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TRICHINELLA SPIRALIS IN THE BLACK BEAR (*URSUS AMERICANUS*) OF PENNSYLVANIA: DISTRIBUTION, PREVALENCE AND INTENSITY OF INFECTION

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K. Darwin Murrell,² and Gary L. Alt³**

ABSTRACT: Samples of tongue or diaphragm from 2,056 black bears harvested in Pennsylvania during the 1981-1983 hunting seasons were examined for larvae of *Trichinella spiralis* by peptic digestion. Sixteen males and 21 females were infected. The overall prevalence of infection was 1.8%. Infected animals were distributed widely throughout the range of the bear in Pennsylvania. In samples from infected bears, the geometric mean density of muscle larvae was 7.8 per g of tissue (LPG). There were neither sex- nor age-related differences in prevalence or intensity of infection. Virtually all bears harvested in Pennsylvania are consumed as food, which often is shared widely among hunters, their friends and relatives. Furthermore, high densities of larvae occurred in some bears (i.e., 300, 348, 465, 512, 555, and 912 LPG). Thus, a basis for potential, single-source outbreaks of severe human trichinosis exists.

INTRODUCTION

As part of a larger investigation examining the epidemiology of trichinosis in the northeastern United States, with particular reference to swine, a 3-yr study was undertaken to determine the distribution, prevalence and intensity of *Trichinella spiralis* infections in the black bear in Pennsylvania. Previous North American studies reported infected black bears in Alaska (Rausch et al., 1956), New York (King et al., 1960), Vermont (Babbott and Day, 1968), Pennsylvania, Vermont, West Virginia, New York (Harbottle et al., 1971), Montana, Idaho, Wyoming (Worley et al., 1974), Quebec (Frechette and Rau, 1977), California, Wisconsin, Idaho (Zimmerman, 1977), Ontario (Addison et al., 1978), Arizona (Le Count, 1981), Pennsylvania (Quinn, 1981), and California (Ruppanner et al., 1982).

Recently, in the eastern United States,

Pennsylvania has ranked second only to Maine in the number of bears harvested annually. However, unlike Maine, Pennsylvania has a significant swine population and because wildlife carcasses are sometimes fed to swine (Andrews et al., 1969; Kazacos, pers. comm.), it was important to know the distribution and prevalence of *T. spiralis* infection in Pennsylvania wildlife, including bears.

Pennsylvania's black bear population, presently estimated as 6,000 animals (Alt, unpubl. data), is under intensive study. A yearly, highly organized bear-hunting season provided us with an opportunity to determine the distribution, prevalence and intensity of infections of *T. spiralis* in a large number of hunter-killed bears during a 3-yr period. We anticipated that the information acquired would have relevance to both livestock and game management, as well as public health.

MATERIALS AND METHODS

In the Commonwealth of Pennsylvania, hunters are required to bring each harvested black bear to one of 20 Game Commission check stations. There the bears are measured, weighed, sexed and a tooth extracted for age determination (Willey, 1974). During the 1981, 1982 and 1983 bear hunting seasons, samples of diaphragm or tongue muscles were removed from carcasses by personnel of the Pennsylvania

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TABLE 1. Prevalence and density of infections of larvae of *Trichinella spiralis* in black bears from Pennsylvania sampled during the 1981–1983 hunting seasons.

Year	Number harvested	Number examined	% Harvest examined	Number infected	Prevalence (%)	Density of infection (LPG)*	
						Arithmetic mean ($\bar{x} \pm SD$)	Geometric mean
1981	819	454	55.4	9	2.0	55.5 \pm 115.5	3.2
1982	585	427	73.0	10	2.3	133.6 \pm 194.9	16.7
1983	1,527	1,175	76.9	18	1.5	112.5 \pm 252.7	3.4
Total	2,931	2,056	70.1	37	1.8	101.3 \pm 206.3	7.8

* Means of those infected.

Game Commission and placed in individual plastic bags marked with the bear's identifying number. The tissue samples from all check stations were assembled at a central location within 2 days of collection and were refrigerated until they could be transported to our laboratory.

Samples were pooled in groups of no more than 20, 5-g samples (i.e., ≤ 100 g) and homogenized for 10 min in 1 liter of prewarmed (37 C) artificial gastric juice (1% HCl-pepsin) in a Stomacher 3500 Lab-Blender (Tekmar Co., Cincinnati, Ohio 45222, USA) at room temperature. Each pool was digested for an additional 4 hr at 37 C on a commercial microbiological shaker. The completed digests were washed by repeated sedimentation in distilled water and after the supernatant was clear, sediments were examined for larvae of *T. spiralis* in gridded counting dishes at 20 magnifications.

When a pooled sample contained larvae, 10 g of each diaphragm or tongue contributing to that pool was digested and examined individually. The individual 10-g samples were homogenized for 5 min in 100 ml of prewarmed (37 C) artificial gastric juice using a Stomacher 400 Lab-Blender and digested as described previously for pooled samples. These methods are a modification of the pooled digestion procedures described by Thomsen (1977).

Specimens of *Trichinella spiralis* larvae of strains isolated from bears in Pennsylvania have been deposited in the U.S. National Museum Parasite Collection (USNM Helm. Coll. No. 78822).

RESULTS

Tongue or diaphragm samples were obtained from bears during a 1-day hunting season in 1981 and 2-day seasons in 1982 and 1983. Thirty-seven of 2,056 bears (1.8%) were infected; 16 were males and 21 were females (Tables 1, 2). Infected

bears ranged from <1 yr of age to 14 yr of age. No sex-, age- or weight-related differences in the prevalence or intensity of infection were observed (Table 2). With respect to age, no trend toward higher densities in older animals was apparent. High densities occurred in a 2-yr-old bear (512 LPG) as well as a 10-yr-old bear (465 LPG). Very low densities occurred in a number of cubs <1 yr of age (0.2 LPG) as well as in a 12-yr-old bear (0.4 LPG) (Table 2). The geometric mean density based on samples from infected bears was 7.8 LPG.

Figure 1 shows the percent of harvested bears sampled for *Trichinella* infections by county and the locations where infected bears were harvested. On a county basis, sampling varied from over 70% of harvested bears in the eastern portion of the state, to between 43 and 64% in the western portion of the state. Infected bears were widely distributed.

Of note was a mother and her three cubs (one male, two females) all of which were infected. These four bears, which were killed in the same township, account for the cluster of four infected bears in the north central part of the state (Fig. 1). The 4-yr-old mother and two female cubs had infections of low density (≤ 0.5 LPG), while the male cub had an infection of moderate density (11.3 LPG).

DISCUSSION

The black bear, the most prized big game animal in the Commonwealth of

TABLE 2. Density (LPG) of larvae of *Trichinella spiralis* in black bears of Pennsylvania by sex, age, and weight of the host.

Males			Females		
Age (yr)	Weight (kg)	Density (# LPG ^a)	Age (yr)	Weight (kg)	Density (# LPG)
0 ^b	27	0.2	0	20	86.0
0	45	11.3	0	33	0.2
0	46	0.5	1	29	72.0
1	47	21.5	1	38	111.4
1	50	0.1	2	72	3.8
2	64	512.0	3	62	555.4
2	72	347.6	3	63	33.8
2	91	0.8	3	64	65.0
2	116	0.1	3	69	0.3
3	61	0.1	3	70	1.3
5	156	0.2	NA ^c	72	0.4
5	163	40.1	3	114	0.1
6	212	0.9	4	81	912.0
9	175	1.6	4	90	0.5
12	186	0.4	5	85	1.3
14	163	32.1	6	73	4.3
			6	110	4.8
			7	80	300.0
			10	78	55.8
			10	98	465.0
			11	80	6.5

^a Larvae per gram of tongue or diaphragm muscle.

^b Bear less than 1 yr old.

^c Age not available.

Pennsylvania, is hunted by approximately 100,000 sportsmen annually for its pelt and meat (Alt, 1980, 1981, 1982, 1983). In the period under study (1981–1983), the harvest ranged from 585–1,527 bears per year. Although only a few bears (1.8%) were infected, they represent a potentially significant public health hazard because of their large size, the attendant large amounts of meat they provide and the frequent, widespread sharing of meat from a single carcass. Indeed, a common-source outbreak that resulted from the consumption of bear meat accounted for 31 human cases of trichinosis in 1978 (Center for Disease Control, 1979).

Infected bears were distributed widely (Fig. 1). Intervening areas where no or few infections were recorded may be explained by the smaller numbers of bears

sampled from counties with urban centers such as the Wilkes-Barre–Scranton urban chain. Nevertheless, infected bears occurred near population centers as well as in more remote portions of the state. On the basis of another study, one that examined trichinosis in small furbearing mammals of Pennsylvania (Schad et al., 1984), we doubt that any area is actually free of trichinosis. In this connection, it is interesting that Worley et al. (1974) found a higher prevalence of infection in bears from remote wilderness areas of Montana than in those from more accessible areas. Similarly, Schad et al. (1984) observed a higher prevalence of trichinosis among furbearing mammals (foxes, skunks, etc.) from less populated and developed parts of Pennsylvania than among hosts of southeastern Pennsylvania with its densely populated, developed areas.

The density of infection varied from a low of 0.1 LPG in several bears to a high of 912 LPG in a 4-yr-old female. Babbott and Day (1968) and Campbell (1983) suggested that the older, large carnivores may be more likely to harbor heavy infections than the younger ones, since they would have had longer life spans during which to accumulate infections through numerous trichinous meals. Our results do not support this suggestion, because high densities of infection (i.e., >100 LPG) were found in 1- and 2-yr-old bears as well as in older animals. The overall low prevalence of infection may indicate that trichinous meals are scarce, and thus, opportunities to accumulate infection may be rare. Additionally, it is noteworthy that in swine, at least, infections are not additive (Murrell, 1985).

Six bears were found to have very dense infections, exceeding 100 LPG, and therefore, as previously mentioned, any such bear could pose a significant public health hazard if its meat were consumed undercooked. High densities of infection (i.e., >100 LPG) have been reported previously by Rausch et al. (1956), Harbottle et

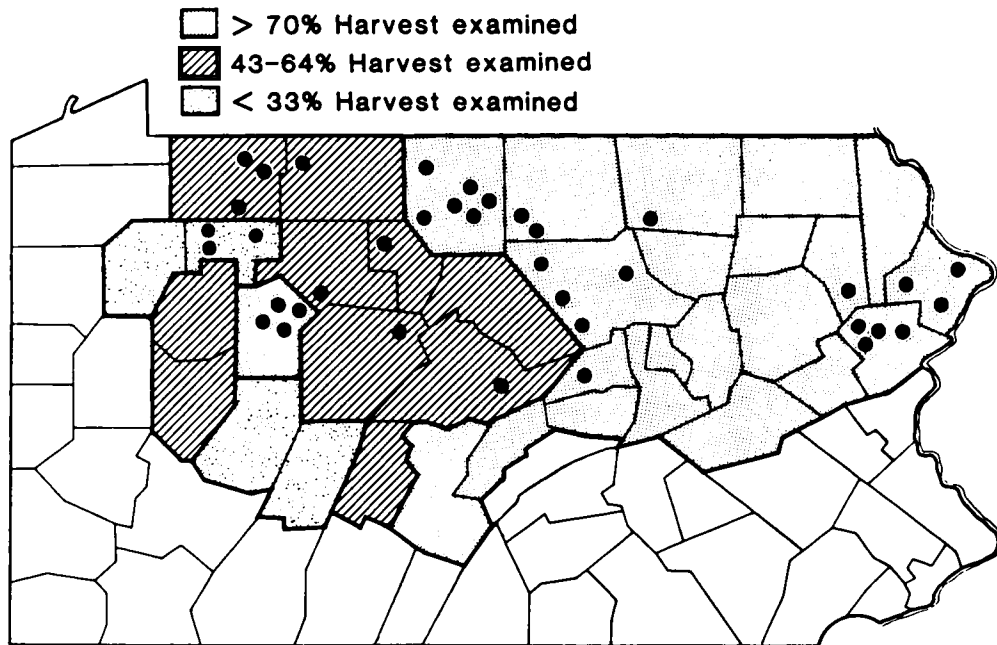


FIGURE 1. Map of Pennsylvania showing the percentage of harvested black bears sampled for *Trichinella spiralis*, by county, during the 1981–1983 bear-hunting season. No bears were harvested in counties shown in white. Solid circles indicate the locations where *T. spiralis*-infected bears were harvested.

al. (1971), Zimmerman (1977) and Le Count (1981). Because these high larval densities are capable of inducing clinical grades of human infection, hunters need to be informed of the risks associated with consumption of improperly cooked bear meat. Zimmerman (1977) suggested establishing programs to examine muscle samples from bears so that hunters could be notified promptly when *T. spiralis* infections were found. This seems particularly appropriate because infected bear meat is becoming an increasingly important source of human trichinosis. As the number of cases due to swine has decreased, the percent resulting from the consumption of bear meat has risen sharply, particularly during the past 4 yr (Center for Disease Control, 1979, 1980, 1981, 1982).

While the occurrence of *T. spiralis* in bears in North America has been well-documented, the source(s) of infection for bears remains largely speculative. Black

bears in Pennsylvania subsist largely on mast, berries, fruits, and vegetation, but they also feed on garbage, rodents and carrion. They have large home ranges and take "exploratory trips" ranging up to 75 km (Alt et al., 1976) and, therefore, nearly all bears in Pennsylvania have access to garbage dumps. In some parts of the state, small, local slaughtering operations discard offal at dumps where it is consumed by bears. Furthermore, bears are fed frequently by homeowners at backyard feeding stations, where they are given grain, garbage, table scraps, and raw meat, including pork.

Babbott and Day (1968) suggested that infections were probably acquired from pork or pork products, scavenged at dumps. Of particular interest, in this connection, are a mother and three cubs that had been captured and tagged previously. This family, referred to previously, frequently fed at dumps and even ate from garbage trucks. All four bears were in-

fect, and presumably they shared the same trichinous meal. However, whether the actual source of infection was garbage is uncertain.

Male bears tend to feed at garbage dumps more frequently than females (Rogers, 1977) and, therefore, sex-specific rates of infection might provide useful information regarding the importance of garbage-feeding for transmission. The prevalence was similar in both sexes (1.56% (16/1,025) in males, 2.04% (21/1,029) in females), but given the relatively small number of infected bears included in the sample, it is premature to attach much significance to the lack of a sharp difference.

The low prevalence of *T. spiralis* infection in swine (Zimmerman and Zinter, 1971) suggests that pork is not an important source of infection for bears. Also, strains of *T. spiralis* from bears generally lack infectivity for swine (Murrell et al., 1985), suggesting that most sylvatic strains are not of porcine origin. Furthermore, Worley et al. (1974) reported that bears from remote areas of Montana, having no access to garbage, had a higher prevalence of infection than those with access to garbage in more populous areas. Therefore, it now appears likely that scavenging on pork waste is a possible source of infection for bears, but that scavenging on carrion, predation on wildlife, or both, play more important roles in the transmission of sylvatic trichinosis.

Carcasses of furbearing mammals probably play a significant role in the transmission of sylvatic trichinosis. In Pennsylvania 3.2% of small furbearers (foxes, raccoons, skunks, opossums, etc.) are infected and their carcasses are frequently found in the wild. Additionally, many skinned carcasses are discarded at dumps (Schad et al., 1984) where they undoubtedly provide sources of infection for bears.

Finally, predation on rodents and other small mammals may be significant as well, but it is difficult to determine the impor-

tance of *T. spiralis* infection in wild rodents, because very large samples have to be examined before any firm conclusions can be drawn (Schad and Chowdhury, 1967).

Perhaps scavenging of carrion will prove to be the most important route of transmission of *T. spiralis* in the wild. Infected furbearers, or other bears, that die from a variety of diseases could provide ample sources for infection, particularly when the infection prevalence among some kinds of furbearers exceeds 10% (Schad et al., 1984). Indeed, it was found that more than 15% of red foxes (*Vulpes vulpes*) in Pennsylvania were infected, suggesting an active cycle of sylvatic trichinosis.

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