THE INFLUENCE OF BIOLOGICAL TRAITS ON BIOCONCENTRATION OF ORGANIC CHEMICALS IN FRESHWATER INVERTEBRATES

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1. BACKGROUND

Chemicals don't just move through aquatic ecosystems; they can accumulate, amplify, and persist within living organisms. The bioconcentration factor (BCF) is used to **quantify this accumulation**, and toxicokinetic testing is increasingly shifting from fish to aquatic invertebrates. However, current approaches may **overlook key biological traits, such as body size and structure, which may influence chemical uptake** [1]. Adding these biological traits may improve predictive models and capture real-world variability in chemical accumulation across species.

2. AIM

To assess how **biological traits** influence BCF in freshwater invertebrates.

3. INVERTEBRATES

Daphnia magna, *Lumbriculus variegatus*, *Crangonyx pseudogracilis*, *Sphaerium corneum*, *Asellus aquaticus*, *Gammarus pulex*, *Ischnura elegans* (larvae), *Radix balthica*, *Erpobdella octoculata*, *Lymnaea stagnalis*, *Anodonta cygnea*

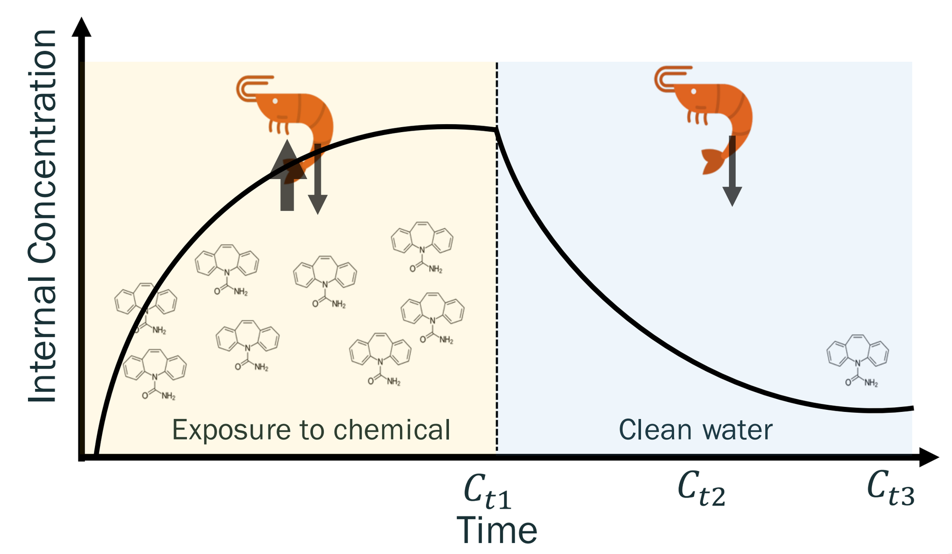
4. TEST DESIGN

Acclimate (48 h)

- 20°C
- 16:8 h light:dark
- Aerated
- No food
- Shape

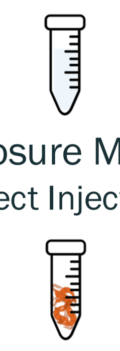
Uptake phase – Exposure (48 h)

Elimination phase – Clean water (48 h)



Minimised Bioconcentration Test Design [2,3]; Tissue sampled at C_{t1}, C_{t2} and C_{t3} (rep = 5).

Extraction – Samples

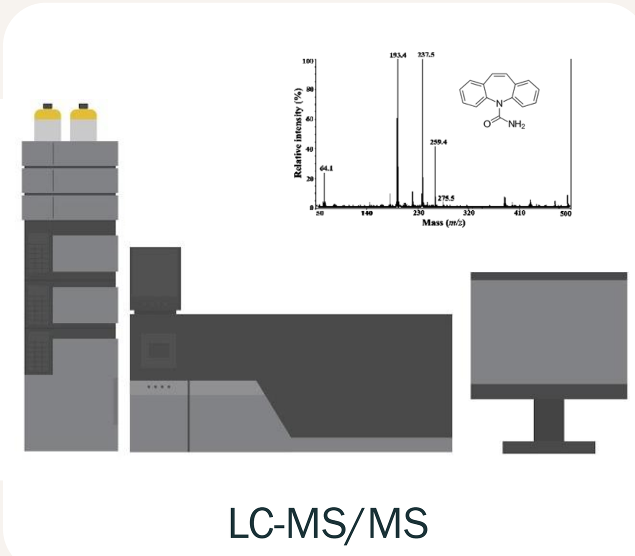


Exposure Matrix: Direct Injection

Tissue: QuEChERS, AOAC extraction, dSPE clean up

Modified QuEChERS [4]

Chemical analysis – LC-MS/MS



TSQ Endura QQQ

Toxicokinetics – Modelling parameters

$$k_2 = \frac{\ln C_{t1} - \ln C_{t2}}{t_d}$$

$$k_1 = \frac{k_2 C_{t1}}{C_w}\left(1 - e^{-k_2 t_u}\right)$$

$$BCF_k = \frac{k_1}{k_2}$$

Toxicokinetic model [5]

5. RESULTS

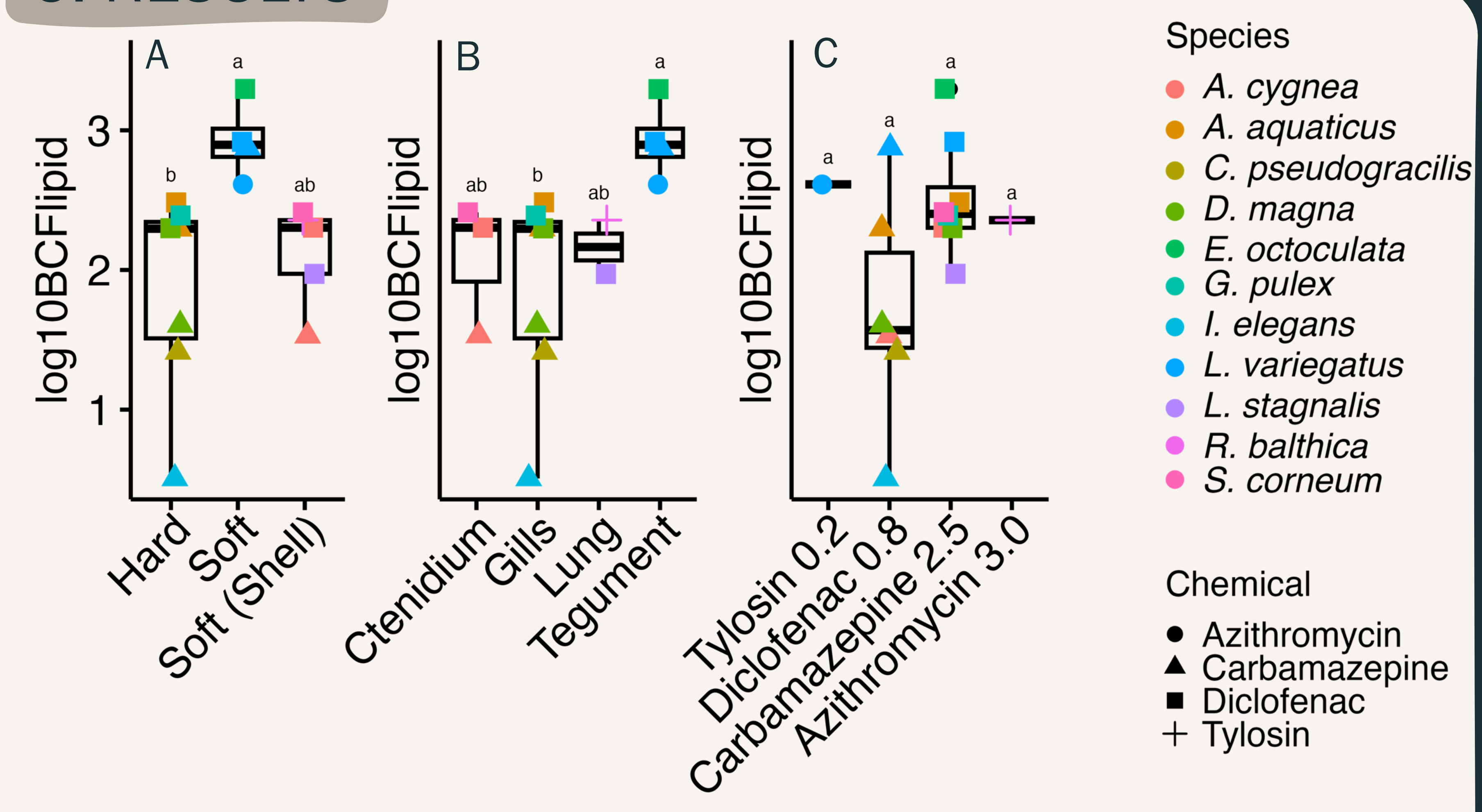


Figure. Variation in lipid-normalised logBCF across traits: body structure (A), respiratory mechanism (B) and distribution coefficient (logD) (C). Statistical differences among groups were evaluated using one-way ANOVA followed by Tukey's HSD post hoc tests.

Table. The significance and influence of selected biological and chemical traits as predictors of lipid-normalised BCF. Multi linear regression models were used to assess the relationship between biological and chemical traits and lipid-normalised BCF. Significant predictors are indicated by p-values < 0.05.

Biological Traits		
Size (SA:V)	> 0.05	Not a strong predictor
Body Structure	< 0.001***	**Soft-bodied** organisms ↑ BCF
Respiration	> 0.05	Not a strong predictor
Chemical Traits		
Hydrophobicity (logD)	< 0.005**	More **hydrophobic** ↑ BCF
Molecular weight	> 0.05	Not a strong predictor

6. DISCUSSION

This study is investigating how biological traits influence bioaccumulation (BCF) in aquatic invertebrates exposed to organic compounds. logD was estimated from logKow, pH, and pKa to account for pH-dependent ionisation under exposure conditions. Overall, BCF was primarily driven by chemical logD and organism body structure, rather than organism size or molecular weight of the compounds. This indicates that **uptake** and retention processes are **more closely linked to chemical partitioning behaviour and physiological traits in invertebrates** than to simple scaling metrics, consistent with previously reported inter-species variability in traits such as lipid content [6].

Incorporating traits, such as body structure, into predictive models may improve model performance and better capture species-specific variability.

7. NEXT STEPS

- Complete toxicokinetic testing of invertebrates across all four organic compounds.
- Expand the dataset to include additional organic chemicals with a wider range of hydrophobicity.
- Integrate chemical properties with biological traits to improve predictive models of BCF.

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[1] Arnot, J. A., & Gobas, F. A. (2006). A review of bioconcentration factor (BCF) and bioaccumulation factor (BAF) assessments for organic chemicals in aquatic organisms. *Environmental Reviews*, *14*(4), 257-297. [2] Carter, L. J., Ashauer, R., Ryan, J. J., & Boxall, A. B. (2014). Minimised bioconcentration tests: a useful tool for assessing chemical uptake into terrestrial and aquatic invertebrates?. Environmental science & technology, 48(22), 13497-13503. [3] Springer, T. A., Guiney, P. D., Krueger, H. O., & Jaber, M. J. (2008). Assessment of an approach to estimating aquatic bioconcentration factors using reduced sampling. Environmental toxicology and chemistry, 27(11), 2271-2280. [4] Anastassiades, et.al(2003). Fast and easy multiresidue method employing acetonitrile extraction/partitioning and "dispersive solid-phase extraction" for the determination of pesticide residues in produce. Journal of AOAC international, 86(2), 412-431. [5] OECD (2012). Test No. 305: Bioaccumulation in Fish: Aqueous and Dietary Exposure. OECD Publishing. [6] Rubach, M. N., Ashauer, R., Maund, S. J., Baird, D. J., & Van den Brink, P. J. (2010). Toxicokinetic variation in 15 freshwater arthropod species exposed to the insecticide chlorpyrifos. Environmental Toxicology and Chemistry, 29(10), 2225-2234.