OUTLINE: Harmonized macroinvertebrate trait database, Aggregation of traits, Trait definitions, Sources

1 Introduction

Intro: For what are traits used?
Knowledge on macroinvertebrate traits → trait databases

Studies that use information on aquatic invertebrate traits from different regions and/or aggregate trait information are increasing

In this paper we examine difficulties that ecologists face when using different macroinvertebrate trait databases together. We explore the effect of different decisions researches have to make when working with trait data from several regions/sources, involving harmonization, handling different codings, normalization, and aggregation of traits.

One of the problems in macroinvertebrate trait research is the use of inconsistent terminology across studies (but see Schmera et al. 2015). For example, some studies used the term "trait" to describe a general organismal property like "generations per year" (Statzner et al. 1997, Usseglio-Polatera et al. 2000), while in other studies this term was related to trait categories/states like "bi/multivoltine" (Haybach et al. 2004, Vieira et al. 2006). Here, we follow the proposal of Schmera et al. (2015) and use the term *trait* for a morphological, physiological, or phenological feature measurable at the individual organism (e.g. tegument, gills, etc.) and the term *grouping feature* to describe a general property of related organismal traits (e.g. respiration).

Therefore, we harmonized six grouping features from four trait databases and aggregated the trait information to family level. We discuss the harmonization and show the effect of different ways of aggregating traits (inter alia Problem of different coding styles (fuzzy vs binary)). We also present an overview of differences in trait definitions among databases. Finally, our paper compares the references for the trait information that were specified in the trait databases we used.

2 Description of harmonized trait database

The harmonized database consists of the available information on aquatic insect traits for the regions Europe, North America, Australia, and New Zealand and comprises the grouping features locomotion, feeding mode, respiration, voltinism, size, and body form. The pattern of development (holometabolous or hemimetabolous) was added as an additional grouping feature based on the orders of the taxa included in each database. Trait information for Australia and New Zealand were retrieved from single database. For Europe we gathered trait information from the freshwaterecology trait database (`https://www.freshwaterecology.info/`) and complemented missing information with the Tachet trait database (Usseglio-Polatera et al. 2000). North American macroinvertebrate traits were retrievied from Laura Twardochleb and complemented by trait information from Vieira et al (Vieira et al. 2006). We did not use the entire data on macroinvertebrates, but limited our analysis to orders of aquatic insects that occurred in all used databases, specifically the orders: ... Table 1 gives an overview of the used databases.
In the following paragraphs, we describe the data processing steps required to establish a harmonized macroinvertebrate trait database.

Table 1: Overview of trait databases.

Region	Coding of trait states	Reference
Europe	Largely fuzzy	Schmidt-Kloiber and Hering 2015
Central Europe	Fuzzy coded	Usseglio-Polatera et al. 2000
North America	Largely binary	Vieira et al. 2006
North America	Largely binary	cite Laura Twardochleb
Australia	Binary & fuzzy coding	Kefford et al. 2019
New Zealand	Fuzzy coded	

- Various preprocessing steps: Taxonomical corrections; Range normalization [0-1] (e.g. in Australia); a few words about spreadsheets etc?
- Harmonization
- (RowSum) Normalization/Standardization
- Aggregation of traits

2.1 Harmonization of traits

- Harmonization process: See also Schmera 2015 et al

- Differences in trait definitions
- Sources of traits

Harmonization of traits is the process of amalgamating several similar trait states into a single trait state. Harmonization has to be undertaken when e.g. traits from different sources (e.g. different regions) are compared and the traits have not the same trait states.

Traits that differed in their trait states among databases have been harmonised by condensing the trait states for each trait in such a way that in the end the same traits in all four databases consisted of the same trait states. This meant reducing the trait states to the smallest number of trait states that occur for a particular trait among all databases. Thereby, trait states were amalgamated based on ecological knowledge or expert judgment. Our approach of harmonizing the traits of the used databases is outlined in figures 1 and 2.

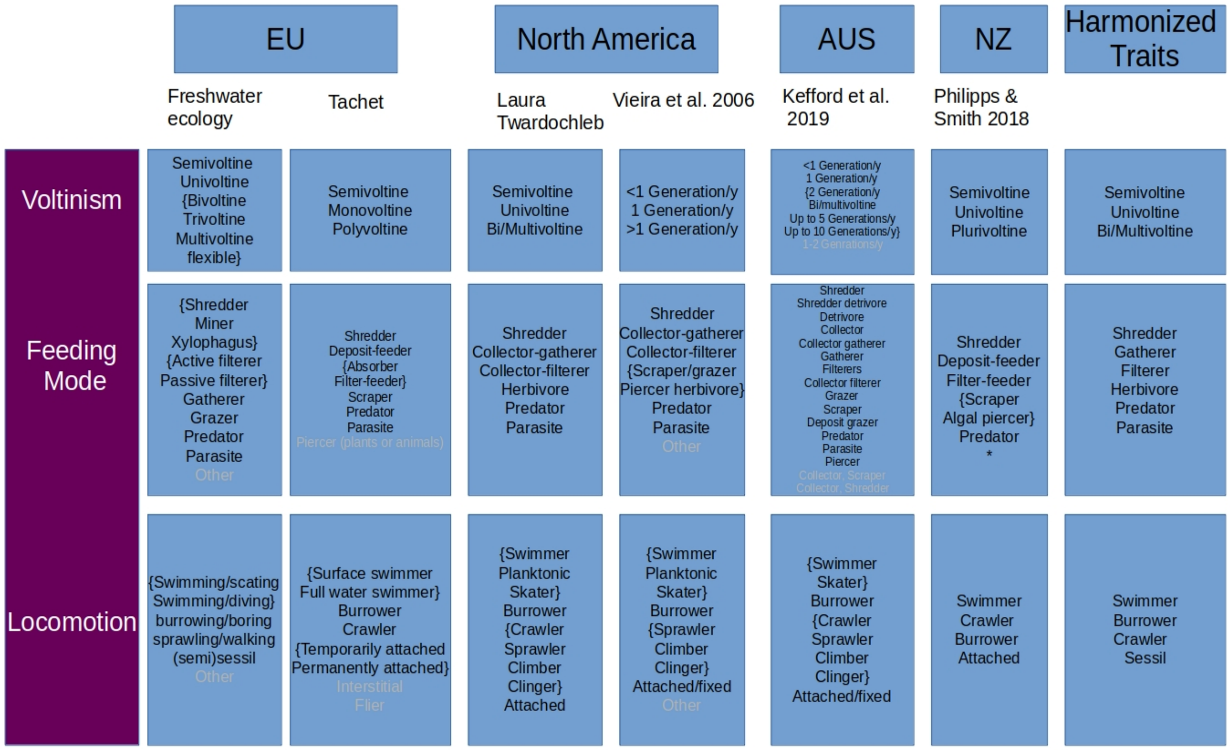

Figure 1: Proposed harmonization scheme for the grouping features voltinism, feeding mode and locomotion. Shown are all traits for the used grouping features in the investigated trait databases and the harmonized traits in the end. Traits in curly brackets were harmonized to one trait. Traits highlighted in Grey were omitted.

** Trait parasite was not available in New Zealand trait database.*

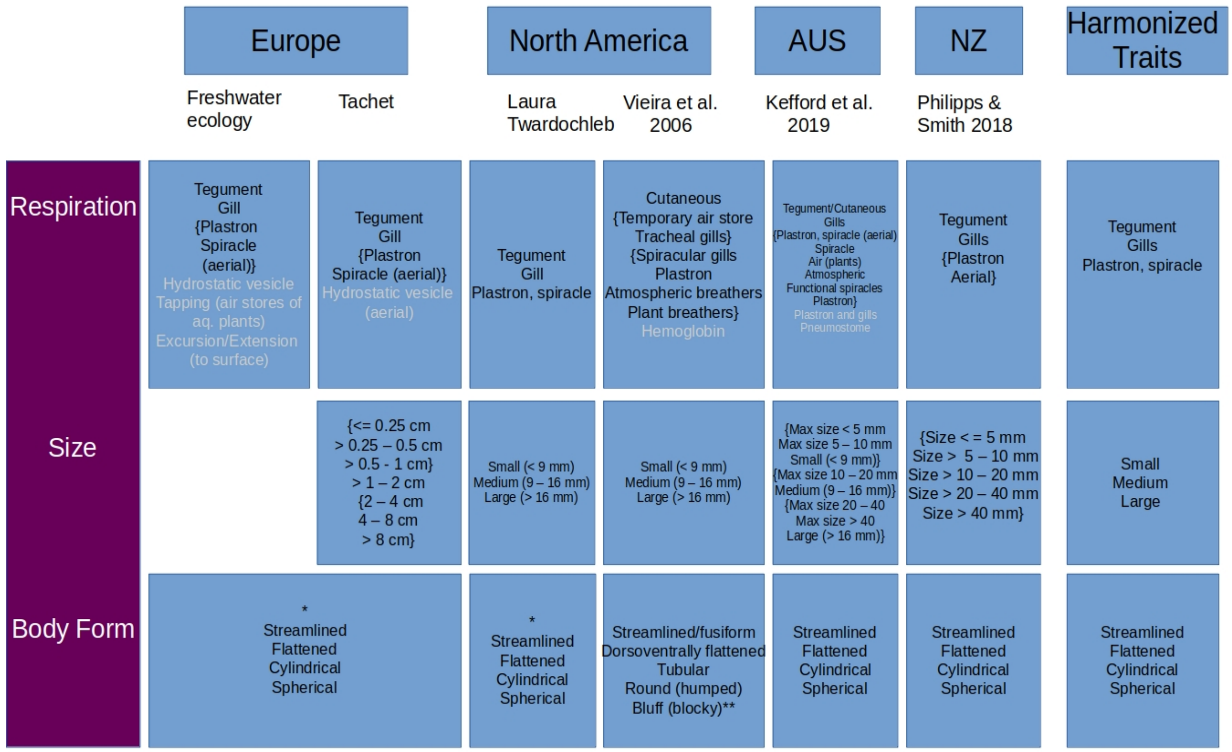

Figure 2: Proposed harmonization scheme for the grouping features respiration, size and body form.
** Body form information provided by Philippe Usseglio-Polatera.*
*** Bluff(blocky) taxa have been reclassified by Philippe Usseglio-Polatera using the traits streamlined, flattened, cylindrical and spherical.*

3 Aggregation of traits

- Describing & testing different approaches
- Problem of coding of traits

Additional ideas

Section Description of databases:

- Describe different databases briefly?
- State goal of analysis → reference to second paper?