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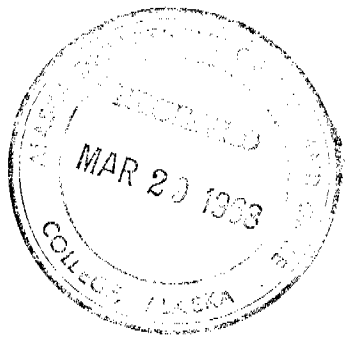
DISEASE AND PARASITE INVESTIGATIONS



by

Kenneth A. Neiland, Leader

Volume III
Annual Project Segment Report
Federal Aid in Wildlife Restoration Act
Project W-6-R-3, Work Plan M

The subject matter contained within these reports is often fragmentary in nature and the findings may not be conclusive; consequently, permission to publish the contents is withheld pending permission of the Department of Fish and Game.

(Printed March 1963)

CONTENTS

Job No.	Title
M-1	Parasitism of Alaskan Mammals and Birds
M-2	Parasitism of Alaskan Wild Ungulates

JOB COMPLETION REPORT
RESEARCH PROJECT SEGMENT
FEDERAL AID TO WILDLIFE RESTORATION

State: Alaska

Name: Alaska Wildlife Investigations

Project No: W-6-R-3

Disease and Parasite Investigations

Work Plan: M

Title: Parasitism of Alaskan Mammals and Birds

Job No: 1

PERIOD COVERED: July 1, 1961 to June 30, 1962

ABSTRACT

A variety of fur bearers, predatory and alternate or intermediate host species were examined. Examples of severe parasitism were rarely observed. Additional data were obtained on acute parasitism in fur seal pups. A number of new host-parasite combinations were recorded for Southeastern Alaska.

RECOMMENDATIONS

Our knowledge of parasitism in Alaskan small mammals, game birds or alternate host species is rudimentary at best. Information is entirely lacking for many host species in many of the major ecological areas of the State. Accordingly, it is essential that the present project be continued on a limited scale and in conjunction with other projects as time permits. Whenever problems of greater importance are recognized, these can be given greater emphasis under separate job descriptions.

JOB COMPLETION REPORT
RESEARCH PROJECT SEGMENT
FEDERAL AID TO WILDLIFE RESTORATION

State:	Alaska	Name:	Alaska Wildlife Investigations
Project No:	W-6-R-3		Disease and Parasite Investigations
Work Plan:	M	Title:	Parasitism of Alaskan Mammals and Birds
Job No:	1		

PERIOD COVERED: July 1, 1961 to June 30, 1962

OBJECTIVES

To determine the incidence and distribution of parasites and other disease organisms in Alaskan fur and small game species, game birds and alternate host species; the extent that parasitism may contribute to mortality or lowered productivity or economic value in these species; the extent that such parasitism may depreciate the value of these animals for use as food by humans or domestic animals.

TECHNIQUES

Specimens of fur bearers, other carnivores and game birds were made available through the cooperation of Department personnel. The fur bearers were provided by the pelt primeness study. Bountied predators and illegal kills were brought in for examination by the personnel of the Protection Division. Routine autopsy methods and microtechniques were employed. These do not require further elaboration at this time.

FINDINGS

The primary and alternate host species examined and the numbers of parasite species observed in each are given in Table 1. These data are discussed below. Items of special interest are considered in greater detail.

Table I. General incidence values of parasitism occurring in furbearers, game birds and alternate host species examined during 1961-1962.

Host (Number Examined)	Number of Species of Parasites	% Host Species Infected
PRIMARY HOST SPECIES:		
Furbearers		
Callorhinus ursinus (2)	4	100
Canis latrans (3)	1	66
C. lupus (6)	2	84
Enhydra lutris (1)	2	100
Gulo gulo (2)	2	50
Lutra canadensis (1)	0	0
Martes americana (1)	1	100
Mustela vison (29)	5	61
Game Birds		
Olor columbianus (3)	5	100
ALTERNATE HOST SPECIES:		
Astur atricapillus (1)	1	100
Myotis lucifugus (1)	3	100
Oncorhynchus kisutch (4)	4	100
O. nerka (21)	3	67
Salmo gairdnerii (21)	8	100
Salvelinus malma (122)	5	70

Number host species examined: 218
Number parasite species observed: 42

Primary Host Species

Marine Mammals:

a) Fur Seal (Callorhinus ursinus) - Two male fur seal pups that died at Pelican, Admiralty Island, January 1962, were sent in for examination. They carried U. S. Fish and Wildlife Service tags, numbers N-13878 and N-9742. In each case the mortality could be attributed, at least indirectly, to parasitism.

Animal #N-13878 was heavily parasitized by nose mites, probably of the genus Orthohalarachue. The severity of the infestation resulted in an extreme secretion of a heavy mucoid material into the nasal passages apparently resulting in substantial impairment of normal breathing. Presumably this led to the animal breathing orally. The bronchi and larger bronchioles of the lungs were occluded by masses of "foreign material" (i.e., dirt, plant fiber, etc.) which led to the suffocation of the pup. Apparently the animal accidentally inhaled the foreign material when it was breathing orally. Relatively few specimens of a nematode, probably Phocanema decipiens, were present in the stomach and intestine. It is unlikely that these were involved in the mortality.

Animal #N-9742 was heavily infected with the same nematode as the preceding pup and also with a few immature tapeworms and some specimens of the acanthocephalan genus, Corynosoma. The latter two parasite species were present in too small numbers to be implicated in the mortality. However, the nematode, P. decipiens (sp?) apparently was the primary mortality factor.

When the abdominal cavity of the pup was opened for inspection it was obvious that the intestines were highly inflamed and that considerable intra-abdominal hemorrhaging had taken place. Closer examination revealed the presence of 169 larval and 1 adult specimen of P. decipiens (sp.?) outside the alimentary tract within the peritoneal cavity. Approximately 300 larval and 4 adult nemas were present in the stomach, and a few specimens were present in the small and large intestine. It appears clear that the death of the pup can be ascribed to severe larval migrans. A similar fur seal mortality was reported by Neiland (1961).

b) Sea Otter (Enhydra lutris) - A 46 pound male sea otter shot at Seward was found to be infected by 2 parasite species. About 50 specimens of Orthosplanchnus fraterculus were found in the gall bladder and biliary ducts of the liver. Characteristic

scarification and thickening of the wall of the gall bladder was noted. While this host reaction may be considered pathological, it apparently results only in restricted bile storage, which appears to be of minor consequence to the otter.

Forty-two specimens of Corynosoma macrosomun were present in the intestine. This species does not appear to be an important pathogen in the relatively moderate infections observed to date. A somewhat heavier infection in sea otter by this helminth was reported by Neiland (1962).

Land Mammals:

a) Mink (Mustela vison) - Twenty-nine mink taken in the Ketchikan area were found to be infected by five species of helminths. Larvae of 2 acanthocephalan genera, Corynosoma (definitive host usually a marine mammal) and Polymorphus (definitive host shore birds or waterfowl) were present in small numbers in 14 and 1 mink, respectively. The former are usually found in fish and the latter in crustaceans, but in this instance both species had apparently adopted the mink as an intermediate host when their usual intermediate hosts were eaten by mink. Moderate infections in one instance each of Mesocestoides (tapeworm sp.?), Soboliphyme (probably the nematode S. baturini) and an unidentified stomach nematode were also observed. All of the mink examined were particularly fat and it is very doubtful that the parasite infections observed were of any consequence to their welfare.

b) Wolverine (Gulo gulo) - A wolverine taken on the mainland near Petersburg was free of parasites. However, another specimen from Haines was infected by two species of tapeworms. Taenia twitchelli is known in the adult stage only from this host species. The larval stage commonly occurs in the porcupine and attempted experimental infections and extensive surveys on other potential host species indicate that the wolverine and porcupine are the only suitable hosts of T. twitchelli (Rausch, 1959). This parasite has only been recorded in Alaska. The second species of tapeworm present in the Haines-host-specimen belongs to the genus Mesocestoides. The life history and significance of this parasite in the welfare of its various carnivorous host species is unknown.

c) Wolf (Canis lupus) and Coyote (C. latrans) - Five of six wolf specimens from the Petersburg area were infected by the adult stage of Taenia hydatigena. The larval stage of this parasite is commonly found in the deer of that area. It is doubtful that either

of the stages in the life cycle of T. hydatigena are significant pathogens in their respective host species, except under unusual circumstances.

Two of three coyote specimens from the Juneau area were infected with Taenia pisiformis which utilizes rodents and rabbits as a host during its larval development. Both of the parasitized animals were very fat and appeared to be in very good condition.

Game Birds:

Three specimens of the whistling swan were the only game birds examined during the past year. They were infected by two or more of the seven or eight species of helminths. An immature male which died from natural causes at Haines was the most heavily parasitized. The following parasites (approximate numbers in parentheses) were recovered from this host specimen: gizzard nematodes (6, probably Amidostomum cygni Wehr, 1933); 3 species of the tapeworm genus Hymenolepis (300-500); strigeid flukes (50-100); and a monostome fluke of the genus Notocotylus (31). The host was in a very weakened, flightless condition when picked up and it died on the following day. When it was autopsied it was observed to be extremely emaciated. It appears likely that the parasite burden recorded above contributed materially to the very poor condition of the host. The primary cause of death could not be established with certainty, but may have been simple malnutrition. The other two swans were illegal hunter kills. These were less heavily parasitized by one or more of the helminths recorded above and in addition by moderate numbers of one or two species of echinostomatid flukes.

Alternate Host Species

This category includes host species which may or may not have primary economic or sports value, but which may be of secondary importance as hosts of parasites (adult or larval stages) or pathogenic microorganisms which infect the former. For this reason it is essential that these so-called "valueless" host species not be overlooked during a parasitological study. In some instances, the alternate hosts (fish, etc.) may also have primary value. Most of the alternate host species examined during the past year were trout or salmon. These will be discussed at greater length below. An immature goshawk harbored two specimens of an intestinal nematode. A little brown bat, Myotis lucifugus, was infected by two, previously unknown species of lecithodendriid flukes (Neiland, in press).

The adult and larval parasites observed in the 168 adult and juvenile, salmon and trout are shown in Table 2. Only four of these are potentially of any consequence in birds or mammals. The trematode metacercaria (last larval stage) present in about one-half of the sockeye smolts could not be identified without experimentally rearing the adult form in a suitable host. This was not possible. They did not appear to be pathogenic in the infections observed. Various fish-eating birds and mammals frequent the area, but present information is insufficient to allow an intelligent guess regarding the final host.

The larval tapeworms (plerocercoids) present in the rainbow and Dolly Varden trout most likely develop into adults of the genus, Diphyllobothrium. This genus of cestodes infects man, as well as other piscivorous animals. Heavy infections of the adult stage in man are known to result in a "vitamin B-12 anemia" because of the selective absorption of vitamin B-12 by the parasite. Under favorable conditions, massive infections of the larval stage can develop in susceptible fish species. This has been observed to frequently result in secondary infection by pathogenic microorganisms followed by mass mortality of the fish host. In most cases of this sort, fish-eating birds (eg. gulls) have been shown to be the primary host (ie. reservoir of infection) of the adult tapeworm.

The larval nematode commonly encountered in the Dolly Varden is probably Phocanema decipiens, but this can only be confirmed by rearing the adult stage for definite identification. Larval worms of this and related species are known to frequently engage in extensive migration within both the final and intermediate hosts. This may lead to severe damage of specific organs or fissues or death (Neiland, 1961). Various marine mammals (ie. hair seals, fur seals, sea otters, etc.) are commonly infected with the adult parasite. A wide variety of fish are known to serve as the intermediate host. Whether or not this species can occasionally infect man is apparently unknown.

The larval acanthocephalan (Corynosoma, sp?) observed in the Dolly Varden very likely matures in marine mammals (seals) and possible marine birds (cormorants). Only in massive infections of either the final (eg. seal) or intermediate host (eg. fish) is there any likelihood of serious consequences. The finding of larval Corynosoma sp. in mink was reported in an earlier part of this report.

Table II. Incidence of helminth parasites in alternate host species, salmon and trout, 1961-1962.

HOST SPECIES	PARASITE SPECIES													LOCALITY & DATE
	Trematodes				Cestodes			Nematodes			Acantho-cephala	Copepod		
	Crepidostomum	Phyllodistomum	"hemiurid"	metacercaria*	Eubothrium	Proteocephalus	Plerocercoids*	Dacinitis (?)	Philonema	"larvae"*	Neoechinorhynchus	Corynosoma*	Salmonicola	
ADULT:														
Oncorhynchus kisutch			2/4		3/4			1/4			1/4			Kitoi Bay, Afognak Island, 9/27/61
Salmo gairdnerii	18/21	3/21				2/21	13/21	12/21	20/21		4/		8/21	Tebay Lakes, Wrangell Mts., 6/10/61
Salvelinus malma					2/10		1/10			3/10		3/10	5/10	Gut Bay, Baranof Is. 5/4-16/61
Salvelinus malma					13/100		7/100			58/100	1/100	12/100	2/100	Lake Eva Weir, Baranof Is., 5/24-26/62
Salvelinus malma										5/11			2/11	Tebenkov Bay, Kuiu Is. 5/4/61
JUVENILE:														
O. nerka (smolts)	4/21			11/21							4/21			Upper Jennifer Lake, Kitoi Bay, 9/20/61

* These forms were present in the larval stage. The hosts of the adult stages are fish-eating birds or mammals.

The adult parasites reported in Table 2 are all widely found in salmonid fish. None of these when present in small numbers are serious parasites of fish. The potential effects of heavy infections of most of these are essentially unknown. Two species, however, merit further consideration. Parasite copepods, including Salmonicola sp. and others, favor the gills of their fish-host species as a place of attachment. When present in large numbers, they can produce serious lesions and materially interfere with the growth of the fish.

Members of the dracunculoid nematode genus, Philonema, infect the ovaries of various species of trout and salmon. It appears that heavy infections can inhibit egg production or spawning. The life cycle is unknown but probably involves a copepod as an intermediate host. Relatively heavy infections were observed in rainbow trout from the Tebay Lakes. However, sufficient data are not yet available to evaluate the importance of philonemiasis in this trout population.

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JOB COMPLETION REPORT
RESEARCH PROJECT SEGMENT
FEDERAL AID TO WILDLIFE RESTORATION

State: Alaska

Name: Alaska Wildlife Investigations

Project No: W-6-R-3

Disease and Parasite Investigations

Work Plan: M

Title: The Parasitism of Alaskan Wild Ungulates

Job No: 2

PERIOD COVERED: July 1, 1961 to June 30, 1962

ABSTRACT

During the past year disease and parasite data on 6 species and 457 specimens of big game herbivores have been obtained. The species examined include 320 moose, 54 caribou, 27 deer, 6 goats, 4 sheep and 46 bison. The data are summarized as follows:

A. Moose

Parasitism in moose was observed to vary considerably from one area to another. A species of filariid nematode, Setaria sp. (?), was found for the first time in Alaskan moose in the Fairbanks area, but not elsewhere. The rumen fluke, Paramphistomum sp. (?), was only found in moose frequenting marshy areas. Hydatid cysts and Taenia cysticerci were uncommon in Kenai moose but frequently found in moose from other areas. Trichostrongylid nematodes are common parasites in the upper small intestines of moose in all the areas sampled. Observations on a limited number of natural mortalities suggest that parasitism may be involved in mortalities, particularly during severe winters.

B. Caribou

A small scale outbreak of foot rot in the Arctic caribou herd is reported. The occurrence of brucellosis in the Arctic herd as demonstrated by the Arctic Health Research Center is noted. However, testing of a limited number of blood samples from the Nelchina herd has not revealed brucellosis. Helminth parasites are relatively uncommon in caribou except Taenia larvae.

Nose bots and warbles infest most caribou. The numbers of warbles infesting individual male caribou were observed to be 2-2.5 times greater than in females.

C. Black-tailed Deer

Deer from Woronkofski Island have more Taenia cysticerci and fewer infections of the caecal worm, Oesophagostomum sp. (?), than do deer from Coronation Island. Lungworms are equally frequent in these two areas.

D. Goats

Coccidiosis is reported for the first time from the mountain goat in North America. The infections observed indicate that three unknown species of Eimeria may be involved. None of the infections observed appeared to involve any marked pathology.

The severity of the past winter apparently resulted in the death by starvation of an old, male goat found near Haines and in the near starvation of two adult males collected at Tracy Arm during mid-February.

E. Sheep

Pellet samples from four sheep from the Tonzona River study area revealed the presence of an unknown number of species of Eimeria. Coccidiosis is previously unknown in Alaskan sheep.

F. Bison

Forty-six bison taken during late August 1961, exhibited a relatively high incidence of lungworms (63%). Unexpectedly, no other parasite species were observed.

RECOMMENDATIONS

The general survey of the quality and quantity of parasitism and disease in Alaskan big game animals should be continued until such time as the major problems of this nature can be clearly identified. At that time those that can be effectively dealth with should be researched in greater detail under separate job descriptions. The opportunity to follow up new leads should always be provided for.

JOB COMPLETION REPORT
RESEARCH PROJECT SEGMENT
FEDERAL AID TO WILDLIFE RESTORATION

State: Alaska

Name: Alaska Wildlife Investigations

Project No: W-6-R-3

Disease and Parasite Investigations

Work Plan: M

Title: The Parasitism of Alaskan Wild Ungulates

Job No: 2

PERIOD COVERED: July 1, 1961 to June 30, 1962

OBJECTIVES

To determine the incidence and distribution of parasites and other disease organisms in the major big game animals of Alaska and in alternate host species; the extent to which the welfare of big game herds may be affected by parasitism and disease, and the extent that such factors may depreciate the value of these animals for use as food by humans or domestic animals.

TECHNIQUES

The major part of the material was collected in cooperation with other P-R projects being done on particular big game species by other departmental personnel.

The field autopsy techniques and laboratory procedures employed are all routine methods which do not require further discussion at this time.

FINDINGS

Because of the bulk, variety, and in some instances inadequacy of specimen material it was not possible to treat all of it in a definitive fashion. As sufficient quantities of specimen material of adequate quality are obtained, the observations on various host species will be prepared for publication. The current status of our knowledge of the disease and parasitism

of six big game species (moose, caribou, black-tailed deer, mountain goats, sheep and bison) on which data are available is discussed below.

A. Moose

During the past hunting season antlerless moose hunts were held in five areas in southcentral and one in central Alaska: Areas A, B and C included most of the Kenai Peninsula; Areas D and E were located in the Susitna River-Talkeetna Mountains area; and Area F included part of the "Tanana Flats" near Fairbanks. The hunt areas will be referred to by their letter designations in the following discussion.

Although I was unable to take an active part in the hunts, the effective cooperation of personnel of the Anchorage office provided field observations on parasitism. The Fairbanks office collected organ samples during the hunt in Area F and from natural mortalities and road kills. These specimens were frozen and held until a later date when it was possible for me to examine them. In addition, I had the opportunity to examine a few hunter kills along the Denali Highway and some natural mortalities which occurred in the Fairbanks area during March. The Petersburg office provided some pathological specimens from a moose taken on the Stikine River. Dr. Jack King, Veterinarian in Charge, Animal Disease Eradication Section, U. S. Department of Agriculture, Anchorage, has provided the results of autopsies which he performed in cooperation with personnel of the Anchorage office. Autopsy data acquired since June 30, 1961, (except that furnished by Dr. King) are summarized in Table I. The results of Dr. King's examination of a few natural mortalities from Cook Inlet area will be included in the discussion of natural mortality in moose this past year. Serological data obtained during the antlerless hunts in Areas A-D through the cooperation of the National Animal Disease Laboratory, Ames, Iowa, are given in Table II.

1. Parasites

a. Hydatid Cysts (= larval stage of Echinococcus granulosus).

This species of tapeworm is widely found during its larval development in a variety of big game herbivores and in various omnivores including man. In North America it appears likely that only the domestic dog and wolves are entirely suitable hosts for

Table I. Incidence* of parasites and pathology in moose, 1961-62.

Area	Sex	Hydatid Cysts (lungs)	Taenia Cysts (liver)	Tapeworms (intestine)	Rumen Flukes	Foot Worm	Other	
	Total	9/34	0/7	2/21	7/15	0/1	6/6	9/22
	Four of six hearts from females showed Taenia sp. cysts.							
Denali Highway	M	0/2	0/0	1/2	2/2	0/0		
Glenn Highway	M	..... one animal, head collected only					3 nose bots recovered from nasal passages of male calf	
Stikine River	M	..... hunter kill, other organs not available.					numerous infectious warts present, some pedunculate	
TOTAL ALL AREAS	M	0/38	6/16	2/32	2/27	0/11		
	F	16/258	67/131	8/239	0/241	0/122		
	U	6/24	1/1	1/19	7/20	0/2		
TOTAL ALL ANIMALS		22/320	74/148	11/290	9/288	0/135		

** Data for animals whose sex are not given are denoted by U (unknown).

*** Data for Area F include, in addition to that obtained during the antlerless hunt, observations on road kills and natural mortalities occurring in the vicinity of Fairbanks and the Richardson and Steese Highways.

* The incidence values show in fractional form the number of animals infected with each species of parasite and the numbers of individuals available for examination.

Table I. (continued)

Area	Sex	Hydatid Cysts (lungs)	Taenia Cysts (liver)	Tapeworms (intestine)	Rumen Flukes	Foot Worm	Other
A	M	0/6	0/2	0/6	0/5	0/4	nematodes (intestine) 1/6
	F	0/61	5/23	2/61	0/62	0/44	" " "
	U**	0/1	0/0	0/2	0/2	0/1	" " "
Total		0/68	5/25	2/69	0/69	0/49	" " 1/69
B	M	0/9	0/3	0/8	0/8	0/3	none reported
	F	1/52	2/21	1/42	0/46	0/14	
	U	0/1	0/0	0/0	0/0	0/0	
Total		1/62	2/24	1/50	0/54	0/17	
C	M	0/1	1/1	0/1	0/1	0/0	none reported
	F	0/15	2/8	1/16	0/16	0/6	
	U	0/2	0/0	1/3	0/3	0/1	
Total		0/18	3/9	2/20	0/20	0/7	
D	M	0/11	4/7	0/9	0/10	0/4	cysts (?) (liver) 0/7
	F	12/116	57/73	2/112	0/112	0/56	" " 1/73
	U	0/5	1/1	0/5	0/5	0/0	" " 0/1
Total		12/132	62/81	2/126	0/127	0/60	" " 1/81
E	F	0/1	1/1	0/1	0/1	0/1	none reported
	only one animal examined in this area						
F***	M	0/8	0/2	1/5	0/1	0/0	Setaria sp. Nematodes
	F	3/11	0/5	1/7	0/4	0/1	(bd. cav.) (intestine)
	U	6/15	0/0	0/9	7/10	0/0	
							M 2/2 4/5
							F 4/4 3/7
							U 0/0 2/10

Table II. Incidence in moose of some infectious diseases as diagnosed by serological tests.

Number of Samples	Disease	Results
464	Brucellosis	All Negative
117	Q Fever	"
117	Leptospirosis	"
102	Anaplasmosis	"

the adult worm. Apparently the larval or hydatid stage is substantially detrimental to the host only when it lodges in the animal at sites where it can cause mechanical or pressure damage as the cyst enlarges (eg, paralysis due to pressure on the brain, etc.). Normally the larvae and resultant cysts are located in the lungs, in which case little or no impairment of function appears to take place.

It seems very likely that E. granulosus is widely distributed in Alaska, particularly in adult moose. The incidence of the larvae in big-game herbivores is directly influenced by:

1) Age of herbivore (intermediate host) - 78 (23 males and 55 females) yearling or calf moose examined in all the hunt areas were free of this parasite, including 37 (7 males and 30 females) juveniles taken in Area D where 12 adult females of 95 adult animals examined were infected. The most probable explanation for this apparent correlation of infection with age is simply that older animals have had more opportunity to accidentally ingest the eggs of the worm after they have been passed from the final host (dog or wolf) in its excrement.

2) Population densities of final hosts - The number of animals in a given area harboring viable, adult tapeworms is likely the most important factor affecting the incidence of hydatid disease. Areas in which low numbers of suitable canine hosts are present (Areas A-C: see Table I) show a much lower incidence (less than 1%) than Areas D (about 12%) or F (about 25%) in which wolves are not uncommon or the Matanuska Valley (25%) (Neiland, 1961) where domestic dogs are allowed to run loose in large numbers. Information regarding the incidence of hydatid or other canine parasite larvae is probably most significant as an indicator of predator densities.

b. Taenia cysts (= Taenia hydatigena and T. krabbei).

Larvae of tapeworms of the genus Taenia, like those of Echinococcus are found in a variety of herbivores and omnivores (except man). The adults of T. hydatigena and T. krabbei typically infect wolves or dogs, but other hosts may be involved.

The larvae of T. hydatigena is most often found in the liver and/or omentum (or other organs of alimentary tract) of the intermediate host and is the most common parasite of big game herbovires in Alaska, at least in areas having appreciable wolf

or dog populations. Area D (Table I) showed an incidence of about 75% and in all areas and animals it was found in 50% of those examined. It should be pointed out that these figures are no doubt biased by the fact that hunters tend to leave infected livers at the kill sites, while taking the uninfected ones out. Nevertheless, if the incidence for Area D is calculated by using the total number of animals examined for all parasites rather than just those in which the liver was available for inspection, the incidence is still 48% or more than five times the incidence of hydatid cysts (9%). Why Taenia hydatigena is so much more common in wild herbivores than Echinococcus granulosus is not known. Perhaps, debilitating infections of hydatid cysts are more common than has been recognized or alternatively, herbivores may be much more resistant to infections of E. granulosus than to those of T. hydatigena.

Occasionally infections of Taenia krabbei cysts are found in game. These normally locate in the skeletal muscle of the hind quarters, but have recently been observed in a number of moose hearts (4/6) from Area F. In sufficiently heavy infections there no doubt is impairment of heart function.

Except in those instances where Taenia cysts locate in abnormal sites (brain, etc.) or are present in massive infections, they are probably only significant as indicators of predator densities.

c. Tapeworms (= Moniezia sp.)

Tapeworms of the genus Moniezia inhabit the small intestine of a variety of wild and domestic herbivores and utilize minute, free-living, soil mites of the family Oribatidae as intermediate hosts. The specific identity of the species present in moose and black-tail deer in Alaska has not been determined with certainty, but it appears that either M. expansa or M. benedeni or both may be present. Moniezia sp. are widely distributed in Alaska moose, but have been found only in about 3% of the moose examined (Table I). They are probably of no great harm to the host except in heavy infections in young animals during periods of poor nutrition.

d. Nematodes (trichostrongylid species)

A variety of species of roundworms of the family, Trichostrongylidae, are known to inhabit the digestive tracts of most species of big game herbivores. The species commonly found in Alaskan moose appears to be Nematodirella longispiculata in most cases, but another minute form was found recently encountered in

one animal from the Fairbanks area. The incidence of intestinal roundworms is relatively high in moose of Southcentral and Central Alaska: (Area F, 41%, Table I) and (Kenai Peninsula, 26%, Matanuska Valley, 38%, and Willow-Talkeetna, 26%, Neiland, 1961a.)

The presence of massive infections of intestinal roundworms observed in a few moose calves this spring suggest that this kind of parasite, in conjunction with inadequate nutrition may materially contribute under certain conditions to loss of calves. This will be considered at further length in the section on natural mortality.

e. Nematodes (filarial species)

Filarial roundworms differ from other kinds of nematodes in that they are transmitted by blood sucking arthropods. The adults inhabit parts of the host other than the alimentary tract (eg. circulatory system, subcutaneous connective tissue, body cavity, etc.) and the larvae (microfilariae) are found in the blood stream. Only one species, Oncocerca reticulata (sp?), has been previously reported from Alaskan moose (Williams & Babero, 1958). This infection was observed in the hind feet of an animal killed on the Taku River in Southeastern Alaska. Examination of 135 moose in Southcentral and Central Alaska during the antlerless hunts this year failed to reveal any infections of foot worm (Table I), but they have been reported (but not collected) from Central Alaskan animals during previous hunting seasons by other Departmental personnel. Infections of footworm have been observed to cause crippling of various domestic and wild animals. Its importance in Alaska is entirely conjectural.

Recently a second kind of filarial worm has been observed in Alaskan moose. This species, Setaria sp.?, was found in the body cavities of six moose calves from the Fairbanks area which I recently had the opportunity to examine in toto. Setaria labiatopapillosa has been reported from two moose from Minnesota and an unidentified species of Setaria has been found in a moose from Quebec (Peterson, 1955). The significance of Setaria as a parasite of moose is unknown.

f. Rumen fluke (=Paramphistomum cervi) (sp.?)

Rumen flukes have not been reported from Alaska although they are common in moose elsewhere in North America (Peterson,

loc. cit.). This past year 9 of 288 animals examined were found to harbor this parasite. The infected animals were all taken in swampy areas adjacent to large rivers (McClaren River, Denali Highway and Tanana River Flats, Fairbanks). This is consistent with the life cycle of the fluke which involves aquatic snails as the first intermediate host and subsequent encystment on aquatic vegetation of the final larval stage.

The significance of Paramphistomum sp.? as a wildlife pathogen is uncertain. Paramphistomum cervi has been implicated in losses of domestic sheep in Wales, England, and in pathology in the European Red Deer in Poland. It has been reported by Departmental personnel that an apparently pathological infection of rumen flukes was observed in a moose taken during the antlerless hunt in Area F. According to the observer, there appeared to be partial denudation of areas of the rumen lining (papillae) where "colonies" of flukes (50-100) were observed. Since flukes of the genus Paramphistomum are provided with particularly powerful, muscular suckers by which they attach to the rumen papillae, it is possible that they could mechanically damage the rumen lining. Unfortunately, these observations cannot be confirmed by histopathological study of the presumed lesions since specimens were not collected.

g. Nose bots (Cephenemyia nasalis)(sp.?)

Nose bots are the larval stages of certain diptera in which the larvae develop while overwintering in the respiratory system of various domestic and wild herbivores. In Alaska the larvae of Cephenemyia nasalis (sp?) were found in over 90% of the caribou examined during April 1961 and 1962. However, nose bots have not been previously reported in Alaskan moose and are known from only three moose elsewhere (Peterson, loc. cit.). In one instance (Quesnel, B.C.) these were identified and reported as C. jellisoni, a common parasite of deer (Peterson, loc. cit.). Recently, a yearling bull which apparently died from natural causes near Eureka on the Glenn Highway yielded three bots from the nasal passages. These appeared to be immature and resembled bots of similar size removed from caribou. The specific identity and conclusions regarding the potential importance of nose bots in Alaskan moose must await the accumulation of adequate specimens and incidence data, etc. However, it may be conjectured that occasional light infections of the caribou nose bot might occur in moose which utilize caribou range during the summer fly season.

h. Lungworms

Various species of lungworms (Dictyocaulus, Protostrongylus and Muellarius) are known to occur in all Alaskan big game herbivores (except musk ox and elk). However, only recently after the examination by the author of over 300 sets of moose lungs have the adult worms (Dictyocaulus sp.?) been observed in situ. This negligible occurrence of Dictyocaulus in moose is difficult to rationalize with the incidences observed in black-tailed deer, caribou and bison (see appropriate sections of this report). The infected animal was a "road kill" in the Fairbanks area, but lungworm in moose is not restricted to that area since it has been reported from the Cook Inlet area by Dr. Jack King (private communication). Either lungworms are extremely uncommon in Alaskan moose or most animals which become infected rapidly succumb to the infection. Dictyocaulus viviparus was reported from 14 of 33 moose in Minnesota according to Peterson (loc. cit.).

2. Infectious Diseases

Under this category are generally included all alterations of normal function which can be ascribed to the presence in the host of microorganisms (protozoa, bacteria rickettsia and viruses). For the most recent and complete review of the disease of moose, the reader can refer to Peterson (loc. cit.). The data in Table II indicate the serological absence of Brucellosis, Q Fever, Leptospirosis and Anaplasmosis in Alaskan moose. Of these four, only Brucellosis is known to occur elsewhere in moose. It has been reported from Minnesota and Montana according to Peterson (loc. cit.). However, since Brucellosis has been recently observed in the arctic caribou herd, it will not be unexpected if it turns up in moose of that area. Whether or not disease plays a role in the biology of Alaskan moose at this time is purely a matter of conjecture.

3. Natural Mortality

The extent of natural mortality in Alaskan moose is essentially unknown. The only available data are based on the examination of a relatively few animals from the Cook Inlet area by Dr. Jack and from Eielson Air Force Base by myself. According to Dr. King (private communication, Feb. 8), "To date,

I have had the opportunity to examine a few moose calves and without exception, in my opinion, the death of these calves may be attributed to internal parasitism. One calf from the Eagle River area, presented a picture of starvation or severe malnutrition. This subject had lung worms in considerable numbers with the right diaphragmatic lobe indicating an acute verminous pneumonia. During the post mortem examination large numbers of stomach worm were found, These resembled a Haemonchus or Osteragi species but were solely found in the terminal duodenum and perhaps into the jejunum. This same subject also had several tapes appearing to be Monezia and also the omentum contained many cysterci reported to be T. hydatigena. Another subject from the Wasilla area presented the same picture with the exception of the lung worm infestation and pneumonia. All the subjects autopsied, so far, have been devoid of fat deposits, have had good quantities of ingesta and did not present any signs of an infectious nature. The first calf did have a sequestrum originating from a fragment of about the sixth or seventh thoracic vertebral spine."

Recently (March, 1962) I had the opportunity to autopsy in toto three calves (two males and one female) which died on Eielson A.F.B. and to examine selected organ samples from another calf (female) from that locality. The three intact carcasses were in extremely poor condition (i.e. no fat depots and watery marrow). In addition all carried light to moderate burdens of the common intestinal nema (Nematodirella sp.?) and the body cavity filariid, nema (Setaria sp.). One of the calves also harbored a moderate infection of Moniezia sp. (?). The digestive tract appeared to be functioning normally with ingesta in all the various parts of typical appearance. One can only conclude that the calves died from starvation, their death from this cause being hastened by the extreme winter experienced this year in that area. Likewise, parasitism may be considered to be a contributing, though secondary, factor.

B. Caribou

During the past year 55 animals were available for at least partial examination. Data obtained from these animals are summarized in Tables III-VI. The available information is discussed in the following sections on 1) parasites and 2) disease.

1. Parasites

The occurrence of various parasitic worms and arthropods is tabulated in Table III. With the exception of lungworm, Dictyocaulus sp. (?), our knowledge at present is limited to those forms which utilize the caribou as an intermediate host for their larval stages. Most of the animals examined to date have been handled under field conditions which precluded the kind of autopsy techniques required to demonstrate parasites of the alimentary tract. Only nine animals have been adequately examined and these failed to reveal the presence of any of the adult stages of species of tapeworm or nematodes which are found in caribou elsewhere.

a) Larval tapeworms (Echinococcus and Taenia sp.)

Hydatid cysts were found in only one of 54 animals and apparently are not nearly as common in caribou as in moose. Our findings are consistent with those of other workers which suggest that caribou are not as satisfactory (ecologically, if not biologically) as an intermediate host as are the moose.

Two species of Taenia (eg. T. hydatigena and T. krabbei) are found in caribou. The incidence of T. hydatigena in caribou is very similar to that obtained for moose. However, T. krabbei which is occasionally observed in the skeletal muscle of caribou (3/45) has not yet been found in heart muscle (45 animals examined), while at least in certain areas (Fairbanks) this species has recently been found to be relatively common in moose heart tissue. Whether or not this is a real or apparent difference between the behavior of what is presumed to be one species of parasite in two different hosts has yet to be determined. For further remarks on Taenia sp. in other big game, see appropriate section under moose and black-tailed deer in this report.

b) Lungworm

An undetermined species of lungworm, Dictyocaulus sp. (?), was present in caribou in about 4% (2/54) of the animals examined. If this incidence is representative for the Nelchina caribou herd as a whole, one may conclude that it is unlikely that lungworm or verminous pneumonia is of any consequence in the population dynamics of this herd. However, one cannot safely apply this assumption to the other caribou herds.

Table III. Incidence of parasitism in caribou.

Locality	Date	Sex	No. Animals	Age Yrs.	Hydatid Cysts	Lung Worms	Taenia Cysts	Nose bots	Warbles	Others
Denali Highway Mi. 66	9/7/61	M	9	7-12	1/9	2/9	2/9	-	-	These animals were all hunter killed in excellent condition. The rumen, small intestines & caecum of each were examined with negative results.
Copper R. & vicinity near Gulkana	4/16-24/62	M	2	calf	---	---	---	2/2	2/2	
"	" "	F	1	calf	---	---	1/1	1/1	1/1	
"	" "	M	4	1-2	---	---	1/4	4/4	4/4	
"	" "	F	5	1-2	---	---	2/5	4/5	5/5	
"	" "	M	5	3-7	---	---	2/5	5/5	5/5	T. krabbei, 1/5 (hindquarters)
"	" "	F	18	3-7	---	---	14/18	16/18	18/18	
"	" "	M	2	8-13+	---	---	0/2	2/2	2/2	
"	" "	F	8	8-13+	---	---	5/8	7/8	8/8	T. krabbei, 2/8 (hindquarters)
"	All Animals		54		1/54	2/54	27/54	41/45	45/45	T. krabbei, 3/45
"	All Females		32		0/32	0/32	22/32	28/32	32/32	T. krabbei, 2/32
"	All Males		22		1/22	2/22	5/22	13/13	22/22	T. krabbei, 1/13

c) Larval Arthropods

The larvae of two species of diptera utilize the caribou as an intermediate host. The nose bot fly, Cephenemyia nasalis (sp.?), has been found in 61 of 65 animals examined during 1961 (20/20) and 1962 (41/45) (Table III). Average infections number 40-50 larvae per animal with similar intensities of infection in both sexes during the period April 1961-April 1962 (Table IV). Three unusually heavy infestations (140, 142 and 150 larvae per animal) were observed but the individuals were in good or better conditions and otherwise of normal appearance.

Larvae of the warble fly, Oedemagena tarandi, have been present in all of the 65 animals examined during 1961-1962 (Tables III & IV). Oddly enough the average infestation, 106 larvae per animal, was the same both years (Table III). This result is undoubtedly coincidental. However, the average infestations computed according to sex reveal that in both years approximately 2-2 1/2 times as many larvae were found in males as in females (Table III). Of 8 infestations recorded with 200 or more larvae present, 7 were from males of all age classes (200-288 larvae while only 1 female (3-7 year age class) harbored in excess of 183 larvae (i.e. 229). The significance of these observations is unknown, and the speculative possibilities are too numerous to profitably consider at this time. The effects of warble infestations on caribou are unknown.

2. Disease

Observations on the occurrence of infectious diseases in caribou are summarized in Tables V and VI. Only the occurrence of foot rot and brucellosis in the Arctic herd warrants further consideration at this time.

a) Foot Rot

Last August word was received via one of the oil companies working out of Umiat that dead caribou were being regularly observed by their survey crews. Apparently carcasses first became evident during early August. Accordingly, my assistant and I immediately flew to Umiat arriving on August 22. The personnel of the different oil companies working in the area were extremely cooperative and it was possible to arrange for the use of a helicopter on the following day. Questioning of all the personnel

Table IV. Variation* of intensity of bot and warble infestations with sex and age.

Age Class (yrs.)	Sex	Bots		Warbles	
		Sample Size	Range (average)	Sample Size	Range (average)
Calf	M	2	20-66 (43)	2	171-212 (196)
"	F	1	66 --	1	61 ---
1-2	M	3	3-50 (24)	4	144-202 (184)
"	F	2	7-20 (13)	5	21-117 (48)
3-7	M	3	3-140 (56)	4	63-288 (175)
"	F	11	7-150 (41)	19	23-229 (88)
8-13+	M	2	20-25 (23)	2	220-250 (235)
"	F	4	10-142 (60)	8	22-116 (60)

Sample Class	Bots			
	1961*		1962	
	Sample Size	Average	Sample Size	Average
All animals	20	49	28	41.4
All males	5	55	10	37.2
All females	15	43	18	43.8

Sample Class	Warbles			
	1961*		1962	
	Sample Size	Average	Sample Size	Average
All animals	20	106	45	106
All males	5	144	12	190.8
All females	15	69	33	75.3

* All data segregated by age class were collected during April, 1962. Data collected during April, 1961, are introduced for comparison in the summary part of the table.

Table V. Incidence of pathology in caribou.

Locality & Date	Sex	Age Yrs.	Pathology
Denali Highway, Mi. 70 9/61	M	3-7	Large abscess deep in the mid-dorsal region of neck. Probably Streptococcus pyogenes, but abscess material not viable in culture.
Denali Highway, Mi. 37 9/61	F	Adult	Epidermal papilloma in axillary region.
9/61	F	Adult	*Bilateral synovioma (?) of front knee joints.
Umiat 8/61	F	Adult	Foot rot, see section on disease for further details.
Copper River - Gulkana 4/62	F	4	*Numerous lung adhesions and mammary lymph nodes caseous.

*Laboratory reports on this material are not available at this time.

Table VI. Incidence of infectious diseases diagnosed by serology.*

Sample Size	Type Test	Results
27	Anaplasmosis	All Negative
40	Leptospirosis	" "
40	Q Fever	" "
40	Brucellosis	" "

* The serological tests were performed by the Animal Disease Eradication Division, Agricultural Research Service, U. S. Dept. Agriculture, Olympia, Washington.

in camp at that time revealed that approximately 20, presumably non-predator killed, natural mortalities had been observed with most of these sighted in the vicinity of the "Itkillik Hills" about 50 miles east of Umiat. On August 23 we flew out to that area, but found relatively few animals present, much to the amazement of the pilot. Apparently the herds had started their annual fall migrations to the south and in fact 3 large herds had been observed about 15 minutes flying-time south of Umiat when we flew in from Fairbanks on the previous day. Two carcasses were sighted, but upon landing they were found to be in too advanced a stage of decomposition for autopsy purposes. Finally, two adult cows both with severe limps were spotted. These were collected, but only one could be autopsied before we were compelled to leave the area ahead of dense fog which suddenly began moving in from the north. Both animals had advanced case of foot rot. In the animal which was autopsied, lesions were observed in other organs as well, suggesting secondary invasion of these by the foot rot organism. The details of our field-autopsy observations are included with the report of the laboratory findings below. After we were forced to leave the "Itkillik Hills" area we flew west to the confluence of the Anaktuvuk and Colville Rivers, up the Anaktuvuk for approximately 50 miles, then across to the Chandler River and finally cross country to Umiat. During the day's flying we observed 127 animals of which 5 (including the 2 collected) were observed to be "limpers" and presumably infected with foot rot. Preparations to close up camp for the season were begun the following day and we were unable to make further survey flights.

Autopsy Report. The animal, an adult cow accompanied by a calf, was extremely emaciated and judging from her movements prior to collection was in a relatively weakened condition. A well developed lesion was present in the right, front foot. A thick mucoid, non-hemorrhagic discharge from the nostrils was noted. Internally, the liver showed what appeared to be a non-pyogenic, zonal necrosis. The lungs seemed to have small areas of abnormal appearance (lesions?) and emphysema were present bilaterally along the margins of the diaphragmatic lobe. The pericardium contained what appeared to be an inordinate amount of fluid and the heart seemed relatively flabby and somewhat distended on the right side. A large lesion was observed at the base of the tongue.

Lab Report. The following tissue samples were collected for laboratory analysis: infected foot, liver, lymph nodes, and tongue. These were sent to Dr. Robert L. Rausch, Arctic Health Research Center, Anchorage, for histo-pathological study with the following results:

"The material examined is as follows:

a. fresh material, from a female caribou (this was designated by your numbers 1 and W_3, and later assigned our numbers 26785 and 26786)

b. tissues preserved by you in AFA solution (our number 26787)

The fresh material had degenerated before fixation, so some of the findings are difficult to evaluate. However, the lesions on the tongue were well defined. The preserved material consisted of lung and of a lymph node. Since normal tissues were not available for comparison, I did not attempt to describe changes in the lymph node. There was also an intact foot, which was later preserved. The significant findings were as follows:

1) Foot - Microscopic examination only. There was a large, more or less circular ulceration on the dorso-lateral surface proximal to the corneum. It evidently penetrated to the tissues surrounding the joints, but this was not confirmed. The same digit also had a large lesion of the interdigital integument, situated more or less ventral and medial. The entire foot was swollen. These lesions are typical of those observed on other animals from which Spherophorus (Actinomyces) necrophorus was isolated.

2) Tongue - More or less superficial ulcerations were present, and these extended through the epithelium into the underlying tissues. There was a zone of leukocytic infiltration, and beyond this was often found a zone of necrosis. The cavities were usually impacted with fragments of vegetation and other debris. The leukocytes consisted of both polymorphonuclear neutrophils and mononuclear leukocytes. In some areas, more or less filamentous organisms were present, and these agreed morphologically with S. necrophorus.

3) Lung - The most striking lesions were present in the lungs. One section showed very little excepting some erythrocytes that possibly had entered post mortem. A second section showed a small abscess surrounded by leukocytes. The spaces were largely filled by erythrocytes in various stages of degeneration, and considerable fluid was present. This appeared to be a cellular, necrotizing pneumonia. In some cavities were large, tangled masses of an eosinophilic, more or less filamentous organism identified as probably S. necrophorus. In all respects this condition was identical with that seen in the lungs of other ungulates affected by necrobacillosis.

As far as I am concerned, there is no doubt as to the nature of the disease occurring in the Umiat caribou. This disease occurs in the summer, and probably will become more widespread as the animals increase in numbers. There is no known remedial measure in the case of wild deer, but outbreaks in reindeer are controlled by slaughter of the affected individuals. Anything that would cause a significant reduction in the numbers of caribou on the Arctic Slope would be helpful."

3. Contributing Factors and Conclusions

While there have been unconfirmed rumors in past years of dead or crippled animals north of the Brooks Range during late summer, this is the first time that it was possible to obtain any definite information. Unfortunately, we received word too late to get into the area in time to accurately evaluate the extent of the outbreak. Apparently a small percentage (about five per cent) of the herd was involved. It appears likely that three factors may have contributed to the situation: 1) an apparent increase in numbers of caribou during the past few years; 2) decimination of the natural predator of the caribou (eg. only three different wolves were observed in the hundreds of hours of flying over hundreds of square miles by the oil exploration crews); and 3) the past summer was considered to be a particularly rainy one, thus favoring the spread of disease entities like foot rot. Whether or not a significant epidemic resulting in substantial losses of caribou will occur in the future is of course unknown at this time. However, there appears to be no reason to doubt that it could happen. An unconfirmed report of a case of foot rot in a moose from the south slopes of the

Brooks Range this past year takes on added interest under these circumstances. The recently introduced restrictions on wolf hunting on the Arctic slope should eventually be of some benefit to the caribou of that area both in regard to disease and also nutrition (range quality). In any case, an epizootic would tend to be self-limiting, even though disastrous to the Natives of the area who rely on caribou for food.

b. Brucellosis

The demonstration last October of a 14% infection rate of brucellosis in caribou migrating through Anaktuvuk Pass by the Arctic Health Research Center has prompted renewed attempts to determine whether or not this disease is present in caribou south of the Arctic Circle. The results of serological tests on blood samples collected from the Nelchina herd this past April are presented in Table VI. To the best of my knowledge, human cases of brucellosis involving the use of caribou meat, etc., have not been reported from areas utilizing the Nelchina herd. The presence of brucellosis in the Arctic herd was first suspected following the findings of a human case in an arctic, Native village. This coming October a more extensive survey of the problem will be made by the Arctic Health Research Center with personnel of our Department cooperating in the field work.

C. Black-tailed Deer

Twenty-seven deer were available for partial or complete examination during the past field season. These animals were relatively free of parasites as evidenced by the data in Table VII. Although the available data are too meager to allow convincing ecological comparisons between the areas that have been sampled during 1960-61 and 1961-62, it is of interest to note the following:

1) Only one of 16 Woronkofski deer harbored Oesophagostomum sp. (?) (caecal worm) while this parasite was observed in 6 of 17 Coronation Island deer in 1960. The low incidence of the caecal worm on Woronkofski as compared with Coronation Island may be related to the relatively more crowded and poorer nutritional condition of the useable deer range on Coronation.

Table VII. Incidence of parasites in black-tailed deer.

Locality	Sex	*Taenia hydatigena* (cysts)	Lung* worms	Caecal** worms	*Taenia krabbei* (cysts)
Kupreanof Is.	F	0/2	0/2	0/2	0/2
Woronkofski Is.	M	5/11	3/11	1/11	2/11
	F	3/5	0/5	0/5	0/5
Wilkes Range (Mainland)	M	0/1	0/1	0/1	0/1
	F	0/2	0/2	0/2	0/2
Pleasant Bay Admiralty Is.	M	---	0/3	---	---
	F	---	0/3	---	---

* An undetermined species of *Dictyocaulus* (probably *D. viviparus*).

** An undetermined species of *Oesophagostomum* (probably *O. venulosum*).

2) Only 1 of 17 Coronation deer harbored Taenia sp. cysts, while 9 of 16 Woronkofski deer were infected by this kind of parasite. Since Coronation Island was known to be free of wolves at the time of the study (July-August, 1960), finding even one infection of Taenia sp. was unexpected.

3) The incidence of lungworms in the deer of these 2 islands appears to be relatively similar (i.e. 2/17, Coronation Island and 3/16, Woronkofski Island). The apparent contrast in the occurrences of caecal worms and lungworms of the two islands is of unknown significance and may be simply a result of inadequate data.

Conclusions and Recommendations

The general survey of the parasites and diseases of black-tailed deer should be continued until adequate samples from the different evironmental areas have been accumulated. At that time it should be possible to select certain localities in which it will be most profitable to attempt more detailed observations (i.e. winter mortality and parasitism, etc.).

D. Mountain Goats

Five goat carcasses and the lungs of another were available for examination from Southeastern Alaska. These specimens provided some very interesting qualitative data on parasites and pathology.

1. Parasites

Only two kinds of parasites were found: lungworms (probably Protostrongylus stilesi) and coccidia (Eimeria sp.). The three lungworm infections observed did not appear to be of more than very moderate intensity. Lungworms have been reported from goats from British Columbia and elsewhere, but have not previously been recorded in Alaska. It is not known whether species of Protostrongylus are as pathological in goats as they have been observed to be in wild and domestic sheep.

Coccidia apparently have never been previously reported in goats, but have world wide distribution in many other species of mountain game and also most of the representative

kinds of all classes of vertebrates, domestic and wild. Each of the three goats examined for coccidia were infected with what appeared to be three distinct species of Eimeria. Although various species of this genus are among the most pathological parasites of domestic animals (sheep, chicken, turkeys, etc.), the present infections appeared to be of relatively light intensity and therefore, pathological only on a very small scale. There is a direct, "one to one," relationship between the severity (pathology) of a coccidial infection and the numbers of organisms (oocysts) observed in fecal samples. Each oocyst produced may result in the destruction or severe injury of one of the cells of some part of the alimentary tract (eg. epithelial lining most frequently, but depending on the species of Eimeria involved other cell-types may be affected). In light infections, only microscopic lesions or ulcers are produced, but in heavy infections massive ulceration takes place with concurrent, severe hemorrhaging usually followed shortly by the death of the host. Coccidiosis, normally, only becomes severe in those animals which suffer massive exposure to the infective stage (oocyst) during a short period of time (eg. lamb's on a feed lot). Moderate or light exposures over longer periods result in the development of a strong immunity to further infection without producing severe damage. There is apparently one reference only to a "pathological" infection of coccidiosis in wild animals. Buechner (1960) reports that a "pathological" infection (severity unstated) of Eimeria ninakohlyakimovae was observed by pellet analysis in a big-horn lamb in Colorado. This species of Eimeria is the most destructive known in domestic sheep and was first described from reindeer in Siberia. Not counting Buechner's (loc. cit.) meaningless report, apparently coccidiosis is not known to be a significant pathogen in wildlife either because:

1) The species normally present in wild animals do not have a high "pathological-potential" in the wild hosts involved or, 2) wild animals are not normally crowded enough to insure massive exposure (via oocysts in their excrement) and consequent severe infection during the short period of time before a strong immunity is developed, and 3) competent observers have not been in the right place at the right time. Lacking experimental proof of the first, the latter two hypotheses must be regarded as equally likely. Coccidiosis in wildlife will be further discussed under the section dealing with sheep.

2. Pathology

One of the goats examined was a large male which was found dead near Haines, Alaska. When the abdominal cavity of this animal was opened for inspection it soon became evident that there was an "extra" organ present. This turned out to be a large tumor of the following description:

The tumor was located predominantly in the abdominal cavity toward the mid-dorsal surface where it was attached by a thin stalk to the ventral surface of the vertebral column. In addition it was adhesed over an area of about 30 sq. cm. to the liver. The anterior portion extended into the thoracic cavity through the diaphragm which was tightly in place around the tumor and provided complete separation of the thoracic and abdominal cavities. The tumor measured approximately 28 cm. long and 17 cm. in maximum width and weighed 11 pounds. Internally, the tumor was composed primarily of a grey, gelatinous material, with a number of more or less hardened areas apparently composed of cartilage and bone. The gross appearance of the structure suggests that it may be a myxoma, a benign tumor of connective tissue derivation. The tumor will be sent to a specialist for diagnosis as soon as one is located. In any case, it appears doubtful that the tumor was involved to any significant extent in the death of the animal.

3. Natural Mortality

Relatively little is known about natural mortality factors in goats, other than those of an accidental nature (eg. slides, falls, etc.). This past winter three adult males were available for complete examination. One of these was found dead near Haines, and is estimated to have died early in February. The other two were collected February 19, in Tracy Arm for museum specimens. The goat from Haines yielded the large tumor described above and a light infection of coccidia. The two animals from Tracy Arm each had light infections of lungworms and coccidiosis. All three of the goats were extremely emaciated, without any appreciable fat stores and the thin, watery, fat-free marrow typical of starvation. It was possible to weigh only the natural mortality from Haines. It weighed 152 pounds intact which is estimated to be 50-100 pounds less than would be expected for a large, mature

(12 years) billy during February of an average winter. However, this past winter was relatively severe in Southeastern Alaska. Heavier snowfall and lower temperatures were experienced than have been recorded for the past few years. It appears very likely that the severity of the past winter, plus the apparent inadequacy of the winter range in some areas during a severe winter resulted in an unknown loss of animals to starvation. The extent to which parasitism may be involved is unknown.

E. Dall Sheep

Our knowledge of parasitism and disease in Alaskan sheep is very limited. Philip (1938) reported Taenia hydatigena cysts from an animal taken in the Alaska Range; Goble and Murie (1942) reported lungworm (Protostrongylus sp.?) from Polychrome Passe, McKinley Park; Murie (1944) found necrotic stomatitis in rams in the same area; and Rausch (1951) failed to observe parasitism in sheep in the Brooks Range.

Dr. Jack King (private communication) reports that a sample of lung tissue from a ram killed in the Wrangell Mountains during 1961 was reported by the National Animal Disease Laboratory, Ames, Iowa, to be infected by larvae of the lungworm, Muellarius minutissimus. Dr. Robert L. Rausch (private communication) has obtained specimens of Wyominia tetoni (tentative identification) from the liver of a Wrangell Mountain ram. This tapeworm has been recently reported from Yukon sheep.

My own observations are limited at this time to the examination of five fecal pellet samples from four animals in the Tonzona River area of the Alaska Range. Single pellet samples from two yearlings and one 3-year old, all males, yielded oocysts of presumably three species of coccidia (Eimeria sp.). Two pellet samples from an 8-year old ram contained amoeba cysts (probably Entamoeba sp.), but no coccidians.

The various species of amoebas that have been reported from domestic and wild animals are not known to be significant pathogens. Accordingly, no further discussion of amoebiasis will be made at this point. However, as pointed out in the

discussion of coccidiosis in goats, some of the most pathogenic and important species of parasites in domestic animals are coccidians of the genus Eimeria, the genus observed in Alaskan goats and sheep. In spite of the fact that a number of species are known to occur in wild sheep elsewhere, and that some of these are severe pathogens of domestic sheep, coccidiosis apparently has never been observed as a source of mortality or significant pathology in the wild. Further discussion of this paradox is provided in the section on coccidiosis of goats. It is hoped that it will prove possible in the near future to experimentally study this problem which appears to be one of the most important unstudied phases of big game disease and parasitism.

F. Bison

Although bison were introduced into Alaska from Montana over 30 years ago, there are no references in the literature to the diseases or parasites of the Alaskan herd. Locker (1953) published a report on the parasites of the donor herd in Montana and included a survey of all references on bison parasites in North America.

During a special bison hunt held last August 1961, it was possible to examine selected organ samples from 46 animals. These included the abomasum, the upper ten feet of the small intestine, the caecum and the lungs (liver when available). Only one parasite species was encountered, much to our surprise. Lungworm (Dictyocaulus sp.?, probably D. viviparus) was observed in 63% of the animals of all age classes (see Table VIII). Of these, approximately 21% were bilaterial in which both sides of the lungs were infected. In two of the bilateral infections, accumulations of non-hemorrhagic mucoid material at the site of infection in the peripheral bronchioles was noted. Otherwise the animals appeared in good condition.

Locker (loc. cit.) reported the following parasites (number infected in parentheses) from eight bison slaughtered at the National Bison Range, Moise, Montana. Fasciola hepatica (1); Moniezia benedeni (5); Dictyocaulus viviparus (2); Trichuris ovis (only one animal examined for this species) and Hypoderma sp. (4). In addition six other species have been reported elsewhere in North America (see Locker, loc. cit.).

Table VIII. Variation of incidence of lungworm (Dictyocaulus sp.) in bison with sex and age.

Age Class	Sex	Positive* Unilateral	Bilateral	Negative
Calf	M	1/3	1/3	1/3
	F	---	---	---
Yearling	M	2/4	1/4	1/4
	F	---	---	---
2-4 years	M	7/13	1/13	5/13
	F	2/4	---	2/4
Young Adult	M	4/6	2/6	---
	F	---	---	2/2
Adult	M	2/6	3/6	1/6
	F	---	---	2/2
Old Adult	M	---	---	1/1
	F	1/1	---	---
Unknown	M	---	1/3	2/3
	F	1/1	---	---
All animals		20/46 (43.5%)	9/46 (21.0%)	17/46 (35.5%)
All males		16/36 (44.5%)	9/36 (25.0%)	11/36 (30.5%)
All females		4/10 (40.0%)	---	6/10 (60.0%)

*Infections were classed according to the presence of worms in one (unilateral) or both (bilateral) lungs.

The comparative lack of variety observed in the parasite fauna of Alaskan bison is difficult to explain. Probably if more animals were examined under conditions allowing more extensive examination, additional species would be found. However, the present findings suggest that if other species are present, they are not likely of significant affect on the bison population as a whole. The high incidence of lungworm is unexpected and its actual affect on the herd is unknown. The relative pathogenicity of lungworm infections in other game, and domestic species, leads one to suspect that under conditions favoring infection when the herd is under the stress of poor nutrition, that significant mortality could take place.

Twenty-three blood samples collected by the management personnel directing the hunt were negative when tested for Brucellosis and Leptospirosis.

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