Predation by crucian carp larva/fry visualizes biological interactions of paddy field community

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Introduction

Carassius auratus grandoculis (nigorobuna in Japanese) is a crucian carp endemic to Lake Biwa, and it is used as an ingredient in Funa-zushi (lacto-fermented fish) that has been the specialty food of Shiga prefecture, Japan.

In recent years, however, its catch has declined drastically. The increase in carnivorous fishes introduced from North America (*Micropterus salmoides* and *Lepomis macrochirus*), reed community decline, and artificial water level regulation are possible causes of the marked decline.

Because it can also reproduce in paddy fields, breeding their larvae/fry in the paddies have been carried out with the aim of reviving the stock. Two ways of breeding are now conducted. One is stocking larvae in paddies, and another is constructing fish pass from drainage to paddies for the run of their adults.

We conducted some experiments to confirm the function of paddies as a nursery of the carp, and those to examine the impact of the larvae/fry stocking on the paddy field ecosystem (Kanao et al. 2009, Yamazaki et al. 2010, Nishimura et al. 2011). These results also visualized some biological interactions of paddy field community.

Rapid growth of fish larva

We released larvae of nigorobuna in paddy fields near Lake Biwa, and thereafter periodically collected them for growth analyses (Kanao et al. 2009).

The larvae rapidly grew: the daily growth rate at five days of age was estimated as 36~58% of body weight per day. Their growth rate was higher than that of ones reared in fishery ponds and raised naturally in reed zones of Lake Biwa. Meanwhile, daily growth increments shifted from an increase to a decrease at 11-24 days of age in total length, and at

About 30 days old juveniles of *Carassius auratus grandoculis* grown in a paddy field. More than five times in length, and 500 times in weight of the newly hatched larva.

15-44 days of age in body weight. This retardation of growth suggests deficient of preferable foods (see below). Ejecting juveniles to the drainage connecting to Lake Biwa in time with mid-season drainage (usually about 40 days after transplanting of rice plant) is, therefore, appropriate for their stock enhancement.

Their survival late by the mid-season drainage was extremely high. It was estimated as 22-91%, although it tended to decrease with higher population density. This result indicated the absence of powerful predators of fish larvae/fry in the paddies.

Impact of fish on their prey

We also examined the effects of predation by the larvae and juveniles on their prey by the comparison of compartments of a paddy field with/without fish stocking (Yamazaki et al. 2010).

Ten-day-old larvae mainly preyed on cladoceran (water fleas) but the juvenile thereafter shifted to chironomid larvae (bloodworms) as their main prey. Ostracods (seed shrimps) cannot be eaten by

Moina macrocopa, the most representative cladoceran in paddy fields with ~1.2 mm in body length. Ideal food of cyprinid larvae. (© Lake Biwa Museum)

the larvae because they have hard calcareous valves, but the juveniles come to eat and digest them along with the development of pharyngeal tooth. Cyclopoid copepods were also sometimes eaten, but these were usually less selected by the fish.

In the fish-stocked compartments, most cladoceran species, preferred by the larvae as a food, extinguished when the fish was in the early stage of juvenile. Ostracods (seed shrimps) subsequently decreased, reflecting the increase of the predating pressure by juveniles. In contrast, copepods were not largely affected in accordance with the low selectivity by fish. Chilonomid larvae were also not largely affected irrespective of the high selectivity by juvenile, probably owing to continuous oviposition by their imago from the outside.

Trophic cascade via cladocerans

Fish stocking also affected many microorganisms those were not eaten by the fish directly (Yamazaki et al. 2010, Nishimura et al. 2011). Among ciliates, small sized *Coleps* and *Halteria* increased after the extinction of many cladoceran species. Phytoplanktons with the sizes of <1/16 mm also became more abundant in fish-stocked compartments. Much the same was true on heterotrophic nanoflagellates and filamentous bacteria.

These results provided an experimental proof of top-down trophic cascade in a paddy field. The sizes of increased microorganisms mostly corresponded to the filterable size of cladocerans in the paddies. We therefore concluded that fish predation decreased cladocerans markedly and release these microorganisms from grazing/predating pressure.

References

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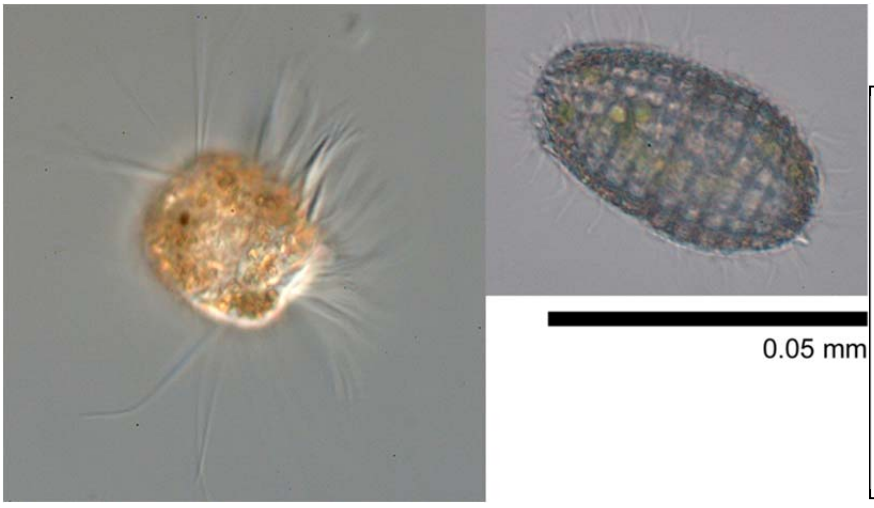

Right: *Halteria* sp., Left: *Coleps* sp. These ciliates became more abundant in paddies with fish larva release probably because of a trophic cascade. (© Lake Biwa Museum)