NEMATODIRELLA ALCIDIS (NEMATODA: TRICHOSTRONGYLOIDEA) IN MOOSE OF NORTHWESTERN ONTARIO

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ABSTRACT: Examination of the abomasum, duodenum and/or feces of wild moose (*Alces alces*) from northwestern Ontario revealed only two species of gastro-intestinal helminths. *Nematodirella alcidis* was present in 19 of 20 (95%) animals examined. A mean of 111±54 (± S.E.) N. alcidis was recovered from infected animals but only 21% of the specimens were mature adults. Immature specimens predominated at all times of the year sampled. Most were short, fourth-stage larve (3.2-4.0 mm long), but longer fourth-stage (5.6 - 7.1 mm) and immature fifth stage worms (9.0 - 14.5 mm) were also present. It is suggested that the development of some *N. alcidis* in moose is arrested at the early fourth larval stage. Although sample sizes were small, host age, sex, and season did not appear to affect the prevalence or intensity of *N. alcidis*. Eggs of the tapeworm, *Moniezia* sp, were detected in the feces of only 2 of 17 moose. No abomasal nematodes or their eggs were found in any of the animals examined.

ALCES VOL. 24 (1988) pp.159-163

The study of gastro-intestinal helminths in such a large herbivore as moose (*Alces alces*) presents obvious problems. Although reports of several incidental studies exist in the literature (see review by Lankester 1987), it may not be surprising that only 2 involve the examination of relatively large numbers of animals (Samuel *et al.* 1976, Stock and Barrett 1983). Our findings on examining the upper gastro-intestinal tract of moose in northwestern Ontario add to this growing body of information.

METHODS

Viscera and/or feces from 20 wild moose from northwestern Ontario were examined for gastro-intestinal helminths. Material from the 20 animals included the abomasum from 14, duodenum from 14, and feces from 17. A 10% subsample of the abomasal contents and all material from within the first 1 m of duodenum were washed separately with running water through a 0.8 mm screen, placed in gridded Petri dishes and examined using a stereo-microscope at 6 to 25X. Material scraped from the wall of these organs also was included. The mucosal lining was inspected directly using a microscope. Feces were examined for ova using a sugar centrifugation technique (see Samuel and Trainer 1969). The ranges of length given for larval and mature worms were detemined by measuring at least 6 specimens, including the longest and shortest in the samples.

Samples from moose collected September to December were provided by hunters; material obtained at other times were from moose killed by vehicles. Animals less than 2 yr were aged by tooth eruption; the teeth of older moose were sectioned and cementum lines were counted (Sergeant and Pimlott 1959).

RESULTS

At least one animal was examined in each month except February, April, and June (Table 1). Eggs, adults, or immature larvae of *Nematodirella alcidis* were recovered in all months from 19 of 20 moose. Only a 3.5-year-old moose killed in October was uninfected. There was a mean of 111±54 (mean ± S.E.) *N. alcidis* in each of 12 duodena containing nematodes but only 21% of these specimens were mature males and females. A few specimens of *N. alcidis* occasionally were recovered in the abomasum.

Immature specimens which predominated at all times of the year included two sizes of fourth-stage larvae as well as immature, fifth-

Table 1. Numbers of *Nematodirella alcidis* in the first m of duodenum and eggs in feces of moose from northwestern Ontario.

No.	Date	Sex	Age (yrs)	EPG[a]	Mature	Immature[b]	Total
1.	Jan. 88	F	1+	85	[c]	-	-
2.	Mar. 86	M	2+	43	-	-	-
3.	May 86	-	-	13	-	-	-
4.	May 86	-	-	9	-	-	-
5.	May 86	-	-	7	-	-	-
6.	May 85	M	5+	1	9	26	35
7.	July 84	M	5+	0	0	5	5
8.	Aug. 85	F	<1	-	Pd	P	P
9.	Aug. 85	F	1+	-	142	420	562
10.	Sept. 84	F	<1	2	-	-	-
11.	Oct. 84	M	1+	18	1	0	1
12.	Oct. 84	F	2+	1	1	0	1
13.	Oct. 84	M	1+	1	20	40	60
14.	Oct. 84	M	3+	0	0	0	0
15.	Oct. 84	M	5+	0	0	4	4
16.	Oct. 85	F	2+	-	13	6	37
17.	Nov. 84	M	1+	21	3	0	3
18.	Dec. 84	F	3+	0	0	11	11
19.	Dec. 84	M	1+	0	1	190	191
20.	Dec. 84	M	8+	21	101	315	416

[a] Eggs/g of dry feces.
[b] Immature worms include inhibited fourth-stage larvae, developing fourth-stage larvae, and non-gravid females and males without sclerotized spicules.
[c] Either feces or duodenum not examined.
[d] Present but not counted.

stage worms. Most of the fourth-stage larvae were short (3.2 - 4.0 mm) with a tail having a terminal spine. Twelve, longitudinal cuticular ridges (the synlophe of Lichtenfels and Pilitt 1983) were present at the level of the esophageal-intestinal junction and continued posteriorly to the anus. The cephalic vesicle was 75 - 98 μm long. Other fourth-stage larvae were longer (males 5.6 - 6.8; females 5.8 - 7.1).

Immature, fifth-stage worms were 9.2 - 12.9 mm (males) and 9.0 - 14.5 mm (females); females were not gravid and spicules were only lightly sclerotized in males. The precise stage of development of immature specimens in 4 moose (nos. 9,16,19,20) was determined. In these animals, respectively, the numbers of short, fourth-stage larvae relative to developing 4th and 5th-stage worms were 227:193, 30:6, 151:39, and 262:53. Sexually mature males and females were up to 17.2 and 25.0 mm, respectively.

Few eggs of *N. alcidis* were recovered from moose feces. Counts ranged from 1 - 85 eggs per g of dried feces (EPG) but generally, there were fewer than 10 EPG. No lesions attributable to *N. alcidis* were observed in the mucosa of the duodenum or abomasum of any moose examined.

Eggs of *Moniezia* sp. were recovered from the feces of 2 of 17 moose. No other gastrointestinal helminths were detected by fecal flotations or at necropsy.

DISCUSSION

Nematodirella alcidis (Dikmans 1935) Ivashkin 1954, is circumpolar in distribution and may be specific to moose (Drozdz and Bylund 1970, Lichtenfels and Pilitt 1983). However, Stock and Barrett (1983) found specimens in wapiti (*Cervus elaphus canadensis*) in Alberta which could not be distinguished from those in moose and Nilsson (1971) reported *Nematodirella alcidis* from roe deer (*Capreolus capreolus*) in Sweden. Duodenal nematodes from moose have been referred to as *Nematodirella* sp., *N. longispiculata*, *N. longissimespiculata*, and *N. alcides* (sic) (see review by Lankester 1987). Lichtenfels and Pilitt (1983) studied specimens collected from moose in Alaska, Alberta, Minnesota and Montana as well as specimens previously studied from moose in Alberta by Cowan (1951) and Samuel *et al.* (1976) and concluded that all were *N. alcidis*. Unidentified species of *Nematodirella* have been reported from moose in Newfoundland (Threlfall 1967), Ontario (Peterson 1955) and British Columbia (Cowan 1946).

In the present study, the prevalence of *N. alcidis* was high (95%) but the mean intensity was low (111±54). The mean number of mature worms in each infected animal was even lower (23±14) comprising only 21% of the specimens recovered. The high prevelance and low intensities found here generally are consistent with other reports of *Nematodirella* in moose. Threlfall (1967) found from 61-277 worms in the anterior one-third of the intestine in each of 10 moose. Olsen and Fenstermacher (1942) found 47% of 30 animals infected. In the first 1.5 m of duodenum, Stock and Barrett (1983) found 1-250 (x=38) in 52% of 140 moose. Nilsson (1971) found 100% of 19 infected with as many as 600 worms in one animal. Hoeve *et al.* (1988) found 100% of 16 moose from eastern Ontario infected with *N. alcidis*, each having from 3-1,009 worms in the first 15 m of intestine examined. Samuel *et al.* (1976) found from 48-74% of 69 animals infected including 58% of 19 calves 4-9 months and 66% of 47 adults >16 months. Although our sample sizes are small, there similarly were no obvious differences in prevalence or intensity of *N. alcidis* infection in young and old animals.

Although conclusive data may be lacking, it is tempting to suggest that the short, fourth-stage larvae of *N. alcidis*, found in moose throughout much of the year, are arrested in their development. Such forms have been reported among the Nematodirinae for *Nematodirella filicollis* by Nilsson (1971) and *Nematodirus abnormalis* by Beveridge *et al.* (1985). Suggested causes of the cessation of larval development are environmental conditions experienced by free-living stages, host immunity, or over-crowding (Michel 1974). However, none of these explanations are well substantiated by observations here on *N. alcidis*. Large proportions of inhibited larvae occur throughout much of the year suggesting that seasonal environmental changes are not responsible. Total numbers of worms and numbers of inhibited larvae seem unrelated to age and therefore the host's immune competence or status is unlikely a strong determinant. And finally, *N. alcidis* is never so numerous that over-crowding *per se* would be expected to inhibit development.

The presence of a large proportion of arrested or inhibited larvae is an innate feature of some trichostrongyloid nematodes and probably a strategic feature of a species' life history. Watkins and Fernando (1986) have suggested that inhibited larvae of *Obeliscoides cuniculi*, a parasite of rabbits, serve as a reservoir to replenish adult worms that are lost. Inhibited larvae of *N. alcidis* may ensure that adults are present and able to disseminate eggs throughout the year. It is interesting to note that the eggs and infective larvae of *N. alcidis* survive freezing and dessication (Fruetel 1987) and may live for extended periods in soil and on vegetation.

Nematodirella alcidis is present in a large

portion of the moose population including animals of all ages but only low numbers of worms occur and only a small proportion are sexually mature. In comparison, the life-history strategy of *N. longissimespiculata*, the duodenal nematode of caribou (*Rangifer tarandus*) is different (Fruetel 1987). Only caribou less than one year old are infected. Older animals, except for a few males during the rut, resist infection. Larger numbers of duodenal worms are seen in young caribou (up to 1220) and almost all of the worms are sexually mature. Calves become infected in their first summer, pass eggs in fall and winter and are free of infection by spring. The eggs of *N. longissimespiculata* also survive freezing and larvae are available on range to infect the new calf cohort the following summer (Fruetel 1987).

Age immunity, similar to that seen in caribou with *N. longissimespiculata*, is known among Nematodirinae in domestic animals (Brunsdon 1962, Smith and Archibald 1968). Older moose, however, do not appear to develop an immunity to infection with *N. alcidis*, perhaps because numbers of adult worms are so low.

Moniezia spp. (including reports of *M. expansa*, *M. benedeni* and *M. evansi*) have been reported from moose across most of their range in North America (Lankester 1987). Prevalence of infection generally is low. Olsen and Fenstermacher (1942) found 16% of moose in Minnesota infected and Samuel *et al.* (1976) reported 15% infected in Alberta.

No abomasal worms were found in this study. A variety of species are common in moose of Scandinavia (Drozdz and Bylund 1970, Nilsson 1971) but few have been reported in moose of North America. In Alberta where they commonly share range with other ungulates, unidentified species of *Ostertagia* (see Barrett 1972, Stock and Barrett 1983) and *Trichostrongylus axei* have been reported from the abomasum of moose (Stock and Barrett 1983).

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