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HELMINTH PARASITES OF BIGHORN SHEEP IN OREGON¹ 2T. P. KISTNER,³ SUSAN M. MATLOCK,³ DELORES WYSE³ and G. ELLIS MASON⁴

Abstract: The lungs and gastrointestinal tracts from 18 hunter-killed bighorn rams (*Ovis canadensis californiana*) were examined in total or in part for helminth parasites during a two-year study of three separate herds in Eastern Oregon. Prevalence was 100% with the lungworm *Protostrongylus stilesi*. The gastrointestinal fauna from 11 rams comprised *Cooperia oncophora*, *Marshallagia marshalli*, *Nematodirus oiratianus*, *Oesophagostomum* spp., *Ostertagia occidentalis*, *O. ostertagi*, *Skrjabinema ovis*, *Trichostrongylus axei* and *Trichuris* spp. Adult *Wyominia tetoni* and cysticerci of *Taenia hydatigena* were recovered from two of six livers examined.

Additionally, searches for potential molluscan intermediate hosts for *P. stilesi* were conducted on one bighorn range. Snails identified as belonging to the genera *Euconulus*, *Pupilla* and *Vallonia* were found on both the summer and winter ranges.

INTRODUCTION

Two subspecies of bighorn sheep originally were native to Oregon, the California bighorn (*Ovis canadensis californiana*) and the Rocky Mountain bighorn (*O. c. canadensis*). The range of the Rocky Mountain bighorn was limited primarily to the northeastern corner of the state, whereas California bighorn populations were found east of the Cascade Mountains throughout Central and Southeastern Oregon.⁶ Decline of bighorn sheep in the state began in the last half of the 1800's, shortly before the influx of white man and domestic animals.^{9,12} It has been speculated that the most severe decimating factors were diseases and parasites of domesticated sheep and over-grazing of the range with resultant starvation.^{6,9,12} By 1916, the California bighorn had disappeared from Oregon.⁶ The last sighting of native Rocky Mountain bighorn was in 1933.^{6,12}

Successful reintroduction of bighorns into Oregon was made in 1954 when 20 California bighorns were captured near Williams Lake in British Columbia (52° 15' N, 122° 45' W) and were released

into a 259 ha. enclosure on Hart Mountain, (42° 45' N, 119° 45' W) Lake County, located in Southeastern Oregon. Some sheep escaped to establish a wild herd in this area. Reproduction was successful in the remaining captive herd and transplants subsequently were made to other southeastern areas. In 1960 and 1961, bighorn sheep were stocked into the Steens Mountain (42° 30' N, 118° 40' W), Harney County; in 1965, into the Owyhee Reservoir area (43° 20' N, 117° 20' W), Malheur County, and in 1971, into the Strawberry Mountains (44° 20' N, 119° W), Grant County.

The present California bighorn populations comprise 125 sheep in Harney County, 125 in Lake County, 75 in Malheur County, and an unknown number in Grant County. Limited sport hunting was initiated in Lake County during 1965 for harvest of five trophy rams; similar seasons subsequently have been established for the Harney and Malheur county herds.¹²

It is well recognized that intelligent management of a species depends on a thorough understanding of all facets of

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the life history. As an initial step for California bighorns in Oregon, examination of hunter harvested rams was requested by personnel of the Oregon Department of Fish and Wildlife (ODFW). Objectives were to determine by parasitologic examinations the presence or absence of potential pathogens in the three major herds. This manuscript reports the results of examination of rams harvested by sportsmen during the 1974 and 1975 controlled hunts.

MATERIALS AND METHODS

During a required pre-hunt indoctrination program, sportsmen were familiarized with the objectives of this study. They were supplied a series of plastic bags for the collection of the lungs, a portion of rectum containing pelleted feces, and the gastrointestinal tract. Collected materials were retrieved by ODFW biologists and delivered to the field laboratory.

Each set of lungs was examined grossly and a sketch was made of the medial and lateral aspects of each right lung depicting the location of lungworm nodules and other gross lesions. A few nodules were excised from infected lungs and teased apart using a dissecting microscope with 10 X magnification. Terminal portions of several male lungworms were extricated and preserved in 5% formalin for later identification. Fifteen tissue sections, 5 mm x 20 mm, were taken randomly from various portions of the left lung and preserved in buffered 10% formalin. These sections were processed routinely, sectioned at 6 μ m, mounted on slides and stained with hematoxylin and eosin. The bronchi and bronchioles of both lungs were then opened and examined for lungworms. The right lung of each ram was placed in a deep pan, covered with water, soaked overnight, rinsed, and discarded. After one hour, the supernatant from the overnight soak and rinse was poured off and the sediment examined under 10 X magnification for adult parasites and larvae.

Feces from 15 rams were individually baermannized overnight, the feces and supernatant discarded, and the sediment examined for lungworm larvae.⁵

The gastrointestinal tracts were subdivided into abomasum, small intestine, and cecum and large intestine, and were examined according to standard parasitologic procedures.²⁰

When included with the viscera, the major bile ducts of each liver were opened, the livers were then cut into 1 cm slices and examined for lesions and visible parasites.¹⁹ Parasites recovered were preserved in 5% formalin. Representative sections of gross lesions were collected for histopathologic examination and processed routinely.

Searches were conducted in lush vegetation growing along springs and creek banks for potential molluscan hosts for *Protostrongylus stilesi* on both the summer and winter ranges in Harney County. Where conditions were extremely dry on winter range, soil and grass samples (30 cm x 15 cm x 5 cm) were collected at 50 m. intervals along a contour where the sheep concentrated in winter. These samples were passed through a series of four Tyler analytical sieves³ ranging in size from 1 cm to 100 μ m. Materials remaining on each screen were examined for snails.

RESULTS

Eighteen rams were examined during the two years. This included two from Lake County, 11 from Harney County and five from Malheur County. Age of rams varied from 3½ to 10½ years.

Lungworm nodules were visible in varying numbers in all lungs collected from 17 rams, with most nodules located in the diaphragmatic lobes; a few nodules were located in the apical and cardiac lobes. All nodules contained viable adult worms; male worms recovered were identified as *P. stilesi*. Adult lungworms were not recovered from the

³ W. S. Tyler Incorporated, Screening Division, Mentor, Ohio 44060, USA.

bronchial lumina. *Protostrongylus* sp. larvae were found in the sediment after overnight soaking of all 17 sets of lungs.

Adult lungworms, eggs and larvae were found in all 17 lungs examined histopathologically. Pathology was limited to granulomas in areas of active infection, with smaller areas of atelectasis in the diaphragmatic lobes. Small atelectatic areas with a large area of hepatization without inflammatory activity were present in the right apical lobes of two rams.

Protostrongylus sp. larvae were recovered from every fecal sample examined from 15 rams, which included the one ram from which lungs were not examined.

Complete gastrointestinal tracts were collected from 11 of 18 rams examined during the two years, which included seven from Harney County and two each from Lake and Malheur Counties. Results of the parasitologic examinations are summarized in Table 1. Of the nine helminths recovered, *Marshallagia marshalli* and *Nematodirus oiratianus* were found in all 11 (100%) of the rams.

Ostertagia ostertagi and *Skrjabinema ovis* were recovered from 8 (72.7%) of the rams. The prevalence of the remaining five parasites are given in Table 1.

The livers from six rams were examined. Gross and microscopic pathology was limited to moderate bile duct hyperplasia in these two livers. *Wyominia tetoni* was found in the bile ducts of two rams from Harney County. Cysticerci of *Taenia hydatigena* were found in two of the livers examined in 1975, one from Harney County and one from Malheur County.

Heavy fat deposits were noted on the pericardium and mesentery of all rams examined.

Many land snails were found in moist areas on both the summer range at 2700 m. and the winter range at 1980 m. on the Harney County range. These were identified as *Euconolus* sp. *Pupilla* spp., and *Vallonia* sp. In addition, a small unidentified slug and snails identified as *Lymnea* sp. were found on the winter range. Snails were not found in the six soil samples examined from the winter range concentration area.

TABLE 1. The range, prevalence and average of gastrointestinal helminth parasites collected from California bighorn sheep (*Ovis canadensis californiana*), from Harney, Lake and Malheur Counties, Oregon 1974-75.

Location	Parasite	Prevalence		
		Range	(%)	Average
Abomasum	<i>Marshallagia marshalli</i>	13-326	100.0	138.6
	<i>Ostertagia occidentalis</i>	0-37	18.1	5.2
	<i>Ostertagia ostertagi</i>	0-567	72.7	100.4
	<i>Ostertagia</i> spp. L-5*	0-32	36.3	7.0
	<i>Ostertagia</i> spp. L-4**	0-27	18.1	3.8
	<i>Trichostrongylus axei</i>	0-32	27.2	6.1
Small Intestine	<i>Cooperia oncophora</i>	0-88	18.1	14.7
	<i>Nematodirus oiratianus</i>	72-5888	100.0	1455.8
	<i>Nematodirus</i> spp. L-5	0-739	90.9	170.3
	<i>Nematodirus</i> spp. L-4	50-3405	100.0	1159.6
Cecum and Large Intestine	<i>Oesophagostomum</i> spp. L-5	0-1	9.0	0.1
	<i>Skrjabinema ovis</i>	0-2905	72.7	650.4
	<i>Skrjabinema</i> spp. L-4	0-30	18.1	3.7
	<i>Trichuris</i> spp.	0-30	45.4	3.8

* Immature adults

**Larvae fourth stage

DISCUSSION

Despite the 100% prevalence of *P. stilesi*, all infections were classified as light.^{15,21} Histopathological examinations of pulmonary tissue confirmed that limited pathology was present in the lungs examined. These findings are as would be expected, since rams of the age classes in this group would represent survivors. Our findings represent a state record for *P. stilesi*, and confirm widespread prevalence of this potential pathogen in these herds.^{9,13,15,21}

Contrasting the prevalence of *P. stilesi* found in this study with other reports, infection rates were 100% in 4 sheep (*O. c. californiana*) from British Columbia,⁹ 91% in 58 sheep (*O. c. canadensis*) from western Canada,²⁵ 98% in 121 sheep (*O. c. canadensis*) from Colorado,²¹ 93% in 143 sheep (*O. c. canadensis*) from Montana¹⁴ and 0% in 3 sheep (*O. c. californiana*) examined during 1974 from Washington.¹⁹ A previous report from Washington indicated light and moderate lungworm infections during 1967.¹⁷

The life cycle of protostrongylid lungworms involves land snails of the families Pupillidae, Valloniidae and Zonitidae as intermediate hosts.^{13,15} Our findings indicated that suitable molluscan hosts were present in the Lake County enclosure, the area surrounding the enclosure and on the ranges in Harney and Malheur counties. The relative abundance of intermediate snail hosts at high and low elevations on the Harney County transmission on this area, as contrasted to fall transmission in Colorado (Hibler, 1974, pers. comm.). On Pikes Peak, Colorado, where fall transmission prevails, massive population declines occurred in Rocky Mountain bighorns at about 20 year intervals⁹ (Hibler, 1975, pers. comm.). Although pathogenicity of *P. stilesi* has not been proven for California bighorns, there is no reason to believe it will behave differently in this subspecies than it does in Rocky Mountain bighorns. With multiseasonal transmission as indicated from our study in Harney County, greater intensities of larval infections could be acquired annually by ewes. Therefore, *P. stilesi* in-

duced population declines may occur in one or more of the Oregon herds at an earlier date than might be anticipated.

The nine gastrointestinal helminths also constituted state records for these parasites from California bighorns in Oregon. All of these parasites have been reported from one or more bighorn subspecies in the following states: *M. marshalli* in Wyoming,^{10,16} *N. oiratianus* in Montana,⁷ *N. spathiger* in New Mexico,⁴ *Nematodirus* spp. larvae and eggs in Washington,^{17,18} *O. ostertagi* in Idaho and Montana,⁷ *S. ovis* in New Mexico,¹ Utah,²⁶ Nevada² and Washington,^{17,18} *Trichuris* spp. in British Columbia,⁸ and *T. discolor* in Nevada² and New Mexico,¹ *T. axei* in British Columbia,⁸ *O. occidentalis* in Idaho^{11,22} and Montana,⁷ *C. oncophora* in Montana,⁷ *Oesophagostomum* spp. in New Mexico¹ and Washington.^{17,18}

Cattle and mule deer utilize summer range areas adjacent to the Harney County bighorn range. The parasites *M. marshalli*, *N. oiratianus* and *O. occidentalis* have not been found in cattle or mule deer, whereas *C. oncophora*, *Oesophagostomum* spp., *O. ostertagi*, *S. ovis*, *T. axei* and *Trichuris* spp. have been found in cattle and/or mule deer from this area (Kistner, 1972-1975 unpublished data). *P. stilesi*, *M. marshalli*, *N. oiratianus* and *O. occidentalis* apparently infected the original sheep transported to Oregon, became established in the Lake County herd, and subsequently have been spread to the Harney and Malheur county ranges.

The gastrointestinal nematode burdens varied considerably between animals, but appeared to have little or no effect on the well-being of these rams, since all animals were in excellent physical condition. Considering potential pathogenicity, a paucity of information exists relative to this group of parasites in bighorn subspecies. Of these parasites, however, *N. oiratianus* could conceivably cause problems in lambs. Although not reflected in Table 1, the mean burden for all stages of *N. oiratianus* in these rams was 2761 worms. It is our opinion that rapid acquisition of similar or greater burdens in susceptible young lambs would probably cause debilitation and/or mortality.

W. tetoni also has been reported from California bighorns in Washington¹⁷ and from bighorn subspecies in Arizona,³ western Canada,²⁴ Colorado,⁷ Idaho,^{7,29} Montana,⁷ Nevada,² Utah,²⁸ and Wyoming.^{16,23} The enlarged bile ducts we noted also were reported earlier.¹⁶ Although we found no evidence of permanent impairment, the earlier report suggested that the parasite may impede the flow of bile, causing chronic conditions.¹⁶ In addition to the state record based on our recovery of cysticerci of *Taenia hydatigena*, this immature tapeworm was

reported from a desert bighorn in New Mexico,⁴ and from a bighorn in Washington.¹⁸

In summary, findings from this study indicated that *P. stilesi* and *N. oiratianus* represent the predominant helminths of California bighorn sheep in Oregon. Following this study, life history investigations have been initiated on the herds in Harney and Lake counties. Hopefully, these studies will provide definitive data on reproduction, lamb survival, and the impact of parasites on the population dynamics of these herds.

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