Flexibility in aquatic food web structure: linking scales and approaches

Supplementary Material

Examples for evidence of how flexible trophic interactions influence ecosystem functions are summarized in Fig. S1 and Table S1. In Fig. S1, arrows connect nodes of mechanisms of flexibility (the lowest level), specific trophic traits driven by the mechanisms (second level), ecosystem properties and processes (third level), and ecosystem functions (top level). Links are supported by studies using different approaches on the small to medium scale (some modelling examples on the large scale) linking flexibility in traits to ecosystem processes/properties. Further links may exist for which no studies were present in the initial literature selection presented here, and those may be added to extend the framework. Feedbacks between traits and downward connections are omitted for the sake of clarity.

For each link, we list example references as numbered labels without attempting a complete review of the abundant literature. Each link indicates the effect(s) of changing at the starting node on the ending node. Only references are included that link flexibility in trophic traits to ecosystem properties and processes. Red (blue) font colour for number codes identify evidence for a positive correlation between nodes, e.g., enhancing the start node leads to increasing in the end node. Black font colour is used if either the evidence of both effects for a pair of nodes is detected or if it is unclear from the analyses presented. References only indirectly implying an effect are indicated by grey shading of the number codes. We distinguish mechanisms and traits of prey and predator, either on the individual or on population level, by green and orange background shading for prey and predator traits, respectively. The shading gradient symbolises that the role of each organism as prey or predator is very variable and may change with every encounter.

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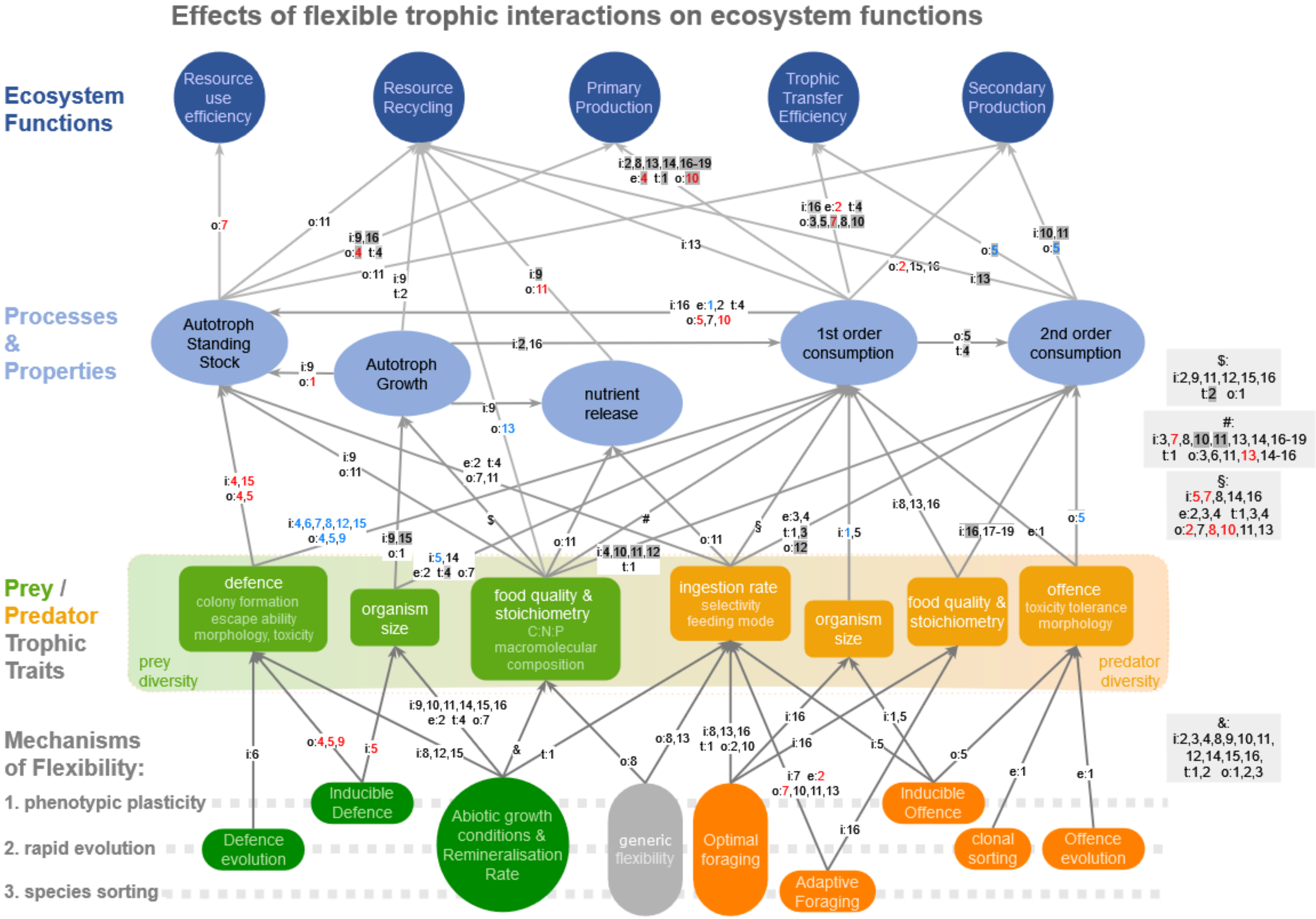
Supplementary Tables and Figures

Table S1: Example literature from different experimental and modelling systems on how mechanisms of trophic flexibility affects ecosystem functions via trophic traits. Literature selection underlying Fig. 2-3 in the main text and Fig. S1 below is indicated by number code used in Fig. S1.

The table is supplied in the file TableS1_FlexibilityInAquaticFoodWebInteractions.pdf



References

microcosms:

i1: Kopp & Tollrian 2003
i2: Hillebrand et al., 2013, Klip et al. 2024
i3: Meunier et al., 2012a
i4: Brandenburg et al., 2018
i5: Kopp & Tollrian 2003b (ELE)
i6: John et al. 2015
i7: Vad et al. 2020
i8: Meunier et al., 2013
i9: Maat et al. 2014
i10: Harrison et al., 1990
i11: Goiris et al., 2015
i12: Brandenburg et al., 2021
i13: Bentley et al., 2021
i14: Herstoff et al., 2020
i15: Martens et al., 2016
i16: McBeain & Halsey, 2018
i17: Boersma et al., 2009
i18: Malzahn et al., 2007
i19: Malzahn et al., 2010

mesocosms:

e1: Chislock et al. 2018
e2: Stibor et al. 2004
e3: Sommer et al. 2003
e4: Worm et al. 2002

time series & field data:

t1: Boersma et al. 2016
t2: Lancelot, 1984
t3: Pohnert et al. 2007
t4: Wollrab et al. 2020

models:

o1: Smith et al., 2016
o2: Pahlow et al., 2020
o3: Kerimoglu et al. 2018; Kwiatkowski et al. 2018
o4: Verschoor et al. 2004
o5: Vos et al. 2004a
o6: Declerck et al., 2015
o7: Wollrab & Diehl 2015
o8: Fleischer et al. 2018
o9: van Velzen et al. 2018
o10: Thongthaisong et al. in prep
o11: Perhar and Arhonditsis 2009
o12: Harvey and Railsback 2013
o13: Raatz et al 2017
o14: Sperfeld et al. 2012
o15: Mitra 2006
o16: Mitra et al. 2007

Figure S1: Detailed vertical upscaling scheme demonstrating how mechanisms of flexibility in trophic interactions (bottom level) affect ecosystem functions (top level) via changes in predator and prey traits (2nd level) that drive ecosystem processes and properties (3rd level). Number codes identify literature examples (see also Table S1), indicating the type of approach (empirical: i[x] - small-scale/microcosms, e[x] - medium-scale/mesocosms, t[x] - time series or field data; o[x] - small- to large-scale modelling). Red and blue number codes indicate positive and negative effects/correlation between nodes, respectively; grey shading indicates links that are not measured, but can only be inferred from the available data.