PARASITES OF MOUNTAIN GOAT, OREAMNOS AMERICANUS (BLAINVILLE), OF WEST CENTRAL ALBERTA WITH A COMPARISON OF THE HELMINTHS OF MOUNTAIN GOAT AND ROCKY MOUNTAIN BIGHORN SHEEP, OVIS C. CANADENSIS SHAW.

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Abstract: Fifty-three mountain goat from in and near Willmore Wilderness Park were examined for parasites between 1970 and 1974. Seventeen species of helminths (12 nematodes, 5 cestodes) and 1 species of tick were recovered. Twenty-five bighorn sheep from various parts of Alberta, and 3 goat from British Columbia also were examined for helminths. Three helminths, Trichuris schumakovitschi, Avitellina sp. and Nematodirus davtiani, are new host records for goat. Several measures were used to compare results of the present study to those of other studies of mountain goat and bighorn sheep where overall helminth fauna information was recorded. Generally mountain goat and bighorn sheep have: 1) similar numbers of helminth species, 2) many helminth species in common, and 3) are accidental hosts of a few others. Several host populations such as bighorn sheep of the National Bison Range, Montana, and the introduced mountain goat of the Black Hills, South Dakota, have unique helminth faunas, some of which were probably acquired from ungulates already established there. The role parasites may play in goat-sheep interaction is discussed.

The mountain goat, Oreamnos americanus (Blainville), and Rocky Mountain bighorn sheep, Ovis canadensis canadensis Shaw, share range in much of mountainous Alberta. Data dealing with specific aspects of this sympatry such as direct competition are non-existent for Alberta and scant for other areas. Nonetheless, the fact that goat and sheep are seen together commonly in the mountains of Alberta raises some interesting questions for parasitologists, the most obvious of which is whether or not these hosts "share" parasites.

The cross-infection capabilities of parasites in sympatric hosts are based, firstly, on the assumption that the hosts have parasites in common. Unfortunately the data base for helminths of both mountain goat and sheep is small: only a handful of studies have dealt with overall parasite faunas of either host. Kerr and Holmes (1966) and Boddicker et al. (1971) presented percent prevalence data for helminths and ectoparasites of 7 and 28 adult goat from west central Alberta and the Black Hills of South Dakota, respectively. Others such as Cowan (1951) and Brandborg (1955) presented a checklist of the parasites of goat from various areas.

Parasite studies of Ovis c. canadensis have emphasized lungworms (Uhazy et al. 1973, Hibler et al. 1974, Forrester and Littell 1976), but several surveys for helminths (Becklund and Senger 1967, Uhazy and Holmes 1971) have been conducted. The literature on parasites of sheep and goat has been reviewed by Post (1971) and Cooley (1976).

Between 1970 and 1974 the University of Alberta and Alberta Fish and Wildlife Division cooperated in a study of the helminth and tick parasites of 53 mountain goat in and near Willmore Wilderness Park west central Alberta. The study was undertaken to determine the prevalence and intensity of parasites of mountain goat from this region. This report summarizes the findings and adds comparative data from 26 bighorn sheep of several National Parks and Willmore Park of Alberta and three goat from Kootenay National Park, British Columbia.

MATERIALS AND METHODS

Willmore Wilderness Park comprises 4600km^2 and is located on the Alberta-British Columbia border north of Jasper National Park (Fig. 1). Approximately 250 goat were present in and near the Park when the study began (unpubl. records of the Alberta Fish and Wildlife Division). The climate, topography and vegetative associations of the region have been described by Kerr (1965) and McFetridge (1977).

Initially 15 goat were collected in the Park between April, 1970 and December, 1970 by personnel of the Fish and Wildlife Division. Four others were collected in the Syncline Hills which are located just outside the Park, near the new town of Grande Cache, and approximately 8km east of Mount Hamell (Fig. 1) in June, 1971 and January, 1972. Samples were taken from 34 other goat killed by hunters in Willmore in October 1972, 1973 and 1974. Goat were examined for ectoparasites in the field, but internal organs were frozen until they could be examined in the laboratory. Age of goat varied from ½ to 12+ years, but only three goat were less than two years of age.

Three goat kids with severe contagious ecthyma (= soremouth) (see Samuel et al. 1975) were collected from Mount Wardle, Kootenay National Park (Fig. 1) and frozen in July 1967, February and April 1972, and examined in 1972.

Complete viscera, or parts thereof, from 26 bighorn sheep of western Alberta were examined for helminths between May 1968 and May 1971. Twelve came from Jasper National Park, three from Banff National Park, six from Waterton Lakes National Park, three from Willmore Wilderness Park, and two from unknown locations in Alberta. Ages varied from 1 to 10 years of age.

Gastrointestinal tracts and lungs of goat and sheep were examined for helminths (and those helminths handled) following the procedures of Pillmore (1961), Uhazy and Holmes (1971), and Uhazy et al. (1973).

Various measures were used to summarize results and to compare the helminth faunas in goat and sheep of Alberta with results of other published surveys. These measures are:

1) the prevalence (percent of the sample infected) of the parasite;
2) the median intensity (median number of individuals per infected host) of the parasite;
3) species richness (the absolute number of species in a collection (Peet 1974));
4) an index of similarity (percent similarity) of species composition between pairs of samples (= studies), calculated by converting the prevalence of each species of helminth recovered from a sample to a percentage of the total prevalences of all species, making a similar conversion for the other sample, and summing the smaller of each value for helminths common to both samples;
5) the size of the population of a parasite expressed as the product of prevalence and median intensity;
6) the relative abundance (i.e., the percentage that each species contributed to the total number of helminths of a sample) expressed as parasite profiles (Uhazy and Holmes, 1971), and
7) Simpson's (1949) index of diversity, calculated as:

$$SI = (Y/_N)^2$$

where Y = the number of worms of each species of helminth recovered from a sample, and N = the total number of worms of all species in a sample.

For convenience of discussion hosts have been categorized according to Dogiel (1966: 437) as "main", "secondary", or "accidental". However, usage here is not confined to the strict definitions of Dogiel. We consider the "main host" as one where the parasite is most "abundant" (see number 5 above), the "secondary host" as one where the parasite is less abundant, and the "accidental host" as one rarely infected. We are not implying, as Dogiel does, that normal growth of the parasite is inhibited in the secondary host or that the secondary host is an "abnormal" host.

RESULTS

Number and Prevalence of Goat Parasites

Seventeen species of helminths (12 nematodes, 5 cestodes) and one species of tick were

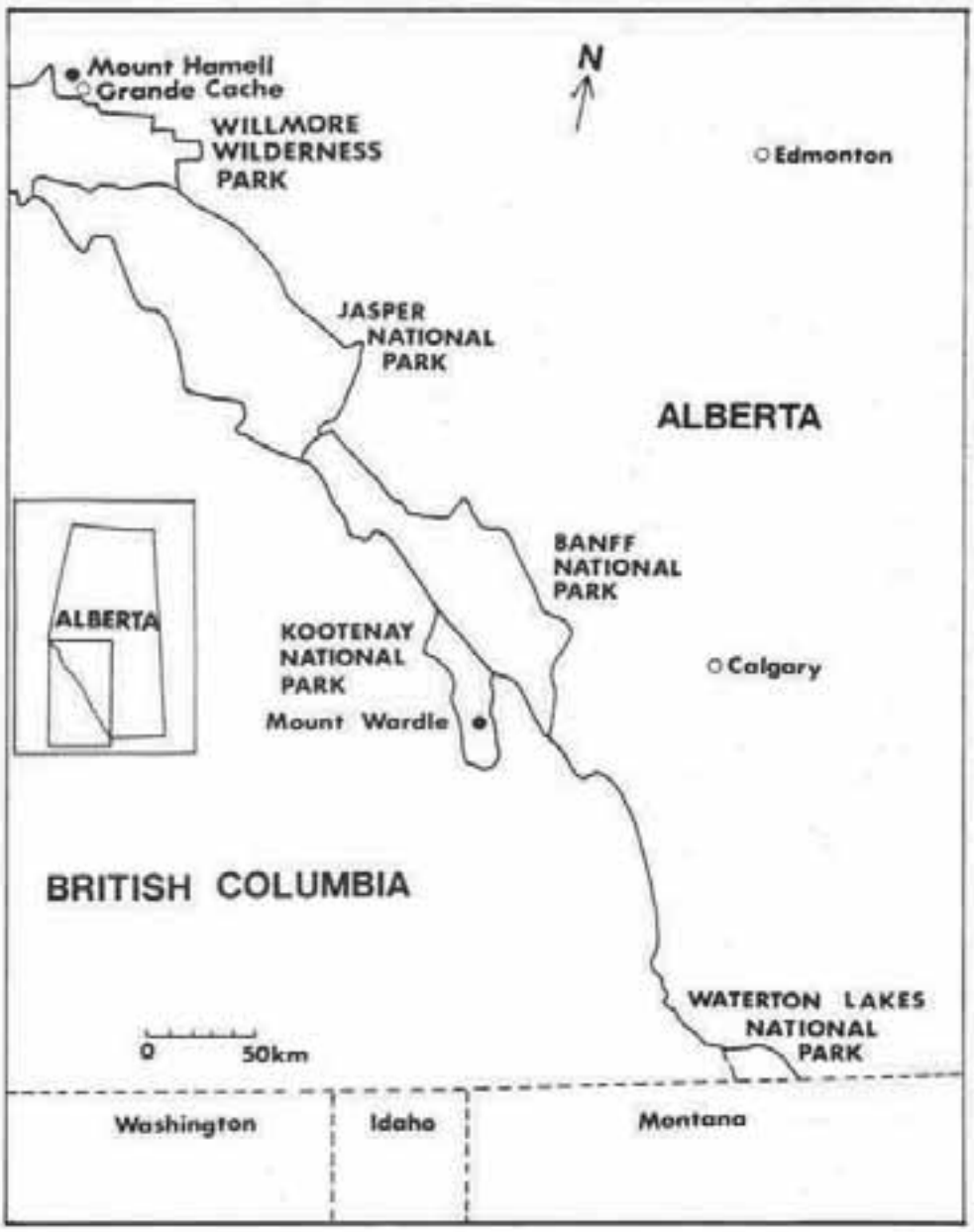

Figure 1. Location of the study area, Willmore Wilderness Park, showing other collection areas for mountain goat and bighorn sheep.

recovered during examination of 53 mountain goat in or near Willmore Wilderness Park (Table 1). Six species of helminths including one, Trichuris oreammos, not found in goat of Willmore Park, were identified from three young goat (two, nine and nine months old) of Mount Wardle, Kootenay National Park, British Columbia. Complete taxonomic citations for each parasite are presented in Table 1. Only Trichuris schumakovitschi, Nematodirus davtiani, and Avitellina sp. are new hosts for goat although T. oreammos was described (Knight 1974) from specimens of this study.

Table 1. Prevalence and intensity of infection with helminths and ticks of mountain goat.

Parasite	-- Willmore Park Area -- Prevalence	Number of parasites	------ Mount Wardle ------- Prevalence	Number of parasites
Nematoda:				
Protostrongylus rushi Dikmans, 1937	46(78)[a]	10(1-35)[a]	3(33)	3
P. stilesi Dikmans, 1931	41(63)	--	3(0)	--
Marshallagia marshalli (Ransom, 1907)	30(87)	36(2-128)	3(67)	423(202,644)
Ostertagia circumcincti (Stadelmann, 1894)	30(97)	184(8-2054)	3(67)	269(94,444)
O. occidentalis Ransom, 1907	30(80)	7(1-29)	3(0)	--
O. trifurcata Ransom, 1907	30(77)	10(1-132)	3(0)	--
Teladorsagia davtiani Andreeva and Satubaldin, 1954	30(67)	4(1-72)	3(0)	--
Marshallagia, Ostertagia and Teladorsagia spp. (females)	30(100)	327(3-2516)	3(67)	875(490,1261)
Nematodirus davtiani Grigoryan, 1949	32(3)	1	3(0)	--
N. helvetianus May, 1920	32(3)	3	3(0)	--
N. maculosus Becklund, 1965	33(82)	53(1-846)	3(100)	4(2-496)
Nematodirus spp. (females)	33(85)	62(1-1062)	3(67)	225(2,449)
Skrjabinema ovis (Skrjabin, 1915)	28(4)	17	3(0)	--
Trichuris sp.	28(1)	3	3(0)	--
T. oreammos Knight, 1974	28(0)	--	3(67)	78(34,123)
T. schumakovitschi (Savinkova, 1967)	28(7)	6(1,11)	3(0)	--
Cestoda:				
Avitellina sp. Gough, 1911	31(19)	6(1-23)	3(0)	--
Moniezia benedini (Moniez, 1879)	31(19)	1(1-17)	3(0)	--
Unidentified Anoplocephalidae	31(10)	--	3(33)	--
Thysanosoma actinioides Diesing, 1834	29(14)	2(1-16)	3(67)	11
Taenia hydatigena Pallas, 1766	39(13)	1(1)	3(0)	--
Anthropoda:				
Dermacentor andersoni Stiles, 1908	18(17)	1(1-2)	3(0)	--

[a]Prevalence = Number goat examined (% infected); median intensity and (range).

Twenty-eight of the 53 goat were examined in their entirety. (For example, only the lungs and/or liver were available for 20 goat.) Where complete examination of goat from Willmore was possible, a mean of seven species (range 1-11) of parasites was present. The youngest goat examined (from Mount Wardle, see above) had only four Nematodirus maculosus while the goat with 11 species was a three year old male in good condition. The total helminth burden in goat of Willmore ranged from 33 to 5314 (median 720) per goat.

Thirty-six goat had Protostrongylus rushi; 26 had P. stilesi (Table 1). No attempt was made to count P. stilesi directly because of their parenchymal location, but a general assessment of the extent of infection was made following the semiquantitative method of Pillmore (1961) which is based on the surface area of the lung with lungworm lesions. Following this technique 25 goat had "light" infections and one had a "heavy" infection. Twenty-two goat had both parasites.

Five species of abomasal nematodes (see Marshallagia, Ostertagia and Teladorsagia of Table 1), three small intestinal nematodes (Nematodirus) and three caecal and large intestinal nematodes (Skrjabinema and Trichuris) were found. Adult males of Ostertagia circumcincta (female nematodes in the abomasum and small intestine were not identifiable at the species level) comprised 85 percent of the abomasal fauna, while adult male N. maculosus dominated (99.8%) the nematodes of the small intestine.

Comparison with Other Studies of Goat and Bighorn Sheep Parasites

Parasite findings for goat of the Willmore Park area were compared to other goat studies in Alberta (Kerr and Holmes 1966) and South Dakota (Boddicker et al. 1971) and sheep studies in Alberta (this study, Uhazy and Holmes 1971) and Montana (Forester and Senger 1964, Becklund and Senger 1967). Data for sheep of Alberta and goat of west central Alberta (Kerr and Holmes op. cit.) are summarized in Table 2.

Table 2. Prevalence and intensities of helminths of adult mountain goat and bighorn sheep of Alberta based on present and previous studies.

Parasite	-Mtn. goat- Kerr and Holmes 1966	Bighorn Sheep			
		Uhazy and Holmes 1971		This Study	
		Prevalence	Number of parasites[b]	Prevalence	Number of parasites[b]
P. rushi)	7(14)[a]	33(30)[a]	7(1-20)	26(48)[a]	5(1-14)
P. stilesi)		33(94)	--	26(92)	--
M. marshalli	7(43)	24(100)	145(1-1270)	16(100)	149(20-985)
O. circumcincta	7(100)	24(13)	19(10-60)	16(25)	144(3-279)
O. occidentalis	7(71)	24(88)	25(2-240)	16(87)	20(2-310)
O. trifurcata	7(71)	24(0)	--	16(0)	--
T. davtiani	7(28)	24(13)	4(2-40)	16(0)	--
Marshallagia, Ostertagia and Teladorsagia spp. (females)	--	24(100)	263(3-1990)	16(100)	269(43-2526)
Capillaria sp.	7(0)	25(4)	2	17(0)	--
Nematodirus archari Sokolova, 1948	7(0)	25(84)	156(1-1318)	17(76)	40(1-269)
N. davtiani	7(0)	25(52)	18(5-398)	17(53)	10(1-106)
N. maculosus	7(86)	25(4)	24	17(0)	--
N. oiratianus Raevskaia, 1929	7(0)	25(64)	47(1-1490)	17(76)	15(1-370)
N. spathiger (Railliet, 1896)	7(0)	25(12)	29(1-32)	17(18)	3(2-30)
Nematodirus spp. (females)	--	25(84)	352(6-2850)	17(94)	82(1-1231)
S. ovis	7(28)	25(8)	1	15(27)	197(2-1000)
Trichuris sp.	7(14)	25(0)	--	15(0)	--
T. schumakovitschi	--	25(68)[c]	20(1-371)	15(47)	18(7-57)
Moniezia expansa Rudolphi, 1810	7(0)	25(12)	3(1-40)	17(12)	2(1-3)
T. actinioides	7(28)	25(0)	--	17(0)	--
Wyominia tetoni Scott, 1941	7(0)	25(4)	1	17(0)	--
T. hydatigena	7(14)	25(20)	2(1-5)	15(7)	4

[a] Number animals examined (percent infected).
[b] Median intensity and (range).
[c] Originally identified by Uhazy and Holmes (1971) as "T. ovis", but recognized as T. schumakovitschi by Knight and Uhazy (1973).

Five helminths of goat (Tables 1 and 2), Ostertagia trifurcata, Nematodirus helvetianus, Moniezia benedeni, Avitellina sp., and Thysanosoma actinioides, were not found in sheep, while six species of helminths in sheep, Capillaria sp., Nematodirus archari, N. oiratianus, N. spathiger, Moniezia expansa, and Wyominia tetoni, were not found in goat. Ten species were common to both hosts.

Prevalence data (Tables 1 and 2) and parasite profiles (Fig. 2) for goat and sheep in the Willmore Park region show that O. circumcincta was the most prevalent and relatively abundant parasite of goat and Marshallagia marshalli of similar position in sheep. Adult males of M. marshalli comprised 49 percent of the small intestinal nematodes. Few other parasites were abundant although N. maculosus comprised nine percent of the goat fauna. Ostertagia occidentalis was prevalent in both hosts, but contributed little to the relative abundance.

Indexes of similarity, which compare helminths common to a pair of samples (= studies), were determined for the three and four known goat and sheep studies and are presented in a "trellis diagram" (Fig. 3) following Holmes and Podesta (1968). High values which indicate similar faunas were found between the two Alberta studies on goat (85%) and the two on sheep (89%), and, unexpectedly, between goat of the Black Hills and the sheep of Wildhorse Island, Montana (91%). Sheep from the National Bison Range, Montana, showed relatively low percent similarities to all other populations and were most similar (67%) to the sheep at Wildhorse Island, only 65km away. Bighorn sheep of this study (termed J_1 on Fig. 3), collected in ranges either shared with goat of Alberta studies or near them, showed higher percent similarities (75 and 70%) with goat of Alberta than did sheep from more distant locations (J_2) (61 and 58%).

Lungworms, particularly P. stilesi, were prevalent in sheep and goat of Alberta and elsewhere (Table 3). There were few similarities between studies when the subjective semiquantification technique of Pillmore (1961) was used. The technique of Forrester and Senger (1964) of multiplying the length of each lesion by its width in order to determine the total area of the lesion, is probably a more appropriate way of assessing infections of P. stilesi.

Table 3. Prevalence, intensity, and estimation of the extent of infection of Protostrongylus spp. for several populations of mountain goat and sheep.

	Prevalence (%)		Intensity of P. rushi		% P. stilesi infections termed		
	P. stilesi	P. rushi	Md.	Mn[a]	Light	Moderate	Heavy
Goat:							
Mt. Hamell, Alberta[b]		14[c]					
Willmore, Alberta[d]	63	78	10		96	0	4
Black Hills, South Dakota[e]	100	38			50	23	27
Bighorn Sheep:							
Alberta[d]	92	48	5		65	35	0
Alberta and British Columbia[f]	91	38	7		55	24	21
Montana[g]	93	40		10			
Colorado[h]	98	16			36	52	12

[a]Md = median, Mn = mean
[b]Kerr and Holmes (1966)
[c]Kerr and Holmes (1966) identified lungworms only as "Protostrongylus spp."
[d]This study
[e]Boddicker et al. (1971)
[f]Uhazy et al. (1973)
[g]Forrester and Senger (1964)
[h]Pillmore (1961)

The abomasal and intestinal fauna (nematodes and cestodes) varied markedly in presence and prevalence between populations. No species of helminth from the abomasum or small intestine was common to all populations. These differences are easily visualized by comparison of the percent prevalences of helminths in goat of Willmore Park and the Black Hills (Fig. 4). Fourteen species were found in the abomasum or small intestine of these goat, but they only had six in common.

The measure of the size of the population of parasites of Alberta sheep and goat was determined by the product of prevalence and the median intensity (Table 4). Parasites were then categorized by host using: 1) this "measure"; 2) prevalences of P. stilesi and T. oreamnos; and 3) prevalence

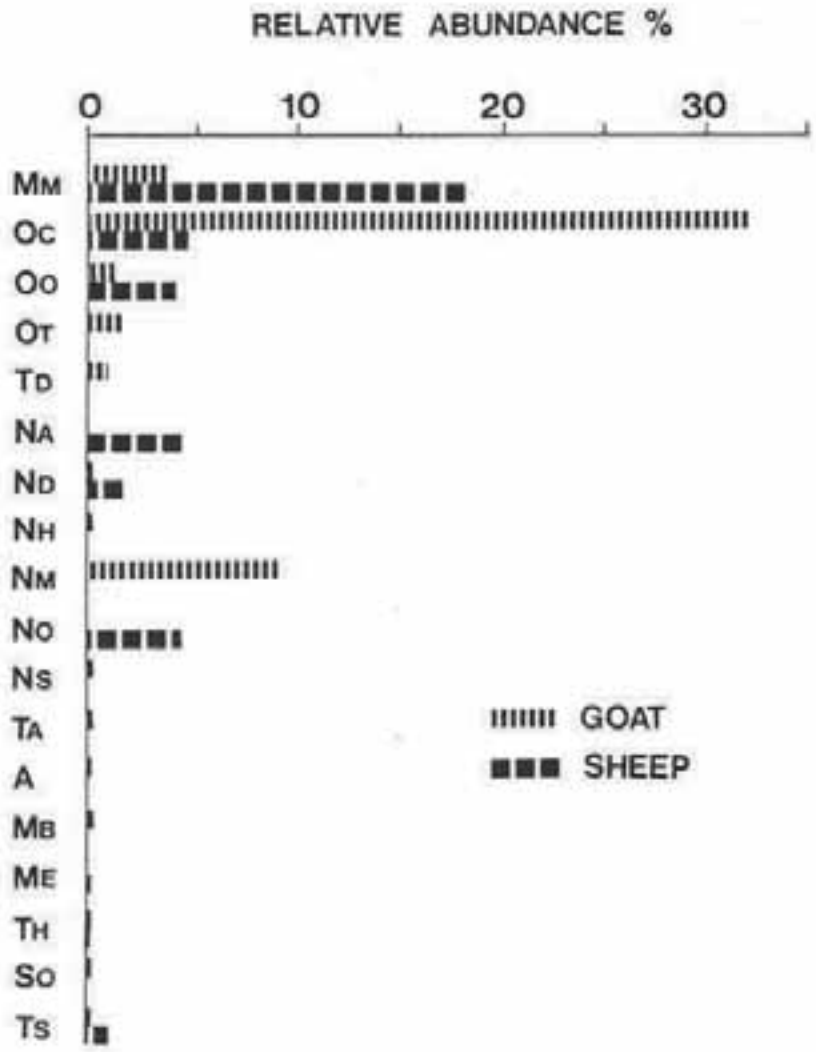

Figure 2.

Parasite profiles for mountain goat of Willmore Wilderness Park and 15 bighorn sheep of Willmore and Jasper National Parks based on total number of worms = 100%. Data for female nematodes of the abomasum and small intestine are not displayed. Mm = Marshallagia marshalli; Oc = Ostertagia circumcincta; Oo = O. occidentalis; Ot = O. triforcata; Td = Teladorsagia davtiani; Na = Nematodirus archari; Nd = N. davtiani; Nh = N. helvetianus; Nm = N. maculosus; No = N. oiratianus; Ns = N. spathiger; Ta = Thysanosoma actinioides; A = Avitellina sp.; Mb = Moniezia benedeni; Me = M. expansa; Th = Taenia hydatigena; So = Skrjabinema ovis; Ts = Trichuris schumakovitschi.

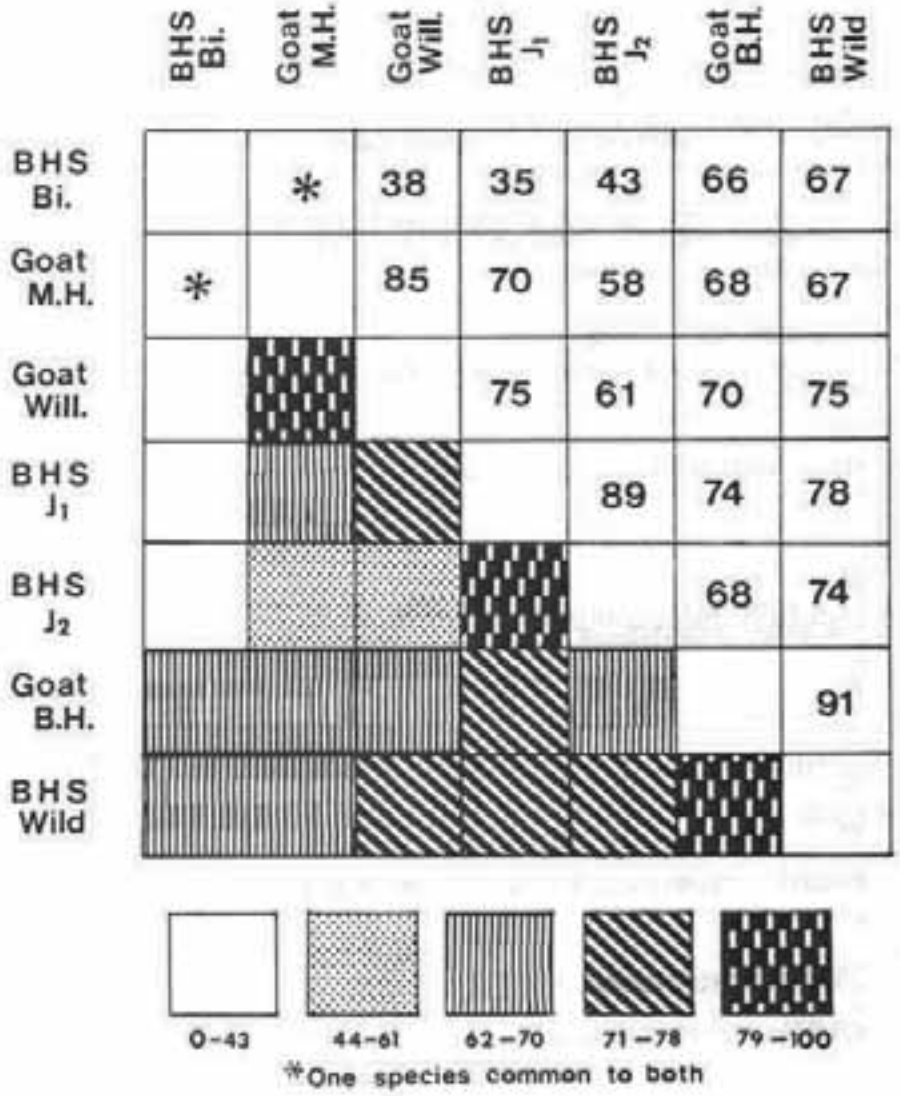

Figure 3.

Trellis diagram showing indexes of similarity between the helminths of mountain goat and bighorn sheep. Bi = National Bison Range, Montana; MH = Mount Hamell, Alberta; Will. = Willmore Wilderness Park, Alberta; J_1 = Jasper and Willmore Parks - this study; J_2 = Jasper National Park and vicinity (Uhazy and Homes 1971); BH = Black Hills, South Dakota; Wild. = Wildhorse Island, Montana.

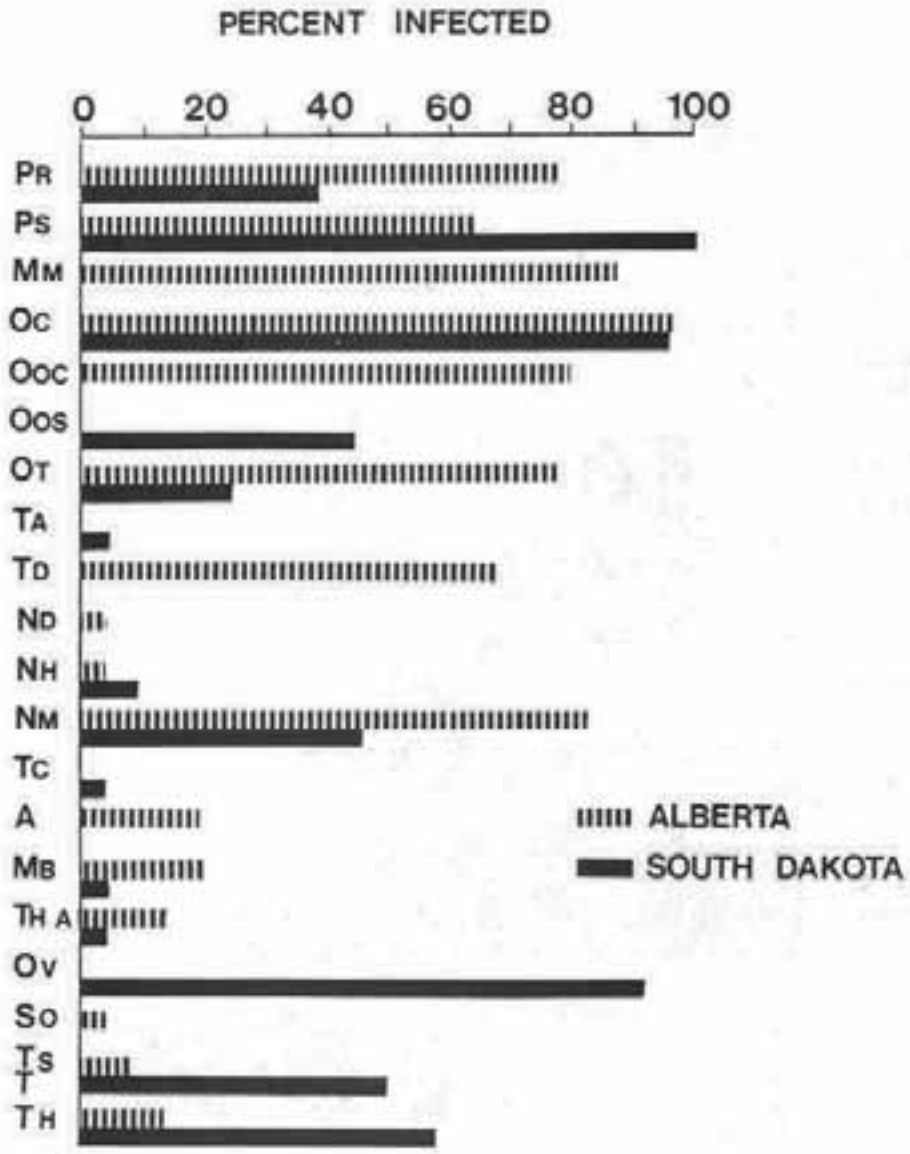

Figure 4.

Percent prevalence of helminths in mountain goat of Willmore Wilderness Park, Alberta, and the Black Hills, South Dakota (Boddicker et al. 1971). Pr = Protostrongylus rushi; Ps = P. stilesi; Oos = Ostertagia ostertagia; Ta = Trichostrongylus axei; Tc = T. colubriformis; Tha = Thysanosoma actinioides; Ov = Oesophagostomum venulosum; T = Trichuris sp. All other abbreviations are explained on Fig. 2.

data for other ungulates available in the literature or from our unpublished files. Five species, O. circumcincta, O. trifurcata, Teladorsagia davtiani, N. maculosus, and T. oreamnos (not shown on Table 5), were clearly parasites of goat and likely are not abundant in other mountain ungulates not examined during this study. Three tapeworms, Avitellina sp., M. benedeni, and T. actinioides, were found only in goat, but have been reported from hosts of other areas or close relations that are present in Willmore Park (Soddicker and Hugghins 1969, Flook and Stenton 1969, Allen 1973).

Table 4. The size of the parasite populations in goat of Willmore Wilderness Park and bighorn sheep of Alberta.

Parasite	Prevalence x Median Intensity			Host Category		
	Goat	BHS[a]	BHS[b]	Main	Secondary	Accidental
P. rushi	7.8	2.3	2.1	G	S	
M. marshalli	31.3	149	145	S	G	
O. circumcincta	178	36	2.5	G	S	
O. occidentalis	5.6	10.7	22	S	G	
O. trifurcata	7.7	0	0	G		
T. davtiani	2.7	0	0.5	G		S
Capillaria sp.	0	0	0.1	?		S
N. archari	0	30	131	S		
N. davtiani	0.03	5.3	9.4	S		G
N. helvetianus	0.03	0	0	?		G
N. maculosus	43.5	0	1	G		S
N. oiratianus	0	11.4	30.1	S		
N. spathiger	0	.5	3.5	S		
S. ovis	0.7	53.2	0.1	S		G
T. schumakovitschi	0.4	8.5	13.6	S		G
Avitellina sp.	1.1	0	0	G		
M. benedeni	0.2	0	0	G		
M. expansa	0	0.2	0.4	S		
T. actinioides	0.3	0	0	G		
W. tetoni	0	0	0.05	S		
T. hydatigena	0.1	0.3	0.4	G-S		

[a] This study
[b] Uhazy and Holmes 1971.

Helminths clearly of bighorn sheep were M. marshalli, O. occidentalis, N. archari, N. davtiani, N. oiratianus, T. schumakovitschi, and W. tetoni. Two, N. spathiger and M. expansa, were found only in sheep, but the small size of their populations and known host distributions suggest that they may be abundant in other ungulates. Categorization of P. stilesi, N. helvetianus, Capillaria sp., Skrjabinema ovis, and Taenia hydatigena was difficult because of similarities between sheep and goat, abundance in only one of the sheep studies (S. ovis), or extremely low values suggesting acquisition from hosts other than sheep and goat. Cysticerci of Taenia hydatigena were prevalent in sheep and goat and probably occur in all species of ungulates of Alberta (Stelfox 1962, and unpub. data of W. M. Samuel).

The diversity of parasites of goat and sheep was determined using species richness (Feet 1974) and Simpson's (1949) index (Table 5). Simpson's index can be used to test the hypothesis that the species in a sample from one area are more equitably distributed than are those in other samples (Holmes and Podesta 1968). Low indexes indicate that the parasites are equitably distributed in the parasite community and high indexes suggest that a few helminth species dominate the community.

Table 5. Species richness (S = number of species) and Simpson's index (SI) for several populations of mountain goat and bighorn sheep.

Study Area	Reference	S	SI	Number hosts Examined
Goat:				
Willmore Park	This study	17	.46	53
Mt. Hamell	Kerr and Holmes 1966	13	--	10
Black Hills	Boddicker et al. 1971	16	--	28
Mt. Wardle, British Columbia	This study	7	--	3
Banff-Jasper Nat'l. Parks, Alberta	Cowan 1951	14	--	10
Idaho-Montana	Brandborg 1955	15	--	--
Sheep:				
Alberta	This study	13	.25	26
Alberta-British Columbia	Uhazy and Holmes 1971	17	.31[a]	36
Nat'l. Bison Range, Montana	Forrester and Senger 1964[b]	1	.40	13
	Becklund and Senger 1967	7 }8		12
Wildhorse Island, Montana	Forrester and Senger 1964	1	.46	9
	Becklund and Senger 1967	7 }8		5
Sun River, Montana	Forrester and Senger 1964	2	--	55
	Becklund and Senger 1967	7 }9		1

[a]Only computed for 11 sheep from in and near Jasper National Park (Uhazy 1969).
[b]Forrester and Senger examined lungs only. Becklund and Senger examined gastrointestinal tracts excluding the caecum and large intestine.

Species richness was 13 or higher for all but one population of sheep or goat in which 10 or more animals were examined (Table 5). Simpson's index was high for the helminths of goat from Willmore Park, and sheep from Wildhorse Island and the National Bison Range, Montana, and low for sheep of Alberta. The goat fauna was dominated by O. circumcincta (Fig. 2), while N. oiratianus and N. spathiger dominated the faunas of the two areas of Montana (Becklund and Senger 1967).

DISCUSSION

This is the third report that presents information on prevalence and/or numbers of helminths of the Rocky Mountain goat. Twenty-two species of helminths have been identified from goat if identifications based on eggs and larvae (Brandborg 1955) are deleted, while thirty species of helminths have been identified from the Rocky Mountain bighorn sheep, if records from sheep in zoological parks and possible errors (Dictyocaulus viviparus and Protostrongylus frosti) are deleted (Becklund and Senger 1967, Uhazy and Holmes 1971). We found four species, Nematodirus davtiani, N. helvetianus, Moniezia benedeni, and Avitellina sp., not found by Kerr and Holmes 1966, even though their study area (= Mount Hamell) is less than 8km from locations where some of our goat were collected (see Fig. 1). However, they only collected seven adult goat: five from Mount Hamell and two from an isolated band at Pinto Creek, 56km east of Mount Hamell. We have assumed that the Protostrongylus sp. and Trichuris sp. of Kerr and Holmes (1966) included the P. stilesi, P. rushi and T. schumakovitschi of our study.

This is the first report of N. davtiani (only 1 male was recovered), T. schumakovitschi, and Avitellina sp. from mountain goat. The Trichuris oreamnos found in two goat of Mount Wardle (Table 1) were described as a new species by Knight (1974). The trichurids reported by Uhazy and Holmes (1971) from bighorn sheep as T. ovis proved to be T. schumakovitschi (Knight and Uhazy 1973), previously known only from domestic sheep of eastern U.S.S.R. (Savinkova 1967). Similarly, this is only the fourth report of N. davtiani in North America but it is a common parasite of domestic sheep and goat of the U.S.S.R. (Becklund and Senger 1967). The Avitellina sp. of this study is very similar to and may be A. arctica (Kolmakov 1938), previously reported from reindeer (Rangifer tarandus) and Siberian roe deer (Capreolus pygargus) in the Soviet Union (Spasskii 1951). Woodland

caribou (R. t. caribou) are sympatric with goat of our study, but Avitellina has not been reported from them (Cowan 1951, Low 1976). The only previous North American record of the genus Avitellina is from the barren-ground caribou (Gibbs 1960).

It is clear "that P. stilesi and P. rushi are fairly host-specific and occur only in native sheep and goats of North America" (Forrester 1971). These lungworms, particularly P. stilesi, "are important in producing the lungworm-pneumonia complex and in the history of the North American bighorn sheep" (Uhazy et al. 1973). The "Discussion" of the Uhazy et al. (op. cit.) paper is worth consulting; it presents an interesting, somewhat hypothetical picture of the role of lungworm in this complex.

Although mountain goat have burdens of lungworms similar to those of sheep (Tables 1-3) and, therefore, may be involved in the same disease syndrome, no die-offs of goat similar to those of sheep have been reported. Boddicker et al. (1971) found "massive" infections of P. stilesi in the lungs of two goat of South Dakota and we found a "heavy" infection in one 12 year old female in very poor condition collected in April, 1970, suggesting that lungworms may contribute to mortality of individual goat.

It was not surprising that the results of the two Alberta studies on goat were similar, particularly since many animals came from adjacent mountain ranges. However, not all adjacent populations of the same host have similar faunas: the helminth faunas of bighorn populations at the National Bison Range and Wildhorse Island (only 64km apart) were remarkably different and had only P. stilesi, P. rushi and cysticerci of Taenia hydatigena in common (Forrester and Senger 1964, Becklund and Senger 1967).

Banff National Park was the origin of the "Blackhills goats" (Boddicker et al. 1971) and the bighorn sheep of the National Bison Range (Becklund and Senger op. cit.). Although the latter authors thought that the unique fauna of the N.B.R. population "may be" related to the herd's origin, it is probably an unimportant factor (Uhazy and Holmes 1971).

Boddicker et al. (op. cit.) found five species, Trichuris sp. ("probably T. ovis"), Ostertagia ostertagia, Oesophagostomum venulosum, Trichostrongylus axei, and T. colubriformis, that have not been reported from goat in Alberta. The opinion of Boddicker et al. (op. cit.) and Uhazy and Holmes (op. cit.) was that some parasites were probably acquired from wild and domestic ungulates already established on the Bison Range and the Black Hills. Ostertagia ostertagia is a common parasite of pronghorn, Antilocapra americana, mule deer, Odocoileus h. hemionus and cattle of South Dakota or Montana (Boddicker and Hugghins 1969, Worley et al. 1970 and Worley and Eustace 1972).

Oesophagostomum venulosum is a well known parasite of domestic animals and was prevalent in wapiti (Cervus canadensis) from the Black Hills (Boddicker and Hugghins 1969). Both T. colubriformis and T. axei were rare in Black Hills goat, but are well known parasites of domestic livestock (Becklund 1964) and mule deer (Worley and Eustace 1972).

We are assuming that transplanted goat take some parasites with them that will become established on new range (example, N. maculosus), acquire new parasites from ungulates established there, and lose some. If the trichurid of South Dakota goat is "probably T. ovis" and not T. oreamnos or T. schumakovitschi of our study, five (see above) parasites of goat of the Black Hills were probably acquired from established ungulates. Species prevalent in goat of Alberta and likely transplanted with their host, but which are now absent in goat of the Black Hills, include N. marshalli, O. occidentalis and T. davtiani. We would have expected that N. marshalli and O. occidentalis would have been reacquired from bighorn sheep of the area (Boddicker and Hugghins 1969) but since goat only share range with mule deer, wapiti and a few whitetail in the Black Hills (Richardson 1971), this has not happened.

Cowan and Brink (1949) attributed the high prevalence of nematodes in mountain goat to their habit of frequenting natural mineral licks with other mountain ungulates such as the bighorn sheep. This assumption implies that species of helminths are exchanged between the two hosts. Bighorn sheep and mountain goat of Alberta have 11 of 22 species of helminths in common, but whether or not any actual sharing occurs remains unknown. Results of Presidente and Knapp (1973) for Dictyocaulus viviparus of black-tailed deer and cattle, and Baker et al. (1957) for trichostrongyles of black-tails and domestic sheep suggest that exchanges are limited. These and most studies of cross-transmission are concerned with the wild ruminant as a contributory factor in the epizootiology of helminthic infection of domestic livestock or vice versa (Dunn 1968). If Dunn's "truism" that "the greatest risk to a domesticated sheep or bovine is not a wild ruminant, but another sheep or bovine" is acceptable, then perhaps a similar truism exists between wild ruminants.

Barbehenn (1969), in a paper largely ignored by parasitologists, "argued convincingly that coexistence between two mammal species is possible if one harbors parasites that are more destructive to the other than to itself, and if the habitat is patchy with respect to parasite distribution" (Cornell 1974). If applied to sympatric populations of goat and sheep one or several of their respective parasites, to which each host would be relatively immune, would adversely affect

its competitor. Cornell (op. cit.) elaborated on how this might happen and concluded that distributional gaps between the hosts may result. Whether such a mechanism is operating between sheep and goat is, perhaps, wild premature speculation, since data on competition or any interaction between these hosts are scant (Klein 1953, Cooley 1976). The ideas of Barbehenn (op. cit.) are introduced here because, as Cornell has stated for comparison of two chickadees (Parus spp.), they "provide some compelling arguments to look beyond conventional competition theory for the answers" to host distributional patterns. Perhaps we should take a different view of Protostrongylus spp. of both sheep and goat and their pathogenic properties when self- and cross-transmitted. Such experiments should be preceded by morphological studies of the lungworms to guarantee that goat and sheep have the same species. If lungworms and/or other parasites are not influential for sheep or goat on native range, perhaps these interactions will be important in areas where goat and sheep transplant programs are underway.

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