Brucellosis trends in caribou and muskoxen from the western Kitikmeot and Inuvialuit regions

Results from Kutz lab health surveillance programs and research projects

Interim report 8th of August 2022

Background

Brucellosis has been recognized in the Arctic since the 20th century. *Brucella suis* biovar 4 (BS4) is the main causative agent of brucellosis in northern regions, in both animals and people. Brucellosis in wildlife is considered a reproductive disease that cause abortion and stillborn or weak calves, yet it can also cause severe disease in mature animals (Aguilar et al. 2022). It is commonly referred as rangiferine brucellosis because the primary hosts for BS4 are caribou and reindeer (*Rangifer* spp.), but BS4 is also present in sympatric wildlife like the muskoxen (*Ovibos moschatus*) (Tomaselli et al. 2019). People from the Arctic are exposed to BS4 while harvesting or butchering infected wildlife or with the husbandry and food products from domestic reindeer.

In the Kitikmeot and Inuvialuit regions from the central Canadian Arctic, brucellosis reports in people and caribou were common in the 80s and 90s on the mainland (Forbes 1991; Gunn et al. 1991). More recent surveys suggest that caribou herds that range in this area have lower exposure (0% to 5%) to *Brucella*, with the exception of the *Dolphin and Union* (DU) herd (15%)(Carlsson et al. 2019). Brucellosis has also been present, and likely increasing, in muskoxen from Victoria Island since the late 90s (Tomaselli et al. 2019). Based on historical data which used different serology methods than those available today, there was no evidence of exposure to *Brucella* in muskoxen around Ulukhaktok between 1994-1999, and very low exposure, 0.9%, in muskoxen around Cambridge Bay between 1989-2001. Seropositivity (exposure) subsequently increased around Cambridge Bay to 5.6% in the period 2010-2016 (Tomaselli et al. 2019).

Recent results on brucellosis

In this report, we compile the results on *Brucella* exposure based on serology, and diagnosed cases (postmortem lesions), since 2016 from our collaborative wildlife health surveillance programs in Kugluktuk, Cambridge Bay and Ulukhaktok. These programs are implemented as a partnership with each community's hunters and trappers organization as well as the wildlife department of the Governments of the Northwest Territories and Nunavut and Canada North Outfitting. We also include new data generated by analyzing four other major migratory tundra caribou herds from the region (ongoing research project supported by a Morris Animal Foundation grant).

Methods

To assess *Brucella* exposure, blood on filter paper was collected by hunters/guides from harvested caribou and muskoxen (Curry et al. 2011), and from caribou captures performed by the GN and the GNWT. Caribou blood samples were tested for *Brucella* antibodies with an in-house indirect ELISA (Gall et al. 2001; Curry et al. 2011) and muskox samples with a competitive ELISA (Nielsen et al. 1994) at the Canadian National Brucellosis Reference Laboratory (CFIA; Canadian Food Inspection Agency-Ontario Animal Health Laboratory, Ottawa). Results for animals 2 years old or older are presented in Table 1 (muskoxen) and Table 2 (caribou). We assessed trends of *Brucella* exposure in each area by fitting generalized linear models with a logit link function and a binomial distribution, including *Brucella* serostatus as the response variable and Year as an explanatory and continuous variable.

Abnormal tissues were derived from the community-based sampling, and were abnormalities either identified by harvesters on sample submission, or identified by researchers when samples were processed. These were initially examined by the Diagnostic Service Unit at the Faculty of Veterinary Medicine, the University of Calgary, and if *Brucella* was suspected they were sent to CFIA for bacteriological isolation and identification.

Results

We found evidence of exposure to *Brucella* in muskoxen on Victoria Island and on the Nunavut mainland, east of Bathurst Inlet (Kent Peninsula and western Queen Maud Gulf Bird Sanctuary) between 2016 and 2021 (Tables 1). Active cases of brucellosis were also diagnosed from hunter submissions of abnormal tissues and lesions found when processing sample kits from these regions (Table 3). We detected a significant increasing trend of *Brucella* exposure in muskoxen on NW Victoria from 2016 (0.0%, CI95%: 0.0-49.4) to 2021(35.3%, CI95%:17.3-58.7) (β=0.58; $p<0.01$) (Table 1). This increase in sample prevalence is consistent with the increasing number of brucellosis cases detected on post mortem examinations from Ulukhaktok in the last years (Table 3). No statistically significant trends in *Brucella* exposure were detected in the other areas, likely because of the low sample sizes.

Exposure to *Brucella* in caribou was detected in all migratory tundra caribou herds analyzed. Seroprevalence (percent of positive samples) was low with the exception of the Dolphin and Union caribou herd where seroprevalence ranged up to 31.6% (Table 2). Several cases of brucellosis were diagnosed from the Dolphin and Union herd based on post mortem lesions between 2018-2020 (Table 3).

Discussion of the results

Brucellosis was first diagnosed on northwest Victoria Island in a single muskox in 1996. Subsequent work by Tomaselli et al. provided compelling evidence that brucellosis had increased in muskoxen from Victoria Island by 2016 (Tomaselli et al. 2019). Our surveillance data since then further support this emergence in muskoxen from Victoria Island with a significant increase on northwest Victoria Island around Ulukhaktok. The sample seroprevalence found in NW Victoria Island is the highest ever documented in muskoxen.

An increase of brucellosis in muskoxen implies an increase of the risk of *Brucella* exposure in people who rely on muskoxen for food. Importantly, 3 clinical cases of brucellosis were 'incidental' findings. These were detected while processing the kidneys in the lab (a standard sample collected by hunters for the sample kits). The harvesters of these animals had not reported any abnormalities in the animals and the meat had been consumed long before the samples were sent to the lab. Harvesters are advised to report any abnormalities when they submit sample kits. If an abnormality is reported, that kit is fast tracked to the lab to analyze the suspect sample and determine if it is a food safety risk. If harvesters do not report anything abnormal, the sample kits may be stored for up to 6-9 months prior to batch processing. Brucellosis is less known in muskoxen with no traditional knowledge on the disease in this species. It is possible that the signs of disease are less noticeable or 'typical' than in caribou, in which swollen joints or testicles are commonly associated with diseased animals (Table 3).

Brucellosis in barren-ground caribou herds from the Central Canadian Arctic was a common finding in the 80s and 90s (Forbes 1991; Gunn et al. 1991), however, we found that, with the exception of the Dolphin and Union herd, exposure in these herds is rarer and more sporadic in the recent decade. Nevertheless, exposure to *Brucella* was detected in all caribou herds tested in 2021, and given the poor understanding of the ecology of this disease in Arctic wildlife, future trends should be monitored.

In the Dolphin and Union caribou herd, brucellosis was first diagnosed in 1997 in an animal hunted nearby Cambridge Bay (Canadian Wildlife Health Cooperative database). Brucellosis-like signs in this caribou herd have been reported for the last two decades by local hunters, with an apparent decrease in occurrence of swollen joints during the last decade (Tomaselli et al. 2019; Hanke et al. 2022). Our surveillance confirmed that brucellosis is maintained in this herd, despite a precipitous population decline between 2015 and 2018 (Leclerc and Boulanger 2020). We also found that adult female caribou that are exposed to *Brucella* are less likely to be pregnant and are in poorer body condition (Aguilar and Kutz 2020).

Brucellosis dynamics in Arctic wildlife are poorly understood, yet emergence and re-emergence is a well-known trait of this disease (Aguilar et al. 2022). Our community-based sampling has shown that diseased animals are not uncommon in the Kitikmeot, NU, and northwest Victoria Island, NWT, and that some of these animals are being eaten thus posing an important exposure risk for people. While the effects of brucellosis on body condition, reproduction and survival of wildlife are well documented, the impacts on the health of muskoxen and caribou at population level are unknown. Additionally, our general understanding of the ecology of brucellosis in the Arctic needs to be revisited. Historically it was thought that caribou and reindeer are the only maintenance host in the Arctic, however, our data demonstrate that the sample prevalence in muskoxen is as high as that in the Dolphin and Union caribou herd. Ongoing surveillance for this disease in country foods is important to assess the risk to local communities and inform them accordingly. Because of the risk of this disease for the health of wildlife and people, further and improved (e.g. increased sampling effort) surveillance in wildlife from this region, together with ongoing and appropriate public health messaging, is recommended.

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Table 1. Sample prevalence (%) of *Brucella* exposure in muskoxen (more than 2 years old) from the western Kitikmeot and the Inuvialuit regions of the Central Canadian Arctic. The Areas are organized by geographic location within Victoria Island (SE: around Cambridge Bay; NW: around Ulukhaktok; SW: Pin-3 Area), and Mainland (E: East of Bathurst Inlet, including Kent Peninsula; W: West Bathurst Inlet).

Area	n	2016	2017	2018	2019	2020	2021	Total
Victoria Island SE	37	10.0 (0.5-40.4)	11.1 (0.6-43.5)	0.0 (0.0-43.4)	0.0 (0.0-65.8)	0.0 (0.0-25.9)	NA	5.4 (1.5-17.7)
Victoria Island NW	75	0.0 (0.0-49.0)	7.7 (0.4-33.3)	5.0 (0.3-23.6)	22.2 (9.0-45.2)	33.3 (1.7-79.2)	35.3 (17.3-58.7)	17.3 (10.4-27.4)
Victoria Island NW	68	0.0 (0.0-49.0)	7.7 (0.4-33.3)	5.0 (0.3-23.6)	22.2 (9.0-45.2)	33.3 (1.7-79.2)	40.0 (16.8-68.7)	16.2 (9.3-26.7)
Victoria Island SW	13	NA	10.0 (0.5-40.4)	0.0 (0.0-56.1)	NA	NA	NA	7.7 (0.4-33.3)
Mainland E	29	0.0 (0.0-94.9)	0.0 (0.0-56.1)	14.3 (5.0-34.6)	0.0 (0.0-56.1)	100.0 (5.1-100.0)	NA	13.8 (5.5-30.6)
Mainland W	94	NA	0.0 (0.0-29.9)	0.0 (0.0-8.0)	0.0 (0.0-8.6)	NA	NA	0.0 (0.0-3.9)

NA: No available samples (2016 onwards) or not comparable results (previous 2016) because samples were analyzed with different laboratory methods.

Table 2. Results on exposure to *Brucella* in migratory tundra caribou (more than 2 years old) from four herds from the western Kitikmeot and Inuvialuit regions.

Herd	**Method (samples)**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Dolphin and Union herd	Captured (n=114)	NA	NA	NA	NA	NA	NA	NA	NA	NA	**21.4¶** (7.6-47.6)	**12.5¶** (3.5-36.0)	NA	**2.2** (0.1-11.6)	NA	NA	**15.4** (7.2-29.7)	10.5 (6.1-17.5)
	Hunted (n=131)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0 (0.0-22.8)	0.0 (0.0-43.4)	0.0 (0.0-39.0)	**31.6** (19.1-47.5)	**20.0** (10.9-33.8)	**14.3** (4.0-39.9)	**10.0** (0.5-40.4)	18.3 (12.6-25.8)
Bathurst herd	Captured (n=190)	NA	0.0 (0.0-29.9)	0.0 (0.0-65.8)	NA	0.0 (0.0-21.5)	0.0 (0.0-25.9)	0.0 (0.0-39.0)	0.0 (0.0-50.0)	**20.0** (5.7-51.0)	0.0 (0.0-11.7)	0.0 (0.0-32.4)	0.0 (0.0-20.4)	0.0 (0.0-29.9)	0.0 (0.0-20.4)	0.0 (0.0-8.2)	**6.7** (0.3-29.8)	1.6 (0.5-4.5)
	Hunted (n=122)	NA	**6.5** (2.2-17.5)	**2.1** (0.1-10.9)	**7.1** (2.0-22.6)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.9 (2.3-10.3)
Bluenose East herd	Captured (n=241)	NA	0.0 (0.0-65.8)	0.0 (0.0-22.8)	0.0 (0.0-10.7)	0.0 (0.0-24.2)	0.0 (0.0-65.8)	0.0 (0.0-17.6)	0.0 (0.0-56.1)	**13.3** (3.7-37.9)	0.0 (0.0-13.3)	0.0 (0.0-20.4)	0.0 (0.0-24.2)	0.0 (0.0-27.7)	0.0 (0.0-20.4)	**2.9** (0.1-14.5)	**3.1** (0.2-15.7)	1.7 (0.6-4.2)
	Hunted (n=116)	0.0 (0.0-21.5)	0.0 (0.0-27.7)	0.0 (0.0-43.4)	0.0 (0.0-12.1)	NA	NA	NA	0.0 (0.0-35.4)	0.0 (0.0-15.5)	NA	NA	NA	0.0 (0.0-14.9)	0.0 (0.0-14.9)	0.0 (0.0-94.9)	NA	0.0 (0.0-3.2)
Beverly-Ahiak herd	Captured (n=213)	0.0 (0.0-17.6)	0.0 (0.0-16.1)	0.0 (0.0-13.8)	NA	0.0 (0.0-94.9)	NA	0.0 (0.0-35.4)	0.0 (0.0-94.9)	0.0 (0.0-14.9)	**4.3** (0.2-21.0)	0.0 (0.0-94.9)	**3.4** (0.2-17.2)	0.0 (0.0-32.4)	**5.0** (0.3-23.6)	0.0 (0.0-56.1)	**8.4** (2.9-21.8)	2.8 (1.3-6.0)
	Hunted (n=29)	NA	NA	NA	0.0 (0.0-11.7)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0 (0.0-11.7)

¶ Part of these results were previously published in Carlsson et al. 2019.

NA: No samples available to analyze.

Table 3. Cases of brucellosis diagnosed in caribou and muskoxen from the Kitikmeot and Inuvialuit regions since 2016. These cases are mostly derived from the community-based sampling and were submitted as "abnormal findings" or discovered during sample processing of harvested animals. Prior to this work, there were only 5 cases of brucellosis, confirmed through bacterial isolation, reported from Dolphin and Union caribou (1998, 2007, 2010 and 2015), and four cases from muskoxen on Victoria Island (1996, 1998, 2014 and 2016). These previous cases were recorded in the Canadian Wildlife Health Cooperative (CWHC) database and the muskox cases were also published in Tomaselli et al. 2016 and Tomaselli et al. 2019.

Animal ID	Date	Community / location	Sex and age	Abnormality detected	Sample submitted/Gross findings
Caribou (Dolphin and Union herd)					
DU-104	2018-05-12	Kugluktuk / Mainland W	Female, 12 years	Swollen joints in both front legs	Two forelimbs / bursitis and hygromas in both carpometacarpal joints
DU-141	2018-05-08	Kugluktuk / Mainland W	Female, Adult	Swollen joint in one front leg	One forelimb / bursitis in metatarsophalangeal joints
DU-201	2018-05-03	Kugluktuk / Mainland W	Female, 3 years	Swollen joints in both front legs	One forelimb / bursitis and hygromas in both carpometacarpal joints
DU-233	2019-05-12	Kugluktuk / Mainland W	Male, 5 years	Swollen testicles and joint in one front leg	Testicles and one forelimb / bursitis in the carpometacarpal joint
DU-236	2019-05-13	Kugluktuk / Mainland W	Male, 5 years	Hard, small lump in each front leg	One forelimb / Bone overgrowth around carpometacarpal joint, consistent with chronic inflammation
CBDU004	2020-11-01	Cambridge Bay / Victoria Island SE	Female, Adult	Liver nodules at section, found while processing sample	Piece of liver / granulomatous lesions

Muskoxen

MX-477*	2018-03-23	Cambridge Bay / Mainland E	Male, >4 years	Swollen joints (abscess) in one front leg	Abscess
MX-544*	2018-04-01	Cambridge Bay / Mainland E	Male, >4 years	Swollen joints (abscess) in both front legs	Abscess
MX-505	2018-05-07	Ulukhaktok / NW Victoria Island	Male, 3 years	Muscle abscess and enlarged lymph nodes	Abscess muscle and lymph node / Caseous lymphadenitis with mineralization
MX-506	2019-04-29	Ulukhaktok / NW Victoria Island	Female, >4 years	Swollen joints (abscess) in one front leg and enlarged lymph nodes	Lymph nodes / Caseous lymphadenitis with mineralization
MX-722	2020-04-12	Cambridge Bay / Mainland E	Male, >4 years	Kidney abscesses, found while processing sample	Kidney / Multiple chronic renal abscesses
ULU-005	2021-04-17	Ulukhaktok / NW Victoria Island	Female, >4 years	Kidney abscesses, found while processing sample	Kidney / Multiple chronic renal abscesses
DSU21-0407	2021-04-24	Ulukhaktok / NW Victoria Island	Female, 3 years	Abscess in one front leg and swollen back leg	Part of the back leg / bursitis and hygroma
ULUMX113	2022-01-19	Ulukhaktok / NW Victoria Island	Female, 3 years	Kidney abscesses, found while processing sample	Kidney / Multiple chronic renal abscesses

* Strong seropositive, but case not confirmed by culture.