Coccidia of Rocky Mountain bighorn sheep in Western Canada

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A survey of coccidia in the Rocky Mountain bighorn sheep (*Ovis. c. canadensis*) in Alberta and Kootenay National Park, British Columbia, was conducted from the winter of 1967 to the spring of 1969. Ninety percent of 510 fecal samples examined were positive for coccidia. The species recovered, in order of prevalence, were *Eimeria ovina* (syn., *E. arloingi*) (56%), *E. parva* (35%), *E. crandallis* (34%), *E. ahsata* (33%), *E. ninakohlyakimovae* (19%), *E. faurei* (6%), *E. intricata* (5%) and *E. granulosa* (1%). Coccidiosis was not encountered in the field; however, evidence which suggests the magnitude of pathogenic infections is presented.

Un relevé des Coccidies dans les mouflons *Ovis c. canadensis* en Alberta et dans le parc national de Kootenay en Colombie-Britannique a été fait de l'hiver 1967 au printemps 1969. Des 510 échantillons fécaux examinés, 90% se sont montrés positifs au point de vue des Coccidies. Les espèces trouvées sont, par ordre de prédominance, *Eimeria ovina* (Syn., *E. arloingi*) (56%), *E. parva* (35%), *E. crandallis* (34%), *E. ahsata* (33%), *E. ninakohlyakimovae* (19%), *E. faurei* (6%), *E. intricata* (5%) et *E. granulosa* (1%). On n'a pas observé sur le terrain des cas de Coccidiose; il est néanmoins évident que les infections pathogènes sont importantes.

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 1964; Demarchi and Demarchi 1967). The lungworm–pneumonia complex apparently involves a reduction in the general resistance of the bighorns as a result of an imbalance in the homeostasis of their environment. Little attention, however, has been given to the possible role of "multiple parasitism" in the syndrome.

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. As a part of that study we attempted to determine the species of coccidia present, their distribution, prevalence, and intensity of infection.

Materials and Methods

Five hundred and ten fecal samples were collected from six bighorn ranges in Western Canada. All samples were fresh, obtained from bighorns observed to defecate or from areas that a herd had just vacated. Some samples were obtained from animals collected for necropsy. Three hundred and twenty-seven of the samples were collected from the Sheep River herd from an estimated 65–75 animals from December 1967 to April 1969. Collections were also obtained regularly from two animals captured in the wild and maintained in captivity at the University of Alberta.

Fecal samples were stored at 4C in 2.5% potassium dichromate, and examined microscopically for coccidial oocysts by a cover slip flotation method (Levine *et al.* 1960). Unsporulated oocysts were identified by morphological criteria in Honess and Winter (1956) and Pellerdy (1965). Intensity of infections were rated subjectively on a 0 to 4 scale (no infection to very heavy infection) after complete examination of two 18-mm cover slips. No attempts were made to determine individual species intensities. A quantitative evaluation of the rating scheme was conducted by comparing ratings made by the cover slip method with the numbers of oocysts per gram of feces determined by a modified McMaster technique (Levine *et al.* 1960) on duplicate samples.

Results

Examination of feces revealed a high incidence of coccidian infection in the Rocky Mountain bighorn sheep. Four hundred and sixty-one (90%) of 510 samples were positive for coccidia (Table 1). The species recovered in order of decreasing prevalence were *Eimeria ovina* Levine and Ivens, 1970 (syn., *E. arloingi* (Marotel, 1905) Martin, 1909); *E. parva* Kotlan, Mocsy and Vajda, 1929; *E. crandallis* Honess, 1942; *E. ahsata* Honess, 1942; *E. ninakohlyakimovae* Yakimoff and Rastegaieff, 1930; *E. faurei* (Moussu and Marotel, 1902) Martin, 1909; *E. intricata* Spiegl, 1925; and *E. granulosa* Christensen, 1938. The five most common

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species were recovered from all six ranges; the three least common species were not found on some ranges, probably because of small sample sizes.

The number of coccidial species recovered from individual samples has been summarized in Table 2. Multiple species infections were found in 61.1% of the positive samples. Infections by one or two species were most commonly encountered while infections by four and five were infrequent. In the examination of repeated samples from two captive bighorns, it became evident that an individual bighorn could harbor many species of coccidia but shed oocysts of only a few species at any one time (Table 3). It is possible, therefore, that repeated samples from the same individuals would have revealed more multiple infections in the free-ranging bighorns.

Clinical signs of coccidiosis were not encountered in the field. The two captive bighorns were passing poorly formed fecal pellets (which could not be ascribed definitely to the effects of the coccidia). Infections in both were rated 4; they shed 100 500 and 146 400 oocysts per gram of feces, respectively. In the free-ranging sheep, the highest number encountered was 76 200 per gram of feces (these pellets were well formed). Based on these observations, the fact that 97% of the infected samples were rated 1, 2, or 3 (Table 4), and the correlation between the rating scheme and the quantitative evaluations (Table 5), it appears that infections in the wild are generally subclinical.

Discussion

Rocky Mountain bighorn sheep are distributed through the eastern ranges of the Rocky Mountains of North America from northern New Mexico to north eastern British Columbia (56° N. lat.). At various localities throughout this distribution they actively compete for range with

TABLE 1

Prevalence of species of *Eimeria* in Rocky Mountain bighorn sheep in Western Canada

		No. bighorns infected								
Location	No. samples	Any species	*E. ovina*	*E. parva*	*E. crandallis*	*E. ahsata*	*E. ninakohl-yakimovae*	*E. faurei*	*E. intricata*	*E. granulosa*
Sheep River	327	295	177	65	81	94	43	18	16	4
Jasper	81	70	25	49	39	29	24	9	1	0
Waterton	46	45	31	23	18	10	7	1	2	0
Banff	28	27	18	10	13	9	10	1	3	1
Kootenay	19	16	2	11	4	6	1	0	0	0
Ram Lookout	9	8	7	1	1	3	3	0	1	0
Totals	510	461	260	159	156	151	88	29	23	5
Percentage		90	56	35	34	33	19	6	5	1

TABLE 2

Frequency of multiple coccidial infections in Rocky Mountain bighorn sheep

		No. species present					
Location	No. examined	0	1	2	3	4	5
Sheep River	327	32	139	113	38	2	3
Jasper	81	11	12	25	20	11	2
Waterton	46	1	9	26	9	1	
Banff	28	1	7	8	8	2	2
Kootenay	19	3	10	5		1	
Ram Lookout	9	1	2	4	2		
Totals	510	49	179	181	77	17	7
Percentage		10	35	36	15	3	1

domestic sheep. Ovine coccidia may have been introduced into North America with the introduction of domestic sheep or with wild sheep invading North America via the Bering land bridge. Further examination of Dall (*Ovis d. dalli*) and Stone Sheep (*Ovis d. stonei*), both geographically isolated from contact with domestic sheep, may provide further data on the introduction of these coccidia. A preliminary study of Dall Sheep by one of us (JLM) revealed *E. ahsata* and *E. crandallis* in a small series of fecal samples from the Northwest Territories.

Fifteen species of coccidia have been reported from wild and domestic sheep (Levine and Ivens 1970; Pellerdy 1965). Ten species are considered to be ubiquitous with eight of the species reported from both wild and domestic hosts. Studies on the wild sheep in North America have

TABLE 3

Occurrence of *Eimeria* species in two captive Rocky Mountain bighorn sheep (A and B)

Date of examination	*E. ahsata*		*E. ovina*		*E. crandallis*		*E. faurei*		*E. intricata*		*E. ninakohl-yakimovae*		*E. parva*	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Nov. 27/68	++		+								+			
29	+		+		++		+		+		+		+	
Dec. 2	++		++						+				+	
3	+		+				++				++		+	
4	+		+		+		++				+		+	
5	+		+				++				++			+
6	+		++				+				+			+
9			+		+		++				++			+
16	++		++				+				+			+
23	+		++				++				+			++

TABLE 4

Distribution of intensity of infection in the Rocky Mountain bighorn sheep

Location	No. examined	Intensity rating				
		0	1	2	3	4
Sheep River	324	32	147	104	31	10
Waterton	46	1	36	5	2	2
Jasper	42	11	13	17	0	1
Banff	23	1	6	10	6	0
Kootenay	18	3	10	5	0	0
Ram Lookout	9	1	6	1	1	0
Totals	462	49	218	142	40	13

TABLE 5

Comparison of the intensity rating and the oocyst output determined by the McMaster technique

Rating category	No. samples	Oocysts per gram of feces	
		Mean*	Range
1	7	3 814 ± 2 129	300 – 6 700
2	5	12 600 ± 1 563	11 000 – 14 500
3	5	28 900 ± 7 610	21 000 – 39 800
4	11	95 081 ± 25 365	46 900 – 146 400

* ± One standard deviation.

been limited to investigations of Rocky Mountain bighorns in Wyoming (Honess 1942; Honess and Scott 1942; Honess and Winter 1956) and Colorado (Spencer 1943) and a report of a single oocyst of *Eimeria* sp. in a California bighorn (*Ovis c. californiana*) in British Columbia (Blood 1963). Eight species of coccidia, all of which were also recovered in this study, were found in bighorns in Wyoming. Three of the same species (*E. ovina* (syn., *E. arloingi*), *E. faurei* and *E. parva*) were found in Colorado. No further comparisons can be made, since the previous studies did not indicate the intensity or the prevalence of the coccidia.

Some of the species recovered have been reported to be pathogenic, causing morbidity and mortality in feedlot lambs (Mahrt and Sherrick 1965). The intensities they reported for the pathogenic infections far exceeded those observed in the two captive bighorns or in any free-ranging bighorns. Clinical signs of coccidiosis were not encountered in the field, although the potential for coccidiosis exists.

The role of coccidian parasites in the ecology and well-being of the host during periods of stress, or during a die-off, has not been investigated. It is apparent from the prevalence and intensity of coccidial infections in the bighorns and from the number of species encountered that their significance as an integral part of the biology of the host and as a possible factor influencing the development of the lungworm–pneumonia complex needs further investigation.

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