Caribou Herds and Arctic Communities: Exploring a New Tool for Caribou Health Monitoring

by Patricia Curry

On the ragged edge of the world I'll roam,
And the home of the wolf shall be my home,
And a bunch of bones on the boundless snows
The end of my trail...who knows, who knows!

Robert Service

THE CLASSIC CANADIAN COLLECTION *Songs of the High North* is full of Robert Service's (1958) imagery of an environment of wildness and extremes. Colourful verses portray a tundra "vast and dark and grim and lone" with driving blizzards and deep snowy graves, gleaming blood-red mosses that are spongy underfoot, and "lightning javelins" being hurled across the sky at night. It certainly doesn't take a long stay in the North to begin to feel the magnetism of that "ragged edge of the world" Service describes. However, his tales tend to chronicle white-man exploits of survival and death in the northern "vastitudes," whereas my mind always bends to thoughts about animals' struggles, human-animal connections, and the challenges of uncovering what happens in this place of endless snows.

One disturbing story unfolding in the North today is the plight of barrenground caribou (*Rangifer tarandus groenlandicus*). Numerous Arctic caribou herds are in serious decline (Nagy and Johnson, 2006; Vors and Boyce, 2009), with population changes considered to exceed "normal" ecological fluctuations. There is uncertainty about the causes of these declines, but driving factors may include climate change, industrial development, altered hunting practices, and other anthropogenic impacts. The gravity of the situation is immense, as caribou are key threads in the fabric of the polar world. In addition to their integral worth, these ungulates are a keystone species, are fundamental to indigenous hunting culture, and hold spiritual value for many aboriginal people. Caribou are hunted for subsistence and contribute significantly to nutrition, economy, and physical and mental health in communities across the Arctic and Subarctic (Myers et al., 2004; Batal et al., 2005; Van Oostdam et al., 2005; Lambden et al., 2007). The severe herd declines are particularly unsettling because it is questionable whether populations can rebound. The Intergovernmental Panel on Climate Change forecasts that "the resilience of many ecosystems is likely to be exceeded this century" through a mix of climate change and other anthropogenic drivers (IPCC, 2007).

Infectious disease plays a role in the dynamics of wildlife populations, and altered disease patterns linked with environmental change are a concern for all Arctic species, including humans (Bradley et al., 2005; Parkinson and Butler, 2005; Greer et al., 2008; Kutz et al., 2009). Authors have pointed to the need for stronger, more widespread surveillance of disease in wildlife from a public health perspective and in the context of climate change (Kuiken et al., 2005; Parkinson and Butler, 2005). Currently, there is a lack of comprehensive knowledge about caribou disease at individual and herd levels. Further, like other wildlife, caribou may carry zoonoses (diseases transmissible between animals and humans, such as brucellosis and toxoplasmosis) that are potential health risks for harvesters during butchering and for those who eat raw or undercooked "country foods" (McDonald et al., 1990; Levesque et al., 2007; Glynn and Lynn, 2008).

Better understanding of caribou disease and valid screening methods are needed in order to monitor changes in disease patterns over time, ensure food safety, and inform management practices. However, voicing these needs and acting on them effectively are different things; collecting biological samples on a large scale in the Arctic environment is no small feat from economic, practical, and cultural perspectives.

OBJECTIVE AND THE FILTER PAPER TOOL

My research began in 2007 and examines one possible way to sample for caribou disease exposure in remote places with harsh climates, such as the Arctic. The overall objective is to develop and implement a diagnostic tool that is practical, versatile, and can facilitate widespread disease surveillance of these ungulates (and potentially other wildlife). The approach involves collecting blood samples on filter paper (FP) (Fig. 1), as opposed to collecting into glass or plastic

FIG. 1. Pat Curry shows a couple of handy filter-paper sets.

FIG. 2. Field collection method: A set of filter papers soaked in jugular blood from a hunter-killed caribou.

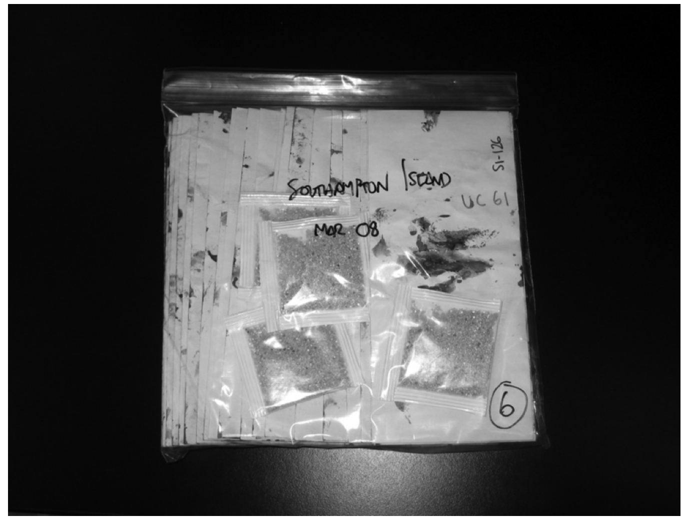

FIG. 3. Storage: Saturated filter papers are either dried and stored in envelopes inside a plastic bag with desiccant (as shown), or else frozen immediately and kept frozen until time of analysis.

tubes, which are breakable and more difficult to transport and process in cold remote settings. Filter-paper blood testing has been used in human medicine since the 1960s, and its applications continue to expand (Mei et al., 2001). Wildlife researchers have also used FP techniques (e.g., Dubay et al., 2006; Trudeau et al., 2007; Yu et al., 2007), but such applications have been limited and validation is often lacking. The FP field method for collecting and storing caribou blood is very simple (Figs. 2 and 3). Pre-cut filter-paper strips are mounted on a cardboard "handle" and several of these sets are collected from each animal. With hunter-killed caribou, a large vein (jugular or femoral) is severed and the collector dips the full length of all FPs into a clean pool of blood. Samples are placed in an antimicrobial-lined envelope and, depending on circumstances, are either dried and then stored at room temperature in a plastic bag with desiccant, or else frozen immediately and stored frozen.

PROJECT PHASES: BRIEF METHODS AND RESULTS

The FP Method: Evaluation of Efficacy

The FP system is simple, handy, lightweight and requires no special training, all of which make it directly accessible to hunters, wildlife officers, biologists, and others. However, the obvious first question is "Does it work?" The initial step of my research is to evaluate the efficacy of FP blood samples for detecting exposure to pathogens with known or potential relevance to caribou health. At its core, this phase involves comparing antibody test findings in FP samples and serum that have been collected simultaneously from individual animals. This has entailed FP collections from hunter-killed and live animals, with the latter done by drawing a syringe of whole blood and immediately saturating the strips. I am currently assaying FP-serum pairs in duplicate at veterinary diagnostic laboratories across Canada. In addition, I am investigating FP for detecting progesterone as a pregnancy indicator in *Rangifer*. Table 1 lists the pathogens and physiological factors in the project.

To date, I have established a method for "eluting" (recovering serum from) caribou FP samples and have collected and tested multiple sets of paired FP-serum samples from three groups: 1) captive reindeer (also *Rangifer tarandus* ssp.) vaccinated for viral pathogens of domestic livestock and West Nile virus (WNV) to achieve known antibody-positive (seropositive) status for these agents; 2) an Alberta reindeer herd with animals known to be seropositive for WNV and the parasite *Neospora caninum*; 3) a wild caribou herd on Southampton Island, Nunavut, with known high prevalence of brucellosis. Samples from the captive reindeer are also being evaluated for detection of progesterone.

A second component of this testing is to gauge the limits of the tool by evaluating the effects of storage time and immediate freezing of samples versus drying. All FP versus serum testing is being repeated at three approximate storage times: 1 month, 6 months, and 12 months or longer. The temperature "treatments" mimic possible northern field scenarios, and a pilot study has suggested that these manipulations have minimal effect on FP samples. A more robust treatment experiment is planned.

Testing is ongoing but, in brief, the results for enzyme-linked immunosorbent assays (ELISAs) of FP samples for *Brucella* (brucellosis), *N. caninum*, and WNV are very promising. They indicate that, at least within several months of storage, FP samples are effective (comparable to serum) for detecting immune response (exposure) to these pathogens. Test performance analysis reveals high sensitivity and specificity when FP samples are compared to serum as the gold standard. As well, strong correlations between duplicate FP results for these agents indicate minimal variation among FPs from any given animal. Initial results from FP evaluation

TABLE 1. Information about the agents and indicators being investigated in the caribou filter paper project.

Agent/Indicator	Type	Effects in Caribou/Reindeer	Zoonotic Impact
Brucella spp.	bacteria	abortion, weak calves, orchitis, joint disease, abscesses	multisystemic chronic disease
West Nile virus	virus	neurological,[1] death (reindeer)	neurological,[1] death
Neospora caninum	protozoan	unknown[2]	none known
Toxoplasma gondii[3]	protozoan	abortion, lethal enteritis (reindeer)	abortion, birth defects
Bovine herpesvirus-1	alphaherpes virus	oral lesions, enteritis (reindeer)	none known
Bovine respiratory syncitial virus	paramyxovirus	unknown[4]	none known
Parainfluenza-3 virus	paramyxovirus	unknown[4] (antibodies detected in caribou)	none known
Bovine viral diarrhea virus – Types I and II	pestiviruses	unknown[4]	none known
Mycobacterium avium ssp. *paratuberculosis*	bacterium	wasting, poor hair coat, chronic enteritis	? – possible Crohn's disease
Progesterone	hormone	n/a (pregnancy indicator)	n/a

[1] Requires mosquito vector.
[2] Causes spontaneous abortion in cattle.
[3] Collaborating with A. Gajadhar, Centre for Animal Parasitology, Canadian Food Inspection Agency.
[4] Risk of transmission from domestic ruminants with northward agricultural expansion (Kutz, 2007).

for progesterone detection by radioimmunoassay are also promising, and results for other parameters are pending.

Community-based FP Sampling: Implementation and Assessment

> Learn from us; we know a little bit about sustainability … Work with us to keep and maintain our way of life…
>
> Sheila Watt-Cloutier
> CBC Radio One interview, 2007

The second step of my research is to implement FP sampling as a hunter-based strategy for caribou disease surveillance and then assess uptake and acceptance. If the field method proves scientifically valid, it can be placed in the hands of caribou harvesters and other caribou samplers with confidence. The proposed community framework involves teams of hunters and scientists working together on an ongoing basis. Samples are collected strictly from animals killed for subsistence, and hunters are key agents in the monitoring of a species that is valued by their community. Successful hunter-based surveillance would provide larger sample sizes and cover temporal and spatial scales that are otherwise not feasible to access.

I am conducting this part of my project as an invited contributor to the Government of Nunavut's Caribou Health Monitoring Program (GNU CHMP) in remote Baffin Island communities. This initiative is new to Nunavut and is being forged by the Department of Environment in consultation with hunters' and trappers' organizations and members of North Baffin communities. In fall 2008, we held meetings in Arctic Bay and Pond Inlet, Nunavut. Representatives from Clyde River participated in the Pond Inlet meetings. We presented the overall program, discussed caribou disease with hunters, and introduced the use of FP as a method for disease sampling. In summer 2009, I returned to conduct follow-up interviews in Pond Inlet and Iqaluit with various stakeholders in caribou health. The broad aim was to acquire a context for understanding potential barriers and pathways to implementing the "simple" FP method in Arctic communities. The questions probed values that participants place on caribou and other wildlife, levels of concern about food safety and wildlife disease, uses of caribou, opinions on hunter-based wildlife sampling programs, and the uptake and perceived value of FP as part of the GNU CHMP. Seventeen interviews (many via Inuktitut-English interpretation) were completed over a two-month period, with participants including community caribou harvesters (men and women), wildlife biologists and technicians, and other individuals. The conversations provided a valuable window on the perspectives of different stakeholder groups. Extended time in Pond Inlet also gave me special occasion to observe the rhythms of life, day-to-day events, and various concerns in a predominantly Inuit community. This was a gift personally as well as for my research, and one that allowed for direct learning about the physical and social environment, people's range of connections with wildlife, and potential impacts of wildlife disease. It also underlined the importance of personal connection and trust, which are crucial to any community-based scientific work that I do now or in future, and which take time and patience to build.

A second year of GNU CHMP community visits and summer follow-up of FP implementation is planned. I will also compare findings in the Baffin Region to an assessment of hunter-based caribou FP sampling in the Sahtu Settlement Region of the Northwest Territories. There, hunters have been collecting FPs as part of the original model community-based caribou health program established in 2005 by Dr. Susan Kutz, University of Calgary, and Alasdair Veitch, Supervisor of Wildlife Management, Government of NWT (see Brook et al., in press). To date, there has been no published evaluation of hunter FP sampling within the Sahtu program. It will be valuable to compare what is happening with uptake and acceptance of the method in these two different settings and stages of use.

Multi-Herd Analyses

In addition to community-based caribou FP monitoring, the intent is to be able to conduct broad-scale disease surveillance using FPs collected by diverse samplers across the North. The third step of my project will be to analyze disease exposures and pregnancy status in circumpolar caribou herds using FP samples and serum collected during the International Polar Year (2007–09). Many of these collections were done by international caribou biologists, research scientists, and others as part of the international Circum-Arctic *Rangifer* Monitoring and Assessment Network (CARMA; www.carmanetwork.com). The ranges of the seven polar herds I will investigate are located from the Yukon to Quebec in Canada, as well as in Greenland (Fig. 4). The latest population estimates indicate that six of these seven herds are in decline. By comparing disease exposure to other individual (pregnancy, age, body condition) and herd (demographics, geographic location, climate, habitat, etc.) parameters, we will gain new insight into the drivers and role of infectious disease in barrenground caribou. Testing for this phase is expected to get underway in fall/winter 2009–10.

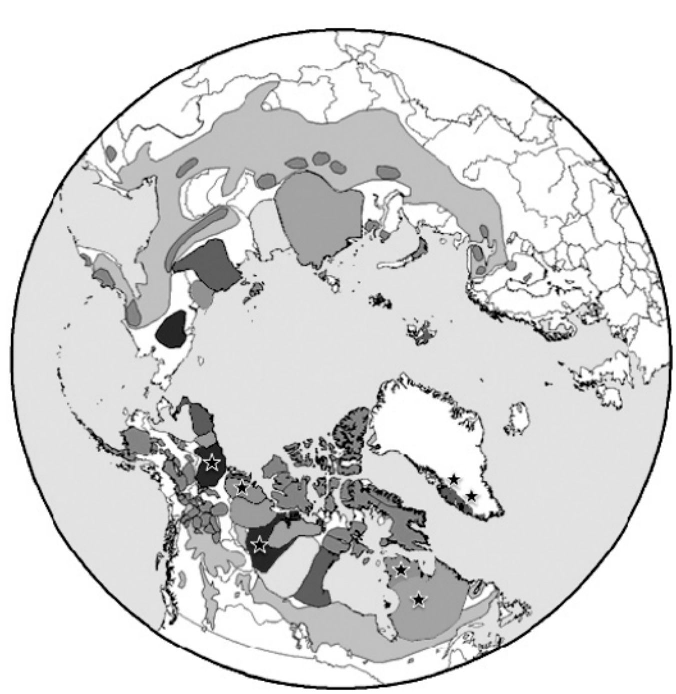

FIG. 4. Circumpolar reindeer and caribou herds (shading). Stars denote herds for which filter-paper blood samples will be used to do epidemiological analyses. Shown from west to east are the Porcupine, Bluenose West, Bathurst, Rivière aux Feuilles (Leaf River), Rivière George (George River), Kangerlussuaq-Sisimiut, and Akia-Maniitsoq herds. Most recent population estimates indicate that all of the starred herds except Rivière aux Feuilles are currently in decline. (Source: www.carmanetwork.com.)

SIGNIFICANCE

Filter-paper blood sampling has exciting potential as a versatile, reliable new tool for widespread health monitoring of caribou. Acceptance by communities, caribou biologists, management agencies, and others will be vital for the long-term surveillance purpose of this tool to come to fruition. It is apt that Northerners, whose health and livelihoods depend on healthy caribou, are integral to this process; yet, their participation will depend on perceived concerns, benefits, and alignment of values. There are some definite challenges to community implementation of FP. Introducing a new wildlife sampling method and program anywhere in the North takes time and perseverance (not to mention logistical leaps, mines of funding, social finesse, and much more!). It is also crucial to find genuine ways to bring these efforts out of the shadow of research fatigue that is understandably prevalent in small Arctic communities. I am hopeful that the epidemiological analysis portion of my project will provide new insight into disease ecology in caribou and will build essential context for community-based FP monitoring and future disease surveillance in barrenground caribou.

Importantly, this research serves as a model for health surveillance in other wildlife species as well. It is of fundamental interest to me because it links human and veterinary medicine, is founded on holistic, noninvasive approaches to ecosystem health, and recognizes the deep significance of human-animal connections.

ACKNOWLEDGEMENTS

It is a true honour to have received the Lorraine Allison Scholarship, and I sincerely thank the selection committee. I feel privileged to be experiencing the North and working along some threads of Lorraine's passions. In that vein, I would also like to warmly recognize Dr. Maëlle Gouix, as this writing about my project was done with Maëlle's love of Canada's North and her current health struggle in mind. I am so grateful to the community members of Pond Inlet (Mittimatalik) and to all interviewees who gave their valuable time to speak with me this summer (Thank you, *Qujannamik*). As well, I have many supportive collaborators (including sample collectors) and funders to thank: Prairie Diagnostic Services; CFIA Brucella Centre of Expertise; BC Animal Health Centre; Nasivvik Centre for Inuit Health and Changing Environments (Canadian Institutes of Health Research); Department of

Environment-Government of Nunavut (Qikiqtaaluq and Kivalliq regions; Debbie Jenkins and Grigor Hope of the GNU CHMP; Mitch Campbell); Mittimatalik Hunters' and Trappers' Organization; NSERC Special Research Opportunities IPY Funding; NSERC Northern Research Internship; Federal IPY Funding for the Circum-Arctic *Rangifer* Monitoring and Assessment Network (CARMA) and everyone involved in CARMA; the Northern Scientific Training Program (Indian and Northern Affairs Canada); AINA Grant-in-Aid; Faculty of Veterinary Medicine at the University of Calgary. Last but definitely not least, I am indebted to all the beautiful animals we work with, and I greatly appreciate the ongoing support and enthusiasm of my supervisor, Dr. Susan Kutz, colleague Dr. Ryan Brook (interviewer extraordinaire), each of my dedicated committee members, and everyone in the Kutz lab at the University of Calgary.

REFERENCES

Batal, M., Gray-Donald, K., Kuhnlein, H.V., and Receveur, O. 2005. Estimation of traditional food intake in indigenous communities in Denendeh and the Yukon. International Journal of Circumpolar Health 64(1):46–54.

Bradley, M., Kutz, S.J., Jenkins, E., and O'Hara, T.M. 2005. The potential impact of climate change on infectious diseases of Arctic fauna. International Journal of Circumpolar Health 64:468–477.

Brook, R.K., Kutz, S.J., Veitch, A., Popko, R., Elkin, B., and Guthrie, G. In press. Generating synergy in communicating and implementing community based wildlife health monitoring and education. EcoHealth.

Dubay, S.A., Rosenstock, S.S., Stallknecht, D.E., and de Vos, J.C., Jr. 2006. Determining prevalence of bluetongue and epizootic hemorrhagic disease viruses in mule deer in Arizona (USA) using whole blood dried on paper strips compared to serum analyses. Journal of Wildlife Diseases 42:159–163.

Glynn, M.K., and Lynn, T.V. 2008. Brucellosis. Journal of the American Veterinary Medical Association 233(6):900–908.

Greer, A., Ng, V., and Fisman, D. 2008. Climate change and infectious diseases in North America: The road ahead. Canadian Medical Association Journal 178:715–722.

IPCC (Intergovernmental Panel on Climate Change). 2007. Summary for policymakers. In: Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Kuiken, T., Leighton, F.A., Fouchier, R.A., Leduc, J.W., Peiris, J.S., Schudel, A., Stohr, K., and Osterhaus, A.D. 2005. Public health: Pathogen surveillance in animals. Science 309(5741):1680–1681.

Kutz, S. 2007. Climate Change Action Fund, Project A760: An evaluation of the role of climate change in the emergence of pathogens and diseases in Arctic and Subarctic caribou populations. Prepared for the Climate Change Action Fund, Government of Canada. Available from Dr. S. Kutz, Faculty of Veterinary Medicine, University of Calgary, 3330 Hospital Drive NW, Calgary, Alberta T2N 4N1. 132 p.

Kutz, S.J., Jenkins, E.J., Veitch, A.M., Ducrocq, J., Polley, L., Elkin, B., and Lair, S. 2009. The Arctic as a model for anticipating, preventing, and mitigating climate change impacts on host-parasite interactions. Veterinary Parasitology 163(3): 217–228, doi:10.1016/j.vetpar.2009.06.008.

Lambden, J., Receveur, O., and Kuhnlein, H.V. 2007. Traditional food attributes must be included in studies of food security in the Canadian Arctic. International Journal of Circumpolar Health 66(4):308–319.

Lévesque, B., Messier, V., Bonnier-Viger, Y., Couillard, M., Côté, S., Ward, B.J., Libman, M.D., Gingras, S., Dick, D., and Dewailly, É. 2007. Seroprevalence of zoonoses in a Cree community (Canada). Diagnostic Microbiology and Infectious Disease 59(3):283–286.

McDonald, J.C., Gyorkos, T.W., Alberton, B., Maclean J.D., Richer, G., and Juranek, D. 1990. An outbreak of toxoplasmosis in pregnant women in northern Quebec. Journal of Infectious Diseases 161(4):769–774.

Mei, J.V., Alexander, J.R., Adam, B.W., and Hannon, W.H. 2001. Use of filter paper for the collection and analysis of human whole blood specimens. Journal of Nutrition 131:1631S–1636S.

Myers, H., Powell, S., and Duhaime, G. 2004. Setting the table for food security: Policy impacts in Nunavut. Canadian Journal of Native Studies 24(2):425–445.

Nagy, J.A., and Johnson, D. 2006. Estimates of the number of barren-ground caribou in the Cape Bathurst and Bluenose-West Herds and reindeer/caribou on the Upper Tuktoyaktuk Peninsula derived using post calving photography, July 2006. Manuscript Report 171. Yellowknife: Department of Environment and Natural Resources, Government of the Northwest Territories. 66 p.

Parkinson, A.J., and Butler, J.C. 2005. Potential impacts of climate change on infectious diseases in the Arctic. International Journal of Circumpolar Health 64(5):478–486.

Service, R. 1958. Songs of the High North. Toronto: McGraw-Hill Ryerson Ltd. 126 p.

Trudeau, S., Mineau P., Cartier, G.S., Fitzgerald, G., Wilson, L., Wheler, C., and Knopper, L.D. 2007. Using dried blood spots stored on filter paper to measure cholinesterase activity in wild avian species. Biomarkers 12:145–154.

Van Oostdam, J., Donaldson, S.G., Feeley, M., Arnold, D., Ayotte, P., Bondy, G., Chan, L., et al. 2005. Human health implications of environmental contaminants in Arctic Canada: A review. Science of the Total Environment 351-352:165–246.

Vors, L.S., and Boyce, M.S. 2009. Global declines of caribou and reindeer. Global Change Biology 15(11):2626–2633, doi: 10.1111/j.1365-2486.2009.01974.x.

Yu, C., Zimmerman, C., Stone, R., Engle, R.E., Elkins, W., Nardone, G.A., Emerson, S.U., and Purcell, R.H. 2007. Using improved technology for filter paper-based blood collection to survey wild Sika deer for antibodies to hepatitis E virus. Journal of Virological Methods 142:143–150.

Patricia Curry, a veterinarian who is currently a doctoral student in the Faculty of Veterinary Medicine, University of Calgary, is the 2009 recipient of the Lorraine Allison Scholarship. E-mail: pscurry@ucalgary.ca.