An Opportunistic Parasitological and Serological Examination of Nuisance Black Bears in the Dehcho Region of the Northwest Territories

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ABSTRACT

One hundred and thirty black bear mortalities (113 nuisance bears and 17 other mortalities) were recorded in the Dehcho region of the NWT from 2002 - 2010. Gastrointestinal tracts, lung, and blood samples were collected from nuisance black bears in 2002 and 2003, while muscle and first pre-molar tooth samples were collected from 121 bear mortalities from 2002 - 2010. The seroprevalence of antibodies to rabies virus, canine parvovirus, canine distemper virus and *Toxoplasma gondii* antibodies in black bears was 0 of 16 (0%), 0 of 14 (0%), 2 of 6 (33%) and 2 of 16 (12.5%), respectively. *Trichinella* spp. larvae were found in 7 of 120 (5.8%) black bears; while three of those seven bears that had tested positive had >1 Trichinella spp. larvae per gram of muscle tissue which is the level considered to pose a food safety risk. The prevalence of *B. transfuga* and *Uncinaria rauschi* was 18 of 28 (64.3%) and 9 of 28 (32.1%) black bears, respectively. Cestode worms were observed in the gastrointestinal tract of 3 of 28 black bears and were assumed to be *Diphyllobothrium* spp. and *Taenia* spp. No lungworms, flukes, *Giardia* spp. or *Cryptosporidium* spp. were documented. An incidental observation of microfilaria in the blood vessels of skin and liver tissue was recorded in one nuisance black bear sampled in 2003; microfilaria were assumed to represent the larval stage of the connective tissue nematode *Dirofilaria ursi*. Sylvatic infections of *Trichinella* spp. occur in black bear populations across Canada and the United States. Consumption of raw or undercooked black bear or walrus meat has been the main cause of human trichinellosis cases in Canada since 1980. *Toxoplasmosis gondii* occurs in a wide variety of wildlife including black bears and the skinning of animals and the ingestion of improperly prepared wild game has been linked to human cases of toxoplasmosis in North America. *Trichinella* spp. infections in black bears is a genuine food safety risk to harvesters from the Dehcho region that can be managed through public awareness programs, monitoring the prevalence or presence of *Trichinella* spp. infection in black bear populations and other harvested species, and proper management of

community waste disposal to prevent scavenging. The risk of *Toxoplasmosis gondii* infection in black bear meat to food safety is unknown, but public awareness programs on proper handling and preparation of meat can allow for safe consumption of wild game. More research is required to assess the ecology of *T. gondii* in wildlife and their potential for human exposure from wildlife sources. Human cases of *Dirofilaria ursi*-like infections are rare, but may cause subcutaneous nodules at sites of black fly bites. More work would help to assess the prevalence of *D. ursi* infections in black bears of the Dehcho. *Baylisascaris transfuga* may be a potential zoonotic pathogen and handling bear feces should be avoided; as well, proper hygiene should be followed after handling any carcasses.

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INTRODUCTION

Black bears are the most common and widely distributed bear species in North America occurring in 39 states, all Canadian provinces and the Yukon and NWT (Pelton 2000). Unlike grizzly and polar bears, the range and numbers of many populations of black bears have not been adversely impacted in the face of expanding human populations. Black bears are found throughout the Dehcho region located in southwestern portion of the NWT (Figure 1). In the Dehcho, black bears are a subsistence harvest species for meat and fur. Black bears are also a big game species harvested by both resident and non-resident hunters. However, most management of black bears in the Dehcho and other regions of the NWT primarily involves dealing with human - bear conflicts and nuisance bears in and around human settlements and industrial developments.

Nuisance black bears killed for public safety provide an opportunity to obtain baseline information on parasites and exposure to disease-causing agents such as viruses, bacteria and parasites, and to determine the presence of zoonotic pathogens known to occur in other black bear populations in Canada or other wildlife populations in the NWT. *Trichinella* spp., a genus of nematodes, is found in a wide variety of mammalian species world-wide and can cause disease in humans that consume raw or under-cooked meat infected with *Trichinella* larvae. In Canada, *Trichinella* is known to occur primarily in mammalian carnivores and omnivores (Appelyard and Gajadhar 2000) and the larvae are found in the musculature of infected hosts. *Trichinella* infections in humans can range from being asymptomatic to life-threatening. Clinical signs in humans occur approximately five to ten days after ingesting infected meat and may include one or more of the following: periorbital and facial edema, muscle pain, conjunctivitis, photophobia, gastrointestinal upset, headache and skin rash (Larter et al. 2011). All human cases of trichinellosis in Canada since 1980, except for one, have been attributed to the consumption of raw or undercooked black bear or walrus meat (Appelyard and Gajadhar 2000).

Toxoplasmosis gondii is a protozoal parasite with world-wide distribution that can cause toxoplasmosis in humans. Domestic and wild felids are the only known definitive host of *T. gondii*. In cats infected with *T. gondii*, protozoa replicate within the gastrointestinal tract producing oocysts that are excreted in the feces. Other mammals including humans become infected when they ingest water or vegetation contaminated with infective oocysts. Within secondary hosts, the oocysts mature in the gastrointestinal tract into developmental stages that enter the bloodstream and lymphatic system and are carried to various tissues where they form tissue cysts. Consumption of tissue cysts is another form of *T. gondii* transmission to secondary hosts. *T. gondii* infection poses the highest risk to pregnant women that have never been exposed to the protozoa, as they may transmit the infection to their unborn fetus. Congenital toxoplasmosis may be asymptomatic, or may cause abortion or a variety of clinical signs with ocular disease being most common and hydrocephalus being the rarest but most severe lesion (Hill and Dubey 2002). Most human infections with *T. gondii* are asymptomatic but can cause severe disease, especially in immunocompromised individuals. Clinical signs occur within 10 to 23 days after ingesting meat infected with tissue cysts and include swollen lymph nodes, muscle pain, fever, headache, fatigue, sore throat and anemia. More severe manifestations of toxoplasmosis include disease associated with destruction of heart, liver, brain and eye tissue (Hill and Dubey 2002). The role of wildlife in the transmission of toxoplasmosis to humans is not well understood. Consumption of raw caribou and skinning animals for fur has been implicated in cases of abortion in women of northern Quebec (McDonald et al. 1990). Black bear and white tail deer populations in North America, especially the eastern United States, have the highest documented prevalence of *T. gondii* exposure or infection (Dubey et al. 2004).

The objectives of this study were threefold. From black bear mortalities opportunistically sampled in the Dehcho region of the NWT we wanted to provide preliminary information on the prevalence of existing diseases documented to occur in black bears and the prevalence of

parasites found in black bears and assess the prevalence of zoonotic pathogens known to occur in black bears. More specific objectives were:

1) To document the seroprevalence of exposure to two canine viruses (canine distemper virus and canine parvovirus-2) and rabies virus to assess the potential significance of these viruses for individual black bear health and population demographics in the Dehcho region;

2) To identify and record the prevalence of gastrointestinal and lung parasites to assess the parasitological potential significance to individual black bear health and population demographics and to identify and assess the risk of potential zoonotic parasites; and

3) To document the seroprevalence of *Toxoplasmosis gondii* antibody and the prevalence of *Trichinella* spp. larvae infection in black bear in the Dehcho region to identify potential food safety risks associated with the handling and consumption of black bear meat.

The post mortem diagnosis from one nuisance black bear is also included in this report.

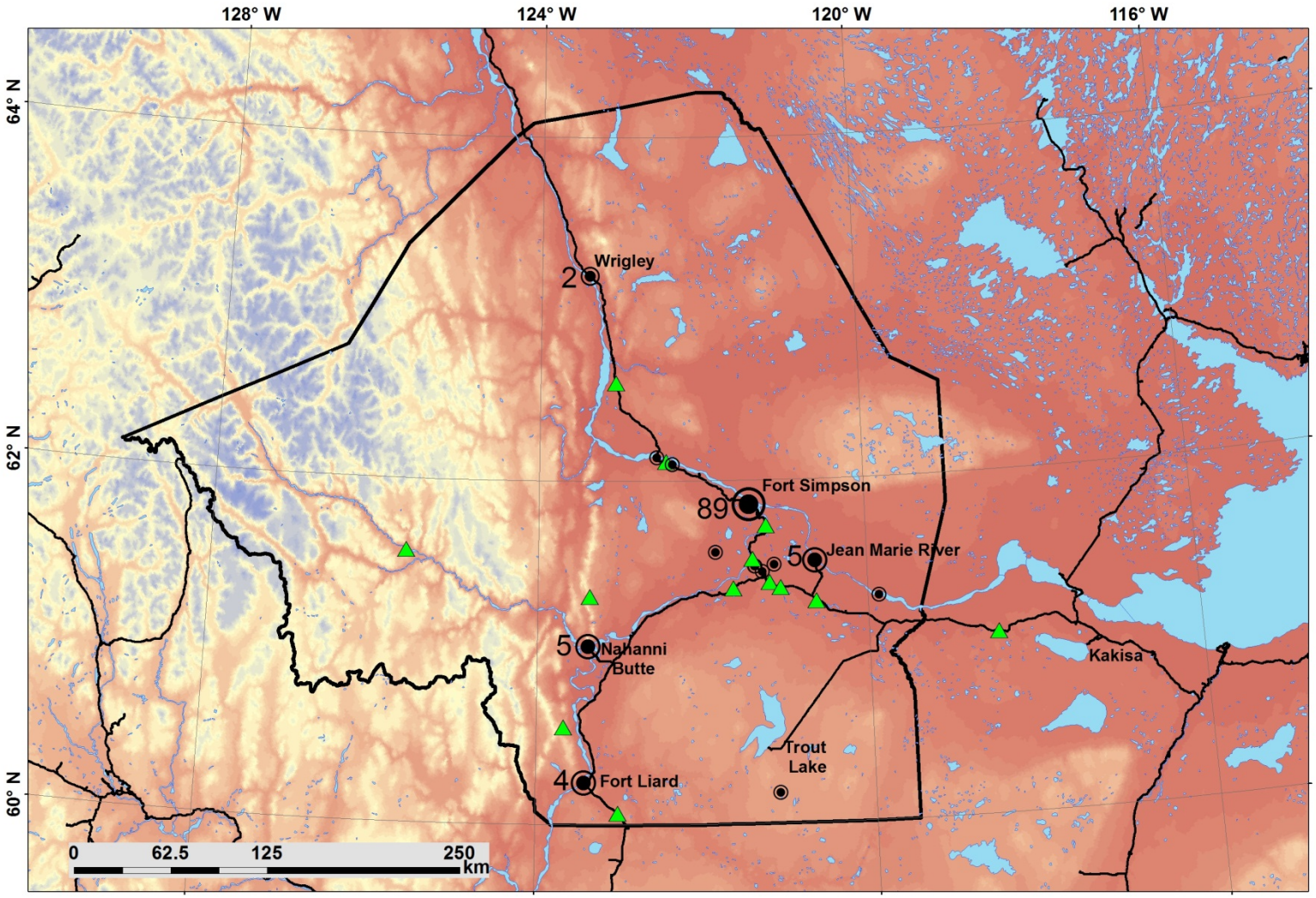

Figure 1: Location of black bear mortalities sampled in the Dehcho region of the NWT from 2002 - 2010. • indicates nuisance bear ▲indicates other type of mortality.

METHODS

From 2002-2010, samples were opportunistically collected from black bears that were either killed for public safety reasons (nuisance bears; n=113) or found dead (n=17) around the communities in the Dehcho region of the NWT (Figure 1). Between 2002 to 2003, the gastrointestinal tract (stomach to rectum) and one lung (other lung was fixed in formalin) were collected from 28 and 27 bears, respectively for parasite analysis; and blood (internal jugular vein) was collected from 16 bears for serological analysis. Additionally, a piece of the tongue was sampled from 119 bears between 2002-2010 to test for *Trichinella* spp. larvae and one bear had the masseter muscle sampled since the tongue was not present. The first premolar was removed from each sampled bear for aging (Table 1). The blood was centrifuged and the serum was stored at -20° C until tested; all other samples were frozen and stored at -20° C until examined.

Table 1: Number of samples collected from individual black bear mortalities in the Dehcho region of the NWT between 2002 - 2010.

Year	Gastrointestinal Tract	Lungs	Feces	Blood	Tongue	First Pre-molar [a]
2002	12	11	11	7	12	13
2003	16	16	16	9	21	21
2004	n/a [b]	n/a	n/a	n/a	7	7
2005	n/a	n/a	n/a	n/a	10	10
2006	n/a	n/a	n/a	n/a	19	20
2007	n/a	n/a	n/a	n/a	9	9
2008	n/a	n/a	n/a	n/a	15	17
2009	n/a	n/a	n/a	n/a	14[c]	14
2010	n/a	n/a	n/a	n/a	13	13

[a] Samples could not always be collected from all bear mortalities, and therefore, the tooth may have been taken but no other samples collected.
[b] No sample collected.
[c] Masseter muscle was sampled for one bear instead of the tongue.

Age Determination

The age of the bears sampled was estimated based on counting cementum annuli from the root of the first premolar (Matson 1981).

Serum Analysis

Serological testing was performed for toxoplasmosis at the Animal Parasitic Diseases Lab (Beltsville, Maryland, USA), rabies virus at the Kansas State University Veterinary Medical Center (Manhattan, Kansas, USA), and canine parvovirus (CPV-2) and canine distemper virus (CDV) at the Prairie Diagnostic Services Lab (Saskatoon, SK). Each serological test is described below.

Toxoplasma gondii

The modified agglutination test (MAT) using formalin fixed tachyzoites as antigen developed by Dubey and Desmonts (1987) was employed to detect the presence of *T. gondii* antibody in black bear serum samples, and is the most sensitive test available to detect latent *T. gondii* infections in black bears (Dubey et al. 1995a). Sera, diluted two fold starting at 1 in 25, was added to an antigen suspension. Based on validity of the MAT technique in domestic pigs, serum samples that agglutinated the antigen suspension at a dilution factor greater than 1 in 25 were indicative of natural and experimental exposure to *T. gondii* (Dubey 1997). Therefore, serum titres ≥25 were considered to be positive for *T. gondii* exposure in black bears.

Rabies virus

The rapid fluorescent focus inhibition test based on Smith et al. (1973) was used to detect the presence of rabies virus antibody in black bear serum samples. Serial five-fold dilutions of sera were mixed with a standard dose of live rabies virus and a tissue culture suspension. A sample of the cell suspension was fixed to a slide and stained with fluorescein-labelled anti-rabies antibodies to detect the presence of non-neutralized rabies virus observed as fluorescent foci under a microscope. If the serum sample did not contain rabies antibodies, or had fewer antibodies than the standard rabies virus added to the sample, the non-neutralized

rabies virus will infect the cells in the tissue culture. The titre was based on the percent of cells infected by rabies virus (fluorescent foci) observed on the slide. A titre <5 was considered negative for rabies antibody.

Canine parvovirus

Black bear sera were tested for antibodies to canine parvovirus-2 (CPV-2) using the hemagglutination inhibition test based on Carmichael et al. (1980). Serial dilutions of sera were incubated with animal red blood cells and a commercial strain of CPV-2. Sera dilutions that completely inhibited hemagglutination of red blood cells were considered positive for CPV-2 antibody. The titre for each serum sample was based on the highest dilution that completely inhibited hemagglutination. A titre ≥ 20 was considered positive for CPV-2.

Canine distemper virus

Viral neutralization based on Appel et al. (1973) was used to detect the presence of antibody to canine distemper virus (CDV) in black bear sera. Serial dilutions of sera were incubated with tissue culture cells and a commercial strain of CDV. The viral antibody titre was determined based on observed cytopathic changes to the tissue culture cells. Sera that produced no cytopathic change were considered positive for CDV antibody. The titre of each serum sample was based on the highest dilution that completely inhibited cytopathic effects. A titre ≥ 12 was considered positive for CDV exposure.

Parasite Analysis

Gastrointestinal and lung parasite analysis was conducted at the Western College of Veterinary Medicine (Saskatoon, SK) and *Trichinella* spp. larvae analysis was performed by the Centre for Animal Parasitology (Canadian Food Inspection Agency, Saskatoon, SK).

Lungs were first examined for presence of lesions and the airways were then incised and grossly examined for parasites. The lungs were rinsed into a sieve with pores 75 microns in diameter. The material collected in the sieve was grossly examined for parasites.

The stomachs were opened and the contents were grossly examined for parasites. The entire intestinal tract except the distal 30 cm of colon was incised and the contents were washed into a bucket. The intestinal content was poured through a sieve with pores 600 microns in diameter. The material collected in the sieve was examined grossly and by stereomicroscope for parasites. Some bears had a large quantity of intestinal content, and therefore, it was not feasible to examine the entire gut content by microscope examination. For these bears, two subsamples containing 5% of the intestinal content collected from the sieve were examined by stereomicroscope and the total number of smaller parasites was extrapolated based on the average number of parasites observed in each aliquot.

Where present, feces were collected from the rectum and distal 30 cm of the colon. A modified Wisconsin floatation technique was used to detect eggs from nematodes and cestodes, and oocysts from protozoal parasites. The presence of larvae in the feces was assessed using the Baermann technique. Sedimentation of the feces ("Flukefinder") was performed to detect flukes. Sucrose gradient floatation and immunofluorescence assay stain was performed to identify *Giardia* spp. cysts. and *Cryptosporidium* spp. oocyts. All fecal examinations for parasites were conducted according to the Western College of Veterinary Medicine parasitology techniques manual (Kutz 2003a, Kutz 2004).

The artificial digestion method using a magnetic stirrer and double separatory funnels (Forbes and Gajadhar 1999) was used to detect the presence of *Trichinella* spp. larvae in the tongue and masseter muscle samples. The samples were thawed, any fat and connective tissue was trimmed from the samples, and the samples were then weighed. Samples were then individually blended and the homogenate was digested using an artificial digestive fluid consisting of 1% pepsin and 1% hydrochloric acid. The digestive fluid was then filtered through two sequential separatory funnels and the suspension allowed to settle. The supernatant was removed and the sediment poured into a gridded petri dish and examined for larvae by

microscope at 15 to 40X magnification. The results were reported as number of larvae per gram of tissue tested.

Statistical methods

Due to the small sample size of bears and the low prevalence of parasites and viruses observed, only descriptive statistics were performed. The data were inadequate to examine whether prevalence varied between sex or age of bears, location of where bears were sampled or the year of sample collection.

Post mortem analysis

The liver and skin of one nuisance bear in 2003 had abnormal liver and skin lesions, additionally; the bear was old, in poor body condition and had areas of hair loss. Frozen liver and skin samples were sent to the Canadian Cooperative Wildlife Health Centre (CCWHC) for gross analysis and histopathology.

RESULTS

Demographics of opportunistically sampled nuisance black bears

There were 130 black bear mortalities reported from 2002-2010, 113 of which were nuisance bears. The average number of sampled bears was 14 per year, range 7 - 21 bears (Table 2). The majority of bears were male (68%), 26% were female, while the sex was unknown for the remainder. Most reported mortalities occurred around the community of Fort Simpson. The average age of sampled bears per year is presented in Table 3 with an average age of 9.3 years reported for the entire collection period. The youngest were cubs of the year that accompanied a sow, while the oldest being a 28-year old nuisance bear. From 2002-2010, the age of animals was skewed towards older animals (Table 4), but during 2002 to 2003, the number of bears <8 years was nearly equal to the number of bears ≥8 years old.

Table 2: Number, sex and location of black bear mortalities per year in the Dehcho region of the NWT between 2002 - 2010. The number in parentheses is the number of nuisance bears put down for public safety.

Year	Number	Sex			Area	
		Female	Male	Unknown	Fort Simpson	Other
2002	15 (12)	7 (6)	7 (6)	1 (0)	12 (11)	3 (1)
2003	21 (20)	5 (4)	14 (14)	2 (2)	16 (15)	5 (5)
2004	7 (7)	1 (1)	6 (6)	0 (0)	4 (4)	3 (3)
2005	11 (8)	4 (1)	6 (6)	1 (1)	4 (4)	7 (4)
2006	21 (18)	4 (3)	16 (14)	1 (1)	16 (15)	5 (3)
2007	9 (7)	3 (1)	6 (6)	0 (0)	5 (5)	4 (2)
2008	18 (15)	6 (5)	10 (9)	2 (1)_	12 (11)	6 (4)
2009	14 (13)	3 (3)	10 (10)	1 (0)	10 (10)	4 (3)
2010	14 (13)	1 (1)	13 (12)	0 (0)	9 (9)	5 (4)
Total	130 (113)	34 (25)	88 (83)	8 (5)	88 (84)	42 (29)

Table 3: Age of black bear mortalities per year in the Dehcho region of the NWT between 2002 - 2010.

Year	Age(years)			
	Average	Standard Deviation	Minimum	Maximum
2002	8.5	6.8	coy [a]	21
2003	8.4	4.7	2	18
2004	11.7	6.8	1	20
2005	11.3	6.7	coy	19
2006	8.9	3.4	coy	15
2007	7.3	5.9	2	17
2008	9.9	5.5	2	22
2009	9.4	6.3	2	22
2010	10.0	8.7	3	28
2002-2010	9.3	5.9	coy	28

[a] Cub of the year.

Table 4: Age category of black bear mortalities per year in the Dehcho region of the NWT between 2002 - 2010.

Year	Age Category (years)					
	< 2 y	≥2 - 4 y	≥4 - 8 y	≥8 - 13 y	≥13 y	n/a [a]
2002	2	2	2	4	3	2
2003		3	7	7	4	
2004	1			3	3	
2005	1	1		3	5	1
2006	1		4	14	1	1
2007		4	2		3	
2008		3	2	8	4	1
2009		2	5	4	3	
2010		2	6	1	4	1
Total number	5	17	28	44	30	6

[a] No tooth was available for aging.

Seroprevalence

Antibody titres for bears tested for canine distemper, canine parvovirus-2, rabies virus and *Toxoplasma gondii* are presented in Appendix A. Seroprevalence by year, sex and age category is presented in Appendix B. Seven and nine bears were tested for *Toxoplasma gondii* and rabies virus antibodies in 2002 and 2003, respectively; while five and nine bears were tested for canine distemper and canine parvovirus-2 antibodies in 2002 and 2003, respectively.

Of the 16 bears tested for exposure to *Toxoplasma gondii* and rabies virus, 69% (11 of 16) were male; 19% were <4 years old, 25% were between 4-8 years and 56% were >8 years old; and all except one bear was from the Fort Simpson area (Appendix A + B). Of the 14 bears tested for CPV-2 and CDV antibody, 71% were male; 22% were <4 years old, 14% were between 4-8 years and 64% were >8 years old; and all except one was collected from around the community of Fort Simpson (Appendix A + B).

Canine Parvovirus

None of the bears tested in 2002 (n = 5) or 2003 (n = 9) had antibodies to canine parvovirus-2 at a significant level (titre ≥20), and therefore, did not show previous exposure to CPV-2 (Appendix B).

Rabies Virus

All bears sampled in 2002 (n = 7) and 2003 (n = 9) tested negative for previous exposure to the rabies virus (titre ≤5) (Appendix B).

Canine Distemper Virus

Eight bear sera samples (three of five samples in 2002 and five of nine samples in 2003) were toxic to the indicator cell line, and therefore, these test results were inconclusive to whether these bears had previous exposure to canine distemper virus (CDV). Of the remaining samples, 33% of six bears tested positive for antibody to the CDV virus (Table 5). Of the six bears with conclusive results, 83% were male (five of six bears), 83% were ≥9 years old and all were collected from the Fort Simpson area; similarly, the two bears that tested positive for previous CDV exposure were both male, ≥9 years old and from the Fort Simpson area.

Table 5: Identification number, year of collection, sex, age, sample location and titre for black bears tested for canine distemper virus antibody.

Bear ID	Year	Sex	Age (years)	Collection location	Canine Distemper Titre [a]
BB4	2002	M	2	Simpson	Inconclusive
BB5	2002	F	13	Simpson	Inconclusive
BB6	2002	F	coy [b]	Simpson	<6
BB14	2002	M	12	Simpson	6
BB15	2002	F	coy	Simpson	Inconclusive
BB19	2003	M	11	Simpson	<6
BB20	2003	M	5	Simpson	Inconclusive
BB21	2003	M	4	Simpson	Inconclusive
BB22	2003	M	18	Simpson	Inconclusive
BB23	2003	M	9	Simpson	Inconclusive
BB24	2003	F	10	Bannockland	Inconclusive
BB25	2003	M	14	Simpson	972
BB26	2003	M	11	Simpson	<6
BB27	2003	M	9	Simpson	18

[a] A titre ≥12 was considered positive for previous exposure to canine distemper virus.
[b] Cub of the year (less than one year old in age).

Toxoplasma gondii

Between 2002-2003, 12.5% of 16 (n=2) opportunistically sampled bears tested positive for exposure to *Toxoplasma gondii* (Table 6). Both positives were sampled in 2003 from the Fort Simpson area and were male; one was 4 years old, while the other was 18 years old.

Table 6: Identification number, year of collection, sex, age, sample location and titre for black bears tested for *Toxoplasma gondii* antibody.

Bear ID	Year	Sex	Age (years)	Collection location	*Toxoplasma gondii* Titre [a]
BB2	2002	M	7	Simpson	<25
BB4	2002	M	2	Simpson	<25
BB5	2002	F	13	Simpson	<25
BB6	2002	F	coy	Simpson	<25
BB10	2002	F	4	Simpson	<25
BB14	2002	M	12	Simpson	<25
BB15	2002	F	coy	Simpson	<25
BB19	2003	M	11	Simpson	<25
BB20	2003	M	5	Simpson	<25
BB21	2003	M	4	Simpson	>1200
BB22	2003	M	18	Simpson	100
BB23	2003	M	9	Simpson	<25
BB24	2003	F	10	Bannockland	<25
BB25	2003	M	14	Simpson	<25
BB26	2003	M	11	Simpson	<25
BB27	2003	M	9	Simpson	<25

[a] A titre ≥ 25 was considered positive for previous exposure to *T. gondii*.

Parasite Prevalence

The number of fecal eggs, cysts and oocysts, gastrointestinal parasites, lung parasites and *Trichinella* spp. larvae observed in the samples collected in 2002 and 2003 are presented in Appendix C; the prevalence of gastrointestinal nematodes and *Trichinella* spp. larvae by sample year, sex and age category is presented in Appendix D. Kutz (2003a and 2004) conducted the parasitological examination of black bear mortalities in the Dehcho during 2002 and 2003.

Fecal eggs, cysts and oocysts

During 2002 – 2003, eggs in the feces from the *Baylisascaris* genus and Strongylidae family were observed in 44% (n = 12) and 11% (n = 3) of 27 of bears, respectively. Additionally, cestode eggs, assumed to be *Taenia* spp., were seen in the feces from one bear in 2003 (prevalence = 3.7%) (Table 7). Bears observed with *Baylisascaris* eggs were mainly male (67%), and 17% were <4 years, 33% were 4 - 8 years, 33% were 8 - 13 years and 17% were

≥13 years old. All bears documented with *Strongylidae* eggs were male and ≥4 years old. The sex and age structure of the bears that tested positive for fecal parasites was similar to all the bears analyzed for fecal parasites, as well as those that tested negative for fecal parasites; namely, the majority were male and ≥4 years of age (see Appendix B).

No fluke eggs, fecal larvae, *Giardia* spp. cysts or *Cryptosporidium* spp. oocysts were observed in feces examined by sedimentation, Baermann or sucrose gradient floatation techniques, respectively.

Table 7: Prevalence of *Baylisascaris*, *Strongylidae* and *Taenia* eggs observed in fecal samples collected from black bear mortalities in the Dehcho region, NWT from 2002 – 2003.

Year	# Samples	*Baylisascaris* eggs	*Strongylidae* eggs	*Taenia* eggs
		Prevalence		
2002	11	36.3%	0.0%	0.0%
2003	16	50.0%	56.3%	6.3%
2002-03	27	44.4%	11.1%	3.7%

Gastrointestinal Parasites

From the samples collected in 2002 and 2003, two nematodes were found in the stomach and intestinal tract; the ascarid identified as *Baylisascaris transfuga* was found in 18 of 28 bears (64% prevalence) and the hookworm, *Uncinaria rauschi*, was found in 9 of 28 bears (32% prevalence) (Tables 8 and 9). Cestodes were observed in the intestinal content of three bears sampled in 2003; the cestodes were most likely *Taenia* spp. and *Diphyllobothrium* spp. An unknown worm was found in the intestinal content of one bear sampled in 2003. The mean intensity of parasites presented in Tables 8 and 9 represents the average number of parasites found in animals positive for gastrointestinal parasites.

Table 8: Prevalence of parasites observed in the stomachs of black bear mortalities in the Dehcho region, NWT from 2002 – 2003.

Year	# Samples	*Baylisascaris transfuga* Gross exam	*Uncinaria* Gross exam
		Prevalence	
2002	12	8.3%	0%
2003	16	6.3%	6.3%
2002-03	28	7.1%	3.6%
		Mean Intensity [a]	
2002	12	14	0
2003	16	1	1
2002-03	28	8	1

[a] Mean number of parasites in positive animals (does not include bears where no parasites were found).

Table 9: Prevalence of parasites observed in the intestinal content from black bear mortalities in the Dehcho region, NWT from 2002 – 2003.

Year	# Samples	*Baylisascaris transfuga* Gross exam	Cestode spp. Gross exam	*Uncinaria* spp. Stereo exam	Unknown Stereo exam
		Prevalence			
2002	12	83.3%	0%	16.7%	0%
2003	16	50.0%	18.8	43.8%	6.3%
2002-03	28	64.3%	10.7%	32.1%	3.6%
		Mean Intensity [a]			
2002	12	20	-[b]	588	0
2003	16	15	-	576	10
2002-03	28	18	-	578	10

[a] Mean number of parasites in positive animals (does not include bears where no parasites were found).
[b] Presence of cestodes was qualitative.

The sex and age structure of the bears that had *Baylisascaris transfuga* was similar to all the bears analyzed for gastrointestinal parasites, as well as those that tested negative for gastrointestinal parasites; namely, most of the bears were male and ≥ 4 years of age (see Appendix D). It appears that bears testing positive for *Uncinaria* spp. in their intestinal tract were more likely to be male, as the proportion of positive males (78%) was higher than all males

sampled (61%) as well as all negative males (53%). Similarly, bears positive for *Uncinaria* spp. were mainly ≥4 years old (see Appendix D).

Lung Parasites

No parasites were observed in the lungs examined in 2002 or 2003.

Trichinella spp. larvae

Seven of 120 bears (5.8% prevalence) sampled from 2002 – 2010 tested positive for *Trichinella* spp. larvae (Table 10). The sex and age structures of the bears that tested positive for *Trichinella* spp. were similar to all the bears analyzed, as well as those that tested negative for *Trichinella* spp.; namely, most of the bears were male and ≥4 years of age (see Appendix D). Three of seven positive bears had >1 *Trichinella* spp. larvae per gram of muscle tissue (Table 10), which is the level of *Trichinella* spp. larvae in meat considered to pose a food safety risk (Larter et al. 2011).

Table 10: Prevalence and number of *Trichinella* spp. larvae observed in skeletal muscle samples from black bear mortalities in the Dehcho region, NWT from 2002 – 2010.

Year	Sample Size	*Trichinella* spp. larvae Prevalence	*Trichinella* spp. larvae Number of larvae/gram
2002	12	0.0%	0
2003	21	4.8% (n=1)	13
2004	7	0.0%	0
2005	10	0.0%	0
2006	19	15.8% (n=3)	0.1, 0.8, 177
2007	9	11.1% (n=1)	0.1
2008	15	0.0%	0
2009	14	0.0%	0
2010	13	15.4% (n=2)	0.75, 1.9
2002-10	120	5.8% (n=7)	

Post mortem result

Frozen liver and skin samples from one nuisance black bear sampled in 2003 were sent to the CCWHC for gross analysis and histopathology. This bear (BB22) was male, 18 years old and in poor body condition. Grossly, the outer surface of the liver was pale and nodular in

texture, which extended approximately 5 – 10 mm into the underlying liver; the remaining liver was tough in texture. The skin sample taken from one of the ankles was sparsely haired, with shorter hairs in reduced numbers. Diagnosis based on histopathology consisted of chronic granulomatous hepatitis characterized by eosinophilia and fibrosis; and chronic granulomatous dermatitis characterized by perivascular eosinophilia. Microfilaria and associated inflammation was observed in the skin and liver samples; therefore, the agent responsible for the skin and liver lesions was concluded to be the larval stage (microfilaria) of the connective tissue nematode *Dirofilaria ursi* (CCWHC 2004).

DISCUSSION

Rabies

None of the black bears tested in 2002 or 2003 had antibodies to the rabies virus. Similarly, there have been no documented cases of rabies in wildlife or domestic dogs from the Dehcho region (B. Elkin pers. comm.). The primary reservoir of rabies in the NWT is the arctic fox, with >95% of cases occurring in the Inuvik region (EpiNews 2005). Rabies cases have also been regularly detected in red foxes in the Inuvik, Sahtu and North Slave (around Lac de Gras) regions of the NWT. Domestic dogs that contact infected foxes are considered to be the most likely potential source of rabies exposure for humans in the NWT, but traditional activities also pose a risk to trappers and hunters where rabies occurs in free-ranging fox populations. There has never been a documented human case of rabies in the NWT (EpiNews 2005).

There have been no documented cases of rabies in black bears in the NWT. In Canada, rabies has occurred in black bears in Ontario where rabies is endemic in wild skunk, bat, fox and raccoon populations and bears have a higher risk of encountering rabid animals (Walroth et al. 1996). In the NWT rabies was detected in one barren-ground grizzly bear from Paulatuk, in Peary caribou from Sachs Harbour on Banks Island and Holman on Victoria Island, and one lynx from Inuvik; these all represent northern communities where arctic foxes are endemic (EpiNews 2005). Rabies has also been documented in a small number of wolves from Inuvik and Fort Good Hope, NWT; this contrasts to Alaska and Russia, where rabies epidemics have occurred in the wolf populations acting as a source of human infection (Mork and Prestrud 2004).

It is assumed that the rabies virus would kill infected species and antibodies would only be found during the incubation stage of the disease. However, rabies antibody has been found in clinically healthy arctic foxes that were presumed to have survived a previous rabies

exposure (Ballard et al. 2001). Therefore, rabies antibodies may indicate previous exposure to the rabies especially in bears that may exhibit increased resistance to infection.

Experimental data suggest that bears may be more resistant to the rabies virus, as a higher infective dose was required to cause disease (Rausch 1975), and therefore, it has been speculated that rabid foxes may not have sufficient rabies virus in their saliva to infect bears. Given the scarcity of rabies reports in black bears and bears in general, and the absence of arctic foxes and low density of red foxes in the Dehcho region, black bears should be considered a rare source of rabies in the Dehcho region. However, rabies should be included in the differential diagnosis for any wildlife displaying neurological signs, and wherever possible, the brain should be submitted for testing.

Canine parvovirus

None of the black bears tested in 2002 or 2003 had antibodies to the canine parvovirus. Canine parvovirus emerged in domestic dogs in 1978 and quickly spread to most species of wild carnivores by 1980 (Steinel et al. 2001). In northern North America, canine parvovirus antibody prevalence in free-ranging wolves ranged from 13 – 76% in Alaska and Yukon (Zarnke et al. 2004). This is similar to past studies throughout North America that have shown high seroprevalence for CPV-2 in wild canids (Brynn et al. 2012, Almberg et al. 2009). Although the effects of CPV-2 on wolf populations throughout North America is generally unknown, there is evidence to suggest that CPV-2 in endemic wolf populations can negatively influence population numbers through decreased pup survival, immigration and emigration (Almberg et al. 2009, Mech et al. 2008).

No reports of serological surveys for CPV-2 have been published on wild canid populations in the NWT, but some unpublished data shows CPV-2 antibody in wolves and grizzly bears (B. Elkin pers. comm.). Although there is no data specific to the Dehcho region, both domestic and wild canid populations may act as a source of CPV-2 infection in black bears.

In North America, CPV-2 antibody has only been documented in free-ranging black bears from Florida, where the seroprevalence was 16 of 62 bears (26%) (Dunbar et al. 1998); serology results collected from black bears in Alaska were negative (Chomel et al. 1998). The only other reports of CPV-2 exposure in bears are from Croatia and Italy (Madic et al. 1993).

These preliminary data may indicate that black bears in the Dehcho region of the NWT are not exposed to CPV-2 or that the sample size was not large enough if the seroprevalence of CPV-2 in black bears is low. Based on other serosurveys of black bears in North America for CPV-2, the former may be more likely. Even though the CPV-2 virus is very resistant in the environment, the combined low density of wolves and black bears in the Dehcho region may limit the exposure of CPV-2 to bears. Nuisance black bears that range near and within communities may be more at risk to CPV-2 exposure from domestic dogs that generally have a low vaccination rate in northern communities with no or limited veterinary service. The risk of CPV-2 on black bear populations in the Dehcho region should be considered low. Future work to document the seroprevalence in wild and domestic dogs in the Dehcho region would help to define the risk to spillover species such as black bears.

Canine distemper virus

Canine distemper virus antibody was detected in 33% of black bears sampled in the Dehcho region from 2002 – 2003 that had conclusive test results (total of 6 bears). The prevalence of CDV exposure in black bears in the Dehcho region is high compared to 0% prevalence and 8% prevalence in free-ranging black bears from Alaska (Chomel et al. 1998) and Florida (Dunbar et al. 1998), respectively, but not in comparison to other Ursidae. In 2003, antibodies to CDV were detected in grizzly bears sampled between Inuvik and Paulatuk in the NWT (n=26, 100%; B. Elkin unpubl. data) and Alaska (8%; Chomel et al. 1998), polar bears from Alaska and Russia (36%, Follman et al. 1996) and Canada (24%, Cattet et al. 2004), and captive and free Marsican brown bears in Italy (16% and 36%, respectively, Marsillo et al.

1997). Canine distemper virus has been observed to cause clinical disease in polar bears and the Marsican brown bear (Deem et al. 2000).

All black bears from the Dehcho region testing positive were ≥9 years old; however, only one bear tested was <1 year of age. The young bear may not have had enough time to be exposed to CDV or develop detectable antibody levels. The predominance of CDV reported in older animals from the Dehcho region may also represent an epizootic event where older bears are the only survivors. However, this seems unlikely since black bear populations in the Dehcho region have been relatively stable over time (N. Larter pers. comm.). Results are more likely due to sampling older bears.

In northern Canada, arctic and red fox populations are believed to be the reservoir of CDV and the source of distemper outbreaks in sled dogs in remote northern communities (Leighton et al. 1987). No serological surveys of arctic or red foxes have been done in the NWT; unpublished data for wolves showed 14 of 34 (41%) seropositive for exposure to CDV (B. Elkin pers. comm.). Ballard et al. (2001) did not find CDV antibody in arctic foxes sampled in Alaska, but most of these animals were juveniles and may not yet have been exposed to the virus or had enough time to develop a detectable humoral immune response. The seroprevalence of CDV in wolves from Alaska and the Yukon ranged from 0 – 41% and 39 – 64%, respectively, depending on the geographic location (Zarnke et al. 2004). Clinical disease from CDV has been observed in arctic and red foxes and coyotes and suspected in free-ranging wolves (Deem et al. 2000).

Unlike parvovirus, canine distemper virus is relatively short-lived in the environment, as it is highly susceptible to ultra-violet light, heat and desiccation; it can survive for 14 days at 5°C or 48 hours at 25°C (Deem et al. 2000). Transmission of CDV is through direct contact with aerosolized respiratory exudate and bodily excretions or secretions (urine, feces, respiratory)

containing the virus or indirectly by virus-contaminated fomites. However, CDV is highly contagious and can be shed for 60 – 90 days post-infection. Arctic and red foxes are assumed to be a reservoir and source of infection for domestic dogs since the virus is short-lived in the environment and foxes occur at higher densities than dogs, increasing the amount of virus shed in the environment and rate of contact to susceptible species.

The source of CDV exposure to black bears is unknown. It is also unknown whether the antibodies are directed against CDV or an unidentified morbillivirus similar to CDV (Cattet et al. 2004, Chomel et al. 1998). The most likely source of CDV in the Dehcho is red foxes since they have higher densities than wolves. It is not believed that CDV or a CDV-like virus has negative effects on black bear populations in the Dehcho region since clinical cases have not been detected and black bear numbers have been stable over time (N. Larter pers. comm.).

Future serosurveys could be done to re-examine the prevalence of CDV in black bears in the Dehcho due to the small sample size and to provide baseline data on the prevalence in wild canid species such as wolves, red foxes and coyotes and other species that may interact with bears such as wolverine. While there is serological evidence of exposure to canine distemper virus in this study, understanding the biological significance to terrestrial wildlife would require isolation of the virus and identification of the type(s) of morbillivirus present.

Toxoplasma gondii

Thirteen percent of 16 black bears sampled in the Dehcho region from 2002 – 2003 had antibody to *T. gondii*, which was relatively low compared to other black bears sampled across North America. The highest prevalence of *T. gondii* in black bears has been recorded in the eastern United States, where approximately 80% of bears in Pennsylvania (Dubey et al. 2004, Dubey et al. 1995a, Briscoe et al. 1993) and 84% of bears in North Carolina (Nutter et al. 1998) were seropositive. Black bears from Alaska had a prevalence of 43% (Zarnke et al. 2000), while bears from Florida (Dunbar et al. 1998), Ontario (Quinn et al. 1976), California (Ruppanner et al.

1982) and Idaho (Binninger et al. 1980) had a seroprevalence of 56%, 44%, 27% and 8%, respectively. The differences in prevalence among black bears across North America may reflect the different types and corresponding density of felids that may act as the source of *T. gondii* infection, the ability of oocysts to survive in the environment increasing the risk of exposure, or other unknown factors. The number of black bears tested in the Dehcho region was relatively small and may not accurately reflect the seroprevalence of *T. gondii*, or there may be a low prevalence of *T. gondii* infection in lynx and other wildlife species or a low density of lynx in the Dehcho region.

Both bears that tested positive for *T. gondii* exposure were male and ≥4 years old. Although sample size was not large enough to determine whether age was related to *T. gondii* exposure in the present study, past work has demonstrated that antibody prevalence in black and grizzly bears (Zarnke et al. 2000, Nutter et al. 1998, Zarnke et al. 1997a, Chomel et al. 1995, Briscoe et al. 1993) and other wildlife species is directly related to the age of the animal (Stieve et al. 2010, Zarnke et al. 2001, Zarnke et al. 2000), as the cumulative likelihood of exposure increases with age.

T. gondii infections occur in a wide range of wildlife species and generally prevalence is greater in carnivores and progressively lower in omnivores and herbivores (Stieve et al. 2010, Zarnke et al. 2000) since the former have a higher risk of exposure from ingesting tissue cysts from infected animals. Herbivores become infected by ingesting vegetation or water contaminated with oocysts from felid feces or the feces of some other unidentified definitive host. Prevalence in carnivores may also be related to the prevalence of *T. gondii* infection in prey species that act as intermediate hosts. In the NWT, seroprevalence in mainland barren ground caribou, muskox and boreal caribou was 37%, 40% and 3%, respectively (Johnson et al. 2010, Kutz et al. 2001, Kutz et al. 2000). Only 4.3 % of Peary caribou on North Baffin Island, Nunavut (NU) and 4.7% muskox from Victoria Island, NU were seropositive (Kutz et al. 2001,

Kutz et al. 2000). In Alaska, documented seroprevalence for black bears, wolves, caribou and moose was 43%, 9%, 6% and 1%, respectively (Zarnke et al. 2000, Stieve et al. 2010). In the United States, antibodies to *T. gondii* have been found in 30 - 60% of different white-tail deer populations (Dubey et al. 2004). The high prevalence in caribou and deer versus moose may be due to differences in foraging. Deer and caribou are mainly grazers and are more likely to ingest vegetation contaminated with fecal oocysts, whereas moose are browsers and less likely to ingest contaminated vegetation. In Alaska, geographic differences in prevalence in various wildlife species can by explained somewhat by the distribution and density of lynx, which is a potential source of *T. gondii* (Zarnke et al. 2000, Zarnke et al. 2001); however, prevalence in grizzly bears is high in northern regions where lynx density is low. This is similar to the NWT that exhibits high prevalence of *T. gondii* antibody in mainland barren ground caribou that spend a considerable portion of the year above treeline where lynx are absent and range below treeline primarily during winter months where lynx are present but cold temperatures limit oocyst survival.

The source of *T. gondii* exposure for black bears in the Dehcho region is unknown, but bears can be exposed by eating tissue cysts from infected animals or ingesting vegetation or water contaminated with infective oocysts. Both domestic and wild felids, such as cougars and bobcats but not lynx, have been documented to be infected with *T. gondii* and shed oocysts in their feces (Aramini et al. 1998, Miller et al. 1972). The seroprevalence of *T. gondii* in lynx from Alaska, Quebec and Sweden was 15%, 44% and 75%, respectively (Ryser-Degioris 2006, Labelle et al. 2001, Zarnke et al. 2001). In the Dehcho region, domestic cats, both companion and feral animals depend on communities to survive and would only act as a potential source of infection within the communities. Lynx and cougars are the only free-ranging felids in the Dehcho region, and it is assumed that lynx due to their greater abundance may potentially act as the major source of *T. gondii* infection. However, other potential definitive hosts for *T. gondii*

in northern Canada and Alaska are plausible given the relatively high seroprevalence of *T. gondii* in wildlife species such as barren ground caribou, muskox and bears that inhabit areas where the density of lynx is low or lynx are absent. In Siberia, Russia, *T. gondii* is maintained by lemming populations (Zarnke et al. 1997a). However, low prevalence in wildlife that inhabit northern areas where lynx do not occur, may also represent false positive results rather than an alternative *T. gondii* source.

Serological evidence does not distinguish between exposure versus infection with *T. gondii*. The MAT is the most sensitive test in black bears to detect antibody to *T. gondii* (Dubey et al. 1995a), but the MAT titre indicative of *T. gondii* infection has not been substantiated. In domestic pigs, a MAT titre of 25 corresponds to *T. gondii* infection (Dubey et al. 1995b, Dubey 1997). Dubey et al. (1995a) were able to extract live *T. gondii* from the myocardium of black bears with a MAT titre of 40. Experimental infections would be required to quantify the titre level associated with *T. gondii* infection, as well the density and distribution of live *T. gondii* in black bear tissues.

Although black bears may be exposed to or infected with *T. gondii*, no clinical cases of toxoplasmosis in bears have been documented (Dubey 2009, Dunbar et al. 1998) and infection is assumed to be asymptomatic or cause mild non-specific clinical signs. Potential clinical signs may be non-specific and related to the tissue or organ infected with cysts; transplacental infection may occur resulting in abortion or still births that could affect bear reproduction and population numbers. Experimental infection studies would be required to understand the clinical significance of toxoplasmosis in black bears. However, black bear populations in the Dehcho region have been stable, and therefore, *T. gondii* does not appear to pose a significant health risk to black bear populations (N. Larter pers. comm.).

It is difficult to accurately assess the public health risk associated with toxoplasmosis in black bears since serological evidence does not distinguish between exposure versus infection, and the organism has not yet been isolated and confirmed from NWT wildlife. In the Dehcho region, black bears are consumed by community members, as are other wildlife species such as boreal and barren ground caribou that may also carry *T. gondii*; trappers that harvest lynx may also be at risk to *T. gondii* infection. Humans are typically exposed to *T. gondii* by consuming cysts in the tissues of intermediate hosts or by ingesting oocysts shed from domestic or wild felids. In northern communities were serosurveys have identified *T. gondii* antibody in harvestable wildlife species, such as Alaska, seroprevalence of exposure was 28% of 1,572 aboriginal people tested in 1970 (Peterson et al. 1974). In northern Quebec, an outbreak of abortion in women was attributed to *T. gondii* and the seroconversion of women was statistically associated with ingestion of raw caribou meat or skinning animals for fur (McDonald et al. 1990).

Further research is required to confirm the presence of *T. gondii* in NWT wildlife. If confirmed, a public information program could be implemented to inform harvesters of the potential risk of toxoplasmosis and how to protect themselves from infection. To reduce human exposure to diseases and parasites including *T. gondii* in harvested wildlife species, it is recommended that hunters and trappers wear gloves when handling carcasses and/or properly wash their hands, knives and cutting boards with soap and water afterwards. All meat should be thoroughly cooked so that it does not look pink inside (at least 66°C for 3 minutes) or completely frozen (domestic freezer for 24 hours) prior to consumption. Air drying meat will not kill tissue cysts. Pregnant women should not eat raw meat from wild game, and should take appropriate precautions and follow proper meat hygiene practices when handling carcasses or preparing meat. Any portions of the carcass not consumed may act as a source of exposure to scavenging wildlife or pets and should be appropriately discarded. Any meat fed to pets should

also be thoroughly cooked or frozen to prevent transmission to dogs and cats. Similarly, gloves should be worn and proper hygiene followed when skinning and handling lynx carcasses; water and soap are effective at killing oocysts.

Future work should be directed at verifying the prevalence of *T. gondii* antibody in black bears in the Dehcho region and identifying the seroprevalence in major wildlife species harvested to qualitatively assess the zoonotic risk of toxoplasmosis to northern harvesters. Annual small mammal trapping is conducted by Environment and Natural Resources, GNWT and could provide samples to test for *T. gondii*. Targeted efforts could be made to isolate and confirm the presence of the actual organism, and the genetic type of *T. gondii* in the Dehcho region should be characterized to compare to wildlife genotypes of *T. gondii* identified in Canada and the United States. An atypical genotype has been identified in a grizzly bear from Alaska that is highly virulent to mice on experimental infection and may be associated with cases of toxoplasmosis in immunocompromised people (Dubey et al. 2010).

Parasitology

Gastrointestinal parasites

Various parasitological investigations of black bears have been conducted in the United States and the Canadian provinces primarily prior to 1980 and more than 30 parasites have been reported from black bears in North America (Rogers and Rogers 1976). The work done in the Dehcho region (Kutz 2004, Kutz 2003a) along with a study in the Sahtu region (Kutz 2003b) of the NWT, were the first to report on the parasites of black bears in the Mackenzie Valley, NWT. Two nematodes were observed from the gastrointestinal tract of black bears sampled in 2002 and 2003, and were identified as *Baylisascaris transfuga* and *Uncinaria rauschi* (Kutz 2004, Kutz 2003a).

B. transfuga is a large roundworm specific to bears. It is commonly found in black, grizzly and polar bears (Kazacos 2001) and has a ubiquitous distribution in North America. *B.*

transfuga has been recorded in black bears from New Brunswick, Quebec, Ontario and Alberta, as well as the northern United States (Duffy et al. 1994, Dies 1979, Addison et al. 1978, Frechette and Rau 1977, Rogers and Rogers 1976). The prevalence of *B. transfuga* in black bears from the Dehcho (64% of 28) was similar to results from the Sahtu region of the NWT (63% of 8), Alberta (62% of 91), and northern Wisconsin (89% of 28), but much higher than reports from Ontario (24% of 83), Quebec (21% of 55) and New Brunswick (8% of 12) (Kutz 2004, Kutz 2003b, Duffy et al. 1994, Dies 1979, Addison et al. 1978, Manville 1978, Frechette and Rau 1977).

Bears are the definitive host of *B. transfuga*. Adult worms are found in the intestine and unembryonated eggs are excreted in the feces. The adult worms are very proliferative, each producing a large number of eggs; for example, the adult worms of *B. procyonis*, a round worm of raccoons, are estimated to lay up to 180,000 eggs per day (Kazacos 2001). Eggs deposited in the environment become infective when second stage larvae develop within the egg capsule. Under optimal warm conditions, it takes approximately 12 days for eggs to develop into the infective form (Kutz 2004). Intermediate hosts, speculated as small mammals or birds for *B. transfuga*, can become infected by ingesting infective eggs in the environment. Within the intermediate host, the eggs hatch in the gastrointestinal tract releasing the larvae to penetrate the intestinal wall. The larvae then enter the bloodstream of the intermediate host and are carried to various tissues and organs within the body. Other black bears become infected with *B. transfuga* by ingesting water or potential food sources contaminated with feces from parasitized bears. Alternatively, bears can also eat an intermediate host infected with larvae of *B. transfuga*.

Hibernation in bears is speculated to affect the parasitism of bears. It has been proposed that adult helminths that get nourishment from the digestive material in the host, such as *B. transfuga*, are passed prior to hibernation, as these parasites are not able to survive the winter

period without food (Rogers and Rogers 1976). The eggs of *B. transfuga* are resistant to freezing and those shed in the fall may act as a source of infection the following spring (Kutz 2004). Larvae that overwinter in the intestinal mucosa of bears and mature upon emergence from hibernation shedding eggs into the environment may also serve as a source of new infection (Frechette and Rau 1978).

Clinical effects of *B. transfuga* on bears have not been studied, but do not appear to be significant. *B. transfuga* has been documented to be the cause of death in a captive black bear due to a large number of adult worms that occluded several passageways (Rogers and Rogers 1976). It is possible that heavy parasite burdens of adult worms could interfere with digestion or cause intestinal obstruction resulting in deteriorating health and disease especially in young bears. However, *B. transfuga* does not appear to cause population effects in black bear populations.

Ten black bears in the Dehcho region had < 10 adult worms in their gastrointestinal tract, 13 bears had < 15 adult worms, 16 bears had < 25 adult worms and the remaining 2 bears had ≥ 75 adults worms. The black bear with the highest adult worm burden was a cub of the year, while the bear with the second highest level was 4 years old. This corresponds to the ecology of *Baylisascaris* where the heaviest infections are found in juveniles rather than adults (Kazacos 2001).

Baylisascaris spp.is found in a number of other wildlife species. *B. procyonis*, found in raccoons, is a zoonotic parasite that can cause neural, ocular or visceral larval migrans in humans. Human infections with *B. procyonis* primarily occur in children that ingest infective eggs from the environment. The eggs hatch in the intestine releasing larvae that can migrate to the brain, eyes and other tissues and may cause organ-specific disease or death; however, clinical cases are rare in people. Infected humans do not transmit *B. procyonis* to other humans

or animals. *B. transfuga* has been shown to cause disease (ocular and neural migrans) in experimentally infected animals (Kazacos 2001). Although *B. transfuga* may potentially cause larval migrans in other animals and humans, it is believed to be less pathogenic than *B. procyonis*. Regardless, *B. transfuga* should be considered a potential zoonotic parasite and contact with bear feces should be avoided. Good hygiene, especially washing hands properly with soap and water should be encouraged after being outdoors or handling bear carcasses.

The hookworm, *Uncinaria rauschi*, was found in 32% of 28 black bears sampled in the Dehcho region in 2002 and 2003; it was not found in any of the black bears sampled from the Sahtu region in 2002 (Kutz 2004, Kutz 2003b). *U. rauschi* has only been reported previously in black and grizzly bears in Alaska (Olsen 1968) and is closely related to *U. yukonensis*. *U. yukonensis* was first observed in black bears from the Yukon; it has also been reported in black and grizzly bears from the Yukon, Montana and Alaska, and black bears in Quebec (Frechette and Rau 1977, Rogers and Rogers 1976). *Uncinaria* spp. worms from the Dehcho were smaller and had shorter spicules than *U. yukonensis* worms, and therefore, were classified as *U. rauschi*. The total length of male worms from the Dehcho was 7.2 – 10.3 mm compared to 10.5 – 12.9 mm for *U. yukonensis* male worms, and the total length of spicules was 0.9 – 1.0 mm compared to 1.65 – 1.75 mm for *U. yukonensis* worms (Kutz 2004). The identity of the *Uncinaria* spp. worms recorded in the Dehcho is to be confirmed by the USDA National Parasite Collection.

No research had been conducted on the ecology and life history of *U. rauschi* or *U. yukonensis*; however, the life cycle of this hookworm has been described for domestic dogs and provides general insight into this parasite. *Uncinaria* spp. is a common parasite of carnivores especially at northern latitudes. It is assumed that the life cycle of all species of *Uncinaria* is similar. This hookworm has a direct life cycle; adult worms live in the intestine and pass non-infective eggs that are shed in the feces. The eggs develop in the environment to an infective

third stage larvae, which takes a minimum of one week to occur. Infective third stage larvae are ingested by other carnivores and mature to adult worms in the intestine.

Adult worms of *Uncinaria* spp. live in the intestine and feed on blood, which can lead to mucosal damage; potential clinical signs that may occur with *Uncinaria* spp. infection include hemorrhagic diarrhea, anemia and weight loss due to malabsorption. The effects of *Uncinaria* spp. in bears from the NWT are unknown at this time. Five of the black bears sampled from the Dehcho region had >250 adult worms in their gastrointestinal tract, while two of these bears had >1700 worms. The weight of the black bears with adult worm burdens >800 was lower than the average weight of bears sampled. It is possible that these bears could have impaired intestinal absorption, but this is purely speculative. *Uncinaria* spp. is not known to be zoonotic.

Unidentified cestode tapeworms were recorded in the gastrointestinal tracts of three black bears sampled from the Dehcho region in 2002 and 2003. Kutz (2004) suggested that these may be *Taenia* spp. and *Diphyllobothrium* spp.; these worms were sent to the USDA National Parasite Collection for further identification. *T. krabbei*, *T. hydatigena*, *Diphyllobothrium* spp. have been recorded in black and grizzly bears across Canada, Alaska and the northern United States (Addison et al. 1978, Duffy et al. 1994, Dies 1979, Frechette and Rau 1977, Gau et al. 1999, Rogers and Rogers 1976). These parasites are very broadly found (spatially, temporally and across age / sex cohorts). *Diphyllobothrium* spp. occurs in fish-eating mammals and has an indirect life cycle that includes fish as an intermediate host. Bears can become infected with *Diphyllobothrium* spp. by consuming fish that contain plerocercoids. *Diphyllobothrium* spp. is zoonotic and humans become infected by infesting raw, unfrozen fish containing plerocercoids. *T. krabbei* has an indirect life cycle; definitive hosts include wolves, coyotes, domestic dogs, bobcats, lynx, black bears and grizzly bears, while moose, caribou, elk and mule deer have been identified as intermediate hosts. Cysts in skeletal and cardiac muscle are commonly seen in moose infected with *T. krabbei*. The definitive host of *T. hydatigena*

includes domestic and wild carnivores and bears, while indirect hosts include domestic and wild herbivores across North America. Liver tapeworm cysts are commonly seen in herbivores infected with *T. hydatigena*. In the Dehcho region, both moose and caribou could serve as intermediate hosts for *Taenia* spp. *Taenia* spp. cysts have been recorded in caribou and muskoxen in the NWT (Kutz 2004). *T. krabbei* and *T. hydatigena* are not considered to be zoonotic.

No *Giardia* spp. or *Cryptosporidium* spp. were recorded in the fecal samples of black bears tested from the Dehcho region in 2002 or 2003. Both are zoonotic pathogens that can cause gastrointestinal-related clinical signs including diarrhea, abdominal pain, bloating and cramps, for example. In the Sahtu region of the NWT, a fluke was identified in the gastrointestinal tract of two black bears, while fluke eggs were observed in the fecal samples of three black bears sampled in 2002. However, no flukes or fluke eggs were recorded in the black bears sampled from the Dehcho region. The fluke has not yet been identified (Kutz 2003b). Most published reports of flukes observed in black bears have been from Florida.

Extra-intestinal Parasites

Microfilaria was identified in blood vessels of skin and liver tissue of one black bear sampled from the Dehcho in 2003. This bear was 22 years old, in poor body condition and had areas of hair loss. The microfilaria represents the larval stage of a connective tissue nematode that is most likely *Dirofilaria ursi*. *Dirofilaria ursi* has been recorded in black bears from the Sahtu region of the NWT and across the Canadian provinces and the northern United States; it is believed to be more common in eastern Canada and United States (Kutz 2003b, Dies 1979, Rogers and Rogers 1976). However, prevalence in the Sahtu region was high with 75% of eight bears infected and similar to levels recorded in eastern North America with 95%, 57% and 100% prevalence in Ontario, Quebec, and Michigan and Minnesota, respectively (Addison et al. 1978, Frechette and Rau 1977, Rogers 1975).

The black bear is the definitive host of *D. ursi*. Adult worms live in the subcutaneous and connective tissue of bears, most commonly around the trachea and perineal region. Adult female worms produce motile embryos called microfilaria that enter the bear's blood stream. Microfilaria in the bloodstream is ingested by different species of black flies where they develop into an infective third stage larvae within the black fly; it takes approximately two weeks for this developmental stage to produce infective larvae. Bears become infected with *Dirofilaria ursi* when they are bitten by black flies containing third stage larvae, as the infective microfilaria travel from the mouth part of the black fly to penetrate the tissue of the bear. Within the bear, the infective third stage larvae develop into adult worms and produce microfilaria that enter the bloodstream approximately seven to nine months later. *Dirofilaria ursi* does not appear to cause disease in bears. Hunters may observe adults worms in the connective tissue when skinning bears. Tissue containing adult worms or microfilaria does not affect the edibility of meat and can be ingested by humans without causing infection.

Humans can act as accidental hosts of *Dirofilaria ursi*, if they are bitten by a black fly that contains infective third stage larvae. The third stage larvae develop into adult worms within connective tissue at the site of the insect bite, but microfilaremia has not been documented (Haldane et al. 1996). *D. ursi* infections are asymptomatic in humans until the adult worms die triggering an inflammatory reaction. A subcutaneous nodule forms within the connective tissue containing the adult worm. Clinical signs of *D. ursi* infection include single or multiple subcutaneous nodules usually in the upper trunk or head region, pyrexia, erythema around the nodules, pain on nodule palpation and anorexia (Haldane et al. 1996). Excision of the nodule(s) is curative. The incidence of documented *D. ursi* infections in humans is rare, but represents a potential cause of subcutaneous nodules where black bears and black flies occur. In the future the connective tissue of nuisance black bears could be sampled to determine the prevalence of *Dirofilaria ursi* in the Dehcho region given the high incidence documented in the Sahtu.

Community members, including health professionals, should be educated on the zoonotic potential of *D. ursi* infection.

Although lungworms were not detected in lungs sampled from black bears in the Dehcho or Sahtu regions of the NWT, *Crenosoma spp.* have been recorded in black bears sampled from southeastern United States, Ontario and New York (Crum et al. 1978). Crum et al. (1978) also reported *Capillaria aerophila* in the lungs of black bears from southeastern United States.

Trichinellosis

In the Dehcho region, 5.8% of 120 black bears tested positive for *Trichinella* spp. larvae. The prevalence of *Trichinella* spp. in black bears varies considerably across Canada along with the intensity of sampling. The highest prevalence was documented in the Kootenay region of British where 12% of 193 black bears were positive (Schmidt et al. 1978). No reports of *Trichinella* spp. have been documented in black bears from Alberta (n = 265), Manitoba (n = 1), the island of Newfoundland (n = 66), Nova Scotia (n = 51) or Prince Edward Island (n = 1) (Appelyard and Gajadhar 2000, Butler and Khan 1992). The prevalence of *Trichinella* spp. larvae in Ontario, Quebec, New Brunswick and Labrador was 2.7% of 73, 1% of 258, 0.4% of 569 and 1% of 96, respectively (Appelyard and Gajadhar 2000, Butler and Khan 1992). In comparison, Gajadhar and Forbes (2010), found 7.3% prevalence (n = 193) black bears sampled between 1998 and 2007 from the NWT, BC, SK and Quebec.

The high number of positive black bears in the Kootenay region of BC corresponds to 12% and 13% of *Trichinella* spp. in black bears sampled from the Rocky Mountains in the United States and California, respectively (Butler and Khan 1992, Zimmermann 1977). The highest prevalence of *Trichinella* spp. of 27.5% in black bears was documented in Alaska based on serological testing (Chomel et al. 1998). The level of *Trichinella* spp. recorded in the remaining states ranged from 0 – 6% but there was considerable variation in sample size,

testing procedures and the period of collection (Pozio et al. 2001, Nutter et al. 1998, Butler and Khan 1992, Schad et al. 1986, Rogers 1975).

The range of *Trichinella* spp. recorded in black bears across North America suggests that regional variation in prevalence likely occurs. Although *Trichinella* spp. is widely distributed among North American black bear populations, human cases of *Trichinella* spp. infection from ingestion of black bear meat have occurred in jurisdictions where the documented prevalence of *Trichinella* spp. is relatively low (Schad et al. 1986). Therefore, human *Trichinella* spp. infection should be considered a potential risk associated with ingestion of black bear meat from the Dehcho region given the documented prevalence.

Black bears can become infected with *Trichinella* spp. by hunting parasitized-prey species, feeding on parasitized-carrion in the wild or at garbage dumps, or cannibalism. Prior to eradication of *Trichinella spiralis* from the domestic swine herd, some black bears were most likely infected with *T. spiralis* by either being baited or fed raw pork or scavenging on raw pork at garbage dumps (Pozio et al. 2001, Schad et al. 1986). However, *Trichinella spp*. infections at the same time had also been documented in remote black bear populations, as well as populations near human settlements since eradication of *T. spiralis* from the domestic swine herd in North American. Accordingly, a sylvatic cycle of *Trichinella* spp. is well recognized in black bears in North America, where black bears act as the natural host.

Trichinella spp. has been documented in 25 species of wildlife in Canada, but little is known of these sylvatic cycles (Appelyard and Gajadhar 2000). Highest prevalence has generally been documented in species such as wolves, polar bears, cougars and wolverine that are strict carnivores (Gajadhar and Forbes 2010), but can also be in other species such as grizzly bears that exhibit cannibalism (Zarnke et al. 1997b). In the Dehcho region of the NWT, prevalence of *Trichinella* spp. infection in grizzly bears and wolves was 73% and 52%,

respectively (Larter et al. 2011). In general, prevalence of *Trichinella* spp. infection is higher in furbearer, carnivore and omnivore species that scavenge, hunt or exhibit cannibalism than small mammal species such as rodents (Appelyard and Gajadhar 2000, Schmidt et al. 1978). There is also wide variation in prevalence by geographical area within a species that may be related to host-specific parasite ecology, diet or geographic distribution of the parasite among various species preyed or scavenged upon (Larter et al. 2011).

The genotype of *Trichinella* spp. found in sylvatic infections of black bears in Canada have been either *T. nativa* (T2) or *Trichinella* T6, with *T. nativa* being more common (Gajadhar and Forbes 2010). Black bears sampled from BC, SK and Quebec were only infected with *T. nativa* (Gajadhar and Forbes 2010), while bears from the Dehcho were infected by either *Trichinella* T2 or T6 (Larter et al. 2011). *Trichinella* T2 is a cold-adapted genotype found in wild mammals from the arctic or subarctic zones of North America, Europe and Asia that is more resistant to freezing temperatures. *Trichinella* T6 is the most common genotype observed in sylvatic infections of Canadian wildlife and has a wider documented host distribution compared to *T. nativa* (Gajadhar and Forbes 2010). *Trichinella* T6 is closely related to *T. nativa* and is also cold-adapted but is less resistant to freezing temperatures (Pozio and Zarlenga 2005). Natural hybrids between *T. nativa* and *Trichinella* T6 have been found in free-ranging wolves from Alaska (Pozio and Zarlenga 2005); a grizzly bear from the Dehcho region was co-infected with both *T. nativa* and *Trichinella* T6 (Larter et al. 2011). It is important to determine the genotype of *Trichinella* spp. infections to better understand the ecology of sylvatic cycles in Canada.

Three of seven positive black bears in the Dehcho region had tissues containing >1 *Trichinella* spp. larvae per gram of tissue, which is considered a level associated with a significant food safety risk (Larter et al. 2011). Since 1980, all human cases of *Trichinella* spp. infection except one have been due to the ingestion of black bear or walrus meat (Larter et al. 2011). The reporting of human trichinellosis in Canada may be underestimated due to the vague

and non-specific clinical signs associated with mild infections. Regardless, ingestion of black bear meat or other free-ranging carnivore and omnivore species in Canada poses a food safety risk for *Trichinella* spp. infection. Since sylvatic cycles of *Trichinella* spp. cannot be eradicated from Canadian wildlife, human cases of trichinellosis should be controlled through public education, food safety programs, diagnosis of *Trichinella* spp. infections before wild game is consumed for species that have a higher risk of carrying *Trichinella* spp. larvae and through garbage control to eliminate scavenging. Black bear meat should be cooked to an internal temperature of 77°C prior to consumption (Food Safety Network 2009). Curing, salting, smoking, drying or microwaving does not consistently kill larvae in *Trichinella* spp. infected meat. *T. nativa* and *Trichinella* T6 are cold-adapted and resistant to freezing; larvae can remain viable for years at freezing temperatures, and therefore, thawed frozen meat still needs to be properly cooked before it is safe for consumption.

Future work in the Dehcho could focus on obtaining samples from a more representative sample of black bears to include adequate representation from all age classes, as well as determining muscle predilection sites for *Trichinella* spp. larvae to improve the likelihood that animals with low parasite levels are detected for food safety purposes. *Trichinella* spp. testing, including genotyping, should be implemented for any carnivorous and omnivorous wild game species that are consumed by the communities such as lynx, as well as co-habitating species (wolverine, beaver, muskrat, etc.) for food safety and to better the understanding of *Trichinella* spp. ecology in the Dehcho. *Trichinella* spp. prevalence is high in grizzly bears and wolves in the Dehcho (Larter et al. 2011), and therefore, future work is warranted to determine the prevalence of *Trichinella* spp. in prey species of these two species.

SUMMARY

Antibodies to canine distemper virus and *Toxoplasma gondii* were documented in black bear mortalities sampled from the Dehcho region of the NWT, while there was no evidence of exposure of black bears to canine parvovirus (CPV) or rabies virus. While canine distemper virus (CDV) has been reported to cause clinical disease in captured bears there is no evidence that CDV has population effects on free-ranging black bears. More work would be required to document the occurrence and seroprevalence of CDV and CPV in free-ranging and domestic canids and carnivores in the Dehcho region.

Baylisascaris transfuga and *Uncinaria rauschi* were identified in the gastrointestinal tracts of sampled black bears, as well as unidentified cestode worms assumed to be *Diphyllobothrium* spp. and *Taenia* spp. *Trichinella* spp. larvae were recorded in the muscle tissue of sampled black bears. As well, microfilaria assumed to be the larval stage of *Dirofilaria ursi* was documented in the skin and liver tissue of one bear. No lungworms, flukes, *Giardia* spp. or *Cryptosporidium* spp. were documented. It is not believed that the identified parasites commonly cause pathological effects, but disease may occur in individual animals with heavy parasite burdens. However, it is impossible to determine whether parasites are the original cause or a secondary effect in weakened bears. Further sampling of gastrointestinal tracts may be warranted to record parasites that have a low prevalence.

Known zoonotic pathogens recorded in black bears from the Dehcho region of the NWT include *Trichinella* spp., *Toxoplasma gondii* and *Dirofilaria ursi*. Sylvatic infections of *Trichinella* spp. occur in black bear populations across Canada and the United States. Consumption of raw or undercooked black bear or walrus meat has been the main cause of human trichinellosis cases in Canada since 1980. *Toxoplasmosis gondii* occurs in a wide variety of wildlife including black bears and the skinning of animals and the ingestion of improperly prepared wild game has

been linked to human cases of toxoplasmosis in North America. *Trichinella* spp. infections in black bears is a genuine food safety risk to harvesters from the Dehcho region that can be managed through public awareness programs, monitoring the prevalence or presence of *Trichinella* spp. infection in black bear populations or individuals and other harvested species, and proper management of community waste disposal to prevent scavenging. The risk of *Toxoplasmosis gondii* infection in black bear meat to food safety is unknown, but public awareness programs on proper handling and preparation of meat can allow for safe consumption of wild game. More research is required to assess the ecology of *T. gondii* in wildlife and their role in the transmission to humans in the NWT. Human cases of *Dirofilaria ursi*-like infections are rare, but may cause subcutaneous nodules at sites of black fly bites. More work is needed to assess the prevalence of *D. ursi* infections in black bears of the Dehcho region. *Baylisascaris transfuga* may be a potential zoonotic pathogen and handling bear feces should be avoided; as well, proper hygiene should be followed after handling any carcasses.

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APPENDIX A

Seroprevalence of canine parvovirus-2, canine distemper virus, rabies virus and *Toxoplasma gondii* in opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

Bear ID	Year	Sex	Age yrs	Collection location	*Toxoplasma gondii* Titre[a]	Canine Parvovirus Titre[b]	Canine Distemper Titre[c]	Rabies Titre[d]
					n=16	n=14	n=14	n=16
BB2	2002	M	7	Simpson	< 25	n/a	n/a	< 5
BB4	2002	M	2	Simpson	< 25	< 20	Inconclusive	< 5
BB5	2002	F	13	Simpson	< 25	< 20	Inconclusive	< 5
BB6	2002	F	coy[e]	Simpson	< 25	< 20	< 6	< 5
BB10	2002	F	4	Simpson	< 25	n/a	n/a	< 5
BB14	2002	M	12	Simpson	< 25	< 20	6	< 5
BB15	2002	F	coy	Simpson	< 25	< 20	Inconclusive	< 5
BB19	2003	M	11	Simpson	< 25	< 20	< 6	< 5
BB20	2003	M	5	Simpson	< 25	< 20	Inconclusive	< 5
BB21	2003	M	4	Simpson	>1200	< 20	Inconclusive	< 5
BB22	2003	M	18	Simpson	100	< 20	Inconclusive	< 5
BB23	2003	M	9	Simpson	< 25	< 20	Inconclusive	< 5
BB24	2003	F	10	Bannockland	< 25	< 20	Inconclusive	< 5
BB25	2003	M	14	Simpson	< 25	< 20	972	< 5
BB26	2003	M	11	Simpson	< 25	< 20	< 6	< 5
BB27	2003	M	9	Simpson	< 25	< 20	18	< 5

[a] A titre ≥ 25 was considered positive to previous exposure to *T. gondii*.
[b] A titre ≥ 20 was considered positive to previous exposure to CPV-2.
[c] A titre ≥ 12 was considered positive to previous exposure to canine distemper virus.
[d] A titre ≥ 5 was considered positive to previous exposure to rabies virus.
[e] Cub of the year.

APPENDIX B

The seroprevalence of canine distemper virus in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# Canine distemper virus positive	# Canine distemper virus negative	Total number sampled
Year	2002	1	1	2
	2003	2	2	4
	Total	3	3	6
Sex	F	0	1	1
	M	3	2	5
	Total	3	3	6
Age category	0-2	0	1	1
	≥2-4	0	0	0
	≥4-8	0	0	0
	≥8-13	2	2	4
	≥13	1	0	1
	Total	3	3	6

The seroprevalence of rabies virus in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# Rabies virus positive	# Rabies virus negative	Total number sampled
Year	2002	0	7	7
	2003	0	9	9
	Total	0	16	16
Sex	F	0	5	5
	M	0	11	11
	Total	0	16	16
Age category	0-2	0	2	2
	≥2-4	0	1	1
	≥4-8	0	4	4
	≥8-13	0	6	6
	≥13	0	3	3
	Total	0	16	16

The seroprevalence of *Toxoplasma gondii* in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# *Toxoplasma gondii* positive	**# *Toxoplasma gondii* negative**	**Total number tested**
Year	2002	0	7	7
	2003	2	7	9
	Total	2	14	16
Sex	F	0	5	5
	M	2	9	11
	Total	2	14	16
Age category	0-2	0	2	2
	≥2-4	0	1	1
	≥4-8	1	3	4
	≥8-13	0	6	6
	≥13	1	2	3
	Total	2	14	16

The seroprevalence of canine parvovirus-2 in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# Canine parvovirus -2 positive	**# Canine parvovirus-2 negative**	**Total number tested**
Year	2002	0	5	5
	2003	0	9	9
	Total	0	14	14
Sex	F	0	4	4
	M	0	10	10
	Total	0	14	14
Age category	0-2	0	2	2
	≥2-4	0	1	1
	≥4-8	0	2	2
	≥8-13	0	6	6
	≥13	0	3	3
	Total	0	14	14

APPENDIX C

Number of nematode and cestode eggs found per gram of feces (wet weight) in opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

Bear ID	Collection location	Year	Sex	Age (Years)	*Baylisascaris* eggs (# per g feces wwt[a])	*Strongyle* eggs (# per g feces wwt[a])	*Taenia* eggs (# per g feces wwt[a])
BB2	Simpson	2002	M	7	23	neg	neg
BB3	Simpson	2002	M	20	21	neg	neg
BB4	Simpson	2002	M	2	neg	neg	neg
BB5	Simpson	2002	F	13	neg	neg	neg
BB6	Simpson	2002	F	coy[b]	neg	neg	neg
BB7	Simpson	2002	M	10	neg	neg	neg
BB8	Simpson	2002	M	9	neg	neg	neg
BB9	Simpson	2002	F	9	55	neg	neg
BB10	Simpson	2002	F	4	neg	neg	neg
BB11	Liard	2002	F	21	neg	neg	neg
BB14	Simpson	2002	M	12	21	neg	neg
BB16	Simpson	2003	F	10	neg	neg	neg
BB17	Jean Marie River	2003	M	16	2.6	neg	neg
BB19	Simpson	2003	M	11	neg	neg	neg
BB20	Simpson	2003	M	5	neg	0.4	neg
BB21	Simpson	2003	M	4	neg	neg	neg
BB22	Simpson	2003	M	18	neg	800	neg
BB23	Simpson	2003	M	9	neg	neg	neg
BB24	Bannockland	2003	F	10	0.2	neg	neg
BB26	Simpson	2003	M	11	74.8	68.4	neg
BB28	Simpson	2003	M	11	neg	neg	neg
BB29	Simpson	2003	F	4	neg	neg	neg
BB31	Simpson	2003	M	2	163.2	neg	neg
BB32	Jean Marie River	2003	M	6	35.8	neg	80.6
BB33	Simpson	2003	F	4	400	neg	neg
BB34	Simpson	2003	M	6	147.6	neg	neg
BB35	Simpson	2003	F	3	1.2	neg	neg

[a] Wet weight
[b] Cub of the year.

Number of fluke eggs, fecal larvae and *Giardia* spp. cysts and *Cryptosporidium* spp. oocysts found per gram of feces (wet weight) in opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

Bear ID	Collection location	Year	Sex	Age (years)	Fluke eggs (# per 2 g feces wwt[a])	Larvae (# per 5 g feces wwt[a])	*Giardi/ Cryptsporidium* (IFA[b])
BB2	Simpson	2002	M	7	neg	neg	neg
BB3	Simpson	2002	M	20	neg	neg	neg
BB4	Simpson	2002	M	2	neg	neg	neg
BB5	Simpson	2002	F	13	neg	neg	neg
BB6	Simpson	2002	F	coy[c]	neg	neg	neg
BB7	Simpson	2002	M	10	neg	neg	neg
BB8	Simpson	2002	M	9	neg	neg	neg
BB9	Simpson	2002	F	9	neg	neg	neg
BB10	Simpson	2002	F	4	neg	neg	neg
BB11	Liard	2002	F	21	neg	neg	neg
BB14	Simpson	2002	M	12	neg	neg	neg
BB16	Simpson	2003	F	10	neg	neg	neg
BB17	Jean Marie River	2003	M	16	neg	neg	neg
BB19	Simpson	2003	M	11	neg	neg	neg
BB20	Simpson	2003	M	5	neg	neg	neg
BB21	Simpson	2003	M	4	neg	neg	neg
BB22	Simpson	2003	M	18	neg	neg	neg
BB23	Simpson	2003	M	9	neg	neg	neg
BB24	Bannockland	2003	F	10	neg	neg	neg
BB26	Simpson	2003	M	11	neg	neg	neg
BB28	Simpson	2003	M	11	neg	neg	neg
BB29	Simpson	2003	F	4	neg	neg	neg
BB31	Simpson	2003	M	2	neg	neg	neg
BB32	Jean Marie River	2003	M	6	neg	neg	neg
BB33	Simpson	2003	F	4	neg	neg	neg
BB34	Simpson	2003	M	6	neg	neg	neg
BB35	Simpson	2003	F	3	neg	neg	neg

[a] Wet weight.
[b] Immunofluorescence assay
[c] Cub of the year.

Number of worms found by gross examination of stomach content in opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

ID#	Year	Collection location	Sex	Age	*Baylisascaris transfuga*	*Uncinaria*
					Gross exam	Gross exam
BB2	2002	Simpson	M	7	neg	neg
BB3	2002	Simpson	M	20	neg	neg
BB4	2002	Simpson	M	2	neg	neg
BB5	2002	Simpson	F	13	neg	neg
BB6	2002	Simpson	F	coy[a]	neg	neg
BB7	2002	Simpson	M	10	neg	neg
BB8	2002	Simpson	M	9	neg	neg
BB9	2002	Simpson	F	9	neg	neg
BB10	2002	Simpson	F	4	neg	neg
BB11	2002	Liard	F	21	neg	neg
BB14	2002	Simpson	M	12	neg	neg
BB15	2002	Simpson	F	coy	14	neg
BB16	2003	Simpson	F	10	neg	neg
BB17	2003	Jean Marie River	M	16	neg	neg
BB19	2003	Simpson	M	11	neg	neg
BB20	2003	Simpson	M	5	neg	neg
BB21	2003	Simpson	M	4	neg	neg
BB22	2003	Simpson	M	18	neg	neg
BB23	2003	Simpson	M	9	neg	neg
BB24	2003	Bannockland	F	10	neg	neg
BB26	2003	Simpson	M	11	neg	1
BB28	2003	Simpson	M	11	neg	neg
BB29	2003	Simpson	F	4	neg	neg
BB31	2003	Simpson	M	2	1	neg
BB32	2003	Jean Marie River	M	6	neg	neg
BB33	2003	Simpson	F	4	neg	neg
BB34	2003	Simpson	M	6	neg	neg
BB35	2003	Simpson	F	3	neg	neg

[a] Cub of the year.

Number of worms found by gross and microscope examination of intestinal content of opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

ID#	Year	Collection location	Sex	Age	*B. transfuga*[a]	*Cestode*	*Uncinaria*	Other
					Gross exam	Gross exam	Stereo[b] exam	Stereo[b] exam
BB2	2002	Simpson	M	7	9	neg	neg	neg
BB3	2002	Simpson	M	20	12	neg	neg	neg
BB4	2002	Simpson	M	2	neg	neg	neg	neg
BB5	2002	Simpson	F	13	1	neg	neg	neg
BB6	2002	Simpson	F	Coy[c]	15	neg	neg	neg
BB7	2002	Simpson	M	10	6	neg	356	neg
BB8	2002	Simpson	M	9	2	neg	neg	neg
BB9	2002	Simpson	F	9	19	neg	neg	neg
BB10	2002	Simpson	F	4	12	neg	neg	neg
BB11	2002	Liard	F	21	neg	neg	820	neg
BB14	2002	Simpson	M	12	12	neg	neg	neg
BB15	2002	Simpson	F	coy	111	neg	neg	neg
BB16	2003	Simpson	F	10	neg	neg	neg	neg
BB17	2003	Jean Marie River	M	16	3	neg	neg	neg
BB19	2003	Simpson	M	11	neg	Positive	70	neg
BB20	2003	Simpson	M	5	2	neg	280	neg
BB21	2003	Simpson	M	4	neg	neg	neg	neg
BB22	2003	Simpson	M	18	neg	neg	1720	10
BB23	2003	Simpson	M	9	neg	Positive	neg	neg
BB24	2003	Bannockland	F	10	neg	neg	neg	neg
BB26	2003	Simpson	M	11	9	neg	1860	neg
BB28	2003	Simpson	M	11	1	neg	neg	neg
BB29	2003	Simpson	F	4	neg	neg	neg	neg
BB31	2003	Simpson	M	2	1	neg	neg	neg
BB32	2003	Jean Marie River	M	6	5	Positive	10	neg
BB33	2003	Simpson	F	4	75	neg	neg	neg
BB34	2003	Simpson	M	6	23	neg	70	neg
BB35	2003	Simpson	F	3	neg	neg	20	neg

[a] *Baylisascaris transfuga*.
[b] Microscope exam of intestinal content.
[c] Cub of the year.

Number of worms found by gross examination and dissection of airways in the lungs of opportunistically sampled black bears in the Dehcho region, NWT from 2002-2003 presented by age, sex, year of collection and sample area.

ID#	Year	Collection location	Sex	Age	Gross exam / Dissection
BB2	2002	Simpson	M	7	neg
BB3	2002	Simpson	M	20	neg
BB4	2002	Simpson	M	2	neg
BB5	2002	Simpson	F	13	neg
BB6	2002	Simpson	F	coy	neg
BB7	2002	Simpson	M	10	neg
BB8	2002	Simpson	M	9	neg
BB9	2002	Simpson	F	9	neg
BB10	2002	Simpson	F	4	neg
BB11	2002	Liard	F	21	neg
BB14	2002	Simpson	M	12	neg
BB15	2002	Simpson	F	coy	neg
BB16	2003	Simpson	F	10	neg
BB17	2003	Jean Marie River	M	16	neg
BB19	2003	Simpson	M	11	neg
BB20	2003	Simpson	M	5	neg
BB21	2003	Simpson	M	4	neg
BB22	2003	Simpson	M	18	neg
BB23	2003	Simpson	M	9	neg
BB24	2003	Bannockland	F	10	neg
BB26	2003	Simpson	M	11	neg
BB28	2003	Simpson	M	11	neg
BB29	2003	Simpson	F	4	neg
BB31	2003	Simpson	M	2	neg
BB32	2003	Jean Marie River	M	6	neg
BB33	2003	Simpson	F	4	neg
BB34	2003	Simpson	M	6	neg
BB35	2003	Simpson	F	3	neg

Number of *Trichinella* spp. larvae found in skeletal muscle (tongue or masseter muscle) of opportunistically sampled black bears in the Dehcho region, NWT from 2002-2010 presented by age, sex, year of collection and sample area.

ID#	Year	Collection location	Sex	Age	*Trichinella* # Larvae/gram muscle
BB2	2002	Simpson	M	7	neg
BB3	2002	Simpson	M	20	neg
BB4	2002	Simpson	M	2	neg
BB5	2002	Simpson	F	13	neg
BB6	2002	Simpson	F	coy[a]	neg
BB7	2002	Simpson	M	10	neg
BB8	2002	Simpson	M	9	neg
BB9	2002	Simpson	F	9	neg
BB10	2002	Simpson	F	4	neg
BB11	2002	Liard	F	21	neg
BB14	2002	Simpson	M	12	neg
BB15	2002	Simpson	F	coy	neg
BB16	2003	Simpson	F	10	neg
BB17	2003	Jean Marie River	M	16	neg
BB18	2003	Jean Marie River	n/a	3	neg
BB19	2003	Simpson	M	11	neg
BB20	2003	Simpson	M	5	neg
BB21	2003	Simpson	M	4	neg
BB22	2003	Simpson	M	18	neg
BB23	2003	Simpson	M	9	neg
BB24	2003	Bannockland	F	10	neg
BB25	2003	Simpson	M	14	neg
BB26	2003	Simpson	M	11	neg
BB27	2003	Simpson	M	9	neg
BB28	2003	Simpson	M	11	neg
BB29	2003	Simpson	F	4	neg
BB30	2003	Nahanni Butte	M	15	neg
BB31	2003	Simpson	M	2	neg
BB32	2003	Jean Marie River	M	6	neg
BB33	2003	Simpson	F	4	neg
BB34	2003	Simpson	M	6	neg
BB35	2003	Simpson	F	3	neg
BB36	2003	Nahanni Butte	?	5	13
BB37	2004	Checkpoint	F	15	neg
BB38	2004	Simpson	M	20	neg

ID#	Year	Collection location	Sex	Age	*Trichinella* # Larvae/gram muscle
BB39	2004	Fort Liard	M	8	neg
BB40	2004	Simpson	M	11	neg
BB41	2004	Simpson	M	19	neg
BB42	2004	Simpson	M	1	neg
BB43	2004	Fort Liard	M	8	neg
BB44A	2005	Wrigley	M	19	neg
BB44	2005	Simpson	M	19	neg
BB45	2005	Antoine Lake	F	8	neg
BB46	2005	Simpson	M	8	neg
BB47	2005	S of Willow River	F	15	neg
BB49	2005	near Kelly Lake (E of JMR jct)	F	9	neg
BB50	2005	10mi E Checkpoint	F	coy	neg
BB51	2005	Bannockland	M	17	neg
BB52	2005	Nahanni Butte	M	15	neg
BB53	2005	Simpson	M	2	neg
BB54	2006	near N'Dulee	M	10	neg
BB55	2006	Shale Creek	M	11	neg
BB57	2006	Checkpoint	M	9	neg
BB58	2006	Simpson	M	5	neg
BB59	2006	Simpson	F	8	neg
BB60	2006	Simpson	M	11	177
BB61	2006	Simpson	M	9	0.8
BB62	2006	Simpson	M	10	0.1
BB63	2006	Simpson	M	5	neg
BB64	2006	Simpson	M	6	neg
BB65	2006	Simpson	M	9	neg
BB66	2006	Simpson	F	11	neg
BB67	2006	Simpson	M	coy	neg
BB68	2006	Simpson	F	15	neg
BB69	2006	Simpson	M	11	neg
BB70	2006	Simpson	M	4	neg
BB71	2006	Simpson	F	12	neg
BB72	2006	Simpson	M	12.5	neg
BB73	2006	Simpson	M	9	neg
BB74	2007	8km NW Checkpoint	M	17	neg
BB75	2007	Wrigley Fire Base	M	3	neg
BB76	2007	Simpson	M	7	neg
BB77	2007	Simpson	M	2	neg
BB78	2007	Liard highway	F	2	0.1

ID#	Year	Collection location	Sex	Age	*Trichinella* # Larvae/gram muscle
BB79	2007	Simpson	M	6	neg
BB80	2007	Simpson	F	14	neg
BB81	2007	South Nahanni River	F	13	neg
BB82	2007	Simpson	M	2	neg
BB84	2008	Jean Marie River	M	11	neg
BB85	2008	Simpson	F	6	neg
BB86	2008	Jean Marie River	F	6	neg
BB87	2008	Simpson	M	12	neg
BB88	2008	Simpson	M	9	neg
BB89	2008	Simpson	M	18	neg
BB90	2008	Simpson	M	10	neg
BB91	2008	Simpson	M	2	neg
BB93	2008	Simpson	F	3	neg
BB94	2008	Simpson	F	2	neg
BB95	2008	Simpson	F	8	neg
BB96	2008	Checkpoint	F	11.5	neg
BB97	2008	Bannockland	M	9	neg
BB98	2008	Simpson	M	22	neg
BB99	2008	Nahanni Butte	M	9	neg
BB101	2009	Simpson	F	4	neg
BB102	2009	Jean Marie River	M	11	neg
BB103	2009	N'Dulee	M	12	neg
BB104	2009	Simpson	M	4	neg
BB105	2009	Simpson	M	11	neg
BB106	2009	Simpson	M	16	neg
BB107	2009	Simpson	F	4	neg
BB108	2009	Simpson	F	9	neg
BB109	2009	Simpson	M	2	neg
BB110	2009	Simpson	M	3	neg
BB111	2009	Simpson	M	20	neg
BB112	2009	Simpson	M	22	neg
BB113	2009	Fort Liard	M	7	neg
BB114	2009	Axe Handle Creek	?	7	neg
BB115	2010	N of JMR	F	4	1.9
BB116	2010	near km 10 Liard Hwy 7	M	3	neg
BB117	2010	Simpson	M	5	neg
BB118	2010	Simpson	M	4	neg
BB119	2010	Simpson	M	22	neg
BB120	2010	Simpson	M	11.5	neg

ID#	Year	Collection location	Sex	Age	*Trichinella* # Larvae/gram muscle
BB121	2010	Simpson	M	4	neg
BB122	2010	Simpson	M	28	0.75
BB124	2010	Jean Marie River	M	18.5	neg
BB125	2010	Simpson	M	18	neg
BB126	2010	Simpson	M	3	neg
BB127	2010	Simpson	M	5	neg
BB128	2010	Jean Marie River	M	4	neg

[a] Cub of the year.

APPENDIX D

The prevalence of gastrointestinal nematodes in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# *Baylisascaris transfuga* positive	# *Baylisascaris transfuga* negative	Total number sampled
Year	2002	10	2	12
	2003	8	8	16
	Total	18	10	28
Sex	F	6	5	11
	M	12	5	17
	Total	18	10	28
Age category	0-2	2	0	2
	≥2-4	1	2	3
	≥4-8	6	2	8
	≥8-13	6	4	10
	≥13	3	2	5
	Total	18	10	28

		# *Uncinaria rauschi* positive	# *Uncinaria rauschi* negative	Total number sample
Year	2002	2	10	12
	2003	7	9	16
	Total	9	19	28
Sex	F	2	9	11
	M	7	10	17
	Total	9	19	28
Age category	0-2	0	2	2
	≥2-4	1	2	3
	≥4-8	3	5	8
	≥8-13	3	7	10
	≥13	2	3	5
	Total	9	19	28

The prevalence of *Trichinella* spp. larvae in opportunistically sampled black bears in the Dehcho region of the NWT presented by sample year, sex and age category.

		# *Trichinella* spp. positive	**# *Trichinella* spp. Negative**	**Total number sampled**
Year	2002	0	12	12
	2003	1	20	21
	2004	0	7	7
	2005	0	10	10
	2006	3	16	19
	2007	1	8	9
	2008	0	15	15
	2009	0	14	14
	2010	2	11	13
	Total	7	113	120
Sex	F	2	31	33
	M	4	80	84
	Total	6	111	117
Age category	0-2	0	5	5
	≥2-4	1	15	16
	≥4-8	2	26	28
	≥8-13	3	40	43
	≥13	1	27	28
	Total	7	113	120