A MINOR DIE-OFF OF BIGHORNS FROM PNEUMONIA IN SOUTHERN ALBERTA (1978)

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ABSTRACT

The events before and after a minor (10%) all age die-off of bighorns (Ovis canadensis canadensis) at the Sheep River Sanctuary in Alberta are described. Coughing bighorns were first observed in early September 1978 and the die-off occurred about the third week in October. Lungworm levels in the survivors were relatively low, averaging 300 larvae/gm of dry feces in late winter 1979. It appeared that in the early fall a few animals had ingested a heavy infection of larvae that matured in synchrony in sufficient numbers to precipitate the death of their hosts from pneumonia. The Sanctuary (since 1973) may be creating a death trap for bighorns from secondary lungworm infections, since the herd is returning early, and concentrating for longer periods on the winter range as a result of avoidance behavior to hunters and/or hikers. Management measures are recommended.

INTRODUCTION

A series of population fluctuations of bighorns during the period 1800-1970 along the eastern slopes of the Canadian Rockies was documented by Stelfox (1971) with some of the more recent declines attributed to "verminous pneumonia". The last major die-off in Alberta from "lungworm disease" occurred in the Bow River Forest Reserve in 1945 (Forsland 1946). Lungworm (Protostrongylus spp.) surveys in Alberta were first conducted by Uhazy et al.

(1973). They collected lung and fecal samples throughout the range of the bighorns in Alberta from 1967-69 and found 91% of the lungs were infected with P. stilesi and 38% with P. rushi. All but 1 of 409 fecal samples contained lungworm larvae. Their results suggested that counts over 1400 larvae/gm feces probably represents heavy infection. In addition, they noted fecal larval output or intensity of infection is non-random and under-dispersed (clumped), thus heavy lungworm burdens concentrate in only part of the population.

Annual differences in the numbers of lungworms in feces appears to be related to precipitation from the previous spring and summer (Forrester and Senger 1964, Uhazy et al. 1973, Gates 1975). In Montana, Forrester and Littell (1976) examined lungs from 124 bighorns (all infected) and found significant correlations between levels of lungworm infection and rainfall during April, May and June in the same year. High humidity and moderate temperatures provide ideal conditions for terrestrial gastropods and the completion of the lungworm cycle in the bighorn. This paper examines the Sheep River die-off in relation to the factors mentioned above.

ACKNOWLEDGEMENTS

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STUDY AREA

The study area is situated along the Sheep River about 50 km southwest of Calgary in the Bow-Crow Forest Reserve. The area lies in the foothills and is an important winter range that presently supports a population of approximately 110 bighorns (nearly double the population of the 1950's and 60's). Other ungulates that use portions of the area are mule deer (Odocoileus hemionus), elk (Cervus canadensis) and domestic cattle. The winter range is a mix of montane forest and aspen (Populus tremuloides) parkland. The grasslands are primarily a Festuca-Danthonia association, however, the most prevalent species are Koeleria cristata, Agropyron spp. and Carex spp. (Wishart 1958). The slopes merge with a broad valley floor that is incised by a steep canyon wall of shale above the river. The shale walls provide escape terrain as well as a source of several mineral licks for nursery herds throughout the summer.

Boag (1980) identified nine species of terrestrial gastropods in the study area. Three of the snail species he found were Euconulus fulva, Vertigo gouldi and Discus cronchitei which are known intermediate hosts for Protostrongylus spp. (Latson and Woodard 1979).

The nearest weather station is Turner Valley (30 km east) where the mean annual temperature is 2.1°C (14.4°C in July and -12.5°C in January). The mean annual rainfall is 35.9 cm and mean snowfall is 224.6 cm. Peak rainfall is in June (11.5 cm) and peak snowfall is in April (45.7 cm) (Environment Canada 1975).

The Sheep River Ranger Station and the R. B. Miller Biological Station are located on the study area and these facilities have allowed surveillance of the herd by various observers since the early 1950's (Wishart 1958, MacDonald 1961, Horejsi 1976, Pall and Mamo 1978). The wintering area was

declared a wildlife sanctuary in 1973. Outside of the sanctuary there are restricted trophy (4/5 curl) and non-trophy (permit) seasons on bighorns from late August until the end of October.

CASE HISTORY

On 3 September, Dr. D. A. Boag, Director of the R. B. Miller Biological Station, observed a herd of about 20 bighorns on the Sheep River winter range. He noted that nearly all of the animals were coughing after a rapid ascent of a cliff. Our research section was notified immediately and we proceeded thereafter to monitor the herd every few weeks throughout the fall and winter of 1978-79 and 1979-80.

The violent coughing spells of the Sheep River bighorns in the fall of 1978 were the first observations of these symptoms since they were last reported by hunters and trappers during the die-off in 1945 (Wishart 1958). Additional accounts in 1978 were reported by hunters who observed prolonged coughing spells in two other bighorns in southern Alberta, however, no die-offs were observed elsewhere in the Province (Jorgenson 1979). The symptoms that we observed were similar to those described by Marsh (1938). The animals arrived on the winter range in the early fall in good condition, but many were suffering from what appeared to be severe chest colds. Coughing was audible for a few hundred meters and sometimes lasted for several seconds. Coughing was observed in all age classes and both sexes and was more severe in some animals than others (Wishart 1978). Although paroxysms of coughing were observed from time to time while the animals were grazing, coughing was more frequent following exertion from running or climbing.

On 14 September we collected a female lamb that was lame and coughing.

In addition, we began a fecal lungworm monitoring program with collections once a month. On 25 October nine bighorns of various ages and both sexes were found dead, lying in or near their beds, while others had tumbled to the bottom of the Sheep River Canyon. They appeared to have died quickly and within a week or 10 days of when they were found. Four other bighorns were found dead in the cliffs above the ranger station, on later dates, in progressive stages of decomposition; these animals may have died in October as well. Although coughing bighorns were observed well into December, no additional carcasses were found and no further reduction in the herd was noted. Coughing was observed again in December 1979 and it persisted in some animals throughout the winter. Lamb production was high in 1979 and no evidence of mortality from pneumonia was found during the winter of 1979-80.

RESULTS

All of the dead sheep were in good to excellent body condition. The mean percentage of femur marrow fat was 87.6 (76.7-94.3). Both sexes and various ages (except older rams) were represented in the die-off (Table 1).

Table 1. Ages of dead bighorns found following Sheep River die-off 1978.

Sex	Age											
	L	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+
M	1	1	2									
F			2	1		1			1			1

The necropsies were performed by the Veterinary Services Branch of the Alberta Department of Agriculture and the Parasitology Section, Dept. of Zoology, University of Alberta. The results are summarized and compared in Table 2 with three specimens that were killed in the Sheep River area in September and March.

Out of six animals that were found dead and suitable for bacteriological examination, the lungs of five had Pasteurella hemolytica and the lungs of one had Corynebacterium pyogenes. It was concluded from eight animals found dead and submitted in October, that they had acute verminous and fibrinous pneumonia caused by Protostrongylus spp. and Pasteurella hemolytica with one animal having chronic pneumonia and pleuritis. Two animals that were killed in September showed numerous "petechial hemorrhages" that may have been a response to a recent re-infection. One gravid ewe that died accidentally in March 1979 had a low level infection of P. stilesi and P. rushi. No lungworm larvae were found in the liver of her fetus.

Fecal lungworm loads were generally low in the Sheep River bighorns (Fig. 1). Spring precipitation in April, May and June was about normal (Table 3) and high lungworm loads were not expected.

DISCUSSION

The factors that predisposed the coughing and the die-off of 13 bighorns at Sheep River in 1978 may have provided an important clue to bighorn management. The high correlation of lungworms and spring precipitation in April, May and June (Forrester and Littell 1976) is also apparent in Alberta bighorn lungworm studies (Figs. 2 and 3). Heavy spring rains may have predisposed the die-off in 1945 (Table 3) and a late summer die-off

Table 2. Summary of bighorn necropsies from Sheep River, Alberta 1978/79.

Date	#	Sex	Age	Cause of Death	Lungs	Lungworm	Bacteria
S14/78	A78-6255L	F	L	Collected	hard granules 1-2 m in diameter appeared as petechial hemorrhages	light intensity of protostrongylid larvae	negative
S29/78	406B	F	Ad	hunter	apparent petechial hemorrhages and nodular lesions	30 gms of nodular tissue digested produces = 120,000 L1's, eggs, & adults of P. stilesi	-
025/78	1A78-7124PH	F	5½	pneumonia	fibrinous pneumonia extensive hemorrhages throughout parenchyma	-	Pasteurella hemolytica
"	2A78	M	L	pneumonia	severe hemorrhagic fibrinous pneumonia	protostrongylid larvae	Pasteurella hemolytica
"	3A78	M	2½	pneumonia	pericarditis and fibrinous pneumonia	30 gms of nodular tissue produced = 1,500,000 L1's and adults of P. stilesi	Pasteurella hemolytica
"	4A78	F	2½	pneumonia	hemorrhagic and fibrinous pneumonia	protostrongylid larvae	Pasteurella hemolytica
"	5A78	F	3½	pneumonia	pericarditis and extensive fibrinous pneumonia	protostrongylid larvae	Pasteurella hemolytica
"	6A78	F	Ad	pneumonia	extensive purulent pleuritis	-	Corynebacterium pyogenes

Continued . . .

Table 2 (Continued).

Date	#	Sex	Age	Cause of Death	Lungs	Lungworm	Bacteria
025/78	7A78	F	Ad	pneumonia	fibrinous pleuritis	-	-
"	8A78	F	2½	pneumonia	fibrinous hemorrhagic pneumonia	-	-
Mar 30/79	1A79-2603PH	F	Ad	accidental	several nodules with local inflammation	P.stilesi and P. rushi in low numbers	negative
"	2A79	-	Fetus	accidental	-	none in liver	-

Table 3. Average spring precipitation (cm) from several Alberta mountain and foothills weather stations prior to southern bighorn pneumonia die-offs 1945 and 1978.

SOUTH

	April	May	June	Total
$\bar{X}$	5.76	7.26	10.10	23.12
1945	8.35	9.85	15.21	33.41
1978	7.16	10.49	5.13	22.78

NORTH

$\bar{X}$	3.45	5.28	7.79	16.53
1945	4.54	5.13	6.50	16.17
1978	4.47	6.27	7.74	18.48

of lambs at Sheep River in 1969 (Horejsi 1976). In the latter case, high precipitation in 1968 was reflected the following spring by the highest lungworm loads so far recorded at Sheep River (Fig. 2). The timing of the lamb die-off in 1969 at Sheep River appears similar to the lamb die-offs in Colorado described by Hibler et al. (1976), i.e., the lambs received fatal lungworm loads through transplacental transmission and began dying approximately six to eight weeks after birth. In 1978, however, heavy spring rains did not occur at Sheep River and predictably fecal lungworm counts were not high in the late winter of 1979 (Fig. 2). In addition, our observations indicated that both lamb production and lamb survival were high in 1979. In other words, there was no evidence from fecal lungworm counts and spring precipitation records that a bighorn die-off should have occurred. The die-off appeared to be an isolated event that may have developed from a series of bighorn management steps that are creating a death trap by concentrating bighorns in a sanctuary. Since the sanctuary was created in 1973, more and more sheep have been returning to the winter range in late summer and early fall than previously recorded (Wishart 1958, Horejsi 1976) apparently as an avoidance strategy to hunters and/or hikers (presumably indistinguishable to sheep). This strategy appears to have backfired on the sheep by re-exposing them to a large concentration of infective snails on the winter range.

The seasonal variations in numbers of first stage larvae appearing in bighorn feces are typified by two distinct periods of shedding; winter being a period of high larval shedding and summer a period of low shedding (Forrester and Senger 1964, Uhazy et al. 1973, Gates 1975), see Fig. 1. The high and low larval outputs appear to be significantly associated with the annual movements of bighorns to and from winter and summer ranges as an adaptation of both the parasite and the host to maximize survival. The

strategy of the parasite is to shed larvae early enough in the winter to become infective again to the sheep via terrestrial snails in the spring. This infective period coincides with the recovery phase of the bighorns from winter when forage quality is reaching its peak in late May and June (Gates 1975, Jorgenson and Wishart 1979), i.e. timed with the increasing competency of the host to infection. The lungworms in the host appear to undergo a diapause when the bighorns become widely dispersed on the summer ranges, i.e., when transmission is least efficient. The strategy of the bighorns is to avoid further infection by generally returning to their winter ranges in the late fall or early winter, during the period when snail activity has generally ceased. The latter strategy has not been the case in recent years at Sheep River.

The circumstances that are developing at Sheep River appear to be a precursor to the die-offs that have occurred in non-migratory herds such as Pikes Peak (Spraker and Lange 1974) and Wildhorse Island (Worley et al. 1976). In retrospect, these problems could be expected when a series of events change the rhythm of a highly evolved host-parasite association.

In summary, the violent coughing may have been caused by the irritation of a large number of infective larvae insulting the lung tissue during a late summer exposure to a contaminated range. It should be noted that the month of July in 1978 had the highest precipitation on record since 1958 which could have provided ideal conditions for a late flush of terrestrial snails. Most of the bighorns were successful in rejecting their untimely exposure, however, the non-random nature of lungworm infection was excessive in some animals. A few animals did not appear to have an adequate immune response to prevent a large re-invasion of infective larvae that matured and began reproducing in synchrony in sufficient numbers to precipitate the

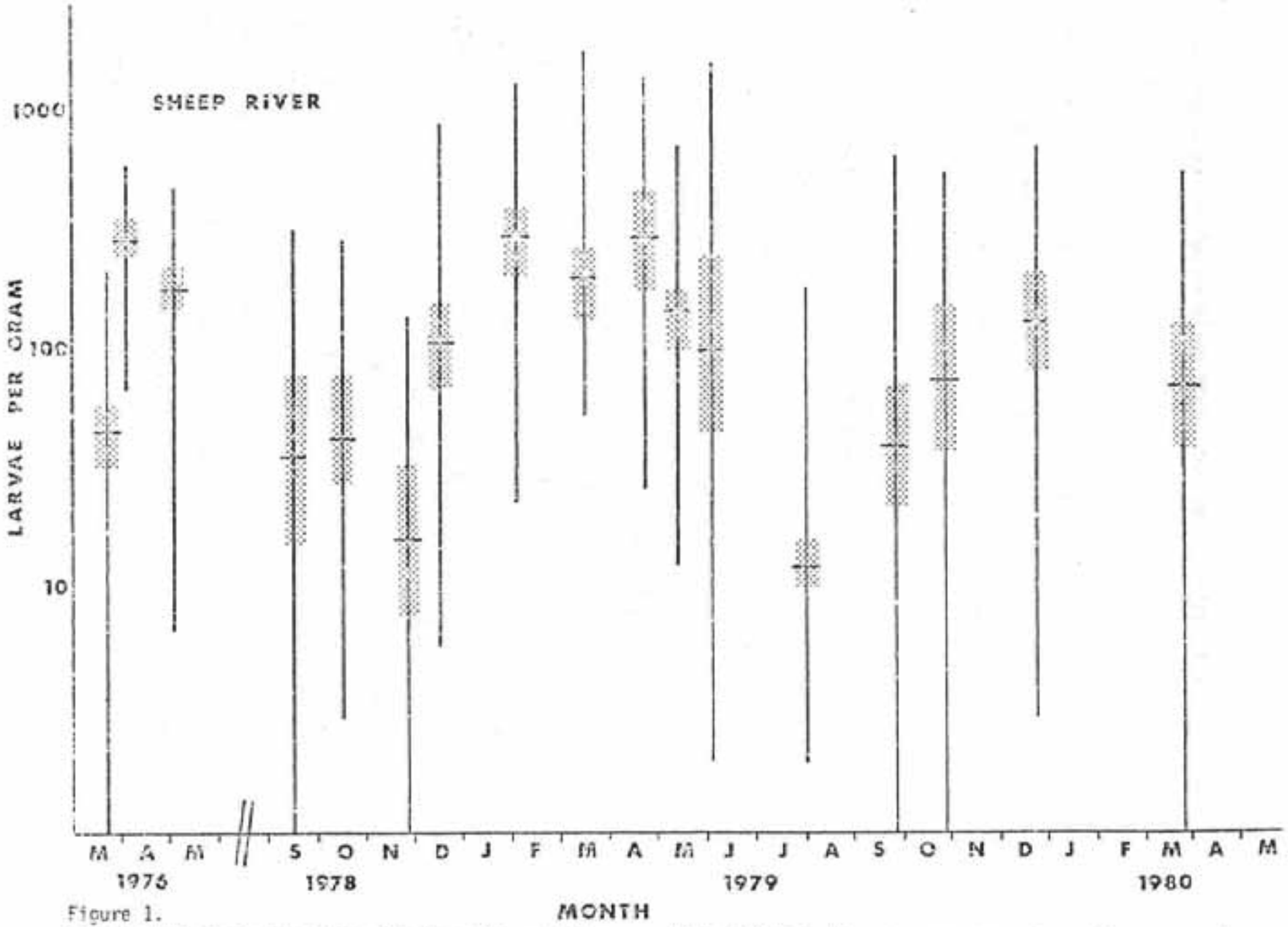

Figure 1.
Mean monthly lungworm levels for Sheep River bighorns - 1976, 1978-80. (Counts were transformed from natural

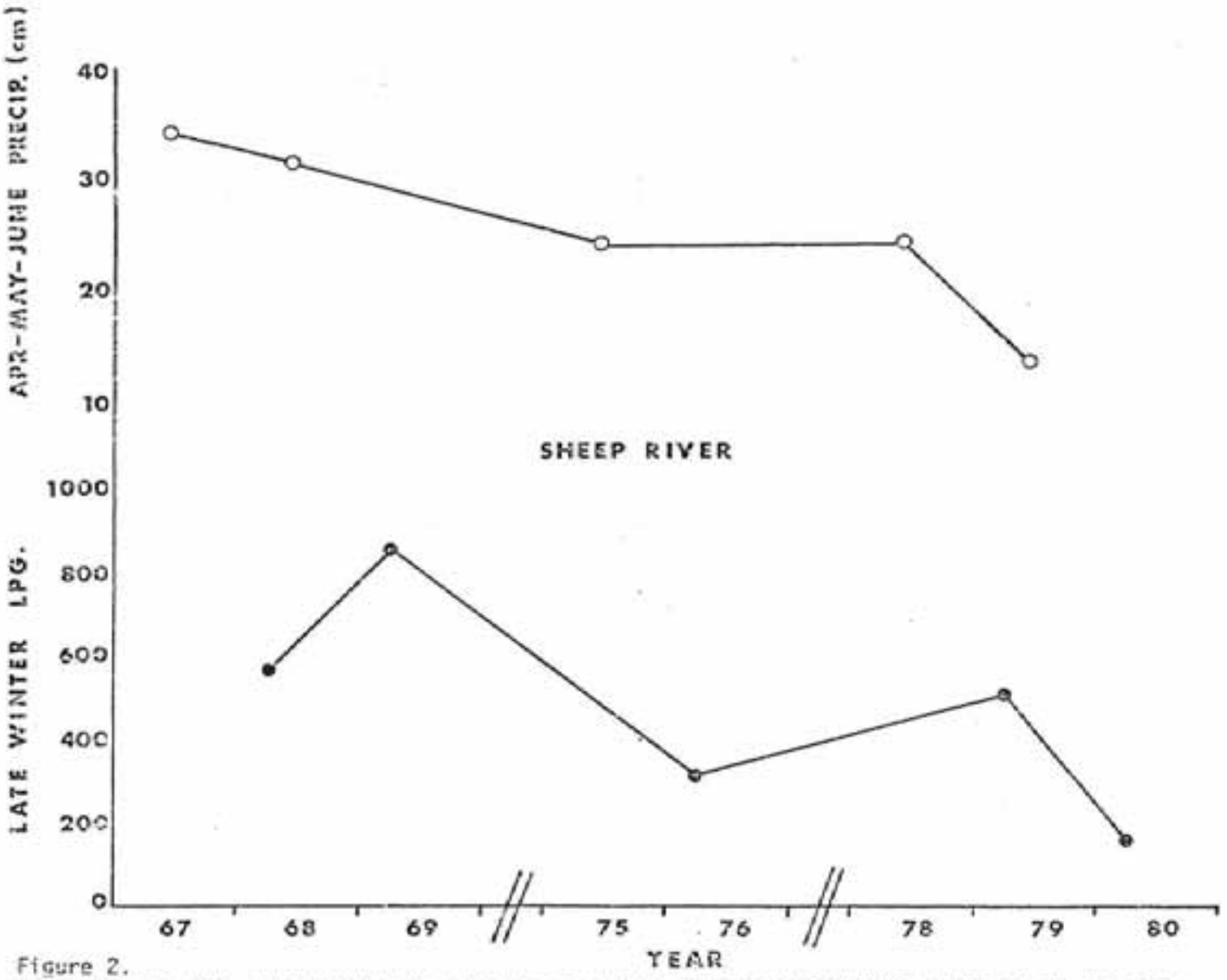

Figure 2.
LATE WINTER FECAL LUNGWORM LOADS RELATED TO SPRING PRECIPITATION FROM SHEEP RIVER, ALBERTA (1967-69, 1975-76, 1978-80).

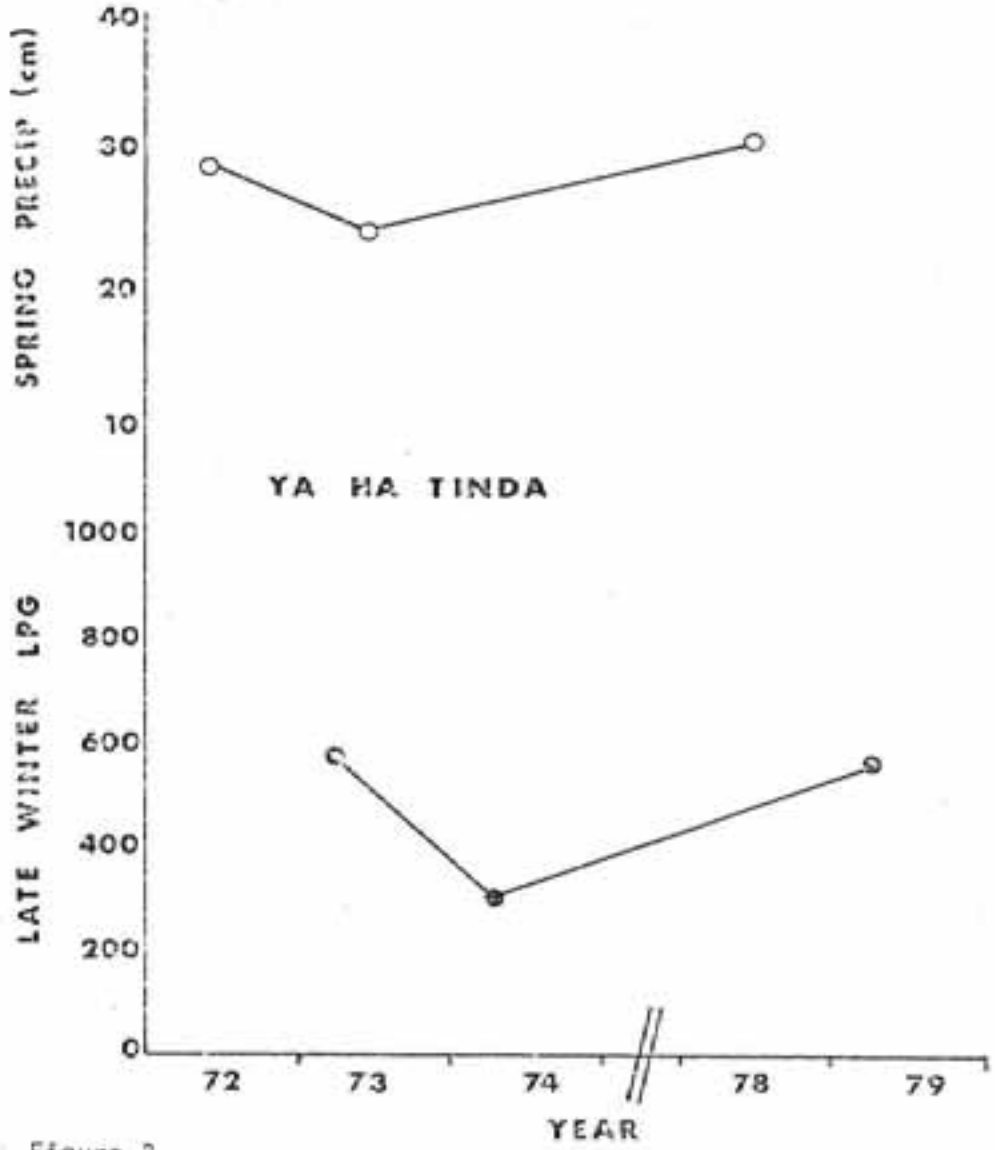

Figure 3.
LATE WINTER FECAL LUNGWORM LOADS RELATED TO SPRING PRECIPITATION

death of their hosts from pneumonia.

Management measures should be undertaken immediately to frighten or harass bighorns away from their winter range during the summer and early fall. Hunting seasons should be delayed until mid-September or later to discourage bighorns from congregating too early on their contaminated retreats.

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Tom Thorne: What was the bacteriology on the ones that died?

Bill Wishart: The lungs were Pasteurella hemolytica.

Tom Thorne: You did get the Pasteurella out of them?

Bill Wishart: Oh, yes.

Tom Thorne: I would wonder if your die-off, at the time of the year and the age spa; if it wasn't more due to Pasteurella than it was the lungworms. And, if they weren't; if nothing more than initiator in 1 or 2 animals or perhaps not involved at all.

Bill Wishart: Well, that's a good question because you know Marsh and some of these guys wrote about die-offs back in the 20's and you read these things it sounds just like we saw. You push these sheep a little bit, they would run up the hill and two-thirds of them would start coughing, yet only few of them died. Now are you suggesting that the Pasteurella was there, just passed on serially sort of thing?

Tom Thorne: Pasteurella is present in many sheep and it's a very effecient pathogen and in itself can kill sheep. What I'm wondering, if the die-off wasn't due to Pasteurella rather than the lungworms. The lungworms may have caused enough damage in some of all of your animals to allow the Pasteurella to kill them. Or, perhaps once the die-off got going it was transmitted from sick sheep to susceptible sheep, and lungworms not being involved there at all.

Nike Goodson: Isn't Pasteurella in most sheep, healthy sheep as well as sick ones?

Bill Wishart: Yes.

Tom Thorne: Right, just because they carry them doesn't mean it won't kill them also.

Nike Goodson: Yes, but it's sort of the same thing as the lungworms or am I contridicting myself?

Bill Wishart: I think what you are saying is, how can Pasteurella suddenly manifest itself. It's there anyway. Suddenly it's manifested.

Tom Thorne: There are a great number of factors and certainly I don't know what they are and I don't thing that anybody does. There are stress of various kinds that most people talk about, but I think there can be other things. That's what I say that, your lungworms in couple of animals could have initiated the illness in those animals. And, it's usually known that Pasteurella, once it goes through animal that is diseased, increases in virulence and there it can transmit to another animal and produce the disease in that.

Bill Wishart: Its kind of like a mutation.

Tom Thorne: Yes, something along that line. This happens in livestock, and I've seen it happen in bighorn sheep I believe and I think that could be what it is, I don't know.

Wayne Heimer: What point were you trying to make with the rain, rainfall?

Bill Wishart: You get an increase number of lungworms appearing in the fall and winter in the feces, or as Montana found, in size of lesions.

Wayne Heimer: That's presumably because the snail bloom?

Bill Wishart: Yes, it's a bloom of snails, right. But, you know the life cycle of the snail and the worm; I don't thing you can do all those things and become infected in April, May and June. I think it kind of lays a trap when they come back in the fall. If there's a bunch of snails lying around when they come back to that fall range, I think that's when it happens. I don't know.