Molecular detection of the myxozoan parasite *Tetracapsuloides bryosalmonae* through highly invasive Dreissenid mussels

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Background

Zebra (*Dreissena polymorpha*) and Quagga (*D. bugensis*) mussels recently invaded and rapidly adapted well to the Great Lakes ecosystems, widely spreading through inland lakes and river watershed. They reproduce and grow fast, covering any surface, accumulating biowaste, and pushing out other native filter feeders after dying, changing freshwater ecosystems (Fig. 1).

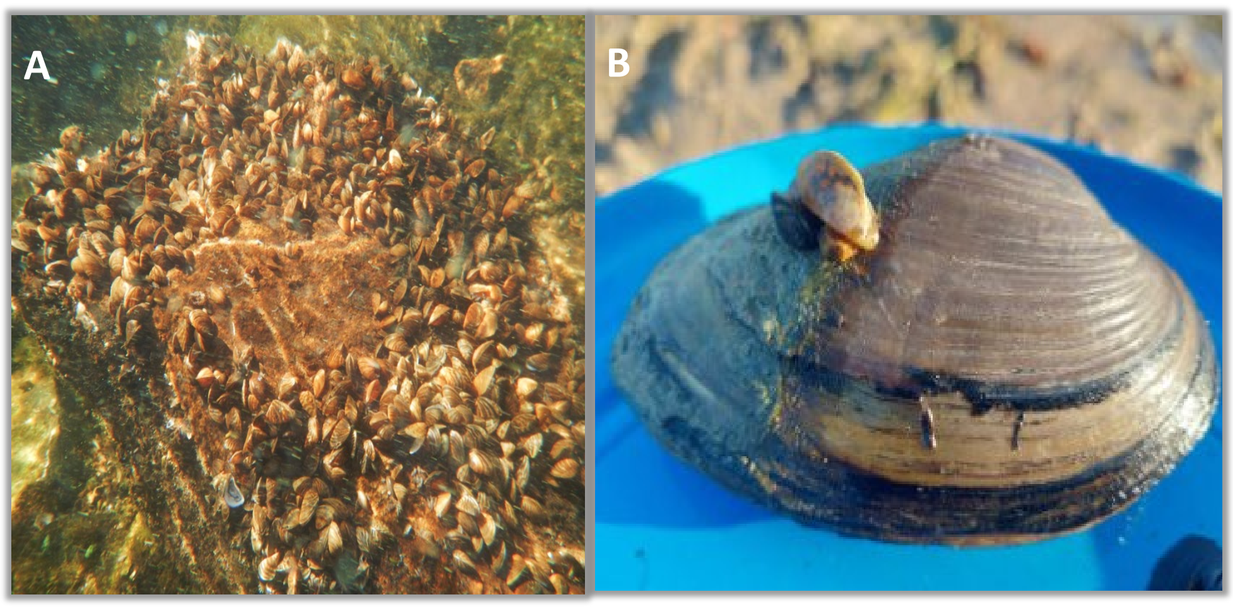


Figure 1. Invasive Zebra mussels altering the riverine ecosystems in the Muskegon River in Michigan (A), and attaching onto native mussels, such as to Giant Floater (*Pyganodon grandis*) (B).

The myxozoan parasite *Tetracapsuloides bryosalmonae* (Malacosporea) acts a two-host life cycle, between freshwater bryozoans and salmonids. During overt infections, several bryozoan species can produce large spore sacs in their coelomic body cavity and release waterborne malacospores that are infectious to fish. Under suitable temperatures, environmental conditions, and in susceptible hosts *T. bryosalmonae* can induce Proliferative Kidney Disease (PKD), a severe chronic lymphoid immunopathology in salmonid fishes.

We recently discovered the presence of *T. bryosalmonae* in several salmonid and bryozoan species across the Great Lakes region of North America.

Several bryozoan species were found growing on top of invasive mussel shells, including the species *Fredericella sultana* (Fig. 2.A) and *Cristatella mucedo* (Fig. 2.B), which are known hosts essential to complete the lifecycle of *T. bryosalmonae*.

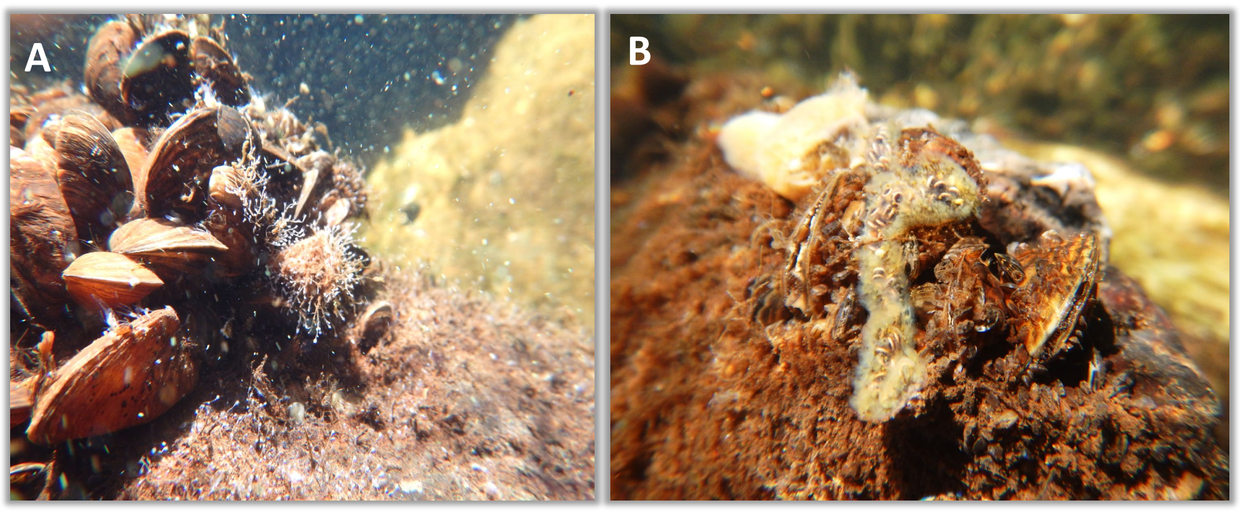


Figure 2. The Phylactolaemata bryozoans *Fredericella sultana* (A) and *Cristatella mucedo* (B) growing on Zebra mussels collected from rivers in Michigan during the Fall of 2024.

Due to their filter-feeding habits and shared environments with bryozoans, these highly invasive Dreissenid bivalves, including both Zebra and Quagga mussels, may potentially act as vectors, or eventually hosts, for *T. bryosalmonae*. They may play a role in capturing malacospores and propagate the parasite lifecycle across waterbodies, spreading the parasite to bryozoans or to susceptible salmonid fishes.

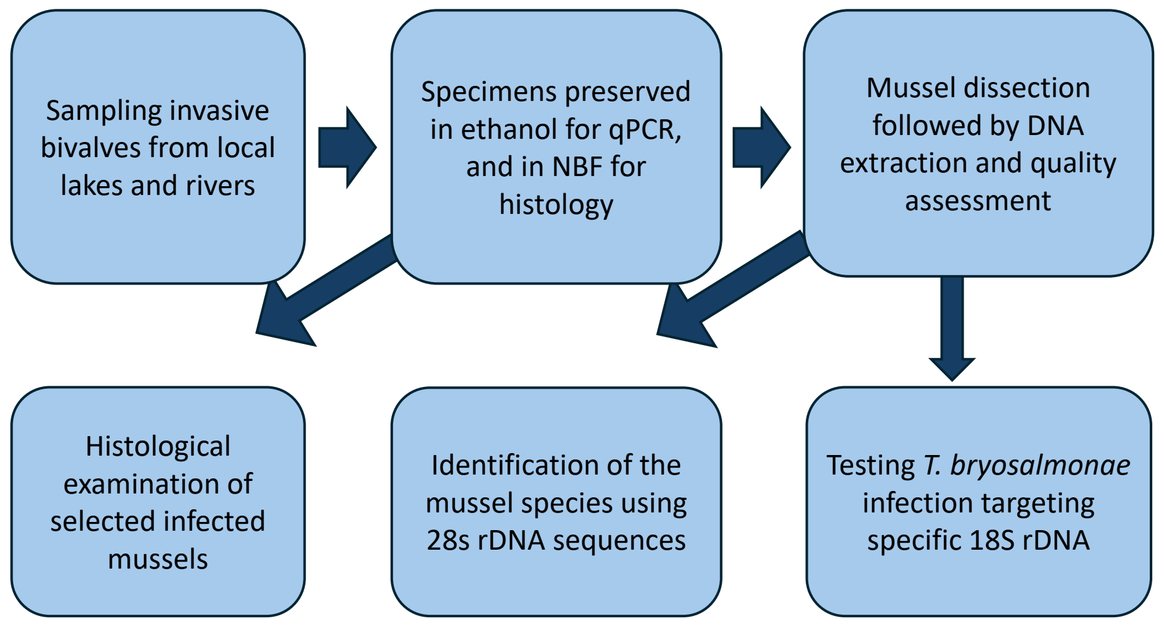
Hypothesis

Highly invasive Zebra and Quagga mussels may be used as bioindicators to detect the reportable fish parasite *Tetracapsuloides bryosalmonae.*

Rationale

- Defining the parasitological meaning of *T. bryosalmonae* detection from invasive freshwater mussels may provide new insights on how, and where, the parasite lifecycle may be completed in the Great Lakes region.
- Sampling bryozoans may be challenging, requiring high dedication upon sampling site exploration by trained personnel during the warm seasons.
- Invasive freshwater mussels are much easier to sample. Many specimens could be easily collected also by non-specialized personnel.
- Efficiently mapping *T. bryosalmonae* detection is needed to guide the management and restocking of salmonid populations in the Great Lakes watershed.

Materials & Methods



Results

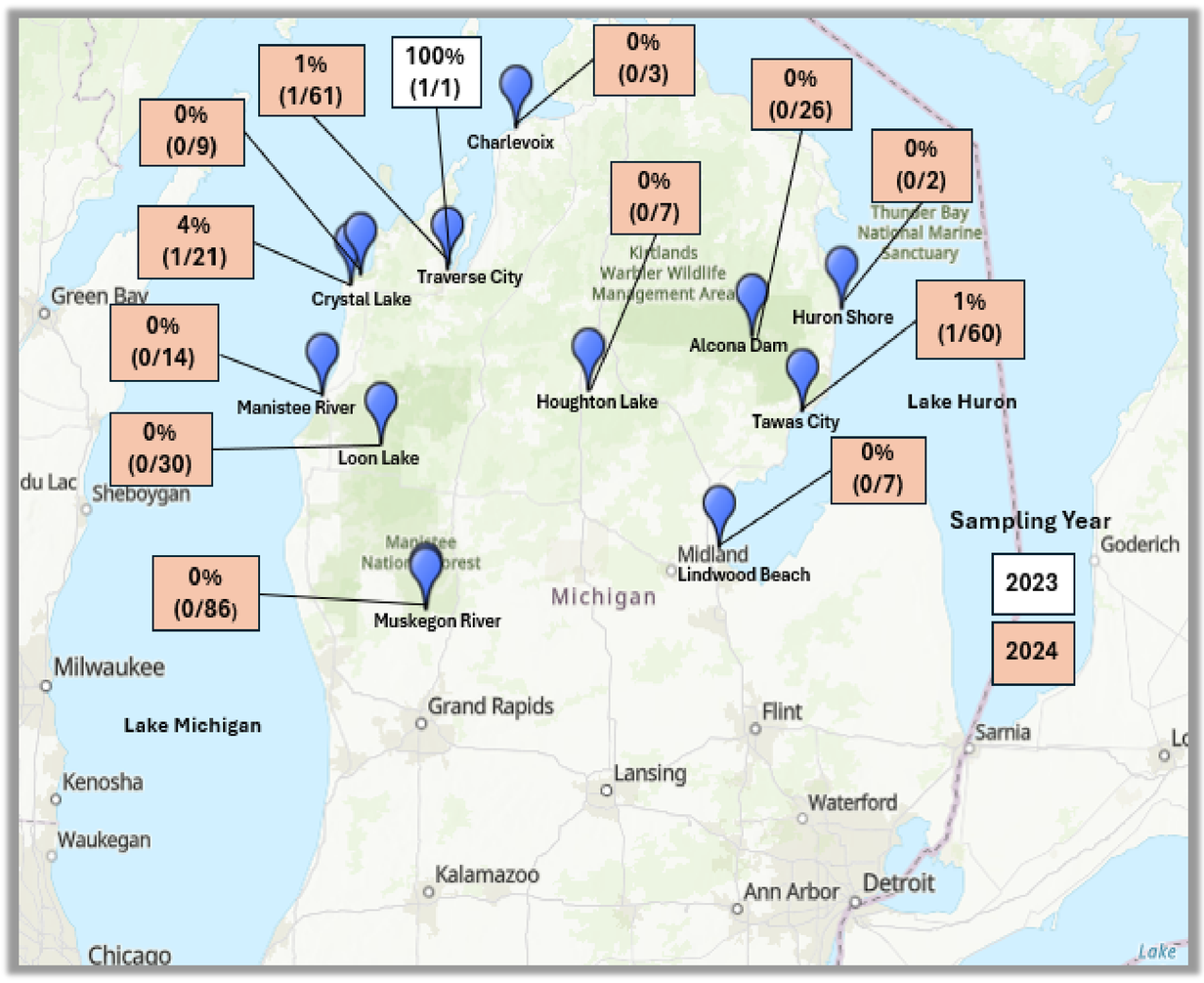


Figure 4 - Invasive Dreissenid bivalves sampling locations in Michigan, with indications of *T. bryosalmonae* detection prevalence.

Sampling Location	Collection Time	Sequencing of Mussel's 28s rDNA			Sequencing of Myxozoan's 18s rDNA		
		Closest published reference sequences			Closest published reference sequences		
		Organism	Identity	Acc number	Organism	Identity	Acc number
Boardman River, Traverse City, MI	October 2023	*D. polymorpha*	100%	XR_008042591.1, XR_008042590.1., and XR_008036095.1	*T. bryosalmonae*	99.65%	KT943757.1
Boardman River, Traverse City, MI	September 2024	*D. polymorpha*	100%		*T. bryosalmonae*	99.88%	FJ981823.1, KF731712.1, and KJ150282.1
Crystal Lake, MI	August 2024	*D. polymorpha*	100%		*T. bryosalmonae*	99.88%	
Saginaw Bay, Tawas City, MI	August 2024	*D. polymorpha*	100%		*T. bryosalmonae*	99.88%	

Table 1 - Summary of sampling locations, species, and year of mussel samples that tested positive for *T. bryosalmonae* by qPCR.

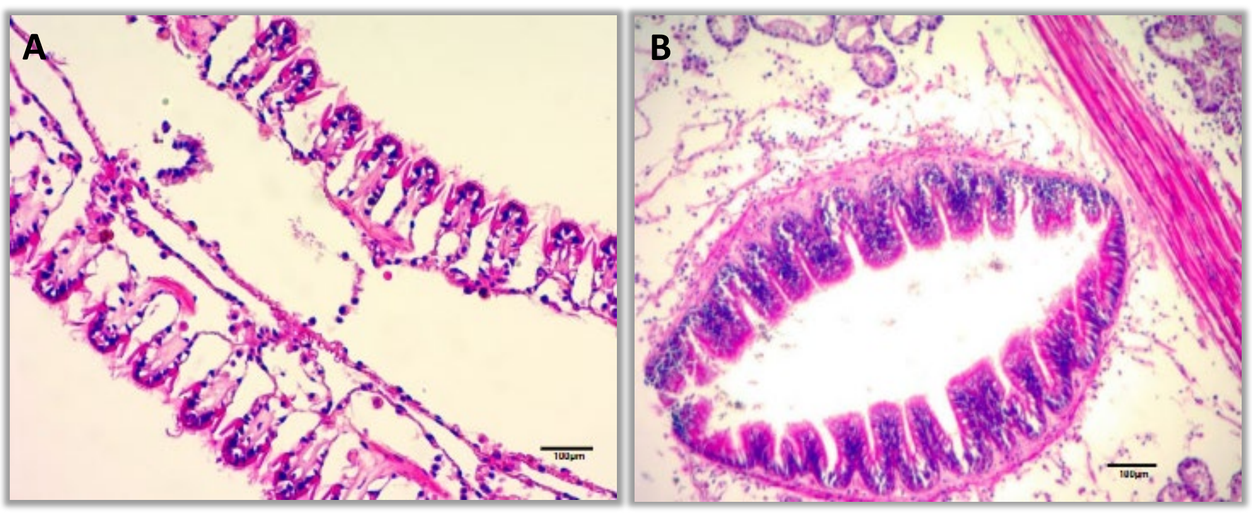


Figure 5 - Histological identification of mussel organs where *T. bryosalmonae* may potentially be detected, including in the gills (A), and the digestive system such as in the esophagus (B). H&E stain.

550 samples of Zebra and Quagga mussels (Fig. 2) were collected from the October of 2023 to November of 2024, from 15 freshwater riverine and lacustric locations across Michigan (Fig. 4). DNA was extracted from 371 specimens. The myxozoan parasite detection results (Tab. 1) provide preliminary evidence to support the hypothesis that invasive mussels in Michigan may be able to act as vectors, and if they could be sensitively used as bioindicators for *T. bryosalmonae* presence.

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