Communicable Disease Risks to Wildlife From Camelids in British Columbia

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Executive Summary

The goal of this report is to provide government and industry with information upon which to develop evidence-based policies and practices regarding the use of llamas and alpacas in backcountry areas. Several sources of information were used to compile this report, including: (1) a computer-based literature review; (2) a survey of BC camelid owners; (3) a review of diagnostic submissions to the BC Animal Health Centre; and (4) a pathogen survey of BC camelids.

Infection risk management has become a predominant part of wildlife management decisions involving translocations. There is an increased awareness of the role of disease and parasites as population density-dependent and non-density-dependent regulating factors in wild species. There are growing concerns that environmental or animal management practices may influence disease and population dynamics of wild species, leading to unanticipated effects, including effects on endangered species. The introduction of disease into wild populations must be considered with greater concern than for domestic animals simply because there are few viable options for controlling and eradicating introduced diseases in wildlife.

Risks from camelids to wildlife in British Columbia remain hypothetical after this risk assessment, as no direct evidence was found to implicate camelids as sources of significant diseases in wildlife in BC or elsewhere. There is a sound basis in the literature and the basic principles of epidemiology to raise the concern that domestic species in wilderness areas can introduce disease agents that can have important effects on local wildlife populations. This concern is greatest for wildlife populations already dealing with other population stressors at the time of pathogen or parasite exposure. There is insufficient data to accurately forecast the probability of disease transmission or to predict its effects; therefore, uncertainty remains an important determinant of risk in this situation.

The overall risk varies, based on the scenarios in question. On a province-wide basis, the risk is low, but for specific vulnerable wildlife, the risk could be high. The primary determinants of risk are the potential for a high magnitude impact coupled with scientific uncertainties that prevent precise forecasting of the situations that will be highly risky.

Llamas are kept on farms throughout the province, mostly in southern BC. Three-quarters of the surveyed owners used their animals as pets and/or for fibre production. Approximately one-third of the survey respondents used their animals for trekking purposes. Virtually all of the farms had animals born in BC (93%). However, a large number of farms had animals born elsewhere, including outside of North America.

Llamas and alpacas in BC suffer from a wide variety of diseases including infectious and parasitic diseases. A number of these diseases and infectious agents are common to ruminants, both wild and domestic. Systematic surveys of llamas have not been possible; therefore, what we know is based on owner reports and examination of animals submitted to diagnostic laboratories. Llamas in BC can be infected or infested with agents that can cause disease in wild ungulates. However, it is very important to emphasize that many of these agents were present in wildlife before the introduction of camelids to the province and that many of these agents have a wide host distribution involving a variety of artiodactyls.

Llama trekkers reported observations of wildlife on trekking excursions. Trekking has, in a broad sense, been taking place in areas of concern to wildlife managers, but there is insufficient local information to ascertain whether there are sufficient interactions occurring to result in disease transmission. Aspects of wildlife population dynamics, including size of range, population size,

proximity to domestic species and other stressors, will affect the results of exposure to pathogenic organisms. The epidemiology and microbial ecology of many of the agents of concern, coupled with the nature of wildlife interactions suggests that fecal-borne organisms and the respiratory spread *Pasteurella* spp. are of most concern. Even in this case, some of these organisms are ubiquitous in the BC environment, others do not survive long without a host and it is questionable as to whether or not camelids would increase the risk of exposure to a significant level.

There is sufficient basis for concern to advise a precautionary approach to managing disease risks to wildlife from camelids. A variety of simple steps can be undertaken to mitigate these risks. Major areas on which to focus risk management strategies are: (1) prevent vulnerable wildlife and their habitat from making contact with camelids and their wastes; (2) ensure a standard of health care for camelids being used for backcountry trekking purposes; and (3) subject animals recently imported to BC to special consideration. A variety of existing regulations, guidelines and standards of practice can be applied to reduce risks by regulating access to wilderness areas of special concern and to ensure a standard of health for camelids entering backcountry areas.

Background to the Risk Assessment

There is a growing demand to allow access to backcountry areas for private owners and ecotourism companies using llamas.[1] The Canadian Llama and Alpaca Association describes these animals as "excellent pack animals" that have an environmental impact equivalent to large deer, leading government agencies in some jurisdictions, such as the U.S. Parks Service, to prefer the use of llamas in wilderness areas to other species, such as horses. Provincial and federal government agents have already received requests for permits to allow camelid access to British Columbia wilderness areas such as Spatsizi Plateau Wilderness Provincial Park and Naikoon Provincial Park. With increasing ecotourism, demands for camelid access to wilderness areas can be expected to increase, thus increasing the need to develop local, risk-based policies and practices.

The International Union for the Conservation of Nature (IUCN) defines an introduction as "the intentional or accidental dispersal by human agency of a living organism outside its historical native range."[2] The introduction of non-native species in areas where they have not formerly occurred has a long history of resulting in harmful effects on native plants and animals in many parts of the world. To try to reduce damaging effects of introductions, governments develop legal and regulatory mechanisms to restrict the uses, numbers and distribution of introduced animals, while the users of exotic species may employ codes-of-practice to regulate their uses and effects. BC currently lacks regulations to manage disease risks to wildlife that may be associated with the use of South American camelids as backcountry pack animals. **The goal of this report is to provide government and industry with information upon which to develop evidence-based policies and practices.**

There is controversy as to the disease risks that camelids create for BC wildlife. Risk perceptions are affected by three main factors: (1) llamas and alpacas do carry pathogens and parasites that can infect native wildlife; (2) there is significant experience showing that the introduction of exotic animals and their movements throughout a region can effectively spread diseases that can result in significant and essentially uncontrollable ecological effects; and (3) there is a theoretical framework to support concerns that introduced diseases can affect wildlife populations. However, there has not been a documented case in BC of the transfer of disease from camelids to wildlife or vice versa.

The BC Ministry of Water, Land and Air Protection (MWLAP) undertook a preliminary problem analysis in 2001. This analysis identified the lack of information on BC camelids as a significant obstacle to forming evidence-based policy regarding camelid access to BC wilderness areas. This risk assessment builds on the problem analysis by expanding the review of laboratory records, trying to document how camelids are used in BC and generating current data on specific pathogens of interest. The intent of this project is to provide resource managers with an understanding of the nature of disease risks that camelids pose to wildlife and options for managing these risks.

The primary beneficiaries of backcountry use of camelids would be recreational and commercial trekkers and guide-outfitters. The economic value of this industry has not been quantified in this report, nor has it been compared to the social and economic values of accessible wildlife that could be adversely affected by introduced diseases. In addition, ecological effects from camelid

[1] There are four species of South American camelids, namely llamas, alpacas, guanacos and vicunas. They belong to the Order Artiodactyla.

[2] http://www.iucn.org/themes/ssc/pubs/policy/transe.htm

land use practices are not considered in this report, which deals exclusively with communicable disease issues.

Methods

This project sought information on:

1. The infectious and parasitic agents affecting camelids in general and specifically in BC.
    a. Derived from a literature review, survey of camelid owners, review of submissions to a diagnostic laboratory servicing the province and a survey of camelids for selected pathogens and parasites.
2. The types of diseases to which BC's wild ruminants are susceptible.
    a. Derived from a literature review, interviews with the provincial wildlife veterinarian and a review of submissions to a diagnostic laboratory servicing the province.
3. The demographics of camelids in the province, with particular reference to their use in backcountry areas and areas home to vulnerable wildlife, and the nature of interactions they have with wildlife.
    a. Derived from a survey of camelid owners and a review of wildlife maps prepared by the Ministry of Water, Land and Air Protection.
4. Efforts that are undertaken to prevent or mitigate risks of disease transmission.
    a. Derived from a survey of camelid owners.

Owner Mail Survey

A standard questionnaire was mailed to 165 owners of camelids in BC. This questionnaire focussed on information about the numbers and sources of camelids used, their general health history, their use and the nature of interactions their animals have with wildlife (Appendix 1). As no list of all camelid owners in BC was found, a stratified random sample of owners was not possible. We, therefore, tried to generate a survey of owners that was representative of the camelid industry in the province, with an emphasis on backcountry trekkers. We began with the list of the members of the BC Llama and Alpaca Association. This was supplemented with information provided by some trekkers and llama veterinarians about owners that were not members of this association. Efforts were made to ensure we included camelid owners from all parts of the province.

Ninety of the 165 farms responded to the mail survey (response rate = 55%). All respondents provided information on general farm demographics and animal medical history. Response to questions regarding herd health practices varied between 65 and 79 people per question. Only 26 people replied that they used their animals for trekking, and only 13 to 18 of these people completed the questions on trekking. Therefore, this survey cannot be viewed as a complete representation of the llama industry due to incomplete response rate.

Additional information on the BC camelid industry was derived from key word Internet searches.

Veterinary Sampling of Llamas

Respondents to the mail survey were included in a list of eligible participants for site visits by study veterinarians. Trekkers not identified in the process of creating the mailing list for the mail survey supplemented this list. Efforts were made to identify farms in each region of the province (regions were defined as the eight MWLAP regions, plus the Yukon Territory) (Figure 1). Participation was on a voluntary basis. Sampling was restricted to llamas, as they were the animals most often used for backcountry purposes.

All animals on the farm were eligible for sampling if the study veterinarians and owners judged that handling and sampling would do no harm to the animal. In some cases, juveniles and pregnant animals were excluded due to owner concerns. On farms with fewer than 20 llamas, all animals were sampled. On larger farms, a random sample was selected by flipping a coin in order to generate a sample size between 20 and 40. The final sample size in these cases was affected by practical limitations such as animal accessibility, owner cooperation and time.

Blood and feces were collected from each animal. Veterinarians also conducted a cursory physical examination. Serum was sent to the BC Animal Health Centre (AHC) for examination for antibodies to infectious bovine rhinotracheitis, bovine viral diarrhea, respiratory syncytial virus, parainfluenza 3 virus and *Mycobacterium paratuberculosis* (Johne's Disease). Whole blood was sent to the BC Centre for Disease Control for examination for *Ehrlichia* spp. Results of the latter tests are primarily of interest to the public health community and were not available at the time of writing this report. Fecal samples were submitted to the Western College of Veterinary Medicine for parasite evaluation. They were examined for parasite ova by quantitative floatation and Baermann methods. All samples were submitted coded to identify the region from which samples were collected while protecting farm confidentiality.

Diagnostic Record Review

The computer database of the BC Animal Health Centre was reviewed for diagnoses assigned to llama and alpaca submissions to the lab between 1992 and 2000 inclusive. The AHC provided the submission number, region of origin of the submission, species and diagnostic codes assigned. As each animal could have more than one diagnostic code assigned, the number of diagnoses exceeds the number of animals/submissions. These data were searched for infectious or parasitic diseases with special emphasis on a search for specific etiologic agents. Wildlife disease reports were taken from the records of the provincial wildlife veterinarian. The wildlife veterinarian had reports that were generated as part of surveys for specific problems (particularly liver flukes) or were reports of wildlife post-mortem examination. However, since there was no indication on these reports as to the qualification of the people making post-mortem observations or the methods used, we restricted our analysis to those generated by qualified veterinary pathologists at the AHC to allow us to compare results for camelids and wildlife.

Literature Review

A computer-based search of the peer-reviewed literature was conducted on the CAB, Agricola and PubMed databases using the words alpaca, llama, bighorn, caribou/reindeer, elk, mountain goat and disease in different combinations. Abstracts were collected from relevant literature. Standard textbooks on zoo and wildlife medicine (Fowler 1986; Fowler, 1993), as well as a general search of the Internet, were also used to describe the general health problems facing llamas and alpacas. No reports were found for llamas and alpacas in BC using this approach.

Description of the Camelid Industry in BC

Neither the BC Ministry of Agriculture, Fisheries and Food (MAFF) nor the Canadian Food Inspection Agency (CFIA) had up-to-date records of the number or distribution of llamas or alpacas in BC. The MAFF Web site estimated that there are 800 llamas in BC on 150 farms. A Vancouver Island tourism Web site estimated that there are 40 llama farms on Vancouver Island alone, with four in the Greater Victoria area. However, our investigation suggests this is a significant underestimate. We were able to identify 165 farms through links to llama or alpaca associations. An additional number of trekkers were found who were not members of these associations.

Llamas are kept on farms throughout the province. Most of the respondents were located in the southern parts of the province (Figure 1). Three-quarters of the respondents reported that their animals were used as pets. The same fraction reported that they used their animals for fibre production. Eighty percent had their animals for breeding purposes.

The survey results included information on 1014 llamas and 1083 alpacas. The average herd size for llama farms (n = 72) was 14 llamas per farm. The average for alpaca farms (n = 45) was 25 alpacas per farm. The largest llama herd had 80 animals, while the largest alpaca herd had 300 animals. Average herd size varied regionally (Figure 2) and ranged from three to 29 animals per herd.

The camelid birth rate for 2001 was 5.3 newborns per farm per year. The largest number of newborns on one farm was 125. Virtually all of the farms (93%) had animals born in BC. However, a large number of farms also had animals born elsewhere (Prairie provinces = 49% of farms; eastern Canada = 4%; U.S. = 16%; outside North America = 24%). Animals born outside of North America came from Australia, New Zealand, Chile and Peru. The average number of new introductions from off the home farm was three per year (range = 0 to 43 per year). Camelids left their home farm at some time during the year on 44% of farms in 2001. The most common reason was for breeding purposes (49%).

Twenty-six people completed the section on how they use their animals for trekking, indicating that almost one-third of llama farms used their animals for trekking. The Lower Mainland and Southern Interior accounted for 50% of sites reported to be used for trekking. However, trekking also occurred in the Vancouver Island, Skeena, Cariboo, Kootenay, Queen Charlotte and Omineca-Peace regions. One respondent reported trekking in Alberta in 2001. A review of Internet sites on llama trekking revealed that parks are being advertised as trekking locations; these include Alouette Park, Alsek Park, East Sooke Park, Evanoff Provincial Park, Golden Ears Provincial Park, Gowland Tod Park, Kakwa Provincial Park, Manning Provincial Park, Naikoon Provincial Park, Spatsizi Plateau Wilderness Provincial Park, Tatshenshini-Alsek Provincial Park and Todagin Wilderness Management Area.

Figure 1 – Percentage of llamas living in different regions of British Columbia (and in the Yukon) based on survey results.

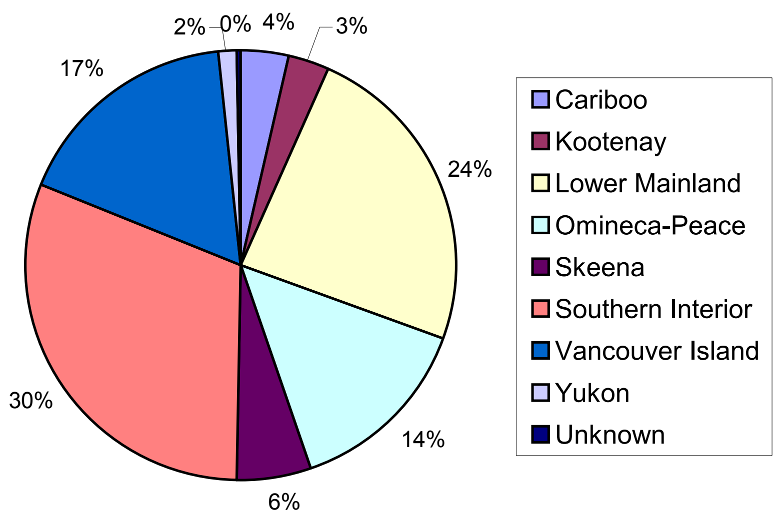
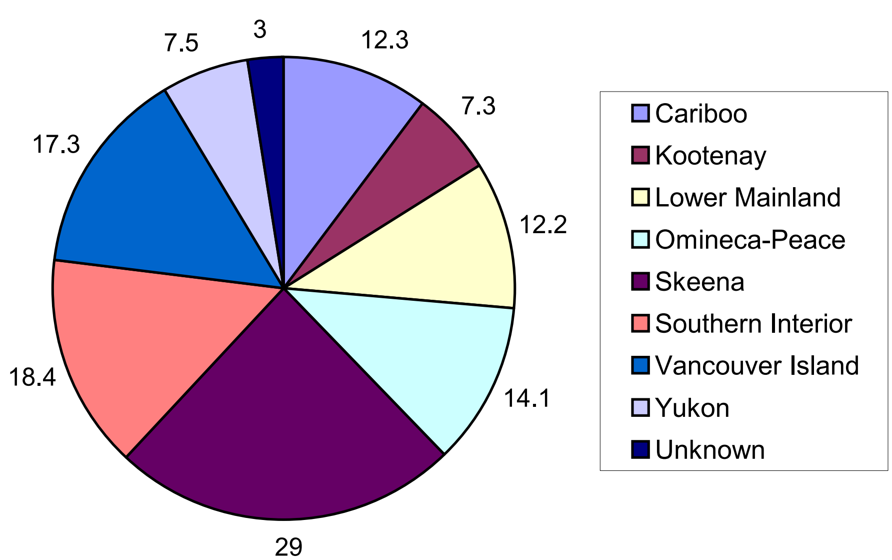


Figure 2 – Average llama herd size in each British Columbia region (and in the Yukon) based on survey results.



Issues Affecting Risk

Question 1: What is the basis for concern about the introduction of disease-causing organisms from camelids to BC wildlife?

Short Answer:
The movement of wildlife or introduction of exotic domestic species has been associated with significant disease outbreaks in wild populations. Infection risk management has become a predominant part of wildlife management decisions involving translocations. There is an increased awareness of the role of disease and parasites as population density-dependent and non-density-dependent regulating factors in wild species. There are growing concerns that environmental or animal management practices may influence disease and population dynamics of wild species, leading to unanticipated effects including negative effects on endangered species. The introduction of disease into wild populations must be considered with greater concern than for domestic animals simply because there are few viable options for controlling and eradicating introduced diseases in wildlife. Uncertainty about the epidemiology of wildlife-domestic animal interactions makes prediction of the health effects of such interactions difficult.

Detailed Answer:
"Translocation of an animal and its potential pathogens, over even a short distance, may threaten the health of indigenous wild species, domestic livestock or humans" (Woodford 2000). All animals, healthy or not, have an inherent fauna of microorganisms in and on them. Some of the microbes can cause disease under appropriate conditions. There are a number of case studies where the translocation of domestic species has negatively affected native wildlife; avian malaria in native Hawaiian birds and bovine tuberculosis in African ungulates serve as dramatic examples. In these and other cases, introduced parasites or pathogens have led to epidemics that dramatically changed the abundance and/or distribution of species in the affected ecosystems. When these epidemics affect keystone species, downhill repercussions can result in community- and ecosystem-level effects (Dobson and Grenfell 1995). Daszak et al. (2001) reviewed a variety of wildlife diseases and concluded that the two key drivers of emergence were: (1) spill-over of pathogens from domestic stock to wildlife; and (2) anthropogenic movement of pathogens into new geographic locations.

There is growing interest in the role of disease in wild animals, primarily for two reasons (Schubert et al. 1998). First, endangered species are, theoretically, of greatest concern when considering introduced diseases. Canine distemper has led to the near-extinction of black-footed ferrets, rabies has been implicated in the decline of African wild dogs, and a variety of parasites have significantly affected Hawaiian avifauna (Schubert et al. 1998). Avian tuberculosis has been a significant constraint to whooping crane reintroduction programs, and paratuberculosis contracted from domestic cattle has complicated Tule elk management.[3] Based upon their review of existing literature, the North Atlantic Salmon Conservation Organization concluded that damage to wild stocks arising from the introduction of exotic diseases could be so severe as to render certain wild salmon stocks extinct (NASCO 1993). Although the relatively small population size of endangered species likely precludes them from maintaining endemic pathogens as a major threat, reduced genetic variability may result in increased susceptibility to diseases acquired from common species (Dobson and Grenfell 1995) and introduced pathogens. Second,

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[3] http://biology.usgs.gov/s+t/noframe/u219.htm#28677
Captive Propagation, Introduction, and Translocation Programs for Wildlife Vertebrates.

there is growing concern that environmental or animal management practices may influence disease dynamics in wild species, leading to unanticipated effects.

In addition to these reasons, there is an increased awareness of the role of disease and parasites as population density- and non-density-dependent regulating factors in wild species. Long-term population studies of red grouse in Scotland have revealed that the host-parasite interaction is the primary cause of long-term cycles in grouse population size through its effect on grouse fecundity (Dobson and Hudson 1994). Just as parasites exploit animal behaviours, such as breeding, foraging and social aggregation, animals modify their behaviours based on their parasite infestation status (Apanius and Schad 1994). Some animals apparently select forages based on the relative risk of exposure to certain parasites or adopt other behaviours, such as migration pathways and group dynamics, to avoid exposure. A variety of animals appear to choose mates based on secondary clues that indicate their parasite load. The latter has been documented for sticklebacks and the ectoparasite *Ichthyophthirius multifiliis* (Apanius and Schad 1994), as well as for songbirds.

Several theoretical models suggest that infectious and parasitic diseases have an important impact on wild populations, but empirical evidence is less available, making it difficult to generalize about the "real-world" effects of disease on wild populations (Gulland 1995). For example, bighorn sheep are very susceptible to pneumonia caused by some biotypes of *Pasteurella haemolytica* from domestic sheep or cattle (Onderka et al. 1988), but predicting the ecological or population-level effects of the disease is more difficult. In some cases, exposure to *Pasteurella* has been associated with significant mortality (Foreyt and Jessup 1982; Spraker et al. 1984), while in other cases, no population effects were observed in exposed bighorn populations (Foreyt 1996; Ward et al. 1997). Such contradictions and uncertainty arise from a few factors. First, ecological and epidemiological models have historically focussed on one- or two-species systems. Few models account for multispecies effects or the role of spatial heterogeneity and immunity in the course of epidemics through wild populations. Simplistic models, though likely approximations of the "truth," fail to consider interactions between multiple pathogens or parasites within the same host and population, or the effects of host dynamics that are determined by competitive or predatory relationships. Including extra factors in theoretical models leads to an increased diversity of outcomes (Begon and Bowers 1995), making prediction more difficult.

Second, wildlife disease reports have, historically, focussed on mortality events. Recent evidence has shown that diseases can affect a range of wildlife ecological variables. For example, L'Heureux et al. (1996), found no mortality effect of contagious ecthyma on bighorn sheep, but did observe that severely affected lambs were lighter and gained less weight than unaffected lambs. Similarly, field experiments demonstrated an effect of gastrointestinal parasites on feed intake and weight gains in semi-wild reindeer, implying that parasite-induced changes in herbivore food intake are not restricted to agricultural systems, and that parasites may have effects on the dynamics of a wide range of herbivore plant communities (Arneberg et al. 1996; Arneberg and Folstad 1999). Other effects of disease on wildlife include reductions in fecundity, increased susceptibility to predation, developmental changes, effects on social hierarchies and increased susceptibility to the effects of habitat change and pollution (e.g., Safriel 1982; Spalding et al. 1993; Loye and Carroll 1995; Morbey 1996; Khan et al. 1997).

Third, historical reports of wildlife disease have focussed largely on the pathological presentation of individual cases and reports of mass mortality, rather than examining the role of confounding factors on the manifestation of host-disease interactions. A number of variables, including stressors (such as habitat change, inclement weather, increased human traffic and interactions with domestic species) (Foreyt and Jessup 1982; Spraker et al. 1984) and topographical features

(Bender and Hall 1996) have been implicated as important variables affecting the manifestation of disease in wild sheep and elk. One of the variables that will have a major impact on the outcome of wildlife exposed to a pathogen or parasite originating from a domestic species is the pre-existing level of individual and population immunity (Lloyd 1995).

The introduction of a foreign animal disease or parasite to an ecosystem is another matter completely and should be prevented at all costs (Bengis 2002). Difficulties in containing foreign animal diseases that are introduced into wild populations amplify the economic consequences of wildlife entering domestic animal disease cycles. For example, Parks Canada took the extraordinary measure of removing all domestic stocks housed at national parks and historic sites in 2001 to reduce the risk of transmission of foot and mouth disease to wildlife, partly because of such a concern.[4] The potential for introducing foreign animal diseases exists in the BC camelid industry, as a significant proportion of farmers responding to our survey had animals born elsewhere (Prairie provinces, eastern Canada, U.S., Australia, New Zealand, Chile and Peru). It is assumed that each of the animals born outside of North America was subject to regulations and inspection regarding the introduction of animals into Canada from foreign countries. However, camelids have been implicated as sources of foreign animal diseases, such as in a recent outbreak of vesicular stomatitis in the United States (Schmidtmann et al. 1999) despite import regulations being in place**.** Moreover, the recent spread of chronic wasting disease within western Canada in farmed elk herds reveals that regulations affecting the movements of animals and their pathogens within Canada are not sufficient to prevent the movement of disease across ecological, as opposed to political, boundaries. There are significant diseases that can cross ecological boundaries in Canada, as well as elsewhere.

The introduction of disease into wild populations must be considered with greater concern than for domestic animals, simply because there are few viable options for controlling and eradicating introduced diseases in wildlife. In large populations living over large areas, it becomes impractical to deliver effective doses of drugs or vaccines. Efforts to do so can be prohibitively expensive. Neither are there useful drugs or vaccines that are efficacious for most wild species and diseases. There are few examples of effective disease management in wildlife. Aerial dropping of rabies vaccines for fox populations in Europe and Ontario may be one example. Due to problems in treating introduced diseases, managing contact between host species in hope of avoiding unexpected or undesired exchange of pathogens can offer a promising alternative to post-hoc disease control (Woodroffe 1999).

Despite a strong theoretical underpinning, there are very few field-based studies that conclusively evaluate the role of disease in wild animal populations. Specific to this risk assessment, there is little known about the epidemiology of domestic animal-wildlife interactions so as to allow predictions of the effects of management decisions. Difficulties in collecting many of the key variables needed to understand transmission dynamics and disease-induced population regulation in wild populations make conclusions regarding the effects of pathogens or parasites introduced to wild animals speculative in many cases. Despite these uncertainties, the BC Ministry of Water, Land and Air Protection Web site lists disease transfer from llamas as a threat to California bighorn sheep populations.

[4] http://www.pc.gc.ca/pn-np/ab/elkisland/ne/ne2_E.asp

Question 2: What do we know about the diseases of llamas in BC?

Short Answer:
Llamas and alpacas in BC suffer from a wide variety of diseases including infectious and parasitic diseases. A number of these diseases and infectious agents are common to ruminants, both wild and domestic. Systematic surveys of llamas have not been possible; therefore, what we know is based on owner reports and examination of animals submitted to diagnostic laboratories. The parasite fauna of llamas tends to be similar to that of cattle and sheep, apart from the parasites that are imported with animals coming from foreign countries.[5]

Detailed Answer:
A total of 114 alpaca and 114 llama submissions were examined at the BC Animal Health Centre between 1993 and 2000. These submissions were characterized using 115 diagnostic categories, resulting in the assignment of 407 diagnoses (206 = alpaca; 201 = llama). The top 10 diagnostic categories were:

- starvation/emaciation/serous atrophy of fat (n = 38, 9%);
- idiopathic abortion (n = 35, 9%);
- gastric ulcer (n = 18, 4%);
- cardiomyopathy (n = 18, 4%);
- hepatitis (n = 11, 3%);
- bronchopneumonia (n = 11, 3%);
- peritonitis (n = 11, 3%);
- parasitic enteritis (n = 9, 2%);
- myopathy (n = 8, 2%); and
- myocarditis (n = 8, 2%).

The majority of llama submissions to the AHC came from the Lower Mainland, while most alpaca cases originated in the Okanagan (Figure 3). Submissions came from all regions serviced by the AHC, except the Yukon. There was only one submission from the Kootenays. Submissions arrived in all months, with a winter peak. A peak in diagnoses that were reflective of infectious or parasitic diseases mirrored the winter peak in submissions (Figure 4).

[5] http://www.usaha.org/reports98/r98idcbl.html.
1998 report of the Committee on Infectious Diseases of Cattle, Bison and Llamas. US Animal Health Association.

Figure 3 – Regional pattern of origin of diagnostic submissions sent to the Animal Health Centre (1993-2000).

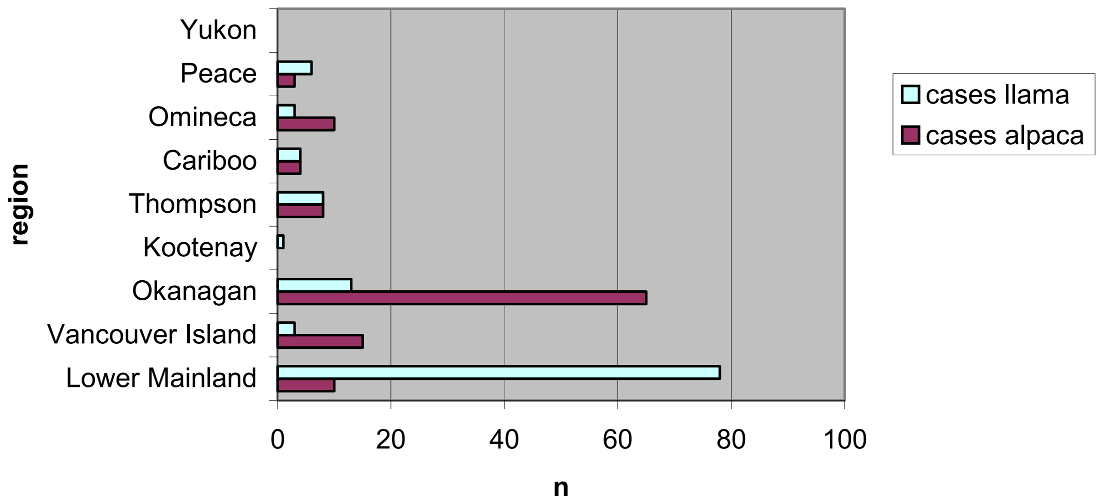
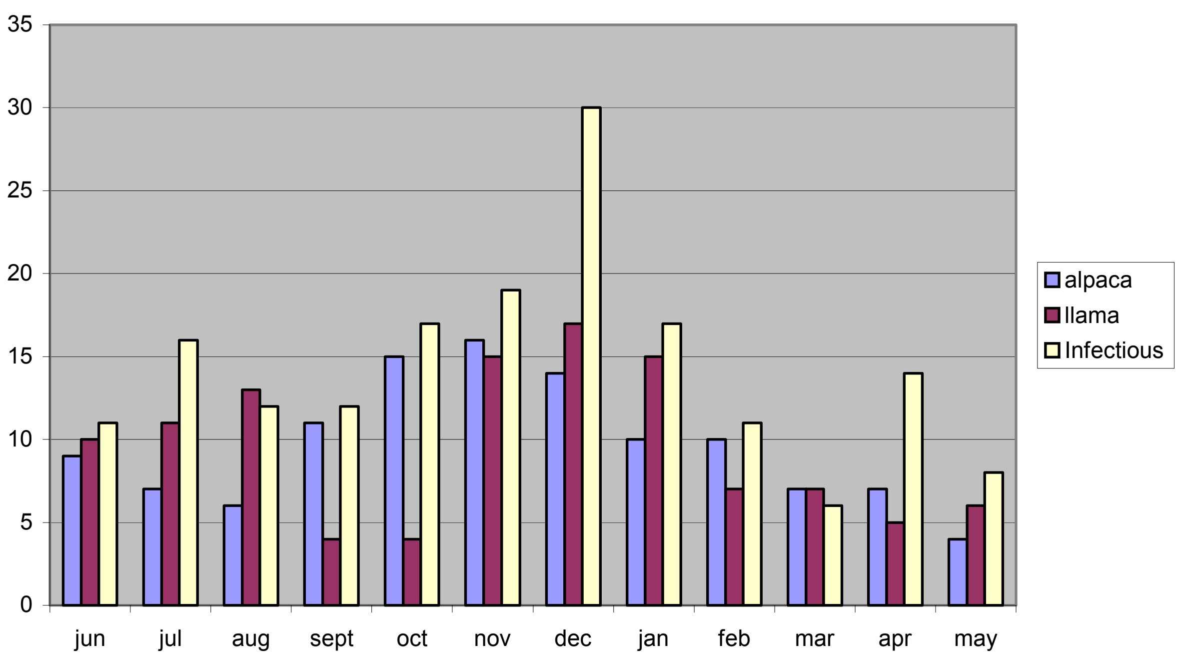


Figure 4 – Seasonal distribution of total llama and alpaca submissions and diagnostic categories that could indicate infectious/parasitic diseases: BC Animal Health Centre (1993-2000).



There was no single diagnostic infectious/parasitic disease category that accounted for this peak. Caution must be taken when interpreting these patterns, as data from the AHC is unlikely to reflect the distribution of camelids or the true prevalence of their diseases because laboratory data tend to reflect factors other than prevalence, such as distance to lab, owner and veterinarian willingness and capacity to submit samples, nature and novelty of the disease problem and familiarity of the veterinarian with the diseases detected.

Gastrointestinal tract disorders accounted for the largest number of diagnoses that could be attributed to infectious or parasitic agents, followed by respiratory tract infections. There was no etiological agent assigned to many of these cases, making it difficult to evaluate their potential for transmission to other hosts (Table 1).

Table 2 presents AHC data that specified etiologic agents. Some of these agents were identified in the literature review and many are known to affect wild cervids and bovids. The route of transmission of some of these agents would allow for spread from camelids to other species. Of particular interest would be those passed by the fecal-oral route, as this route does not require animals to be in direct contact. Other agents, such as *Leptospira* sp. and coronavirus, also do not need direct contact, but they have limited environmental survival, thus reducing the chance for transmission to wildlife hosts. A number of the organisms isolated from camelids at the AHC can be considered opportunistic pathogens that are normal residents of the host or are acquired from environmental sources. None of the organisms isolated from camelids in BC were unique to llamas or alpacas. No foreign animal disease agents were described.

The AHC records likely underestimated the number and variety of pathogens in the reproductive tracts of llamas and alpacas. Idiopathic abortions were second only to emaciation/starvation as the most common diagnosis assigned to llama/alpaca submissions to the AHC. Johnson (1993) reported that abortions are a common problem for South American camelids, but no recognized infectious entity has been described to account for contagious embryonic loss. A variety of organisms that could lead to abortion have been commonly cultured from the uterus, including: streptococci, staphylococci, coliform species, clostridial species, *Actinobacillus pyogenes* and *Bacteroides* sp. Agents that are suspected but not proven to cause abortion in South American camelids are *Leptospira* sp., *Toxoplasma gondii*, *Escherichia coli*, *Chlamydia* sp., *Brucella* sp., *Salmonella* sp., *Listeria* sp., bluetongue virus, infectious bovine rhinotracheitis virus, bovine viral diarrhea virus and equine herpes 1 (Johnson 1993).

South American camelids are exotic to BC. Originally, all animals were derived from sources outside of Canada. An increasing number are bred and reared in BC due to the growth of breeding farms. The Canadian Food Inspection Agency requires alpacas and llamas imported into Canada to test negative for brucellosis, bovine tuberculosis and bluetongue virus. In addition, they must originate from facilities that have no zoosanitary restrictions or quarantines for any reason and must be accompanied by a USDA health certificate when coming from the United States.

Common alpaca and llama diseases/conditions reported on an eastern U.S. Web site included esophageal choke, tooth root abscess, skin problems (mange, zinc responsive disorders, solar dermatitis), heat stress, meningeal worm infection, gastrointestinal ulcers and gastrointestinal parasites (tapeworm, liver flukes, coccidia).[6]

[6] http://www.purdyvet.com/diseases.html

Table 1 – Infectious and parasitic disease categories* found in diagnostic records for llamas and alpacas provided by the BC Animal Health Centre (1992-2000).

GASTROINTESTINAL (42)	Peritonitis (10)	Salmonellosis (2)
	Parasitic enteritis (10)	Parasitic hepatitis (2)
	Coccidiosis (8)	Ostertagiasis (1)
	Bacterial enteritis (4)	Tyzzer's disease (1)
	Gastrointestinal parasites (3)	Viral enteritis (1)
RESPIRATORY (14)	Bronchopneumonia (11)	Interstitial pneumonia (1)
	Mycotic pneumonia (1)	Granulomatous pneumonia (1)
CENTRAL NERVOUS (9)	Meningitis (8)	Bacterial encephalitis (1)
REPRODUCTIVE (5)	Bacterial abortion (2)	Metritis (1)
	Abortion - Leptospirosis (2)	
OTHER (25)	Septicemia (7)	Bacterial pericarditis (1)
	Abscess (7)	Omphalitis (1)
	Lymphadenitis (4)	Sarcocystis (1)
	Bacterial osteomyelitis (2)	Pediculosis (1)
	Endocarditis (1)	

*Categories that represented inflammation but not necessarily infection, such as hepatitis, were not included.

Survey respondents reported an average annual camelid death rate of 1.8%. Of all reported deaths (n = 39), 56% were animals less than one year old and 44% involved animals greater than one year old. The primary causes of death reported were neonatal failure to thrive or stillbirths (26%), injury (18%), ulcers (presumably gastrointestinal) (15%), tumours (11%) and infection (11%). Other causes included old age, plant toxicity and culling. However, only 65% of all deaths were diagnosed by a veterinarian.

Table 2 – Specific disease-causing agents identified in llama and alpaca submissions to the BC Animal Health Centre (1992-2000).

	Agent	**Mode of transmission**
Bacteria	*Actinobacillus capsulates*	Commensal of mucous membranes. Enters via trauma.
	*Actinomyces pyogenes**	Environmental. Enters via wounds.
	Bacillus piliformis	Environmental spore, plus carried in GI tract.
	Clostridium perfringens type D	Soil contamination of wounds or GI commensal.
	Clostridium sordelli	As for *Clostridium perfringens*.
	Corynebacterium sp.*	Opportunist. Enters wounds.
	*Escherichia. coli **	Fecal-oral.
	Fusobacterium sp.*	Environmental.
	Hemophilus sp.	Respiratory, STD, respiratory commensal.
	*Leptospira * icterohemmorhagica **	Urine-mucous membrane.
	*Listeria monocytogenes * and innocua*	Environmental.
	*Pasteurella hemolytica **	Respiratory, respiratory commensal.
	Salmonella sp.*	Fecal-oral.
	Streptococcus sp. *	Skin, mucous membranes and GI tract resident.
	Streptococci – Alpha-haemolytic	As *Streptococcus* sp.
	Streptococci – Beta-haemolytic	As *Streptococcus* sp.
	Streptococcus equi subsp. *zooepidemicus*	Commensal of skin and mucous membranes.
	Yersinia pseudotuberculosis	Fecal-oral.
Viral	Bovine coronavirus *	Fecal-oral.
	Herpes virus *(Bovine)	Respiratory/contact.
Fungal	*Absidia corynebifora*	Environmental sources.
	Aspergillus sp.*	Environmental sources.
Parasitic	*Ostertagia s*p. *	Fecal-oral.
	Coccidia sp.*	Fecal-oral.
	Sarcocystis sp.*	Predator-prey cycle. Fecal-oral for ruminants.
	*Lice**	Direct contact.
	*Strongylidae sp.**	Fecal-oral.
	Trichuris sp.*	Fecal-oral.
	Eimeria sp. *	Fecal-oral.

* Found in some of elk, Dall's sheep, bighorn sheep or caribou in the international literature. Although the genus of parasites or pathogens found were the same in camelids and wildlife, differences at the species level occurred in some cases.

Table 3 – Owner-reported causes of illness in camelids in BC based on study survey results.

Category	Adults number (%)	Juveniles number (%)
Jaw/tooth abscess	4 (16%)	0
Cancer	4 (16%)	0
Ulcers	3 (12%)	1 (14%)
Dental problems	2 (8%)	0
Unknown	2 (8%)	1 (14%)
Diarrhea	1 (4%)	2 (29%)
Failure to thrive	1 (4%)	1 (14%)
Injury	1 (4%)	0
Kidney failure	1 (4%)	0
Plant toxicity	1 (4%)	0
Skin problems	1 (4%)	0
Urinary tract infection	1 (4%)	0
Vaginal infection	1 (4%)	0
Abscess	0	1 (14%)
Kidney stone	0	1 (14%)

Question 3: Is it reasonable to believe that camelids in BC could harbour contagious disease agents to which BC wildlife could be susceptible?

Short Answer:
Three lines of evidence indicate that there is a significant overlap of disease-causing agents in wild ungulates and camelids in BC. First, a literature review revealed an overlap of pathogens and parasites affecting both groups of animals. Second, the diagnostic records from the Animal Health Centre allowed us to conclude that this overlap does exist for BC. Finally, the fecal and sero-survey results demonstrate that an overlap continues to exist in the province. These data also showed that these infectious agents have been associated with disease in wild ungulates. We can, therefore, confidently conclude that llamas in BC can be infected or infested with agents that can cause disease in wild ungulates in BC. However, it is very important to emphasize that many of these agents were present in wildlife before the introduction of camelids into the province, many of these agents have a wide host distribution involving a variety of artiodactyls and no direct evidence of transmission from camelids to wildlife was found.

Detailed Answer:
A review of the literature demonstrated the variety of organisms to which llamas and alpacas are susceptible and established an overlap between some diseases of camelids and selected wildlife (Tables 4–7). It can be assumed that this list is an underestimate of the number of pathogens and parasites that could be shared between South American camelids and native BC artiodactyls, as it is believed that there is ready exchange of many disease-causing organisms between members within this order (Fowler 1986). Certainly, experience in other systems has demonstrated that wild artiodactyls share parasites and pathogens with their domestic relatives (e.g., Callan et al. 1991; Singer et al. 1997). South American camelids are susceptible to most of the infectious and parasitic agents affecting domestic ruminants. Johnson (1993), for example, concluded that the "list of infectious agents causing abortion (in llamas) might include all those known to infect common domestic species, and perhaps all may eventually be incriminated."

Tables 4 to 7 illustrate the international experience in shared pathogens between species of concern (see Appendix 2 for the complete list of literature used to generate these tables).

Local variations in animal sources, susceptibilities and interactions may prevent generalization of the international experience to the BC situation. Therefore, we sought evidence of the nature of agents affecting wildlife and camelids in the province. A total of 172 records of wildlife submissions from 1973 to 2001 were available from the AHC (Table 8). Almost three-quarters of these (127) were submitted in the past decade.

Table 4 – Pathogens, parasites or infectious diseases of llamas, alpacas and selected wild ungulates derived from a literature review: viral pathogens.

VIRUS	Llama	Alpaca	Wildlife
Adenovirus	x		
Bluetongue virus	x	x	BHS, CE
Border disease virus		Sero +ve (Peru)	
Bovine adenovirus	Sero +ve (Argentina)		
Bovine enterovirus	Sero +ve (Argentina)		
Bovine herpes-1	x	Sero +ve (Peru)	CA (sero), CA2 (BHV-like virus), CE
Bovine rotavirus	Sero +ve (Argentina)		
Bovine respiratory syncytial virus	Sero +ve (Argentina)	Sero +ve (Peru)	BHS
Bovine viral diarrhea virus	Sero +ve (Argentina)		CA, CE, EK (experimental)
Contagious ecthyma virus		Sero +ve (Peru)	CA, DS, CE
Coronavirus	x		
Equine herpesvirus-1	Experimental	x	
Foot and mouth virus	x	Sero +ve (Peru)	CE
Influenza A virus		Sero +ve (Peru)	
Parainfluenza-3		Sero +ve (Peru)	BHS, CE
Rotavirus		Sero +ve (Peru)	
Rabies virus	x	x	CE
Retrovirus	Suspected		
Vesicular stomatitis virus	x	Sero +ve (Peru)	CE

CA = caribou; CA2 = reindeer; BHS = bighorn sheep; DS = Dall's sheep; EK = elk; CE = cervids.
Notes: These data cannot be used to specify diseases present in British Columbia, as few reports originated in the province.
Boxes marked with an x indicate reports that have isolated the organism or have associated it with clinical disease.
Sero +ve means that animals had antibodies to the organisms indicated.

Table 5 – Pathogens, parasites or infectious diseases of llamas, alpacas and selected wild ungulates derived from a literature review: bacterial pathogens.

BACTERIA	Llama	Alpaca	Wildlife
Actinobacillus sp. *	x		
Actinomyces sp. *	x		EK, CE, BHS
Bacillus anthracis	x	x	CE
Brucella abortus	experimental		EK, CE, CA (*B. suis*)
Burkholderia pseudomallei		x	
Clostridia sp. *	x		EK, CE
Corynebacterium pyogenes	x	x	CE
Enterococcus sp.	x		
Escherhicia coli *	x	x	CA, CE
Fusobacterium necrophorum	x	x	CE
Klebsiella pneumoniae	x		BHS
Leptospira sp. *	x (*L. grypptotyphosa*)		EK (*L. interrogans*), CE
Listeria monocytogenes	x		CA2, CE
Morexella lacunata	x	x	
Mycobacterium bovis	x		EK, CE
Mycobacterium paratuberculosis	x	x	EK, CE, BHS
Nocardiosis sp.	x		
Pasteurella spp.	x		
Rhodococcus equi	x	x	BHS, CE
Salmonella sp. *	*x* (*S. choleraesuis*)		CE
Streptococcus zooepidemicus	x	x	BHS (*S. spp.*)

CA = caribou; CA2 = reindeer; BHS = bighorn sheep; DS = Dall's sheep; EK = elk; CE = cervids.
Notes: These data cannot be used to specify diseases present in British Columbia, as few reports originated in the province.
Agents also identified in the BC Animal Health Centre data are marked by *.
Boxes marked with an x indicate reports that have isolated the organism or have associated it with clinical disease.
Sero +ve means that animals had antibodies to the organisms indicated.

Table 6 – Pathogens, parasites or infectious diseases of llamas, alpacas and selected wild ungulates derived from a literature review: fungal pathogens.

FUNGUS	Llama	Alpaca	Wildlife
Aspergillus spp.		x	
Blastocystis sp.	x		
Coccidiomycosis sp.	x (*C. imitis*)		
Condiobolus coronatus	x		
Cryptococcus sp.		x	
Entomophthoramycosis conidobolae	x		
Histoplasma sp.	x		
OTHER			
Ehrlichia sp.	x		EK

CA = caribou; CA2 = reindeer; BHS = bighorn sheep; DS = Dall's sheep; EK = elk; CE = cervids.
Notes: These data cannot be used to specify diseases present in British Columbia, as few reports originated in the province.
Boxes marked with an x indicate reports that have isolated the organism or have associated it with clinical disease.

Table 7 – Pathogens, parasites or infectious diseases of llamas, alpacas and selected wild ungulates derived from a literature review: parasites.

PARASITES	Llama	Alpaca	Wildlife
Bunostomum sp.	x	x	
Camelostrongylus mentulatus	x		
Capillaria sp.	x		
Cepenemyia sp.	x		
Chorioptes sp.	x	x	
Coccidiosis sp. *	x	x	
Cooperia sp.	x		
Cryptosporidia sp.		x	
Damalinia breviceps	x	x	
Dictyocaulus viviparus	x	x	EK, CA, CE
Graphinema aucheniae	x	x	
Haemonchus sp.	x		
Echinococcus granulosus	x	x	
Eimeria spp.	*E. alpacae*, *E. punoensis*, *E. lamae*, *E. macusaniensis*		DS (*E. dalli*)
Eperythrozoon-like parasite	x		
Fasciola hepatica	x	x	EK (*F. magna*)
Giardia sp.	x		
Haemonchus contortus	x	x	
Lamenema chaveze	x	x	
Microthororacius mazzai (sucking louse)	x	x	
Nematodirus battus	x		
Oesophagostomum	x	x	
Ostertagia sp. *	x		CA2, CE
Phthiraptera spp. (lice)		x	
Parelaphostrongylus tenuis	x		EK, CE
Psoroptes sp.	x		DS, EK, BHS
Sarcoptes scabei	x	x	CA2,
Sarcocystis sp. *		x	CA, EK
Spiculopteragia peruvians	x	x	
Strongyloides sp.	x		
Teladorsagia sp.	x		
Thelazia sp.	x	x	CE
Thysaniezia giardi	x	x	
Trichostrongyles	x		CA2
Trichuris sp.	x (*T. tenuis*)		
Toxoplasma gondii	Sero +ve	Sero +ve	CA, DS, BHS

CA = caribou; CA2 = reindeer; BHS = bighorn sheep; DS= Dall's sheep; EK = elk; CE = cervids.
Notes: These data cannot be used to specify diseases present in British Columbia, as few reports originated in the province.
Agents also identified in the BC Animal Health Centre data are marked by *.
Boxes marked with an x indicate reports that have isolated the organism or have associated it with clinical disease.
Sero +ve means that animals had antibodies to the organisms indicated.

Table 8 – Etiologic agents identified from wild ungulate samples submitted to the BC Animal Health Centre (1973-2001).

Agents		Bighorn Sheep	Deer	Elk	Caribou	Moose	Mountain Goat
Parasites	*Coccidia sp.*	11					
	GI helminths	6	1		1		
	Cephenemya sp.		1				
	Capillaria sp.	1	1				
	Moniezia sp.	1	1		2		
	Nematodirus sp.	6	1				
	Oesophogostomum sp.		1				
	Strongyles	3					
	Stomach worm	1					
	Tricholiperussp.		1				
	Trichostrongyles		1				
	Trichuris sp.	8	2				
	Whipworm	3					
	Taenia sp.		1	1			
	Liver fluke	1		2			
	Fascioloides magna		2				
	Echinococcus granulosus		1			2	1
	Cysticercus tarandi					1	
	Lungworm	6	1				
	Dictylocaulus viviparous	1	2				
	Protostrongylus sp.	17					
	Sarcocystis sp.	1	1		3	2	
	Onchocerca cervipedis					1	
	Dorsal spined larvae		1		1		
	Parelasphostrongylus sp.		1				
	Lice		2				
	Nasal bots		1				
	Otobius megnini	1					
Bacteria	*Actinomyces pyogenes*	12					
	Aeromonas sp. (hemolytic)	1					
	Arcanobacterium pyogenes	1					
	Bacillus sp.		1				
	Clostridium perfringens	1				1	
	Coliforms	2	2				
	Corynebacterium pseudotuberculosis	1	5				
	Corynebacterium pyogenes	1					
	Corynebacterium sp.		1				
	Corynebacterium ulcernas	1					
	Escherischia coli	10	5				
	Leptospira grippotyphosa	1					
	Leptospira pomona	1					
	Pasteurella hemolytica	1					
	Pasteurella multocida	12	3				
	Pasteurella trehalosi	3					
	Proteus sp.		1				
	Pseudomonas aeruginosa	4					
	Staphylococcus albus (non-hemolytic)	3	3				
	Staphylococcus aureus (hemolytic)	1	1			1	

Agents		Bighorn Sheep	Deer	Elk	Caribou	Moose	Mountain Goat
	Streptococcus (alpha hemolytic)	6					
	Streptococcus sp. (Group B)		1				
Mycoplasma (PCR)		7					
Viral (PCR or serology)	Bovine respiratory syncytial virus (BRSV)	1					
	Ovine RSV	4					
	Parainfluenza 3	3					
	Deer papovavirus		1				
	Sheep parapox virus	1					
	Malignant catarrhal fever virus	2					

Our third set of data came from our prospective survey. A total of 175 serum samples were examined for antibodies toward *Mycobacteria paratuberculosis* (Johne's disease), bovine viral diarrhea, bovine respiratory syncytial disease, bovine herpesvirus-1 (infectious bovine rhinotracheitis) and parainfluenza 3. Results were:

- 13% (n = 23) positive antibody response to parainfluenza 3;
- 10% (n = 17) positive antibody response to *M. paratuberculosis*;
- 6% (n = 10) positive antibody response to bovine viral diarrhea virus;
- 5% (n = 9) positive antibody response to bovine herpesvirus-1; and
- 0 positive antibody response to bovine respiratory syncytial virus.

The presence of a positive antibody titre does not mean that the animals were infected, but instead reveals evidence of exposure to the agent or a cross-reacting agent. As there are no data to calculate the predictive value and false positive/negative rates for the tests used on llamas, caution must be exercised when extrapolating these data to gauge prevalence information. For this study, these results can simply be used to infer that BC camelids are exposed to the agents tested for.

Fecal samples were collected from 154 animals from Vancouver Island (26), Prince George (17), the Fraser Valley (15), the Skeena region (17) and the Okanagan (79). Three cases had insufficient material for Baermann examination. Previous freezing of the samples prevented examination for lungworm in these samples. No protostrongylid larvae or eggs of *Marshallagia* sp. or pinworm were observed. The results were:

- 62% (n = 96) animals revealed at least one parasite species.
- 38% of positive animals (36 of 96) had more than one parasite noted.
- The most common parasites were nematodes (42%), followed by *Trichuris* sp. (27%), *Capillaria* sp. (15%), *Trichostrongylus* sp. (7%) and *Eimeria* sp. (5%).

Paired samples were submitted from 26 animals. These samples were collected on the same day from the same animals. Diagnosticians were not aware that these were paired samples. Test results on the types of parasites present disagreed in 58% (15) of the pairs. Seven of these 15 resulted in one set of tests not finding any parasites, while the second test found at least one type. The diagnostic agreement between the tests was moderate (kappa statistic = 0.36 for presence of at least one parasite; kappa = 0.41 for helminths). These results suggest that relying on a single fecal sample to classify the infestation status of a single animal is not reliable.

Table 9 summarizes the percent positive on a site basis for the results of our prospective study. The results demonstrate, as expected, that parasites are common and prevalent. Data (not shown) are also consistent with known parasite dynamics (heterogeneous distribution of parasites in host populations), in that most animals had a smaller number of parasites and only one animal had a higher number. It also demonstrates how various pathogens tend to cluster by farm. Rather than all farms having a low level, most farms were negative for the viruses and bacteria tested for, with a few being positive. This suggests that farms with high prevalence of a pathogen were more likely to be positive for more than one agent. This could be due to a number of reasons including: (1) these farms had a lesser level of biosecurity or husbandry so that transmission of infectious agents was more likely; (2) the herds were older on average, thus having a greater lifetime exposure probability; (3) the herds were made up of additions from a wider variety of sources; or (4) the apparent pattern is an artefact of the sample size and strategy.

Table 9 – Percentage of samples positive for pathogens and parasites prospectively sampled in BC camelids.

Site	Johne's	PI3	BRSV	BVD	IBR	Any parasite	Most common parasite
1	0	0	0	0	0	NT	NT
2	0	0	0	0	0	NT	NT
3	0	6%	0	0	0	75%	67%(Nm)
4	7%	0	0	0	0	67%	67%(Nm)
5	0	0	0	11%	0	20%	2%(Nm)
6	33%	0	0	0	0	NT	NT
7	16%	0	0	0	0	88%	58%(Nm)
8	12%	4%	0	0	0	66%	41%(Nm)
9	20%	0	0	4%	36%	87%	53%(Tr)
10	4%	48%	0	7%	0	48%	28%(Tr)
11	14%	43%	0	22%	0	45%	45%(Nm)
12	NT	NT	NT	NT	NT	65%	91%(Nm)
Mean	10%	9%	0	4%	3%	62%	

NT= not tested; Nm = Nematodes; Tr = Trichuris.

During the course of this study, we received anecdotal reports from the Canadian Food Inspection Agency that a BC herd of llamas had tested positive for *Brucella* sp. Unfortunately, the tests used to confirm *Brucella* infections have not been validated in llamas. These were assumed to be false positive reactions. A 2000 report of the US Animal Health Association stated that *Brucella abortus* has never been reported naturally in South American camelids anywhere in the world, but noted that validation of the test is needed.[7] This same report claimed that there has not been a definitive diagnosis of bluetongue virus or epizootic hemorrhagic disease virus in South American camelids either, but that there have been positive serological diagnostic test results for these agents from clinically normal animals. The report also noted the one llama in New Mexico from which vesicular stomatitis virus has been isolated, in 1997.

A review of diagnostic records of the Canadian Cooperative Wildlife Health Centre yielded only 59 records for ungulates from BC. Of these, only 18 were wildlife; the rest were from game farms, zoos or other captive situations. No additional pathogens were identified in this review apart from the report of *Yersinia enterocolitica* associated with captive caribou suspected of drowning.

[7] http://www.usaha.org/speeches/speechoo/soofrost.html

Wildlife submissions to the AHC were generally of three types: (1) hunters submitting carcass samples to determine if the animal was safe to eat; (2) samples from die-offs; and (3) samples from wildlife rehabilitation facilities. Survey respondents reported that 75% of adult camelid illnesses and 85% of juvenile illnesses were diagnosed by veterinarians. We do not know the proportion of cases attended by veterinarians that resulted in a sample submission to a diagnostic laboratory. Tables 4 to 8, therefore, cannot be used to estimate prevalence of diseases or the relative frequency in camelids versus wildlife, due to different rates and reasons for submissions to the laboratory. However, they can be used to identify shared susceptibilities and to develop a list of shared pathogens and parasites (Table 10). Note that sharing does not imply transmission between camelids and wildlife, but instead indicates that the microorganisms infect both groups of animals.

There is evidence that a number of the shared agents identified above were in wildlife in BC before camelids were present in the province. For example, the proceedings of the 1951 Fifth Annual Game Convention (McTaggart-Cowen 1988) show that many of the agents identified in our review of records and survey work have been described in mammals in western Canada for more than half a century (Table 11). Moreover, the agents described in the camelids for BC could reasonably be expected to be present in other domestic ruminants. Based on these data, we can conclude that South American camelids in BC and wild ungulates in the province share similar susceptibilities to a range of viral, bacterial and parasitic pathogens. As discussed below, it is more difficult to infer in which direction transmission occurs between these groups of animals, if it does indeed take place.

Table 10 – Potentially pathogenic microorganisms and pathogens shared by South American camelids and BC wild ungulates as diagnosed at the Animal Health Centre.

Microorganism		Found in BC ungulates at the AHC	Found in BC SA camelids at the AHC	Found by study survey	Found in SA camelids in literature
Parasites	*Coccidia sp.*	X	X	X	X
	Caphenemya sp.	X			X
	Capilleria sp.	X		X	X
	Nematodirussp.	X		X	X
	Oesophogostomum sp.	X		X	X
	Strongyles	X			X
	Trichostrongyles	X		X	X
	Trichurissp.	X	X	X	X
	Echinococcus granulosus	X			X
	Dictyocaulus viviparous	X			X
	Sarcocystis sp.	X	X		X
	Parelaphostrongylus sp.	X			X
	Lice	X	X		
Bacteria	*Actinomyces pyogenes*	X	X		X
	Bacillus sp.	X	X		X
	Clostridium perfringens	X	X		
	Corynebacterium sp.	X			X
	Corynebacterium pyogenes	X	X		X
	Escherichia coli	X	X		X
	Leptospira sp.	X	X		X
	Pasteurella sp.	X	X		X
	Streptococcus sp. (alpha haemolytic)	X	X		X
	Streptococcus sp. (Group B)	X	X		X
	Mycobacteria paratuberculosis			X	
Viruses	Bovine respiratory syncytial virus	X			X
	Parainfluenza 3 virus	X		X	X
	Bovine viral diarrhea			X	X
	Infectious bovine rhinotracheitis			X	

Table 11 – Pathogens and parasites described in BC wildlife prior to 1951 (McTaggart-Cowan 1988).

Disease Agent	Coast Deer	Mule Deer	White-tailed Deer	Elk	Moose	Caribou	Bighorn Sheep	Mountain Goat
Moniezia sp.	X	X			X		X	X
Thysanasoma sp.	X	X					X	X
Cysticerus tenuicolis	X	X	X	X	X	X	X	X
Echinococcus granulosus	X	X		X	X			
Taenia ovis or *krabbei*	X				X	X		
Fascioloides magna	X	X		X	X			
Dictyocaulus viviparous	X	X		X	X			
Protostrongylus sp.							X	X
Ostertagia sp.	X						X	X
Nematodirus sp.	X						X	X
Trichuris sp.	X							X
Capillaria sp.	X							
Haemonchus sp.	X							
Esophagostomumsp.	X					X		X
Lice (various species)	X	X	X	X				X
Actinomyces sp.	X	X		X	X		X	X
Mycobacterium				X	X	X		
Corynebacterium ovis		X						
Papilloma virus	X	X			X			
Pasteurella sp.							X	

Question 4: Are there camelid-wildlife interactions that can result in transmission of disease?

Short Answer:

The mere co-existence of vulnerable populations with pathogens and their reservoirs is insufficient to result in disease. The single factor that carries infection from one animal to another and from one time period to another is the probability of adequate contact of a susceptible animal with enough infectious agent. Increasing the frequency, duration and intimacy of interactions between species can reasonably be expected to increase the likelihood of disease transmission between animals. Interactions between wildlife and domestic species have resulted in significant effects elsewhere. Llama trekkers reported observations of wildlife on excursions. Some areas of trekking involved locations of concern for regional wildlife managers. Some trekking has, in a broad sense, been taking place in areas of concern to wildlife managers, but there is insufficient local information to ascertain if there are interactions occurring that are sufficient to result in disease transmission.

Aspects of wildlife population dynamics, including size of range, population size, proximity to domestic species and other stressors, will affect the results of exposure to pathogenic organisms. The epidemiology and microbial ecology of many of the agents of concern coupled with the nature of wildlife interactions indicates that fecal-borne organisms and the respiratory spread of *Pasteurella* spp. are of most concern. Some of these organisms are ubiquitous in the BC environment, others do not survive long without a host and it is unknown whether camelids would increase the risk of exposure to a significant level. Apart from managing the infection status of the domestic species, little can be done to prevent disease interactions with wildlife when livestock are taken into wilderness areas.

Detailed Answer:
The specific effects of a disease on wildlife are dependent on the particular epidemiological and ecological conditions associated with an outbreak or pathogen introduction (Murray et al. 1999). In some cases, an introduced pathogen may have no effect, while in others the effects of an outbreak can be devastating. Although we lack specific evidence from which to predict the outcome of pathogen introduction in wild populations, we can rely on some general trends and epidemiological theory to identify potentially higher risk situations.

Domestic Animal Exposure
Increasing the likelihood and frequency of contact between animal subpopulations can be reasonably expected to increase the exchange of infectious and parasitic agents and thus increase the amount and spread of disease (Hess 1996). Wildlife epidemics have, in a large number of cases, been associated with contact with domestic animals (Hess 1996; Woodroffe, 1999). Options cited by Woodroffe (1999) to minimize the risks to wildlife include preventing domestic animals from entering areas occupied by threatened species and minimizing contact between threatened species and other species that can be reservoirs of pathogens and parasites. The majority of die-offs of bighorn sheep are thought by some authors to be initiated through transmission of strains of *Pasteurella* from domestic sheep (Monello et al. 2001). Recent work has demonstrated that persistence of bighorn sheep populations is strongly correlated with greater distances away from domestic sheep (Singer et al. 2001). Diseases of domestic animals that spread to contiguous wild populations may cause serious mortality. Bovine tuberculosis, which is believed to have spread from adjacent domestic cattle in the 1960s, has infected more than half of the Cape buffalo in the Kruger National Park, South Africa (Bengis et al. 1996). In Tanzania, canine distemper virus has caused the death of lions and other wild carnivores (Roelke-Parker et al. 1996) and is believed to have been transmitted to the wildlife by infected domestic dogs owned by local tribesmen.

Operators using camelids for trekking often advertise that their excursions will expose participants to wildlife viewing opportunities. However, the nature of contact between llamas and wildlife is not specified, especially from a disease transmission viewpoint. The average trekker took 4.6 trips into the wilderness each year (range: one to 18 trips per year). Typically, trekkers took three animals per trip (range: one to six) and they spent four days in the wilderness per trip (range: zero to 14 days). In no case did trekkers report that their camelids were ill two weeks before or two weeks after a trek. Table 12 summarizes the frequency that trekkers reported seeing wildlife when on wilderness trips. One-quarter of survey respondents reported that wildlife was seen in their camelids' home pastures on a daily basis, whereas 44% reported that they never saw wildlife sharing the pasture with their llamas or alpacas. Wildlife was rarely seen in the barns with the camelids (10%). Sixty percent of survey participants reported seeing birds on their farms. Deer and rodents were the most commonly seen mammals on farms (49% and 48% of respondents respectively), followed by coyotes (39%) and bears (18%). Moose (11%) and elk (4%) were less commonly reported. Caribou and bighorn sheep were never seen on farms.

Table 12 – Frequency that trekkers reported seeing wildlife when on wilderness trips (total number of responses = 20).

Wildlife	% of trekkers that saw wildlife on trekking excursions
Bears	60
Deer	55
Moose	40
Coyotes	30
Elk	15
Mountain goats	15
Wolves	15
Bighorn sheep	5
Birds	5
Other	25
Stone sheep	0

Table 13 was constructed through survey results, Internet searches and interviews. It lists locations where llama trekking has taken place in the province. This list is incomplete because: (1) some survey respondents provided insufficient information to specify the location; (2) not all trekkers were involved in the study; and (3) lack of specific location information prevented detailed comments by wildlife managers. However, it does indicate that trekking occurs widely throughout the province and has taken place in areas of concern to wildlife managers. Managers concerns focussed largely on habitats used by small populations. Managers expressed concerns that disease transmission from camelids to these remnant populations could have drastic effects that could limit the capacity for the populations to recover. However, it is important to note that the wildlife managers were basing these concerns on basic principles or analogy with other situations rather than knowledge of camelids serving as sources of significant diseases for wildlife.

Table 13 – General locations used by llama trekkers in BC and notes on concerns of wildlife managers.

Provincial land use district	Location cited	Wildlife manager concerns
New Westminster	Alouette Park	
	Elk Mountain	
	Fraser Valley (unspecified)	
	Golden Ears Provincial Park	
	Kanaka Creek	
	Matsqui Dyke	
	Pitt Meadows	
	Vedder Mountain/River	
Yale	Othello Tunnels	Remnant mountain goat population
	Manning Provincial Park	
Lillooet	Goldbridge	Mountain goat
	Shulops Peak	Mountain goat and bighorn sheep
Cariboo	Alpine areas near Prince George	
	Cariboo Mountains	
	Evanoff Provincial Park	
	Fort George Canyon	
	Kakwa Provincial Park	
	McGregor Range	
	Tabor Recreation Area	
Kootenay	Cathedral Provincial Park	Mountain goat and bighorn sheep
	Downie Creek	Variety of general concerns
	East Kootenays (Unspecified)	
	Goldstream River	
	Mica Dam area	
	Standard Basin	Variety of general concerns
	West Kootenays (Unspecified)	
Cassiar	Alsek Park	Stone's sheep
	Gnat Pass	Stone's sheep
	Omineca Mountains	
	Spatsizi Plateau Wilderness Provincial Park	Mountain goat, Stone's sheep,
	Tatshenshini-Alsek Provincial Park	Mountain caribou
	Todagin Mountains	Dall's sheep
		Stone's sheep
Queen Charlottes	Graham Island	
	Grey Bay	
	Naikoon Provincial Park	
	Queen Charlotte City	
Coast	Tatlayoko	
	Taylor Basin	Mountain goat
	Taylor Creek	Mountain goat
Vancouver Island	East Sooke Park	
	Gowland Tod Park	
Unspecified district	Currie Mountain	
	Hoover Lake	
	Raven Lake	
	Salmon River Valley	
	Whispering Falls	

Table 14 lists Red and Blue-listed ungulates in the province. The Red List includes any indigenous species or subspecies that has, or is a candidate for, extirpated, endangered or threatened status. Endangered taxa (species or subspecies) are those facing imminent extirpation or extinction, while threatened taxa are those likely to become endangered if limiting factors are not reversed. Blue-listed taxa include any indigenous species or subspecies that have been designated of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Bighorn sheep are Blue-listed because their winter ranges are threatened by past overgrazing, competition with domestic stock and other ungulates, land alienation and human encroachment.[8] They are also threatened by diseases, particularly those transmitted by domestic sheep. Populations that were formerly identified as a separate subspecies known as California bighorn sheep are scattered in small herds on the mountains and grasslands of the Ashnola River system, the east side of the South Okanagan Valley in the vicinity of Vaseux Creek, Shorts Creek west of Okanagan Lake, the Fraser River basin from Lillooet north to Williams Lake, the upper Taseko and Chilko rivers and an isolated herd on Far Mountain, north of Anaheim Lake.

Table 14 – BC Red- and Blue-listed ungulates.

Wood bison	*Bison bison athabascae*	Red
Plains bison	*Bison bison bison*	Blue
California bighorn sheep	*Ovis canadensis californiana*	Blue
Rocky Mountain bighorn sheep	*Ovis canadensis canadensis*	Blue
Stone's sheep	*Ovis dalli stonei*	Blue
Dall's sheep	*Ovis dalli dalli*	Blue
Roosevelt elk	*Cervus elaphus roosevelti*	Blue
Caribou (southern populations)	*Rangifer tarandus*	Red

Two herds of "California" bighorn sheep have been established near Kamloops Lake and Grand Forks following transplants. Populations that were formerly identified as a separate subspecies known as Rocky Mountain bighorn sheep are found primarily in the southern Rocky Mountains and Rocky Mountain Trench east of the Columbia River, from the 49th parallel north to the Blaeberry River. Smaller herds are located between the Blaeberry and upper Wapiti rivers. Transplants have created bands near Salmo, Castlegar, Squilax, Spences Bridge and Adams Lake.

The current range of the mountain caribou includes the Rocky Mountains near the Yellowhead Highway and parts of the Cariboo, Monashee, Selkirk and Purcell mountains as far south as northern Washington and Idaho.[9] Loss of habitat, habitat fragmentation, access and predation are considered the major threats to this species.[10] Given their specialized habitat requirements, dispersion to other areas is not an option for this species to avoid disturbance. Seven of the 13

[8] http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/other/species/species-33.htm
[9] http://wlapwww.gov.bc.ca/wld/documents/caribou.pdf
[10] http://wlapwww.gov.bc.ca/wld/documents/mtcaribou_rcvrystrat02.pdf

herds in the province are small and vulnerable to unexpected events such as extremes of weather. A readily communicable disease could, hypothetically, serve as such an event and result in significant losses in these subpopulations.

Wood bison are threatened for a variety of reasons. Interbreeding with introduced plains bison, infection with tuberculosis and brucellosis (which were introduced with plains bison), excessive hunting pressures in the past, predation, and habitat alienation due to industry development and agriculture have all adversely affected this species. The current occupied range of free-ranging wood bison in BC is in the northeast corner of the province, near the junction of BC, Alberta, and the Yukon and Northwest Territories borders. A program is reintroducing and supporting the recovery of wood bison in this area. This population is believed to be tuberculosis- and brucellosis-free, as are other nearby herds in these jurisdictions. The largest free-ranging population of wood bison is within and adjacent to Wood Buffalo National Park. The herds associated with the park are infected with both tuberculosis and brucellosis. Since bison can and do move long distances, the Wood Bison National Recovery Plan (Gates et al. 2001) considers that disease, particularly tuberculosis and brucellosis, is the single largest obstacle to successful recovery of this species.

Roosevelt elk[11] are restricted to Vancouver Island and isolated locations on the Sunshine Coast. Human settlement and hunting have reduced this species' numbers in the past, though their numbers are currently stable. Elk herds frequently use agricultural or golf course lands and are often the source of conflicts. Recent recovery efforts include translocation to historic habitats.

The province's Dall's sheep populations consist of approximately 400 to 600 animals in a remote area of the extreme northwest corner of the province.[12] Much of the population is found within Tatshenshini-Alsek Provincial Park. Overharvesting and disturbance are considered the major threats. Little is known of the health status or diseases of thinhorn sheep in general (including Stone's sheep), although recent research indicates that a variety of micro and macro parasites may be important. Increased human presence in thinhorn sheep range (tourism, sport hunting, forestry, oil and gas and mining exploration and development), together with changes in climate, is expected to result in changing, and most likely increased, pressure on the sheep populations. Thinhorn sheep appear to be as sensitive to such pressures as bighorn sheep and may be more so since human access is much more recent (Jenkins et al. 2000; Kutz et al. 2000).

This overview of Red- and Blue-listed species indicates not just that there are pre-existing concerns regarding disease transmission, but that the ranges of these animals overlap with some areas used by camelid trekkers in the broad sense. However, in the absence of location-specific information, we do not know if trekkers are utilizing habitat features that would result in direct contact or transmission of disease agents between wild and domestic species.

Features of Population Ecology

As habitat size decreases, there are a number of consequences that can affect disease dynamics. First, the number of susceptible animals per unit area increases, thus increasing the likelihood of transmission of infectious agents. Second, competition for resources can stress the population, increasing the level of population susceptibility. Diseases that play a regulatory role for populations dispersed over large areas may become agents of extinction as habitat size contracts (Hess 1996). Areas of increased concern would be those where available habitat is small or the

[11] http://wlapwww.gov.bc.ca/wld/documents/spsum/AMALC01013.pdf

[12] http://wlapwww.gov.bc.ca/wld/documents/spsum/AMALE04022.pdf

effective habitat is limited. An example of the latter may be mountain valleys where animals are constrained by geography (Hess 1996).

Population size and connectivity also play important roles. Singer et al. (1997) demonstrated that larger bighorn sheep populations (>250 animals) were more likely to recover rapidly after disease outbreaks, assuming the proportion of animals affected in large and small populations was the same.

Monello et al. (2001) showed that bighorn sheep pneumonia outbreaks occurred during or within three years of peak population numbers. The authors were unclear as to whether or not this was due to competition leading to increased susceptibility (malnutrition and social stress) or due to increased animal movement. The study concluded that bighorn populations that show increasing numbers and are in close proximity to domestic sheep should be carefully monitored for pneumonia outbreaks.

Nature of the Pathogens and Parasites Involved

Historically, bacteria, viruses, protozoa and fungi have been associated with outbreaks in free-ranging wildlife (Murray et al. 1999) while macroparasites (worms, lice, etc.) tend to be more regularly associated with non-lethal effects (reduced reproduction, affects on mate selection, growth rate, etc.). However, there can be a synergy between the two groups of parasites, such as has been suggested for lungworm and *Pasteurella* pneumonia for bighorn sheep (Monello et al. 2001). Woodroffe (1999) considered the threat to wildlife from infectious disease to be greatest for small populations exposed to “generalist pathogens, often of domestic animal origin.” After a review of the effects of disease on large carnivore conservation, Murray et al. (1999) concluded that pathogens of greatest concern will be those affecting multiple taxonomic families, as well as those that are spread directly at a high rate among hosts. Metapopulation models suggest that highly contagious diseases of moderate severity may pose the greatest risk to wildlife, as such diseases can be easily spread throughout the population and can significantly reduce the average lifespan of members of infected populations (Hess 1996).

As shown in Table 2, many of the infectious organisms identified in BC camelids have an environmental source. Unless clinically ill and shedding such organisms, it is unlikely that camelids will increase the background levels of these agents in wilderness areas. Given that survey respondents reported that their llamas were not ill two weeks before or after trekking, the rate of ill camelids in wilderness areas can be estimated to be very low. The transmission of other agents requires intimate contact between an infected camelid and susceptible wild animal (skin-associated and some respiratory-associated agents). Certain animal behaviours and social barriers may prevent effective contact for certain agents (Loehle 1995). Therefore, the agents of most concern are: (1) agents that are shed in feces and can persist in a viable state for a period of time in the environment; (2) agents that are shed in respiratory secretions, urine or saliva and can persist in a viable state for a period of time in the environment; and (3) agents that, once shed by a camelid, can find a secondary host that allows the agent to be perpetuated or magnified outside of camelids or wildlife of special concern. While the survival time of shed pathogens and parasites may be short, especially under dry conditions, some of these microorganisms can have prolonged environmental survival (Table 15).

As many of the agents found in the AHC records and in the literature review are environmental in origin, are not exotic to BC and have been found in wildlife, it is possible that some wildlife may have some level of immunity to many of the agents carried by llamas and alpacas. However, it is unknown if such levels are sufficient to prevent the spread of an introduced disease agent within and between wildlife populations, nor is there information on geographic variations in wildlife immune status.

Ability to Prevent Exposure

It is relevant to this risk assessment to compare information on llama trekking with other domestic animal uses of wilderness areas, such as the use of sheep for vegetation control on forest lands. In 2001, 19 150 domestic sheep were used for vegetation control throughout the province. The lands used by these animals (harvested forests) will have a significantly different wildlife composition than the more pristine areas favoured by camelid trekkers; however, wildlife encounters can be expected in both settings. The primary mechanisms used to prevent adverse wildlife-domestic animal disease interactions have been ensuring that projects occur at least 15 km away from known native sheep and goat habitats, the use of adequate numbers of effective and recognized livestock guardian dogs and strict government-generated domestic sheep health inspection and treatment protocols intended to ensure animals released to graze do not present unacceptable disease risks. It is also common practice to follow specific but voluntary guidelines for disease prevention before releasing cattle onto community pastures as a means to reduce disease interactions between cattle of diverse origins. Apart from managing the infection status of the domestic species, little can be done to prevent disease interactions with wildlife when livestock are taken into wilderness areas.

Table 15 – Environmental fate of selected pathogens and parasites found in BC in camelids.

Pathogen/parasite	Environmental Fate
Escherischia coli	Fairly resistant to drying.
Pasteurella sp.	Does not survive well in environment (<24 hours); needs blood or serum to grow.
Hemophilus sp.	Can survive 70 days at 23ºC when mixed with blood or nasal mucus. Survives less than 24 hours in urine.
Leptospira sp.	Survives relatively poorly away from host; for 4-6 weeks under optimal conditions of wetness, alkaline pH, warm conditions. Inhibited by pH below 6 and above 8 and temperatures below 7ºC and above 36ºC. Moisture is the most important factor influencing persistence. Can persist for as long as 183 days in water-saturated soil, but survives for only 30 minutes when the soil is air-dried.
Salmonella sp.	Can remain viable in the environment for up to 3 months, especially if protected by fecal material (7 months for *S. typhimurium*). Can remain viable in water for 9 months. Susceptible to drying and sunlight.
Streptococci sp.	Commensal of mucosal surfaces, occasionally of skin. Needs blood or serum to grow; generally survives poorly off host.
Mycobacterium paratuberculosis	Can remain viable in the environment for up to 1 year, especially if protected by fecal material. Organism is relatively susceptible to sunlight, drying, high calcium content and high pH of the soil.
Bovine coronavirus	At 25ºC could last about 24 hours. RNA virus, which tend to degrade fairly quickly.
Bovine herpesvirus	Sources of infection are nasal exudates, genital secretions, semen, fetal fluids and tissues. In a cool, damp environment could survive about 2-3 weeks before

Pathogen/parasite	Environmental Fate
	all residual infectivity is gone.
Ostertagia sp.	Eggs and larvae can survive for extended periods in fecal material, often under adverse weather conditions. Larvae can also survive less severe conditions by hiding under vegetation or in depressions in the ground. Larvae can go underground to avoid hot, dry or freezing weather and then re-emerge from depths of at least 15 cm. Eggs and larvae cannot survive continual freezing and thawing but can survive for about 1 year at temperatures near freezing.
Coccidia spp.	Oocysts must sporulate before they are infective. Require temperatures in range of 12-32ºC. They resist freezing down to –8ºC for 2 months. They may survive in favourable conditions for up to 2 years.
Trichuris spp.	Eggs are hardy and resistant to extremes of temperature, can survive for several years in environment. Eggs are susceptible to desiccation; as the temperature increases, moisture requirements also increase.

Mechanisms to Mitigate Risks

Relevant Regulations and Guidelines

Existing regulations restrict or place conditions on the use of camelids in national and provincial parks.

National Parks Domestic Animal Regulations (1998, 98-03-19)[13]:

- Prevent people from bringing llamas into national parks or allowing them to graze without an authorized licence.
- Licences can be cancelled or refused in a park if the superintendent determines that the presence or grazing of these animals is detrimental to natural resources.
- Animal owners are required to keep domestic animals under physical control at all times.
- No person can knowingly bring an animal into, or keep an animal in, a park if it has any disease that may be infectious or dangerous to wildlife.
- If an animal shows signs of disease, the superintendent can require the keeper/owner to obtain a veterinarian's statement that the animal is not contagious or show it has been vaccinated for specific diseases of concern.

BC Parks regulations governing domestic animals in parks[14]:

- No person shall have a horse or other draught or riding animal in a park or recreation area except in an area or on a trail as permitted by a sign or as authorized by a park officer.
- A person who has a domestic animal in a park or recreation area shall dispose of excrement from that domestic animal in a manner and at a location where the excrement will not cause a public inconvenience or annoyance.

[13] See section I.01 http://laws.justice.gc.ca/en/c-38.7/sor-96-313/74954.html

[14] http://www.qp.gov.bc.ca/stat_reg/reg/P/Parks/180_90.htm

- Except as authorized by a park officer, no person shall allow a domestic animal to enter or remain in frontcountry or in backcountry that is less than 2000 ha in size unless the domestic animal is restrained by a leash not longer than 2 m or confined in a container, enclosure or motor vehicle.
- Except as authorized by a park officer, no person who owns or is responsible for an animal shall, in a park or recreation area, allow that animal to graze, browse or otherwise consume vegetation, or roam at large.

Many of the regulations seem to be concerned with companion animals such as dogs and cats, but other sections are relevant to llamas and alpacas.

The Identified Wildlife Management Strategy is a component of the *Forest Practices Code* of British Columbia and its replacement, the *Forest and Range Practices Act*.[15] The goal is to preserve elements of biodiversity that are not addressed through other components of the Code. For the most part these are threatened and endangered species or plant communities. To date, 36 species/subspecies and four plant communities have been designated as Identified Wildlife. Ungulates included in Volume 1 of this list include California bighorn sheep, Rocky Mountain bighorn sheep and mountain goat. Most of this strategy is focussed on plans to reduce habitat disturbance and contact with people and thus it is unlikely to be a mechanism to manage wildlife-camelid interactions.

The Ministry of Agriculture, Food and Fisheries, in cooperation with the Ministry of Forests and the Ministry of Water, Land and Air Protection, has developed protocols that must be followed for domestic sheep that are used for forestry vegetation control in the province.[16] This system can be viewed as an example of how domestic animal-wildlife interactions are dealt with in other sectors. All producers wishing to graze their animals under these conditions must comply with the protocols. An accredited veterinarian must examine all domestic sheep within 30 days prior to them being put out to graze. "Sheep with footrot, caseous lymphadenitis, contagious ecthyma, conjunctivitis, internal or external parasites and other causes of poor health and condition are excluded from grazing on plantations."

Herd Health and Disease Control Standards

Standard advice on reducing risks associated with animal translocations includes:

- a clinical evaluation of the health status of the source animals and those at the translocation destination;
- a period of quarantine;
- appropriate health-screening procedures;
- consideration of the legal and veterinary restrictions on translocation of wild animals to and from certain geographic areas or populations; and
- when necessary, pre-release treatment and immunization (Woodford 2000).

The IUCN advises that artiodactyls should not be translocated to or from geographic areas or populations that are known to harbour wild or domestic ungulates infected with chronic wasting disease (cervids in the U.S.), brucellosis, bovine tuberculosis, paratuberculosis, foot and mouth

[15] www.for.gov.bc.ca
[16] http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh34.pdf
and http://www.for.gov.bc.ca/hfp/forsite/sheep/appendix3.htm

disease, rinderpest or septicaemic pasteurellosis. Thus, by appropriate adherence to current importation and testing requirements, adequate health care and disease prevention, and examinations of animals prior to introduction to wilderness areas, risks can be significantly reduced. Detailed attention should be directed toward strategies that reduce the likelihood of diseases of special interest that have been described for BC camelids, such as pasteurellosis.

Many of the respondents to our survey replied that they undertook some preventive health measures. Of the 79 respondents providing information on vaccination programs, 87% reported that they had vaccinated their animals within the past 12 months. The majority (82%) vaccinated against clostridial diseases. Smaller proportions vaccinated against leptospirosis (6%) and rabies (3%). Other responses indicated that they did not know what their animals were immunized against. Sixty people provided information on parasite control. Most (83%) had given their animals antiparasitic drugs in the past 12 months. Ivermectin (92%), fenbendazole (8%), pyrantel pamoate (5%) and albendazole (5%) were most commonly used. Use of amprolium, coumaphos, louse powder and herbs to control parasites was reported by one respondent each.

Only 21 of 76 respondents reported that they quarantined new additions to the farm. Most often (81%), quarantine consisted of using separate pastures. A minority of the farmers conducted fecal examinations (13%), had a health check done (13%) or vaccinated and dewormed animals (19%) before new additions were added to the herd. Quarantine typically lasted one to two weeks, but some people had quarantines as short as 48 hours or as long as three months. Twenty-one percent reported that their animals had had tuberculosis tests and 22% reported previous brucellosis tests. In no case was a positive result reported.

Risk Assessment

Disease risks from camelids to wildlife in BC remain hypothetical after this risk assessment, as no direct evidence was found to implicate camelids as sources of significant diseases in wildlife in BC or elsewhere. There is a sound basis in the literature and the basic principles of epidemiology to raise the concern that domestic species in wilderness areas can introduce disease agents that can have important negative effects on local wildlife populations. This concern is greatest for wildlife populations already dealing with other population stressors at the time of pathogen or parasite exposure. There is insufficient data to accurately forecast the probability of disease transmission or to predict its effects; therefore, uncertainty remains an important determinant of risk in this situation.

The other main determinants of risk in this case are:

(1) Camelids are taken into wilderness areas. Therefore, there is the capacity to take camelid-associated parasites and pathogens beyond the farm gate and introduce them into areas used by wildlife. (Affects probability of exposure.)

(2) Wild animals are susceptible to pathogens and parasites associated with BC camelids. There are cases where interactions between domestic species and wildlife have resulted in significant disease outcomes. (Affects the magnitude of impact if exposure occurred.)

(3) Camelids continue to be imported from regions and countries outside of BC, thus creating the possibility that foreign pathogens can be imported. (Special case pathogens of high magnitude.)

Risk determinant 1: Camelids are taken into wilderness areas.

A majority of camelid owners use their animals as pets or for breeding and fibre production. These animals rarely leave the farm, except for breeding loans. Therefore, their contact with wildlife is limited to interactions that occur on farms. A minority of camelid owners use their animals for backcountry use. Their trips tend to be short in duration and relatively infrequent on the most part. Camelid owners reported that their animals were not ill within two weeks before or two weeks after trekking, thus suggesting that any pathogen shedding would be due to chronically and/or sub-clinically infected animals. The number of agents that have prolonged shedding from asymptomatic animals is less than the total list of pathogens identified in camelids and would be largely associated with enteric parasites and bacteria. Given that infectious diseases were reported to be relatively infrequent causes of death or disease in llamas and alpacas in the province, the likelihood of an infectious llama being used for trekking is further reduced.

Moreover, llamas are typically restrained or controlled when in the backcountry, thus reducing the distribution of excretions and secretions. All of these factors significantly limit the geographic and temporal opportunities for backcountry exposure of wildlife to pathogens of camelid origin. We can conclude that this probability of exposure is not zero, as the locations of trekking coupled with their duration and the numbers of animals taken do create a possibility of wildlife being exposed to excretions or secretions from llamas and alpacas that could harbour viable pathogens. Since many viruses and respiratory pathogens tend not to have prolonged environmental residue times, the pathogens of higher concern will be enteric bacteria and parasites. However, there are no data to indicate if this exposure occurs, how often it occurs and the frequency at which such exposure leads to diseases. Significant research would need to be undertaken to quantify this feature of risk.[17] We are, therefore, left to rely on analogy with other cases (notably wild and domestic sheep interactions) and basic principles of epidemiology to conclude that it is reasonable to state that such transmission can occur.

There is no reason to believe that the frequency and amount of pathogens or parasites released by camelids in wilderness areas are greater than for domestic sheep or cattle grazing in community pastures or clearcuts. In fact, one could conclude that this value is lower for camelids simply due to the relative number of animals in wilderness areas (llamas versus domestic sheep and cattle). The primary difference is that camelids have been taken into areas with different wildlife values (such as parks or locations of concern due to vulnerable populations) than those in grazing areas used by sheep and cattle. Therefore, the risk of wildlife exposure in general may be equal to or lower than with other domestic ruminants, but the probability of exposure of vulnerable wildlife or wildlife of special value (Red- or Blue-listed) is higher at a local level.

Subjective Risk Summary

Probability of camelid-wildlife interactions resulting in effective exposure of wildlife to disease-causing organisms:

Not able to quantify.

Very low on a provincial basis, but can be *low to moderate* at a local level.

Level of uncertainty:

Moderate to high.

Overall risk:

Low to moderate.[18]

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[17] Key issues include mechanisms for exposure, environmental survival of disease agents and the nature of wildlife-llama interactions from a disease-transmission perspective.

[18] Subjective rankings: Low = more likely to not occur than occur; Moderate = as likely to occur as not occur; High = more likely to occur than not occur.

Risk determinant 2: Wild ungulates are susceptible to pathogens and parasites associated with BC camelids.

Wild ungulates and South American camelids in BC are susceptible to many of the same viruses, bacteria and parasites. No diseases or infections reported for camelids in BC were foreign to wildlife, nor was there evidence that pathogens and parasites currently present in BC had been introduced to wildlife from camelids. Virtually all of the infectious agents we identified in camelids in BC and North America are shared with a wide variety of ungulates, both wild and domestic. Furthermore, few of these have been linked to significant disease effects on wildlife. However, some, such as *Pasteurella* sp., have been associated with significant effects arising from domestic animal-wildlife interactions (bighorn sheep pneumonia). Moreover, there has been little work done on sub-lethal effects of pathogen and parasite exposure in wildlife; thus, the true magnitude of effects of acquiring infectious and parasitic microorganisms from domestic species cannot be quantified.

An overwhelming concern in this case is that disease, though unlikely to be a mechanism for extinction on its own, can serve as a significant impediment to the recovery of wildlife that are compromised by other factors, such as habitat loss, reduced numbers or other pressures. Historical examples provide evidence that disease interactions between domestic and wild species can be catastrophic. However, few wildlife populations or the pathogens associated with camelids are similar to the features of scenarios where catastrophic outcomes could be reasonably predicted. Of particular concern would be gregarious species that are restricted to small ranges and are challenged with other factors.

<u>Subjective Risk Summary</u>

Magnitude of impact:

Provincial level and for most wildlife populations – *Very low to low*.
Local level, individual animals – *Moderate*.
Local level, populations – Potential for *very high*.

Level of uncertainty:

Provincial level – *Low to moderate*.
Forecasting specific outbreaks under specific conditions – *High*.

Overall risk:

Moderate.

Risk determinant 3: Camelids are foreign animals.

It is generally accepted that animals of foreign origin need to be viewed with greater care than animals born in a given location. To date, we have no evidence that imported camelids have brought with them diseases foreign to BC. All of the pathogens and parasites identified in camelids in this survey were known in domestic species and wildlife prior to the introduction of camelids. However, experience with other species elsewhere warns us that the potential for introducing foreign agents exists, even in the presence of regulations to prevent this occurrence. Camelids present a unique problem in that few (if any) of the tests used to detect foreign agents are validated for camelids and we lack experience needed to identify the full range of disease agents in all source locations for camelids entering the province. Therefore, there remains a probability that foreign animal diseases can be imported with camelids. But we must conclude that this probability is extremely low due to lack of evidence of such an occurrence, apart from one instance in the United States. This low probability is counter-balanced with the potentially very large magnitude of effects if a foreign pathogen is introduced to wildlife by backcountry llama use.

Subjective Risk Summary

Probability that camelids will expose wildlife to foreign animal diseases:

Not able to quantify.

Very low.

Magnitude of effect if wildlife is exposed to a foreign animal disease:

Not able to quantify.

High.

Overall risk:

Moderate.

Overall Risk Assessment

The overall risk varies, based on the scenarios in question.

On a province-wide basis, the risk is low, but for specific vulnerable wildlife, the risk can be high.

The primary determinants of risk are the potential for a high-magnitude negative effect coupled with remaining uncertainties that prevent precise forecasting of the situations that will be highly risky.

Recommendations

There is sufficient basis for concern to advise a precautionary approach to managing disease risks to wildlife from camelids. A number of simple steps can be undertaken to mitigate these risks.

1. Prevent vulnerable wildlife and their habitat from making contact with camelids and their wastes.
    a. Vulnerable wildlife are those that are at risk of population declines and that can plausibly be susceptible to camelid-associated pathogens and parasites.
        i. Specifically, wild ungulates already coping with significant population pressures that place populations at risk of local, regional or national extinction or that are preventing the recovery of same populations. An example is wood bison in northeastern BC.
        ii. Of special concern are populations that are small and restricted to a small habitat. An example is mountain caribou in southwestern BC.
    b. Exclusion zones should be based on preventing overlap of areas used by camelids and frequented by vulnerable wildlife, in order to prevent direct contact or exposure to fecal wastes or camelid secretions. An example is a population of thinhorn sheep never before exposed to domestic species.
2. Ensure a standard of health care for camelids being used for backcountry trekking purposes.
    a. Trekkers should have an ongoing herd health program that includes:
        i. A consulting veterinarian that diagnoses causes of death and disease, submits the required diagnostic samples to identify the cause of illness or death and advises on the following:
            1. a program of parasite- and infection-control and prevention;
            2. a standard quarantine period for new additions to the herd;

        3. veterinary examination of animals before they are released from quarantine; and
        4. veterinary examinations prior to animals being taken into backcountry areas.
            a. The period before trekking should be within the plausible incubation period of most diseases (such as 14 days).
            b. Examination for parasites should precede this examination to allow time for treatment as required.
                i. This report indicates that more than one sample should be examined per animal (minimum of two to three negative tests to call an animal negative).
            c. Both an individual animal examination and a review of the herd disease history should be undertaken.
            d. If the veterinarian determines that it is reasonable to believe an animal is infected, based on examination, test results or herd history, that animal should be excluded from backcountry use until such time that it is no longer reasonable to believe it presents an infection risk.
    ii. Adequate health records should be made available to wildlife or park managers or their designates.

3. Ensure animals recently imported to BC undergo special consideration. It may be advisable to prohibit imported camelids from being used in backcountry situations for prolonged periods after their arrival in BC, given recent experience with diseases such as chronic wasting disease.
    a. Quarantine periods should be based on the pathogens expected in the region of origin. The length of quarantine will depend on: (1) how risk-adverse managers are; (2) the diseases in the animal's country of origin; and (3) results of increased understanding about transmission probabilities in backcountry situations.

It is anticipated that these will be acceptable recommendations as, based on the survey, many camelid owners already have the foundation for herd health programs, many imported animals have been brought in for breeding rather than trekking purposes and regulations already exist to prevent exposure of vulnerable wildlife to anthropogenic risks.

It is important to emphasize that risk factors are not homogeneous across the province. Variations in the threats to wildlife, habitat and exposure opportunities, the number of camelids used and local wildlife values will need to be considered on a case-by-case basis.

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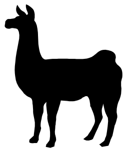
Appendix 1: Survey Sent to Camelid Owners



BC CAMELID HEALTH SURVEY 2001

Measuring the health of llamas and alpacas in British Columbia

Please take the time to complete this form and return it in the self-addressed enveloped included. Your response will help us to identify major health issues affecting camelids in BC and to find ways to minimize the risk of disease moving between camelids and wildlife.

Note: There may be more than one correct answer for some questions.

Thank-you for your participation

FARM INFORMATION

How many camelids do you own?	Llama [ ] Other [ ]*List*	Alpaca [ ]	
Where were your animals born?	BC [ ] USA [ ]	Prairie provinces [ ] Other	Eastern Canada [ ] Don't know [ ]
How many camelids were born on your farm in the past 12 months?	Number [ ]		
How many camelids were introduced onto your farm in the past 12 months?	Number [ ]		
Did any camelids leave your farm and return in the past year?	Yes [ ]	No [ ]	Why?
What other animals are on your farm?	Cattle [ ] Goats [ ]	Horses [ ] Other	Sheep [ ]

MEDICAL HISTORY

How many adult camelids (> 1yr old) were sick in the past 12 months?	Number [ ] What were the causes? ________________________________ __________________________________ Who made the diagnosis? Veterinarian [ ] Laboratory [ ] Owner [ ]; Other [ ]
How many juveniles (<1yr old) were sick in the past 12 months?	Number [ ] What were the causes? ________________________________ __________________________________ Who made the diagnosis? Veterinarian [ ] Laboratory [ ] Owner [ ]; Other [ ]
How many camelids died in the past 12 months?	Adult [ ] Juvenile [ ] What were the causes? ________________________________ __________________________________ Who made the diagnosis? Veterinarian [ ] Laboratory [ ] Owner [ ]; Other [ ]

WILDLIFE INTERACTIONS

What do you use your camelids for ?	Pets/Pleasure [ ] Fibre sales [ ] Breeding [ ] Pack animals/trekking [ ] Other
Do you see wildlife sharing the same pastures as your camelids?	Daily [ ] Weekly [ ] Monthly [ ] >Monthly[ ] Never [ ]
Do you see wildlife sharing the same barn as your camelids?	Daily [ ] Weekly [ ] Monthly [ ] >Monthly [ ] Never [ ]
What types of wildlife have you seen in the same pasture or other feeding areas as your camelids?	Deer [ ] Elk [ ] Bighorn Sheep [ ] Moose [ ] Caribou [ ] Rodents [ ] Birds [ ] Coyotes [ ] Wolves [ ] Bear [ ] Other

DISEASE PREVENTION PRACTICES

Have you vaccinated your camelids in the past 12 months?	Yes [ ] No [ ] Do not know [ ]
What did you vaccinate your camelids with?	Do not know [ ] Clostridial disease (7-way, 8-way) [ ] Lepto [ ] Rabies [ ] Other (specify) [ ]
Have you used any drugs or other products to prevent or treat your camelids for parasites??	Yes [ ] No [ ] Do not know [ ]
What products did you use to treat or prevent parasite problems?	Do not know [ ] or List products
Do you quarantine new additions to your farm	Yes [ ] No [ ] If yes, briefly describe what you do
Have your animals been tested for tuberculosis and/or brucellosis	Do not know [ ] Tuberculosis: Yes [ ] No [ ] Brucellosis: Yes [ ] No [ ]
Did any animals test positive for the following diseases?	Tuberculosis: Yes [ ] No [ ] Brucellosis: Yes [ ] No [ ] Do not know [ ]

If you use your animals for pack animals, please answer the following:

How many times in the past 12 months did you take your camelids into wilderness areas? _________
How many camelids did you take out on the average trip? ____________________________________

How many days were you in the wilderness with your animals?	Average ________Shortest trip _______ Longest trip ________
Did any of your camelids get sick within 2 weeks of returning from the trip?	Yes [ ] No [ ]
Were any of your camelids sick within 2 weeks before a trip?	Yes [ ] No [ ]
What types of wildlife did you see on your trips?	Deer [ ] Elk [ ] Bighorn Sheep [ ] Stone Sheep [ ] Moose [ ] Caribou [ ] Mountain goats [ ] Wolves [ ] Coyotes [ ] Bear [ ] Other
What time of the year did you go?	Summer [ ] Fall [ ] Winter [ ] Spring [ ]
How do you control your animals when packing/trekking?	
Where did you go trekking?	

COMMENTS

Appendix 2: References Used to Establish Overlap of Camelid and Wildlife Pathogens and Parasites

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