Consumer-driven nutrient recycling promotes algal diversity by creating temporal and spatial heterogeneities.

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Theoretical studies of ecology and biodiversity have shown that temporal or spatial heterogeneity of competitive environments promotes the coexistence of competing species by changing the superiority among competitors. Contrary to this prediction, in aquatic ecosystems such as lakes, a large number of phytoplankton species can be found although their environments are physically less structured. This discrepancy has been called as the 'paradox of the plankton'.

The recent theory of ecological stoichiometry suggested that the N:P ratio of nutrient release by the herbivorous consumers (consumer-driven nutrient recycling, CNR) depends highly on deviation in the ratios between food and their body. In aquatic environments, the nutrient supply through CNR is one of the major nutrient sources for algae, and distribution of planktonic herbivores changes ephemerally but not necessarily uniformly. Thus, planktonic herbivores can create spatial and temporal heterogeneities in supply rates and ratios of nutrients. Since different algal species use nutrients at different rates and ratios, such heterogeneities may promote their coexistence.

In this study, a three-trophic-level model composed of planktonic herbivores, algal preys and nutrients was constructed to examine the effects of CNR on the algal species richness with and without spatial structure. The model assumed that either of two essential nutrients (N and P) limited growth of algal populations and that consumer individuals moved randomly in the lattice and grazed all the algal species with the same efficiency. The results showed that when there was no CNR, the number of persistent algal species was affected by neither supply rates of external nutrients nor spatial structure and was consistently low. The algal species richness changed with supply rates of external nutrients when there was CNR: it was high at low nutrient loadings but decreased with increasing nutrient loadings when there were no spatial structure, whereas it increased decreased with increasing nutrient loadings when there were spatial structures. The present study suggests that through grazing and nutrient recycling, consumer individuals can create ephemeral heterogeneity in growth environments for algal species and that this ephemerality is one of the keys to understanding algal species in nature.