Prevalence of gastrointestinal nematodes in winter slaughtered reindeer of northern Finland

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Abstract: The objective of this study was to determine the prevalence and intensity of gastrointestinal nematodes in winter-slaughtered reindeer during 2002-2004, from northern reindeer herding cooperatives in Finland. *Ostertagia gruehneri* of the abomasum was prevalent with low levels of infections in 100% of calves, (n = 53; mean ≈ 1300 worms per animal) and in 98% of adults, (n = 41; mean ≈ 3900 worms per animal). There was no difference in the number of *O. gruehneri* between male and female calves. The proportion of *O. gruehneri* inhibited larvae was significantly higher in calves (81%) than in adult reindeer (39%) (P = 0.005). The intestinal nematodes, *Nematodirus tarandi* and *Nematodirella longispiculata,* were detected only in reindeer calves. The numbers of these worms did not differ between male and female calves, but there was a difference in abundance between sites. High prevalence and low intensity of gastrointestinal nematodes characterized the patterns of infection of the reindeer examined in this study. It is assumed that these infections are sub-clinical and would not contribute to productivity losses.

Key words: arrested development, Nematodirinae, *Ostertagia gruehneri*, parasites, semi-domesticated reindeer.

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Introduction

Semi-domesticated reindeer represent an important livestock industry in northern Finland. They are likely to be affected by similar productivity constraints as domestic ruminants, such as sheep, goats, and cattle. Many studies throughout the world have shown that nematode parasitic infections have deleterious effects on grazing livestock (McLeod, 1995; Perry *et al.,* 2002), with losses due to mainly sub-clinical infections resulting in reduced productivity, rather than mortality (Waller, 2005).

There are few areas in Fennoscandia (Norway, Sweden, and Finland) where reindeer are free ranging year-round on natural pastures, without overlapping home ranges with domestic ruminants. In the extreme north of Finland, reindeer are managed with little or no competition from domestic ruminants or wild ungulates. In many of the southern reindeer herding cooperatives in Finland, reindeer may be confined in corrals during the winter months to receive supplemental feed. During the spring and early summer it is not uncommon for sheep to occupy the same fenced areas (S. Laaksonen, pers. comm.). Hrabok *et al.* (2006a) showed that reindeer are suitable hosts for nematodes of sheep (*Haemonchus contortus, Teladorsagia circumcinta*) and cattle (*Ostertagia ostertagi, Cooperia* spp.). Handeland & Sparboe (1991) have also demonstrated that the meningeal nematode of reindeer, *Elaphostrongylus rangiferi*, can be transmitted to conventional domestic ruminants. Therefore, the risk of spread of nematode infection between sheep, goats, cattle and reindeer should not be overlooked.

Many northern Sami reindeer herders utilize a combination of traditional and modern methods of herding which vary considerably between cooperatives, dependent upon their size, quality of vegetation, parasite control methods, and risk of predation. Environmental variables such as precipitation, snow depth, insect harassment, temperature, wind, and light/darkness regime directly influence herd management and productivity, however the importance of nematode parasitism in reindeer managed in these co-operatives is largely unknown.

With the aim of determining the seasonal transmission pressure of nematode parasites in reindeer of northern Finland, an epidemiological investigation was conducted at the Kutuharju Experimental Reindeer Station, Kaamanen, whereby contamination of pastures was monitored monthly over a 2.5 year period by conducting nematode faecal egg counts on calves and adult female reindeer, as well as assessing pasture infectivity, using the tracer animal technique (Hrabok *et al.*, 2006b).

The current study was undertaken to complement the above investigation to determine the prevalence and intensity of naturally occurring gastrointestinal nematode infections in the neighbouring reindeer cooperatives, where the animals are managed according to the usual Sami herding methods of northern Finland.

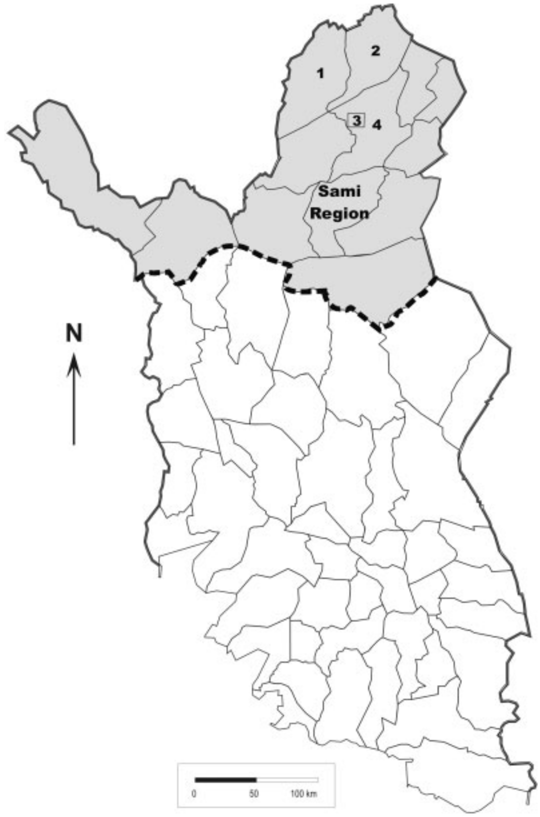

Fig. 1. Reindeer herds studied for the prevalence of gastrointestinal nematodes in the Sami region. The whole map represents the Finnish Reindeer Husbandry Area. Investigated cooperatives are: 1. Paistunturi, 2. Kaldoaivi, and 4. Muddusjärvi. Area 3 surrounded by a quadrangle identifies the general location of the fenced-in Kutuharju Experimental Reindeer Herd.

Material and methods

Study area and animals

This study was conducted in the Sami Reindeer Husbandry Region in northern Finland (approx. 69°48′N, 26°49′E to 69°54′N, 27°01′E). Reindeer belonged to four discrete herds comprising the Paistunturi, Kaldoaivi, and Muddusjärvi Cooperatives, and the Kutuharju experimental herd (Fig. 1). Herds ranged in size from 6000 to 7000 reindeer with exception of Kutuharju with only 200 animals. A post-harvest winter population structure of all herds was approximately 50% adult females, 30% calves, 15% castrated males, and 5% bulls. Grazing areas ranged in size from 2500 to 3000 km^2 in the Paistunturi, Kaldoaivi, and Muddusjärvi cooperatives, and 42 km^2 at Kutuharju. Grazing regions were sub-divided into summer and winter pastures, with population densities of 2.3 to 2.5 reindeer per km^2 at Paistunturi, Kaldoaivi, and Muddusjärvi, and 11 reindeer per km^2 at Kutuharju. The herds had a history of being anti-parasitic treated once per year with ivermectin (Ivomec SC® 10 mg/ml vet. inj. Merial; [RDR] 200 μg/kg, or generic product) between October and December during the winter roundups, for approximately the preceding seven years. Adult animals in this study were de-wormed the previous winter (~12 months) and the current season cohort of calves had never received anthelmintics.

Pastures

The reindeer husbandry areas of the two northern cooperatives, Paistunturi and Kaldoaivi, have biological and ecological characteristics differing from Muddusjärvi and Kutuharju which may potentially affect the transmission of nematode parasites (Kumpula *et al.*, 2004).

In summer, Paistunturi/Kaldoaivi reindeer graze on a tussock tundra/taiga landscape of open rangelands with rolling fjelds and birch interspersed with grasses, sedges, and lichen. Marshland areas are limited and the prevailing winds tend to reduce insect harassment. Muddusjärvi and Kutuharju reindeer graze in a pine-dominated forest with numerous swamps and marshlands, where mosquitoes are a common annoyance to reindeer in the summer causing them to aggregate in large herds in sheltered areas.

In winter, Paistunturi/Kaldoaivi reindeer graze on open landscapes consisting of mostly sedges and grasses. Commercial pelleted feed is offered throughout the winter to supplement their dietary needs, as lichen is overgrazed in many areas. A few reindeer herding families manage their individual herds as a common group over the winter.

Muddusjärvi cooperative is adjacent to the grazing range of the Kutuharju experimental herd, being separated by a fence, but sharing a similar pine and birch forest with a relatively level aspect. Muddusjärvi winter pastures are generally in better condition than those of the northern cooperatives, attributed to availability of lichen. Reindeer from Muddusjärvi and Kutuharju graze freely in the winter in the pine-dominated forests. Commercial pelleted feed is offered to Muddusjärvi reindeer during adverse climatic conditions (ice layers over the ground, or deep snow). Kutuharju reindeer receive commercial feed once per day during the winter.

Management

Calves in the two northern cooperatives (Paistunturi and Kaldoaivi) are born in spring to early summer (late April-mid June) on the tundra/taiga without interference from the owners. Earmarking is performed in September when calves are 4 months old. In Muddusjärvi, pregnant reindeer are gathered into fenced enclosures from early April-late June and are usually supplementary fed in May. Calves are usually earmarked a few hours after birth and are monitored daily. The Kutuharju herd is inspected daily with monthly gathering for sampling and weighing as part of a long-term research project. Kutuharju calves are born in a large enclosure on pasture, earmarked within 24 hrs of birth and monitored daily. They remain with their mothers in a fenced area of forest until July, thereafter released to join the entire herd.

Slaughter of animals and collection of viscera

The choice of animals for slaughter was based entirely on the owners' decisions. Culling occurred between October and January from 2002 to 2004. Animals were consigned to the regional reindeer slaughterhouse in Kaamanen within the Muddusjärvi pasture area. The abomasa and small intestines were obtained from this facility, together with trace-back information (origin) of the animals, as well as their sex and age (Table 1). Additionally, *post-mortem* material was obtained from the Muddusjärvi reindeer herding cooperative, Tsiuttajoki station, at the time of winter roundups. It was not always possible to collect the abomassum and matching intestine from each individual. Adult reindeer were predominantly 4-7 year old castrated males at time of culling.

Parasitological procedures

The viscera (abomasum and the proximal 7-10 m of small intestine) were processed according to Donald *et al*. (1978). Two 20 mL (with exception for October and November 2002, in which 30 mL sub-samples were taken) replicate sub-samples were taken from each abomasal (3 L) and small intestinal contents (3 L). The mucosal lining of each abomasum was collected

Table 1. Inventory of biological samples examined for gastrointestinal nematodes from reindeer (*Rangifer tarandus*) calves and adults from four herds in northern Finland.

		Calves						Adults					
		Abomasum			Small Intestine			Abomasum			Small Intestine		
Winter	Herd	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
2002-2003 (Oct-Jan)	Kaldoaivi	13	11	24	6	4	10	2	1	3	0	0	0
	Paistunturi	4	5	9	4	6	10	0	0	0	0	0	0
	Muddusjärvi	0	0	0	0	0	0	2	0	2	0	0	0
	Kutuharju	6	7	13	6	7	13	3	0	3	0	0	0
2003-2004 (Dec-Jan)	Kaldoaivi	0	0	0	0	0	0	14	3	17	0	0	0
	Paistunturi	0	0	0	0	0	0	0	0	0	0	0	0
	Muddusjärvi	0	0	0	0	0	0	10	0	10	9	1	10
	Kutuharju	4	3	7	4	3	7	0	8	8	0	0	0
	Subtotal	27	26	53	20	20	40	31	12	43	9	1	10

and subject to digestion (1 L) to obtain nematodes arrested in development. All sub-samples were preserved by freezing at -18 °C (Dobson *et al*., 1990). When required for worm counting and species differentiation, the 20 mL sub-samples were thawed on a 30 µm sieve using a gentle stream of warm tap water. All material, including nematodes retained on the sieve, were back-washed into a beaker, stained with Lugol's iodine and examined with a stereomicroscope and sub-phase illumination at 16-20 X. The detection limit of our parasitological sampling technique from the abomasum contents was such that one worm recovered equated to a total burden of 150 worms.. Intestinal nematodes *Nematodirus tarandi* and *Nematodirella longispiculata* were not reliably differentiated into species. When either was recovered from the samples they were recorded as individuals from the family Nematodirinae. All early fourth-stage nematode larvae (EL4) were identified at 400 X using compound light microscopy. An Olympus digitizer DP50 3.0 and Soft Imaging System AnalySIS 3.1 software was used to distinguish between nematode taxa with the use of scientific keys (Durette-Desset, 1983; Barth, 1991).

Statistical procedures

Differences in mean intensity of nematodes among reindeer age class, or reindeer gender, or reindeer herds, or year were tested using a Student's *t*-test on logarithmically transformed data corrected for small sample sizes and the assumption of unequal population variances. A probability level of <0.05 was considered significant.

Results

Worm burdens of reindeer calves

Abomasal nematodes were recorded in all calves (n = 53) slaughtered (see Table 2). Adults of only one trichostrongylid nematode species were recovered. They were identified as *Ostertagia gruehneri* based on morphological characteristics, and therefore we assumed that the larvae of the abomasal contents and digests also belonged to this species.

Although *O. gruehneri* was statistically more abundant during the winter of 2002-03 in Kaldoaivi than in the other herds (P < 0.001), the difference between means of overall worm burdens was too low to ascribe this as being biologically significant. There was no difference in the number of *O. gruehneri* between male and female calves, and the majority of the worm population (~80%) were in the early fourth larval (EL4) stage of development. Similar findings were found in the Kutuharju animals slaughtered in 2003-2004.

Intestinal nematode infections belonged to the family Nematodirinae (*Nematodirus tarandi* and *Nematodirella longispiculata)* (see Table 3). Overall, the prevalence of infection during winter 2002-03 was higher in the Kutuharju calves (90%; infection in 12 of 13) than the other herds (45%; 9 of 20). There was no significant difference in the abundance of Nematodirinae between male and female reindeer calves, and approximately 30% of this worm burden occurred as EL4. Worm burdens of calves slaughtered in 2003-2004 were similar to the previous year.

Worm burdens of adult reindeer

Ostertagia gruehneri was found in all but one animal of the 43 processed. Overall, *O. gruehneri* was statistically more abundant in adult reindeer (mean ≈ 3900, n = 43) than in calves (mean ≈ 1300, n = 52) (P < 0.001), but the percentage of EL4 was significantly less in adult reindeer (mean = 40%) than in calves (mean = 80%) (P = 0.005) (see Table 4). No parasites were found in the small intestine of adult reindeer.

Discussion

This study showed the ubiquitous presence of the abomasal parasite *O. gruehneri* amongst the reindeer herds investigated in northern Finland. All calves (n = 52) and all except one adult (n = 42) reindeer were infected with low numbers of this parasite at the time of winter slaughter. The total mean worm burden of *O. gruehneri* in adult reindeer was approximately 3900 worms per animal compared to 1300 worms per animal for an equal number of calves. These findings are in accord with Hrabok *et al.* (2006a), who found that previously worm-free 'tracer' calves allowed only 4 to 6 weeks access to reindeer pastures, together with a free-ranging but more intensively stocked herd, all acquired high prevalence and low level infections with *O. gruehneri*.

Reindeer are herded in groups of a few animals up to a few hundred, and occasionally up to a thousand animals during the roundups (M. Lehtola, pers. comm.). Unlike domestic livestock, reindeer have access to extensive grazing ranges with low densities of approximately 2.5 animals per square kilometer. There is little resource sharing with alternative host species such as sheep, goats, and cattle, as these species are essentially non-existent in the northern Finland reindeer husbandry area. The worm burdens we found are very low for grazing ruminants allowed long-term exposure on pasture, particularly when compared with infections acquired by sheep, goats, or cattle raised under much more intensive livestock conditions (for reviews, see Michel, 1976; Barger, 1982).

Table 2. Infection of *Ostertagia gruehneri* in reindeer calves. Mean intensity (range in parenthesis), prevalence (% infected), and percentage of nematodes found in the early fourth-stage of larval development (number of larvae and adults in parenthesis) of the abomasum (liquid contents and digested mucosa).

Winter	Herd	Calf	Intensity of *O. gruehneri*		Prevalence	% of early
		Gender	Larvae	Adults	(n)	fourth-stage larvae
2002-2003 (Oct-Jan)	Kaldoaivi	Male	1010 (400-1933)	217 (50-750)	100 (13)	86 (13133:2167)
		Female	1073 (200-1967)	140 (75-267)	100 (11)	90 (11808:1258)
	Paistunturi	Male	633 (367-967)	144 (33-200)	100 (4)	85 (2533:433)
		Female	500 (267-800)	75 (50-100)	100 (5)	94 (2500:150)
	Total for northern herds		908 (200-1967)	167 (33-750)	100 (33)	88 (29975:4008
	Kutuharju	Male	968 (83-1700)	346 (200-917)	100 (6)	74 (5808:2075)
		Female	555 (33-1450)	212 (100-300)	100 (7)	72 (3883:1483)
		All cavles	746 (33-1700)	160 (100-917)	100 (13)	73 (9692:3558)
2003-2004 (Dec-Jan)	Kutuharju	Male	1881 (1400-2775)	863 (325-1525)	100 (4)	69 (7525:3450)
		Female	1867 (1600-2150)	517 (350-600)	100 (3)	78 (5600:1550)
		All calves	1875 (1400-2775)	714 (325-1525)	100 (7)	72 (13125:5000)

Table 3. Infection of Nematodirinae nematodes in reindeer calves. Mean intensity (range in parenthesis), prevalence (% infected), and percentage of nematodes found in the early fourth-stage of larval development (number of larvae and adults in parenthesis) of the small intestine.

Winter	Herd	Calf	Intensity of Nematodirinae		Prevalence	% of early
		Gender	Larvae	Adults	(infect/n)	fourth-stage larvae
2002-2003 (Oct-Jan)	Kaldoaivi	Male	150 (150)	300 (300)	33 (2/6)	20 (150:600)
		Female	225 (150-300)	875 (150-1600)	50 (2/4)	20 (450:1750)
	Paistunturi	Male	100 (100)	300 (300)	25 (1/4)	25 (100:300)
		Female	433 (200-600)	425 (200-700)	67 (4/6)	43 (1300:1700)
	Total for northern herds		214 (100-600)	483 (150-1600)	45 (9/20)	26 (1500:4350)
	Kutuharju	Male	450 (100-1150)	779 (375-1300)	100 (6/6)	32 (2250:4675)
		Female	300 (50-650)	917 (550-1850)	86 (6/7)	25 (1800:5500)
		All calves	368 (50-1150)	848 (375-1850)	92 (12/13)	28 (4050:10175)
2003-2004 (Dec-Jan)	Kutuharju	Male	338 (225-450)	1400 (300-2475)	75 (3/4)	14 (675:4200)
		Female	1238 (1200-1275)	1763 (1725-1800)	67 (2/3)	41 (2475:3525)
		All calves	788 (225-1275)	1545 (300-2475)	71 (5/7)	29 (3150:7725)

Table 4. Infection of *Ostertagia gruehneri* in adult reindeer. Mean intensity (range in parenthesis), prevalence (% infected), and percentage of nematodes found in the early fourth-stage of larval development (number of larvae and adults in parenthesis) of the abomasum (liquid contents and digested mucosa).

Winter	Herd	Intensity of *O. gruehneri*		Prevalence	% of early
		Larvae	Adults	(infect/n)	fourth-stage larvae
2002-2003	Kaldoaivi	956 (50-1500)	839 (150-1467)	100 (3/3)	53 (2867:2517)
	Muddusjärvi	338 (125-550)	2775 (300-5250)	100 (2/2)	11 (675:5550)
	Kutuharju	3211 (1033-4400)	1278 (500-2000)	100 (3/3)	72 (9633:3833)
2003-2004	Kaldoaivi	418 (25-1675)	1855 (75-3975)	94 (16/17)	17 (5850:27825)
	Muddusjärvi	1808 (725-3625)	4215 (2125-7175)	100 (10/10)	30 (18075:42150)
	Kutuharju	3031 (1375-5900)	3156 (1425-9050)	100 (8/8)	49 (24250:25250)

The high proportion of *O. gruehneri* larvae found in the reindeer indicates that these populations have undergone inhibited development. Inhibition of larval development is a well-described phenomenon for a range of important nematode parasites of livestock (for review, see Eysker, 1997) and is generally attributed to an environmental trigger. Inhibited development enables the parasite to survive within the host at times when conditions for survival in the external environment are unfavourable. Inhibition delays the development of parasites to egg-laying adult populations during adverse climatic conditions, exemplified by the winter conditions of the north. In this study, the proportion of inhibited *O. gruehneri* was higher in reindeer calves (approx. 80%) compared to adult animals (approx. 40%), with the overall abundance of *O. gruehneri* populations being statistically higher in adult reindeer than in the calves. Extensive studies on the closely related *Ostertagia/Teladorsagia* species in other ruminant livestock show that inhibited larvae can accumulate to massive numbers in adult cattle (*O. ostertagi:* Eysker, 1993) and in sheep (*T. circumcincta:* Waller *et al*., 2004).

Given that the annual treatment of reindeer with ivermectin during the preceding winter would have effectively removed any *O. gruehneri* populations at this time (Oksanen *et al.,* 1992), the worm burdens that were recorded in these animals would have been acquired since the previous winter anthelmintic treatment. Our findings of higher worm burdens in adult reindeer compared to calves support the theories of Irvine *et al.* (2000) who found no evidence of reindeer mounting an immune response to *O. gruehneri* as there was no apparent decline in nematode abundance with host age. Halvorsen *et al.* (1999) also showed that the abundance of total abomasum nematode infection in reindeer increased rapidly during the first 2 years of life and appeared to level off at about 5 years of age.

Nematodirinae (*Nematodirus tarandi* and *Nematodirella longispiculata)* were detected in the intestine of reindeer calves but not in adult reindeer. This finding agrees with the dynamics of *Nematodirus* spp. in other ruminant livestock species, which is restricted to young animals that rapidly mount a strong immune response (Urquhart *et al*., 1996).

Overall, our findings support the conclusions of Hrabok *et al*. (2006b), that although gastrointestinal nematode parasites of reindeer in northern Finland are common, they are not likely to be of sufficient abundance to have an economic impact on the reindeer industry. Should the current herding management change, e.g. by altering the reindeer population density, quality of pastures, increasing interaction with domestic livestock, time spent in corrals for supplemental winter feeding, and/or winter anthelmintic treatment of herds, then this matter must be re-evaluated.

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Ruuansulatuskanavan sukkulamatojen esiintyminen talvella teurastetuissa pohjoissuomalaisissa poroissa

Abstract in Finnish/Lyhennelmä: Tämän työn tavoitteena oli määrittää ruuansulatuskanavan sukkulamatojen prevalenssi ja tartunnan aste talvella teurastetuissa Suomen pohjoisten paliskuntien poroissa vuosina 2002-2004. Juoksutusmahan *Ostertagia gruehneri* - loisella oli korkea prevalenssi, mutta infektion aste (matojen lukumäärä) oli melko matala; 100% vasoista oli infektoituneita (n=53; keskimäärin 1300 matoa mahassa) ja 98% aikuisista (n=41, keskimäärin 3900 matoa). Juoksutusmahamatojen määrissä ei ollut eroja naaras- ja urosvasojen välillä. Kehityksessään estyneiden (pysähtyneiden) *O. gruehneri* - matojen osuus oli tilastollisesti merkitsevästi korkeampi vasoilla (81%) kuin aikuisilla poroilla (39%) (P=0.005). Suolistosukkulamatoja *Nematodirus tarandi* ja *Nematodirella longispiculata* tavattiin ainoastaan vasoilla. Näiden matojen määrä ei eronnut naaras- ja urosvasojen välillä, mutta maantieteellisiä eroja yleisyydessä havaittiin. Tutkimuksen poroille leimallinen loisten korkea prevalenssi ja matala infektioaste viittaa oireettomuuteen ja siihen, että ne ehkä eivät aiheuta tuotantotappioita.