Distribution of Daphnia Resting Eggs: Invasive vs Native and their Effects

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Abstract: *Daphnia lumholtzi* is an example of a successful aquatic invasive species. When conditions are less favorable, *D. lumholtzi* switch from producing female eggs to the production of diapausing eggs (called ephippia) that are encased in chitinous shells and can form an egg bank in the sediment. Southern reservoirs do not experience extreme seasonal changes in temperature, so *D.lumholtzi* may rely less on resting eggs for maintaining their populations, because they can survive through most of the year compared to *D. lumholtzi* populations in northern reservoirs. The purpose of this study was to document the densities of ephippia from *D. lumholtzi* and native *Daphnia* in a sediment core collected from Grand Lake, OK. The *D. lumholtzi* ephippia were dispersed at a relatively constant rate throughout the vertical core. *Daphnia lumholtzi* did not appear to have a negative effect on the native *Daphnia spp.* based on the results that the ephippia of native *Daphnia* were not negatively related to the ephippia of *D. lumholtzi*. Future efforts should focus on spatial dynamics within reservoirs to determine how egg bank composition differs spatially, as well as, methods for identifying native *Daphnia* ephippia to the species level.

Keywords: Ephippia, *Daphnia Lumholtzi*, *Daphnia*

Introduction

An invasive species is a species that disrupts a new area by causing ecological or economic harm (Amstutz 2017). Invasive species tend to have high reproductive rates, high dispersal rates, and an extensive tolerance of environmental conditions (Havens 2012). Introducing an organism into a new ecosystem can have drastic and complex effects on the ecosystem, like a ripple effect (Amstutz 2017).

Daphnia lumholtzi is an example of a successful aquatic invasive species. The species was first documented in the U.S. in 1991 in a small reservoir in Texas (Havens 2012). *Daphnia lumholtzi* is commonly known as the water flea and has distinguishing characteristics like long helmet and tall spines. The tail spine can be as long as its body length and the helmet is larger than those found on native species. The invasion of *D. lumholtzi* may have a negative impact on the native zooplankton which could then be detrimental to fish population that depends on the native zooplankton because of their inability to handle the spines of *D. lumholtzi* (Benson 2018).

Daphnia lumholtzi also produce resting eggs (called ephippia) when conditions are less favorable (Pietrzak 2006). The ephippia are released into the water where they can settle and for an egg bank in the sediment and wait for hatching cues (Smith et al. 2009). These ephippia may contribute to *D. lumholtzi*'s invasion success in two ways: they let time pass by during harsh conditions (which prevents the population from completely dying off) and they allow the eggs to be dispersed from one body of water to another (Pietrzak 2006). The *D. lumholtzi* ephippia have hair and spines that can attach to boats and other objects, which could be a factor in its successful dispersal to new habitats (Dzialowski et al. 2000).

The first record of invasion in Oklahoma was in 1989 at the Robert S. Kerr Reservoir, and the most recent record was in 2018 at Lake Thunderbird in Cleveland County. There are currently 15 total observations of *D. lumholtzi* in Oklahoma (Benson

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2018). *Daphnia lumholtzi* is an important grazer of algae and an important food resource for fish (Havens 2012). Because of its ability to be transported to other reservoirs without being noticed, the species has been able to spread rapidly throughout the United States (Work et al. 1999). It most likely owes its invasion success to its ability to avoid predation (Benson 2018) and its ability to attached to boats. Recreational boating is correlated with the invasion of *D. lumholtzi* because the species was not detected in places inaccessible to boats, like small ponds (Dzialowski et al. 2000). *Daphnia lumholtzi* appears to be most abundant during the summer months with the high temperatures (Work et al. 1999), and is associated with lower concentrations of suspended solids, high algal biomass and higher temperature (Havens 2012). Havel et al. (1995) suggest that reservoirs located downstream or in close proximity to already invaded reservoirs will have the highest probability of being colonized by *D. lumholtzi*. Additionally, reservoirs with more frequent boat traffic from other lakes that have been invaded will also have a high probability of colonization (Havel et al. 1995).

The resting eggs that *D. lumholtzi* produce are important because they are useful to gather information on dispersal and range expansion as well as their long-term establishment patterns. The ephippia accumulate in sediments over an extended amount of time with older ephippia being deeper in the sediments than the younger ephippia. The abundance of ephippia in the sediment may possibly be useful to infer the population densities over time. In particular, we may be able to use ephippia and their vertical position in the sediment to determine the invasion history for individual reservoirs and determine when *D. lumholtzi* invaded and how populations have changed over time. Data on the distribution of ephippia in the sediments may also help us to determine if there have been changes in the ephippia of the native *Daphnia* species, and if so, these distribution changes may indicate that *D. lumholtzi* has had a negative competitive effect if there are changes in native ephippia that correspond with population increases of *D. lumholtzi*.

Our research will address several questions. Can we use the ephippia in the sediment to determine the invasion history of *D. lumholtzi* in individual reservoirs? Can we determine if and how *D. lumholtzi* has impacted native *Daphnia* species through changes in ephippia? We predict there will be reductions in the native ephippia due to the competition with *D. lumholtzi*.

Methods

<u>Core Collection</u>

Sediment cores were collected from Grand Lake in north-eastern Oklahoma. The sediment cores were collected from a boat using a KB-Sediment corer with clear cellulose acetate butyrate (CAB) tubes (5 cm in diameter and 50 cm long). Once the cores were collected they were brought to the laboratory at Oklahoma State University and sectioned into 2 cm sections.

<u>Sediment Sifting</u>

We poured a 2 cm interval sample over a sediment sieve (425μm) and gently rinsed with deionized water until it seemed like no more sediment was moving through the mesh. We transferred materials to a second, finer filter (80μm) and rinsed again with DI water. We then collected the material into a petri dish with artificial pond water (COMBO) and used forceps to remove any ephippia that were stuck to the filter. The petri dishes were stored in the

a b

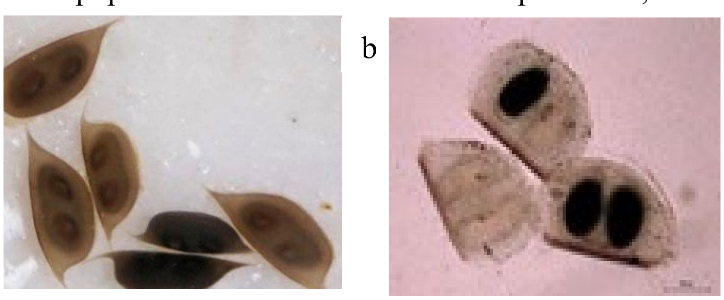

Figure 1: This figure demonstrates the differences between the Daphnia lumholtzi *(a) and the native* Daphnia *ephippia.*

fridge and the sediment sieve was rinsed with DI water between each sample.

Sediment Processing

We examined each petri dish sample under a dissecting microscope to locate *Daphnia* ephippia. We transferred ephippia from the petri dish using fine point tweezers to an appropriately labeled 6-well plate with a minimal amount of DI water. We counted native *Daphnia* ephippia and invasive (*Daphnia lumholtzi*) ephippia using figures to distinguish (Figure 1).

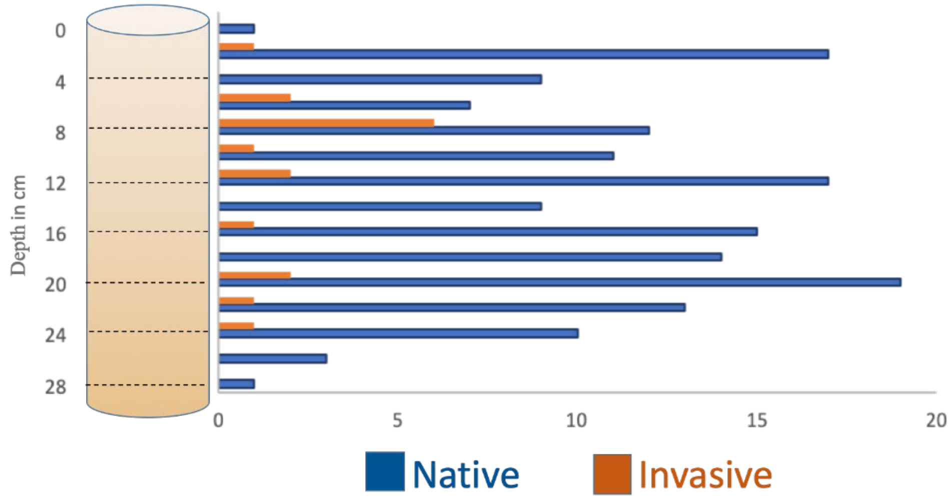

Figure 2: This figure demonstrates the depth distribution of ephippia (native and invasive Daphnia spp.) in sediment at Grand Lake, OK in 2 cm intervals.

Results

As shown in Figure 2, the *D. lumholtzi* ephippia were dispersed at a relatively constant rate at every 2 cm interval (with the exception of the depth of 8cm). Average number of ephippia for every 2 cm interval was 10.53 native *Daphnia spp.* (±5.68) and 1.13 *D. lumholtzi* ephippia (±1.55). *Daphnia lumholtzi* did not appear to have a negative effect on the native *Daphnia spp.* based on the epphipia that we found in the sediment core.

Discussion

Daphnia lumholtzi ephippia were relatively uncommon throughout the sediment core compared to those of the native *Daphnia spp.* There was no clear relationship between the ephippia densities of *D. lumholtzi* and the native *Daphnia spp.* We could not determine the impact of *Daphnia lumholtzi* on the native *Daphnia spp. Daphnia lumholtzi* is known to occur in higher densities in turbid, riverine zones of reservoirs (Dzialowski et al. 2000), so they may be naturally uncommon in this portion of the reservoir from where we collected the core. Southern reservoirs do not experience extreme seasonal changes in temperature, so *D. lumholtzi* may rely less on resting eggs for maintaining their populations, because they can survive through most of the year compared to *D. lumholtzi* populations in northern reservoirs. Future efforts should focus on spatial dynamics within reservoirs to determine how egg bank composition differs spatially, as well as, methods for identifying native *Daphnia* ephippia to the species level.

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