). The 7% prevalence for coyotes in Missouri is similar to prevalences in midwestern states which are all less than those of the warmer southern and western states such as 43 of 115 (37%) in California (Weinmann and Garcia, 1980), 41 of 71 (58%) in Louisiana (Crowell et al., 1977), 127 of 193 (66%) in northeastern Arkansas (King and Bohning, 1984) and 17 of 24 (71%) in Texas/Louisiana (Custer and Pence, 1981).

Prevalence appears to be lower for foxes than coyotes or dogs in any given area. The prevalence in red foxes in the midwestern United States is usually low, viz., 5 of 145 (3%) in southern Illinois (Dyer and Klimstra, 1981), 8 of 225 (4%) in Illinois (Hubert et al., 1980), 3 of 113 (3%) in Indiana (Kazacos and Edberg, 1979) and 5 of 85 (6%) in red foxes in our study. King and Bohning (1984) reported 1 of 26 (4%) heartworm infected red foxes in northeast Arkansas. Prevalence in gray foxes in the United States is usually low also: 3 of 267 (1%) in Illinois (Dyer and Klimstra, 1982), 3 of 81 (4%) in Indiana (Kazacos and Edberg, 1979), 3 of 163 (2%) in northeast Arkansas (King and Bohning, 1984) and none in 70 gray foxes in Missouri.

In coyotes from the northeastern United States, the prevalence of *D. immitis* was lowest in 1- to 2-yr-old animals and highest in 3- to 4-yr-old coyotes with older individuals showing a decrease again. Decreased infection in older coyotes may indicate that heartworm infection may contribute to mortality of older infected individuals (Agostine and Jones, 1982; Graham, 1975). On the other hand, Custer and Pence (1981) found a positive correlation between host age and prevalence and mean intensity of heartworms which they attributed to increased exposure.

Otto (1969, 1974) has contended that wild canids, other wildlife species and humans are only accidental hosts and are more medical curiosities than reservoirs, although adult *D. immitis* with gravid fe-

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males and circulating microfilariae have been found in red wolves (*Canis rufus*), coyotes, gray foxes and red foxes. In Kansas where 8% of 111 coyotes were found to be infected with *D. immitis*, it was estimated that they comprised 1% of the *D. immitis* reservoir (Graham, 1975). In Louisiana (Crowell et al., 1977), the higher prevalence of heartworm in coyotes (58%) may represent a significant reservoir population or it may merely be the result of a hyperenzootic prevalence in dogs. Custer and Pence (1981) and Weinmann and Garcia (1980) concluded that coyotes are natural definitive hosts and reservoirs of dirofilariasis in the Gulf Coastal prairies of Louisiana and Texas and in California, respectively. In Missouri, the prevalence of heartworm in dogs varies among the six zoogeographic regions. We (Pratt et al., 1981) reported that the prevalence (determined by modified Knott's examination for microfilariae) in pound dogs from communities near the Mississippi River was 9%, whereas in those from central Missouri it was 2%. According to veterinarians surveyed by questionnaire, prevalence of heartworm in dogs in southeastern Missouri is as high or higher than the prevalence in coyotes in the adjoining area of Arkansas as reported by King and Bohning (1984). Considering this and the prevalence (7%) and highest possible patency (37% of those infected) from the present study, we have concluded that coyotes are not a major reservoir for *D. immitis* throughout Missouri. Although the prevalence of heartworm in red foxes was not significantly different from that in coyotes, apparently none of the infected red foxes had patent infections. None of the gray foxes was infected. Therefore, it is unlikely that foxes act as reservoirs of *D. immitis* infection in Missouri. We speculate that the pathophysiologic stress of dirofilariasis in the wild canid population does reduce survivability to the next mosquito season. An interesting study would be the impact of the infected domestic dog, including feral, population on the wild canid population.

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