Using DNA Barcoding to Analyze Biodiversity of Duckweed - Understanding the Effects of Human Activity on Water Quality

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Abstract

80% of global wastewater is discharged untreated, harming aquatic ecosystems and biodiversity of plant species. Duckweed plays a key role in water quality. Since certain duckweed species thrive in pollution while others don't, we hypothesized that urban pollutants affect their biodiversity. With a ladle we collected 16 samples in the Tenakill Brook area in Tenafly, New Jersey to compare species between a polluted pond and a clean stream . When we analyzed these using DNA barcoding and phylogenetic analysis, the pond showed species that form dense mats, reducing biodiversity, while the stream included a diverse mix of sensitive types, as expected. Although the study of algae was this project's original goal, due to winter conditions and mishaps the emphasis has been shifted. Our results nevertheless support the argument that duckweed can help monitor water quality and prove the impact of human activities.

Figure 1: Polluted Pond, *Lemna minor* dominated

Figure 2: Undisturbed Stream, *Spirodela polyrhiza* and *Landoltia punctata* dominated

Introduction

Even though water is what gives and sustains life, wastewater is actually harming aquatic ecosystems. The indicator that an ecosystem has been affected? Shifts in duckweed species. Resilient types of duckweed such as *Lemna minor* often dominate polluted waters, while more sensitive species which mark healthy water quality like *Spirodela polyrhiza* and *Landoltia punctata* disappear and are formed in clean water conditions. This reduction in biodiversity and shift in species composition serves as a clear warning sign of declining ecosystem health.

Although we originally planned to assess water quality using other biological markers, winter conditions and the high abundance of duckweed at our study sites shifted our focus. Duckweed ability to produce resting fronds allows it to persist through unfavorable conditions, making it a consistent presence even in winter[4]. To test this, duckweed samples from different sites were analyzed using DNA barcoding to identify species and categorize them by pollution sensitivity[5].This research highlights the connection between human activity and aquatic biodiversity, emphasizing duckweed as a natural water quality indicator to inform conservation efforts and deepen our understanding of human impacts on freshwater ecosystems.

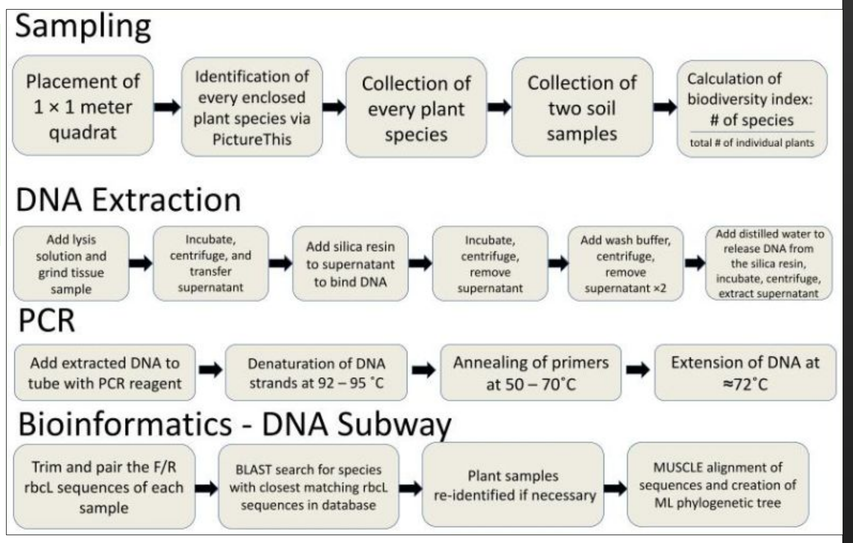
Aim: To evaluate whether duckweed species composition, identified through DNA barcoding, reflects water quality differences across two contrasting water bodies.

Hypothesis: Sites with poorer water quality will show reduced duckweed species diversity and be dominated by more pollution-tolerant species.

Materials and Methods

Figure 3: Collection Sites

Figure 4: Samples collected in plastic bottles



Results

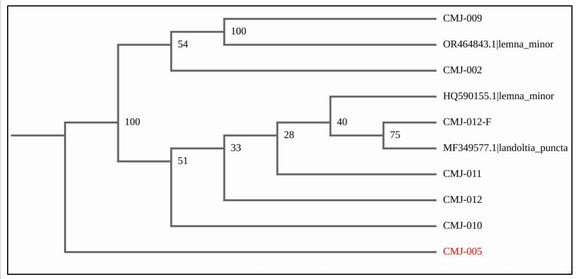


Figure 5: Phylogenetic Tree with CMJ-005 as the outgroup

Site	Species Present	Species Count (n)	Total (N)	Proportion (p)	H' = -∑(p × ln p)
Polluted Pond	*Lemna minor*	9	9	1.00	0.00
Clean Stream	*Landoltia punctata, Spirodela polyrhiza*	5.4	9	0.56, 0.44	0.69

Figure 6: Shannon-Wiener Biodiversity Index Table

Figure 7: Scientific names and species

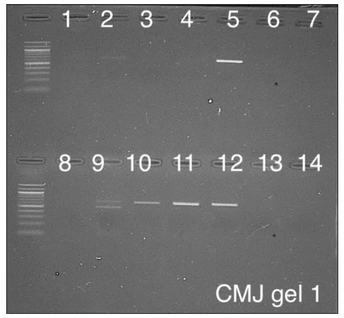


Figure 8: Gel electrophoresis results after PCR

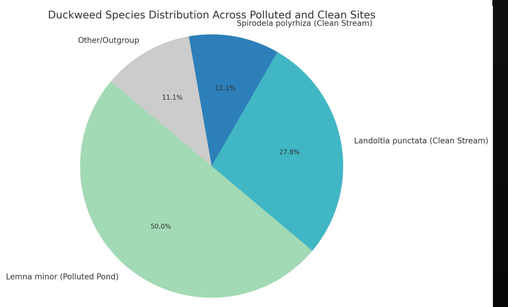


Figure 9: Pie chart showing the distribution of duckweed species

Discussion

- Polluted pond was dominated by Lemna minor → indicates poor water quality due to its pollution tolerance
- Clean stream contained Spirodela polyrhiza and Landoltia punctata → S. polyrhiza only thrives in unpolluted conditions
- Complete species separation between sites → strong evidence duckweed reflects pollution gradient
- L. minor dominance may result from pollution or competition → winter sampling limits species detection
- DNA analysis had minor issues, but patterns of duckweed distribution remained ecologically meaningful
- Polluted pond has no biodiversity while the clean stream has a Shannon-Wiener Diversity Index of 0.69

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