Assessing zooplankton foraging depths using a Bayesian fatty acid-specific stable isotope mixing model

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Background

- **Lake zooplankton** typically perform diel vertical migration movements and **feed on particles**, mostly phytoplankton (<40 μm) for herbivorous zooplankton, across the lake **water column**.
- **Edible phytoplankton** vary in their **dietary energy composition** that consumers rely on for their somatic development, reproduction, and eventually survival.
- **Lake zooplankton** access dietary energy, such as lipids and their fatty acids, at various lake depth and require the essential fatty acids **linoleic acid** (LIN; 18:2n-6) and **α-linolenic acid** (18:3n-3, ALA), and long-chain polyunsaturated fatty acids (PUFA), such as **eicosapentaenoic** (EPA; 20:5n-3).

Problem

- The presence of zooplankton at specific lake depths does not necessarily correlate with their **feeding location**, hence spatial and temporal zooplankton feeding dynamics throughout the lake water column requires high temporal sampling resolution
- The use of **bulk stable isotopes** does not discriminate between **diet sources from different lake layers** and are not linked with information about the nutritional quality of site- and lake depth-specific available diets.

Objective

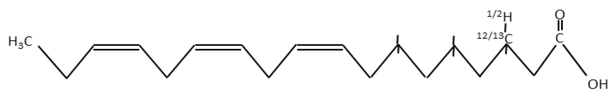
- To examine **spatial and temporal zooplankton feeding dynamics** across various lake depths, and
- To assess **source-specific metrics of diet quality** across the lake water column using a compound-specific stable hydrogen (δ^2H) and carbon (δ^{13}C) isotopes of fatty acids.

Hypothesis

- Compound-specific stable isotope analysis (CSIA) of fatty acids can discern the foraging depth and diet quality of zooplankton species

Compound-specific stable isotope analysis (CSIA)

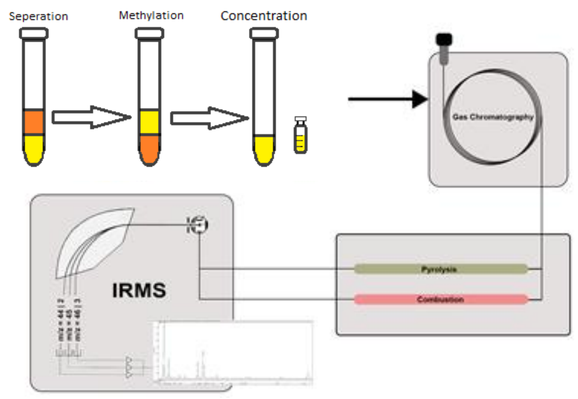
Fatty acid e.g.: ALA



C18:3ω3

Fatty acid Extraction
Chloroform/Methanol/NaCl
2:1:0,8

Element	Z	N	A	Abundance (%)	Symbol
Hydrogen	1	0	1	99.985	^{1}H
	1	1	2	0.0155	^{2}H; D
Carbon	6	6	12	98.892	^{12}C
	6	7	13	1.108	^{13}C



Results

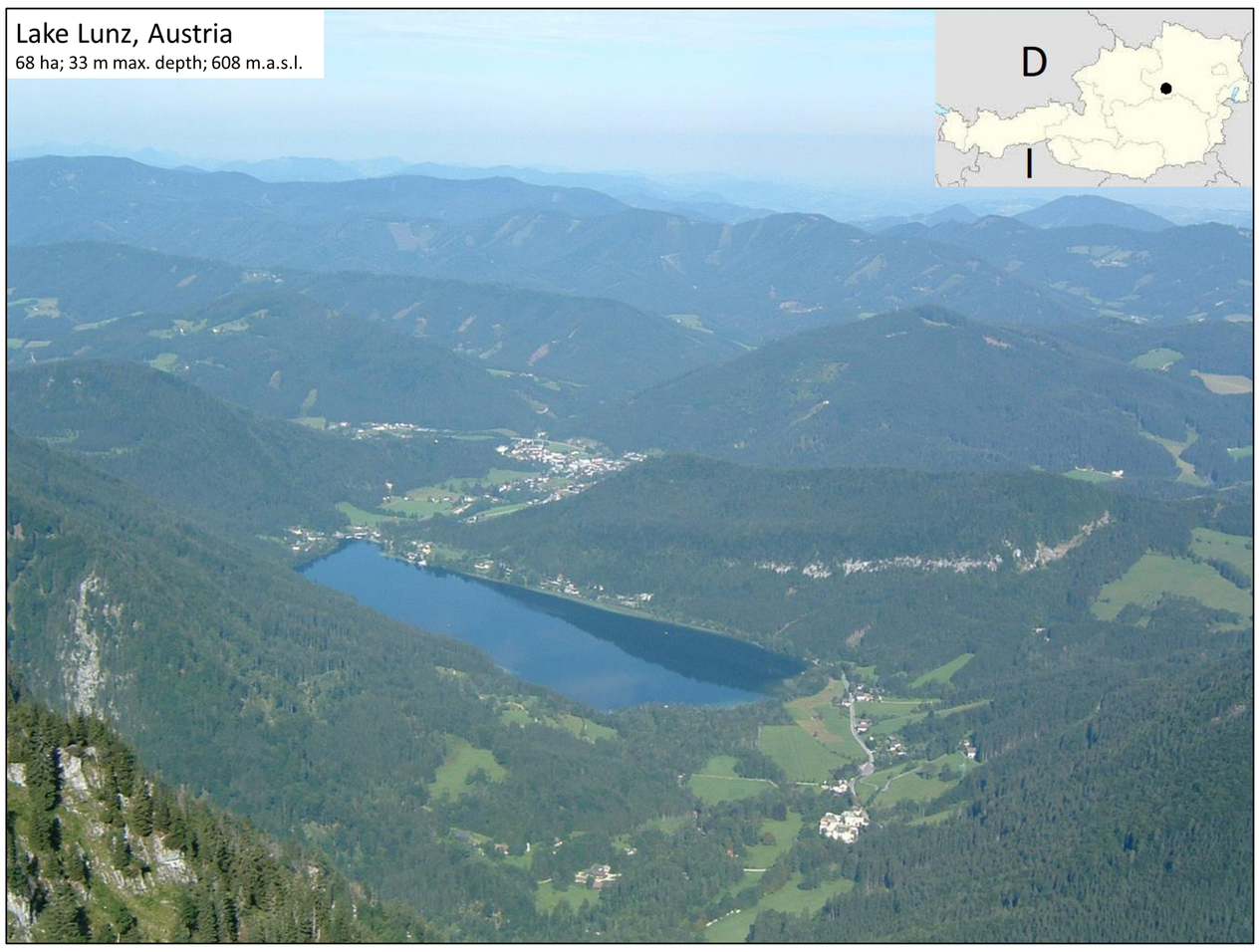
- Dual-carbon and hydrogen analysis revealed different feeding grounds for the acquisition of ALA and LIN of the four zooplankton genera (Fig. 2).
- *Daphnia* showed the highest probability of feeding on epilimnetic seston (Fig. 3).
- *Calanoids* were the only zooplankton group with significant diet contributions attributed to hypolimnetic seston (Fig. 3).
- Bayesian Mixed Model suggests different feeding habits for different zooplankton body sizes (Fig. 3)

→ **The dual-isotope (δ^{13}C and δ^{2}H) CSIA of FA approach can identify the zooplankton feeding grounds and also provides diet quality data for zooplankton**

Implications for trophic ecology

Fatty acid-specific stable isotopes provide

- information about **feeding grounds of zooplankton** at various lake depths;
- more details on spatial and temporal **trophodynamics of planktonic food webs** than bulk stable isotopes;
- a measure of **dietary energy acquisition** for zooplankton and other consumers, including fishes.



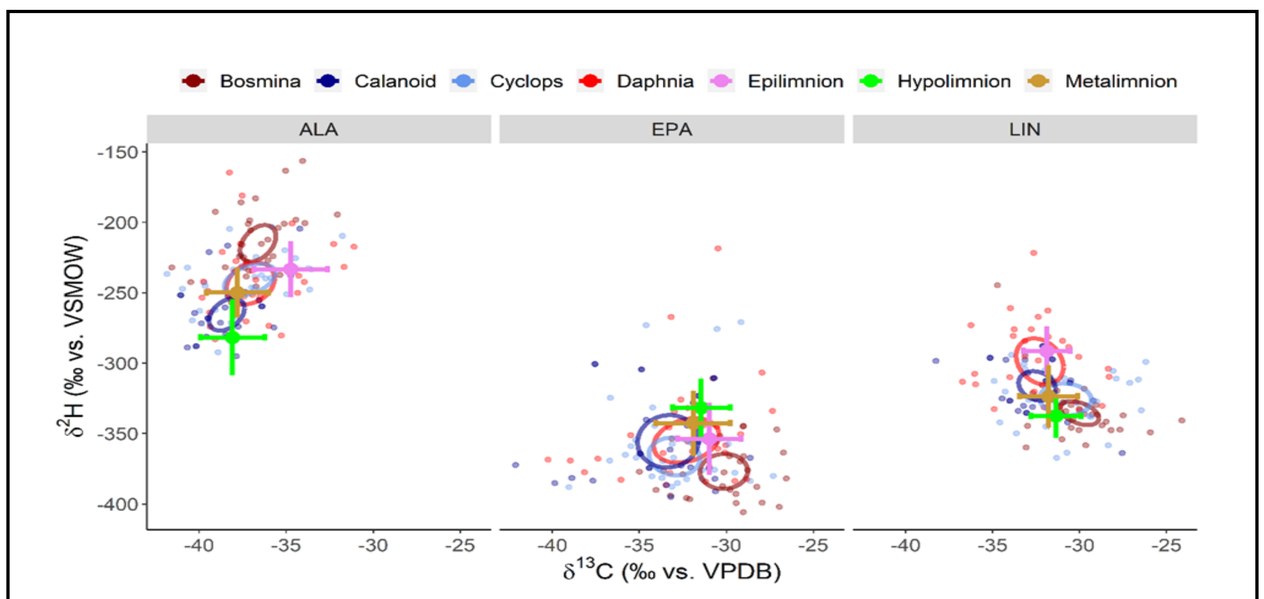


Fig. 2: **Isotopic biplot of δ^2H and δ^{13}C values of polyunsaturated fatty acids**. LIN and ALA cannot be synthesized *de novo* by consumers and thus must be acquired via diet. Thus, apart from a small trophic fractionation factor, they directly reflect the dietary sources of a consumer. On the other hand, EPA can be bioconverted from precursors, or, if not physiologically required, used as energy sources by consumers, thus altering the isotopic signature. For example, d^2H_{EPA} values of consumers tend to be lower than d^2H_{EPA} values of the potential dietary sources, which is most likely due to endogenous bioconversion from ALA

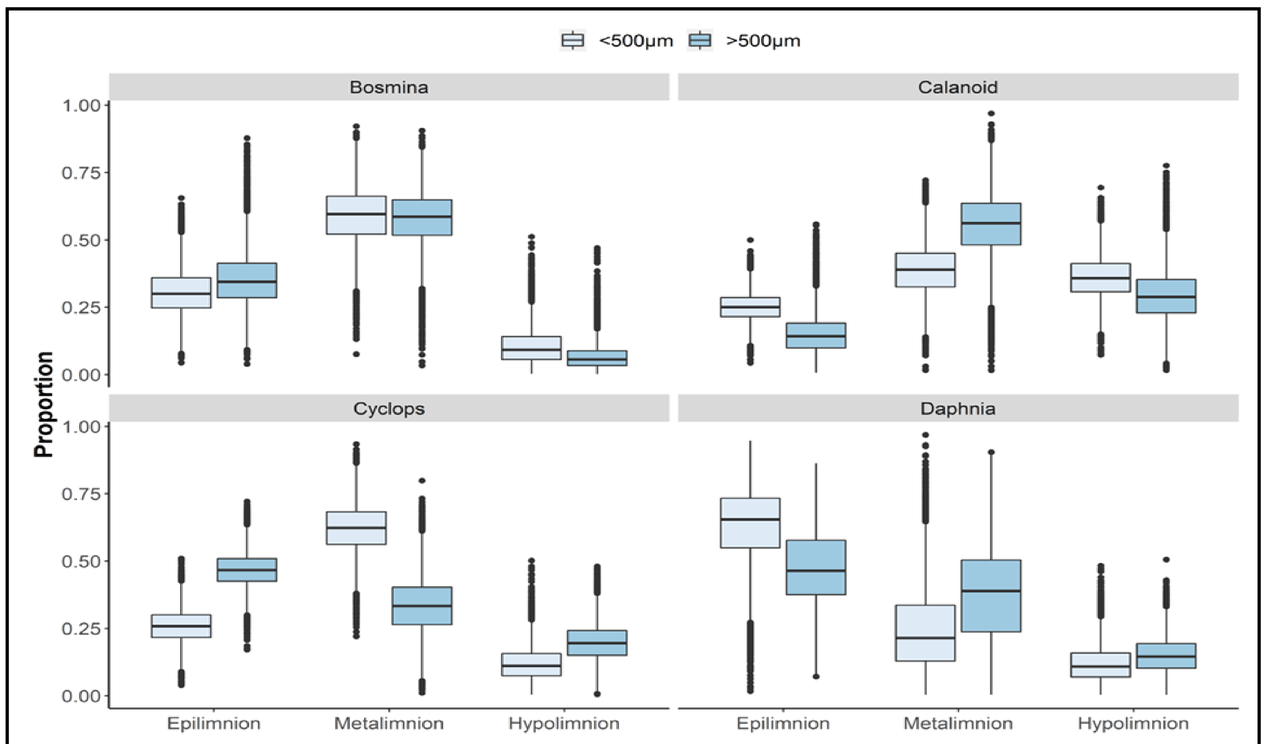


Fig. 3: Bayesian mixed models using δ^2H and δ^{13}C values of LIN and ALA indicate preferential foraging layers of the zooplankton genera (R software, using *simmR*).

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