Occurrence and pathology of liver worms in burbot from the McKenzie River Delta

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Background

Parasites can cause a wide range of problems for their hosts, from reduced weight gain, to reduced reproduction, to subtle affects on behaviour. Negative effects on physiological status are also well known. Such negative effects are often clearest, and most easily detectable, when parasites enter the 'wrong' host. *Raphadascaris acus* is a well-known and cosmopolitan nematode worm that matures in the small intestine of pike and walleye. These piscivores become infected when they ingest resting stages of the parasite. In northern and central Canada, ciscoe and whitefish are the typical intermediate hosts, often containing 100's of cysts on the viscera.

When burbot ingest infected ciscoe and whitefish, the larval nematodes excyst, but fail to migrate to the small intestine. Rather, the worms reside in the liver, undergo a period of growth and development, and then are destroyed by the host immune system. A combination of damage via ingestion of tissue, migration through tissue, and also immunopathology are thought to lead to marked liver damage in burbot. Infected livers tend to be darkened by the deteriorating worms, leaving noticeable migration tracks and signs of necrosis. Earlier studies by Lionel Bernier and Terry Dick in the 1980's confirmed that burbot collected from various sites along the McKenzie River were infected with *R. acus* and showed obvious signs of liver damage. Given the cultural significance of burbot livers to local Inuit, this study was undertaken to further evaluate the linkage between infection with *R. acus* and liver damage. Further, anecdotal observations from local fishermen indicated a concern that worm-induced damage to livers had markedly increased since the 1980's. In this study, we used standard parasitological methods to compare worm numbers in burbot collected during fall 2007 and 2008 to those collected over 20 years earlier from similar sites.

Methods

Burbot were collected by local fishermen from 4 general sites located within the lower McKenzie River delta (Fig. 1). Collections occurred between November and late December in 2007 and in 2008. Individual fish were weighed and measured for maximum length, and then their livers, gonads and stomachs removed for later analysis. Aging structures were also removed. Stomachs were evaluated for food contents. Frozen livers were sent to the Parasitology lab at University of Lethbridge. Total worm counts were estimated by subsampling 3 randomly selected sections of liver. The sections were weighed and the total numbers of worm in each section counted under a dissecting microscope. Total worm counts per host were estimated by scaling up to the total weight of the liver.

Results

Table 1 and Figure 1 provide summary infection characteristics for the total of 145 livers that have been evaluated for *R. acus* from burbot collected at the 4 sites. Prevalence of *R.*

acus in the burbot populations was very high, with almost all hosts in each population containing at least one worm. The mean numbers of worms per liver varied from 0 to near 100, with most hosts containing approximately 35 worms. Samples from Inuvik, Aklavik, and Fort MacPherson contained similar numbers of worms, whereas samples from Arctic Red River were relatively lightly infected.

Relative to comparisons between the two sampling periods (2007/8 vs. 1985), only samples from the Arctic Red River are comparable. Thus, samples from Inuvik, Aklavik, and Fort MacPherson are not available from the 1980's. Differences in the methodology associated with assessment of worm counts make direct comparison problematic. However, overall prevalence of infection of *R. acus* between burbot collected in 1985 and in 2007 are very similar. Further, estimates of the mean numbers of worms per gram of liver tissue between the two sampling periods are low and not significantly different.

Conclusions

- Burbot collected from 3 general sites along the lower McKenzie river are heavily infected with *R. acus*. Almost all hosts within each of these 3 sites are infected, typically with about 35 worms. These infection characteristics are approximately an order of magnitude higher than those reported in burbot from earlier studies.
- Liver damage reported in the earlier studies was also evident in livers sampled in 2007/08. Further physiological assays that more rigorously assess the magnitude of worm-associated liver damage are underway.
- The comparison between past and current infection levels is severely confounded by site. Thus, only one site is comparable between the two periods. At this site, there is no evidence for an overall increase in worm burdens in burbot. Rather, infection levels show remarkable consistency between the two time periods.
- The earlier study (1980's) focused on burbot sampled from sites further upstream on the McKenzie River, up to Fort Simpson. Prevalence of *R. acus* infection was characteristically low, with few hosts containing more than 5 worms. In contrast, almost all burbot sampled from sites within the delta are infected, with most hosts containing from 30-50 worms. One explanation is that reduced rates of water flow lead either to higher infection levels of resting stages in ciscoe and whitefish, or higher rates of predation by burbot on these intermediate hosts. Regardless of the underlying mechanisms, burbot livers are most heavily infected, and presumable most heavily damaged, at sites furthest downstream.

Work remaining

- We wish to finish parasitological analyses on approximately 50 more livers so that we complete approximately 30 adult burbot from each site, each year.
- Some of the samples have been accurately aged. This provides a rare opportunity to evaluate the linkage between host age and worm numbers (and damage). If the worms are strongly pathogenic, then the average number of worms per host should decline in the oldest hosts (because old, heavily-infected hosts die). We can test this by increasing the numbers of burbot livers dissected from Fort MacPherson, where sample sizes of aged hosts are highest.

- We are collaborating with an ecophysiology lab to more accurately assess physiological markers of liver damage in infected burbot. We have performed preliminary analyses on samples of lightly vs heavily infected livers, but further analyses are required. The assay we use is cumbersome because it cannot distinguish parasite-induced damage to livers vs. parasite-induced up-regulation of the immune system. We are currently working to refine our methods. The overall intent of this component is to more accurately assign ‘damage’ due to parasites vs damage due to other factors such as host starvation.

Fig. 1. Summary infection characteristics of *Raphadascaris acus* in burbot collected from 4 sites in the lower MacKenzie River. Data is presented as mean numbers of worms (+/- standard deviation). Sample sizes of necropsied livers are indicated within the coloured boxes.

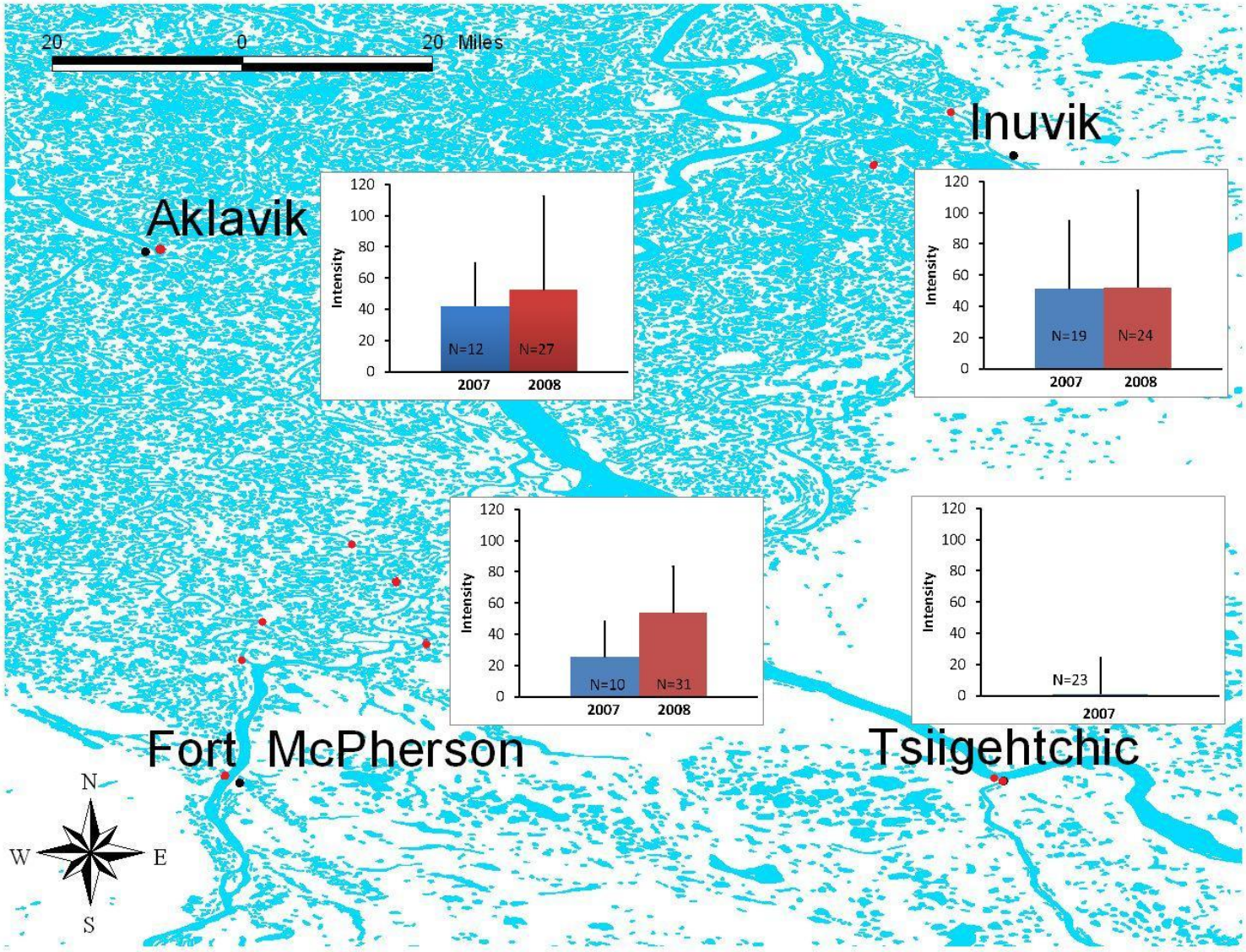

Table 1. Summary host and infection characteristics of *Raphadascaris acus* in burbot collected from 4 downstream sites on the McKenzie River. Means are presented as x +/- standard deviation.

	Aklavik		Fort Mcpherson		Inuvik		Tsiigehtchic	
	2007	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
Host Characteristics:								
n	33	100	50	87	25	69	28	-
Condition index	0.82 ± 0.12	0.89 ± 0.14	0.88 ± 0.12	0.84 ± 0.13	0.93 ± 0.32	0.78 ± 0.11	0.68 ± 0.09	-
Gonadosomal index	5.20 ± 1.05	7.01 ± 4.01	5.40 ± 2.80	6.70 ± 3.41	6.88 ± 3.07	6.79 ± 3.53	4.18 ± 5.12	-
Length (cm)	75.3 ± 5.8	72.8 ± 8.4	68.6 ± 10.3	75.2 ± 8.1	76.1 ± 8.7	74.2 ± 8.9	71.3 ± 7.5	-
Weight (g)	3535 ± 859	3517 ± 1189	2979 ± 1289	3648 ± 1162	4130 ± 1631	3267 ± 1085	2527 ± 849	-
% male	36.4	44.0	32.0	20.7	20.0	21.7	53.6	-
Parasite Characteristics:								
n	12	27	10	30	19	24	23	-
Prevalence(%)	100	96	90	97	84	96	78	-
Intensity	42.1 ± 27.6	52.5 ± 60.5	25.4 ± 22.7	53.7 ± 30.0	51.0 ± 43.8	52.2 ± 62.2	16.6 ± 23.3	-