

Spiny Water Flea (*Bythotrephes longimanus*)



Bythotrephes longimanus, *cederstroemi*, spiny water flea (SWF), is a cladoceran (Crustacea) zooplankton, native to the Palearctic (Eurasia) region (Berg & Garton, 1994). This organism is an aquatic macroinvertebrate predator that can alter zooplankton communities (Drake, Drury, Lodge, Blukacz, & Yan, 2006; Yan & Pawson, 1997). Like most aquatic invaders from Eurasia, the SWF has been transported to North America's Great Lakes via ballast water from Baltic ports. *B. longimanus* has been observed in Lake Ontario since 1982 and soon after in Lakes Huron and Erie (Bur, Klarer, & Krieger, 1986; Lange & Cap, 1986). Since 2008 it has been established in the Great Sacandaga Lake in New York and has been discovered in other Adirondack water bodies including Peck Lake, Stewarts Bridge Reservoir, and Sacandaga Lake (Ballinger, 2012). This summer (2012) the spiny water flea's presence has been confirmed further north in the Adirondack Park at Lake George (New York Department of Environmental Conservation [NYDEC], 2012). There is a growing consensus that humans are the primary transporters of spiny water flea, and it is important to understand its role and effects on the aquatic ecosystem (Weisz & Yan, 2010).

SWF is most commonly found in large, deep, oligotrophic lakes with extensive surface areas and drainage basins (Maclsaac, Ketelaars, Grigorovoich, Ramcharan, & Yan, 2000). These lakes generally have relatively low chlorophyll concentration and phytoplankton production with comparatively cooler bottom temperatures during the summer. However it is quite plastic and can tolerate a wide range of salinities, pH, temperatures, and conductivities and can occur in very shallow, fishless ponds, pools, and lakes (Grigorovich, Pashkova, Gromova, & van Overdijk, 1998).

The spiny water flea is a free swimming, cladoceran zooplankton with a unique body structure. Its average length is only about one centimeter, but its long tail spine (70% of animal's total length) makes it easily distinguishable from other invertebrates and zooplankton. The spine has one to four

pairs are thorn-like barbs (Caceres & Lehman, 2010). The barbs can be used to determine the age of the crustacean for offspring are born with one pair and gain more barbs throughout life (Caceres & Lehman, 2010).

This large predatory zooplankton is a generalist feeder and commonly preys upon small bodied, slow cladocerans. It has a large, black compound eye, and therefore vision is thought to play a role in *B. longimanus*'s prey detection and encounter (Muirhead & Sprules, 2003). SWF's predation rates and success positively correlate with the increase in light intensity specifically with *Daphnia mendotae* (an herbivorous, cladoceran zooplankton) (Pangle & Peacor, 2009). Most rapacity and highest densities of SWF occur in the first ten meters of the epilimnion which further supports vision mediated predation (Muirhead & Sprules, 2003). These findings suggest that water clarity and turbidity play an important role in the establishment of SWF as well as supports its distribution in clear, oligotrophic lakes (Pangle & Peacor, 2009).



Spiny water flea (bottom) and fish hook water flea (top); both are invasive species.

The spiny water flea's life cycle has rapid and unique reproductive strategies. Like other water fleas, *Bythotrephes* partakes in seasonal parthenogenesis (Drake et al., 2006; Wittman, Lewis, Young, & Yan, 2011; Caceres & Lehman, 2010). During late spring individuals emerge from resting eggs in lake sediments. When temperatures are warm enough and food is abundant, *B. longimanus* will exhibit parthenogenesis. This asexually mode of reproduction allows female spiny water fleas to produce one to ten eggs independent of fertilization that successfully develop into genetic replicas of the mother (Caceres & Lehman, 2010). At optimum temperatures parthenogenesis produces a new generation of females in less than two weeks. Female clones are propagated throughout the summer or until temperature and food availability is unfavorable for SWF.

B. longimanus's offsprings sex is determined by environmental cues like the end of a summer's declining ecological quality (Caceres & Lehman, 2010; Wittman et al., 2011). In the fall when food availability is low and temperatures are descending, adult females respond by producing male offspring (Caceres & Lehman, 2010). These males are then able to participate in sexual reproduction with the remaining females, which encourages genetic exchange and generate next season's resting eggs (Caceres & Lehman, 2010). These hardy eggs are eventually released by the female and fall to the sediments where they survive a period of dormancy throughout the winter (Drake et al., 2006; Wittman et al., 2011). In late spring or early summer offspring from the resting eggs emerge from the lake

bottom to start the parthenogenesis to sexually reproduction cycle all over again (Caceres & Lehman, 2010; Drake et al., 2006; Wittman, 2011).

The spiny water flea's dense populations from constant reproduction and generalistic predation of zooplankton during the summer result in changes of zooplankton species richness and composition following the establishment of this invader (Drake et al., 2006; Kelly, Yan, Walseng, & Hessen, 2012; Strecker, Arnott, Yan, Girard, 2006; Yan & Pawson, 1997). A study that examined zooplankton species richness from May-September in Canada has found significantly reduced cladoceran (SWF main prey) species richness, diversity, and abundance as well as a loss in total zooplankton community richness, diversity, and abundance (Strecker et al., 2006). Another lake in Canada with a 15-year pre-SWF invasion data set has experienced a reduction or loss of some small zooplankton species and an increased abundance of large body cladocerans (Yan & Pawson, 1997).

Similar findings have been recorded by Jokela, Arnott, & Beisner (2011), but they have also documented a shift in zooplankton distribution throughout the water column. They have recorded a native, macroinvertebrate predator abundance increase with the increase in SWF's relative abundance in the epilimnion. Also zooplankton prey (e.g., *Daphnia*) have been found lower in the epilimnion when *Bythotrephes* abundance was high, which may be evidence of an avoidance behavior by the prey (Jokela et al., 2011).

Another study compares zooplankton communities in native (Norway) and invaded (Canada) lakes (Kelly et al., 2012). They have confirmed that zooplankton communities varied between lakes with and without SWF in Canadian Lakes (non-indigenous). While in *Bythotrephes*'s native range in Norway, zooplankton communities did not vary with the presence and absences of SWF. Short-term effects on Canadian lakes have been documented by a decrease in zooplankton diversity, particularly cladoceran species, but long-term effects of SWF on Norwegian lakes have exhibited a greater diversity of zooplankton, especially copepod species (Kelly et al., 2012).

Kelly et al. (2012) suggest that some species appear to adapt to the presence of *Bythotrephes* over time. They hypothesize that the long-term effects of *Bythotrephes* on Norwegian lakes are a result of interspecific community interactions and avoidance behavior by the prey, thus allowing species to increase their populations in space and time. If Canadian zooplankton communities adapt similarly to Norwegian zooplankton communities, then the long-term effects of *Bythotrephes* could be less severe than those first observed in the first few decades after its initial invasion (Kelly et al., 2012).

SWF effects on aquatic ecology are hard to distinguished, but they certainly alter native zooplankton community distribution and structure within the water column (Kelly et al., 2012; Jokela et



Spiny water flea can be a nuisance to fisherman by clogging eyelets, downrigger cable and fishing line.

al., 2011; Strecker et al., 2006; Yan & Pawson, 1997). . With anthropogenic activities being the main inter-water transport vector and its distribution advancing northward in the Adirondack Park, eliminating and reducing the spread of spiny water flea is extremely important because there are no widely used and effective methods for control and management once SWF is established (Weisz & Yan, 2010).

Works Cited

- Ballinger, N. (2012). *Aquatic Nuisance Species Threats*. Retrieved September 11, 2012, from Lake Champlain Basin Program: <http://www.lcbp.org/ansthreats.htm#fleas>
- Berg, D. J., & Garton, D. W. (1994). Genetic differentiation in North American and European populations of the cladoceran *Bythotrephes*. *Limnology and Oceanography*, *39*(7), 1503-1516.
- Bur, M. T., Klarer, D. M., & Krieger, K. A. (1986). First records of a European cladoceran, *Bythotrephes cederstroemi*, in Lake Erie and Huron. *Journal of Great Lakes Research*, *12*, 144-146.
- Caceres, C. E., & Lehman, J. T. (2010, January 26). *Life history and effects on the Great Lakes of the spiny tailed Bythotrephes*. Retrieved September 11, 2012, from Minnesota Sea Grant: <http://www.seagrant.umn.edu/exotics/spiny.html>
- Drake, J. M., Drury, K. L., Lodge, D. M., Blukacz, A., & Yan, N. D. (2006). Demographic stochasticity, environmental variability, and windows of invasion risk for *Bythotrephes longimanus* in North America. *Biological Invasions*, *8*, 843-861.
- Grigorovich, I. A., Pashkova, O. V., Gromova, Y. F., & van Overdijk, C. D. (1998). *Bythotrephes longimanus* in the Commonwealth of the Independent States: variability, distribution, and ecology. *Hydrobiologia*, *379*, 183-198.
- Jokela, A., Arnott, S. E., & Beisner, B. E. (2011). Patterns of *Bythotrephes longimanus* distribution relative to native macroinvertebrates and zooplankton prey. *Biological Invasions*, *13*, 2573-2594.
- Kelly, N. E., Yan, N. D., Walseng, B., & Hessen, D. O. (2012). Differential short- and long-term effects of invertebrate predator on zooplankton communities in invaded and native lakes. *Diversity and Distributions*, 1-15.
- Lange, C., & Cap, R. (1986). *Bythotrephes cederstroemi* (Schoedler) (Cercopagidae: Cladocera): a new record for Lake Ontario. *Journal of Great Lakes Research*, *12*, 142-143.
- Maclsaac, H. J., Ketelaars, H. A., Grigorovovich, I. A., Ramcharan, C. W., & Yan, N. D. (2000). Modeling *Bythotrephes longimanus* invasions in the Great Lakes basin based on its European distribution. *Archiv fuer Hydrobiologie*, *149*(1), 1-21.
- Muirhead, J., & Sprules, W. G. (2003). Reaction distance of *Bythotrephes longimanus*, encounter rate and index of prey risk for Harp Lake, Ontario. *Freshwater Biology*, *48*, 135-146.
- New York Department of Environmental Conservation. (2012, August 1). *Spiny waterflea confirmed in Lake George*. Retrieved from New York State Department of Environmental Conservation: <http://www.dec.ny.gov/press/83913.html>
- Pangle, K. L., & Peacor, S. D. (2009). Light-dependent predation by invertebrate planktivore *Bythotrephes longimanus*. *Canadian Journal of Fisheries and Aquatic Sciences*, *66*, 1748-1757.
- Strecker, A. L., Arnott, S. E., Yan, N. D., & Girard, R. (2006). Variation in the response of crustacean zooplankton species richness and composition to the invasive predator *Bythotrephes longimanus*. *Canadian Journal of Fisheries and Aquatic Sciences*, *63*, 2126-2136.

- Weisz, E. J., & Yan, N. D. (2010). Relative value of limnological, geographical, and human use variables as predictors of the presences of *Bythotrephes longimanus* in Canadian Shield lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, *67*, 462-472.
- Wittman, M. J., Lewis, M. A., Young, J. D., & Yan, N. D. (2011). Temperature-dependent Allee effect in a stage-structured model for *Bythotrephes* establishment. *Biological Invasions*, *13*, 2477-2497.
- Yan, N. D., & Pawson, T. W. (1997). Changes in the crustacean zooplankton community of Harp Lake, Canada, following invasion by *Bythotrephes cederstroemi*. *Freshwater Biology*, *37*, 409-425.