Helminths of the Rocky Mountain bighorn sheep in Western Canada

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Thirty-six Rocky Mountain bighorn sheep (*Ovis c. canadensis*), 33 from four areas in Alberta and 3 from Kootenay National Park, British Columbia, were examined for helminths. Data from these examinations were supplemented by examination of 462 fecal samples from the same areas.

Seventeen species of helminths were recovered: 3 cestodes, *Moniezia expansa* and *Wyominia tetoni* and the cysticerci of *Taenia hydatigena*; and 14 nematodes, *Capillaria* sp., *Marshallagia marshalli*, *Nematodirus archari*, *N. davtiani*, *N. maculosus*, *N. oiratianus*, *N. spathiger*, *Ostertagia circumcincta*, *O. occidentalis*, *Protostrongylus rushi*, *P. stilesi*, *Skrjabinema ovis*, *Teladorsagia davtiani*, and *Trichuris ovis*. The records of *Capillaria* sp., *Nematodirus maculosus*, and *Teladorsagia davtiani* are apparently the first from bighorn sheep. Nine other records are new for bighorn sheep in Canada.

Total numbers of helminths (excluding lungworms) per bighorn ranged from 36 to 8345. There was little variation in the prevalence or the relative abundance of the different species in the areas sampled.

Introduction

Since 1900 numerous die-offs of North American Rocky Mountain bighorn sheep (*Ovis canadensis canadensis* Shaw) have been attributed to a lungworm–pneumonia complex (Forrester and Senger 1963; Demarchi and Demarchi 1967). In Canada, five major die-offs which occurred between 1937 and 1950 have been attributed to a combination of the lungworm–pneumonia complex and severe winter weather (Stelfox 1969).* Cowan (1951) found that multiple parasitism was the normal situation in bighorn sheep and other ungulates, but that abnormally high numbers of parasites resulted in marked host disability and disease. Cheatum (1951) gave evidence for the possible complicity of multiple parasitism, malnutrition, and inadequate shelter in producing winter mortality of deer; the mortality was attributed to a terminal pneumonia. The importance of multiple parasitism as a part of the lungworm–pneumonia complex has not been studied extensively.

From the winter of 1967 to the spring of 1969, a study of the parasites of *O. c. canadensis* in Alberta and Kootenay National Park, British Columbia, was conducted as one of several studies on the biology of the bighorn sheep. The study was undertaken to determine the species of helminths present, their prevalence and intensity, and their geographical distribution.

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*STELFOX, J. G. 1969. Bighorn sheep in the Canadian Rockies: A history 1800 to 1967. Unpublished.

Materials and Methods

Complete viscera, or portions thereof, from 36 Rocky Mountain bighorn sheep were examined for helminths (Table 1).† Seven sheep came from Banff National Park, 10 from Jasper National Park, 8 from Ram Lookout, 8 from Sheep River (all in Alberta), and 3 from Kootenay National Park, British Columbia. A few animals were collected specifically for this study, but most of the materials were obtained from bighorns collected for other research projects, or from hunter kills, road kills in the National Parks or animals in the National Parks observed to be emaciated and subsequently destroyed by park officials. The handling of the material varied markedly; often only portions of the viscera were collected and returned in a condition suitable for examination. In most instances, the date of death, location, sex, age, and weight of the bighorns were recorded. Most of the viscera were frozen until examined.

Lungs were examined for the presence of lungworm lesions, and the trachea, bronchi, and bronchioles were incised in search of lungworms. The surfaces of the abdominal organs and the associated peritoneum were examined macroscopically. The heart, liver and kidneys were sliced at 1- to 2-cm intervals and examined. The gall bladder, aorta, and esophagus were incised, washed, and examined. The abomasum, small intestine, caecum, and colon were individually separated from their mesenteries, flushed with water under pressure, incised, and scraped. The wash in each case was passed through a series of sieves (10, 20, 45, and 60 mesh) and washed thoroughly until most of the extraneous fine debris was removed. The residue from the final wash was resuspended in water and examined against a black background using an oblique light source. All helminths recovered were sorted to group and sex and counted. When

†Copies of this table may be obtained, free, on request to:

Depository of Unpublished Data,
National Science Library,
National Research Council of Canada.
Ottawa, Canada.

high numbers of nematodes were encountered, the final wash was brought to 3000 ml and mixed thoroughly, and one-fifth of the sample examined.

Cestodes were washed in tap water, relaxed in cold water if alive, and fixed in A.F.A. (ethyl alcohol – formal – acetic acid). They were stained with Ehrlich's hematoxylin or Blachin's lactic acid carmine and mounted in Canada balsam. Larval cestodes were dissected out and the scolex squashed in Aquamount so that hook characteristics could be used for identification.

Living nematodes were fixed in hot glycerine alcohol (5% glycerine in 70% ethyl alcohol), dead ones in cold fixative. They were cleared and studied in temporary mounts in beechwood creosote – lactophenol (50:50).

Four hundred and sixty-two fecal samples were collected from the same areas, plus Waterton Lakes National Park. The feces, obtained from animals observed to defecate and fixed in 2.5% potassium dichromate, were examined for helminth ova by a cover slip flotation method (Levine *et al.* 1960). Ova were identified with the aid of drawings and measurements given by Kates and Shorb (1943) or Lapage (1959) and by direct comparison with ova in gravid helminths.

Results

Data on each animal examined, and the species and numbers of helminths recovered from each, are given in Table 1 (see footnote under Material and Methods). Thirty (91%) of the 33 lungs examined were infected with the lungworm, *Protostrongylus stilesi* Dikmans, 1931. It was not possible to count the number of these worms in an infected animal because of their parenchymal location. It was noted, however, that the lesions were more prominent on the dorsal diaphragmatic surface and on the right half of the lungs.

Ten bighorns were infected with from 1 to 20 (median, 7) *Protostrongylus rushi* Dikmans, 1937. They exhibited no preference for either side of the lung. They were usually found in the bronchi or bronchioles; in a few instances they were in the trachea. *Protostrongylus rushi* were found only in animals infected with *P. stilesi*. Further details about these two species of lungworms will be presented in a separate paper.

Twenty-seven of the 28 animals necropsied (range in age, 0.5 to 14 years) contained gastrointestinal helminths. The only animal which did not was a lamb about 2 months old. Numbers of helminths recovered (in complete necropsies, not including lungworms) ranged from 36 to 8345 (median, 1012) worms. There was no statistically significant correlation between number of worms and host age or season of the year collected. A statistically significant correlation was found between the total number of helminths and the presence of symptoms of disease

TABLE 2

Prevalence and intensity of infection with gastrointestinal helminths of the bighorn sheep

Parasite	No. examined	No. infected	Prevalence	Intensity	
				Md.*	Range
Nematoda					
Marshallagia marshalli	24	24	100	145	(1–1270)
Ostertagia circumcincta	24	3	13	19	(10–60)
O. occidentalis	24	21	88	25	(2–240)
Teladorsagia davtiania	24	3	13	4	(2–40)
Marshallagia, *Ostertagia* and *Teladorsagia* spp. (females)	24	24	100	263	(3–1990)
Nematodirus archari	25	21	84	156	(1–1318)
N. davtiani	25	13	52	18	(5–398)
N. maculosus	25	1	4	24	
N. oiratianus	25	16	64	47	(1–1490)
N. spathiger	25	3	12	29	(1–32)
Nematodirus spp. (females)	25	21	84	352	(6–2850)
Capillaria sp.	25	1	4	2	
Skrjabinema ovis	25	2	8	1	
Trichuris ovis	25	17	68	20	(1–371)
Cestoda					
Moniezia expansa	25	3	12	3	(1–40)
Wyominia tetoni	25	1	4	1	
Taenia hydatigena	25	5	20	2	(1–5)

*Md. = median.

caused by a pathogen other than a metazoan parasite (Uhazy *et al.*, unpublished).*

Fourteen species of gastrointestinal helminths (12 nematodes, 2 cestodes) were recovered. Data on their abundance is presented in Table 2. The mean number of species per host was 5.5 (range, 3 to 8).

Four trichostrongylids, *Marshallagia marshalli* (Ransom, 1907) Orlov, 1933; *O. circumcincta* (Stadelmann, 1894) Ransom, 1907; *Ostertagia occidentalis* Ransom, 1907; and *Teladorsagia*

*UHAZY, L. S., J. C. HOLMES, and L. C. GRAHAM. Heavier burdens of helminths associated with unrelated disease. Unpublished.

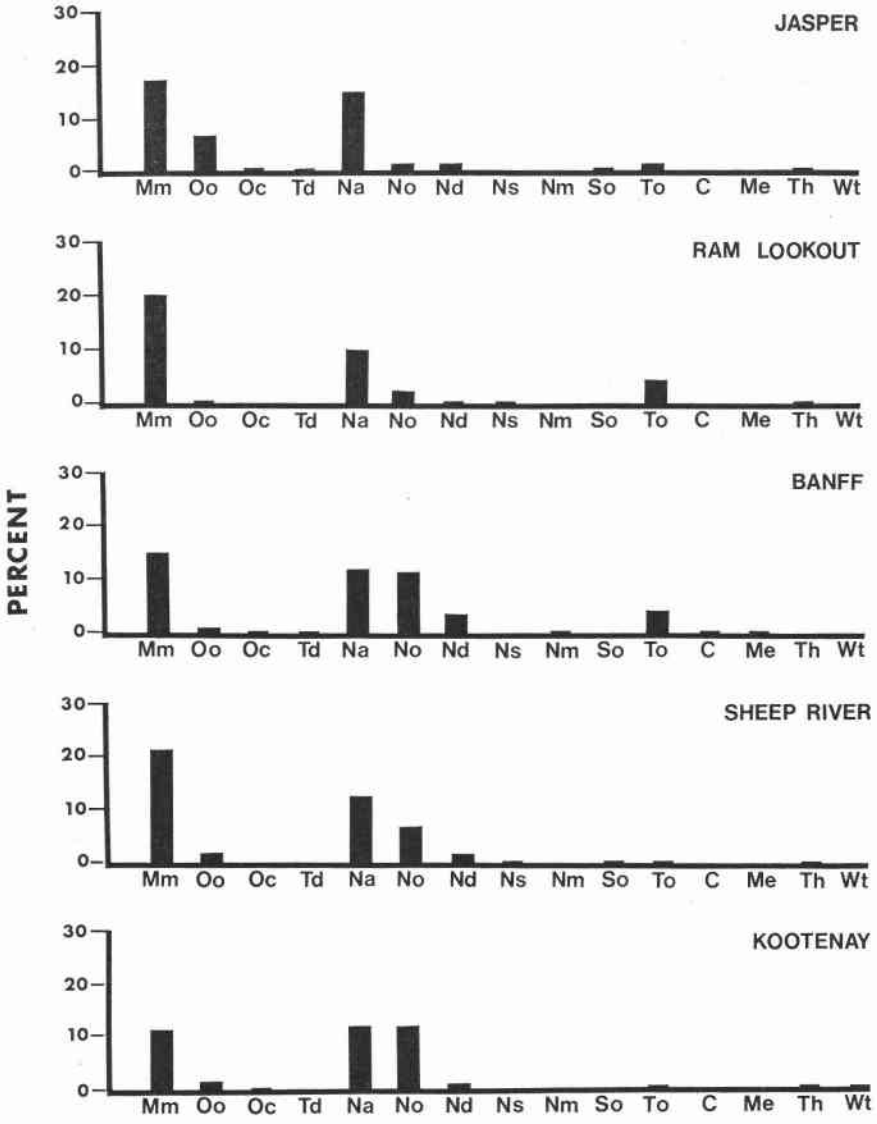

FIG. 1. Parasite profiles for bighorns from different regions. Percentages of parasite species based on total number of worms = 100%. Mm = *Marshallagia marshalli*; Oo = *Ostertagia occidentalis*; Oc = *O. circumcincta*; Td = *Teladorsagia davtiani*; Na = *Nematodirus archari*; No = *N. oiratianus*; Nd = *N. davtiani*; Ns = *N. spathiger*; Nm = *N. maculosus*; To = *Trichuris ovis*; So = *Skrjabinema ovis*; C = *Capillaria* sp.; Me = *Moniezia expansa*; Th = *Taenia hydatigena*; Wt = *Wyominia tetoni*.

davtiani Andreeva and Satubaldin, 1954, were recovered from the abomasum and occasionally from the duodenum. Only males were identified to species. Samples of each have been deposited in the United States Department of Agriculture Parasite Collection (*Teladorsagia davtiani*, No. 66602; *Ostertagia occidentalis*, No. 66603; *O. circumcincta*, No. 66604; *Marshallagia marshalli*, No. 66605).

The number of stomach worms recovered varied from 4 to 3345 per host. The prevalence data (Table 2) and profiles of relative abundance (i.e., the percentage that each species contributed to the total number of worms recovered at that location) for each collecting area (Fig. 1) show *M. marshalli* to be the most prevalent and abundant stomach worm. *Ostertagia occidentalis* had a high prevalence but a low relative abundance in all locations. *Ostertagia circumcincta* and *Teladorsagia davtiani* were the least prevalent, the least abundant, and were not recovered from all areas. Female ostertagids were found in all sheep examined, and were generally more abundant than males, constituting 26 to 38% of the total number of gastrointestinal worms.

In 24 abomasa examined, 3 were infected with *M. marshalli* alone, 17 with *M. marshalli* and *O. occidentalis*; 1 with *M. marshalli*, *O. occidentalis*, and *O. circumcincta*; 1 with *M. marshalli*, *O. occidentalis*, and *T. davtiani*; and 2 with all four species.

In three animals, high numbers (2905, 3231, 3345) of *M. marshalli* and *O. occidentalis* had produced distinct ulcerous lesions in the pyloric region of the abomasum. Histological examination of one of the lesions revealed that the mucosa was badly eroded by the preadult stages of these worms.

Fecal examination showed a lower prevalence of infection (55%) with ostertagids than did the necropsies.

Five species of thread necked strongyles, *Nematodirus archari* Sokolova, 1948; *N. davtiani* Grigoryan, 1949; *N. maculosus* Becklund, 1965; *N. oiratianus* Raevskaya, 1929 (syn., *N. lanceolatus* Ault, 1944); and *N. spathiger* (Railliet, 1896) Railliet and Henry, 1909, were recovered from the small intestine and less frequently the abomasum. Only the males were identified to species. Samples of the males have been deposited in the United States Department of Agriculture Parasite Collection (*Nematodirus archari*, No. 66606; *N. maculosus*, No. 66607; *N. oiratianus*, No. 66608; *N. davtiani*, No. 66609; *N. spathiger*, No. 66610).

Numbers of thread necked strongyles recovered varied from 1 to 4806 worms per host. *Nematodirus archari*, *N. oiratianus*, and *N. davtiani* were the most frequently encountered (Table 2). *Nematodirus archari* was generally the most abundant, *N. oiratianus* was as abundant as *N. archari* in Banff and Kootenay but less abundant in the other locations, and *N. davtiani* was the least abundant of the three (Fig. 1). *Nematodirus spathiger* and *N. maculosus* were encountered infrequently. *Nematodirus maculosus*, a parasite of the mountain goat (Becklund 1965; Kerr and Holmes 1966), was recovered only from a diseased yearling collected at Healy Creek, Banff. Female *Nematodirus* infections were generally more prevalent and abundant than the males, and constituted 23 to 31% of the total number of worms.

Multiple *Nematodirus* infections were common. Six of 25 animals contained a single species (*N. archari* or *N. oiratianus*), 4 contained two species, 8 three, and 4 four species. No infections with all five species were encountered.

Nematodirid eggs were found in 82% of the fecal samples. The whip worm, *Trichuris ovis* Abildgaard, 1795 (Table 2) was most frequently encountered in the cecum but occasionally, in heavy infections, in the anterior portion of the colon. Generally, less than 30 whipworms were encountered; however, counts as high as 371 were recorded. Its relative abundance was low (Fig. 1).

Fecal examination revealed a prevalence for *T. ovis* (31%) considerably lower than that indicated by the necropsies (68%).

Two females of an unidentifiable species of *Capillaria*, a genus not previously reported from bighorn sheep, were found in the small intestine of a single animal, a diseased lamb from Healy Creek, Banff. *Capillaria* eggs were not recovered in fecal examinations.

A pinworm, *Skrjabinema ovis* (Skrjabin, 1915) Vereschagin, 1926, was recovered from the anterior colon of a yearling ewe from the Sheep River and of a 2-year-old ewe from Jasper. One female worm was recovered in each case. Eggs of *S. ovis* were found in a single fecal sample from the Sheep River herd.

One, three, and forty *Moniezia expansa* Rudolphi, 1810 were recovered from the middle small intestine of three yearling sheep collected in Banff in February and March 1967, and May 1969. *Moniezia* eggs were detected in 20% of the fecal samples, and from all locations except Kootenay.

Wyominia tetoni Scott, 1941 was recovered from the bile duct of a sheep collected at Radium Hot Springs, Kootenay National Park. Eggs of *W. tetoni* were not encountered.

In addition to the lungworms and gastrointestinal helminths, the bighorn sheep harbored the cysticerci of *Taenia hydatigena* Pallas, 1766. Cysticerci were recovered from the greater omentum and, in one instance, the rectal region of five sheep. Their prevalence was low (Table 2) and relative abundance was less than 1%. No animals from Banff were infected.

Discussion

There are only two reports of lungworms in Rocky Mountain bighorn sheep from Canada. Cowan (1951) reported *Protostrongylus stilesi* in the lungs of bighorns from Banff and Jasper and *Dictyocaulus viviparus* Railliet and Henry from an animal collected from Jasper. The report of *D. viviparus* may be a misidentification of *P. rushi*, which is similar in gross appearance. First stage protostrongylid larvae were recovered from feces collected on the Sheep River range (Wishart 1958). Although they were identified as *P. stilesi*, this identification is questionable because of the lack of discernible differences between the larvae of *P. stilesi* and *P. rushi*. Neither report presented quantitative data.

Quantitative data have been presented by Pillmore (1961), who found 98% of 121 bighorns from Colorado infected with *P. stilesi* with 16% infected concurrently with *P. rushi*, and Forrester and Senger (1964), who found 93% of 143 bighorns from Montana infected with *P. stilesi* with 40% infected concurrently with *P. rushi*. Since Pillmore's study was done near the southern end of the distribution, Forrester and Senger's near the middle, and this study near the northern end, it is obvious that, throughout their distribution, Rocky Mountain bighorns are almost universally infected with *P. stilesi* and are frequently concurrently infected with *P. rushi*. The only contradictory evidence is that of Boddicker and Hugghins (1969), who examined three bighorns from South Dakota (introduced animals which came from Colorado). They found *P. rushi* in two of the bighorns. They did not report *P. stilesi* from the bighorns in their table, or in the portion of the text dealing with bighorns, but in the text dealing with mountain goats they state, "there are numerous reports of *P. stilesi* from bighorn sheep . . . in addition to our report from bighorns in this paper . . . ." The lesions they describe in the lung of the bighorns are more characteristic of *P. stilesi* than of *P. rushi*.

Cowan (1951), in his study of diseases and parasites of big game mammals of western Canada, reported nine species of helminths in the bighorn sheep. This study revealed 17 species, 5 of which had been reported by Cowan: *Taenia hydatigena*, *Protostrongylus stilesi*, *Ostertagia circumcincta*, *O. occidentalis*, and *O. marshalli* (= *Marshallagia marshalli*). Cowan also recorded *Nematodirus filicollis* Rudolphi, *Moniezia benedeni* Moniez, and *Thysanosoma actinioides* Diesing, which were not recovered in the present study, and *Dictyocaulus viviparus* (= *P. rushi* ? see above). Most of the remaining species (Table 2) have been reported from bighorn sheep before but these are new records for the bighorn sheep of Canada, and extend their known distributions.

Based upon the review of Becklund and Senger (1967), three of these species are new host records: *Teladorsagia davtiani*, a parasite reported previously from domestic sheep, domestic goats, reindeer (*Rangifer tarandus* Linnaeus) (Becklund 1962), and mountain goats (Kerr and Holmes 1966), was recovered in low numbers from Banff and Jasper; *Nematodirus maculosus*, a parasite of mountain goats (Becklund 1965; Kerr and Holmes 1966) was recovered from a diseased sheep collected from Banff; and *Capillaria*, which could not be identified to species, was collected from Banff. Both *T. davtiani* and *N. maculosus* were recovered from ranges frequented by mountain goats.

This is the second report of *Nematodirus archari* and the third of *N. davtiani* in North America. Becklund and Senger (1967) recovered them from bighorns on Wildhorse Island, Montana. Both are parasites of domestic sheep and goats in the U.S.S.R.

The species of gastrointestinal helminths Becklund and Senger recovered from bighorns on Wildhorse Island and the Sun River range differed completely from those from bighorns on the National Bison Range. They ascribe the differences to the origin of the herds. However, the herd on the National Bison Range was derived from 12 bighorns from Banff National Park. The species we recovered from Banff were the same as those from Wildhorse Island and the Sun River range, not the National Bison Range. The species recovered by Boddicker and Hugghins (1969) from bighorns in South Dakota were also more similar to those from Wildhorse Island and the Sun River range. The unusual species composition from bighorns on the National Bison Range may reflect the influence of a new habitat or, more likely, the acquisition of parasites from other ungulates already well established on the Bison Range.

Although Cowan (1951) did not report the intensities of the infections he encountered, he did comment on the apparent role of multiple parasitism and the effect of host condition on the severity and eventual pathogenicity of these infections. Cheatum (1951) reiterated this idea but also failed to present quantitative data. Becklund and Senger (1967) were the first to give quantitative data on parasite burdens in wild sheep. They examined 18 bighorns from three herds and found gastrointestinal helminths in numbers ranging from 275 to 5300 per host. They did not relate the numbers to host condition, but concluded that parasite burdens in the bighorns examined were very low, presumably by comparison with pathogenic burdens in domestic sheep. Burdens in the bighorns examined in this study varied considerably, but were comparable to those reported by Becklund and Senger.

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