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PARASITES OF THE ARCTIC FOX (*ALOPEX LAGOPUS*) IN ICELAND

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ABSTRACT: Forty-four of 50 arctic foxes (*Alopex lagopus*) in Iceland harbored 15 species of intestinal parasites, including Protozoa: *Eimeria* sp. or *Isospora* sp. (in 4%); Trematoda: *Cryptocotyle lingua* (24%), *Plagiorchis elegans* (4%), *Brachylaemus* sp. (12%), *Tristriata* sp. (10%), and *Spelotrema* sp. (8%); Cestoda: *Mesocestoides canislagopodis* (72%), *Schistocephalus solidus* (2%), and *Diphyllobothrium dendriticum* (4%); Nematoda: *Toxascaris leonina* (50%), *Toxocara canis* (2%), *Uncinaria stenocephala* (4%), and eggs of the lung worm *Capillaria aerophila* (6%); and Acanthocephala: *Polymorphus meyeri* (8%) and *Corynosoma hadweni* (2%). Only four of the species previously had been recorded in Iceland. Eleven species are new records in Iceland and six appear to be new host records. Two additional nematodes, *Stegophorus stercorarii* and *Syphacia* sp., probably were ingested accidentally with the prey. Foxes from coastal habitats harbored 14 parasitic species while only five species were found in foxes from inland habitats. Arctic foxes from coastal habitats generally had higher helminth burdens and harbored more parasitic species per fox than foxes from inland habitats.

Key words: Parasites, arctic fox, *Alopex lagopus*, Iceland, habitats.

INTRODUCTION

Krabbe (1865) and Baer (1962) found the cestode *Mesocestoides canislagopodis* (syn. *Taenia Canis lagopodis*) (Rudolphi 1810) in the arctic fox (*Alopex lagopus*) in Iceland. However, no more cestodes were found in an examination of 80 arctic foxes caught from 1960 to 1975 (Pálsson, 1984). Two other parasites of the arctic fox, the ear canker mite *Otodectes cynotis* (Gunnarsson et al., 1991) and the sporozoan *Encephalitozoon cuniculi* (Hersteinsson et al., 1993) also have been found. Our objective was to determine the parasites present in arctic foxes of western and northern Iceland.

MATERIALS AND METHODS

Intestines of 50 arctic foxes caught in 1986 and 1987 in the western and northern parts of Iceland, from Thingvellir to Eyjafjordur (64°10′ to 66°24′N, 18°05′ to 24°30′W) were examined for parasites. They were chosen from this area to search for the cestode *Taenia ovis*. Data were obtained for each fox as regards killing site, date of death, and sex. Age was determined by counting cementum annuli in histological sections of teeth (Allen and Melfi, 1985). One fox was caught in March, another in May, and the rest in the months of June and July. Twenty-eight foxes were caught in coastal habitats and 22 in inland habitats according to Hersteinsson's (1984) classification of habitats. The ages ranged from 2 mo to 11 yr, four were pups, 21 were yearlings, 10 were 2-yr-olds and 15 were 3 to 11-yr-olds. The age distribution was similar in both habitats. There were equal numbers of each sex.

The gastrointestinal tracts were removed during autopsy and kept frozen until examined for parasites. After thawing, the gut was cut open and washed in a stream of water; the contents were passed through a mesh with an aperture of 100 μm. The contents of the small intestine and the cecum and colon were examined separately for parasites under a stereoscope. All parasites were counted, identified and preserved in 10% formalin. When a great number of some parasitic species was present, subsamples were taken in order to estimate the total numbers. If necessary, the helminths were cleared in lactophenol or stained in carmalum (Kruse and Pritchard, 1982) for identification. The identification of the parasites, particularly the trematodes, was sometimes difficult because of partial decomposition. The helminth identifications were based on the descriptions of Dawes (1968), Georgi (1974), Krabbe (1865), McDonald (1981), Petrochenco (1971), Soulsby (1965), Thienpont et al. (1979) and Wardle and McLeod (1952).

Fecal samples from the rectum of the foxes were examined for the presence of coccidian protozoans and helminth eggs using standard concentration or sedimentation techniques (Allen and Ridley, 1970; Helle, 1971; Young et al., 1979).

Chi-square (χ^2) tests of independence (Sokal and Rohlf, 1969) were used to compare the prevalence of parasites in coastal and inland habitats.

TABLE 1. Occurrence and prevalence of parasite species in the arctic fox (*Alopex lagopus*) in two different habitats in Iceland.

	Coastal foxes (n = 28)	Inland foxes (n = 22)	Total (n = 50)
Sporozoa	2 (7)[a]	0 (0)	2 (4)
Eimeria sp. or *Isospora* sp.[b]	2 (7)	0 (0)	2 (4)
Trematoda	20 (71)	0 (0)	20 (40)
Cryptocotyle lingua[b]	12 (43)	0 (0)	12 (24)
Plagiorchis elegans[b]	2 (7)	0 (0)	2 (4)
Brachylaemus sp.[b,c]	6 (21)	0 (0)	6 (12)
Tristriata sp.[b,c]	5 (18)	0 (0)	5 (10)
Spelotrema sp.[b,c]	4 (14)	0 (0)	4 (8)
Cestoda	23 (82)	13 (59)	36 (72)
Mesocestoides canislagopodis	23 (82)	13 (59)	36 (72)
Schistocephalus solidus[c]	1 (4)	0 (0)	1 (2)
Diphyllobothrium dendriticum	2 (7)	0 (0)	2 (4)
Nematoda	18 (64)	11 (50)	29 (58)
Capillaria aerophila[b]	1 (4)	2 (9)	3 (6)
Toxascaris leonina[b]	17 (61)	8 (36)	25 (50)
Toxocara canis	0 (0)	1 (5)	1 (2)
Uncinaria stenocephala[b]	1 (4)	1 (5)	2 (4)
Acanthocephala	4 (14)	0 (0)	4 (8)
Polymorphus meyeri[b,c]	4 (14)	0 (0)	4 (8)
Corynosoma hadweni[b,c]	1 (4)	0 (0)	1 (2)

[a] Number (percent) infected.
[b] New record for Iceland.
[c] Not recorded previously in the arctic fox.

RESULTS

Fifteen species of parasites were found in the alimentary tracts of 44 (88%) of the 50 foxes examined (Table 1). A great difference was in parasitic burdens and in number of species in foxes from the two different habitats, coastal and inland. Fourteen parasite species were found in foxes inhabiting coastal areas and only one (4%) fox from the coastal area was free of intestinal parasites (Table 1). Five species were found in foxes originating from inland areas and five (23%) foxes from this habitat were free of parasites (Table 1).

Most (64%) foxes harbored ≤2 species of parasites but 36% harbored three to six species. Coastal and inland foxes differed significantly ($P < 0.001$) in this respect. Each coastal fox harbored ≤6 species ($\bar{x}$ = 3.1; SE = 0.3) while each inland fox harbored ≤3 ($\bar{x}$ = 1.1; SE = 0.2).

Protozoa: *Eimeria* sp. or *Isospora* sp. oocysts were found in the feces of one fox and in microvilli in the small intestine of another animal. The oocysts were in poor condition and could not be identified.

Trematoda: Five species of trematodes were found. Twenty (71%) of the 28 coastal foxes harbored one or two species whereas the 22 inland foxes had none. *Cryptocotyle lingua* was found in twelve coastal foxes (six males, six females) in numbers ranging from 1 to 130,000 ($\bar{x}$ = 12,280; SE = 10,807). The two most heavily infected foxes carried 15,000 and 130,000 worms, respectively. Most parasites were found in the small intestine, although some (<1%) were recovered from the colon and cecum. *Plagiorchis elegans* was found in the small intestine of two coastal foxes, with 1 and 47 specimens, respectively. *Brachylaemus* sp. (Brachylaimidae) was found in six coastal foxes, in numbers ranging from 1 to 49 ($\bar{x}$ = 10; SE

= 7.8) worms per host; most (95%) were found in the small intestine, although some (5%) were recovered from the colon and cecum. The trematodes found were stout and cylindrical, 1.8 to 3.1 mm in length, 0.5 to 1.0 mm in width; the size of eggs was 25 to 34 × 17 to 25 μm. *Tristriata* sp. (Notocotylidae) was found in five coastal foxes, in numbers ranging from 1 to 134 ($\bar{x}$ = 38; SE = 26) worms per host. Most (88%) were found in the colon and cecum, although some (12%) were recovered from the small intestine. The trematodes found in the Icelandic foxes were 3 to 8 mm long. The eggs measured 23 to 28 × 11 to 16 μm and had very long polar filaments at the polar plugs. *Spelotrema* sp. (Microphallidae) was found in four coastal foxes in numbers ranging from 1 to 980 ($\bar{x}$ = 250; SE = 243) worms per host. Most (98%) worms were found in the small intestine, but 2% were recovered from the colon and cecum. The trematodes found in the Icelandic foxes were 1.0 to 1.3 mm long and 0.3 to 0.4 mm wide; the eggs were 26 to 29 × 11 to 13 μm.

Cestoda: Three species of cestodes were found. Twenty-three coastal foxes and 13 inland foxes harbored cestodes; they had only one or two species each. *Mesocestoides canislagopodis* was the most common parasite found in this study. The cestode was found in 23 (82%) of the coastal and 13 (59%) of the inland foxes. The prevalences were not statistically different. Intensity ranged from 1 to 5,950 ($\bar{x}$ = 502; SE = 174) worms per host. Nine foxes harbored 500 or more cestodes and six foxes carried more than 1,000 worms. Twenty-three (92%) of 25 foxes ≥2 yr old were infected. Of the remaining 25 pups and yearlings, only nine (36%) were infected with the parasite. Most worms were found in the small intestine but occasionally were recovered from the colon. *Schistocephalus solidus* was represented by a single mature specimen from the small intestine of a yearling caught in coastal habitat. *Diphyllobothrium dendriticum* occurred in two coastal foxes, an adult breeding pair caught at the same den. The cestodes were found in the small intestine; four were in one animal and eight in the other.

Nematoda: Four species of nematodes were found. Twenty-nine foxes were infected, each animal harbored either one or two nematode species. The prevalence of the nematodes was similar in coastal and inland foxes. *Capillaria aerophila* eggs (size: 68 to 74 × 34 to 37 μm) were found in the feces of one coastal and two inland foxes. *Toxascaris leonina* was the second most prevalent parasite (Table 1). There were 1 to 58 ($\bar{x}$ = 5.4; SE = 2.3) *T. leonina* per infected fox with most of the worms recovered from the small intestine. Thirteen (52%) of the foxes infected were yearlings, but the animal with the highest worm burden was a 2-yr-old. *Toxocara canis*, the dog ascarid, was represented by a single immature specimen in the small intestine of an inland pup. *Uncinaria stenocephala* was found in the small intestine of two foxes; a single worm occurred in each animal.

Stegophorus stercorarii was found in four coastal foxes and *Syphacia* sp. was found in two coastal foxes. Foxes probably are not natural hosts for those nematodes. We assume that these worms were accidentally ingested with the prey. *Stegophorus stercorarii* was always found among remains of the fulmar (*Fulmarus glacialis*) and the pinworm *Syphacia* sp. was found among remains of the field mouse (*Apodemus sylvaticus*). Neither of these two nematodes had been recorded previously in Iceland.

Acanthocephala: Two species of acanthocephalans were found in four of the coastal foxes. One fox harbored both species. *Polymorphus meyeri* was found in four coastal foxes in numbers ranging from 1 to 228 ($\bar{x}$ = 70; SE = 54). The acanthocephalan was recovered from the small intestine (68%) and the colon and cecum (32%). *Corynosoma hadweni* was represented by two specimens found in the small intestine of one coastal fox.

Small craterlike ulcers, up to 2 mm in

diameter, were seen in the wall of the colon and cecum of many foxes. We assume that these ulcers might be signs of a previous acanthocephalan infection. We looked for ulcers in 21 coastal foxes and in 15 inland foxes. They were present in 19 (90%) coastal foxes and in eight (53%) inland foxes. The difference in prevalence was statistically significant ($P = 0.0112$).

Voucher specimens: The following specimens have been deposited in the Icelandic Museum of Natural History, Hlemmur 3, 105 Reykjavík, Iceland: *Cryptocotyle lingua* (accession number E391-87, Al 1564), *Plagiorchis elegans* (E469-86, Al 1431), *Brachylaemus* sp. (E345-87, Al 1508), *Tristriata* sp. (E384-87, Al 1563), *Spelotrema* sp. (E343-87, Al 1506), *Mesocestoides canislagopodis* (E337.1-86, Al 1334), *Schistocephalus solidus* (E469-86, Al 1431), *Diphyllobothrium dendriticum* (E346-87, Al 1509), *Toxascaris leonina* (E235-86, Al 1281), *Toxocara canis* (E241c-86, Al 1303), *Uncinaria stenocephala* (E236-86, Al 1282), *Polymorphus meyeri* (E391-87, Al 1564), *Corynosoma hadweni* (E391-87, Al 1564), *Stegophorus stercorarii* (E230-86, Al 1278) and *Syphacia* sp. (E192-87, Al 1477).

DISCUSSION

Four of the species found in this study had been recorded previously in Iceland but 11 were recorded for the first time (Table 1). There was a marked difference in number of species and prevalence of parasites between arctic foxes feeding in coastal areas and those living inland (Table 1); this may reflect differences in the foods available to foxes in the two ecologically different habitats. The trematodes, two of the cestodes, and both acanthocephalans found require marine or freshwater invertebrates or fish as intermediate hosts to complete their life-cycles. The cestode, *M. canislagopodis*, requires terrestrial animals as intermediate hosts. The protozoan and nematode parasites found have direct life-cycles, although mice may serve as paratenic hosts for *T. canis* and *T. leonina* (Soulsby, 1965; Mehlhorn, 1988).

Protozoa: There are no previously published records of coccidian parasites in arctic foxes in Iceland.

Trematoda: The high abundance and prevalence of *C. lingua* came as a surprise since its larval stages never have been recorded from intermediate hosts from Icelandic coastal waters. Marine snails, *Littorina littorea*, can serve as the first intermediate hosts (Stunkard, 1930; Werding, 1969; Køie, 1977) but this species is not found in Iceland. Many marine fish species can serve as the second intermediate hosts (Christensen and Roth, 1949). The usual definitive hosts for *C. lingua* are gulls, terns, and other fish-eating birds; but the trematode also has been found in seals, dogs, farmed foxes (Christensen and Roth, 1949; Malczewski, 1962; Soulsby, 1965; Grabda, 1991), and occasionally in humans (Babbot et al. 1961; Noble et al., 1989). *Plagiorchis elegans* has been found previously in the arctic fox and in other canids in the Holarctic region (Rausch et al., 1983). Apparently mature *Brachylaemus* spp. have not been reported previously in carnivores; they usually occur in birds and rodents (Ubelaker and Dailey, 1966; Dawes, 1968). Our specimens of the genus *Tristriata* fit the description of McDonald (1981) and are consistent with *T. elegans*. *Tristriata* spp. have been recorded only from birds; the source of infection is unknown (McDonald, 1981). Three species of Microphallidae have been recorded from Icelandic birds, *Spelotrema pygmaeum* and two species of *Gymnophallus* (Brinckmann, 1956). The helminth found in the arctic fox in this study, *Spelotrema* sp., is not *S. pygmaeum* (Dawes, 1968) and seems to be the first record of a new species in Iceland. Microphallid trematodes occur in various shorebirds (Dawes, 1968) but have not been recorded from mammals.

Cestoda: Mesocestoides canislagopodis originally was recorded and described by Krabbe (1865) from dogs, cats, and one arctic fox in Iceland. A redescrip-

tion of *M. canislagopodis* from our material, together with discussion on the possible life cycle of the species, has been published (Loos-Frank et al., 1992). In Iceland, rodents might possibly serve as intermediate hosts (Loos-Frank et al., 1992). The increased prevalence of *M. canislagopodis* in Iceland with increasing age of foxes almost certainly is due to the longevity of the worms (Loos-Frank et al., 1992). Many bird species in Iceland have been recorded as definitive hosts for *S. solidus* (Baer, 1962). Several publications record *Diphyllobothrium* larvae in Icelandic freshwater fishes and adult cestodes in birds and mammals (Krabbe, 1865; Baer, 1962; Richter, 1982; Malmquist et al., 1986; Eydal, 1989). *Diphyllobothrium dendriticum* has been identified from a gull (*Larus marinus*) in Iceland (Baer, 1962) but this is the first report from the arctic fox in Iceland. The cestode appears to be rather uncommon in arctic foxes elsewhere (Rausch et al., 1983).

Nematoda: Capillaria aerophila inhabits the lungs of foxes and many other carnivores world-wide (Soulsby, 1965). *Toxascaris leonina* is a common nematode of canids in the arctic and subarctic regions but its prevalence in arctic foxes varies geographically (Rausch et al., 1983). *Toxocara canis*, a cosmopolitan nematode of many carnivores (Malczewski, 1962; Soulsby, 1965), is a well known parasite of dogs in Iceland (Krabbe, 1864; Kreis, 1958; Richter, 1981) but this is the first record from the arctic fox in Iceland. *Uncinaria stenocephala* occurs in several carnivore species world-wide (Malczewski, 1962; Soulsby, 1965). It has been found in arctic foxes in Greenland and other northern regions but its prevalence usually is low (Rausch et al., 1983).

Acanthocephala: We have not been able to find any records of *P. meyeri* in mammals; the usual final hosts are ducks. *Corynosoma hadweni* occurs naturally in many seal species in Alaska (Van Cleave, 1953; Petrochenco, 1971) but we have not been able to find records of this species in terrestrial mammals.

Many of the helminths found in the foxes seem to be opportunistic parasites in the final host. Some are known to have a wide host range, including the trematodes *C. lingua* and *Brachylaemus* sp., and the cestodes *S. solidus* and *D. dendriticum*. As is common among acanthocephalans, *P. meyeri* and *C. hadweni* seem to be able to thrive in many unrelated hosts. A total of six species found in this survey apparently have not been recorded previously from the arctic fox (Table 1). None are believed to be host specific.

The cysticerci (larval stages) of two cestode species, *Taenia ovis* (first found in Iceland in 1983) and *T. hydatigena* are found occasionally in sheep in Iceland, but *Echinococcus granulosus* seems to have been eradicated and *Multiceps multiceps* has not been found for decades (Pálsson, 1984; Richter et al., 1984, 1985, 1987). The absence of taeniid cestodes in the arctic foxes examined in this survey does not necessarily exclude the arctic fox as a host.

Several papers report intestinal parasites in arctic foxes in other northern regions, such as in the Soviet Union, North America, and Greenland (Heptner and Naumov, 1974; Eaton and Secord, 1979; Rausch et al., 1983). Farm foxes also have been examined (Malczewski, 1962; Romaniuk and Bogdan, 1982). Rausch et al. (1983) found eight species of intestinal helminths in 38 foxes examined in Greenland, compared to 14 helminth species found in the 50 foxes in this study. Four of the species found in Greenland, *P. elegans, D. dendriticum, U. stenocephala* and *T. leonina* also were found in this survey. In previous studies on parasites in wild arctic foxes, prevalences reported usually are low for *P. elegans, D. dendriticum* and *U. stenocephala*, and variable but usually high for *T. leonina* (Rausch et al., 1983). This is consistent with the observed prevalences in Greenland and Iceland except for *P. elegans* which was the most prevalent of

the eight species reported in Greenland; it was found in 45% of the foxes. The difference between the helminth fauna in foxes in Greenland and Iceland probably is due to differences in the availability of various intermediate hosts. It is likely that arctic foxes from Greenland on rare occasions enter Iceland on drift-ice (Gunnarsson et al., 1991). The foxes examined by Rausch et al. (1983) in Greenland originated from the west coast. The parasitic fauna of foxes from the east coast of Greenland perhaps would exhibit more similarities as it lies closer to Iceland.

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