Prevalence of *Trichinella* spp. in Black Bears in the Dehcho, 2002-2014

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ABSTRACT

The ingestion of either black bear or walrus meat has been the source of almost all human cases of *Trichinella* spp. infections in Canada since 1980. Black bears are a food source for residents in the Dehcho. As part of a wildlife disease monitoring program we monitored the presence of *Trichinella* spp. in muscle tissue of black bears from 2002-2014. Tongue (n=151) or masseter (n=1) muscle samples were collected opportunistically from 192 black bears that were either killed for public safety (n=170), killed in collisions with motor vehicles (n=9), found dead (n=7) or legally harvested (n=6) in the Dehcho. Prevalence of *Trichinella* spp. was 446% (n=8), with three bears having parasite infection intensities of >1 *Trichinella* spp. larvae per gram of muscle tissue, the level considered to pose a food safety risk. Continued monitoring of the prevalence of *Trichinella* spp. in black bears, as well as documenting prevalence in cohabiting scavenger populations, and continued public awareness of *Trichinella* spp. should help reduce the food safety risk to harvesters in the Dehcho.

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INTRODUCTION

Black bears (*Ursus americanus*) are the most common and widely distributed bear species in North America (Pelton 2000), and are found throughout the Dehcho region located in southwestern portion of the NWT (Figure 1). In the Dehcho, black bears are harvested for meat and fur by local Aboriginal hunters. Black bears are also a big game species harvested by both resident and non-resident hunters. Most management of black bears in the Dehcho primarily involves dealing with human - bear conflicts. 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 Northwest Territories (NWT).

Trichinella spp., a genus of nematode found in a wide variety of mammalian species world-wide, can cause disease in humans that consume raw or under-cooked meat infected with *Trichinella* larvae. All but one human case of trichinellosis in Canada since 1980 have been attributed to the consumption of raw or undercooked black bear or walrus meat (Appelyard and Gajadhar 2000). *Trichinella* spp. infections in black bears is a genuine food safety risk to harvesters from the Dehcho (Johnson et al. 2013).

As part of a wildlife disease monitoring program and to assess the food safety risk posed by *Trichinella* spp. in black bears, we opportunistically collected muscle (primarily tongue) samples (from 2002-2014) from black bears that were either killed for public safety, killed in collisions with motor vehicles, found dead, or legally harvested in the Dehcho. Muscle samples were tested for the presence of *Trichinella* spp. larva. The presence, prevalence, and intensity of *Trichinella* spp. larvae found in black bears from the Dehcho during 2002-2014 are reported.

STUDY AREA

The study area was the entire Dehcho political region of the southwestern NWT (Figure 1).

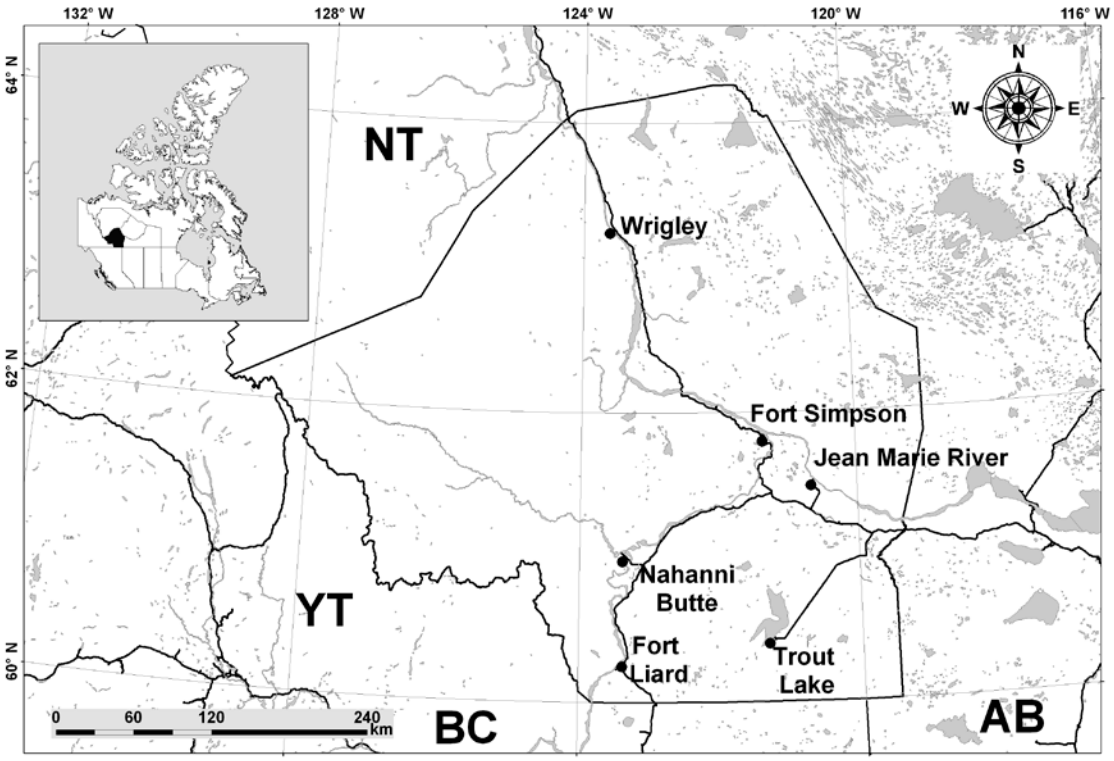

Figure 1. The Dehcho political region, road system, and the location of communities.

METHODS

From 2002-2014, samples of tongue (n=179) or masseter muscle (n=1) were opportunistically collected from the 192 bears that were either killed for public safety reasons (nuisance bears and defense kills; n=170), killed in collisions with motor vehicles (n=9), legally harvested (n=6) or found dead (n=7) around the communities in the Dehcho region of the NWT (Figure 1). A location, date of death, and sex of the animal sample was collected when possible. Muscle tissue samples were stored frozen in the regional office in Fort Simpson. From 2002-2011 frozen samples were forwarded annually to the Centre for Food-borne and Animal Parasitology, Canadian Food Inspection Agency, Saskatoon. Frozen samples from 2012-2014 were forwarded in 2013 and 2014 to the Veterinary Pathology Lab at the Western College of Veterinary Medicine, Saskatoon.

Frozen tongue samples were thawed to room temperature and trimmed to remove fat and connective tissue. The digestion assay for the detection of *Trichinella* spp. larvae in muscle tissue followed Forbes and Gajadhar (1999) and Forbes et al. (2008). Weights of tested tongue (and one masseter muscle) ranged from 1.8-62.2g (mean 18.5, median 12.8, standard deviation 12.8) for samples from 2002-2011 and 0.2-20.3g (mean 8.3, median 7.4, standard deviation 4.9) for samples from 2012-2014. Because sample size varied, results were converted to larvae/g (LPG) of muscle tested.

The first premolar was removed from each sampled bear for aging following the counting of cementum annuli technique (Matson 1981).

RESULTS

Eight of 180 bears (4.4% prevalence) sampled from 2002-2014 tested positive for *Trichinella* spp. larvae (Tables 1, 2).

Table 1. The number of bears tested for *Trichinella* spp. presence, mean and range of tested bear ages, and number of positive tests for each year 2002-2014.

Year	# Tested	Mean Age	Min Age[1]	Max Age	# Positive
2002	12	8.9	coy	21	0
2003	21	8.4	2	18	1
2004	7	11.7	1	20	0
2005	10	11.2	coy	19	0
2006	19	8.8	coy	15	3
2007	9	7.3	2	17	1
2008	15	9.2	2	22	0
2009	14	9.4	2	22	0
2010	13	10.0	3	28	2
2011	20	8.3	coy	19	1
2012	14	8.2	1	16	0
2013	18	6.3	coy	25	0
2014	8	6.1	2	16	0
Total	180	8.6	coy	28	8

[1] coy is cub-of-the-year and age of 0 used for all calculations.

Table 2. Calculated prevalence and intensity (number of larvae/g for positive animals) of *Trichinella* spp. in black bears of the Dehcho from 2002-2014.

Year	# Tested	Prevalence	Intensity (Larva/gram)
2002	12	0.0%	
2003	21	4.8% (n=1)	13
2004	7	0.0%	
2005	10	0.0%	
2006	19	15.8% (n=3)	177; 0.8; 0.1
2007	9	11.1% (n=1)	0.1
2008	15	0.0%	
2009	14	0.0%	
2010	13	15.4% (n=2)	1.9; 0.75
2011	20	5.0% (n=1)	0.04
2012	14	0.0%	
2013	18	0.0%	
2014	8	0.0%	
Total	180	4.4% (n=8)	177; 13; 1.9; 0.8; 0.75; 0.1; 0.1; 0.04

The sex and age structures of the bears that tested positive for *Trichinella* spp. were similar to those that tested negative for *Trichinella* spp.; namely, most of the bears were male and ≥4 years of age (Table 3, Appendix 1). Three of eight positive bears had >1 *Trichinella* spp. larvae per gram of muscle tissue (Table 2), which is the level of *Trichinella* spp. larvae in meat considered to pose a food safety risk (Larter et al. 2011).

Table 3. Sample ID, age, sex, date sampled, location, and larvae/g of muscle tissue for each of the eight black bears that tested positive for *Trichinella* spp. presence.

Sample ID	Age	Sex	Date Sampled	Location	Larvae/g
BB36	5	n/a	15-Aug-03	Nahanni Butte	13
BB60	11	M	25-Jun-06	Fort Simpson	177
BB61	9	M	26-Jun-06	Fort Simpson	0.8
BB62	10	M	29-Jun-06	Fort Simpson	0.1
BB78	2	F	3-Aug-07	Km 230 Liard Highway	0.1
BB115	4	F	15-Feb-10	North of Jean Marie River	1.9
BB122	28	M	16-Aug-10	Fort Simpson	0.75
BB142	18	M	26-Aug-11	Fort Simpson	0.04

DISCUSSION

Sampling intensity for *Trichinella* spp. varies considerably across Canadian jurisdictions and not surprisingly so do reported prevalence. No positive reports have been documented from Alberta (AB) (n=265), Manitoba (MB) (n=1), the island of Newfoundland (NFLD) (n=66), Nova Scotia (NS) (n=51) or Prince Edward Island (PEI) (n=1) (Appelyard and Gajadhar 2000, Butler and Khan 1992). Prevalence in Ontario (ON), Quebec (QC), New Brunswick (NB) and Labrador were 2.7% (n=73), 1% (n=258), 0.4% (n=569) and 1% (n=96), respectively (Appelyard and Gajadhar 2000, Butler and Khan 1992). Gajadhar and Forbes (2010), found 7.3% prevalence (n=193) black bears sampled between 1998 and 2007 from the NWT, British Columbia (BC), SK and QC. The highest reported prevalence was 12% (n=193) from black bears in the Kootney region of BC (Schmidt et al. 1978). The prevalence we report for the Dehcho is 4.4% (n=180).

The range of *Trichinella* spp. reported in black bears across jurisdictions suggests there may be regional variation in prevalence. Human cases of *Trichinella* spp. infection from the ingestion of black bear meat have occurred in jurisdictions where the documented prevalence of *Trichinella* spp. is relatively low (Schad et al. 1986). Given the fact that 1.7% (three of 180) of bears in the Dehcho region had infestations of >1 *Trichinella* spp. larvae per gram of muscle tissue, human *Trichinella* spp. infection should be considered a potential risk associated with ingestion of raw or undercooked black bear meat from the Dehcho region.

Black bears can become infected with *Trichinella* spp. consuming *Trichinella* infected prey species, feeding on parasitized-carrion in the wild or at garbage dumps, or cannibalism. A sylvatic cycle of *Trichinella* spp. is well recognized in black bears in North America, where black bears act as the natural host. 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). Larter et al. (2011) found bears from the Dehcho were either infected with *Trichinella* T2 or T6. *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 T2 (Gajadhar and Forbes 2010).

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). Larter et al. (2011) and Johnson et al. (2013) suggested that monitoring the prevalence of *Trichinella* spp. in cohabitating mammalian food sources could provide a better understanding of the ecology of *Trichinella* spp. in the Dehcho. Preliminary results from subsequent sampling of many cohabiting mammalian food sources show no positive results from any samples of moose (*Alces alces*), wood bison (*Bison bison athabascae*), Dall's sheep (*Ovis dalli*), mountain goat (*Oreamnos americanus*), woodland or barren-ground caribou (*Rangifer tarandus caribou, R.t. groenlandicus*), lynx (*Lynx canadensis*), marten (*Martes americana*), snowshoe hare (*Lepus americanus*), beaver (*Castor canadensis*) or small rodents (mice, voles, shrews) (N. Larter unpublished data). Prevalence for cohabiting scavengers is 50% (n=4) in red fox (*Vulpes vulpes*), 25% (n=49) in wolverine (*Gulo gulo*), 62% (n=76) in wolves (*Canis lupus*), and 64% (n=14) in grizzly bear (*Ursus arctos*) (N. Larter unpublished data). Low prevalence in small mammals versus scavengers is consistent with what has been found elsewhere. The low prevalence in both small and large mammal prey species indicates that prey species are an unlikely source of *Trichinella* spp. for predators and scavengers, yet these predators and scavengers have a high prevalence.

Since sylvatic cycles of *Trichinella* spp. cannot be eradicated from Canadian wildlife, its presence in black bears, even though at a low prevalence, needs to be considered a potential food safety concern. To reduce human cases of trichinellosis through ingestion of black bear meat public education is important. Black bear meat should be cooked to an internal temperature of 77°C prior to consumption (Food Safety Network 2009). Larvae are not killed consistently by curing, salting, smoking, drying or microwaving infected meat. *T. nativa* (T2) and *Trichinella* T6 are cold-adapted and resistant to freezing. Larvae can remain viable for years at freezing temperatures so thawed frozen meat still needs to be properly cooked before it is safe for human consumption.

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APPENDIX 1

Sample ID, sampling date, sex, age, location, and presence of *Trichinella* from all tongue (and one masseter muscle) of black bears from the Dehcho 2002-2014. Coy is cub-of-the-year.

ID	Date	Sex	Age	Location	*Trichinella*
BB2	14-Aug-02	M	7	Fort Simpson	Neg
BB3	14-Aug-02	M	20	Fort Simpson	Neg
BB4	14-Aug-02	M	2	Fort Simpson	Neg
BB5	16-Aug-02	F	13	Fort Simpson	Neg
BB6	16-Aug-02	F	coy	Fort Simpson	Neg
BB7	19-Aug-02	M	10	Fort Simpson	Neg
BB8	21-Aug-02	M	9	Fort Simpson	Neg
BB9	24-Aug-02	F	9	Fort Simpson	Neg
BB10	25-Aug-02	F	4	Fort Simpson	Neg
BB11	26-Aug-02	F	21	Fort Liard	Neg
BB14	7-Oct-02	M	12	Fort Simpson	Neg
BB15	26-Oct-02	F	coy	Fort Simpson	Neg
BB16	5-Jun-03	F	10	16 km NW Checkpoint	Neg
BB17	21-Jun-03	M	16	Jean Marie River	Neg
BB18	28-Jun-03	n/a	3	Jean Marie River	Neg
BB19	7-Jul-03	M	11	Fort Simpson	Neg
BB20	7-Jul-03	M	5	Fort Simpson	Neg
BB21	12-Jul-03	M	4	Fort Simpson	Neg
BB22	13-Jul-03	M	18	Fort Simpson	Neg
BB23	13-Jul-03	M	9	Fort Simpson	Neg
BB24	13-Jul-03	F	10	Bannockland (FS)	Neg
BB25	14-Jul-03	M	14	Fort Simpson	Neg
BB26	17-Jul-03	M	11	Fort Simpson	Neg
BB27	18-Jul-03	M	9	Fort Simpson	Neg
BB28	19-Jul-03	M	11	Fort Simpson	Neg
BB29	6-Aug-03	F	4	Fort Simpson	Neg
BB30	8-Aug-03	M	15	Nahanni Butte	Neg
BB31	12-Aug-03	M	2	Fort Simpson	Neg
BB32	13-Aug-03	M	6	Jean Marie River	Neg
BB33	14-Aug-03	F	4	Fort Simpson	Neg
BB34	24-Aug-03	M	6	Fort Simpson	Neg
BB35	31-Aug-03	F	3	Fort Simpson	Neg
BB36	15-Aug-03	n/a	5	Nahanni Butte	Pos
BB37	5-May-04	F	15	Checkpoint	Neg
BB38	8-Jul-04	M	20	Fort Simpson	Neg
BB39	16-Jul-04	M	8	Fort Liard	Neg
BB40	19-Aug-04	M	11	Fort Simpson	Neg
BB41	31-Aug-04	M	19	Fort Simpson	Neg
BB42	31-Aug-04	M	1	Fort Simpson	Neg

ID	Date	Sex	Age	Location	*Trichinella*
BB43	5-Sep-04	M	8	Fort Liard	Neg
BB44A	16-May-05	M	19	Wrigley	Neg
BB44	7-Jul-05	M	19	Fort Simpson	Neg
BB45	9-Jul-05	F	8	Antoine Lake	Neg
BB46	19-Jul-05	M	8	Fort Simpson	Neg
BB47	20-Jul-05	F	15	S of Willow River	Neg
BB49	31-Jul-05	F	9	near Kelly Lake	Neg
BB50	12-Aug-05	F	coy	10 mi E Checkpoint	Neg
BB51	14-Aug-05	M	17	Bannockland (FS)	Neg
BB52	31-Aug-05	M	15	Nahanni Butte	Neg
BB53	10-Sep-05	M	2	Fort Simpson	Neg
BB54	20-May-06	M	10	near N'Dulee Crossing	Neg
BB55	24-May-06	M	11	Shale Creek	Neg
BB57	9-Jun-06	M	9	Checkpoint	Neg
BB58	17-Jun-06	M	5	Fort Simpson	Neg
BB59	21-Jun-06	F	8	Fort Simpson	Neg
BB60	25-Jun-06	M	11	Fort Simpson	Pos
BB61	26-Jun-06	M	9	Fort Simpson	Pos
BB62	29-Jun-06	M	10	Fort Simpson	Pos
BB63	4-Jul-06	M	5	Fort Simpson	Neg
BB64	6-Jul-06	M	6	Fort Simpson	Neg
BB65	10-Jul-06	M	9	Fort Simpson	Neg
BB66	11-Jul-06	F	11	Fort Simpson	Neg
BB67	11-Jul-06	M	coy	Fort Simpson	Neg
BB68	27-Jul-06	F	15	Fort Simpson	Neg
BB69	6-Aug-06	M	11	Fort Simpson	Neg
BB70	9-Aug-06	M	4	Fort Simpson	Neg
BB71	13-Aug-06	F	12	Fort Simpson	Neg
BB72	16-Aug-06	M	12.5	Fort Simpson	Neg
BB73	18-Aug-06	M	9	Fort Simpson	Neg
BB74	26-May-07	M	17	8 km NW Checkpoint	Neg
BB75	29-May-07	M	3	Wrigley Fire Base	Neg
BB76	10-Jul-07	M	7	Fort Simpson	Neg
BB77	18-Jul-07	M	2	Fort Simpson	Neg
BB78	3-Aug-07	F	2	Liard highway (km 230)	Pos
BB79	5-Aug-07	M	6	Fort Simpson	Neg
BB80	14-Aug-07	F	14	Fort Simpson	Neg
BB81	5-Sep-07	F	13	South Nahanni River	Neg
BB82	7-Sep-07	M	2	Fort Simpson	Neg
BB84	12-May-08	M	11	Jean Marie River	Neg
BB85	22-May-08	F	6	Fort Simpson	Neg
BB86	29-Jun-08	F	6	Jean Marie River	Neg
BB87	7-Jul-08	M	12	Fort Simpson	Neg

ID	Date	Sex	Age	Location	*Trichinella*
BB88	8-Jul-08	M	9	Fort Simpson	Neg
BB89	28-Jul-08	M	18	Fort Simpson	Neg
BB90	30-Jul-08	M	10	Fort Simpson	Neg
BB91	2-Aug-08	M	2	Fort Simpson	Neg
BB93	13-Aug-08	F	3	Fort Simpson	Neg
BB94	14-Aug-08	F	2	Fort Simpson	Neg
BB95	16-Aug-08	F	8	Fort Simpson	Neg
BB96	18-Aug-08	F	11.5	Checkpoint	Neg
BB97	25-Aug-08	M	9	Bannockland (FS)	Neg
BB98	4-Sep-08	M	22	Fort Simpson	Neg
BB99	18-Aug-08	M	9	Nahanni Butte	Neg
BB101	14-May-09	F	4	Fort Simpson	Neg
BB102	22-May-09	M	3	Jean Marie River	Neg
BB103	29-May-09	M	7	N'Dulee Crossing	Neg
BB104	13-Jun-09	M	2	Fort Simpson	Neg
BB105	5-Aug-09	M	2	Fort Simpson	Pos
BB106	14-Aug-09	M	6	Fort Simpson	Neg
BB107	24-Aug-09	F	14	Fort Simpson	Neg
BB108	28-Aug-09	F	13	Fort Simpson	Neg
BB109	9-Sep-09	M	2	Fort Simpson	Neg
BB110	10-Sep-09	M	n/a	Fort Simpson	n/a
BB111	17-Sep-09	M	11	Fort Simpson	Neg
BB112	21-Sep-09	M	6	Fort Simpson	Neg
BB113	22-Sep-09	M	6	Fort Liard	Neg
BB114	5-Oct-09	n/a	12	Axe Handle Creek	Neg
BB115	15-Feb-10	F	4	N of Jean Marie River	Pos
BB116	19-May-10	M	3	Liard highway (km 10)	Neg
BB117	29-May-10	M	5	Fort Simpson	Neg
BB118	31-May-10	M	4	Fort Simpson	Neg
BB119	4-Jul-10	M	22	Fort Simpson	n/a
BB120	14-Aug-10	M	11.5	Fort Simpson	Neg
BB121	16-Aug-10	M	4	Fort Simpson	Neg
BB122	16-Aug-10	M	28	Fort Simpson	Pos
BB124	19-Aug-10	M	18.5	Jean Marie River	Neg
BB125	21-Aug-10	M	18	Fort Simpson	Neg
BB126	28-Aug-10	M	3	Fort Simpson	Neg
BB127	10-Sep-10	M	5	Fort Simpson	n/a
BB128	12-Sep-10	M	4	Jean Marie River	Neg
BB129	17-May-11	M	8	Shale Creek	Neg
BB130	17-May-11	M	6	Fort Simpson	Neg
BB131	3-Jun-11	M	11	near Willowlake River	Neg
BB132	5-Jul-11	M	5	top of 4 mile hill (FS)	Neg
BB133	18-Jul-11	F	6	km 534 gravel pit	Neg

ID	Date	Sex	Age	Location	*Trichinella*
BB134	8-Aug-11	F	18	Trail River	Neg
BB135	14-Aug-11	M	2	Fort Simpson	Neg
BB136	14-Aug-11	M	9	Fort Simpson	Neg
BB137	13-Aug-11	M	2	near Notana Lake	Neg
BB138	15-Aug-11	F	19	Fort Simpson	Neg
BB139	16-Aug-11	M	4	Fort Simpson	Neg
BB140	16-Aug-11	F	6	Fort Simpson	Neg
BB141	18-Aug-11	M	6	Nahanni Butte	Neg
BB142	26-Aug-11	M	18	Fort Simpson	Pos
BB143	8-Sep-11	M	17	Fort Simpson	Neg
BB144	9-Sep-11	M	5	Fort Simpson	Neg
BB145	10-Sep-11	M	11	Rabbitskin River	Neg
BB146	11-Sep-11	M	4	Wrigley	Neg
BB147	11-Sep-11	M	8	Wrigley	Neg
BB148	28-Sep-11	F	coy	Fort Simpson	Neg
BB149	30-May-12	F	5	Jean Marie River	Neg
BB150	4-Jun-12	M	4	Fort Simpson	Neg
BB151	8-Jun-12	M	15	Shale Creek	Neg
BB152	8-Jul-12	M	15.5	Fort Simpson	Neg
BB153	8-Aug-12	M	6	Fort Simpson	Neg
BB154	8-Aug-12	M	4	Fort Simpson	Neg
BB156	12-Aug-12	M	15	Blackstone	Neg
BB158	13-Aug-12	M	1	Fort Simpson	Neg
BB159	15-Aug-12	F	4	Fort Simpson	Neg
BB160	15-Aug-12	M	5	Fort Simpson	Neg
BB161	16-Aug-12	M	14	Fort Simpson	Neg
BB162	21-Aug-12	M	7	Fort Simpson	Neg
BB163	22-Aug-12	M	3	Fort Simpson	Neg
BB164	23-Aug-12	M	16	Nahanni Butte	Neg
BB165	23-May-13	M	13	Shale Creek	Neg
BB166	11-Jul-13	M	3	Trout Lake	Neg
BB167	19-Jul-13	F	25	Liard River Crossing	Neg
BB168	7-Aug-13	F	12	Fort Simpson	Neg
BB169	7-Aug-13	F	coy	Fort Simpson	Neg
BB170	7-Aug-13	M	coy	Fort Simpson	Neg
BB171	11-Aug-13	M	20	Fort Simpson	Neg
BB172	12-Aug-13	M	4	Fort Simpson	Neg
BB173	23-Aug-13	M	3	Fort Simpson	Neg
BB174	24-Aug-13	M	5	Fort Simpson	Neg
BB175	25-Aug-13	F	4	Fort Simpson	Neg
BB176	26-Aug-13	M	3	Fort Simpson	Neg
BB177	8-Sep-13	F	6	Jean Marie River	Neg
BB178	8-Sep-13	F	coy	Jean Marie River	Neg

ID	Date	Sex	Age	Location	*Trichinella*
BB179	8-Sep-13	F	coy	Jean Marie River	Neg
BB180	8-Sep-13	F	coy	Jean Marie River	Neg
BB181	10-Aug-13	M	12	Nahanni Butte	Neg
BB182	5-Oct-13	M	4	Fort Simpson	Neg
BB183	26-May-14	M	5	Fort Simpson	Neg
BB184	30-May-14	M	3	Sambaa Deh Park	Neg
BB185	26-Jul-14	M	16	Nahanni Butte	Neg
BB186	2-Aug-14	M	5	Jean Marie River	Neg
BB187	24-Aug-14	M	6	Mackenzie Mountains	Neg
BB188	1-Sep-14	M	8	Nahanni Butte	Neg
BB189	26-Sep-14	F	2	Fort Liard	Neg
BB192	27-Sep-14	M	4	Fort Liard	Neg