Establishing a model system to restore zooplankton abundance in a Connecticut Lake with an introduced landlocked Alewife population.

Title:	**Establishing a model system to restore zooplankton abundance in a landlocked Connecticut Lake**
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Summary

The objective of this project was to develop an optimal methodology for the large-scale raising of *Daphnia magna*. This project supported the STEM training of a first-generation underserved Latina graduate student by partially funding her research thesis on lake management. The graduate student learned to identify, culture and quantify naturally occurring algae, and to test alternative food sources on growth rates of cultured *Daphnia magna.*

The experimental work for this project was conducted at the WCSU Biology Department in the summer of 2023. The food option that yielded significantly more neonate and adult growth was a combination of YCT[1]/*Scenedesmus sp.*/*Chlorella vulgaris* compared to only YCT, suggesting that maximum population growth demands a diverse microalgae cocktail diet. The results of this work will inform changes to Lake Waramaug zooplankton farm management, and may support changes in lake management practices that can benefit from increased large-bodied zooplankton populations.

Introduction

In the early 1970s, Lake Waramaug, and many other lakes in Connecticut, were stocked with the zooplanktivorous alewife (*Alosa pseudoharengus*). The unintended consequence of this action resulted in land-locked fish that preyed on naturally occurring *D. magna* and *D. pulex,* two large-bodied zooplankton native to New England lakes. Subsequent studies of Lake Waramaug reported the eradication of large-bodied water fleas (i.e., Cladocera) from the lake (Hug-Anderson & Carlson, 1989; Kortmann, 1994). Large-bodied water fleas, such as *Daphnia sp.,* are essential to freshwater systems for controlling algae and bacteria populations (Urrutia-Cordedo, 2016). When the eradication of grazing *Daphnia* occurred, it was suggested to correspond with an increase in algae and cyanobacteria populations in Lake Waramaug. This shifted the

[1] Yeast, Cherophyll®, and trout chow

zooplankton biodiversity to small-bodied zooplankton and may have resulted in an imbalance in the trophic dynamics that can lead to algal blooms.

Many lakes around the world are experiencing more frequent and intensive cyanobacteria blooms which are impacting drinking water supplies and recreation (O'Neil, 2012). Some bloom-forming cyanobacteria produce toxins that can pose a threat to human and animal health (CT DPH & CT DEEP, 2021). In humans they can cause dermal contact irritation, liver cancer, neurological disease, and gastroenteritis (Rao, 2002). If a waterbody lacks important microalgal grazers the trophic dynamics can favor cyanobacteria over other microalgae taxa.

The Lake Waramaug Task Force was organized in 1975. Its mission is to manage and maintain healthy Lake Waramaug conditions. To that end, The Task Force is trying to restore the *D. magna* population to pre-alewife concentrations. Currently, efforts to raise *Daphnia* include feeding them a mixture of yeast, sugar, and flour in large lakeside lagoons. Cultured *Daphnia* are released weekly into the lake from the concrete lagoons as part of a restoration program initiated in 2016. Although *Daphnia* populations are slowly rebounding, the concentrations remain too low to significantly restore trophic dynamics in the lake (Hug-Anderson & Carlson, 1989). This project examined *Daphnia* concentrations fed several food types including native algal combinations to test if zooplankton concentrations could be scaled up when offered a varied diet.

Objective(s)

The objective of this project was to train a graduate student to develop an optimal practice for the large-scale raising of *Daphnia magna*. This project has lake management value because the optimal practice developed for improving *Daphnia* growth rates may be used towards increasing large-bodied *Daphnia* abundance in a lake where *Daphnia* previously occurred.

Results/Discussion

Preliminary work during summer 2021 & 2022 at Lake Waramaug, where raised *Daphnia* were restricted to a diet of yeast, suggested that the current culturing methodology was resulting in approximately one organism per liter. A healthy population should be closer to 10 organisms per liter (B. Kortmann personal communication, January 17, 2019). This project investigated food choice practices that could scale up *Daphnia* concentrations, and provide access to experimental research and lake management training for a first generation Latina, a demographic significantly underrepresented in this (i.e., water quality science) job sector.

The food option that yielded significantly more neonate and adult *Daphnia* growth was a combination of YCT /*Scenedesmus sp.*/*Chlorella vulgaris* compared to YCT alone. *Scenedesmus* and *Chlorella* are two genera of planktonic Chlorophyta (aka green algae).YCT was used as a control. Furthermore, *Scenedesmus sp.* significantly yielded more neonates compared to only YCT (See Figures 3 & 4) after 9 weeks of growth experiments. All experimental food sources yielded more than 10 organisms per liter, suggesting that yeast alone is a poor food source for raising *Daphnia*.

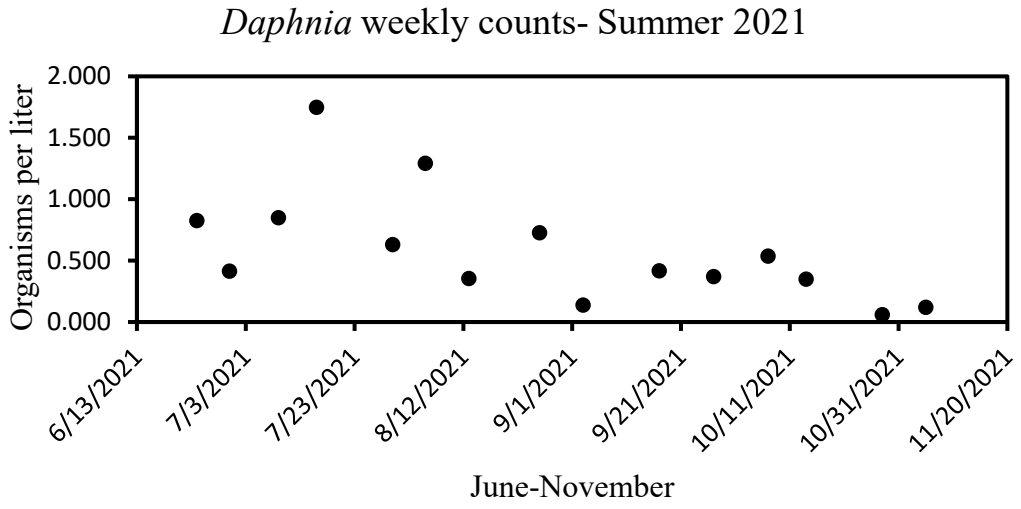

Figure 1. Weekly *Daphnia spp.* counts from the Lake Waramaug Farm from June to November 2021. These *Daphnia* were fed yeast only. Generated in Microsoft Excel.

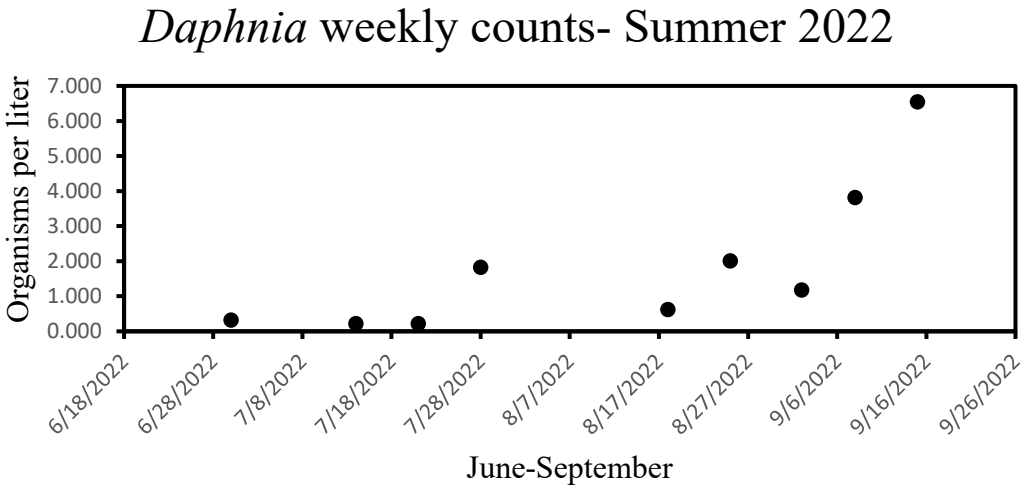

Figure 2. Weekly *Daphnia spp.* counts from the Lake Waramaug Farm from June to November 2022. Similar to 2021, the yeast fed *Daphnia* rarely increased to a concentration above 2 per liter. Generated in Microsoft Excel.

The organisms per liter in the lake in the summers of 2021 & 2022 were less than 10 organisms per liter as seen in Figures 1 & 2.

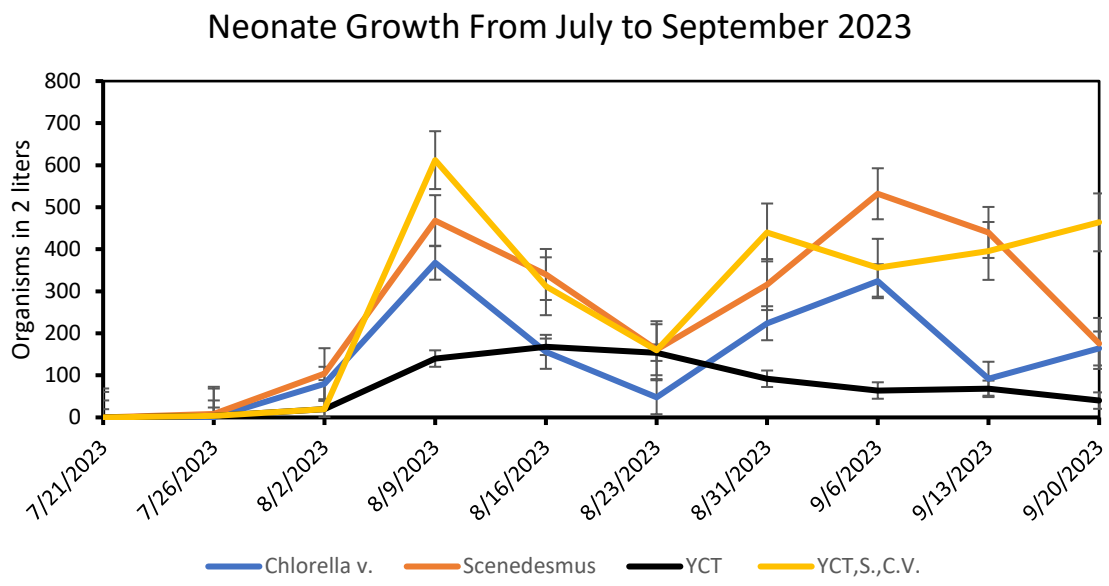

Figure 3. Line graph of weekly population growth of neonates from July to September 2023. Generated in Microsoft Excel.

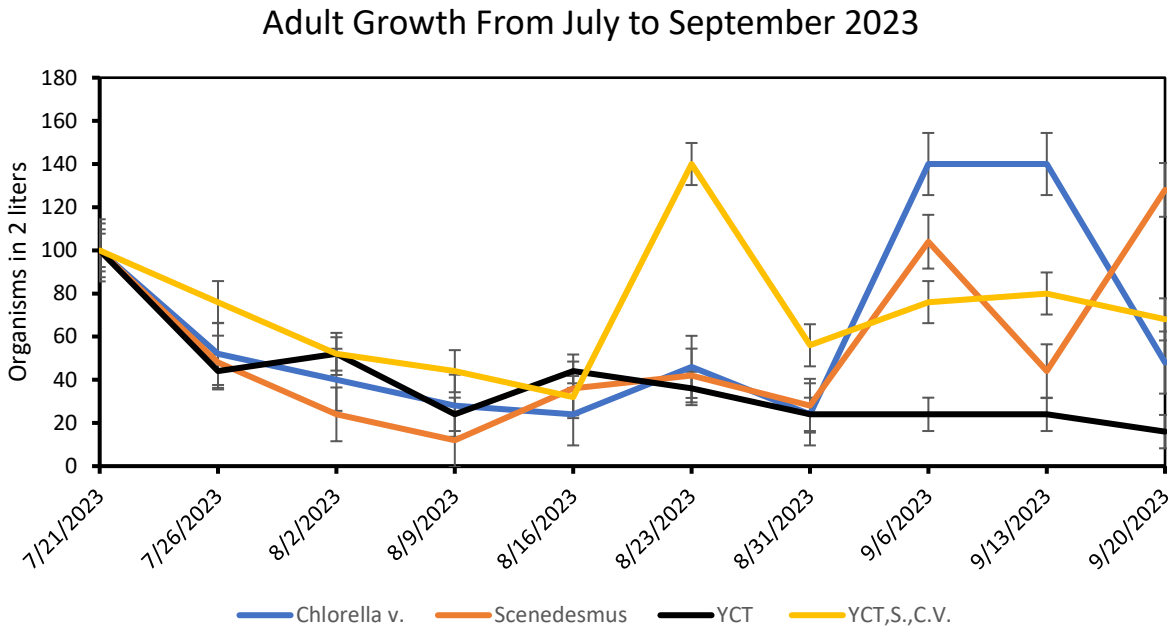

Figure 4. Line graph of weekly population growth of adults from July to September 2023. Generated in Microsoft Excel.

Conclusions

The food option that yielded significantly more neonate and adult growth was the most varied combination of YCT/*Scenedesmus*/*Chlorella vulgaris.* When compared to the control (YCT) the adults and neonates reached concentrations above 70 organisms in 1 liter at their peak, but experiments lasted only 9-weeks, and were not continued long enough to stabilize the *Daphnia* growth cycle. This varied food option likely yielded the most organisms because *Daphnia magna* have a varying diet in their natural settings: including microbes, green algae and other phytoplankton (Bednarska, 2023). The two green algal species were a high-quality food source that may have stimulated *Daphnia* population growth. Over time, *Scenedesmus sp.* alone significantly yielded more neonates compared to YCT and *Chlorella vulgaris.* This may be due to this species of algae being twice as big as *Chlorella vulgaris* which may suggest to be able to sustain a higher *Daphnia* population over time.

The preliminary data collected from the Lake Waramaug Farm in the summers of 2021 & 2022 (Figures 1 & 2) where the *Daphnia* were fed a combination of yeast, flour and sugar apart from the food available in the lake during this time. Regardless of the food source, the populations of *Daphnia spp.* in a natural setting never reached 10 organisms per liter while in an experimental setting they exceeded that amount. Though the feeding practices for both data (Yeast for Figures 1&2 *vs* YCT/*Scenedesmus sp.*/*Chlorella vulgaris* for Figures 3 & 4) sets were different, comparing the data showed that past methods weren't sufficient for maximizing *Daphnia* growth. New methods and approaches will need to be applied to the Lake Waramaug Farm to be able to yield the concentration of *Daphnia* measured in the experimental setting. Developing capacities at Lake Waramaug to culture *Scenedesmus sp.* and incorporate that into diet of *Daphnia* raised at Lake Waramaug Farm may improve the efficacy of that program to increase populations of large-bodied Cladocera in the lake.

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