The effect of food quantity and food quality on Daphnia: morphology of feeding structures and life history.

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Summary

Water fleas (Cladocera) feed on seston that is dominated by algae and dead organic matter with bacteria (detritus). In eutrophic lakes also cyanobacteria are important. Cladoceran grazers are faced with constantly varying conditions in lakes since their main food, seston, is highly variable both temporally and spatially. In order to cope with variable feeding conditions grazers have to be flexible. This study concentrated on the phenotypic plasticity of life history traits and filtering structures of taxa belonging to the cladoceran genus *Daphnia*.

As food environments for grazers, highly eutrophic lakes in the Netherlands differ from less eutrophic lakes. In highly eutrophic lakes seston biomass is usually high during the whole growing season and seston composition shows limited variation. The seston of highly eutrophic lakes is often dominated by cyanobacteria and detritus originating from cyanobacteria. Comparisons of *D. cucullata* and *D. galeata* clones originating from mesotrophic and highly eutrophic lakes revealed that life-history parameters of clones originating from the same lake resembled each other while clones from different lakes diverged. However, these life history responses could not be explained by different feeding conditions in the lakes of origin. Therefore, it was concluded that the *Daphnia* life histories had primarily adapted to environmental factors other than food conditions. For all clones a diet consisting of filamentous cyanobacterium supported clearly lower growth and reproduction than a diet of green alga. Biochemical parameters that are important in *Daphnia* nutrition of the green alga and the cyanobacterium were comparable. Therefore, it was concluded that the filamentous cyanobacterium *Oscillatoria limnetica* is of low food quality mainly because of its shape that interferes with the feeding process. Detritus derived from filamentous cyanobacterium was, however, of higher food quality to the *Daphnia* than live filaments. Abundance of detritus may make highly eutrophic lakes better food environments than previously thought.

*Daphnids* filter the water with their filter screens. In the filter chamber of *Daphnia*, water is pressed through the filter screens at the third and fourth appendages. The particles caught by the filter screens are transported to the gut. *Daphnia* filter-feeds on particles within a suitable size range (0.5-40 μm) rather non-selectively. *Daphnia* can adjust the area of the filter screens during molting (i.e. approximately every third day at 18°C). At low food concentrations (< 0.1 mg C l⁻¹), the filtering areas are larger. By feeding the *Daphnia* with food types of varying quality, it was revealed that the *Daphnia* used its own nutritional condition as a cue for adapting the filtering area. Animals in good condition (i.e. high growth rate) exhibited smaller filtering areas in relation to their body length than animals limited either by food quantity or quality. Larger screens increase clearance rate and food intake. At high food availability (> 1.0 mg C l⁻¹), larger screens are not needed because food is not limiting. On the contrary, at high food concentrations a larger filtering area can have a negative influence on the energy budget of the animal. Collecting more food than can be ingested per time unit leads to an increased food rejection rate and will consequently cause an increase in respiration rate and reduce growth. *D. galeata* clones collected from contrasting lakes (mesotrophic versus highly eutrophic) did not differ in either mean filtering areas or in the degree of plasticity. All the clones exhibited plasticity in filtering area. Thus it was concluded that, either maintaining phenotypic plasticity is advantageous in both mesotrophic and highly eutrophic lakes, or the evolution is constrained. Studies quantifying the cost of having a 'wrong-sized' filter screen at different food quantities and qualities are needed to clarify this point.

*D. galeata*, *D. cucullata* and their interspecific hybrid, *D. cucullata × galeata*, are commonly found in European lakes in variable proportions. The taxa-specific differences in responses to variable food quantities and food qualities were supposed to reveal a mechanism explaining their successful coexistence. The tested *Daphnia* taxa differed in body length, *D. cucullata* being the smallest species, *D. galeata* being the largest species and the hybrids having an intermediate length. The
variability of clearance rate with body length of all taxa fitted into one uniform relationship. The taxa, however, differed in mesh size of the filter screens. The hybrids exhibited the largest absolute mesh size of the taxa. Since mesh size determines the smallest particle that can be ingested, the observed difference contributes to the successful coexistence of the taxa. Parental species can be assumed to collect smaller food particles (bacteria) more efficiently than the hybrids. Effective feeding on bacteria by the parental species may be important when algal food is limiting. At high concentration of algal food, the hybrids, however, had the highest somatic growth rate of the taxa. On the other hand, the growth and reproduction of the small bodied D. cucullata were the least inhibited when filaments were abundant in the diet. The gradual differences in feeding characteristics, the filament handling capacity, the utilization of bacteria and the food saturated growth rate of the two Daphnia species and their hybrids may contribute to the observed seasonal succession in the zooplankton.