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Helminth parasites of muskoxen *Ovibos moschatus* in Norway incl. Spitsbergen and in Sweden, with a synopsis of parasites reported from this host

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Three species of cestodes and 14 genera of nematodes, with 10 identified species, have been found in muskoxen according to the available literature. The helminths of the present study are from 3 wild muskoxen from Spitsbergen, 3 captive animals from a muskox farm at Bardu in North Norway, 27 wild muskoxen from the Dovrefjell in South Norway, and 2 individuals from a wild population in Härjedalen, Sweden. The cestodes *Moniezia expansa* and cysticerci of *Taenia hydatigena* were recorded. Nineteen nematode species were identified of which the following 12 species have not been published from muskoxen before: *Chabertia ovina, Cooperia oncophora, Nematodirus filicollis, N. skrjabini, N. spathiger, Ostertagia arctica, O. gruehneri, Teladorsagia davtiani, Trichostrongylus axei, T. capricola, T. colubriformis, T. vitrinus.* In addition the caecum nematode *Trichuris* and larvae of an unidentified species of lungworm (the latter not reported from muskoxen before) were found. Neither helminth species of muskoxen reported in the literature nor those found during the present study are specific for muskoxen; all have also been found in reindeer or domestic ruminants. Apparently muskoxen are easily infected with parasites normally occurring in other ruminant species.

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INTRODUCTION

Muskoxen have their native areas in East - Greenland and Arctic North America. Animals have on many occasions been kept in captivity in Europe and North America. Attempts have also been made to establish wild populations in new areas (Alendal 1980a, 1980b).

In September 1929, 6 yearlings and 11 calves were introduced to Spitsbergen at 78°N (Fig. 1) from East Greenland via Norway (Alendal 1976). This population decreased drastically in the 1970s. A single cow only was seen in 1979 (Alendal 1980b).

In August 1969, 25 muskox calves were transferred for domestication purposes from East Greenland to Bardu, 68°47'N, North Norway (Fig. 1) (Teal 1970). Disease (Falk 1978, Kummeneje & Krogsrud 1978), parasites and accidents made this attempt unsuccessful.

Muskoxen have been transplanted several times from East Greenland to the Dovrefjell area (62°23'N) in central South Norway (Fig. 1). Of 10 animals released in 1932 and 2 in 1938, and their descendants, none survived World War II (Olstad 1943, Lønø 1960). In the years 1947—53, 3 yearlings and 24 calves were captured in East Greenland to be transferred to the same area in the Dovrefjell. Some died before they were released, and some died soon afterwards. There were probably only 10 survivors by the late autumn of 1953 (Alendal 1980b). The surviving population has remained within an area of 8 by 13 km at an altitude of 700—1600 m. By midsummer 1982 there were 33 muskoxen in the Dovrefjell.

In the summer and autumn of 1971 a group of 5 animals wandered from their range in the Dovrefjell to Härjedalen, Sweden (62°27'N) (Fig. 1), where they have remained in a mountain area, about 140 km east of their original range. By the summer of 1978 they had increased to 16 animals (Lundh 1979). In 1976 a single bull wandered to Sweden from the Dovrefjell, but did not join the other muskoxen in Sweden.

It has been suggested that internal parasites

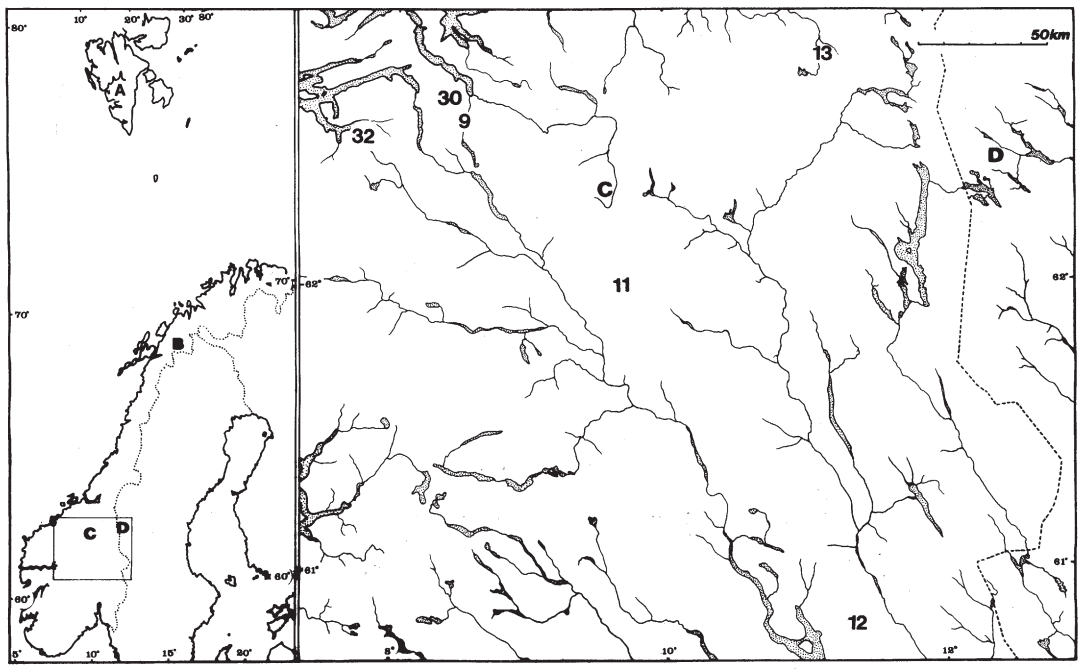

Fig. 1. Localities from which muskox parasites have been collected. Letters indicate permanent localities for muskoxen. Numbers indicate bulls straying from their range in the Dovrefjell. A. Nordenskiöld Land, Spitsbergen. B. Bardu, North Norway. C. Dovrefjell, South Norway. D. Härjedalen, Sweden. 9. Litledalen near Sunndalsøra. 11. Haverdalen, Rondane. 12. Løten near Hamar. 13. Ålen north of Røros. 30. Øksendal near Sunndalsøra. 32. Åndalsnes.

have been an important cause of the problems encountered in the establishment of new muskox populations south of the Arctic areas, especially for animals in captivity. In this paper our first aim is to bring together all the scattered reports and records of internal parasites of muskoxen in captivity as well as in the wild state in Europe, East Greenland and North America. Secondly we present the results of investigations of 3 wild muskoxen from Spitsbergen, 3 animals from the muskox farm at Bardu, North Norway, 27 wild muskoxen from South Norway, and 2 wild muskoxen from Sweden.

Previous records of parasites in muskoxen

A survey of parasites recorded from muskoxen in captivity and in wild muskoxen is given in Tables 1—3. In addition Warble fly larvae have been reported from muskox skins from Great Bear Lake, Canada (Hone 1934), and Nunivak Island, Alaska (Bos 1967). Jansen (1970) found larvae of *Oedemagena tarandi* (L., 1758) in a muskox skin from Canada.

The records of parasites from muskoxen in their native areas and in Norway will be commented.

East Greenland. Apparently the first observation of parasites in a muskox was made 15 August 1870, on Hudson Land, East Greenland by Koldeway (1873:686) who on examining a bull, noted: «Im Uebrigen war es interessant zu sehen, dass auch dieses Geschöpf von Bandwürmern geplagt wird». The viscera of this bull were collected, and may have been the material which led Möbius (1874:257) to describe: «*Taenia expansa* Rudolphi . . . aus dem Darm von *Ovibos moschatus*» — now known as *Moniezia expansa* (Rudolphi, 1805).

Jensen (1904:38) reported «a tapeworm in the bladder phase» from the liver of a young bull shot 7 August 1900 at Hurry Inlet, Scoresby sound. W.G. Smillie (in Hone 1934:80) visiting East Greenland in the summer of 1933, was impressed by the relative absence of parasitic infections in muskoxen. To the best of our knowledge, these four references are the only known reports on muskox parasites in East Greenland.

Table 1. Survey of Protozoa of muskoxen reported in the literature. Records from animals in captivity are marked with an asterisk.

Parasite	Location in host: Muscles	Oesophagus	Faeces	Locality	Reference
Protozoa					
Coccidia			+	Vermont/USA*	Durrell & Bolton 1957
"			+	Leipzig/E. Germany*	Schnurrbusch et al. 1973
Eimeria spp.			+	Nunivak, Bathurst, Devon, College†, Alberta†, Quebec†, Bardu/N. Norway*	Samuel & Gray 1974
E. arloingi			+	E. Berlin*	Tscherner 1973, Seidel 1979
E. crandallis			+	" "	" " " "
E. faurei			+	" "	" " " "
" "			+	Nunivak, Bathurst, Alberta†, Quebec/Canada†, Bardu*	Duszynski et al. 1977
E. granulosa			+	Nunivak, Bathurst, Bardu*	" " " "
E. intricata			+	E. Berlin*	Tscherner 1973, Seidel 1979
E. moschati			+	Nunivak, Bathurst, Alberta†, Quebec†, Bardu*	Duszynski et al. 1977
E. ninakohlyakimovae			+	E. Berlin*	Tscherner 1973, Seidel 1979
E. oomingmakensis			+	Bathurst, Bardu*	Duszynski et al. 1977
E. ovibovis			+	Bathurst, Alberta†, Quebec†, Bardu*	" " " "
E. ovina			+	Nunivak, Bathurst, Alberta†, Quebec†, Bardu*	" " " "
E. parva			+	E. Berlin*	Tscherner 1973, Seidel 1979
Sarcocystis sp.	+			Dombås/Norway*	Norw.Coll.Vet.Med. 1949
" "		+		Ellesmere Isl./Canada	Samuel & Gray 1974

Arctic North America. There is some confusion concerning the early findings of parasites in muskoxen from this area. Nares' expedition in 1875—76 procured one muskox in Hall Land, North Greenland, and 62 muskoxen in Grinnell Land, Ellesmere Island, Canada (Nares 1878:352—353). Feilden (1877), the expedition's naturalist, stated: «This animal is infested with two species of worms, a *Taenia* and a *Filaria*». It is not quite clear whether these were his own observations, as he refers in the same paper (p. 355) to Koldewey's work, in which *Taenia* is reported from East Greenland.

Tener (1965:97, later cited by several authors) wrongly held Feilden to be the first to report parasites from muskoxen, found in animals from East Greenland. The participants of Nares' expedition in 1875—76 did not visit East Greenland, and the only white men who had seen muskoxen in East Greenland, were the participants of Koldewey's expedition in 1869—70 (Koldewey 1873 & 1874). If *Taenia* and *Filaria* really were collected during Nares' expedition, the locality must be Ellesmere Island, Canada. (See also Feilden's edited journals (Feilden 1878 & 1879)).

Since then parasites have been found several times in muskoxen on the mainland as well as on the islands of Arctic North America (Tables 1, 2 and 3).

South Norway. Some of the earliest investigations of muskoxen in Norway were rather superficial, and in some cases internal organs were not available. Some parasites were, however, registered.

In 2 bulls and 3 cows killed by an avalanche in April 1934, the only parasites found were 2 bladderworms (species not stated) in the omentum of a 3-year-old bull (Slagsvold 1934). These muskoxen had been held captive near Ålesund, West Norway, from August 1931 to October 1932, when they were released in the Dovrefjell (Alendal 1980b), where they shared a grazing range with sheep, cattle and reindeer. The origin of the bladderworms is unresolved, but a Norwegian infection seems most probable. Gjestvang (1942) found many bladderworms in the omentum of a bull that died in July 1942 in Nystuguhø in the Dovrefjell.

Three calves from East Greenland died in November 1949 on a farm at Dombås before they could be set free in the Dovrefjell, and they were examined at the Norwegian College of Veterinary Medicine, Department of Pathology. The muscles of the calves were heavily infected with

Table 2. Survey of Cestoda of muskoxen reported in the literature. Records from animals in captivity are marked with an asterisk.

Parasite	Location in host: Lungs	Omentum and peritoneum	Liver	Small int.	Faeces	Locality	Reference
Cestoda							
Tapeworm						Hudson Land/E. Greenland	Koldewey 1873
Moniezia sp.				+		College/Alaska*	Palmer & Rouse 1936
"				+		Ellesmere Island/Canada	Tener 1954
"				+		Nunivak Island/Alaska	Bos 1967
"						" " "	Spencer & Lensink 1970
"					+	Leipzig/E. Germany*	Schnurrbusch et al. 1973
"						Bardu/N. Norway*	Wilkinson 1974
"				+		Nunivak Isl.	Samuel & Gray 1974
"					+	Nunivak, Bathurst, Devon, College‡ Alberta/Canada*	" " "
Moniezia expansa				+		Hudson Land?/E. Greenland	Möbius 1874
" "				+		Dombås/Norway*	Norw.Coll.Vet.Med. 1949
" "				+		Vermont/USA*	Durrell & Bolton 1957
" "					+	Copenhagen/Denmark*	Andersen / Poulsen 1958
" "				+		Thelon/Canada	Gibbs & Tener 1958
" "						Ellesmere Isl.	Tener 1965
" "				+		" "	Webster & Rowell 1980
Taenia sp.						Ellesmere Isl./Canada(?)	Feilden 1877
T. hydatigena, cystic.		+				College*	Palmer & Rouse 1936
" " "		+	+			North America	Dikmans 1939
" " "		+	+			Thelon	Gibbs & Tener 1958
" " "			+			"	Tener 1965
" " "		+	+			Ellesmere Isl.	" "
" " "		+				" "	Webster & Rowell 1980
Bladderworm			+			Hurry Inlet/E. Greenland	Jensen 1904
"		+				Dovrefjell/Norway	Slagsvold 1934
"		+				" "	Gjestvang 1942
"	+		+			Iceland*	Lønø 1960
Echinococcus granulosus			+			Copenhagen*	Andersen & Poulsen 1958
" "	+					Thelon	Gibbs & Tener 1958

sarcocysts. In 2 of the calves a few specimens of the nematode *Nematodirus filicollis* were found, and in one of them the cestode *Moniezia expansa* (Norw. Coll. Vet. Med. 1949).

MATERIAL AND METHODS

Information concerning the investigated muskoxen is shown in Table 4. Some of the animals had migrated out of their regular range, as noted in the table. The captive animal No. 4 had just previously been treated with the anthelmintic thiabendazole. Not all the internal organs were available from some of the animals.

The muskoxen from Spitsbergen, North Norway and Sweden were examined at autopsy by various methods by different veterinary surgeons. The abomasum and intestines of animal No. 6 from the muskox farm at Bardu were collected unopened and the helminths were later counted by the method described by Helle (1971). Methods suitable for the detection of nematode larvae in the lungs were only used for animals Nos. 34 and 35 from Sweden.

Some of the muskoxen from Dovrefjell were examined rather superficially in the field (Table 4, No. 7—11, 33). Viscera, sometimes incomplete, of 21 animals (Table 4, No. 12—32) were frozen and later examined at the Zoological Laboratory of the University of Bergen. The following methods were used for recovering helminths.

Lungs. The lungs were filled with water through a rubber tube fixed to a tap. The water was then forced out of the lungs again and filtered through a sieve with 360 µm openings. If no nematodes were recovered, the process was repeated 3—4 times. No lungworms were found at the opening of the bronchioles after this process.

Liver. The liver was cut into 1—2 cm thick slices and washed, and the water was filtered through the same sieve as used for the lungworms.

Table 3. Survey of Nematoda of muskoxen reported in the literature. Records from animals in captivity are marked with an asterisk.

Parasite	Location in host: Lungs	Abomasum	Small int.	Caecum	Colon	Faeces	Locality	Reference
Nematoda								
Ascaris sp.						+	E. Berlin*	Seidel 1979
Capillaria sp.						+	Leipzig/E. Germany*	Schnurrbusch et al. 1973
"						+	College/Alaska; Alberta; Bardu*	Samuel & Gray 1974
C. longipes						+	E. Berlin*	Seidel 1979
Cooperia sp.						+	"	"
Dictyocaulus sp.	+						Nunivak Island/Alaska	Bos 1967
"	+						College*	Beckley & Dieterich 1970
"	+						E. Berlin*	Seidel 1979
D. viviparus	+						Vermont/USA*	Durrell & Bolton 1957
" "	+						Thelon/Canada	Gibbs & Tener 1958
" "							Dunstable/England*	Manton 1971
" "							Leipzig*	Schnurrbusch et al. 1973
" "	+						Bathurst Island/Canada	Samuel & Gray 1974
" "	+						Dunstable*	Manton 1978
Filaria sp.							Ellesmere Island/Canada(?)	Feilden 1877
Haemonchus sp.		+					Nunivak Isl.	Bos 1967
"						+	E. Berlin*	Seidel 1979
H. contortus		+					Philadelphia/USA*	Canavan 1929
" "		+					Vermont*	Durrell & Bolton 1957
" "		+	+				Alberta/Canada*	MacDonald et al. 1976
" "						+	E. Berlin*	Seidel 1979
Marshallagia sp.						+	Nunivak, Bathurst Alberta; Quebec; Bardu*	Samuel & Gray 1974
M. marshalli		+					North America	Dikmans 1939
" "			+				Ellesmere, Devon/Canada	Webster & Rowell 1980
Nematodirella sp. and/ or Nematodirus spp.						+	Nunivak, Bathurst, Devon, College; Alberta; Quebec; Bardu*	Samuel & Gray 1974
Nematodirella longissimespiculata			+				Thelon	Gibbs & Tener 1958
" "			+				Ellesmere, Bathurst/Canada	Samuel & Gray 1974
Nematodirus sp.						+	E. Berlin*	Seidel 1979
N. filicollis		+	+				Dovrefjell/Norway*	Norw.Coll.Vet.Med. 1949
N. helvetianus			+				Bathurst, Ellesmere	Samuel & Gray 1974
" "			+				Devon, Ellesmere	Webster & Rowell 1980
Oesophagostomum sp.						+	E. Berlin*	Seidel 1979
Ostertagia spp.						+	Bathurst, Devon, Nunivak, Spitsbergen, Alberta; Quebec; Bardu*	Samuel & Gray 1974
"						+	E. Berlin*	Seidel 1979
O. circumcincta		+					North America	Dikmans 1939
" "		+					Thelon	Gibbs & Tener 1958
O. occidentalis		+					North America	Dikmans 1939
O. trifurcata			+				Ellesmere	Webster & Rowell 1980
Strongylidae						+	Copenhagen/Denmark*	Andersen & Poulsen 1958
"						+	Dunstable*	Manton 1971
"						+	Leipzig*	Schnurrbusch et al. 1973
Strongyloides sp.						+	E. Berlin*	Seidel 1979
Trichostrongylidae						+	Alberta*	Oeming 1965
"							Copenhagen*	Andersen 1966
"						+	Leipzig*	Schnurrbusch et al. 1973
Trichostrongylus sp.		+					Nunivak	Bos 1967
"						+	E. Berlin*	Seidel 1979
Trichuris sp.						+	Leipzig*	Schnurrbusch et al. 1973
"						+	Alberta; Bardu*	Samuel & Gray 1974
"				+			Alberta*	MacDonald et al. 1976
"				+			Dunstable*	Manton 1978
Trichuris ovis					+		Philadelphia*	Canavan 1929
" "						+	E. Berlin*	Seidel 1979

Table 4. Muskoxen from Norway incl. Spitsbergen and from Sweden that were examined for internal parasites.

No.	Date of death	Sex	Age in years	Locality	Km from range	Cause of death
	Spitsbergen. Wild muskoxen.					
1	26/04-76	♀	1	Fivelflyane, Adventdalen	0	Emaciated. Probably starved to death.
2	28/04-76	♀	Adult	Moskushamn, Adventfjorden	0	Emaciated. Starvation.
3	03/05-76	♀	1	Longyearbyen	0	Emaciated and weak. Shot.
	North Norway. Captive muskoxen.					
4	14/10-69	♀	Calf	Muskox farm, Bardu	0	Prolonged diarrhoea. Emaciation.
5	Oct. -70	♀	1.5	" " "	0	Emaciation.
6	26/09-73	♀	Calf	" " "	0	"
	South Norway. Wild muskoxen.					
7	16/05-70	♂	Adult	Dovrefjell	0	Hurt by train. Shot.
8	27/05-71	♂	3	"	0	" " " "
9	31/07-71	♂	4	Litledalen near Sunndalsøra	55NW	Overdose of drugs during immobilization.
10	07/08-71	♂	>7	Grønbakken, at main road	5SE	Shot to avoid muskox-human accident.
11	23/10-73	♂	>9	Haverdalen, Rondane	30SSE	Immobilized in Rondane the summers-71-72-73 and brought back to range, then shot legally.
12	31/08-74	♂	5?	Løten at Hamar	190SE	Shot to avoid muskox-human accident.
13	27/10-76	♀	Adult	Ålen	100NE	Hurt by car. Shot 2 days later.
14	02/06-77	♂	Adult	Drivstua	3NE	Shot to avoid muskox-human accident.
15	12/07-77	♂	Adult	Dovrefjell	0	" " " " " "
16	05/07-78	♀	12	"	0	Lightning.
17	05/07-78	♀	Ca 10	"	0	"
18	05/07-78	♀	3	"	0	"
19	05/07-78	♀	3	"	0	"
20	05/07-78	♀	2	"	0	"
21	05/07-78	♀	2	"	0	"
22	05/07-78	♀	2	"	0	"
23	05/07-78	♂	1	"	0	"
24	05/07-78	♂	1	"	0	"
25	05/07-78	♂	1	"	0	"
26	05/07-78	♀	Calf	"	0	"
27	05/07-78	♀	Calf	"	0	"
28	08/07-78	♂	Adult	"	0	Shot to avoid muskox-human accident.
29	04/09-78	♂	2	"	0	Killed by train.
30	19/05-79	♀	Adult	Øksendal near Sunndalsøra	70NW	Shot to avoid muskox-human accident.
31	27/07-80	♂	Adult	Dovrefjell	0	" " " " " "
32	28/07-80	♀	Adult	Åndalsnes	96WNW	" " " " " "
33	03/07-81	♂	Adult	Dovrefjell	0	Abdomen perforated, probably by another muskox.
	Sweden. Wild muskoxen.					
34	April-76	♂	5	Storvålen at Tänndalen. Wandered to Sweden in 1971.	0	Emaciated. Tangled in iron wire. Overdose of drugs when immobilized.
35	April-77	♂	4?	Tännån at Urgneset. Wandered to Sweden in 1976.	0	Emaciation and peritonitis. Had eaten a 25x1 cm twig of spruce that had punctured his stomach.

Abomasum. A sample from the abomasum was washed in water and filtered through the same sieve as above. Small samples from the sieve were examined using a dissecting microscope.

Small intestines. A 20—40 cm piece of duodenum and first part of jejunum was opened, washed, and its contents filtered through the same sieve as used for the lungs. The material was further examined as the abomasum. The entire small intestine was then cut open in the search for cestodes.

Colon. Fifty to 100 cm of the first part of the colon was opened, and its contents rinsed with water and examined macroscopically in small portions after sedimentation for some minutes. If no nematodes were found, the entire colon was examined.

Caecum. When opened, its contents were processed in the same way as those of the colon.

The nematodes recovered were fixed and stored in 70 % ethanol, then cleared in lactophenol for identification. Some were also mounted in glycerol jelly. Most of the cestodes examined were fixed in 70 % ethanol and stained with Borax carmin.

The identification of the nematodes belonging

Table 5. Helminths found in wild muskoxen from Spitsbergen, South Norway and Sweden and in captive muskoxen in North Norway. In the table it is also remarked whether the species is common in Norwegian cattle (C), and sheep (S), and whether it is reported from reindeer (R).

			Spits-bergen	North Norway	Animal No. South Norway																										Sweden		In other ruminants
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
Cestoda	Om-ent.	Taenia hydatigena, cysticerc.										+			+	+			+											+				+			C S R
	Small intest.	Moniezia sp.				+											+		+		+		+	+	+			+								
		M. expansa						+																					+								C S R
Nematoda	Lung	Dictyocaulus sp.										+							+	+		+			+	+											
		D. viviparus							+	+	+					+					+		+					+		+	+			+		+	C R
		Protostrongylid larva																																		+	+	S R
	Abomasum	Ostertagia sp.				+																							+								
		O. arctica	+		+																																R
		O. circumcincta						+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+			+		+	S R
		O. gruehneri	+		+									+			+							+						+					+	R
		O. occidentalis	+		+			+																													R
		O. trifurcata										+		+	+		+						+	+						+	+			+			S R
		Marshallagia sp.															+																				
		M. marshalli	+	+	+			+							+				+		+	+	+	+		+	+				+			+			S
		Teladorsagia davtiani																				+									+			+			S
		Trichostrongylus axei													+	+																		+			S
	Small intestines	Cooperia oncophora																				+	+				+			+		+	+				C S
		Nematodirella longissime-spiculata				+						+			+	+					+	+		+	+						+	+	+	+	+			R
		Nematodirus filicollis																			+			+						+	+	+	+	+			S
		N. helvetianus	+	+	+	+		+						+			+													+							C
		N. skrjabini											+											+													R
		N. spathiger				+		+						+	+		+			+		+	+	+	+						+		+				S
		Trichostrongylus capricola																												+			+		+		S
		T. colubriformis																														+					S
		T. vitrinus																														+					S
	Large intest.	Chabertia ovina								+				+	+		+	+		+		+	+	+	+	+			+	+	+		+			S
		Trichuris sp.												+			+					+	+													+	C S

to *Strongylata* has been based on Skrjabin et al. (1952, 1954), Dróżdż (1965), Jansen & Gibbons (1981) and Gibbons & Khalil (1982). The species have been named according to Skrjabin et al. (1952, 1954). For the *Ostertagia* spp. the generic names used by Gibbons & Khalil (1982) are presented in brackets as synonyms.

RESULTS

The helminth species found in muskoxen during the present study are listed in Table 5. Some parasites which are normally found in the abomasum were also found in the small intestines. In Table 5 such parasites are listed for the abomasum only. In the same way nematodes normally occurring in the small intestines are only presented from that organ, although a few also were found in the abomasum. No parasites were found in tle liver of any of the examined animals.

In the yearlings (Nos. 1 and 3) from Spitsbergen, substantial numbers of *Marshallagia marshalli* (Ransom, 1907) and *Ostertagia gruehneri* Skrjabin, 1929, were found in the abomasum, and *Nematodirus helvetianus* May, 1920, in the small intestines. *Ostertagia* (syn. *Skrjabinagia) arctica* Mitskevich, 1929, and *O.* (syn. *Grosspiculagia) occidentalis* Ransom, 1907, occurred in low numbers. In the adult cow (No. 2) from Spitsbergen, moderate numbers of nematodes were found.

In animal No. 4 from Bardu, no nematodes were found, apparently due to recent treatment with thiabendazole. There were, however, many specimens of *Moniezia,* on which thiabendazole has no effect. In animal No. 5 from Bardu there were substantial numbers of nematodes in the abomasum and large numbers in the small intestines, where *Nematodirella longissimespiculata* (Romanovich, 1915) and *Nematodirus helvetianus* dominated. The nematodes were, however, not counted. An estimate of the numbers and variety of parasites in the abomasum of a 4 months old calf (No. 6) from Bardu gave the figures 267 for *Marshallagia marshalli,* 400 for *Ostertagia* spp. and 1767 specimens of IV-stage nematode larvae. The small intestines of the same calf contained 400 specimens of *Marshallagia* and *Ostertagia* spp., 3467 of *Nematodirus* spp. and 1833 IV-stage nematode larvae. The total number of nematodes was 8134, consisting of 4534 adult specimens and 3600 IV-stage larvae. Within the genus *Ostertagia, O.* (syn. *Teladorsagia) circumcincta* (Stadelman, 1894) was most numerous and only a few *O. occidentalis* were found. *Nematodirus helvetianus* and *N. spathiger* (Railliet, 1896) occurred in almost equal numbers. This calf also harboured the cestode *Moniezia expansa.*

In the wild muskoxen from South Norway the lungworm *Dictyocaulus viviparus* (Bloch, 1782) was found in several animals, but in low numbers. *Marshallagia marshalli* and *Nematodirella longissimespiculata* occurred in abundance in some of the samples. In one individual (No. 31) the sample collected contained many specimens of *Nematodirus spathiger.* In other individuals *N. spathiger* occurred in low numbers. *Ostertagia circumcincta* was usually the most prevalent of the genus *Ostertagia.* The species *Cooperia oncophora* (Railliet, 1898), *Nematodirus filicollis* (Rudolphi, 1802), *N. skrjabini* Mitskevich, 1929, *Ostertagia occidentalis, O.* (syn. *Teladorsagia) trifurcata* Ransom, 1907, *Teladorsagia davtiani* Andreeva and Satubaldin, 1954, *Trichostrongylus axei* (Cobbold, 1879), *T. capricola* Ransom, 1907, *T. colubriformis* (Giles, 1892), and *T. vitrinus* Loos, 1905, occurred in low numbers.

Chabertia ovina (Fabricius, 1788), which is common in domestic sheep, was found in many of the animals from the Dovrefjell. Species identification was sometimes impossible due to lack of male specimens, for instance of *Trichuris* Roederer, 1761. A few cysticerci of *Taenia hydatigena* Pallas, 1766, were found in the omentum. Most of the *Moniezia* specimens were fixed in an inferior condition and did not stain properly.

The protostrongylid larvae found in the lungs of the 2 muskoxen from Sweden resembled those of *Muellerius capillaris* (Mueller, 1889), but they were not identified with certainty. Cysts of *Sarcocystis* sp. were found in the heart of one of the bulls (No. 34) from Sweden, the other bull harboured *Eimeria* sp. in its intestines.

DISCUSSION

Most of the material of this study was not examined for protozoans. Cysts of *Sarcocystis* sp. were found in the heart of a cow (No. 2) from Spitsbergen (Hanssen 1977), in the heart of a bull (No. 34) from Sweden and in the muscles of 3 penned calves at Dombås in 1949 (Norw. Coll. Vet. Med. 1949). As some of these parasites have shown marked pathogenicity in other ruminants, their influence on muskoxen should be investigated further. The validity of the *Eimeria* spp. in Table 1 may be questioned. Eight of the

11 species recorded occur normally in sheep or goats. The identity of the coccidia in muskoxen requires further investigation.

In previous investigations of wild muskoxen 3 genera of cestodes and 8 genera of nematodes have been found. Of the latter, 7 species are identified and 3 unidentified. When muskoxen kept in captivity are included, the list of helminths increases to 17 genera. Among the nematodes, 11 were identified to species level (Tables 2 and 3). Trematodes are not reported from muskoxen.

Some of the old findings reported in Tables 2 and 3 may be questioned. The *Taenia* reported by Feilden (1877) may have been *Moniezia,* as the genus *Moniezia* Blanchard, 1891, was named *Taenia* in earlier days. The *Filaria* reported by the same author may have been another genus, e.g. *Dictyocaulus* or one of the gastrointestinal nematodes occurring in Arctic Canada (see Samuel & Gray 1974).

In the present investigation we found 2 cestode species and 19 nematode species plus one species which remained unidentified due to lack of male specimens *(Trichuris).* Eleven nematode species belonging to 6 genera are reported from muskoxen for the first time (Table 5). In addition Protostrongylid larvae were found in the 2 animals from Sweden. Furthermore, the species *Nematodirus filicollis* found in 2 penned calves on a farm at Dombås, South Norway, (Table 3) has not been published from muskoxen before. None of the helminths found in muskoxen seem to be specific for that animal, as all the species recorded are also known from either reindeer or domestic ruminants.

Wild muskoxen in their native areas in Arctic North America and East Greenland seem from the literature to harbour low numbers of helminths, and few species of parasites are recorded from these regions. The species are: the cestode *Moniezia expansa,* cysticerci of *Taenia hydatigena* (syn. *Cysticercus tenuicollis)* and *Echinococcus granulosus* Batsch, 1786), the lung nematode *Dictyocaulus viviparus,* and the gastrointestinal nematodes *Marshallagia marshalli, Nematodirella longissimespiculata, Nematodirus helvetianus, Ostertagia circumcincta, O. occidentalis* and *O. trifurcata* (Tables 2 and 3).

The parasite fauna of muskoxen in the present material exhibits some differences between the four areas. The 3 individuals from Spitsbergen had 5 helminth species of 3 different genera. The only previous record from a muskox on this island are eggs of *Ostertagia* from a fecal sample (Samuel & Gray 1974). The ancestors of these muskoxen could have brought with them helminths from East Greenland or from Norway in 1929, but some of the species may also originate from the reindeer population in Spitsbergen.

Little information exists on the helminth fauna of muskoxen in East Greenland. Of the species found in muskoxen from Spitsbergen *Marshallagia marshalli, Nematodirus helvetianus* and *Ostertagia occidentalis* are also known from Arctic Canada (see Table 3). Nine muskoxen (3 calves and 6 yearlings) of the 17 animals released on Spitsbergen had been kept in captivity for 3 weeks near Ålesund, West Norway. Some cattle have been kept in Spitsbergen for milk production.

In the viscera of reindeer *Rangifer tarandus platyrhynchus* on Spitsbergen, Bye (1980) found *Marshallagia marshalli, Ostertagia gruehneri, O. occidentalis, Skrjabinagia lyrata* and *Teladorsagia circumcincta* and in faeces from these reindeer, eggs of *Nematodirus* sp. In our material *Nematodirus helvetianus* was found. In addition to that species, *Ostertagia arctica* was the only species from muskoxen which Bye did not find in the Svalbard reindeer. *Dictyocaulus* sp. was not found in lungs of reindeer (Bye 1980) or muskoxen from Spitsbergen.

The muskoxen kept in captivity at Bardu, North Norway, contained some of the helminth species found in Arctic Canada and Spitsbergen: *Moniezia expansa, Marshallagia marshalli, Nematodirus helvetianus* and *Ostertagia occidentalis.* In addition they carried species common in Norwegian sheep: *Nematodirus spathiger* and *Ostertagia circumcincta.* The 10-acre area of the muskox farm at Bardu had occasionally been grazed by sheep until the introduction of the 25 muskox calves from East Greenland in 1969. Some of the muskoxen on the farm were not thriving, which was attributed to parasites. In spite of frequent anthelminthic treatment, *Moniezia expansa* especially seemed difficult to control. In fecal samples from 24 yearlings on this farm, Samuel & Gray (1974) found coccidia and eggs of *Moniezia* sp., *Capillaria* sp., *Marshallagia* sp., *Nematodirella* sp. and/or *Nematodirus* spp., *Ostertagia* spp. and *Trichuris* sp. It was not verified whether the parasites were the main cause of the inferior condition of the animals at the Bardu farm, but the parasites found in animals Nos 5 and 6 would indicate that they were of importance.

The wild muskoxen in the Dovrefjell share their range with reindeer, and during the summer also with 100—200 domestic sheep (since 1972—75) and 30—40 horses. A few cattle may

graze in the periphery of their range too. Straying moose may occasionally visit the area. The muskoxen are thus exposed to parasites which are found in the other ruminants mentioned.

The nematodes most frequently found in sheep from mountain grazings in South Norway are *Ostertagia* spp. and *Nematodirus* spp. (Helle 1971). Of these, *O. circumcincta, N. filicollis* and *N. spathiger* are the most common. Among the parasites from muskoxen listed in Table 5, the following species have further been found in sheep from mountain pastures in South Norway: *Cooperia oncophora, Nematodirus helvetianus, Ostertagia trifurcata, Teladorsagia davtiani, Trichostrongylus axei, T. colubriformis, T. capricola,* and *T. vitrinus* (Helle, unpubl.). The *Trichostrongylus* spp. are most common on lowland pastures in South Norway. The genus was found in 5 muskoxen; 3 of these had migrated out of their range and were shot within farming areas (Nos. 13, 30 and 32). *Cooperia oncophora* and *Nematodirus helvetianus* are mainly cattle parasites. *Marshallagia marshalli* has been recorded from sheep in Norway (Helle, unpubl.). *Nematodirella longissimespiculata, Nematodirus skrjabini* and *Ostertagia gruehneri* have been recorded from reindeer (Skrjabin et al. 1954), although there is little information on their occurrence in Norway.

The lungworm *Dictyocaulus viviparus* was frequently found in muskoxen in the Dovrefjell. *Dictyocaulus* has been found in Norwegian reindeer in the south as well as in the north of Norway (Hellesnes 1935, Kummeneje 1977).

Dictyocaulus viviparus is also seen in cattle in all parts of Norway, but does not seem to be common.The *Dictyocaulus* in reindeer is thought to be *D. viviparus,* although it is not clear whether the species from reindeer in Norway is identical with that of cattle or a separate species *D. eckerti* Skrjabin, 1931. It is most likely that the *Dictyocaulus* from muskoxen in this material is of reindeer origin.

The cestodes found in muskoxen from the Dovrefjell were *Moniezia* sp. and cysticerci of *Taenia hydatigena;* both are common in sheep and cattle and may also be seen in reindeer. The species identification of *Moniezia* was difficult due to inferior samples. *M. expansa* is the only species reported from muskoxen in the literature. In Norway *M. benedeni* and *M. expansa* are found in cattle as well as in sheep.

The present investigations do not indicate that the internal parasites interfere significantly with the health of the wild muskoxen within their range in the Dovrefjell. This may be due to the small muskox population in this high-altitude area. The number of helminths on Norwegian mountain grazings generally seem to be low. Studies by Helle (1970) showed that domestic lambs which were kept on mountain grazings from 1000—1400 m a.s.l. harboured only one tenth of the number of nematodes found in lambs kept on lowland pastures.

Few parasites were found in the 2 muskoxen from Sweden. The nematode species, *Dictyocaulus viviparus, Ostertagia circumcincta* and *Trichuris* sp. are common in the material from the Norwegian muskoxen. An unidentified *Ostertagia* sp. is thought to be *O. gruehneri* which also was present in muskoxen from southern Norway. The protostrongylid larvae which were found in Sweden may be one of the species occurring in sheep, but *Elaphostrongylus* sp. should also be considered.

Information from the literature and from the present investigations shows that muskoxen may easily be infected with parasites which are normally found in several domestic and wild ruminants. In their native areas muskoxen seem to harbour small numbers of parasites. The exposure to new species and a higher number of parasites when transferred to warmer and more southern areas may have serious effects on this mammal (Durrell & Bolton 1957, Lønø 1960, Oeming 1965, MacDonald et al. 1976).

As muskoxen apparently have a low resistance against parasites, the establishment of muskox populations should be restricted to areas of ample size, and with as little interference with other ruminants as possible. It has not been proved that new parasites with a negative influence on other animal hosts have been established when muskoxen have been transplanted from their native regions to new areas.

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