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Helminth and Arthropod Parasites of Grizzly and Black Bears in Montana and Adjacent Areas

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INTRODUCTION

Parasites of free-ranging grizzly and black bears in North America have been investigated periodically since the early part of the present century. The emphasis in many of these studies was on the role of bears as potential sources of parasites transmissible to man such as the trichina worm, *Trichinella spiralis* (Maynard & Pauls 1962, Harbottle *et al.* 1971, Wand & Lyman 1972) and the broad fish tapeworm (Vergeer 1930, Rush 1932, Skinker 1931, 1932). Other work has been confined primarily to taxonomic surveys or descriptive studies of parasitism in wild bears (Horstman 1949, Olsen 1968, Choquette *et al.* 1969). Little of the literature has been concerned with the potential influences of parasitism on the health of bear populations in the environment. The present study was designed with this objective in mind.

MATERIALS AND METHODS

Entire carcasses or selected organs or tissues from grizzly and black bears were obtained from a variety of sources, including National Park Service personnel in Yellowstone and Glacier National Parks, Fish and Wildlife service predator control agents, Montana Fish and Game Department biologists, and hunters. The area surveyed included approximately the western third of Montana and Yellowstone National Park. Most bears were necropsied within 48 hours after death except for the examination for *T. spiratis* larvae, for which tissues were frozen and stored for periods of 1 to 6 months before processing. Samples of tongue, masseter, diaphragm and femoral muscle were examined routinely for the presence of trichina larvae as described previously (Worley *et al.* 1974). If only the head was available, tongue and masseter were examined. Complete necropsies were performed on 70 grizzly and 30 black bears. 160 grizzly and 80 black bears were checked for *Trichinella* larvae. Ages of 127 grizzly bears were determined according to the techniques listed by Greer (1974). Ages of black bears were not determined.

Other organs which were examined routinely when the entire carcass was submitted were liver, lungs, heart, kidneys, urinary bladder, subcutaneous con-

TABLE 1. PREVALENCE AND INTENSITY OF PARASITES IN GRIZZLY BEARS FROM MONTANA AND WYOMING

		Percent positive by age class						
Parasite	Mean percent prevalence*	cub	1-2	3-5	6-9	10-15	16+	Av. intinsity of infection (range)
Nematoda								
Trichinella spiralis	61.3$(\frac{98}{160})$	11$(\frac{1}{9})$	50$(\frac{9}{18})$	67.9$(\frac{19}{28})$	63.3$(\frac{19}{30})$	38.9$(\frac{7}{18})$	87.5$(\frac{21}{24})$	51.1(0.12-708)†
Baylisascaris transfuga	75.7$(\frac{53}{70})$	40$(\frac{2}{5})$	76.9$(\frac{10}{13})$	80$(\frac{4}{5})$	92.3$(\frac{12}{13})$	90$(\frac{9}{10})$	80$(\frac{12}{15})$	33.8(1-480)
Uncinaria sp.	17.3$(\frac{12}{69})$	0$(\frac{0}{5})$	46.1$(\frac{6}{13})$	40$(\frac{2}{5})$	7.6$(\frac{1}{13})$	0$(\frac{0}{10})$	13.3$(\frac{2}{15})$	128.8(1-900)
Dirofilaria ursi	2.8$(\frac{2}{70})$	0$(\frac{0}{5})$	7.6$(\frac{1}{13})$	0$(\frac{0}{5})$	7.6$(\frac{1}{13})$	0$(\frac{0}{10})$	0$(\frac{0}{15})$	3.5(2-5)

Cestoda								
Diphyllobothrium sp.	24.2($\frac{16}{66}$)	20($\frac{1}{5}$)	7.6($\frac{1}{13}$)	20($\frac{1}{5}$)	23($\frac{3}{13}$)	70($\frac{7}{10}$)	13.3($\frac{2}{15}$)	49.6(0.1-379)‡
Taenia sp.	21.2($\frac{14}{66}$)	0($\frac{0}{5}$)	23($\frac{3}{13}$)	0($\frac{0}{5}$)	30.7($\frac{4}{13}$)	10($\frac{1}{10}$)	26.6($\frac{4}{15}$)	71.5(15.5-145)‡
Trematoda								
Echinostoma revolutum	3.03($\frac{2}{66}$)	0($\frac{0}{5}$)	7.6($\frac{1}{13}$)	20($\frac{1}{5}$)	0	0	0	6.5(6-7)
Arthropoda								
Dermacentor andersoni — 1 infested bears§								
Arctopsylla sp. — 1 infested bear§								

*Based on total bears examined including animals whose age was not determined. The fraction indicates the number of positive animals over the total number examined.

†Expressed as larvae/gm. of tongue.

‡Volume of tapeworm biomass in ml.

§Represents ectoparasites observed; routine examinations not performed.

nective tissue and superficial musculature, pleural and peritoneal cavities, mesenteries, and the entire gastrointestinal tract including contents. The external surface of the body was sometimes examined for ectoparasites, but frequently was given only a cursory search due to time limitations.

Standard parasitological procedures were used to recover parasites from the gastrointestinal tract. After the contents of the alimentary canal were washed on 20-, 40-, or 80-mesh screens to separate worms from ingesta, the washed contents were searched with the aid of an illuminated tray (Barber & Lockard 1973). Any parasites recovered were fixed in AFA solution (tapeworms and flukes) or glycerine-alcohol (roundworms). Attempts were made to identify and enumerate all parasites recovered in order to assess quantitatively the total parasite population from each host. Qualitative fecal examinations were performed routinely to detect worm eggs and coccidian oocysts, using saturated sodium chloride solution for flotation.

RESULTS

Nine species of parasites were found in 160 grizzlies examined partially or in detail during the period from 1968 through 1973 (Table 1). The most frequent of these was the intestinal nematode *Baylisascaris transfuga*, followed in order of prevalence by the trichina worm (*T. spiralis*), broad fish tapeworm (*Diphyllobothrium* sp.), taeniid tape worm (*Taenia* sp.), and hookworm (*Uncinaria* sp.).

Other parasites, which occurred infrequently or rarely, were intestinal flukes (*Echinostoma revolutum*), filarial worms (*Dirofilaria ursi*) wood ticks (*Dermacentor andersoni*), and fleas (*Arctopsylla* sp.).

The acquisition of ascarid infections by *U. arctos* was related directly to the age of the host. The percentage of infected animals increased from 40% in cubs to 92% in 6 to 9 year-old bears. Ascarid worm burdens averaged 33.8 worms and ranged from approximately 1 worm per cub to an average of 58 ascarids per bear in the 10-15 year age class. Worm populations in other age groups were: 1 and 2 years old, 20; 3-5 years old, 3; 6-9 years old, 52; and 16+ years of age 8.

Tissue infections with *T. spiralis* larvae were the second most frequent parasitism encountered in the grizzly (Table 1). Based on data from 130 bears collected between 1968 and 1972, the prevalence of this nematode varied from 45.1% in grizzlies originating in Yellowstone or Glacier Parks to 58.4% in grizzlies from wilderness areas in northern or western Montana. The average concentration of trichinae in the tissues of Park bears was 32 larvae/gm. of tissue (LPG) compared with 59 LPG in wilderness bears. A comparison of predilection sites of *Trichinella* larvae in 42 grizzlies from which several tissues were examined indicated that larval density was highest in tongue (46 LPG), followed by femoral muscle (17 LPG), masseter (14 LPG) and diaphragm (10 LPG). Grizzlies older than 15 years had the highest prevalence but the lowest intensity of *T. spiralis* infection, as estimated by larval concentrations in the tongue.

The relative intensity of tissue infections was highest in the 3-5 year age class (104 LPG), followed by 1-2 and 6-9 year-old bears (intensities of 97 and 36 LPG, respectively). Ten to 15 year-old bears, cubs and 16+ age classes had levels of infection ranging from 21 to 9 LPG.

Two genera of tapeworms were recovered from grizzlies: a *Diphyllobothrium* species which occurred only in Yellowstone Park bears, and a *Taenia* species which was found throughout the survey area. Based on a volumetric method of determining the total tapeworm biomass per host, taeniid infections averaged 71.5 ml of worm material compared with 49.6 ml for diphyllobothriid populations. The largest tapeworm burden noted during the study was 797 *Diphyllobothrium* in a 14 year-old grizzly collected along the west side of Yellowstone Lake in 1970.

Eight species of parasites were recovered from a total of 80 black bears examined partially or completely during the period from 1966 to 1973 (Table 2). Ascarids were the most common parasite in *U. americanus*, with a composite prevalence of 80% and an average worm burden of 22.7 nematodes per infected host. With two exceptions, all helminths which occurred in grizzlies also were found in black bears. However, the prevalence and intensity of these infections were markedly lower in black bears. Since a majority of the animals on which this study was based originated in the Yellowstone ecosystem in northwestern Wyoming and southwestern Montana, the differences in prevalence of the various helminths and arthropods in the two hosts appear to reflect differences in susceptibility and/or exposure rates resulting from variations in food habits and behavior of the two species.

DISCUSSION

Any assessment of the role of parasites as morbidity or mortality factors in wild bear populations is extremely difficult to document. Individual cases of parasitic disease resulting from excessive parasite burdens have occasionally been observed. Rausch (1955) described a fatal case of *Diphyllobothrium* infection in a young black bear which had been experimentally exposed to an unknown number of plerocercoid larvae. The presence of moderate to large numbers of *Diphyllobothrium* specimens in a few bears in the present study was noted in mature or aged grizzlies which apparently foraged predominantly in inlets and bays of Yellowstone Lake. Most bear infections consisted of from 1 to 100 tapeworms ranging in biomass from 2 to 20 ml.

A potentially detrimental effect of broad fish tapeworms is their ability to absorb large quantities of vitamin B_{12} from the host's intestine. In man, this can result in pernicious anemia due to the inability of the host to synthesize adequate numbers of red blood cells (Von Bonsdorff 1947). The degree of clinical correlation between *Diphyllobothrium* infections in man and bears is not known. However, Cameron (1945) believed that *D. latum* is an indigenous parasite in North America which may have originated in the brown bear. On the other hand, Rausch & Hilliard (1970) found that *D. ursi* was the common pseudophyllidean tapeworm of bears in Alaska. In the present study, the species of *Diphyllobothrium* occurring in Yellowstone Park bears was not determined because morphological criteria were not considered adequate for a definitive identification. Post (1971) reached a similar conclusion after restudying data and specimens from bears collected over a period of many years in the area of Yellowstone Lake.

The high prevalence of ascarids in both grizzly and black bears and their common occurrence in bears of all ages suggest that the functional immune response to this nematode in bears is minimal. This contrasts with the generally accepted concept that ascarid infections are self-limiting and normally are restricted to immature or young adult animals. In human ascariasis, infection rarely persists for more than one year (Faust 1955). The severity of symptoms in human ascarid infection is proportional to the level of larval

TABLE 2. PREVALENCE AND INTENSITY OF PARASITES IN BLACK BEARS FROM MONTANA AND WYOMING

Parasite	Percent positive*	Location	Av. intensity of infection (range)
Nematoda			
Trichinella spiralis	6. 3($\frac{5}{80}$)	striated muscle	18. 1 (0. 02-26. 4)†
Baylisascaris transfuga	80($\frac{24}{30}$)	small intestine	22. 7 (1. 177)
Uncinaria sp.	3. 3($\frac{1}{30}$)	small intestine	23 (—)
Cestoda			
Diphyllobothrium sp.	6. 6($\frac{2}{30}$)	small intestine	11. 5 (0. 2-20)‡
Taenia sp.	6. 6($\frac{2}{30}$)	small intestine	—
Arthropoda			
Dermacentor andersoni	6. 6($\frac{2}{30}$)	external body surface	—
Trichodectes pinguis euarctidos	3. 3($\frac{1}{30}$)	external body surface	—
Pulex sp.	3. 3($\frac{1}{30}$)	external body surface	—

*The fraction indicates the number of positive animals over the total number examined.

†Expressed as larvae/gm. of tongue

‡Volume of tapeworm biomass in ml.

exposure and includes liver damage, intestinal obstruction, pneumonia and a variety of intestinal complications (Arean & Crandall 1971). In view of the widespread occurrence of bear ascarids, they must be considered as one of the most important parasites occurring in *Ursus* spp. in the Montana/Wyoming area.

The potential for trichinosis in grizzly bears ranks *T. spiralis* as a significant parasite in this host. Adverse effects produced by the migrating larval stage in man such as toxemia and elevated body temperature suggest that a similar course of events could occur in bears. A marked inflammatory reaction to the invading parasite in the muscles and other tissues coincides with severe muscle pain, edema, destruction of tissue and blood abnormalities in man (Ribas-Mujal 1971). Gould (1945) estimated that an intake of 3 or 4 trichinae per gram of body weight is lethal in humans. Although considerable variation may exist in the ability of various mammalian species to tolerate the various manifestations of trichinosis, the high intensity of grizzly infections (51.1 larvae per gm. of infected tissue) and the widespread occurrence of the parasite throughout the study area (61.3% infected) implicate it as a potentially serious pathogen of *U. arctos*. Additionally, its ability to alter the host's behavior due to pain associated with the migration of larvae in the muscles cannot be excluded as a possible contributor to the abnormal behavior which is occasionally observed in grizzlies in parks and elsewhere throughout the range of the species.

Further studies are needed to characterize the infectivity and survival of bear strains of *T. spiralis* in swine and laboratory animals, in view of the ability of larvae of bear origin to survive for extended periods of time in frozen tissues. In the present study, viable trichina larvae were recovered repeatedly from tongue, masseter and other bear tissues which had been stored at approximately −20°C. For periods of up to 6 months. These observations contrast with those of Ransom (1916), who found that none of the trichina larvae originating in swine, rats or rabbits survived for as long as 20 days at −15°C. when stored in meat. Present regulations involving cold storage of pork are based in part on the belief that freezing for short periods of time eliminates the possibility of human infection with trichinae. The need to reevaluate this aspect of the biology of *T. spiralis* from bears and prepare specific recommendations for cold storage of bear meat intended for human consumption is obvious.

Hookworms (*Uncinaria* sp.) were found to be relatively common parasites of the grizzly in the area north of the 47th parallel in Montana. Since this infection apparently does not occur in either host species in the Yellowstone region, the percentage of infected bears in the enzootic area of northern Montana (54.5%) is a more accurate indication of its regional frequency. The average worm burden of 128.8 hookworms per infected host suggests that it may constitute a significant drain on northern Montana grizzly populations. Clinical signs of *Uncinaria* infection in other hosts include anemia, hemorrhagic diarrhea and impaired intestinal absorption (Soulsby 1965). Another facet of hookworm infection involves its effect on fetal mortality and survival of newborn animals. Olsen & Lyons (1962, 1965) have shown that death losses occurring in fur seal pups were due to *Uncinaria lucasi* infections acquired shortly after birth via milk-borne larvae transmitted from mother to offspring during nursing. In dogs, hookworms are frequently transmitted across the placenta from the mother to her unborn pups, resulting in abortion or stillbirth (Stone *et al.* 1970). Although none of these problems are known to occur in hookworm-infected bears, the possibility that similar consequences could result deserves serious consideration.

The filarial worm *Dirofilaria ursi* was described from *Ursus torquatus japonicus* in Japan by Yamaguti (1941). In North America, it has been reported in black bears from widely scattered areas, including Ontario (Anderson 1952), New York (King *et al.* 1960), northern Michigan and Minnesota (Rogers 1975), Montana (Jonkel & Cowan 1971) and Idaho (Furniss, pers. comm.). Both infected grizzlies in the present study were collected in northern Montana in mid-summer. Worms were situated in membranous capsules located in connective tissue surrounding the trachea. No information is available on the pathogenesis of this infection in bears.

Infections with the intestinal trematode *Echinostoma revolutum* were noted twice: in a yearling grizzly collected near Slough Creek in Yellowstone Park and in a three-year-old grizzly taken near Augusta in northwestern Montana. This fluke is known to occur in a variety of hosts, including man, dogs, cats, swine, rats, muskrats, rabbits, otters and monkeys (Beaver 1937). The grizzly is apparently an accidental definitive host which acquires the infection by ingestion of various mollusks, tadpoles or fish containing the metacercarial stage.

Although coccidian oocysts were noted occasionally in the feces of both *Ursus* species examined during the study, it was difficult to determine whether they originated in the bears or had been ingested accidentally during the process of scavenging on carcasses of other animals. For this reason, no data are included on the prevalence of coccidia. This aspect of parasitism in bears remains an obscure subject, although Hair & Mahrt (1970) described *Eimeria albertensis* and *E. borealis* from black bears in Alberta. Their work constituted the first report of coccidia from ursids in North America.

The relatively common occurrence in grizzly bears of trichina worms, ascarids and hookworms and the frequency of concurrent infections with two or more species of helminths suggest that internal parasites may have a substantial effect on the health of grizzly populations which are subjected to other environmental stresses. Complications resulting from parasitism superimposed on malnutrition or other problems no doubt contribute to some grizzly mortality in the field. The types and intensities of parasitism occurring in grizzlies throughout the study area probably would not produce recognizable symptoms of acute disease. However, the overall impact of parasitic disease on the well-being of existing populations of grizzly bears in the United States clearly requires further investigation. The clinical effects of parasitism in black bears would be expected to be much less pronounced because of lower rates of infection and less intensive parasite burdens. The ability of both species to act as reservoirs of certain human parasites, particularly *T. spiralis*, indicates that bears may be largely responsible for the maintenance of zoonoses such as trichinosis in the northern Rocky Mountain region.

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