Comparing phenotypic plasticity in bacterial prey traits and ecological consequences by using specialist vs. generalist strains and organic aggregates as model systems

Currently, the role of adaptive dynamics in microbial communities is under growing interest as a potential food web buffer of environmental and ecological perturbations in various ecosystems. In aquatic systems, pelagic bacteria can be classified into free living and particle attached life modes, which either dwell in the water column or attach to suspended particles. In addition, bacteria with a “generalist life style” can actively shift between these two life styles. Globally increasing densities of natural and artificial particles such as inorganic sediment and microplastics particles, respectively, enhance habitat heterogeneity, with potential consequences for system stability and trophic transfer through aquatic food webs.

In this project we aimed to investigate the consequences of different bacterial lifestyles, namely adaptive vs. fixed habitat choice on species coexistence and dynamics. For this, we theoretically and experimentally investigated a simplified bacterial community consisting of two specialist bacterial prey species (free and attached), a generalist bacterial prey species with the ability to shift between both habitats, and two protist predators, specialized on either the water or particle compartment.

For the basic model, we assumed a shared resource pool for particle attached and free-living bacteria, considering particles only as a habitat for colonization but not as a source for nutrients or carbon, reflecting inert particles like inorganic sediments or microplastics. The model results reveal that coexistence between specialist and generalist bacteria strongly depends on the interplay of costs associated with active habitat choice and speed of adaptation, but is also determined by resource availability. Moreover, the presence of the generalist species stabilizes system dynamics by pushing population minima away from zero. Furthermore, the presence of generalist bacteria leads to higher average protist biomass compared to the situation with only non-adaptive prey species, thereby affecting energy transfer via the microbial loop. Investigation of a model extension which takes the surface available for colonization in the particle attached compartment into account and includes the possibility of particles as a source of carbon and/or nutrients, reveals that community dynamics and especially coexistence of the generalist bacteria critically depends on particle concentration, but also on particle type. Overall community dynamics are characterized by strong oscillatory behavior. Under high particle concentrations, cycle dynamics are speeded up for the case of highly bioavailable particles in comparison to less bioavailable particles. The results furthermore indicate

that the effect of increasing loads of inorganic particles will be context dependent, i.e. if the bacterial community is adapted to highly or less bioavailable particles. This has important implications for the influence of increasing loads of microplastics on microbial community stability and energy flow in aquatic systems.
Experimental investigations of particle attached bacteria revealed an escaping behavior of the model bacterium *Marinobacter adhaerens* in the presence of the amoeba *Vanella anglica* preying on the particle surface, which led to increasing bacterial biomass in the water habitat, but decreasing bacterial biomass on the particle surface. On the other hand, *Cafeteria roenbergensis* feeding on free-living bacteria did not significantly affect the dynamics of *M. adhaerens* in the water habitat. These results might stem from an additional defense mechanism via clumping observed in the presence of *C. roenbergensis* which therefore went almost extinct after an initial increase in the first days.

Both the theoretical and experimental results highlight the importance of flexible habitat choice for system stability and energy flow through pelagic microbial systems with direct consequences for higher trophic levels. Also, it highlights that particle concentration and dominating particle type (inorganic vs. organic, bioavailable vs. less bioavailable) strongly influence predictions on community composition, system stability and energy flow. Particle concentration and composition might therefore have important consequences for biogeochemical organic matter and nutrient cycling.