UMEÅ UNIVERSITET

USING ENVIRONMENTAL DNA TO UNRAVEL AQUATIC ECOSYSTEM DYNAMICS

Fredrik Olajos

Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i Stora hörsalen KBE303, KBC-huset, den 14 Juni kl. 13:00. Avhandlingen kommer att försvaras på engelska.

Fakultetsopponent: Prof. Elizabeth Clare,
York University, Toronto, Kanada

Department of Ecology and Environmental Science (EMG)

Organization
Umeå University
Department of Ecology and Environmental Science (EMG)

Document type
Doctoral thesis

Date of publication
24 05 2024

Author
Fredrik Olajos

Title
Using Environmental DNA to Unravel Aquatic Ecosystem Dynamics.

Abstract

Human-induced climate change has led to unprecedented declines in Earth's biodiversity and significant habitat loss. Aquatic ecosystems are especially at risk, facing pollution, overexploitation, and destruction. Consequently, monitoring biodiversity is critical. Traditional monitoring methods are often low in detection rates, time-consuming, invasive, and harmful to species, which hampers comprehensive biodiversity assessments. Environmental DNA (eDNA) offers a rapid alternative for taxonomic identification, extracting genetic material from soil, sediments, or water without capturing living organisms, proving useful where traditional methods fall short. However, its integration into aquatic ecology is hampered by unresolved methodological issues.

This thesis demonstrates how eDNA can help reconstruct fish colonization histories in lakes post-glacial retreat. I employed species-specific primers with digital droplet PCR and metagenomic shotgun sequencing on ancient DNA from Holocene lake sediments. My findings show the detectability of DNA from ancient fish populations. However, each method exhibited technical limitations that led to varying degrees of false negatives and false positive results. Additionally, I examined how Northern pike (*Esox Lucius*) affects ecological speciation in European whitefish (*Coregonus lavaretus*), promoting a shift from insectivorous to piscivorous states, enhancing predator biodiversity and biomass. Diet analyses of piscivorous birds through digital droplet PCR revealed that smaller whitefish support a larger, more diverse bird community. Finally, I compared two molecular techniques for quantifying bird diets from fecal DNA, finding that metabarcoding with a universal fish primer and digital droplet PCR yielded similar results. This research enhances our understanding of the potential and limitations of molecular tools for species identification and aids the integration of eDNA into aquatic ecology.

Keywords
Environmental DNA, ancient DNA, colonization, apex predator, pike, whitefish, piscivorous birds, aquatic ecosystems, metabarcoding, digital droplet PCR

Language
English

ISBN
print: 978-91-8070-412-0
PDF: 978-91-8070-413-7

ISSN

Number of pages
24 + 4 papers