Established Hydrilla Verticillata Impacts on Dissolved Oxygen Levels: Finding Low but Stable Oxygen Concentrations around Lake Norman, North Carolina

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Short Report

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Abstract

Hydrilla verticillata invasions impact freshwater ecosystems across America, with one key factor being the depletion of dissolved oxygen (DO) levels. This study examined the relationship between *Hydrilla* presence and DO dynamics in a beaver pond connected to Lake Norman in North Carolina. DO levels were compared between a *Hydrilla*-infested pond and a clean, *Hydrilla*-free pond over an eight-week period. The results indicated that while *Hydrilla* contributed to lower DO levels, it also stabilized these levels over time, in contrast to the clean pond, where DO declined progressively over the summer. Statistical analyses revealed a significant difference in DO concentrations between the two ponds ($t_{(30)} = 12.928$, $p < 0.001$). Over time, the clean pond showed a decrease in DO levels ($r = -0.644$, $p = 0.007$), whereas the *Hydrilla* pond showed no significant trend ($r = 0.320$, $p = 0.227$). These findings suggest that *Hydrilla* may create a more consistent low-DO environment, potentially buffering against environmental fluctuations. This stability could have important implications for managing *Hydrilla* invasions, as it may contribute to a dangerous feedback loop in which degraded water quality fosters further invasion, complicating eradication efforts. Future research should focus on more frequent DO sampling and post-removal studies to assess potential DO recovery.

1. Introduction

Hydrilla verticillata (hereafter *Hydrilla*) is an invasive aquatic plant that significantly impacts freshwater ecosystems by reducing dissolved oxygen (DO) levels, particularly during warmer months (True-Meadows, Haug, and Richardson, 2016). It lowers DO through respiration, where oxygen consumption exceeds photosynthesis at night, and through the aerobic decomposition of dead plant material (Bradshaw, Allen, and Netherland, 2015; Mangsang, Tarnchalanukit, and Duangsawasdi, 2010). In smaller water bodies *Hydrilla* can create hypoxic conditions, sometimes causing DO levels to drop severely (Bradshaw, Allen, and Netherland, 2015; Lv et al., 2023). These smaller ponds can also act as stepping stones for *Hydrilla* invasion feeding into larger lakes, like Lake Norman in North Carolina, by dispersing seeds or turions into the main water body (Havel et al., 2015). This research highlights how populations of *Hydrilla* can significantly influence the extent of DO depletion in freshwater ecosystems.

2. Methods

2.1 Dissolved Oxygen Sampling

To assess DO levels a *Hydrilla*-infested beaver pond and a *Hydrilla*-free or 'clean' pond along Lake Norman were selected (Figure 1). On-site testing was conducted along the shoreline of each location. A HI-3810 Dissolved Oxygen test kit was used to measure DO levels. Sampling involved submerging the sample vial a few centimeters underwater and following the manufacturer's instructions for DO measurement. Three replicates were taken at each site to ensure data reliability. Environmental variables, including visible water level changes, recent and current weather conditions, and rainfall, were recorded as they can influence DO levels.

Sampling was conducted twice weekly over an eight-week period, beginning on July 17th and concluding on September 8th, 2023. Each site visit occurred in the morning (before 11:00 AM) to minimize the effects of diurnal fluctuations in DO levels. While site visits were initially scheduled for Mondays and Wednesdays, adjustments were made based on weather conditions.

Figure 1: Google Maps satellite imaging of the water testing site locations. The label 'Infected' marks the *Hydrilla*-infested beaver pond, while 'Clean' indicates the pond where no *Hydrilla* is present.

2.2 Data Analysis

Post-sampling, the three DO replicates from each site visit were averaged to obtain representative weekly values for both the *Hydrilla*-infested and clean pond. An independent t-test was conducted, comparing DO measurements from the clean pond to those from the *Hydrilla*-infested pond. Additionally, a Pearson correlation analysis was conducted to evaluate the relationship between DO levels and time for both the *Hydrilla*-infested and clean pond datasets.

3. Results

The comparison of DO levels between the *Hydrilla*-invaded pond and the clean pond revealed differences over the study period. Testing indicated that the clean pond had a significantly higher DO level compared to the *Hydrilla* pond ($t_{(30)} = 12.928$, $p = <0.001$).

The Pearson correlation analysis, between day and DO levels, showed a significant negative correlation in the clean pond ($r = -0.644$, $p = 0.007$; Fig. 2), indicating a decrease in DO over time. In contrast, no significant correlation was found in the *Hydrilla* pond ($r = 0.320$, $p = 0.227$: Fig. 3), suggesting no clear trend in DO levels over time in the presence of *Hydrilla*.

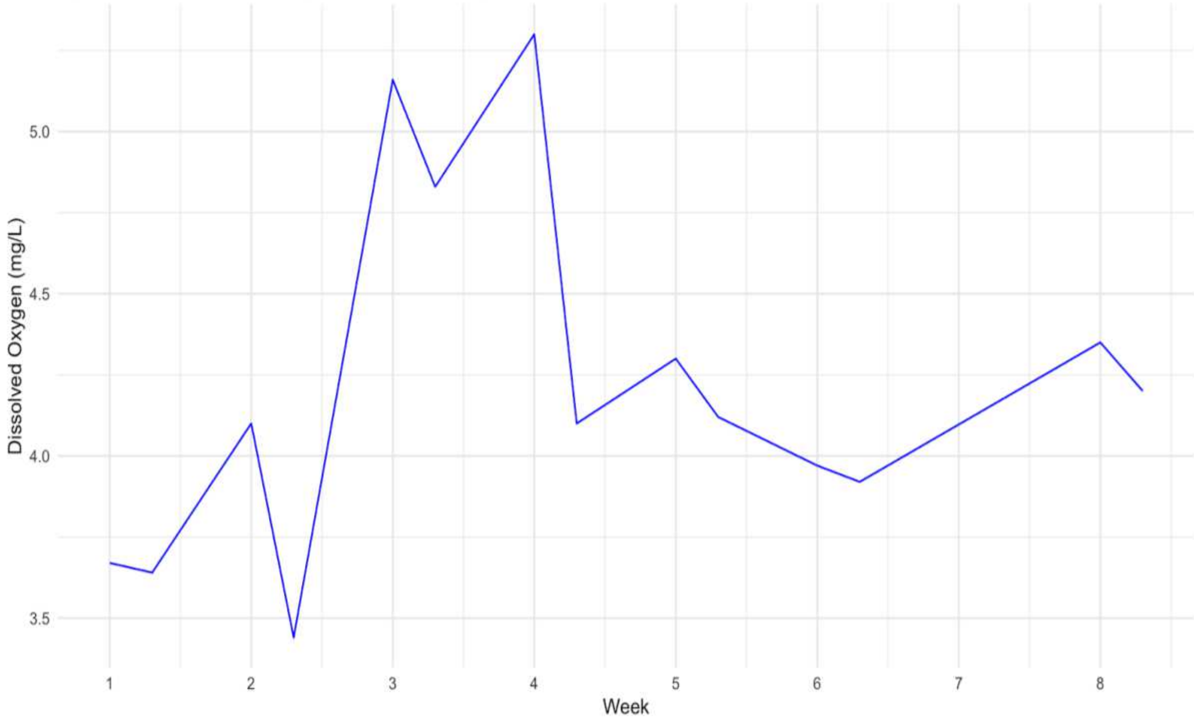

Figure 2: Dissolved oxygen level in the *Hydrilla*-infested pond over the 8 weeks of data collection. No readings were taken during week 7 due to hazardous weather conditions.

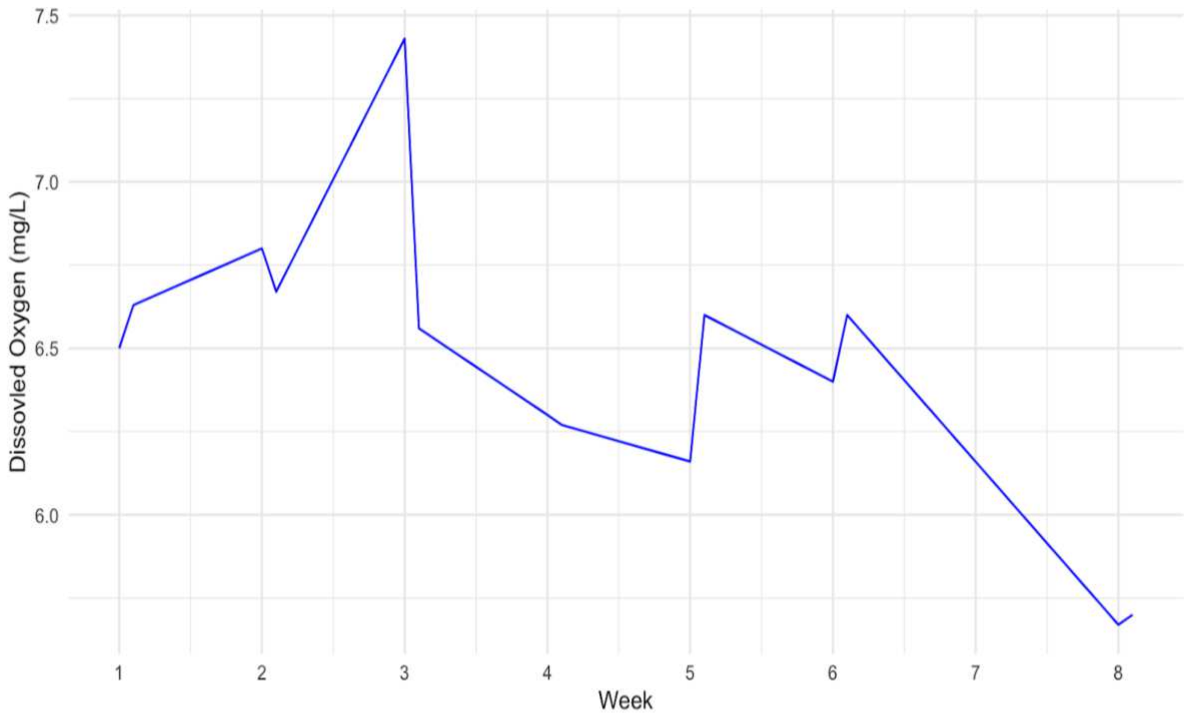

Figure 3: Dissolved oxygen level in the clean pond over the 8 weeks of data collection. No readings were taken during week 7 due to hazardous weather conditions.

4. Discussion

One of the most unexpected findings of this study is the differing trends in DO levels between the *Hydrilla*-infested pond and the clean pond over time. Figure 3 illustrates this phenomenon, revealing that despite *Hydrilla's* known effects on oxygen depletion, its presence in the beaver pond did not lead to progressively worsening DO levels. In contrast, Fig. 2 shows that the clean pond, which lacked *Hydrilla*, exhibited a continuous decline in DO. These graphs illustrate how over the sampling period, the Hydrilla-infested pond had a lower, but more stable level of dissolved oxygen compared to the continually depleting levels in the clean pond.

This stability in the *Hydrilla*-infested pond is particularly intriguing given that *Hydrilla* is typically associated with fluctuating DO levels due to its dense biomass and decomposition processes (Bradshaw, Allen, and Netherland, 2015; Mangsang, Tarnchalanukit, and Duangsawasdi, 2010). One possible explanation for this unexpected pattern is that once a certain *Hydrilla* biomass is established, the system may reach a new equilibrium, where DO remains at a low but stable state rather than continuing to decline. This is in contrast to the clean pond, where external environmental factors, such as microbial respiration, organic matter breakdown, and stratification, may drive a gradual reduction in DO over time.

Another key factor influencing these patterns is the difference in pond size. The *Hydrilla*-infested beaver pond is approximately half the size of the clean pond, making it more susceptible to stratification and rapid DO fluctuations (Stefan et al., 1996). However, despite this increased susceptibility, the *Hydrilla*-infested pond did not experience the same continuous decline in DO as the clean pond. This suggests that *Hydrilla* may play a role in buffering against certain environmental fluctuations, possibly by stabilizing the oxygen-depleting processes within the system. The clean pond, on the other hand, may be more influenced by external conditions such as temperature changes, rainfall, and organic matter accumulation, leading to the observed progressive DO decline.

These findings have important implications for reinfestation and the management of *Hydrilla* in Lake Norman and similar lakes across America. While the results of this study suggest that *Hydrilla* lowers DO levels, it may also create a more stable oxygen regime at that lowered level compared to non-infested systems, which are more vulnerable to gradual DO declines due to environmental factors. Long-term DO reductions, driven by climate change and human activities, complicate the management of invasive species like *Hydrilla* (Luo et al., 2024; Missaghi, Hondzo, and Herb, 2017). As climate-induced DO declines are projected to worsen, *Hydrilla* may contribute to a feedback loop in which degraded water quality promotes further invasions, reinforcing low-oxygen conditions (Krabbenhoft and Kashian, 2022). *Hydrilla*-induced DO depletion is linked to habitat degradation, fish displacement, and changes in aquatic community structure (Missaghi, Hondzo, and Herb, 2017). Additionally, low DO concentrations can amplify the effects of climate change on freshwater ecosystems, further adding to the challenges of managing *Hydrilla* infestations (Luo et al., 2024; Missaghi, Hondzo, and Herb, 2017). Overall, the results suggest that *Hydrilla* invasions not only alter DO dynamics but may also create conditions that perpetuate their own dominance, complicating eradication and restoration efforts.

5. Future Research and Recommendations

Future research should focus on increasing the frequency of DO sampling, particularly during peak *Hydrilla* growth seasons, to better capture the dynamics of oxygen fluctuations. Sampling three times per week during summer months would provide more detailed insights into how *Hydrilla* influences DO over time. Additionally, a follow-up study after *Hydrilla* removal from the beaver pond attached to Lake Norman would be valuable in determining whether its absence allows for DO recovery and improved water quality.

Understanding these interactions is crucial for developing effective freshwater management strategies, particularly in ecosystems like Lake Norman, where the threat of returning *Hydrilla* infestations continue to pose significant management challenges. Moving forward, integrated management approaches that consider both *Hydrilla* control and broader DO stabilization strategies will be essential for maintaining healthy aquatic ecosystems and preventing further habitat degradation.

6. Acknowledgements

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Statements and Declarations

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All authors contributed to the study conception and design. Data collection and analysis were performed by Willaim Yates. Data refinement and analysis were performed by Laura Chapman. The first draft of the manuscript was written by William Yates and author Laura Chapman commented on previous versions of the manuscript. All authors read and approved the final manuscript.