Supporting Information - Tackling discrepancies in freshwater invertebrate trait databases: Harmonising across continents and aggregating taxonomic resolution

Stefan Kunz[1], Ben J. Kefford[2], Astrid Schmidt-Kloiber[3], Christoph D. Matthaei[4], Philippe Usseglio-Polatera[5], Wolfram Graf[3], N. LeRoy Poff[6], Leon Metzeling[7], Laura Twardochleb[8], Charles P. Hawkins[9], and Ralf B. Schäfer[1]

[1]Institute for Environmental Sciences, University of Koblenz-Landau, Landau, Germany

[2]Centre for Applied Water Science, Institute for Applied Ecology, University of Canberra, Canberra, Australia

[3]Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences Vienna (BOKU), Vienna, Austria

[4]Department of Zoology, University of Otago, Dunedin, New Zealand

[5]University of Lorraine, CNRS, LIEC, Metz, France

[6]Department of Biology, Colorado State University, Fort Collins, USA

[7]Environment Protection Authority Victoria, Applied Sciences Division, Macleod, Australia

[8]Department of Fisheries and Wildlife, Michigan State University, East Lansing, USA
[9]Department of Watershed Sciences, National Aquatic Monitoring Center, and the Ecology Center, Utah State University, Logan, USA

Table S1: Comparison of trait definitions between invertebrate trait databases. Only traits that are differently described across databases are listed. The definition is quoted if it enables differences to be identified, otherwise the differences are described. The hyphen indicates a missing trait. Reproduction was captured in multiple grouping features per database. Hence, differences for reproduction have been described in the paper. Body form traits are not different between databases, except that the Vieira database contains the trait Bluff (blocky) which does not appear in the other databases.

Trait	Freshwater-ecology.info	Tachet	CONUS	Vieira	Australia	New Zealand

Feeding shredder	”Feed from fallen leaves, plant tissues, CPOM”	”Eat coarse detritus, plants or *animal material*”	• ”Shred decomposing vascular plant tissue” • Trait herbivore includes among others insect that shred *living aquatic plants*	Shredder	• Detrivore† • Trait herbivore includes among others the trait shredder	Shredders

Feeding predator	”Eating from prey”	• Carvers, engulfers & swallowers • Piercers (plants & animals) are an additional trait	Engulfers (”ingest prey whole or in parts”) & piercers (”prey tissues and suck fluids”)	Predator	Piercer & engulfer	Predator
Feeding filter-feeder	Distinguishes between active and passive	No distinction between active and passive	No distinction between active and passive	No distinction between active and passive	No distinction between active and passive	No distinction between active and passive
Semivoltine	”One generation in two years”	”Life cycle lasts *at least* two years”	”$<$ 1 generation per year”	”$<$ 1 generation per year”	”$<$ 1 generation per year”	”$<$ 1 reproductive cycle per year”

Multi-voltine	"*Three* or more generations per year"‡	"Able to complete *at least* two successive generations per year"	"> 1 generations per year"	"> 1 generations per year"	• 1-2 generations per year • bi/multivoltine • up to 5 generations per year • up to 10 generations per year	"> 1 reproductive cycles per year"

Locomotion swimming	• Passive movement like floating or drifting (trait swimming/scating) • Active movement (trait swimming/diving) .	• Surface swimmers (over and under the water surface) • Full water swimmers (e.g. Baetidae).	”Adapted for ”fishlike” swimming”	Swimmer	Distinguishes swimmer and skater	Swimmers (water column)

Locomotion burrowing	”Burrowing in *soft* substrates or boring in *hard* substrates”	• Burrowing ”within the first centimeters of the benthic fine sediment” • Differentiates also the trait interstitial (endobenthic)	”Inhabiting *fine* sediment of streams and lakes”	Burrower	”Moving deep into the substrate and thus avoiding flow”	Burrowers (infauna)
Locomotion sprawling & walking	”Sprawling or walking actively with legs, pseudopods or on a mucus”	-	Sprawling: ”inhabiting the surface of floating leaves of vascular hydrophytes or fine sediments”	Sprawler	-	-

Locomotion crawling	-	"Crawling over the bottom substrate"	Defined as crawling on the surface of floating leaves or fine sediments on the bottom	-	Database contains traits crawler, sprawler, climber and clinger.	Crawlers (epibenthic)
Locomotion sessil	Does not distinguish temporarily and permanently attached	Distinguishes temporarily and permanently attached	Does not distinguish temporarily and permanently attached	Does not distinguish temporarily and permanently attached	Distinguishes temporarily and permanently attached	Does not distinguish temporarily and permanently attached

Respiration plastron & spiracle	Plastron and spiracle (aerial) are two separate traits	Definition includes respiration using air stores of aquatic plants	Plastron and spiracle combined into one trait	Distinguishes spiracular gills, plastron, atmospheric breathers and plant breathers	Plastron and spiracle (termed aerial) occur as separate and combined traits. Contains also traits: air (plants), atmospheric, and functional spiracles	Distinguishes plastron and spiracle (termed aerial)
Body size small	-	Multiple size classifications¶	< 9 mm	< 9 mm	< 9 mm †§	Multiple size classifications⋆
Body size medium	-		9 - 16 mm	9 - 16 mm	9 - 16 mm	
Body size large	-		> 16 mm	> 16 mm	> 16 mm	

† Traits from Botwe et al.

‡ Contains also bivoltine (two generations per year), trivoltine (three generations per year) and flexible.

§ Contains a size trait with numeric size values. Contains also traits classifying size like Tachet and like the North American trait databases.

¶ Size classifications: $<= 0.25$ *cm*, $> 0.25 - 0.5$ *cm*, $0.5 - 1$ *cm*, $1 - 2$ *cm*, $2 - 4$ *cm*, $4 - 8$ *cm*, > 8 *cm*. No distinction into small, medium and large.

⋆ Size classifications: $> 0.25 - 0.5$ *cm*, $0.5 - 1$ *cm*, $1 - 2$ *cm*, $2 - 4$ *cm*, $4 - 8$ *cm*. No distinction into small, medium and large.

Comparing aggregation methods

Comparison of family-level aggregated traits with family-level assigned traits

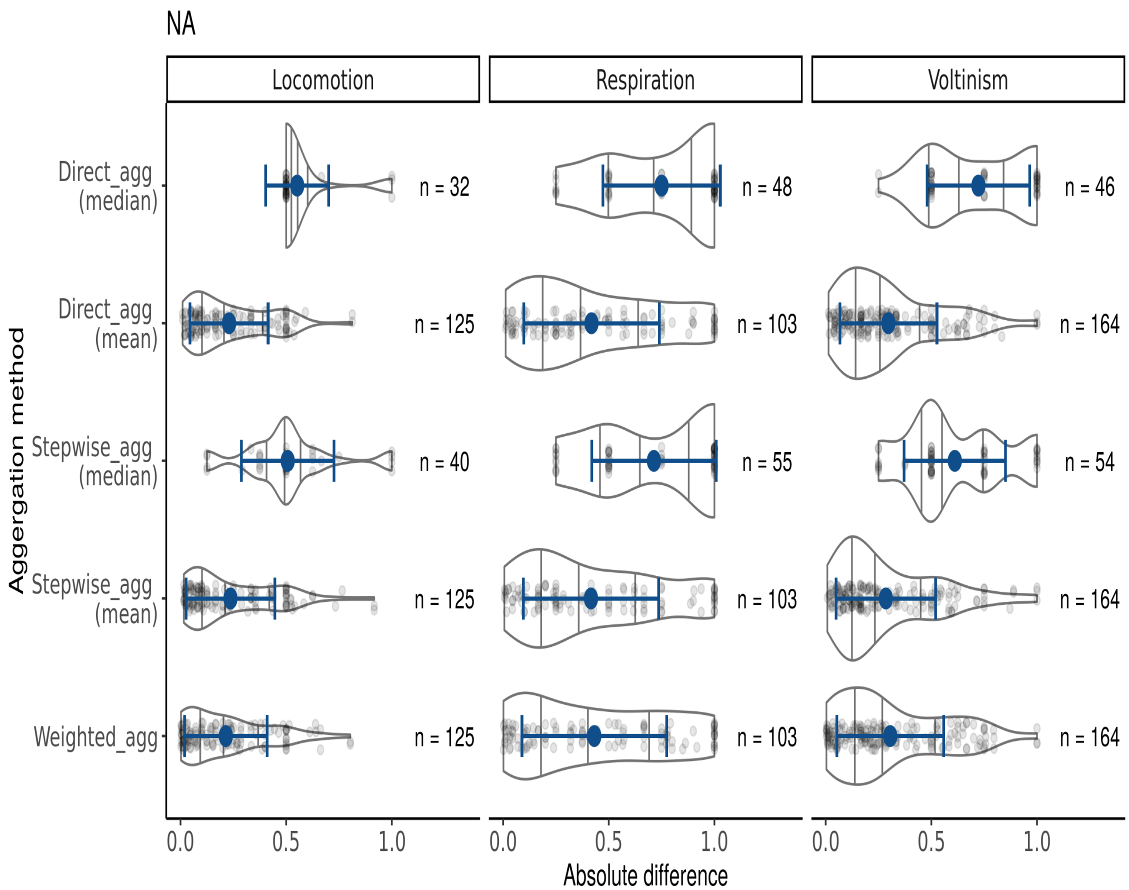

Figure S1: Cases (factor combination of investigated families and traits) where differences occurred between aggregated traits and expert assigned traits at family level for the North American dataset. Violin plots - mirrored density plots - show the density of the absolute trait affinity differences for the grouping features locomotion, respiration, and body size. For more details see Figure 2.

Comparison of aggregation methods with varying taxonomic hierarchies and trait variability

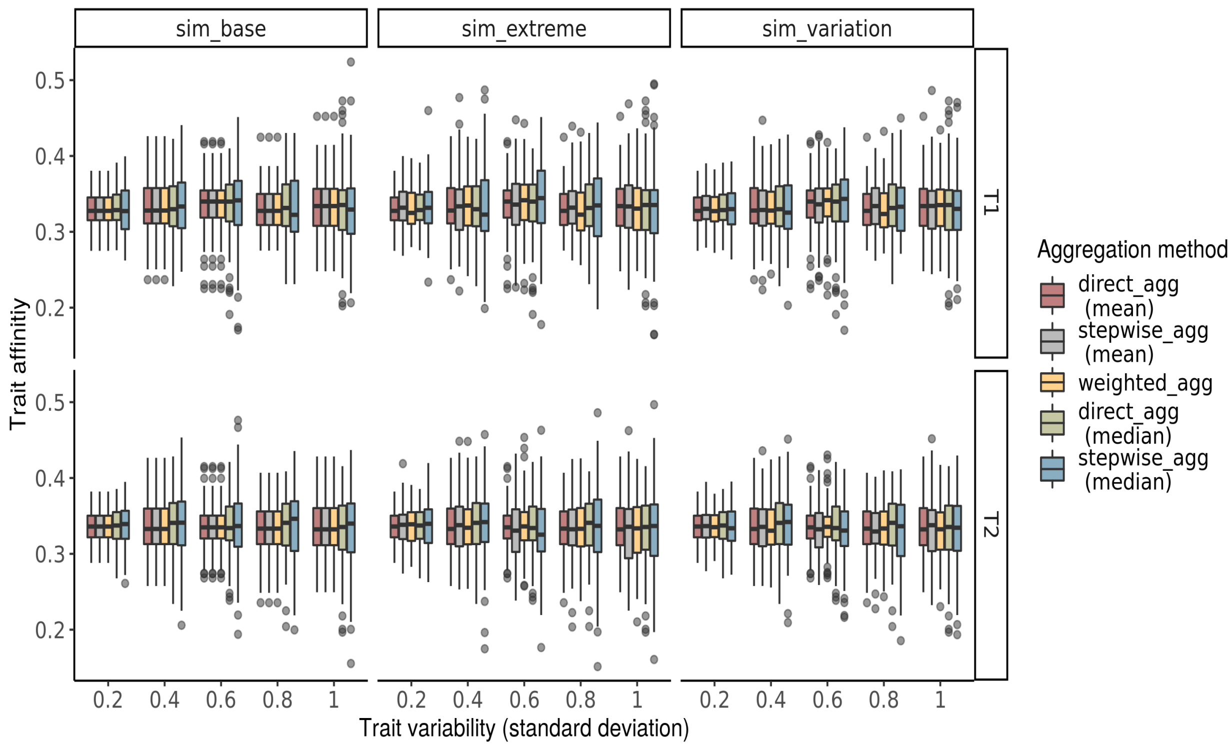

Figure S2: Ranges of aggregated trait affinities for the three examples of taxonomic hierarchies and simulated levels of trait variability. Shown are the results for the simulated traits T2 and T3. Boxplots depict results for 100 replicated simulations of each trait aggregation method. Trait aggregation methods are in order of least to greatest produced ranges to improve visual inspection. For more details see Figure 3.

Taxonomic hierarchy in the trait datasets used for comparisons with assigned traits at family level

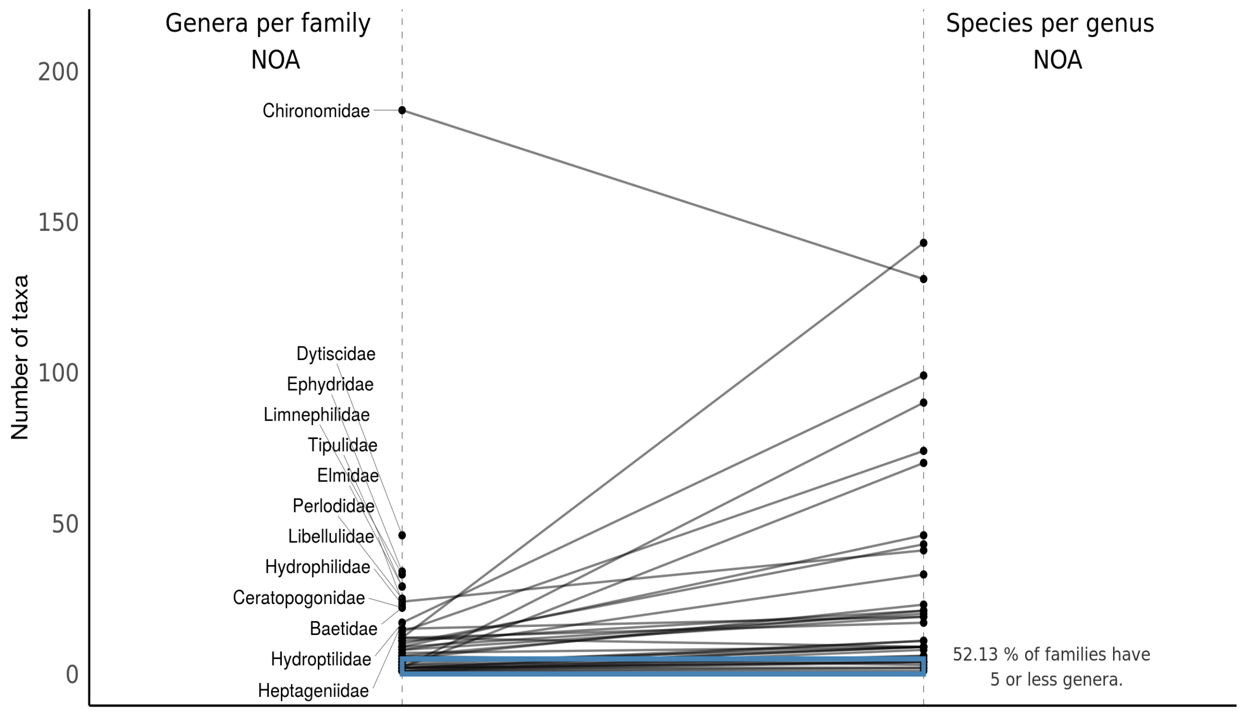

Figure S3: Number of genera per family and species per genus for those families of the North American trait dataset that have been compared with assigned traits at family level. For better visual display only families with more than 15 genera are displayed.

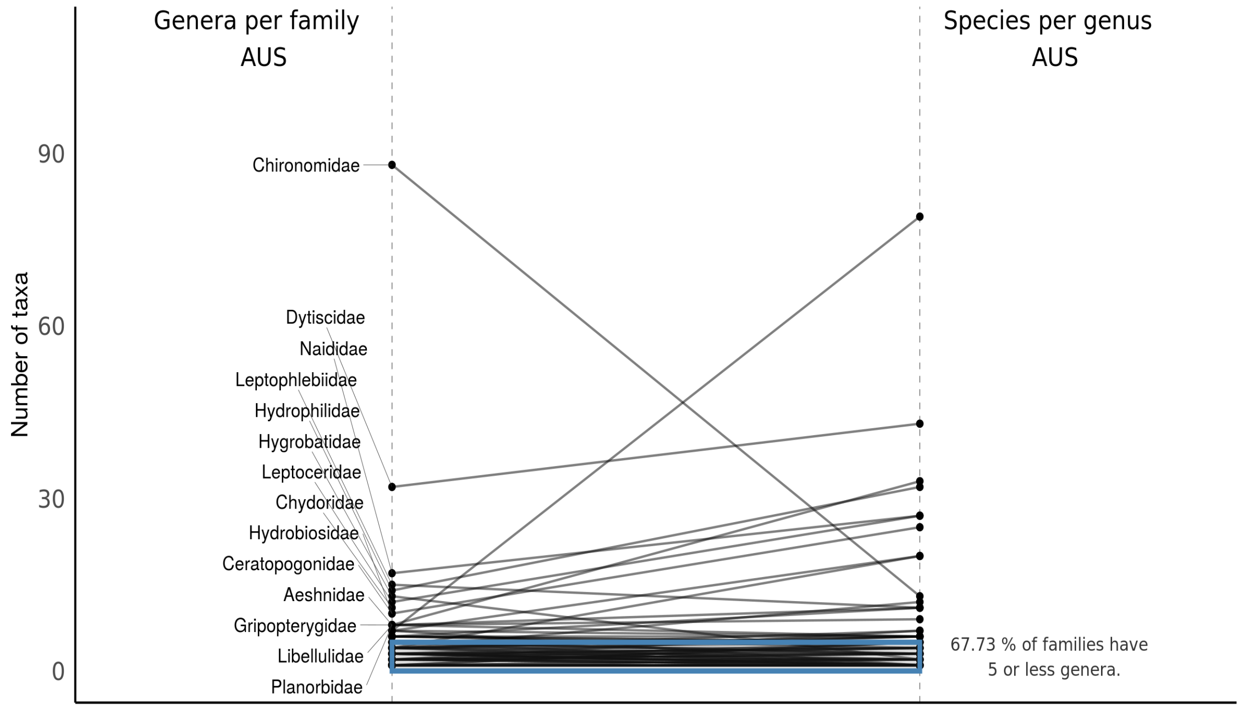

Figure S4: Number of genera per family and species per genus for the Australian trait dataset. For better visual display only families with more than 7 genera are displayed.

Effects of harmonisation and trait aggregation on inferences regarding trait-environment relationships

Table S2: Mean, median and standard deviation of the affinities of traits that were responsive to the salinity gradient in the original study but not in the re-analysis using the harmonised European trait dataset.

Type	Trait	Mean	Median	SD	Responsive?
Stepw_median	Shredder	0.20	0.14	0.25	No
Stepw_mean	Shredder	0.18	0.12	0.22	No
Direct_median	Shredder	0.21	0.14	0.25	No
Direct_mean	Shredder	0.19	0.14	0.22	No
Weighted	Shredder	0.19	0.14	0.22	No
Harmonised; not_aggregated	Shredder	0.18	0.12	0.24	No
Original	Shredder	0.25	0.14	0.32	Yes
Stepw_median	Gills	0.30	0.27	0.32	Yes
Stepw_mean	Gills	0.29	0.22	0.32	Yes
Direct_median	Gills	0.30	0.30	0.32	Yes
Direct_mean	Gills	0.30	0.30	0.32	Yes
Weighted	Gills	0.30	0.30	0.32	Yes
Harmonised; not_aggregated	Gills	0.30	0.25	0.32	No
Original	Gills	0.28	0.00	0.33	Yes
Stepw_median	Short life cycle	0.64	0.75	0.39	No
Stepw_mean	Short life cycle	0.64	0.79	0.39	No
Direct_median	Short life cycle	0.67	0.75	0.37	Yes
Direct_mean	Short life cycle	0.67	0.79	0.38	Yes
Weighted	Short life cycle	0.67	0.79	0.38	Yes
Harmonised; not_aggregated	Short life cycle	0.64	0.75	0.40	Yes
Original	Short life cycle	0.64	0.75	0.40	Yes
Stepw_median	Long life cylce	0.36	0.25	0.39	No
Stepw_mean	Long life cylce	0.36	0.21	0.39	No
Direct_median	Long life cylce	0.33	0.25	0.37	Yes
Direct_mean	Long life cylce	0.33	0.21	0.38	Yes
Weighted	Long life cylce	0.33	0.21	0.38	Yes
Harmonised; not_aggregated	Long life cylce	0.36	0.25	0.40	Yes
Original	Long life cylce	0.36	0.25	0.40	Yes

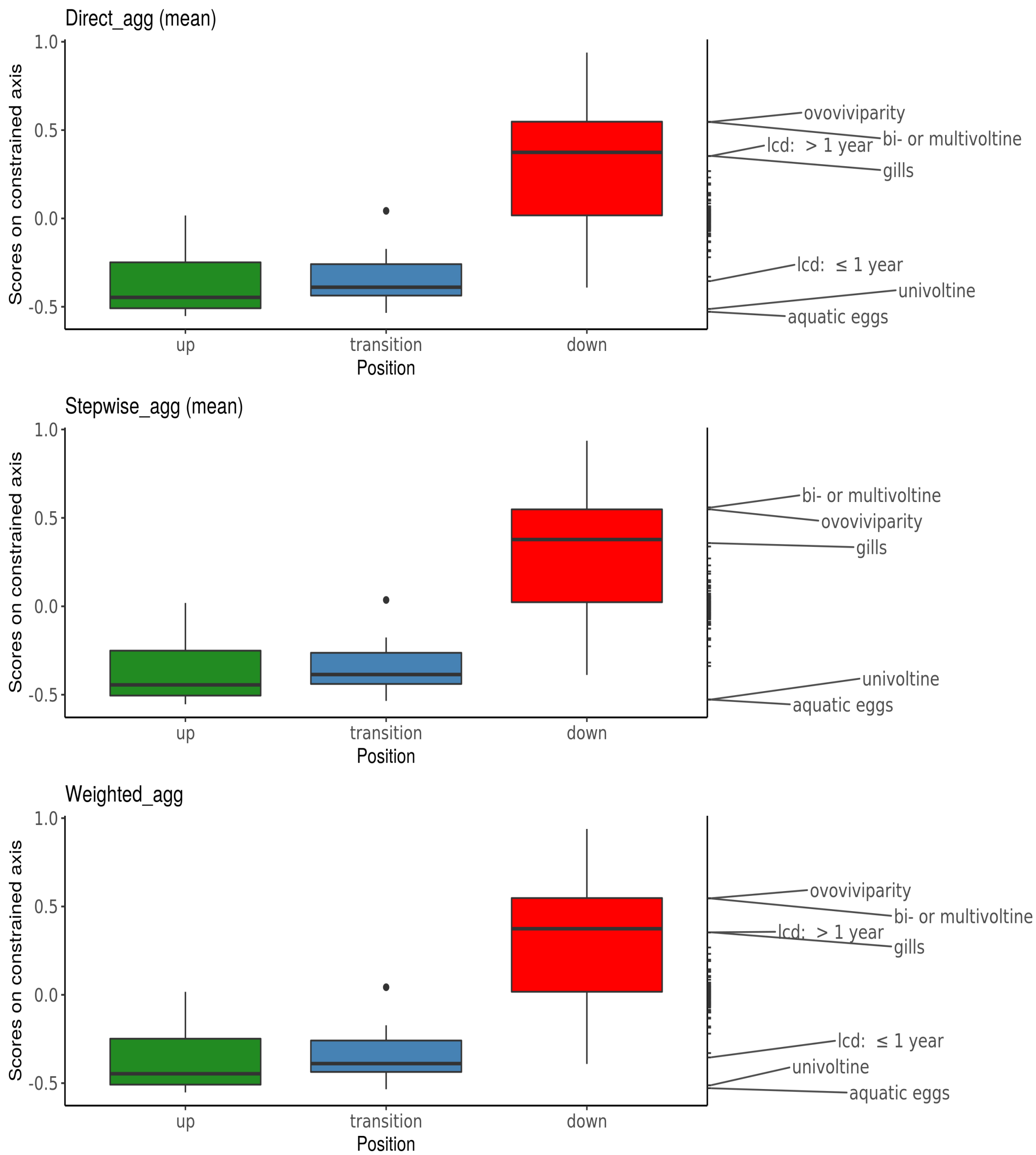

Figure S5: RDA of traits constrained by electric conductivity for the data aggregated with *direct_agg* $_{mean}$, *stepwise_agg* $_{mean}$, and *weighted_agg*. Shown are boxplots of the site scores along the conductivity axis. The rug on the right side of each plot indicates species scores of the traits on the conductivity axis. For more details see Figure 6. Abbreviations: lcd, life cycle duration; nr.cy, potential number of cycles per year.