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Serologic Survey of Alaska Wildlife for Microbial Pathogens

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FINAL RESEARCH REPORT

STATE: Alaska **STUDY NO.:** 18.7

GRANT NO.: W-23-5, W-24-1, W-24-2, W-24-3 and W-24-4

STUDY TITLE: Serologic Survey of Alaska Wildlife for Microbial Pathogens

PERIOD: 1 July 1991 through 20 April 1996

SUMMARY

A serologic survey of selected wildlife species from Alaska was conducted. There was little or no evidence of most diseases in most host species. Based on serologic test results, some notable exceptions were apparent:

1 Prevalence of 3 respiratory viruses (infectious bovine rhinotracheitis [IBR], bovine viral diarrhea [BVD], and parainfluenza III [PI3]) was significantly higher in northern caribou (*Rangifer tarandus*) herds as compared with herds in other parts of the state.

2 The Southern Alaska Peninsula Caribou Herd has been experiencing declines in herd size and productivity. Serologic tests revealed no evidence that infectious diseases were a factor in the dynamics of the herd.

3 Several caribou herds were recently added to the survey. Results fit established patterns for other herds in the vicinity which had been previously tested.

4 Serologic evidence of exposure to PI3 virus and/or BVD virus was found in moose (*Alces alces*), muskox (*Ovibos moschatus*), and Dall sheep (*Ovis dalli*) populations from northeast and northwest regions. In some cases, antibody prevalence was quite high. This pattern coincides with the pattern for caribou. Apparently, some environmental factor favors transmission of these respiratory viruses in these areas.

5 There was very little evidence of respiratory syncytial virus (RSV) in any species.

6 Prevalence of PI3 virus in the Delta Bison (*Bison bison*) Herd remained high.

7 The dramatic increase in prevalence of PI3 in the Delta Bison Herd has raised concerns that this agent may spread to other wildlife species in the vicinity with serious consequences. To date, there is no evidence of spread to either the Macomb Caribou Herd, Dall sheep at Granite Creek, or a small sample of moose.

8 Serologic evidence of exposure to bluetongue and/or epizootic hemorrhagic viruses was found in mountain goat (*Oreamnos americanus*), caribou, and Dall sheep. Antibody prevalence was very low. These results continue the unpredictable pattern revealed in previous surveys.

9 More than 500 wolf (*Canis lupus*) sera collected from 1984-1994 from 11 locations were tested for evidence of exposure to: 1) canine distemper virus (CDV), 2) infectious canine hepatitis virus (ICH), 3) canine parvovirus (CPV), 4) canine coronavirus (CCV), and 5) *Francisella tularensis*. There were 2 peaks in antibody prevalence for CDV. The first was during 1987-1988. The second was from 1990-1994. Serologic evidence of exposure to ICH virus was high in all areas throughout the sampling period. Antibody prevalence for CPV followed no clear pattern. These results may reflect asynchronous outbreaks in disjunct wolf populations. Antibody prevalence for CCV was low in most areas. Antibody prevalence for *F. tularensis* increased in some areas during the early 1990s. These increases may have been linked to wolf predation on snowshoe hares (*Lepus americanus*) during the high phase of the hare cycle.

10 Mustelid sera were incorporated in the survey for the first time. Species included: 1) mink (*Mustela vison*), 2) marten (*Martes americana*), 3) river otter (*Lutra canadensis*), and 4) wolverine (*Gulo gulo*). There was no evidence of exposure to 1) ICH virus, 2) 2 serovars of *Leptospira interrogans*, or 3) Aleutian disease virus. Four male wolverines captured during 1993 on the North Slope in the Yukon Territory of Canada had been exposed to CDV. This time period coincides with an increase in CDV antibody prevalence in wolves from the same area. Three female wolverines from the same area had not been exposed.

Key words: Alaska, disease, serologic survey, wildlife.

CONTENTS

BACKGROUND

There have been few documented instances of infectious diseases having a detectable effect on wildlife populations in Alaska. Brucellosis in caribou (*Rangifer tarandus*) and rabies in canids have been notable exceptions. In an effort to evaluate the disease status of various Alaskan wildlife populations, a serologic survey has been conducted throughout the state.

Disease surveys conducted by means of serologic tests have many advantages:

1 Blood samples are easy to collect.

2 It is not necessary to sacrifice animals to test for evidence of previous exposure to disease(s).

3 Periodic samples can be collected from the same animal(s) over an extended time frame, thus providing information on the timing of exposure.

4 Tests are relatively inexpensive.

5 A single sample can be tested for evidence of many different diseases, rather than requiring a specific tissue or organ for each disease of concern.

6 Sera are stable for a long time (under adequate storage conditions), thus providing the basis for a functional archive system which can be analyzed in the future.

7 If the sample size is adequate, it is possible to evaluate the status of an entire population in relation to a disease.

8 If populations are monitored over time, it is possible to determine changes in the disease status of the population.

9 Early warning of such changes in disease status of a population allow for the consideration of human intervention into the disease process at the most opportune time and place.

Within a living animal, antibody molecules are produced in response to invading disease agents. For certain agents, antibody may decay to undetectably low levels over a relatively short period (ca. several months). For other agents, antibody may be more long-lived and may remain at detectable levels for many years. Furthermore, reexposure to the same disease agent usually causes an increase in the level of antibody in circulation. These factors all confound attempts to correlate the level of antibody in the serum to the date of exposure of the host to the agent.

Perhaps the most reasonable means of determining the time frame during which an animal has been exposed to an infectious disease agent is to periodically collect serum specimens from a specific animal. However, in most cases such periodic sampling schemes are not practical for free-ranging animals. Thus, determining the timing of exposure of either specific individuals or populations is difficult.

Test results for samples which have been collected during any particular year do not necessarily reflect the transmission pattern during that year. For example, animals with evidence of exposure may have been infected during previous years. However, analyzing such test results based upon the year in which the samples were collected may reveal long-term trends in the frequency of disease transmission. Although this approach of grouping samples according to the year in which they were collected may not be infallible, it serves a practical purpose and therefore has become an accepted technique for evaluating data. This sample grouping approach will be used throughout the discussion of the study.

Alaska Department of Fish and Game (ADF&G) has conducted serologic surveys since the early 1960s. During the early years such surveys were limited in the scope of disease agents and host species which were investigated. Over the past decade the survey has been expanded to include both more potential host species and more disease agents.

Abstracts of selected formal manuscripts which have been produced during the past 5 years as a result of the serologic survey are presented in Appendices A-C.

OBJECTIVE

The objective of this survey has been to monitor Alaskan wildlife populations for the occurrence of microbial disease agents which may have a detrimental effect upon the health of both individual animals and entire populations.

METHODS

Most blood samples were collected by ADF&G biologists who captured animals to meet objectives of other studies. Hunters collected and contributed samples from bison (*Bison bison*), caribou, Dall sheep (*Ovis dalli*), and Sitka blacktail deer (*Odocoileus hemionus sitkensis*). General collection areas are indicated in Figs 1-4.

Most blood samples were allowed to settle at ambient or refrigerated temperatures for 6 to 36 hours and then centrifuged. Sera were then removed by aspiration and dispensed in vials. Sera were kept frozen until the time of testing. Serologic tests were performed by personnel of the: 1) National Veterinary Services Laboratories (USDA, Ames, Ia), 2) Wyoming State Veterinary Laboratory, (Laramie, Wyo), and 3) Washington State University (Pullman, Wash). Disease agents were selected for inclusion in this survey based upon past or potential problems with wildlife species in Alaska or other parts of the world.

Sera were tested for evidence of exposure to:

1 Infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), parainfluenza III (PI3), respiratory syncytial virus (RSV), canine distemper virus (CDV), infectious canine hepatitis virus (ICH), canine parvovirus (CPV), and canine coronavirus (CCV), by the serum neutralization test (Thorsen and Henderson 1971).

2 Epizootic hemorrhagic disease and bluetongue, by the immunodiffusion test (Pearson and Jochim 1979).

3 *Leptospira* spp., by the microscopic agglutination test (Cole et al. 1973).

4 *Francisella tularensis*, by the rapid plate agglutination test (Owen 1970).

5 Aleutian disease virus by the counter immuno-electrophoresis test (Aasted and Cohn 1982).

Minimum titers for all tests were established based upon natural or experimental infection of the species in question or of a domesticated species. Sera which met or exceeded these titers (plus those designated "positive" in the immunodiffusion test and brucellosis plate test) were considered to contain evidence of past infection by the agent in question. Hereafter, these samples may be referred to as "positive." All other samples may be referred to as "negative."

Two types of potential qualitative errors should be considered in evaluating the significance of serologic survey results: 1) samples from animals which have in fact been infected by the disease agent in question may be incorrectly categorized as "negative," and 2) samples from animals which have never been exposed to an agent may be incorrectly deemed "positive." Explanations for the former include: 1) natural antibody decay over time, 2) antibody degradation due to improper handling of the specimen, 3) establishment of the threshold titer value at a level that is too high, 4) improper inspection or evaluation of the test, and 5) inaccuracies in recording data. Explanations for the latter include: 1) presence of "nonspecific" reacting substances in the sample, 2) improper inspection or evaluation of the test, and 3) inaccuracies in recording data. With these disclaimers in mind, discussion of the test results may proceed.

RESULTS AND DISCUSSION

In most cases test results provided no evidence of exposure to a particular disease in a particular host species. This discussion will focus on those situations where evidence of previous exposure was found.

RESPIRATORY VIRUSES

Four viral diseases, IBR, BVD, PI3, and RSV, are commonly referred to, collectively, as the "bovine respiratory group." As this generic term implies, the viruses often cause upper respiratory infections (Dieterich 1981). Morbidity (rate of illness) may be high in an infected population, but mortality (rate of death) is usually low. Major effects on individual animals occur via lowered body condition, decreased weight gain, and increased susceptibility to other infectious diseases. Transmission usually occurs via aerosol droplet, but the venereal route may also play a role (Dieterich 1981). Serologic evidence of exposure has been previously reported for various wildlife species (Thorsen and Henderson 1971, Parks and England 1974, Stauber et al. 1980)

IBR, BVD, and PI3 continue to be more prevalent in the northern caribou herds (Western Arctic, Teshekpuk, Central Arctic, Porcupine, and Fortymile) compared with herds in other portions of Alaska and the Yukon Territory (Tables 1-28). Results for samples collected from the Porcupine Herd in Canada follow this pattern (Table 25). We can now add the Galena Mountains (Table 5) and perhaps Bonnet Plume (Table 18) herds to this group. The Ray Mountains (Table 6) and White Mountains (Table 7) herds are more closely aligned with other Interior herds. Several southern caribou herds were recently added to the survey and helped to further clarify this pattern. There have been few observed cases of pneumonia in any of these herds (R Zarnke, unpubl data). Several of the northern herds have experienced significant growth during the course of this study. The significance of the higher antibody prevalence of IBR, BVD, and PI3 on the health of caribou remains unknown.

Antibody prevalence for PI3 was quite high in moose populations from northeast and northwest Alaska (Tables 29-30). There was no evidence of PI3 exposure in moose from other areas (Tables 31-33). Prevalence of PI3 was also high in muskox from the northeast

portion (Table 34). In addition, there was limited evidence of exposure in Dall sheep from the northeast arctic (Table 35) and muskox from the Seward Peninsula (Table 34). Prevalence for BVD was moderate in moose from the northwest arctic (Table 30). There was no evidence of BVD exposure in muskox or Dall sheep (Tables 34-35). This is the first broad-based evidence of PI3 and/or BVD exposure in these species from these regions. Apparently, some environmental factor favors transmission of respiratory group viruses among free-ranging ungulates in northern Alaska. Effects on moose, muskox, and Dall sheep is unknown.

Antibody prevalence of PI3 in the Delta Bison Herd rose dramatically from 0% in 1977 to 100% by 1984 (Zarnke and Erickson 1990) and remains near 100% (Table 36). No health-related problems have been linked to this increased prevalence of PI3. Domestic livestock have been implicated in the introduction of PI3 into the bison herd (Zarnke and Erickson 1990). This situation represents an example of how easily an introduced disease agent can spread through a naive population. For the first time, there is some minimal evidence of RSV exposure in the herd (Table 36).

BLUETONGUE AND EPIZOOTIC HEMORRHAGIC DISEASE

Bluetongue (BLU) and epizootic hemorrhagic disease (EHD) are viral diseases of wild and domestic ruminants. Symptoms may include anorexia, ataxia, dyspnea, and depression. The 2 diseases are most often recognized postmortem by acute subcutaneous and/or internal hemorrhaging (Hoff and Trainer 1978). The oral route may be important for transmission during enzootic periods, but arthropod vectors play a big role during epizootics (Hoff and Trainer 1978).

The situation surrounding EHD and BLU in Alaskan wildlife is more confusing than for most other diseases. On occasions when positive samples were detected by means of immunodiffusion tests, USDA personnel attempted to determine which of the 2 viruses (EHD and BLU) was responsible. This was done by means of implementing the more specific serum neutralization test. In virtually all cases where this was done, test results were inconclusive and were accompanied by the following comment: "significance of these results is difficult to evaluate in an area where no [overt disease] has ever been reported. The reaction may be due to exposure to an antigenically similar virus." Mention of antigenic variation and overlap are inherent in any discussion of these 2 viruses. Although discernible from each other, EHD and BLU are closely related antigenically. On the other hand, there are at least 19 distinct strains of BLU. It is not inconceivable that there is a distinct relative of EHD and BLU present in Alaskan wildlife. The proper means of addressing such a problem is to isolate and identify the disease agent in question. In the absence of clinical disease, the likelihood of isolating the agent is small.

There is some question regarding the transmission of either EHD or BLU in Alaska. In North America, a midge (*Culicoides variipennis*) is the most common vector of these viruses. There is some debate as to whether this particular gnat species exists in Alaska. Certainly, members of the genus *Culicoides* do occur in Alaska and experience in other

parts of the world indicates that in the absence of the preferred vector species, other members of the genus will occupy this ecological niche and serve as vectors.

Based on serologic evidence, exposure of a variety of ungulate species to EHD and BLU continues to occur (Tables 1-39). There have been no clinical cases of hemorrhagic disease reported. In the absence of clinical cases, clarification of the epizootiology of these viruses will be complicated. I sense no threat to wildlife in Alaska from EHD and/or BLU.

CANINE DISTEMPER VIRUS

Signs of CDV infection may include discoloration and ulceration in the mouth, swollen foot pads, loss of appetite, decreased mobility, difficult breathing and neurologic abnormalities. Previous studies reported antibody prevalences between 2% and 12% (Zarnke and Ballard 1987). In the current survey, prevalences fell into 2 distinct groups (Table 40). One group ranged from 0% to 8%. These values are similar to those from earlier surveys. The other group ranged from 34% to 52%. There was no obvious geographic pattern. At this time, there is no easy explanation for this discrepancy. There were 2 time periods when prevalence was elevated. The first was during 1987-1988. The second was from 1990-1994. CDV may have been a direct source of mortality during these outbreaks.

Four male wolverines captured during 1993 on the North Slope in the Yukon Territory of Canada had been exposed to CDV (Table 45). This time period coincides with an increase in CDV antibody prevalence in wolves from the same area. Three female wolverines from the same area had not been exposed.

INFECTIOUS CANINE HEPATITIS VIRUS

Signs of ICH virus infection (also known as canine adenovirus) may include nasal discharge, decreased mobility, loss of appetite, blood in feces, clouding of the eyes, and occasionally convulsions leading to paralysis and death. Previous surveys in Alaska reported high antibody prevalences (Zarnke and Ballard 1987). Results of the current survey are in agreement with those early studies (Table 41). Prevalence was uniformly high in all areas and all time periods. High antibody prevalence concurrent with stable wolf populations indicates that impact of ICH exposure on wolves is minimal.

CANINE PARVOVIRUS

CPV was first reported in domestic dogs in 1978. A wide variety of free-ranging canids have been exposed. CPV infection can range from inapparent to fatal in domestic dogs. Infection affects the heart and/or the gastrointestinal tract. A previous survey of wolves in southcentral Alaska reported that prevalence increased from 0% in the 1970s to approximately 50% during the early 1980s (Zarnke and Ballard 1987). Prevalences in the current survey covered a broad range (Table 42). These values presumably reflect asynchronous outbreaks within disjunct wolf populations. There were no apparent geographic or chronologic patterns. There is no evidence that CPV has affected productivity or survival of wolves in Alaska or the Yukon.

CANINE CORONAVIRUS

Some experts believe that CCV and CPV operate synergistically to cause gastrointestinal dysfunction. Interest in CCV is relatively recent. There are no previous published CCV serologic surveys on free-ranging wolves. In the current study, prevalences were low in most areas (Table 43). Prevalences were moderate in the Galena and Kobuk areas.

FRANCISELLA TULARENSIS

Tularemia is a bacterial disease caused by *F. tularensis*. Snowshoe hares are the primary reservoir. Infection often localizes in spleen, liver and lymph nodes. Signs of disease include elevated body temperature, loss of appetite, diarrhea, labored breathing and lethargy. Infection is rarely fatal. Presumably; wolves are exposed when they kill and consume hares. A previous survey of wolves in Alaska reported prevalence of 25% (Zarnke and Ballard 1987). In the current survey, prevalences are slightly lower (Table 44). Hare populations in most regions peaked around 1990. Antibody prevalences in wolves in some areas seemed to increase in the early 1990s. Perhaps the higher antibody prevalences reflect wolf predation on hares during the high phase of the hare cycle. Impact of tularemia is believed to be minimal in otherwise healthy wolves.

ACKNOWLEDGMENTS

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Figure 1 Locations at which blood samples were collected from specified caribou herds (*Rangifer tarandus*) for serologic survey

A	Teshekpuk
B	Western Arctic
C	Galena Mountains
D	Wolf Mountain
E	Ray Mountains
F	White Mountains
G	Delta
H	Macomb
I	Fortymile
J	Chisana
K	Nelchina
L	Kenai
M	Mulchatna
N	Nushagak
O	North Alaska Peninsula
P	Southern Alaska Peninsula
GG	Aishihik
BB	Bonnet Plume
FF	Burwash
II	Carcross
HH	Chisana
EE	Ethel Lake
DD	Finlayson
	Klaza
AA	Porcupine
	Tatchum Tatchunchini
CC	Tay River
JJ	Wolf Lake

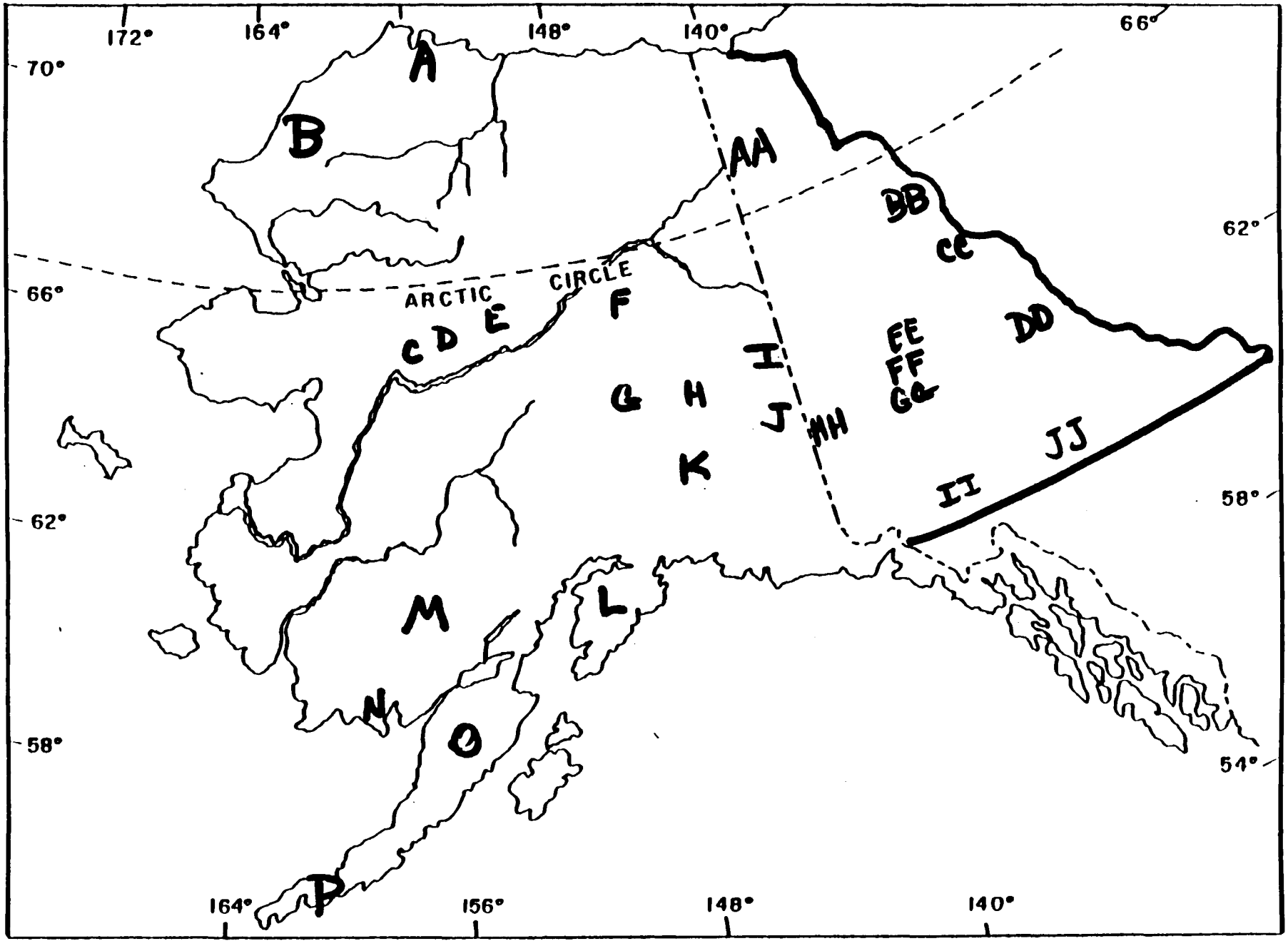

Figure 1 Locations at which blood samples were collected from specified caribou herds (*Rangifer tarandus*) for serologic survey

Figure 2 Locations at which blood samples were collected from moose (*Alces alces*) for serologic survey

A	Arctic National Wildlife Refuge
B	Noatak River drainage
C	Selawik River drainage
D	Seward Peninsula
E	Birch Creek
F	Delta Junction
G	Nelchina River drainage

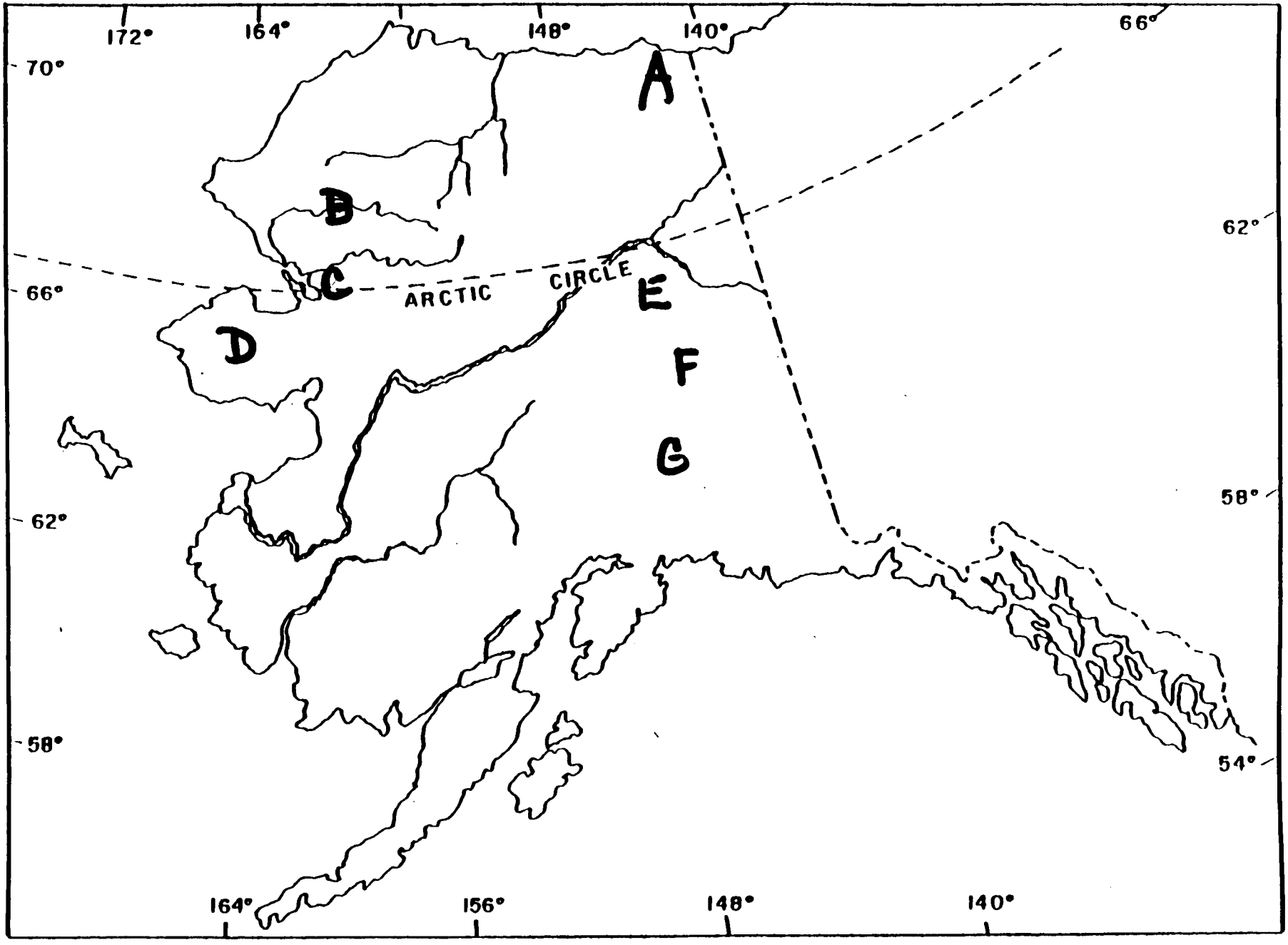

Figure 2 Locations at which blood samples were collected from moose (*Alces alces*) for serologic survey

Figure 3 Locations at which blood samples were collected from wolves (*Canis lupus*) for serologic survey

A	Arctic National Wildlife Refuge
B	Gates of the Arctic National Wildlife Refuge
C	Kobuk River drainage
D	Kanuti National Wildlife Refuge
E	Galena
F	Denali National Park
G	Fairbanks
H	Tok
I	Nelchina River drainage
J	Cordova

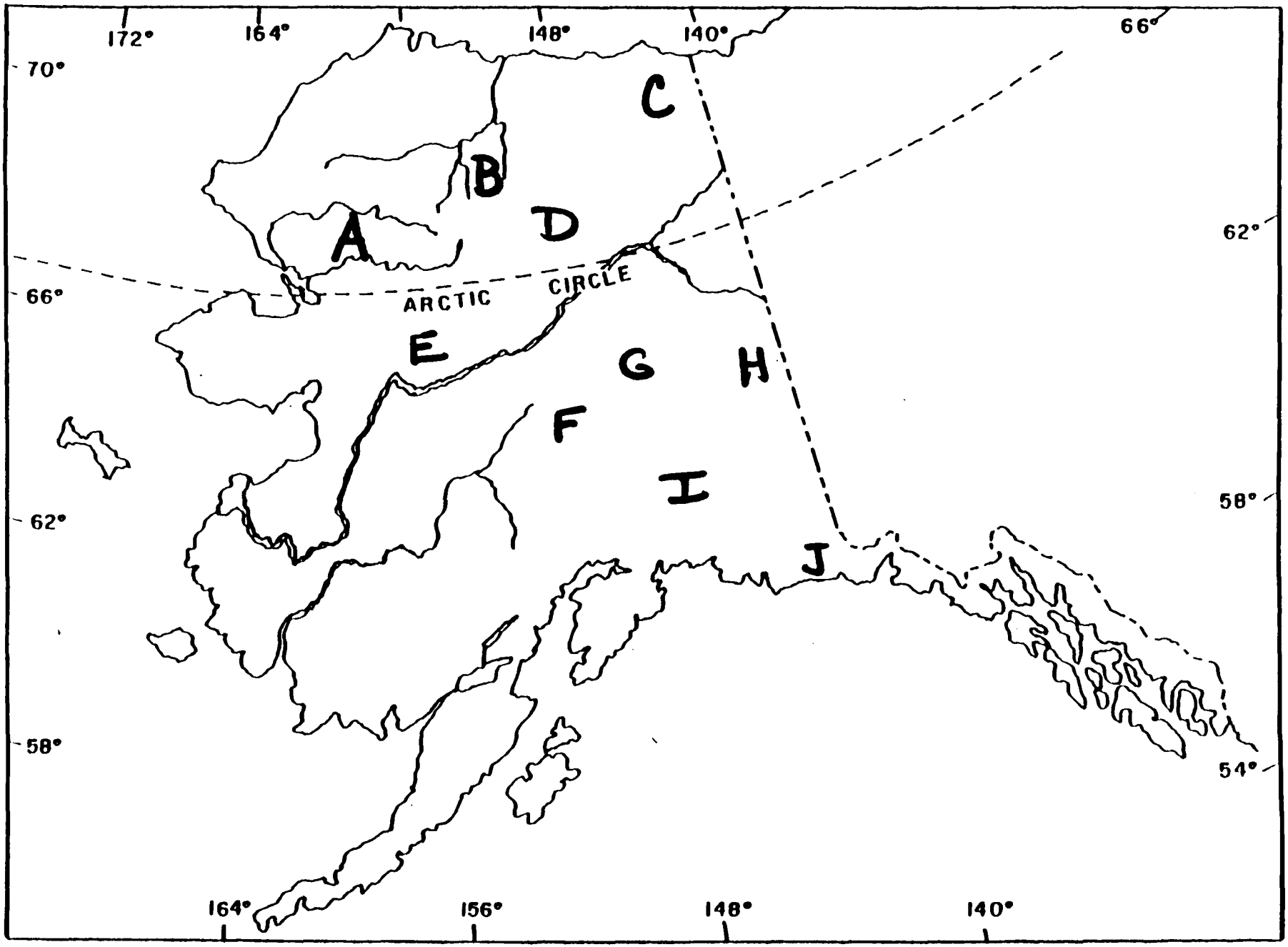

Figure 3 Locations at which blood samples were collected from wolves (*Canis lupus*) for serologic survey

Figure 4 Locations at which blood samples were collected from selected species for serologic survey

A	Yukon Territory (wolverine)
B	Arctic National Wildlife Refuge (Dall sheep, muskox)
C	Northwest Arctic (wolverine)
D	Seward Peninsula (muskox)
E	Delta Junction (bison)
F	Granite Creek (Dall sheep)
G	Sheep Creek (Dall sheep)
H	Talkeetna Mountains (wolverine)
I	Prince William Sound (sea otter, blacktail deer)
J	Afognak Island (elk)
K	Kodiak Island (blacktail deer)
L	Chichagof Island (marten, mink)
M	Juneau (mountain goat)
N	Baranof Island (blacktail deer)
O	Ketchikan (mountain goat)

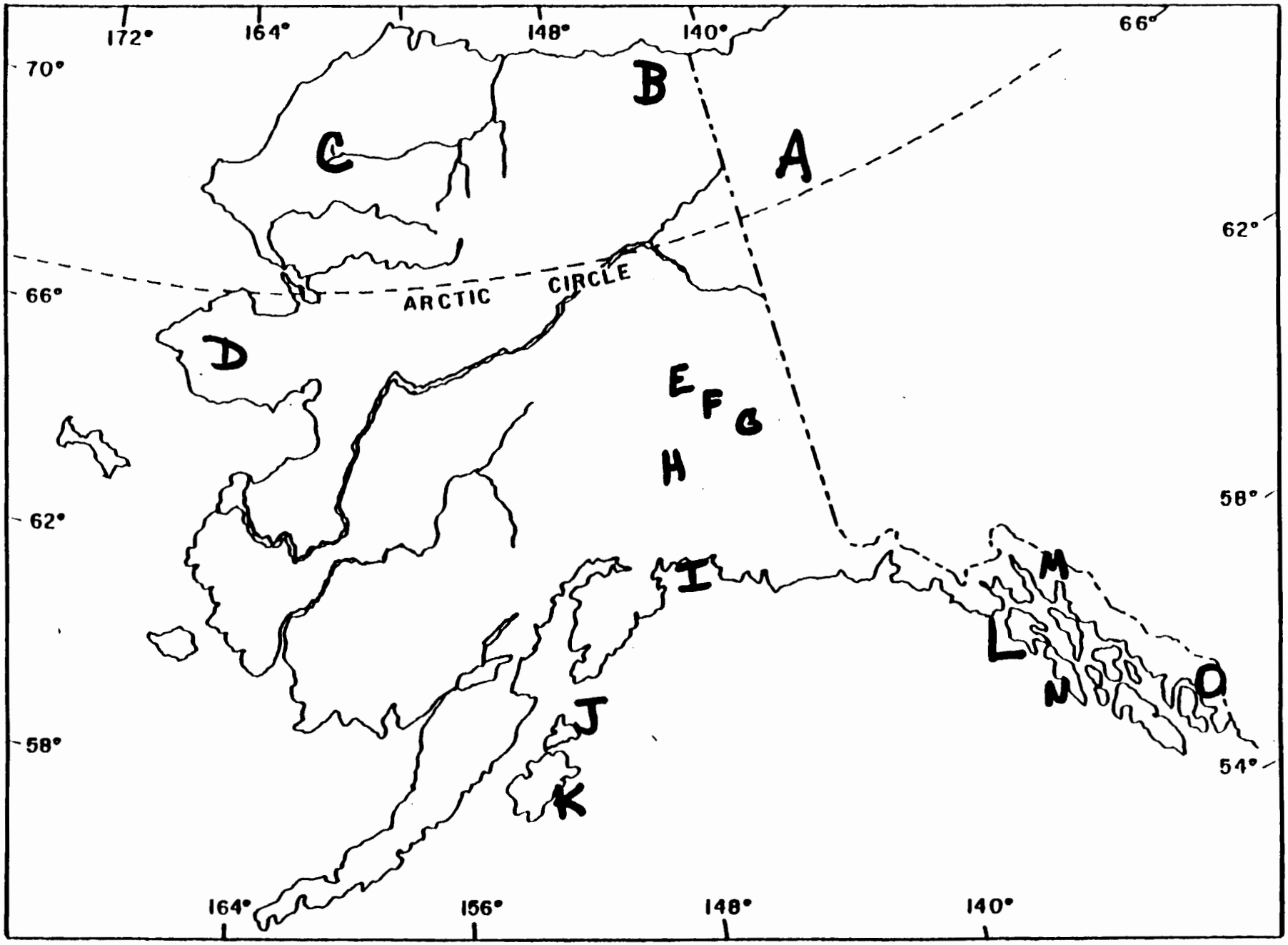

Figure 4 Locations at which blood samples were collected from selected species for serologic survey

Table 1 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Western Arctic Herd, Alaska, 1992-1995

Agent	1992	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	18/69[c]	5/63	3/64	3/46
Bovine viral diarrhea virus SN (32)	21/66	19/63	14/64	21/46
Parainfluenza 3 virus SN (32)	29/68	31/63	27/64	9/46
Respiratory syncytial virus SN (32)	0/62	0/63	0/63	0/46
Epizootic hemorrhagic disease virus ID (±)	0/69	3/63	8/64	0/46
Bluetongue virus ID (±)	0/9	0/63	0/64	0/46
Leptospira interrogans bacterium MAT (100)	3/69	3/63	1/64	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 2 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Teshekpuk Herd, Alaska, 1990-1993

Agent	1990	1991	1992	1993
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/5[c]	0/11	0/10	0/19
Bovine viral diarrhea virus SN (32)	4/5	0/11	1/10	4/19
Parainfluenza 3 virus SN (32)	1/5	1/11	1/10	1/19
Respiratory syncytial virus SN (32)	0/5	0/4	0/8	0/19
Epizootic hemorrhagic disease virus ID (±)	0/5	0/11	0/10	0/19
Bluetongue virus ID (±)	0/5	0/11	3/10	0/19
Leptospira interrogans bacterium MAT (100)	0/5	0/11	0/10	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 3 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Fortymile Herd, Alaska, 1990-1995

Agent	1990	1991	1992	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/9[c]	0/39	0/8	0/14
Bovine viral diarrhea virus SN (32)	0/14	7/39	0/5	0/14
Parainfluenza 3 virus SN (32)	0/14	0/39	0/8	0/14
Respiratory syncytial virus SN (32)	0/14	0/39	0/4	0/14
Epizootic hemorrhagic disease virus ID (±)	0/14	0/39	0/8	0/14
Bluetongue virus ID (±)	0/9	0/39	0/8	0/14
Leptospira interrogans bacterium MAT (100)	0/12	1/36	0/7	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 4 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Wolf Mountain Herd, Alaska, 1995

Agent	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/8[c]
Bovine viral diarrhea virus SN (32)	0/8
Parainfluenza 3 virus SN (32)	0/8
Respiratory syncytial virus SN (32)	0/8
Epizootic hemorrhagic disease virus ID (±)	0/8
Bluetongue virus ID (±)	0/8

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 5 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Galena Mountain Herd, Alaska, 1992 and 1994

Agent	1992	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/15[c]	0/12
Bovine viral diarrhea virus SN (32)	3/9	1/12
Parainfluenza 3 virus SN (32)	8/15	0/12
Respiratory syncytial virus SN (32)	0/10	0/12
Epizootic hemorrhagic disease virus ID (±)	0/15	0/12
Bluetongue virus ID (±)	0/15	0/12
Leptospira interrogans bacterium MAT (100)	0/15	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 6 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Ray Mountains Herd, Alaska, 1994

Agent	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/20[c]
Bovine viral diarrhea virus SN (32)	0/20
Parainfluenza 3 virus SN (32)	0/20
Respiratory syncytial virus SN (32)	0/20
Epizootic hemorrhagic disease virus ID (±)	0/20
Bluetongue virus ID (±)	0/20

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 7 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the White Mountains Herd, Alaska, 1991 and 1995

Agent	1991	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/9[c]	0/4
Bovine viral diarrhea virus SN (32)	0/9	0/4
Parainfluenza 3 virus SN (32)	0/9	0/4
Respiratory syncytial virus SN (32)	0/9	0/4
Epizootic hemorrhagic disease virus ID (±)	0/9	0/4
Bluetongue virus ID (±)	0/9	0/4
Leptospira interrogans bacterium MAT (100)	0/9	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 8 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Delta Herd, Alaska, 1991-1993

Agent	1991	1992	1993
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/40[c]	0/13	0/6
Bovine viral diarrhea virus SN (32)	0/40	0/6	0/5
Parainfluenza 3 virus SN (32)	0/40	0/12	0/6
Respiratory syncytial virus SN (32)	0/40	0/4	0/3
Epizootic hemorrhagic disease virus ID (±)	1/40	0/13	0/6
Bluetongue virus ID (±)	0/40	1/13	0/6
Leptospira interrogans bacterium MAT (100)	1/40	0/12	0/6

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 9 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Macomb Herd, Alaska, 1994

Agent	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/11[c]
Bovine viral diarrhea virus SN (32)	0/11
Parainfluenza 3 virus SN (32)	0/11
Respiratory syncytial virus SN (32)	0/11
Epizootic hemorrhagic disease virus ID (±)	0/11
Bluetongue virus ID (±)	0/11

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 10 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Chisana Herd, Alaska, 1990-1991

Agent	1990	1991
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/11[c]	0/10
Bovine viral diarrhea virus SN (32)	0/12	0/10
Parainfluenza 3 virus SN (32)	0/12	0/10
Respiratory syncytial virus SN (32)	0/12	0/10
Epizootic hemorrhagic disease virus ID (±)	0/12	0/10
Bluetongue virus ID (±)	0/8	0/10
Leptospira interrogans bacterium MAT (100)	0/12	0/10

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 11 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Nelchina Herd, Alaska, 1990 and 1992

Agent	1990	1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/11[c]	0/5
Bovine viral diarrhea virus SN (32)	0/11	0/3
Parainfluenza 3 virus SN (32)	0/11	0/5
Respiratory syncytial virus SN (32)	0/11	0/3
Epizootic hemorrhagic disease virus ID (±)	0/11	0/5
Bluetongue virus ID (±)	0/11	0/5
Leptospira interrogans bacterium MAT (100)	0/11	0/5

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 12 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Kenai Herd, Alaska, 1991-1992

Agent	1991	1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/30[c]	2/7
Bovine viral diarrhea virus SN (32)	0/30	0/7
Parainfluenza 3 virus SN (32)	0/30	0/7
Respiratory syncytial virus SN (32)	0/24	0/7
Epizootic hemorrhagic disease virus ID (±)	0/30	0/7
Bluetongue virus ID (±)	0/29	0/7
Leptospira interrogans bacterium MAT (100)	0/30	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 13 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Mulchatna Herd, Alaska, 1990-1995

Agent	1990	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/14[c]	0/21	0/7
Bovine viral diarrhea virus SN (32)	0/14	0/21	0/7
Parainfluenza 3 virus SN (32)	0/14	0/21	0/7
Respiratory syncytial virus SN (32)	0/14	0/21	0/7
Epizootic hemorrhagic disease virus ID (±)	0/14	0/21	0/7
Bluetongue virus ID (±)	0/14	0/21	0/7
Leptospira interrogans bacterium MAT (100)	0/14	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 14 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Nushagak Herd, Alaska, 1995

Agent	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/12[c]
Bovine viral diarrhea virus SN (32)	0/12
Parainfluenza 3 virus SN (32)	0/12
Respiratory syncytial virus SN (32)	0/12
Epizootic hemorrhagic disease virus ID (±)	0/12
Bluetongue virus ID (±)	0/12

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 15 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the North Alaska Peninsula Herd, Alaska, 1990-1995

Agent	1990	1992	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/14[c]	0/15	0/14	0/18
Bovine viral diarrhea virus SN (32)	0/14	0/14	0/14	0/18
Parainfluenza 3 virus SN (32)	0/14	0/14	0/14	0/18
Respiratory syncytial virus SN (32)	0/14	0/14	0/14	0/18
Epizootic hemorrhagic disease virus ID (±)	1/14	0/15	0/14	0/18
Bluetongue virus ID (±)	0/14	0/15	0/14	0/18
Leptospira interrogans bacterium MAT (100)	0/14	1/15	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 16 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Southern Alaska Peninsula Herd, Alaska, 1990 and 1994

Agent	1990	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/18[c]	0/11
Bovine viral diarrhea virus SN (32)	0/18	0/11
Parainfluenza 3 virus SN (32)	0/18	0/11
Respiratory syncytial virus SN (32)	0/18	0/11
Epizootic hemorrhagic disease virus ID (±)	0/18	0/11
Bluetongue virus ID (±)	0/18	0/11
Leptospira interrogans bacterium MAT (100)	0/18	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 17 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Aishihik Herd, Yukon Territory, Canada, 1991-1995

Agent	1991	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/53[c]	0/21	0/10	0/14
Bovine viral diarrhea virus SN (32)	0/52	0/21	0/10	0/14
Parainfluenza 3 virus SN (32)	0/52	0/21	0/10	0/14
Respiratory syncytial virus SN (32)	0/53	0/21	0/6	0/14
Epizootic hemorrhagic disease virus ID (±)	4/52	0/21	0/9	0/14
Bluetongue virus ID (±)	ND[d]	ND	0/6	0/14
Leptospira interrogans bacterium MAT (100)	0/52	0/21	ND	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 18 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Bonnet Plume Herd, Yukon Territory, Canada, 1993

Agent	1993
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/20[c]
Bovine viral diarrhea virus SN (32)	0/20
Parainfluenza 3 virus SN (32)	0/20
Respiratory syncytial virus SN (32)	0/20
Epizootic hemorrhagic disease virus ID (±)	0/20
Bluetongue virus ID (±)	0/20
Leptospira interrogans bacterium MAT (100)	1/20

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 19 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Burwash Herd, Yukon Territory, Canada, 1993-1994

Agent	1993	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/9[c]	0/5
Bovine viral diarrhea virus SN (32)	0/9	0/5
Parainfluenza 3 virus SN (32)	0/9	0/5
Respiratory syncytial virus SN (32)	0/9	0/5
Epizootic hemorrhagic disease virus ID (±)	0/9	0/5
Bluetongue virus ID (±)	0/9	0/4
Leptospira interrogans bacterium MAT (100)	0/9	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 20 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Carcross Herd, Yukon Territory, Canada, 1994-1995

Agent	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/15[c]	1/19
Bovine viral diarrhea virus SN (32)	0/14	0/19
Parainfluenza 3 virus SN (32)	0/15	0/19
Respiratory syncytial virus SN (32)	0/12	0/19
Epizootic hemorrhagic disease virus ID (±)	0/15	0/19
Bluetongue virus ID (±)	0/11	0/19

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 21 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Chisana Herd, Yukon Territory, Canada, 1990-1995

Agent	1990	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/4[c]	0/4	0/30	0/21
Bovine viral diarrhea virus SN (32)	0/4	0/4	0/28	0/21
Parainfluenza 3 virus SN (32)	0/4	0/4	0/29	0/21
Respiratory syncytial virus SN (32)	0/4	0/4	0/25	0/21
Epizootic hemorrhagic disease virus ID (±)	0/4	0/4	0/29	0/21
Bluetongue virus ID (±)	0/4	0/4	0/25	0/20
Leptospira interrogans bacterium MAT (100)	0/4	0/4	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 22 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Ethel Lake Herd, Yukon Territory, Canada, 1990

Agent	1990
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/7[c]
Bovine viral diarrhea virus SN (32)	0/7
Parainfluenza 3 virus SN (32)	0/7
Respiratory syncytial virus SN (32)	0/7
Epizootic hemorrhagic disease virus ID (±)	0/7
Bluetongue virus ID (±)	0/7
Leptospira interrogans bacterium MAT (100)	0/7

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 23 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Finlayson Herd, Yukon Territory, Canada, 1991 and 1993

Agent	1991	1993
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	1/28[c]	1/20
Bovine viral diarrhea virus SN (32)	0/27	0/20
Parainfluenza 3 virus SN (32)	0/27	0/20
Respiratory syncytial virus SN (32)	0/27	0/20
Epizootic hemorrhagic disease virus ID (±)	0/28	0/20
Bluetongue virus ID (±)	0/28	0/20
Leptospira interrogans bacterium MAT (100)	0/28	0/20

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 24 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Klaza Herd, Yukon Territory, Canada, 1993-1995

Agent	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/4[c]	1/6	0/4
Bovine viral diarrhea virus SN (32)	0/4	0/6	0/4
Parainfluenza 3 virus SN (32)	0/4	0/8	0/4
Respiratory syncytial virus SN (32)	0/4	0/5	0/4
Epizootic hemorrhagic disease virus ID (±)	0/4	1/6	0/4
Bluetongue virus ID (±)	0/4	0/3	0/4
Leptospira interrogans bacterium MAT (100)	0/4	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 25 Serum antibody prevalence of 6 infectious disease agents in caribou (*Rangifer tarandus*) from the Porcupine Herd, Yukon Territory, Canada, 1994

Agent	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/9[c]
Bovine viral diarrhea virus SN (32)	4/9
Parainfluenza 3 virus SN (32)	1/9
Respiratory syncytial virus SN (32)	0/9
Epizootic hemorrhagic disease virus ID (±)	0/9
Bluetongue virus ID (±)	0/9

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 26 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Tatchun Herd, Yukon Territory, Canada, 1993-1995

Agent	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/4[c]	0/1	0/5
Bovine viral diarrhea virus SN (32)	0/4	0/1	0/5
Parainfluenza 3 virus SN (32)	0/4	0/1	0/5
Respiratory syncytial virus SN (32)	0/4	0/1	0/5
Epizootic hemorrhagic disease virus ID (±)	0/4	0/1	0/5
Bluetongue virus ID (±)	0/4	0/1	0/5
Leptospira interrogans bacterium MAT (100)	0/4	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 27 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Tay River Herd, Yukon Territory, Canada, 1993

Agent	1993
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/20[c]
Bovine viral diarrhea virus SN (32)	0/20
Parainfluenza 3 virus SN (32)	0/20
Respiratory syncytial virus SN (32)	0/20
Epizootic hemorrhagic disease virus ID (±)	0/20
Bluetongue virus ID (±)	0/20
Leptospira interrogans bacterium MAT (100)	0/20

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 28 Serum antibody prevalence of 7 infectious disease agents in caribou (*Rangifer tarandus*) from the Wolf Lake Herd, Yukon Territory, Canada, 1993 and 1995

Agent	1993	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/28[c]	0/8
Bovine viral diarrhea virus SN (32)	0/28	0/8
Parainfluenza 3 virus SN (32)	0/28	0/8
Respiratory syncytial virus SN (32)	0/28	0/8
Epizootic hemorrhagic disease virus ID (±)	0/28	0/8
Bluetongue virus ID (±)	0/28	0/8
Leptospira interrogans bacterium MAT (100)	1/28	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 29 Serum antibody prevalence of 6 infectious disease agents in moose (*Alces alces*) from the Arctic National Wildlife Refuge, Alaska, 1995

Agent	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/52[c]
Bovine viral diarrhea virus SN (32)	0/52
Parainfluenza 3 virus SN (32)	9/52
Respiratory syncytial virus SN (32)	0/51
Epizootic hemorrhagic disease virus ID (±)	0/52
Bluetongue virus ID (±)	6/52

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 30 Serum antibody prevalence of 7 infectious disease agents in moose (*Alces alces*) from northwestern Alaska, 1992-1995

	Noatak River drainage				Selawik River drainage	Seward Peninsula
Agent	1992	1993	1994	1995	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/62[c]	0/15	0/16	0/53	0/61	0/12
Bovine viral diarrhea virus SN (32)	5/62	1/17	0/16	1/54	2/61	0/12
Parainfluenza 3 virus SN (32)	26/62	5/17	4/16	16/54	30/61	7/12
Respiratory syncytial virus SN (32)	0/62	0/13	0/14	0/52	0/58	0/12
Epizootic hemorrhagic disease virus ID (±)	0/62	0/17	0/16	0/54	0/61	0/12
Bluetongue virus ID (±)	0/62	0/17	0/16	0/54	0/61	0/12
Leptospira interrogans bacterium MAT (100)	0/62	ND[d]	ND	ND	ND	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 31 Serum antibody prevalence of 6 infectious disease agents in moose (*Alces alces*) from Birch Creek, Alaska, 1993-1994

Agent	1993	1994
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/8[c]	0/9
Bovine viral diarrhea virus SN (32)	0/8	0/9
Parainfluenza 3 virus SN (32)	0/8	0/9
Respiratory syncytial virus SN (32)	0/8	0/9
Epizootic hemorrhagic disease virus ID (±)	0/8	0/9
Bluetongue virus ID (±)	0/8	0/9

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 32 Serum antibody prevalence of 6 infectious disease agents in moose (*Alces alces*) from Delta Junction, Alaska, 1990-1991

Agent	1990	1991
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/10[c]	0/4
Bovine viral diarrhea virus SN (32)	0/10	0/4
Parainfluenza 3 virus SN (32)	0/10	0/4
Respiratory syncytial virus SN (32)	0/10	0/3
Epizootic hemorrhagic disease virus ID (±)	0/10	0/4
Bluetongue virus ID (±)	0/10	0/4

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

Table 33 Serum antibody prevalence of 7 infectious disease agents in moose (*Alces alces*) from the Nelchina River drainage, Alaska, 1992-1995

Agent	1992	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/2[c]	0/41	0/34
Bovine viral diarrhea virus SN (32)	0/2	0/41	0/34
Parainfluenza 3 virus SN (32)	0/2	0/41	0/34
Respiratory syncytial virus SN (32)	0/2	0/41	0/34
Epizootic hemorrhagic disease virus ID (±)	0/2	0/41	0/34
Bluetongue virus ID (±)	0/2	0/41	0/34
Leptospira interrogans bacterium MAT (100)	0/2	ND[d]	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 34 Serum antibody prevalence of 7 infectious disease agents in muskox (*Ovibos moschatus*) from Seward Peninsula and the Arctic National Wildlife Refuge, Alaska

	Seward Peninsula			Arctic National Wildlife Refuge	
Agent	1987	1988	1989	1991	1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/4[c]	0/10	0/7	0/11	0/7
Bovine viral diarrhea virus SN (32)	0/4	0/10	0/7	0/11	0/7
Parainfluenza 3 virus SN (32)	1/4	0/10	0/7	10/11	7/7
Respiratory syncytial virus SN (32)	0/4	0/10	0/6	0/11	0/7
Epizootic hemorrhagic disease virus ID (±)	0/4	0/10	0/6	0/11	0/7
Bluetongue virus ID (±)	ND[d]	ND	ND	0/11	0/7
Leptospira interrogans bacterium MAT (100)	0/4	0/10	1/7	ND	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 35 Serum antibody prevalence of 7 infectious disease agents in Dall sheep (*Ovis dalli*) from selected areas of Alaska, 1990-1992

	Arctic National Wildlife Refuge			Granite Creek		Sheep Creek
Agent	1990	1991	1992	1991	1992	1991
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/19[c]	0/20	0/28	0/19	0/13	0/10
Bovine viral diarrhea virus SN (32)	0/19	0/20	0/28	0/19	0/12	0/10
Parainfluenza 3 virus SN (32)	0/19	3/20	0/28	0/19	0/13	0/10
Respiratory syncytial virus SN (32)	0/19	0/20	0/30	0/19	0/12	0/10
Epizootic hemorrhagic disease virus ID (±)	0/19	0/20	0/30	3/19	0/13	0/10
Bluetongue virus ID (±)	0/19	0/20	0/30	0/19	0/13	0/10
Leptospira interrogans bacterium MAT (100)	0/19	0/20	0/30	0/9	0/13	0/10

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.

Table 36 Serum antibody prevalence of 7 infectious disease agents in bison (*Bison bison*) from Delta Junction, Alaska, 1990-1995

Agent	1990	1991	1992	1993	1994	1995
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/63[c]	0/59	0/54	0/67	0/49	0/6
Bovine viral diarrhea virus SN (32)	1/63	0/58	0/53	0/65	0/49	0/6
Parainfluenza 3 virus SN (32)	63/63	54/59	54/54	63/67	49/49	6/6
Respiratory syncytial virus SN (32)	4/61	0/55	0/50	1/64	0/49	0/6
Epizootic hemorrhagic disease virus ID (±)	0/63	0/59	0/54	0/67	0/49	0/6
Bluetongue virus ID (±)	0/63	0/59	0/54	0/67	0/49	0/6
Leptospira interrogans bacterium MAT (100)	1/39	0/13	0/54	ND[d]	ND	ND

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 37 Serum antibody prevalence of 7 infectious disease agents in elk (*Cervus canadenis roosevelti*) from Afognak Island, Alaska, 1989 and 1992

Agent	1989	1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/6[c]	0/14
Bovine viral diarrhea virus SN (32)	0/5	0/14
Parainfluenza 3 virus SN (32)	0/6	0/14
Respiratory syncytial virus SN (32)	0/5	0/14
Epizootic hemorrhagic disease virus ID (±)	0/6	0/14
Bluetongue virus ID (±)	0/6	0/14
Leptospira interrogans bacterium MAT (100)	0/5	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 38 Serum antibody prevalence of 7 infectious disease agents in deer (*Odocoileus hemionus sitkensis*) from selected areas of Alaska, 1989-1992

	Kodiak		Prince William Sound	Baranof Island
Agent	1989	1990	1989	1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/1[c]	0/15	0/2	1/2
Bovine viral diarrhea virus SN (32)	0/1	0/14	0/2	1/2
Parainfluenza 3 virus SN (32)	0/1	0/15	0/2	1/2
Respiratory syncytial virus SN (32)	0/1	0/14	0/1	1/2
Epizootic hemorrhagic disease virus ID (±)	0/1	0/15	0/2	0/2
Bluetongue virus ID (±)	0/1	0/15	0/2	0/2
Leptospira interrogans bacterium MAT (100)	0/1	0/15	0/2	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 39 Serum antibody prevalence of 7 infectious disease agents in mountain goat (*Oreamnos americanus*) from Ketchikan and Juneau, Alaska, 1991-1992

Agent	Ketchikan 1991	Juneau 1992
Infectious bovine rhinotracheitis virus SN[a] (32)[b]	0/15[c]	0/11
Bovine viral diarrhea virus SN (32)	0/15	0/11
Parainfluenza 3 virus SN (32)	0/15	0/11
Respiratory syncytial virus SN (32)	0/15	1/11
Epizootic hemorrhagic disease virus ID (±)	0/15	0/11
Bluetongue virus ID (±)	0/15	2/11
Leptospira interrogans bacterium MAT (100)	0/15	ND[d]

[a] Test method: SN = serum neutralization test, ID = immunodiffusion test, MAT = microscopic agglutination test.
[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."
[c] Number positive/number tested.
[d] Not done.

Table 40 Serum antibody prevalence[a] of canine distemper virus in wolves (*Canis lupus*) from 11 areas of Alaska and the Yukon Territory, Canada, 1984-1994

Area	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total (%)
Arctic National Wildlife Refuge	1/8	2/10	0/2	7/12	2/6	1/5	3/4					16/47 (34)
Denali National Park			1/13	6/15	6/10	3/14	2/14	10/33	16/20	3/16		47/135 (35)
Galena			0/1	0/4			12/20		2/8	0/2	3/13	17/48 (35)
Canada		0/1	0/1		2/26	1/28		18/21	14/16	7/14	18/24	42/107 (46)
Kanuti National Refuge							10/13	5/16				15/29 (52)
Kobuk River drainage				0/10	0/10	1/21	2/28	2/11				5/80 (6)
Gates of the Arctic Refuge				1/15	0/1							1/16 (7)
Fairbanks	0/1		0/1	1/5	0/11	0/3			1/5			2/26 (8)
Tok					0/2		0/1	0/1	2/23	0/2		2/29 (7)
Nelchina River drainage									0/6			
Cordova									0/6			

[a] Serum neutralization test. Threshold titer = 32.

Table 41 Serum antibody prevalence[a] of infectious canine hepatitis virus in wolves (*Canis lupus*) from 11 areas of Alaska and the Yukon Territory, Canada, 1984-1994

Area	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total (%)	
Arctic National Wildlife Refuge	6/7	5/6	2/2	12/12	10/10		4/4					39/41	(95)
Denali National Park			10/13	15/15	8/11	10/13	13/14	25/32	19/20	9/11		109/129	(84)
Galena			1/1	2/4			18/19		8/8	2/2	9/12	40/44	(91)
Canada		0/1	1/1		21/24	18/24		12/19	14/15	9/13	22/24	75/97	(80)
Kanuti National Refuge							8/11	14/15				22/26	(85)
Kobuk River drainage				9/10	9/10	20/21	26/27	11/11				75/79	(95)
Gates of the Arctic Refuge				10/13									(77)
Fairbanks	1/1		0/1	3/5	10/10	0/3			5/5			19/25	(76)
Tok					1/2		1/1	0/1	22/22	2/2		26/28	(93)
Nelchina River drainage									6/6			6/6	(100)
Cordova									1/4			1/4	(25)

[a] Serum neutralization test. Threshold titer > 36.

Table 42 Serum antibody prevalence[a] of canine parvovirus in wolves (*Canis lupus*) from 11 areas of Alaska and the Yukon Territory, Canada, 1984-1994

Area	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total (%)
Arctic National Wildlife Refuge	2/8	1/6	2/2	2/11	4/10		0/4					11/41 (27)
Denali National Park			6/12	4/13	4/9	4/12	7/14	10/30	1/20	1/10		37/120 (31)
Galena			0/1	2/3			13/19		7/8	0/2	11/12	33/45 (73)
Canada		1/1			3/22	5/24		9/19	2/15	3/13	8/24	28/94 (30)
Kanuti National Refuge							3/12	6/15				9/27 (33)
Kobuk River drainage				4/10	5/9	15/21	15/28	5/11				44/79 (56)
Gates of the Arctic Refuge				2/12								2/12 (17)
Fairbanks	1/1		1/1	3/5	5/9	1/3			3/5			14/24 (58)
Tok					1/2		1/1	1/1	7/19	2/2		12/25 (48)
Nelchina River drainage									4/6			4/6 (67)
Cordova									0/1			0/1 (0)

[a] Serum neutralization test. Threshold titer > 36.

Table 43 Serum antibody prevalence[a] of canine coronavirus in wolves (*Canis lupus*) from 11 areas of Alaska and the Yukon Territory, Canada, 1984-1994

Area	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total (%)
Arctic National Wildlife Refuge	1/8	0/7	0/2	0/12	0/10		0/4					1/43 (2)
Denali National Park			0/13	0/15	0/11	0/13	0/14	3/30	0/20	11/11		4/127 (3)
Galena			0/1	0/4			3/19		0/8	0/2	4/13	7/47 (15)
Canada		0/1	0/1		0/19	0/24		2/20	0/15	1/13	0/24	3/117 (3)
Kanuti National Refuge							0/12	0/15				0/27 (0)
Kobuk River drainage				1/10	1/10	3/21	0/28	5/11				15/80 (19)
Gates of the Arctic Refuge				0/14								0/14 (0)
Fairbanks	1/1		0/1	0/5	0/9	0/3			0/5			1/24 (4)
Tok					0/2		0/1	0/1	0/20	0/2		0/26 (0)
Nelchina River drainage									0/6			(0)
Cordova									0/4			(0)

[a] Serum neutralization test. Threshold titer > 32.

Table 44 Serum antibody prevalence[a] of *Francisella tularensis* in wolves (*Canis lupus*) from 11 areas of Alaska and the Yukon Territory, Canada, 1984-1995

Area	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total (%)	
Arctic National Wildlife Refuge	1/10	1/11	0/1	0/13	0/6	0/5	0/4						2/50	(4)
Denali National Park			4/13	1/15	0/10	1/14	1/14	14/33	5/20	2/16			28/135	(21)
Galena				0/3			1/20		2/8	0/2	2/13		5/46	(11)
Canada		0/1	0/2		0/27	7/28		13/21	7/16	2/14	10/23		39/134	(29)
Kanuti National Refuge							2/13	2/16					4/29	(14)
Kobuk River drainage				2/10	1/10	2/17	1/28	0/11					6/76	(8)
Gates of the Arctic Refuge				3/15	0/2								3/17	(18)
Fairbanks	1/1		0/1	2/4	1/11	1/3			0/3			3/21	8/44	(18)
Tok					0/1		0/1	0/1	2/23	0/2			2/28	(7)
Nelchina River drainage									1/6				1/6	(17)
Cordova									0/5				0/5	(0)

[a] Rapid plate test. Threshold titer = 20.

Table 45 Serum antibody prevalence of 4 infectious disease agents in 4 mustelid species from Alaska and Canada, 1980-1993

Agent	Wolverine (*Gulo gulo*) Northwestern Alaska 1980, 1981, 1989	Wolverine (*Gulo gulo*) Talkeetna Mountains 1992-1993	Wolverine (*Gulo gulo*) Yukon Territory 1993	River otter (*Lutra canadensis*) Prince William Sound 1989-1990	Marten (*Martes americana*) Chichagof Island 1992	Marten (*Martes americana*) Chichagof Island 1993	Mink (*Mustela vison*) Chichagof Island 1992-1993
Canine distemper virus SN[a] (10)[b]	0/6[c]	0/7	4/7	0/22	0/13	0/11	0/24
Infectious canine hepatitis virus SN (10)	0/6	0/7	0/7	0/22	0/13	0/11	0/24
Leptospira interrogans							
serovar canicola	0/6	0/7	0/7	0/22	0/13	0/11	0/24
serovar icterohemorrhagiae MAT (100)	0/6	0/7	0/7	0/22	0/13	0/11	0/24
Aleutian disease virus CEP (±)	0/6	0/7	0/7	0/22	0/13	0/11	0/24

[a] Test method: SN = serum neutralization test, MAT = microscopic agglutination test, CEP = counter immuno-electrophoresis.

[b] Number in parentheses indicates minimum titer necessary to be considered evidence of exposure to agent in question. (±) indicates that test is interpreted as simply either "positive" or "negative."

[c] Number positive/number tested.

APPENDIX A Serologic survey for *Trichinella* spp. in grizzly bears (*Ursus arctos*) from Alaska, 1973 to 1987

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ABSTRACT: Blood was collected from 878 grizzly bears (*Ursus arctos*) in seven geographic areas of Alaska from 1973 to 1987. An enzyme-linked immunosorbent assay procedure was used to test sera for evidence of exposure to *Trichinella* spp. Serum antibody prevalence ranged from 10 positive of 196 tested (5%) in the Southern Region of the state to 355/430 (83%) in the Northern Region. These major discrepancies may be a result of differing food habits of bears in the major geographic areas. Prevalence was higher in older age cohorts. Neither year-of-collection nor sex had a significant effect on prevalence.

Key words: Grizzly bear, serology, *Trichinella* spp., trichinellosis, *Ursus arctos*.

APPENDIX B Serologic survey for *Toxoplasma gondii* in grizzly bears (*Ursus arctos*) from Alaska, 1973 to 1987

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ABSTRACT: Blood samples were collected from 887 grizzly bears (*Ursus arctos*) in Alaska (USA) from 1973 to 1987. Sera were tested for evidence of exposure to *Toxoplasma gondii* by means of the modified agglutination test. Six hundred seventy-two sera (75%) had titers < 25. Twenty-four samples (3%) had titers of 25. One hundred thirty-two specimens (15%) had titers of 50. Sixty-four sera (7%) had titers greater than or equal to 500. Antibody prevalence increased from 9% (18 positive of 196 tested) in southern areas to 37% (162 of 433 tested) in northern areas. There was no readily apparent explanation for these discrepancies in location-specific prevalence.

Key words: Alaska, grizzly bear, *Toxoplasma gondii*, serology.

APPENDIX C Serologic survey for Phocid herpesvirus-1 in marine mammals from Alaska and Russia, 1978-1994

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ABSTRACT: Blood samples were collected from 1125 mammals off the coast of Alaska and Russia during the period 1978 to 1994. Nine species were represented, including sea otter (*Enhydra lutris*) and eight species of pinnipeds. Sera were tested for the presence of neutralizing antibodies to the 1984 Pieterburen isolate of phocid herpesvirus-1 (PhHV-1). Species-specific antibody prevalences ranged from 0% to 77%. Prevalence was > 70% for ringed seals (*Pusa hispida*), spotted seals (*Phoca largha*), and harbor seals (*Phoca vitulina*). Prevalence was < 10% for sea otter. For each species, differences in antibody prevalence were not related to: 1) sex, 2) location of capture, or 3) year of collection. Antibody prevalence for walruses (*Odobenus rosmarus*) could be quantitatively predicted as a function of age. No evidence of PhHV-1 induced mortality has been detected in areas included in this survey. Based on results of this survey, PhHV-1 is not considered to be a significant mortality factor in mammals which inhabit the marine environment off the coast of Alaska or Russia.

Key words: Alaska, marine mammals, Russia, seal herpesvirus, serology.

NOTES

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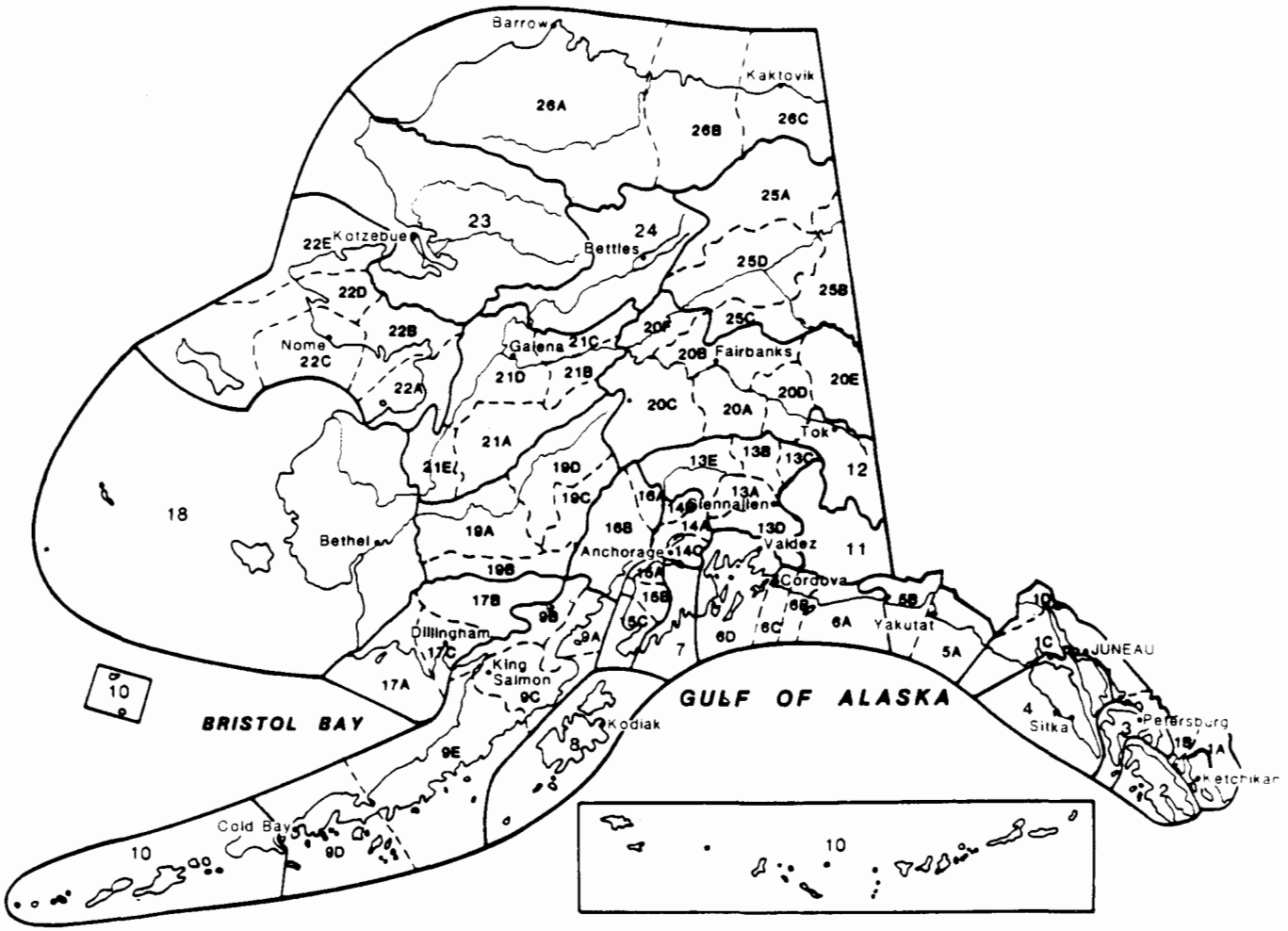
Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.

KEN WHITTEN