

HEARTWORMS (*DIROFILARIA IMMITIS*) IN COYOTES (*CANIS LATRANS*) IN ILLINOIS

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ABSTRACT

Dirofilaria immitis was found in 103 of 472 (21.8%) coyotes (*Canis latrans*) collected from fur buyers and trappers in 28 Illinois counties during 1977 through 1980. The overall prevalence rate was 9.4% in the northern one-half of the state compared with 23.8% in the southern one-half. In southeastern Illinois where 28.0% of all coyotes examined were infected, the prevalence rate for juveniles was significantly lower than that for adults. Infection levels ranged from 1 to 52 heartworms per animal and averaged 9.6. In general the mean number of worms per infection in adults was higher than in juveniles. Ten of 29 (34.5%) coyotes from Clay and Richland counties had single sex heartworm infections. The parasite sex ratio was 1.11:1, female to male. The finding of *D. immitis* in coyotes represents a new host record for the state.

INTRODUCTION

The first report of heartworm (*Dirofilaria immitis*) in a coyote (*Canis latrans*) was made in 1924 in Missouri (see reference in Otto 1975). For many years most studies revealed low prevalence rates in comparison with dogs (*Canis familiaris*)

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from the same localities suggesting that coyotes did not constitute any reservoir problem (Otto 1972, 1975). However, recent reports, which document high prevalence rates in coyotes from California (Weinmann and Garcia 1980), Louisiana (Crowell et al. 1978), and the Gulf Coast of Texas and Louisiana (Custer and Pence 1981), indicate a need to consider this wild canid as a potential reservoir host in areas where heartworms are prevalent. Illinois is such an area. Domestic canine infections are consistently diagnosed throughout the state (Noyes 1978) with prevalence rates as high as 48% being encountered (Otto 1972). Also, *D. immitis* has been found to infect both red foxes (*Vulpes vulpes*) (Hubert et al. 1980, Dyer and Klimstra 1981) and gray foxes (*Urocyon cinereoargenteus*) (Dyer and Klimstra 1982, Hubert et al. 1982) in several southern Illinois counties.

Cardio-pulmonary deficiencies caused by *D. immitis* are probably more serious in a highly active predator like the coyote than in a domestic dog (Gier and Ameel 1959), but the effects of heartworm on the health or livability of coyotes remain uncertain (Gier et al. 1978). Some of the basic information about characteristics of heartworm infections in coyotes needed to assess these effects is becoming available. For example, Graham (1975), Crowell et al. (1978), Weinmann and Garcia (1980), and Agostine and Jones (1982) reported age-specific prevalence rates among host coyotes, the number, sex ratio, and length of *D. immitis* recovered from coyotes, and the prevalence of circulating microfilariae. Comparative data for Illinois are not available even though coyotes are common throughout the state. Fur-takers harvested an average of 7,600 coyotes (1 per 19.2 km²) in Illinois annually from 1975 through 1982 (Hubert, unpublished data).

The primary objective of our study was to determine the prevalence of heartworm in coyotes throughout Illinois. In addition, we collected information about the characteristics of *D. immitis* infections in coyotes from the southeastern part of the state.

MATERIALS AND METHODS

Coyote carcasses were collected from fur buyers during November 1977-February 1978, November 1978-March 1979, and October 1979-February 1980. These fur buyers were located in Clay, Clinton, DeKalb, Edgar, Hancock, Jasper, Livingston, Menard, Moultrie, and Richland counties. Although precise capture locations were not available for some animals, all were captured in Illinois within the following radii of the various furhouses where obtained: Clay and Richland counties, 100 km; DeKalb, Edgar, Hancock, and Livingston counties, 80 km; Clinton County, 48 km; Jasper County, 32 km; Moultrie County, 24 km; and Menard County, 16 km. Additional coyote hearts from specimens caught during November-December 1977 in Bond County, November-December 1978 in Bond and Pope counties, and October-December 1979 in Carroll, Ford, Knox, and Mason counties were supplied by cooperating trappers.

Several carcasses were frozen when received and subsequently thawed for heart removal. Hearts collected by cooperating trappers were frozen; these were also thawed prior to examination. Ventricles, atria, and pulmonary arteries were inspected macroscopically for heartworms. All worms were identified and, if possible, sexed according to Yorke and Maplestone (1969). Representative specimens of *D. immitis* have been deposited in the U.S. National Parasite Collection, Beltsville, Maryland (Accession No. 75856).

Age was determined only for those coyotes collected in southeastern Illinois from which skulls were available. Coyotes were assigned to 1 of 2 age classes based on canine tooth characteristics (Linhart and Knowlton 1967). Animals less than 1 year old were classified as juveniles; those older were considered adults.

Statistical comparisons of prevalence rates were accomplished with chi-square tests (Snedecor and Cochran 1967:215). Relationships between mean parasite burdens and the sex and age of infected coyotes were evaluated using the *t*-test for unequal sample sizes (Snedecor and Cochran 1967:104). Significance was determined at the 0.05 level of probability.

RESULTS

Specimens of *D. immitis* were collected from 103 of the 472 (21.8%) coyotes examined (Table 1). Fifty-seven of 246 (23.2%) male coyotes and 46 of 223 (20.6%) females were infected; the difference was not significant ($\chi^2 = 0.44$, 1 df, $p > 0.30$). In the northern one-half of Illinois the overall prevalence rate was 9.4% compared with 23.8% in the southern one-half. This difference was significant ($\chi^2 = 6.72$, 1 df, $p < 0.01$).

Adult heartworms occurred in 49 of 175 (28.0%) coyotes checked at furhouses in Clay and Richland counties in southeastern Illinois (Table 2). All nematodes found were in the right atrium and frequently extended into the pulmonary artery. Prevalence rates for juvenile male coyotes (20.3%) and juvenile females (15.3%) did not differ significantly ($\chi^2 = 0.55$, 1 df, $p > 0.30$), but those for adult males (45.5%) and adult females (78.6%) did ($\chi^2 = 4.36$, 1 df, $p < 0.05$). The difference between the prevalence rate for all juvenile coyotes (18.0%) and that for all adults (55.3%) was also significant ($\chi^2 = 23.79$, 1 df, $p < 0.01$).

The level of infection (worm burden) in coyotes from southeastern Illinois ranged from 1 to 52 and averaged 9.6 (Table 2). The mean worm burdens for male (12.8) and female (2.9) juvenile coyotes and those for male (8.4) and female (12.9) adult coyotes did not differ significantly ($t = 1.39$, 15 df, $p > 0.10$; $t = 1.00$, 20 df, $p > 0.30$) by sex. Also, there was no significant difference ($t = 0.37$, 37 df, $p > 0.70$) when the average level of infection for juveniles (8.7) was compared with that for adults (10.2). However, the latter comparison was largely influenced by two juvenile males that harbored 42 and 52 worms, respectively.

Ten of 29 (34.5%) infected coyotes collected in Clay and Richland counties, and from which all heartworms could be sexed, had single sex infections. These included 6 unisexual infections among 12 juveniles and 4 among 17 adults. The parasite sex ratio among these host animals was 1.11:1, female to male ($n = 293$).

DISCUSSION

No previous records of heartworms in coyotes in Illinois exist although infections have recently been documented in adjacent states (Franson et al. 1976, Kazacos 1977). Our data indicate the prevalence of heartworm infection in Illinois coyotes is among the highest reported in the United States. Only California (37%) (Weinmann and Garcia 1980), Louisiana (58%) (Crowell et al. 1978), southern Texas (23%) (Thornton et al. 1974), and the coastal prairies of Texas and Louisiana (71%) (Custer and Pence 1981) show higher levels. However, sample sizes in the latter two studies were small (< 25). Prior to our study, the highest

prevalence rate in the central United States was 8% reported in Kansas and Colorado (Graham 1975). Perhaps the incidence of heartworms in midwestern coyotes has increased substantially during the last 5 to 8 years, or conditions in Illinois are more suitable for development and transmission of this parasite than in surrounding areas.

The prevalence rate in coyotes was over 2.5 times greater in southern Illinois than in the northern one-half of the state. Marquardt and Fabian (1966) reported a similar pattern in dogs. The longer breeding season for mosquitoes in southern Illinois (Ross 1947) probably contributes to this variation, but other factors may be involved because high prevalence rates have been recorded for dogs examined in extreme northeastern Illinois counties (Otto 1972).

No significant difference in overall prevalence rates for male and female coyotes was detected; this is consistent with the findings of Graham (1974) for dogs and Weinmann and Garcia (1980) for coyotes. Therefore, the significant difference in prevalence rates between sexes of adult coyotes in southeastern Illinois probably reflected sampling variability. However, behavioral differences between male and female adult coyotes, especially those associated with movement patterns and the rearing of young, may increase the likelihood of adult females becoming infected. Additional research is needed to clarify the situation.

The significantly higher prevalence rate observed among adult coyotes compared with juveniles parallels findings of Graham (1975), Crowell et al. (1978), Weinmann and Garcia (1980), and Custer and Pence (1981). Obviously adult coyotes have been exposed longer, thus increasing their chances of becoming infected. In addition, we observed older coyotes generally, but not always, had higher mean worm burdens than younger coyotes as did earlier researchers. Up to 52 adult heartworms were recorded from a juvenile coyote. In contrast, the highest worm burden previously reported for a juvenile was six (Graham 1975).

The effect of heartworms on the health of coyotes is not clear. Jackson et al. (1966) reported that 25 worms in dogs gave no indication of disease, but 47 to 58 worms resulted in moderate to severe disease. Maximum heartworm burdens reported previously in midwestern coyotes varied from 12 in Kansas (Graham 1975) to 23 in Iowa (Franson et al. 1976); our study documented a maximum of 52. Burdens exceeding 50 worms per animal have also been encountered in other areas (Crowell et al. 1978, Weinmann and Garcia 1980, Custer and Pence 1981). These data, plus results of clinical studies on cardiopulmonary lesions of captive coyotes infected with heartworms (Ross and Suzuki 1973) support the suggestion (Crowell et al. 1978) that *D. immitis* may limit coyote populations in enzootic areas.

Our findings of 1.11 female heartworms for each male are consistent with those reported by Weinmann and Garcia (1980) and Custer and Pence (1981). In contrast Agostine and Jones (1982) documented 2.2 females per male in New Hampshire from a sample of eight positive coyotes. The female:male ratio is frequently above unity in many nematode infections and is positively correlated with the intensity of infection; the female:male ratio decreases as worm burdens increase (Young and Pence 1979). Overall, most data appear to indicate the female:male ratio in heartworm infections in coyotes is near 1:1 and not significantly affected by the intensity of infection.

Within the last 15 years researchers have suggested that the coyote is an unnatural host for *D. immitis* and thus a poor reservoir of infection because of low

prevalence of infection, low worm burdens, preponderance of single-sex infections, and/or the failure of heartworms to produce microfilariae (Otto 1969, 1972, 1975, Graham 1975). Graham (1975:515) proposed that "*D. immitis* must be transmitted to coyotes by mosquitoes from infected dogs, and the occurrence of heartworm in coyotes is of no importance to a dog population." However, 2 years earlier Monson et al. (1973) recognized coyotes as a possible reservoir for heartworm infection in dogs. It was suggested for coyotes to serve as a reservoir host they must be capable of supporting full development of the heartworm to sexual maturity and microfilarial production. Coyotes are now known to fulfill both requirements. Over 65% of the positive coyotes examined from Clay and Richland counties for which complete data are available harbored both sexes of adult heartworms. Weinmann and Garcia (1980) reported bi-sexual infections in 63% of the positive coyotes checked. Also, uterine microfilariae were present in 82% of the 280 female heartworms they recovered, and microfilariae were abundant in lung smears from all positive coyotes harboring mature male and female *D. immitis*. Our data on prevalence rates, mean worm burdens, and incidence of bi-sexual infections in coyotes support Weinmann and Garcia (1980) in that the coyote appears to be as suitable a host for *D. immitis* as the dog and is likely a reservoir of infection in certain areas. Crowell et al. (1978) and Custer and Pence (1981) agree. Further study of microfilarial development and transmission along with infectivity trials to more clearly delineate the coyote's role in the epizootiology of canine heartworm disease should be pursued, especially where preventive programs for dogs have been instituted.

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Table 1. Prevalence of *Dirofilaria immitis* in coyotes collected in Illinois, November 1977-February 1978, November 1978-March 1979, and October 1979-February 1980.

County	Male	Female	Sex unknown	Totals
<u>North of 40° N. Latitude</u>				
Bureau	1/3 ^b	—	—	1/3
Carroll	—	0/1	—	0/1
DeKalb	0/1	0/2	—	0/3
Ford	0/4	1/3	—	1/7
Hancock	0/1	0/1	—	0/2
Henderson	0/1	1/5	—	1/6
Kane	0/1	0/3	—	0/4
Knox	2/10	1/15	—	3/25
LaSalle	0/3	—	—	0/3
Lee	—	0/1	—	0/1
Livingston	0/1	0/1	—	0/2
Mason	0/4	0/1	—	0/5
McHenry	—	0/1	—	0/1
Mercer	—	0/1	—	0/1
Subtotals	3/29	3/35	—	6/64
<u>South of 40° N. latitude</u>				
Bond	3/29	8/45	—	11/74
Clark	—	0/1	—	0/1
Clay ^a	14/52	10/42	—	24/94
Coles	—	0/1	0/1	0/2
Edgar ^a	13/33	9/35	—	22/68
Jasper ^a	1/5	1/2	0/1	2/8
Jefferson	1/13	1/5	—	2/18
Marion	0/1	—	0/1	0/2
Menard ^a	0/2	0/3	—	0/5
Moultrie ^a	—	0/4	—	0/4
Pope	—	0/1	—	0/1
Richland ^a	19/72	14/47	—	33/119
Shelby	0/1	—	—	0/1
Washington	3/9	0/2	—	3/11
Subtotals	54/217	43/188	0/3	97/408
<u>Statewide</u>				
Totals	57/246	46/223	0/3	103/472

^aExact origin uncertain; county indicates location of furhouse where animal was examined.

^bNumber infected/number examined.

Table 2. Characteristics of *Dirofilaria immitis* infections in coyotes collected from fur buyers in Clay and Richland counties, Illinois, January 1978-January 1980.

Age-sex of coyote	Number positive		Parasites per infection		
	Number examined	N	Mean \pm SE	Range	Total
Juvenile male	14/69 (20.3) ^a	10	12.8 \pm 5.9	1-52	128
Juvenile female	9/59 (15.3)	7	2.9 \pm 1.1	1-9	20
Adult male	15/33 (45.5)	13	8.4 \pm 2.3	1-25	109
Adult female	11/14 (78.6)	9	12.9 \pm 4.2	1-41	116

^aNumbers in parentheses indicate percent positive.