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SHEEP DISEASE STUDIES

by

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Kenneth A. Neiland		
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SUMMARY

Information on the prevalence of three common parasites of Dall sheep is presented. The lungworm, *Protostrongylus stilesi*, apparently occurs with about half the frequency in the Tok Management Area herd that it does in the Dry Creek and Crescent Mountain herds. At the same time it appears that members of the Tok herd are nutritionally and reproductively superior to the other two herds.

Comparatively low intensity infections of *Sarcocystis* occurred in cardiac tissue of about half of the Dall sheep examined.

Examination of over 100 Dall sheep has failed to reveal the presence of hydatid cysts which are otherwise common in moose and caribou in Alaska.

BACKGROUND

Specimens of Dall sheep *(Ovis dalli dalli)* collected for studies on their nutritional and reproductive biology have been routinely subjected to examination for parasite and/or disease agents or conditions. We have been particularly interested in the prevalence and intensity of infection of the lungworm, *Protostrongylus stilesi*, a parasite common to all North American wild sheep. The present report summarizes such data collected to date.

The recent elucidation of the complete life cycle and pathogenic potential of the ubiquitous coccidian parasite, *Sarcocystis*, prompted us to survey various Alaskan big game species for this parasite. The preliminary results of our survey are presented in the following section.

The larval stage of *Echinococcus granulosus*, the so-called hydatid cyst, is a common parasite of moose *(Alces alces)* and caribou *(Rangifer tarandus)* wherever wild (or feral domestic) canids which serve as the definitive (final) host are common. The negative prevalence data presented below bear out the hypothesis that the form of the parasite which occurs in Alaska is the so-called "cervid strain" which is highly host-specific for cervid intermediate hosts.

OBJECTIVES

To qualitatively and quantitatively evaluate diseases and parasites as potential limitations to Dall sheep populations on several study areas in the Alaska Range.

FINDINGS AND DISCUSSION

During the past year I have been concerned with several potentially pathologic agents which occur in Dall sheep, and/or in some cases in other wild Alaskan ruminants. These include the lungworm, *Protostrongylus stilesi*, found in all wild sheep in North America; *Sarcocystis spp.*, a two-host, coccidial-like protozoan parasite of predator and prey species; and the larval stage of *Echinococcus granulosus*, the so-called "hydatid cyst" which is conspicuous by its absence in Dall sheep. These respective disease conditions or agents will be discussed separately in the following section.

Much of the data to be reported were collected during routine necropsy of animals collected for studies on Dall sheep nutrition and reproduction by Mr. Wayne Heimer, sheep research specialist in Region III. He will include general information on condition, etc., obtained at necropsy in his progress report.

A. Lungworm

The complex disease syndrome, verminous pneumonia, is at the present time recognized as one of the more important diseases of North American wild ruminants. Ever since the disease was first recognized and the apparently important predisposing role of the lung parasite, *Protostrongylus stilesi*, was realized, there have been many reports on the occurrence of this parasite in wild sheep populations in North America (Forrester 1971). These reports have presented data on the presence or absence of lungworm nodules and an estimation of the surface area of the lung apparently infected. More recently there has been an attempt to quantify observations on lungworm infections. McGlinchy (1971) presented a method for estimating the number of lungworm larvae in lesions and Neiland (1972) reported a simple procedure for determining the relative volume of lesions. A combination of these two procedures would go far toward maximizing the quantitative description of the lesions seen in most wild sheep. As suggested by Neiland (1972), this kind of information might provide us with better insight into the epidemiologic dynamics of verminous pneumonia in sheep populations. A "combined procedure" has not yet been developed.

The observations on lungworm lesions made during the past year are summarized in Table 1. These include specimens from animals collected over several years and frozen for later examination. Animals collected during the past year were used in a "whole-body," nutritional analysis study and the lungs from these were available only for superficial examination at necropsy. Relative size of lesions was determined by dissecting out suspected lesion tissue from thin serial slices of lungs, fixed in formalin. The presence of lungworm larvae was confirmed by microscopic examination of "squashed bits" of lesion tissue. The total volume of the lung and of lesion tissue was determined by displacement. The procedure is the same as originally reported by Neiland (1972).

It is unfortunate for sake of comparing the data in Table 1 that lungs from animals taken in the Tok Management Area were used in other studies. Superficial examination cannot be relied upon to reveal all infections. In spite of this cautionary note and the limited sample size, it seems apparent that there is a distinctly lower level of infection by lungworms in the Tok population than in the Dry Creek or Crescent Mountain herds.

I propose to investigate this possibility further by quantitative analysis of all lungs of additional animals collected from the Tok herd. Fecal pellet analysis may also be helpful in assessing the prevalence of lungworms in the Tok herd with greater certainty. Confirmation that only about 60 percent of this herd is infected by lungworms is of special interest, since elsewhere in North America prevalence rates for infection of wild sheep by lungworms range from 90-100 percent. The one apparent exception involves the desert bighorn, *Ovis canadensis nelsoni*, in Nevada where only about half of 21 animals were found infected (Forrester 1971). Perhaps environmental conditions in that area are unfavorable for the species of terrestrial molluscs which serve as the obligatory intermediate host of *Protostrongylus stilesi*.

Table 1. Prevalence and Relative Size of Lungworm Lesions in Lungs of Dall Sheep From Interior Alaska.

Locality	Age (years)	Sample Size[1]	Relative Size of Lesions[2] Range Infected	Range Negative	Average Lesion Size
Dry Creek, Alaska Range	1	4 F + 1 M	0.6-4.3	None	2.4
Dry Creek, Alaska Range	2	1	1.2	None	1.2
Dry Creek, Alaska Range	3	1	2.3	None	2.3
Dry Creek, Alaska Range	4	3	0.2-1.5	None	0.6
Dry Creek, Alaska Range	5	4	Present	None	Present
Dry Creek, Alaska Range	6	4 F + 1 M	Present	None	Present
Dry Creek, Alaska Range	7	8	0.3-7.5	None	3.9
Dry Creek, Alaska Range	8	3	1.9-10.0[2]	None	4.0
Dry Creek, Alaska Range	9	1	20.0[2]	None	20.0[2]
Dry Creek, Alaska Range	10	2	11.4-heavy[2]	None	11.4
Dry Creek, Alaska Range	11	3	2.3-17.9	None	6.7
Dry Creek, Alaska Range	13	1	1.7	None	1.7
Dry Creek, Alaska Range	14	1	--	1	No lesions seen
Granite Range	8	1	2.5	None	2.5
Granite Range	10	3	0.7-1.8	1	1.2
Granite Range	11	2	0.1-10.8	None	5.4
Tok Management Area	6 Weeks	1	0.6	None	0.6
Tok Management Area	6 Months	2	--	2	--
Tok Management Area	1	1	Present[2]	None	Light[2]
Tok Management Area	2	1	Present[2]	None	Light[2]
Tok Management Area	3	3	Present[2]	2	Moderate[2]
Tok Management Area	5	1	Present[2]	None	Light[2]
Tok Management Area	6	2	Present[2]	None	Light[2]
Tok Management Area	8	6	Present[2]	3	Light[2]
Total Examined:					
Dry Creek		38	0.3-20.0	1(2.6%)	--
Granite Range		6	0.1-10.8	1(16.7%)	--
Tok Maintenance Area		17	--	7(41.2%)	--
Crescent Mountain[3]		46	0.2-35.4	5(10.9%)	--

1. All females unless otherwise noted.

2. Lungs examined superficially, intensity of infection estimated (light < 5%; moderate 6% - 10%; heavy > 10%).

3. Data from Neiland (1972).

Low prevalence of lungworms in the Tok herd is consonant with our other knowledge of this herd. The population is less dense and presumably because of greater availability of forage produces more and bigger lambs that the Dry Creek or Crescent Mountain herds (Heimer 1977). Horn growth rates are also higher (Heimer and Smith 1975). We assume that environmental requirements of the land snails serving as intermediate hosts of *P. stilesi* on the Tok and Dry Creek Ranges are probably similar. The wetter summertime conditions generally found on the Kenai Peninsula, and presumably the Crescent Mountain area specifically, may be more favorable to land snails. Accordingly the comparatively high prevalence of lungworms in the Crescent Mountain herd (i.e. about 90%) may be somewhat more a matter of opportunity of infection than of nutritional conditions. Level and quality of nutrition may be of somewhat higher relative importance in interpreting the difference in lungworm prevalence between the Dry Creek and Tok herds. There are numerous factors which may influence the population levels of lungworms in host populations. Such factors may be of both direct and indirect effect on both host and parasite. Accordingly simplistic explanations of prevalence should be avoided unless the supporting evidence is strong.

B. *Sarcocystis spp.*

The genus *Sarcocystis* belongs to an assemblage of spore-forming protozoans which includes the closely related ubiquitous, coccidian genus *Eimeria*. Unlike *Eimeria*, which requires only one host in which to carry out both sexual (gametogony) and asexual (sporogony) reproduction, *Sarcocystis* requires two hosts. Sexual reproduction occurs in meat-eaters (including humans) and spore-bearing cysts are formed in prey species. The sexual stages occur in cells lining the digestive tracts of carnivores, while the asexual stages in prey species develop in various muscle cells. It is the frequently quite large, spore-filled cysts (i.e. sarcocysts) which were first recognized about a century ago that provided the rationale for its scientific name. Its obligatory, two-host life cycle has been only quite recently discovered. This discovery has led to the recognition that this very common, seemingly innocuous, muscle-cell parasite is in fact sometimes a very serious pathogen. The delayed recognition of the pathologic potential of *Sarcocystis spp.* resulted from the fact that the readily observed muscle cysts (i.e. sarcocysts) are not the pathologic stage of the life cycle. Once the sarcocysts become evident, the crisis is past. The pathology is caused by the single-celled stage which moves out of the gut into the circulatory system and the body following ingestion of infective sporocysts produced in the carnivore. The carnivore becomes infected upon eating muscle tissue in which sarcocysts occur. Prior to a knowledge of the complete life cycle, pathologists were unable to correctly diagnose mortality caused by the invasive stage of *Sarcocystis*. They only recognized the ubiquitous occurrence of sarcocysts in domestic and wild animals (and even occasionally man), many in otherwise robust, good health or which had died from other clearly-seen causes.

Recently several examples of fatal, natural or experimental infections in domestic and wild animals have been documented. These have provided the impetus for an explosion of research on *Sarcocystis* around the world and I have been similarly motivated.

During late summer 1976 I initiated a survey to determine the prevalence of this potentially serious pathogen in Alaskan wildlife. The data accumulated on all species and individuals thus far examined are presented in Table 2 and those for sheep alone in Table 3. The information on non-ovine species is included for purposes of comparison and that specifically on *Rangifer* will be discussed in greater detail in another report soon to be completed.

Nearly all of the data in Tables 2 and 3 are based upon the examination of one or two thin histologic sections of cardiac, ventricular tissue comprising about 1-2 cm^2 area. Because there is the possibility of more than one species of *Sarcocystis* parasitizing a host animal, each specifically residing in a particular kind of muscle tissue (e.g. cardiac, smooth or skeletal), the negative data in Table 2 only apply to cardiac tissue. Accordingly, if representative sections of all muscle types in each host species were examined, we may find that most individuals which attain adulthood become infected by at least one species of *Sarcocystis*. Whether or not the species of *Sarcocystis* in Alaskan wildlife are highly host specific is unknown. In order to determine the identity of the forms present it will almost certainly be necessary to carry out experimental infections. A limited amount of work of this nature has already been attempted, though with negative results. I propose to continue experimental efforts to determine the life cycles and identity of the more common forms, particularly those in caribou and reindeer. This work is being carried out in cooperation with Dr. Robert Dieterich, Institute of Arctic Biology, University of Alaska and Dr. Ronald Fayer, Animal Parasitology Institute, U. S. Agricultural Research Center, Beltsville, Maryland.

At present about the only thing we can say about *Sarcocystis* in Alaskan wildlife is that some host species, particularly caribou, evidently have great opportunity to become infected. Because the complete life cycle almost certainly involves one or more canids as the final host, their abundance, as well as other factors including feeding behavior, susceptibility, etc., directly influence the prevalence and intensity of infection of the intermediate host, i.e. wild ruminant.

It appears that *Sarcocystis* is not as prevalent in Dall sheep as in caribou and the infections evidently are less intense. Nevertheless, future examination of sheep from the western Brooks Range or caribou from the eastern and central Alaska Range may show more similar infection rates for sheep and caribou.

Comparatively little has been published on the occurrence of *Sarcocystis* in wild sheep elsewhere. Kalyakhin and Zasukhin (1975) in an attempt at surveying recent literature, showed *Sarcocystis gusevi* (Krylov and Sapozhnikov), 1965, in *Ovis ammon* as the only sarcocyst in wild sheep known to them.

Table 2. Preliminary Observations on the Prevalence of *Sarcocystis spp.* in Cardiac Muscle of Alaskan Wildlife.

Host Species	Area	Number Examined	Percent Infected	Apparent Intensity
Caribou	Western Arctic Herd	34	100.0	Moderate to hea
Caribou	Delta Herd	1	100.0	Heavy
Blacktail Deer	Southeastern Alaska	20	20.0	Light
Mountain Goats	Southeastern Alaska	3	33.3	Moderate
Sheep	Alaska Range, Region III	18	55.5	Light
Moose	Southeastern Alaska	11	9.1	Light
Moose	Interior Alaska	8	25.0	Light
Bison	Big Delta Herd	29	3.4	Light
Seals	North Pacific & Bering Sea	30	0.0	--
Misc. Carnivores	Interior Alaska	2	0.0	--

Table 3. The Occurrence of *Sarcocystis* in Dall Sheep in Alaska.

Specimen **Number**	**Sex**	Age (yrs)	Locality	Intensity and Site of Infection
4452S	Male	6	Usibelli Coal Mine	Heart, few cysts
4406S	Female	3	Sheep Creek, GMU 12	Heart, negative
4407S	Female	13-15	Sheep Creek, GMU 12	Intercostal, few cysts
4408S	Male	11	Tazlina Glacier	Nuchal, negative
4545S	Male	3	Unknown	Masseter, few cysts
4566S	Female	14	Dry Creek	Heart, 4 cysts
4567S	Female	7	Dry Creek	Heart, moderate to heavy
4568S	Female	7	Dry Creek	Heart, 4 cysts
4569S	Female	?	Dry Creek	Heart, 4 cysts
4601S	Female	8	Dry Creek	Heart, negative
4597S	Female	8	Tok Management Area	Heart, 3 cysts
4596S	Female	6	Tok Management Area	Heart, 1 cyst
4607S	Female	3	Tok Management Area	Heart, negative
4599S	Female	8	Tok Management Area	Heart, 3 cysts
4594S	Female	3	Tok Management Area	Heart, negative
4598S	Female	5	Tok Management Area	Heart, negative
4595S	Female	6	Tok Management Area	Heart, negative
4593S	Female	6	Tok Management Area	Heart, negative

Prevalence: 10 of 18, light to heavy infections.

However, Honess and Winter (1956) reported a number of infections of *Sarcocystis tenella* (Railliet 1886), (a common parasite of domestic sheep) in the bighorn sheep, *Ovis canadensis canadensis*, in Wyoming. More recently, Kutzer and Hinaidy (1969) reported *Sarcocystis gracilis* (vonRatz 1909) in *Ovis musimon* in Austria.

It appears nothing is known of the pathogenicity of *Sarcocystis spp.* in wild sheep. However, Heydorn and Gestrich (1976) reported the early death of two of four domestic lambs experimentally infected with a species of *Sarcocystis* in which canids serve as the final host.

It also appears that there is no direct information on the life cycles of *Sarcocystis spp.* occurring in wild sheep. It seems most likely, however, that one or more canids (e.g. coyote, *Canis latrans*, wolf, *Canis lupus*, etc.) may serve as the so-called final host in which sexual reproduction occurs. In this respect it is interesting to note that Arthur and Post (1977) reported finding the sporocysts of a species of *Sarcocystis* in 17 of 82 fecal samples from coyotes of eastern Colorado. In this specific area, the species involved may actually be transmitted to domestic sheep, cattle or deer. But, it may also be transmitted to bighorn sheep in western Colorado and Wyoming. As already noted, Honess and Winter (1956) reported sarcocysts in bighorns in Wyoming.

Fayer and Johnson (1975) reported finding sporocysts of *Sarcocystis fusiformis* in 21 of 150 fecal samples from coyotes in Utah and Idaho. Hudkins and Kistner (1977) described a new species, *Sarcocystis hemionilatranis*, which utilizes coyotes and mule deer (*Odocoileus hemionus*) as final and intermediate hosts, respectively, in eastern Oregon. Experimental studies with this parasite demonstrated that it could be highly pathogenic in mule deer fawns. Whether any of these various species of *Sarcocystis* seen in coyotes can infect wild sheep remains to be seen.

C. Hydatid cysts

The so-called hydatid cyst is the larval stage, occurring in various prey species, of a tapeworm, *Echinococcus granulosus*, which matures in certain canids. It appears that several strains of this species have evolved as part of long-term predator-prey associations. The various strains apparently have developed comparatively narrow specificity for one or another kind of intermediate host, and are selective for bovids, ovids, cervids, etc. Table 4 summarizes the data we have collected to date on the prevalence of infection in Alaskan wild animals. It is noteworthy that hydatid cysts have not been found in a substantial number of Dall sheep even though the sheep came from areas in which the parasite is more or less common in wolves (final host) and moose and caribou (intermediate hosts).

It appears, as others have pointed out (Rausch and Williamson 1959), that the so-called "cervid strain" of *Echinococcus granulosus* is the only one which naturally occurs in Alaska. The two presumed infections in

Table 4. The Prevalence of Hydatid Cysts in Alaskan Wild Ruminants.

Host Species	Prevalence			
	Positive	Negative	Total	Percent Infected
Alces a. gigas	117	999	1116	10.5
*Bison bison**	2(?)	142	144	1.4(?)
Odocoileus hemionus sitkensis	0**	115	115	--**
Oreamnos americanus	0	6	6	--
Ovibos moschatus wardi	0	3	3	--
Ovis dalli dalli	0	121	121	--
Rangifer tarandus granti	69	1036	1105	6.2

* These unexpected infections are based upon field observations of biologists familiar with hydatid cysts in moose. However, no reference specimens were collected.

** Many of the deer found free of infection were taken in areas in Southeastern Alaska where wolves (or dogs) are absent or scarce. However, wolves are commonly infected (10%) in some areas there and it is reasonable to assume that deer serve as the intermediate host in those localities.

Bison bison listed in Table 4 were seen in animals inhabiting the Delta farming region and could conceivably represent the importation of a bovid strain from outside the state. On the other hand, Rausch and Williamson (1959) reported a hydatid infection in a mountain goat (*Oreamnos americana*) from Southeastern Alaska. It may be that the so-called cervid strain can rarely infect suitable individuals of non-cervid species.

The data on hydatid cysts in moose and caribou will be discussed in detail in a report on caribou currently being prepared.

ACKNOWLEDGMENTS

I wish to take particular note of the assistance provided by Mrs. Carol Nielsen in various aspects of our studies on sheep parasites and diseases. Most of our current work would have been impossible without the generous cooperation of Mr. Wayne Heimer who collected all of the sheep from Interior Alaska. The comparative data on *Sarcocystis* and the hydatid larvae in non-ovine species would not be available without the cooperation of many biologists over a period of many years.

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