

Title: First report of ciliate epibionts (Suctororia) on the invasive *Bythotrephes cederstroemii* (Schödler, 1877) in Canada.

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Abstract

Invasive species have a significant negative impact on aquatic ecosystems, including the spiny waterflea, an aquatic invasive cladoceran of the genus *Bythotrephes*. Ciliate epibionts can be found on several species of marine and freshwater crustaceans including cladocerans, copepods, ostracods, mysids, amphipods, isopods, and crayfish. *Daphnia* species are the most common with this kind of association. There are currently two species (*B. longimanus* and *B. cederstroemii*) found in many freshwater ecosystems across Canada. During the analysis of samples for the monitoring of aquatic invasive species in Manitoba, many individuals of *B. cederstroemii* from Cedar Lake, were observed to be carrying suctorian ciliate epibionts in very high density. The species of ciliate epibiont could be identified as *Paracineta elegans*, according to previous records from Europe. However, further research is being conducted to confirm the correct taxonomic identification. This could be the first report of this association on an invasive species in Canada. Ciliate epibionts may affect their host in different ways, becoming a significant source of stress. The presence of ciliate epibionts on the *Bythotrephes* sp. may have an impact on the current and future population dynamic of the Spiny Waterflea. There was a significant population increase in 2021 compared to previous years with most of individuals being adult females carrying resting eggs that could survive in the sediment for many years and spread easily by predatory fish species.

Introduction

Suctorian ciliates may be found attached to various aquatic invertebrates like crustaceans and molluscs (Fig. 1).

Most of the ciliate epibionts reported are on cladocerans from European waterbodies, with *Daphnia* being the most common genus with this kind of association. Ciliates identification to the level of species is very challenging (Chatterjee *et al.*, 2013). So far, there is only one report of ciliate epibiont on the cladoceran *Bythotrephes longimanus* (Fernandez-Leborans, 2009; Chatterjee *et al.*, 2013).

Ciliate epibionts may affect their host in different ways, becoming a source of stress. They may increase their weight and sensitivity to contaminants, as well as competing for shared food resources (Puckett and Carman, 2002; Bickel *et al.*, 2012), while significantly decreasing their fitness as observed in copepods (Burris and Dam, 2014; Karpowicz and Kalinowska, 2018).



Fig. 1. Suctorian ciliates on various invertebrate species found in plankton samples from across Canada. (A,B) Calanoid copepod *Epischura lacustris* with *Acineta tuberosa* Ehrenberg, 1833; (C,D) Cladoceran *Leptodora* sp.; (E) Cladoceran *Daphnia* sp.; (F,G,H) snail species with *Vorticella globosa* Ghosh, 1922.

Results

A total 1217 individuals of the aquatic invasive species *B. cederstroemii* were identified, counted, and examined in 116 samples from Cedar Lake, Manitoba. A suctorian ciliate initially identified as *Paracineta elegans* (Collin, 1912), was first observed in 2021 and it continued to be present in samples from 2022 and 2023 (Fig. 2).

Taxonomic classification taken from Fernandez-Leborans and Tato-Porto (2000):

Phylum Ciliophora (Doeflin 1901)
Class Phyllopharyngea
Subclass Suctororia
Order Exogenida
Family Urnulidae
Genus *Paracineta*

Most of the *B. cederstroemii* individuals observed in the Cedar Lake samples were gamogenetic females with resting eggs in very high density and with ciliate epibionts, while most juvenile individuals had no ciliates. A sample from 2021 (Fig. 2) had a total of 43 individuals in which 70 % had suctorian ciliates, most of them were gamogenetic females with resting eggs (Fig. 2, A), while only 2 individuals were parthenogenetic females.

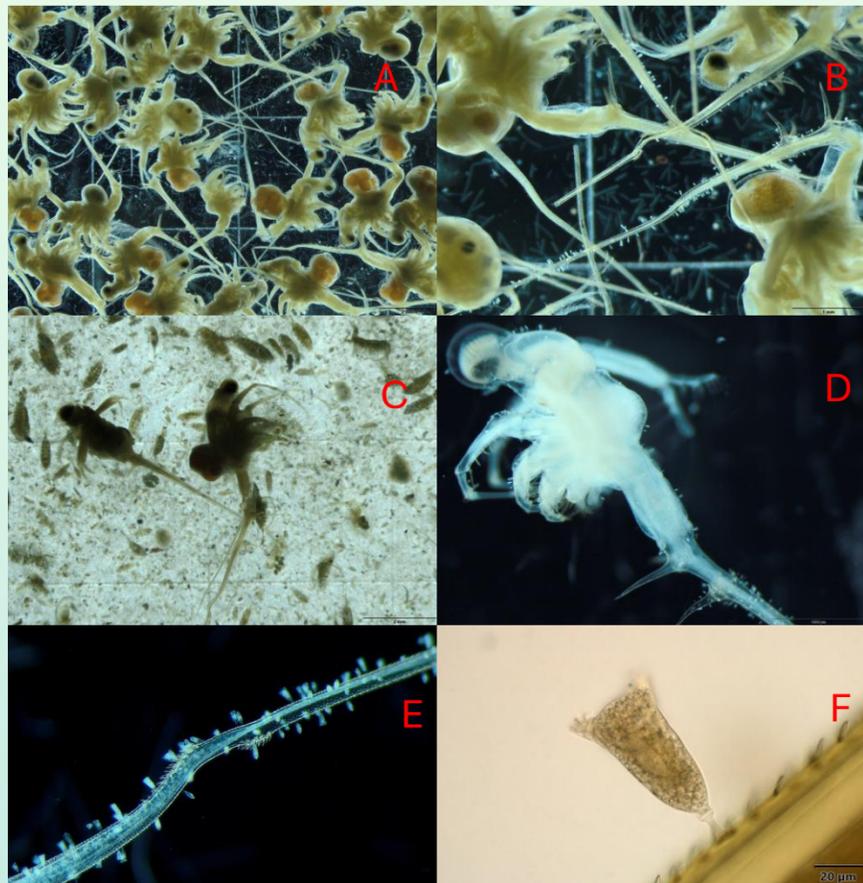


Fig. 2. Individuals of *B. cederstroemii* from a 2021 Cedar lake sample. (A,B) sample dominated by gamogenetic females with resting eggs; (C) community composition of sample; (D) male with ciliates all over its body; (E) tail of female with a high concentration of ciliate epibionts; (F) Suctorian ciliate *Paracineta elegans*.

Results (continue)

The density of *B. cederstroemii* increased significantly since 2021 based on the total number of individuals per year and the average number of individuals per sample (Fig. 3 and 4). In 2023 a total of 487 bythos were identified, of those, 32% were gamogenetic females with resting eggs while only 8.6% were parthenogenetic females.

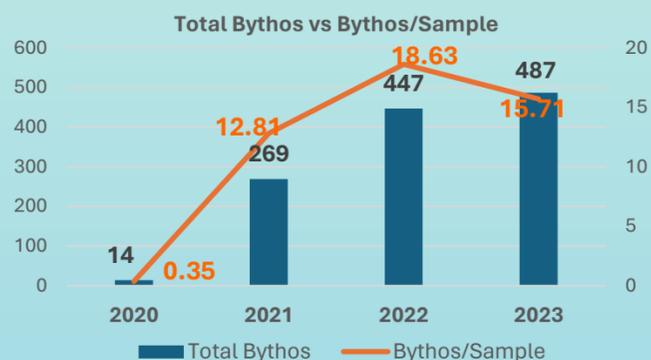


Fig. 3. Total number of *Bythotrephes* in samples from Cedar lake by year, and by average of individuals per sample.



Fig. 4. The average number of *Bythotrephes* per sample collected from Cedar Lake at various sites since 2020.

Discussion

Ciliate epibionts seem to be a cause of environmental stress on the population of *B. cederstroemii* in Cedar lake by inducing sexual reproduction on the invasive cladoceran. The production of resting eggs in most females could also be the result of increased environmental stress, like climate change, high density of cyanobacteria, or poor water quality favoring the epibiont, ultimately causing a feedback loop effect benefiting the invasion. The favoring of the production of resting eggs was seen by Suhett *et al.* (2011) while studying the effects of Humic Substances (HS) as a stressor on the cladoceran *M. macropoda*. Stress could be sometimes beneficial to many organisms (Steinberg, 2012).

In addition, research conducted by Bickel *et al.*, 2012, in German lakes, *Daphnia* sp. was the cladoceran with the highest number of ciliate epibionts. The spiny water flea main prey are *Daphnia* species, contributing to a significant decline of *Daphnia* populations. The appearance of ciliate epibionts on *Bythotrephes* could be a result of host switching from prey to predator as the host becomes scarce. The host switching phenomenon has been previously reported between a non-native crayfish and a native copepod due to the population decimation of the native host crayfish (Hugs *et al.*, 2014).

Conclusions

This is the first record of a Suctorian ciliate on the invasive *B. cederstroemii* in Canada. The ciliate epibiont is a cause of stress that benefits the invasive species by increasing its fitness and the production of resting eggs that could survive in the sediment for many years and spread easily by predatory fish species. This association favoring the invasive species may have a greater detrimental effect on the ecosystem.

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