Interplay between trait variation, food web dynamics and maintenance of biodiversity

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What this subproject is about

Inherent trait variation of individuals, populations and communities allows them to adjust to altering environmental conditions. Using mathematical models, we contribute to a unifying theory that explicitly considers how such trait variation affects the dynamics and stability of food webs, and of predator-prey systems in particular. We postulate that (1) the available trait variation (functional diversity) influences biomass and trait dynamics and (2) this, in turn, influences the maintenance of trait variation in concert with the trade-off(s) among traits. We consider the quantitative and qualitative dynamic properties, which are highly relevant for ecosystem functions and services. We aim at understanding not only ecoevolutionary dynamics but also the effects of trait changes resulting from mechanisms other than evolution – such as species sorting and phenotypic plasticity – that occur simultaneously in natural systems.

Update of achievements during 2015-present (2017)

Klauschies, Vasseur & Gaedke (2016) investigated how the range and the speed of trait adaptation influence species coexistence in diverse, mutually adaptive predator-prey systems. Using an innovative multispecies predator-prey model that allows for intraspecific trait changes of all species based on adaptive phenotypic plasticity or clonal sorting, we show that trait adaptation may jointly promote coexistence by enabling a temporally variable convergence and divergence of species traits. Hence, species became temporally more similar (decreasing fitness differences) or dissimilar (increasing niche differences) giving rise to a balance between stabilizing and equalizing mechanisms over time. Furthermore, coadaptation allowed the prey and predator species to cluster into different functional groups. This equalized the fitness of similar species while maintaining sufficient niche differences among functionally different species delaying or preventing competitive exclusion. Compared to previous studies, the emergent feedback between biomass and trait dynamics enabled supersaturated coexistence for a broad parameter space.

Coutinho, Klauschies & Gaedke (2016) compared the biomass and trait dynamics of a novel full trait distribution model to the ones of a corresponding aggregate model considering only the temporal development of the mean and variance of the assumed normal trait distribution. We altered the shape of the trade-offs between prey edibility and growth rate, and predator selectivity and attack rate to compare the outcome of the two models under different selection regimes, leading to trait distributions increasingly deviating from normality. The predictions of the aggregate models are reliable under ideal conditions such as stabilizing or weak directional selection but have to be questioned when confronted with more complex selection regimes and trait distributions, which are commonly observed in nature.

In **Raatz, Gaedke & Wacker (2017)**, we went beyond the usual consideration of trophic interactions based solely on energetic constraints. We investigated for the first time the interplay between food quality and trait adaptation, here defence of the prey. The results reveal that low food quality of prey can, similar to defence, provide protection against extinction by predation. Counterintuitively, we also found that high food quality is not necessarily detrimental for a prey species but instead can protect it against extinction and promote species richness and functional biodiversity

Ruiter & Gaedke (2017) investigated facilitation based on a species-sorting model and Lake Constance data (Tirok & Gaedke 2010). Inspired by an experiment with algae and ciliates (Filip, Gaedke, Moorthi *et al.* 2014), the study reveals that the positive effects from indirect facilitation can be sufficiently strong to dominate over direct negative effects, thus preventing competitive exclusion. The mechanism behind this facilitation arises from resource partitioning among predators, implying that grazing by less selective ciliates protected the more edible and preferred algae for the selective ciliates by competitive release.

The results stimulate a reconsideration of concepts in fundamental ecology that form the basis for nature conservation. In addition, they will help unravelling mechanisms maintaining biodiversity that can then be implemented in applied forecasting models of biodiversity change.

There is more ongoing work which has not been published yet, but will be soon during 2017. Please contact the researchers of U. Gaedke's lab if you are interested in knowing more about our ongoing projects.

Our latest key publications:

Klauschies T, Vasseur DA, and Gaedke U (2016). Trait adaptation promotes species coexistence in diverse predator and prey communities. Ecology and Evolution 6: 4141–4159.

Coutinho R, Klauschies T, and Gaedke U (2016). Bimodal trait distributions with large variances question the reliability of trait-based aggregate models. Theoretical Ecology, 9: 389-408.

Raatz M, Gaedke U and Wacker A (2017). High food quality of prey lowers its risk of extinction. Oikos. (doi: 10.1111/oik.03863).

Ruiter, PC de and Gaedke U (2017). Emergent facilitation promotes biological diversity in pelagic food webs. *Food Webs,* 10:15-21.

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