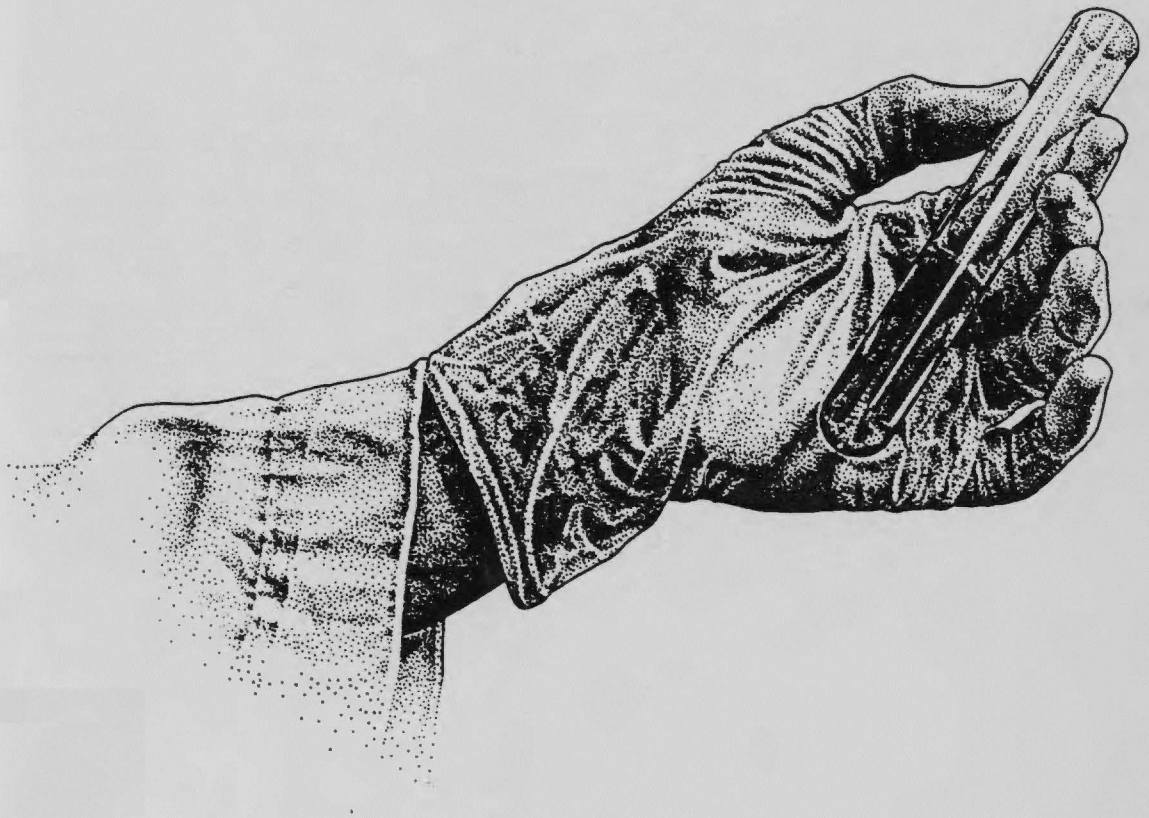
Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Progress Report

SEROLOGIC SURVEY FOR MICROBIAL PATHOGENS



by
Randall L. Zarnke
Project W-23-2
Study 18.6
March 1990

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DEPARTMENT OF FISH AND GAME
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PROGRESS REPORT (RESEARCH)

State: Alaska

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Study No: 18.6 Job Title: Serologic Survey of Alaskan Wildlife for Microbial Pathogens

Period Covered: 20 April 1988-19 April 1989

SUMMARY

A serologic survey of selected wildlife species from Alaska was conducted. Evidence of exposure to parainfluenza III virus remained high in bison (Bison bison). Antibody prevalence of bovine viral diarrhea virus in bison was low and sporadic. Although prevalence of these agents, as well as infectious bovine rhinotracheitis virus, was relatively common in northern caribou (Rangifer tarandus) herds, it was absent in caribou elsewhere. Prevalence of parainfluenza III virus in Dall sheep (Ovis dalli) and bovine viral diarrhea in muskox (Ovibos moschatus) remained low. Evidence of exposure to contagious ecthyma virus was common in Dall sheep, but rare and sporadic in caribou and moose (Alces alces). There was no evidence of exposure to pseudorabies virus in black bears (Ursus americanus). Evidence of leptospirosis was common in grizzly bears (Ursus arctos), but low for bison, moose, and black-tailed deer (Odocoileus hemionus sitkensis). Antibody prevalence of epizootic hemorrhagic disease virus and/or bluetongue virus in moose and caribou was low. Brucellosis was more common in Brooks Range grizzly bears than in those from other areas of the state. Dall sheep and deer specimens contained evidence of exposure to Coxiella burnetti (i.e., the causative agent of Q fever). Evidence of tularemia was widespread in grizzly bears, although these results are subject to question. There was no evidence of toxoplasmosis in grizzly bears.

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

CONTENTS

BACKGROUND

Few instances of infectious diseases having an observed impact on wildlife populations in Alaska have been documented. 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 chronology of exposure.

4. Tests are relatively inexpensive to perform.

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

6. Sera are stable for a long period of time (under adequate storage conditions), thus providing the basis for a functional archive system that can be utilized 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 a period of 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 allows for the consideration of human intervention into the disease process at the most opportune time and place.

Within a living animal, antibody molecules, which are produced in response to some disease agents, may decay to undetectably low levels over a relatively short period (ca. several months). The rate of degradation is an exponential decay function expressed as the "half-life." Antibody that is produced in response to other agents may be more long-lived and may remain at detectable levels for many years. Furthermore, reexposure of a previously infected host to the disease agent in question may cause an increase in the level of antibody 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 the specific animal involved. However, in most cases such periodic sampling schemes are not practical for free-ranging animals. Thus, determining the timing or exposure of either specific individuals or populations is difficult.

Test results for samples that have been collected during any particular year do not necessarily reflect the transmission pattern during that year. 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 current study.

Alaska Department of Fish and Game (ADF&G) staff have conducted serologic surveys since the early 1960's. During the early years, such surveys were limited in the scope of disease agents and host species that were being investigated. Over the past decade, the survey has expanded to include several species of wild mammals and disease agents.

Results of disease surveys often have significant implications for wildlife management and human health. For example,

understanding of the epizootiology of rabies (especially host range) has been expanded by surveys in Africa. In another example from the contiguous United States, results of surveys for duck virus enteritis in waterfowl have allowed management agencies to focus disease control efforts in areas most likely to be affected. Following an outbreak of contagious ecthyma involving captive Dall sheep (Ovis dalli) and muskoxen (Ovibos moschatus) near Fairbanks, eradication of the captive animals was proposed as a means of preventing spread of the disease to wildlife. Serologic surveys revealed that the disease was common in free-ranging Dall sheep and therefore precluded the need for such action.

OBJECTIVE

To monitor Alaskan wildlife populations for the occurrence of microbial disease agents that 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 had captured animals (Fig. 1) to meet objectives of other studies. Gnerally, blood samples were allowed to settle at ambient or refrigerated temperatures for 6 to 36 hours and then centrifuged; serum was then removed by aspiration. Sera were kept frozen until the time of testing. All serologic tests were performed by personnel of the National Veterinary Service Laboratories (USDA, Ames, Iowa). Serology is a suitable diagnostic tool for most viral and bacterial infections. 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 antibodies to (1) Brucella spp. by the buffered acidified plate antigen test (Angus and Barton 1984); (2) tularemia by the tube agglutination test (Owen 1970); (3) Q fever and contagious ecthyma by the complement fixation test (Erickson et al. 1975); (4) Leptospira spp. by the microscopic agglutination test (Cole et al. 1973); (5) infectious bovine rhinotracheitis, bovine viral diarrhea, respiratory syncytial virus, and pseudorabies by the serum neutralization test (Thorsen and Henderson 1971); (6) epizootic hemorrhagic disease, bluetongue, and ovine progressive pneumonia by the immunodiffusion test (Pearson and Jochim 1979); (7) parainfluenza III by the hemagglutination-inhibition test (Thorsen and Henderson 1971); and (8) Toxoplasma gondii by the indirect hemagglutination test (Lunde 1973).

Twelve Leptospira interrogans serovarieties were included in the tests: pomona, ballum, canicola, icterrohemorrhagiae, wolffi, grippotyphosa, hardjo, autumnalis, bataviae, tarassovi, australis, and pyrogenes. Minimum titers for all tests were established, based upon natural or experimental infection of the species in question or of a domesticated species. Sera that 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."

RESULTS AND DISCUSSION

In most cases, test results provided no evidence of exposure to a particular disease in a particular host species (Tables 1-13). This discussion will focus on those situations where evidence of previous exposure was found.

Respiratory Viruses

Three viral diseases, infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), and parainfluenza III (PI3), 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 (i.e., rate of illness) may be high in an infected population, but mortality (i.e., rate of death) is usually low. Transmission usually occurs via aerosol droplet, but the veneral 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).

Serum antibody prevalence of PI3 remains high in the Delta Bison (Bison bison) Herd (Table 1). To date, there have been no reports of clinical disease in the herd. Attempts to isolate the virus from nasal swabs collected by hunters have been unsuccessful. The low antibody prevalence of BVD (Table 1) fits established patterns of low and sporadic occurrence for this agent (Zarnke 1986).

Antibody prevalence of IBR, BVD, and PI3 in caribou exhibited the same apparent geographic demarcation (Tables 2-7) described earlier (Zarnke 1986, 1987). Although evidence of exposure to these agents is virtually nonexistent in herds south of Fairbanks, it is relatively common in herds north of Fairbanks. The cause of this apparent discrepancy is currently unknown. There have been no verified reports of respiratory distress or related symptoms in the northern herds. Thus the effects of this phenomenon are likewise unknown. Exposure of Dall sheep to PI3 (Table 8) and muskox to BVD (Table 9) remains rare.

Contagious Ecthyma

Contagious Ecthyma (CE) is a viral disease primarily found in sheep and goats, both wild (Samuel et al. 1975) and domestic (Beck and Taylor 1974). Infection causes crusty, proliferative lesions on exposed skin near the mouth, eyes, udder, anus, and/or hoof line (Beck and Taylor 1974, Dieterich et al. 1981).

Anorexia and ataxia are common symptoms (Beck and Taylor 1974). The virus is shed in scabs and remains infective for years (Beck and Taylor 1974). Direct contact transmission also plays a role (Beck and Taylor 1974). The epizootiology of CE in Alaska has been discussed previously (Dieterich et al. 1981, Zarnke et al. 1983).

Antibody prevalence of CE in Dall sheep was moderate (Table 8). This continuation of previous patterns supports the hypothesis that CE is enzootic in free-ranging Dall sheep populations (Zarnke et al. 1983) and may be fatal in lambs (Zarnke et al. 1983); however, it usually causes only transient illness in healthy adults. The disease is not believed to be a significant factor in sheep population dynamics.

Test results for both moose (Alces alces) (Table 10) and caribou (Tables 2-7) follow established patterns with sporadic evidence of exposure to CE (Zarnke 1986). Both species are susceptible to experimental infection (Zarnke et al. 1983). Opportunity for exposure in nature is probably limited; CE is probably not a major factor in the life history of either species.

Pseudorabies

Pseudorabies (PR) (also known as Aujeszky's disease) is a viral disease manifested by severe itching and self-mutilation (Bush 1983). The disease is transmitted via oral and nasal secretions. The virus proliferates in the central nervous system. Swine are considered to be the primary natural host (Bush 1983). Domestic cattle, dogs, and cats are also susceptible (Bush 1983). Natural infections of various wildlife species have also been reported, including red fox (Vulpes vulpes) (Bitsch and Munch 1971), Arctic fox (Alopex lagopus) (Ljubashenko et al. 1958), and black bear (Ursus americanus) (Schulze et al. 1986).

This is the 1st survey of free-ranging black bears in Alaska for evidence of exposure to PR (Table 11). The absence of any such evidence is favorable for the health of the bear population in the southcentral portion of the state.

Leptospirosis

Leptospirosis is caused by one or more so-called "serovarieties" of a spirochete known as Leptospira interrogans (Busch 1970). Symptoms may include chronic kidney infections (Diesch et al. 1970), hepatitis (Bishop et al. 1979), and/or abortion. Transmission usually occurs via contamination of water by leptospires that are shed in urine (Busch 1970). Also, the disease may be passed along the food chain from prey to predators (Reilly et al. 1970). Exposure to more than 1 serovar is not uncommon.

Antibody prevalence for Leptospira interrogans in bison (Table 1), Sitka black-tailed deer (Odocoileus hemionus

sitkensis) (Table 12), and moose (Table 10) was low. These results fit established patterns for bison and moose (Zarnke 1986). This is the first known evidence of leptospirosis in Alaska deer, but small sample size limits interpretation of results.

Evidence of leptospirosis in grizzly bears (Ursus arctos) (Table 13) remains common (Zarnke 1986). Geographic differences in the frequency of specific serovars was not as clear as in past surveys, with the exception of Kodiak Island where serovar candida was most numerous.

Bluetongue (BLU) and Epizootic Hemorrhagic Disease (EHD)

BLU and EHD are viral diseases of wild and domestic ruminants. Symptoms may include anorexia, ataxia, dyspnea, and depression, but 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 or 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." Antigenic variation and overlap must also be considered 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 conceivable that there may be 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 midge species exists in Alaska. I recently attempted to collect midges for identification, but failed because of difficult trapping conditions during long summer evenings. Certainly, members of the genus Culicoides 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. The sporadic evidence of

exposure to BLU in moose (Table 12) and EHD in both moose (Table 12) and caribou (Tables 3-8) follow established patterns for these 2 host species (Zarnke 1986, 1987).

Brucellosis

Brucella suis IV is the causative agent of the type of brucellosis found in Alaska. The most well-studied host species include caribou and their associated predators (Neiland et al. 1968, Neiland 1975). Infection usually localizes in joints or reproductive organs, causing arthritis and/or abortion (Neiland et al. 1968). Transmission occurs venerally (Neiland et al. 1968) or via the food chain (Neiland 1970, 1975).

Evidence of brucellosis in grizzly bears continues to be widespread, with antibody prevalence in the Brooks Range remaining higher than in other areas of the state (Table 13). Effects of this disease on bears are still unknown, but presumably it can cause abortion and/or sterility.

Q fever

Q fever is caused by the rickettsium Coxiella burnetti (Randhawa et al. 1977). The organism usually localizes in the respiratory tract. Although the disease is generally mild in domestic species, abortions can occur in sheep and goats. Death is rare (Bell 1981). Coxiella burnetti is shed in milk, feces, birth fluids, and placental tissues (Enright et al. 1969).

Evidence of Q fever in Dall sheep (Table 8) continues to appear sporadically. We have obtained the first known evidence of Q fever in Alaska deer (Table 12); however, small sample sizes continue to limit interpretation of results.

Based upon past serologic evidence, Q fever has a broad host range in Alaska (Zarnke 1986, 1987). To date, there has been no evidence of clinical disease.

Tularemia

Tularemia is an acute, febrile, plague-like disease of wild lagomorphs and rodents caused by the bacterium Francisella tularensis. Snowshoe hares (Lepus americanus) are the primary reservoir of tularemia in Alaska (Dieterich 1981). The disease is transmitted usually among hares by ticks, particularly when the population density of hares is high. Transmission to predators occurs usually as a result of their preying on infected hares. Historically, serum antibody prevalence has been low in red fox and domestic dog populations in Alaska (Zarnke et al. 1983).

This is the first geographically widespread evidence of tularemia in Alaskan grizzly bears (Table 13). As such, I find it

confusing. It is possible that these test results represent cross-reacting antibody to Brucella suis IV. However, there are numerous examples where test results do not coincide; i.e., the test result for one of these diseases in a particular sample cannot be used to predict the test result for the other disease. Although there may be some cross-reactivity, this does not fully explain the unexpectedly high antibody prevalence of tularemia.

Toxoplasmosis

Toxoplasma gondii is a protozoan parasite with a broad host range. Although infection is common, clinical disease is rare. Organisms may be found lying free or encysted in tissues. Transmission occurs via ingestion of meat infected with tissue cysts. In acute cases, signs may include enlargement and/or inflammation of the spleen, liver, lungs, heart, and brain (Sangr 1971).

Serologic evidence of infection in moose (Kocan et al. 1986) and humans (Peterson et al. 1974) has been reported from Alaska. Histologic examination of liver sections from a newborn harbor seal (Phoca vitulina) revealed Toxoplasma gondii cysts and trophozoites (Van Pelt and Dieterich 1973).

The absence of evidence of exposure to Toxoplasma gondii in grizzly bears from 4 areas of the state (Table 13) suggests that this protozoan parasite is not found in this potential host species.

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Fig. 1. Locations at which blood samples were collected for disease survey.

A. Game Management Unit 20E
B. Tok
C. Sheep Creek
D. Granite Creek
E. Delta Junction
F. Headwaters Little Delta River
G. Dry Creek
H. Game Management Unit 13
J. Denali Park
K. White Mountains
L. Arctic National Wildlife Refuge
M. Atigun Gorge
N. Gates of the Arctic
P. Driftwood
Q. Koyukuk River
R. Seward Peninsula
S. Innoko River
T. Nunivak Island
U. Becharof
V. Kodiak Island
W. Baranof and Chichagof Islands

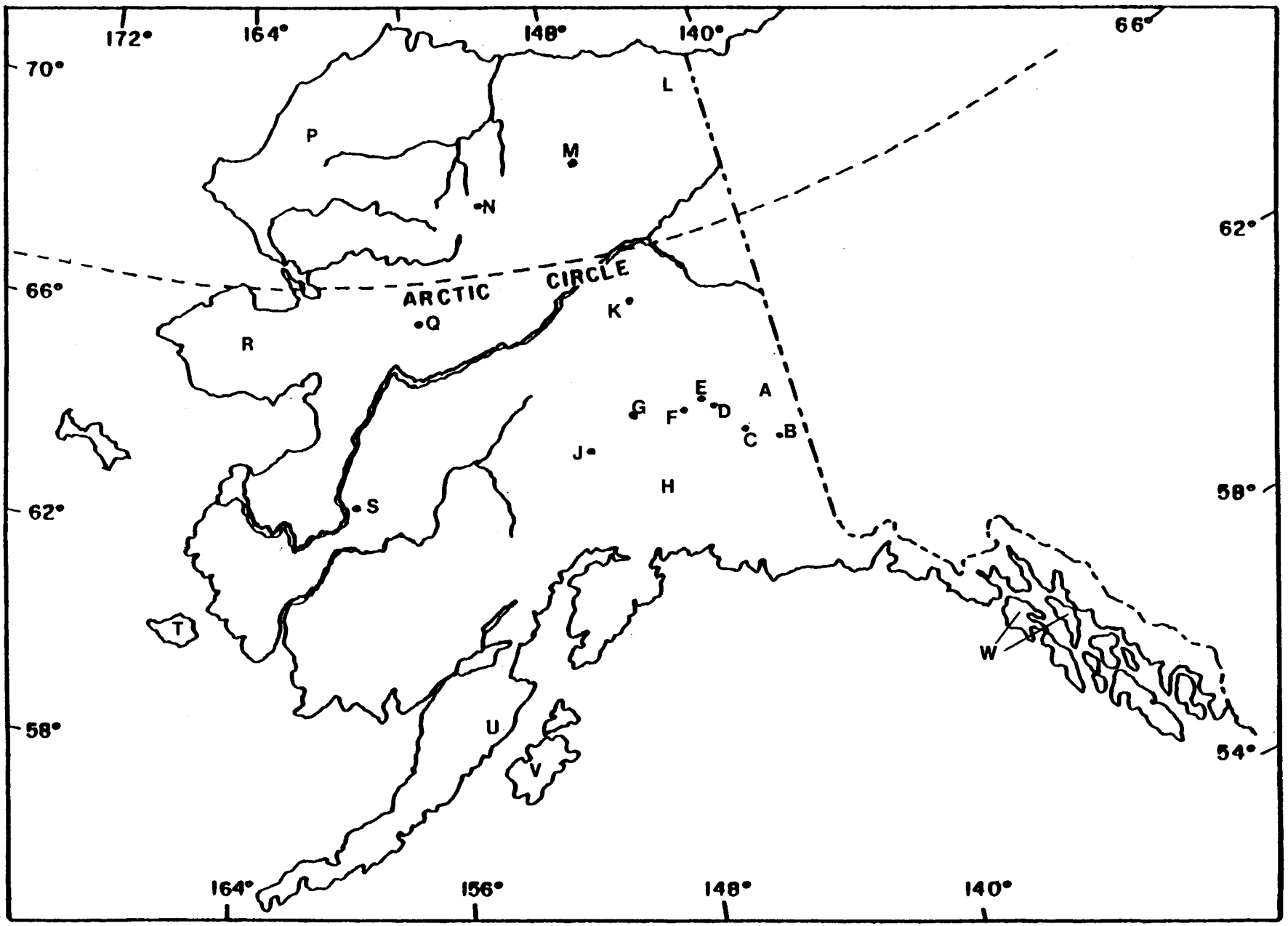
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Fig. 2. Approximate home ranges of caribou herds from which which blood samples were collected for disease survey.

A. Western Arctic Herd
B. Teshekpuk Herd
C. Central Arctic Herd
D. Porcupine Herd
E. Fortymile Herd
F. Nelchina Herd
G. Delta Herd
H. Yanert Herd
J. Denali Herd
K. Galena
L. Alaska Peninsula Herd

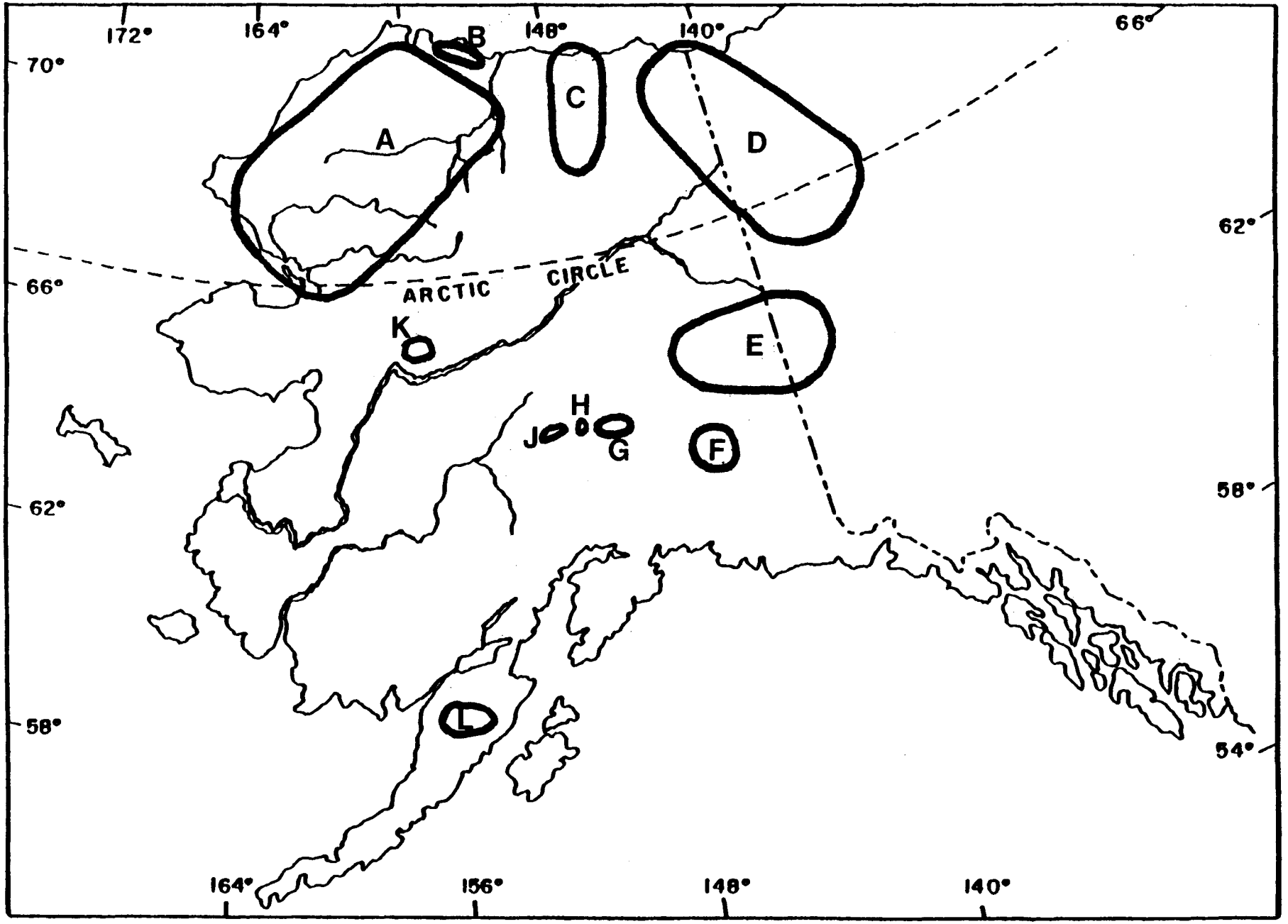
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Table 1. Serum antibody prevalence for 9 infectious agents in bison collected from Delta Junction, Alaska, 1985-87.

Disease	1985	1986	1987
Infectious bovine rhinotracheitis SN 8[c]	Pre[a] 0/6[b]	0/22	0/42
Bovine viral diarrhea SN8	Pre 0/9	2/22	0/42
Parainfluenza III virus HI 8	Pre 29/30	22/22	28/42
Respiratory syncytial virus SN 8	0/1	0/22	0/42
Epizootic hemorrhagic disease ID (±)	0/29	0/22	0/42
Bluetongue virus ID (±)	0/30	0/22	0/41
Q fever CF 20	0/28	0/22	0/38
Brucellosis BAPA (±)	ND[d]	ND	0/37
Leptospirosis MAT 100	0/1	5/22	1/6

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Number positive/number tested.

[c] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[d] ND = not done.

Table 2. Serum antibody prevalence for 9 infectious agents in caribou collected from the Porcupine Herd, 1984-86.

Disease	1984	1985	1986
Infectious bovine rhinotracheitis SN 8[b]	ND[c]	Pre[a] 3/17[d]	2/21
Bovine viral diarrhea SN 8	ND	Pre 2/17	1/21
Parainfluenza III virus HI 8	ND	Pre 2/19	8/21
Respiratory synctial virus SN 8	ND	ND	0/21
Epizootic hemorrhagic disease ID (±)	0/19	0/21	0/23
Bluetongue virus ID (±)	0/19	0/21	0/23
Contagious ecthyma virus CF 5	ND	0/17	0/22
Q fever CF 20	0/19	0/21	0/23
Leptospirosis MAT 100	ND	0/21	ND

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[c] ND = not done.

[d] Number positive/number tested.

Table 3. Serum antibody prevalence for 9 infectious agents in caribou collected from the Central Arctic Herd, 1984-86.

Disease	1984	1985	1986
Infectious bovine rhinotracheitis SN 8[a]	ND[b]	ND	4/29[c]
Bovine viral diarrhea SN 8	ND	ND	2/29
Parainfluenza III virus HI 8	ND	ND	1/28
Respiratory syncytial virus SN 8	ND	ND	0/29
Epizootic hemorrhagic disease ID (±)	0/11	0/7	0/27
Bluetongue virus ID (±)	0/11	0/7	0/30
Contagious ecthyma virus CF 5	ND	ND	1/24
Q fever CF 20	0/11	0/7	0/27
Leptospirosis MAT 100	ND	ND	0/28

[a] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] ND = not done.

[c] Number positive/number tested.

Table 4. Serum antibody prevalence for 9 infectious agents in caribou collected from the Nelchina Herd, 1980-86.

Disease	1980	1981	1985	1986
Infectious bovine rhinotracheitis SN 8[a]	ND[b]	ND	ND	0/63[c]
Bovine viral disease SN 8	ND	ND	ND	0/63
Parainfluenza III virus HI 8	ND	ND	ND	0/61
Respiratory syncytial virus SN 8	ND	ND	ND	0/63
Epizootic hemorrhagic disease ID (±)	0/12	0/2	0/44	0/61
Bluetongue virus ID (±)	0/12	0/2	0/43	0/63
Contagious ecthyma virus CF 5	ND	ND	ND	0/61
Q fever CF 20	0/12	0/2	0/43	0/61
Leptospirosis MAT 100	ND	ND	ND	0/64

[a] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] ND = not done.

[c] Number positive/number tested.

Table 5. Serum antibody prevalence for 9 infectious agents in caribou collected from the Fortymile Herd, 1984-86.

Disease	1984	1985	1986
Infectious bovine rhinotracheitis			
SN 8[b]	ND[c]	Pre[a] 4/6[d]	0/1
Bovine viral diarrhea			
SN 8	ND	Pre 1/6	0/1
Parainfluenza III virus			
HI 8	ND	Pre 5/6	0/1
Respiratory syncytial virus			
SN 8	ND	ND	0/1
Epizootic hemorrhagic disease			
ID (±)	0/11	0/6	0/1
Bluetongue virus			
ID (±)	0/11	0/6	0/1
Contagious ecthyma virus			
CF 5	ND	0/5	0/1
Q fever			
CF 20	0/11	0/5	0/1
Leptospirosis			
MAT 100	ND	ND	0/1

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[c] ND = not done.

[d] Number positive/number tested.

Table 6. Serum antibody prevalence of 7 infectious agents in caribou collected from the Delta Herd, 1984-85.

Disease	1984	1985
Infectious bovine rhinotracheitis		Pre[a]
SN 8[b]	ND[c]	0/14[d]
Bovine viral diarrhea		Pre
SN 8	ND	0/15
Parainfluenza III virus		Pre
HI 8	ND	0/15
Epizootic hemorrhagic disease		
ID (±)	0/25	0/15
Bluetongue virus		
ID (±)	0/27	0/15
Contagious ecthyma virus		
CF 5	ND	1/14
Q fever		
CF 20	0/25	0/15

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[c] ND = not done.

[d] Number positive/number tested.

Table 7. Serum antibody prevalence for 9 infectious agents in caribou collected from 6 herds, 1984-87.

Disease	Yanert Herd 1984	Teshekpuk Herd 1986	Denali Herd 1986	Western Arctic Herd 1986	Galena area herds 1986-87	Alaska Peninsula Herd 1985
Infectious bovine rhinotracheitis						
SN 8[a]	ND[b]	1/16[c]	0/26	1/32	1/8	ND
Bovine viral diarrhea						
SN 8	ND	3/16	0/26	1/32	0/8	ND
Parainfluenza III virus						
HI 8	ND	0/15	0/18	10/33	0/8	ND
Respiratory synyctial virus						
SN 8	ND	0/16	0/26	0/32	0/8	ND
Epizootic hemorrhagic disease						
ID (±)	0/9	0/15	0/22	1/32	0/9	0/6
Bluetongue virus						
ID (±)	0/10	0/15	0/25	0/32	0/9	0/3
Contagious ecthyma virus						
CF 5	ND	0/14	0/15	0/6	0/9	ND
Q fever						
CF 20	0/9	0/15	0/16	0/32	0/9	0/1
Leptospirosis						
MAT 100	ND	0/16	0/27	0/33	0/8	ND

Table 7. Continued.

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[a] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] ND = not done.

[c] Number positive/number tested.

Table 8. Serum antibody prevalence for 10 infectious agents in Dall sheep collected from 6 areas of Alaska, 1984-88.

Disease	Dry Creek 1984	Dry Creek 1985	Dry Creek 1986	Sheep Creek 1984	Sheep Creek 1985	White Mountains 1985	Atigun Gorge 1986	Headwaters Little Delta River 1988	Granite Creek 1988
Infectious bovine rhinotracheitis		Pre[a]			Pre	Pre			
SN 8[b]	0/15[c]	0/30	0/24	0/22	0/23	0/7	0/5	0/10	0/14
Bovine viral diarrhea		Pre			Pre	Pre			
SN 8	0/15	0/30	0/24	0/22	0/22	0/7	0/5	0/5	0/14
Parainfluenza III virus		Pre			Pre	Pre			
HI 8	0/15	1/30	0/24	0/22	0/23	1/7	1/5	0/10	0/14
Epizootic hemorrhagic disease	Pre			Pre					
ID (±)	0/14	0/30	0/24	0/22	0/23	0/7	0/5	0/10	0/14
Bluetongue virus	Pre			Pre					
ID (±)	0/14	0/30	0/24	0/22	0/23	0/7	0/5	0/10	0/14
Respiratory syncytial virus	Pre			Pre					
SN 8	0/14	ND[d]	0/24	0/22	ND	ND	0/5	0/10	0/14
Contagious ecthyma virus									
CF 5	4/15	3/28	4/20	4/23	0/23	0/4	0/5	4/10	2/14
Ovine progressive pneumonia									
ID (±)	0/15	ND	ND	0/22	ND	ND	ND	0/10	0/14

Table 8. Continued.

Disease	Dry Creek 1984	Dry Creek 1985	Dry Creek 1986	Sheep Creek 1984	Sheep Creek 1985	White Mountains 1985	Atigun Gorge 1986	Headwaters Little Delta River 1988	Granite Creek 1988
Q fever									
CF 20	0/14	0/30	0/22	2/19	0/23	0/7	0/5	0/9	0/14
Leptospirosis									
MAT 100	0/15	ND	0/24	0/23	ND	ND	0/5	ND	ND

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indcates that a test is simply read as either positive or negative.

[c] Number positive/number tested.

[d] ND = not done.

Table 9. Serum antibody prevalence for 9 infectious agents in muskoxen collected from 2 areas of Alaska, 1986.

Disease	Seward Peninsula	Nunivak Island
Infectious bovine rhinotracheitis SN 8[a]	0/5[b]	0/7
Bovine viral diarrhea SN 8	1/5	0/7
Parainfluenza III virus HI 8	0/6	0/8
Respiratory syncytial virus SN 8	0/5	0/7
Epizootic hemorrhagic disease ID (±)	0/5	0/8
Bluetongue disease ID (±)	0/6	0/8
Contagious ecthyma virus CF 5	0/4	0/0
Q fever CF 20	0/5	0/6
Leptospirosis MAT 100	0/5	0/6

[a] Name of test: SN - serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] Number positive/number tested.

Table 10. Serum antibody prevalence for 9 infectious agents in moose collected from 5 areas of Alaska, 1985-88.

Disease	Unit 13 1985	Unit 13 1986	Unit 13 1987	Koyukuk River 1985	Koyukuk River 1986	Tok 1986	Tok 1988	Innoko River 1986	Delta Junction 1985
Infectious bovine rhinotracheitis	Pre[a]			Pre					Pre
SN 8[b]	0/4[c]	0/5	0/17	0/3	0/4	0/8	0/37	0/29	0/4
Bovine viral diarrhea	Pre			Pre					Pre
SN 8	2/4	0/5	0/17	1/4	0/4	0/8	0/37	0/29	0/4
Parainfluenza III virus	Pre		Pre						Pre
HI 8	0/4	0/5	0/17	2/4	0/4	0/8	0/37	0/29	0/4
Respiratory syncytial virus									
SN 8	ND	0/5	0/17	ND	0/4	0/8	0/37	0/29	ND
Epizootic hemorrhagic disease									
ID (±)	0/4	1/5	0/17	0/8	0/4	1/8	0/37	0/30	0/4
Bluetongue virus									
ID (±)	0/4	1/5	0/17	0/8	0/4	0/8	10/37	0/30	0/4
Contagious ecthyma virus									
CF 5	1/3	1/3	0/17	0/8	0/4	0/8	1/36	2/29	0/4
Q fever									
CF 20	0/4	0/5	0/17	0/8	0/4	0/8	0/37	0/30	0/4
Leptospirosis									
MAT 100	ND[d]	0/5	2/17	ND	0/4	0/8	0/34	0/30	ND

Table 10. Continued.

[a] Pre = previously reported in Zarnke, R. L. 1987. Serologic survey for microbial pathogens. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 30pp.

[b] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[c] Number positive/number tested.

[d] ND = not done.

Table 11. Serum antibody prevalence for pseudorabies virus in black bears collected from Unit 13, 1980-83.

Disease	1980	1981	1982	1983
Pseudorabies SN[a]	0/28[b]	0/1	0/1	0/18

[a] Name of test. SN = serum neutralization test.

[b] Number positive/number tested.

Table 12. Serum antibody prevalence for 9 infectious agents in Sitka black-tailed deer collected from 2 areas of Alaska, 1984-85.

Disease	Kodiak 1984	Baranof and Chichagof Islands 1985
Infectious bovine rhinotracheitis SN 8[a]	0/2[b]	0/21
Bovine viral diarrhea SN 8	0/2	0/21
Parainfluenza III virus HI 8	0/2	0/21
Epizootic hemorrhagic disease ID (±)	0/2	0/24
Bluetongue virus ID (±)	0/2	0/24
Contagious ecthyma virus CF 5	ND[c]	0/11
Q fever CF 20	1/2	1/8
Brucellosis BAPA (±)	0/2	0/24
Leptospirosis MAT 100	0/2	2/24

[a] Name of test: SN = serum neutralization test; HI = hemagglutination-inhibition test; ID = immunodiffusion test; CF = complement fixation test; BAPA = buffered antigen plate agglutination test; MAT = microscopic agglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] Number positive/number tested.

[c] ND = not done.

Table 13. Serum antibody prevalence for 5 disease agents in grizzly bears collected from 7 areas of Alaska, 1981-86.

Area/Year	Brucellosis BAPA (±)[a]	Brucellosis STT 25	Tularemia TAT 20	Leptospirosis MAT 100	Q fever CF 20	Toxoplasma IHA 64
Kodiak 1981	0/3[b]	ND[c]	0/3	0/3	ND	ND
Kodiak 1984	3/40	2/3	1/40		0/24	ND
Kodiak 1986	ND	ND	ND	4/14	0/15	ND
Arctic National Wildlife Refuge 1984	8/37	5/8	18/37	ND	0/18	ND
Arctic National Wildlife Refuge 1985	9/50	7/9	23/50	0/50	0/43	0/48
Arctic National Wildlife Refuge 1986	ND	ND	ND	ND	1/2	0/2
Driftwood 1984	5/19	4/5	3/19	ND	0/9	ND
Driftwood 1985	9/28	8/9	9/19	2/19	0/20	0/19
Driftwood 1986	ND	ND	ND	1/14	0/15	ND
Alaska Range 1984	2/19	2/2	12/19	ND	0/14	ND
Alaska Range 1985	0/14	ND	7/14	2/11	0/12	0/14
Alaska Range 1986	ND	ND	ND	2/14	0/16	ND
Unit 13 1983	3/29	3/3	7/29	ND	0/25	ND
Unit 20E 1985	0/8	ND	8/8	1/8	0/6	0/8

Table 13. Continued.

Area/Year	Brucellosis BAPA (±)[a]	Brucellosis STT 25	Tularemia TAT 20	Leptospirosis MAT 100	Q fever CF 20	Toxoplasma IHA 64
Becharof 1986	ND	ND	ND	4/16	0/19	ND

[a] Name of test: BAPA = buffered antigen plate agglutination test; STT = standard tube test; TAT = tube agglutination test; MAT = microscopic agglutination test; CF = complement fixation test; IHA = indirect hemagglutination test. Numbers indicate minimum titers necessary to be considered as evidence of previous infection. The (±) indicates that a test is simply read as either positive or negative.

[b] Number positive/number tested.

[c] ND = not done.

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