Survival Strategies of the Rotifer *Brachionus rotundiformis* for Coexisting with the Copepod *Apocylops borneoensis* in Laboratory Culture

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Abstract

Interspecific relationship between a euryhaline rotifer *Brachionus rotundiformis* and a cyclopoid copepod *Apocylops borneoensis* was investigated in the laboratory culture. In a mixed culture of *B. rotundiformis* and *A. borneoensis*, population growth of *B. rotundiformis* was suppressed from day 10, while growth in a monoculture population continuously increased throughout the experimental period. However, the population growth of *A. borneoensis* in the mixed culture did not markedly differ from that in a monoculture population. Suppression of *B. rotundiformis* growth coincided with a decrease in the numbers of both non-egg-bearing and egg-bearing females, and increasing resting egg formation. Growth of *A. borneoensis* was not affected by the presence of the rotifer. However, relative growth index of ovisac bearing females in the mixed culture was 1.62 times higher than that in the monoculture. Presence of the copepod did not greatly reduce the food available to the rotifer population. The rotifer *B. rotundiformis* responded in a unique way, to stresses such as physical damage (filtering by *A. borneoensis*) with the production of many resting eggs to increase its chances of survival.

Key words: *Apocylops borneoensis*, *Brachionus rotundiformis*, Cyst, Interspecific relation, Resting egg, Rotifer

Introduction

Rotifers are some of the most important zooplankton, and are the focus of much attention from aquaculture scientists. Rotifers have been used as a primary live food for the seedling production of many economically important marine animals, because rotifers can be easily cultured at high densities. Stable mass culture of rotifers is needed for successful fish larval rearing. A variety of mass culture methods should be developed to facilitate successful aquatic animal culture through stable live food organism production. However, the instability or sudden crashes of rotifer mass cultures remain problematic. The causes of such culture failures are not fully understood, although it is predicted that one major cause is contamination by other organisms such as protozoa (Takayama, 1979; Reguera, 1984; Chen et al., 1997), copepods (Fukusho et al., 1976) and bacteria (Yu et al., 1990).

Coexisting populations of different taxonomic groups depend on the organisms that occur together in space and time, and interact with each other through the processes of mutualism, parasitism, predation and competition (Begon et al., 1990). The relationships between *Brachionus rotundiformis* and other zooplankton species have been well examined (Gilbert and Stemberger, 1985; Gilbert, 1988; Hagiwara et al., 1995a; Jung et al., 1997), and competitive interference has been reported between rotifers and cladocera in fresh water. Under marine culture conditions, there is considerable evidence for interspecific relationships between a rotifer, *B. rotundiformis*, and two species of copepods, *Tigriopus japonicus* and *Acartia* sp. (Jung et al., 1997).
Copepods and rotifers coexist in estuaries as well as in brackish water fish culture ponds in North Sulawesi, Indonesia. Of several copepod species collected, the only one that could be adapted to laboratory culture was *Apocylops borneoensis*. It is unknown which species (*B. rotundiformis* or *A. borneoensis*) dominates earlier, or which is more susceptible to the rigorous conditions of the ponds. Therefore, it is of interest to examine the nature of the relationship between these two species. Such information is useful both for assessing their ecological significance in a brackish water ecosystem, as well as for establishing techniques for mono- and mixed-species cultures for aquaculture purposes as live food organisms.

Here, I observed, the survival strategies involved in the interspecific relationship between *B. rotundiformis* and *A. borneoensis* under laboratory experimental conditions. I focused on the interspecific interactions of the rotifer and the copepod from a microcosm viewpoint of aquaculture ecology.

**Materials and Methods**

Copepods and rotifers were collected from a milkfish pond in Bitung, 30 km east of Manado, North Sulawesi, Indonesia. The pond is separated from the adjacent sea by mangroves, but is connected through an inlet during high tide. Throughout the year, salinity of the pond varies from 12 to 25 psu and temperature ranges from 29°C to 35°C.

The specimens were kept in darkness during a three-day acclimation culture to laboratory conditions before isolation. Various copepods were included in the sample, but only a cyclopoid copepod survived. The species was identified as *Apocylops borneoensis* by Dr. H-S. Kim (Research Institute for Basic Science, Cheju National University of Korea). The rotifers were morphologically analyzed by Fu et al. (1991), and evidently belonged to an ultra minute strain of *Brachionus rotundiformis* (Hagiwara et al., 1995a). We refer this rotifer *B. rotundiformis* as a Bitung strain.

Experimental design and conditions used were the same as those described by Hagiwara et al. (1995b). Salinity, temperature, and culture volume were 22 psu, 25°C and 40 mL, respectively. The organisms were cultured in total darkness. The initial number of animals in mixed cultures was 20 females of the Bitung rotifer strain of *B. rotundiformis* and 3 ovisac-bearing females of *A. borneoensis*. In the monocultures, the numbers of rotifers and copepods were the same as in mixed cultures, but were cultured separately. Mono- and mixed-species cultures were conducted with three replicates for 16 days. Stereo-microscopic observation was carried out on fresh culture medium including *Tetraselmis suecica* (7 × 10⁵ cells/mL) every two days. Total number of test animals was counted and remaining algal food density was also counted by a haemacytometer (Kayagaki Irika Kogyo Co. Ltd., Tokyo, Japan). The algal food *T. suecica*, was grown in modified Erd-Schreiber medium (Hagiwara et al., 1994) and centrifuged. Density of food added was 7 × 10⁵ cells/mL, and was readjusted every two days after observation.

For the observation and calculation of the rotifer mixis rate (%), all individual non-egg bearing females, amictic females, unfertilized and fertilized mictic females, males and resting eggs were counted, and the mixis rate was calculated (Hagiwara et al., 1988). The numbers of all individual nauplii, copepodites and egg-bearing females of the copepod *A. borneoensis* were recorded. Relative population growths between monocultures of each species and mixed culture conditions were compared by student’s t-test.

**Results**

Predator-prey interactions were not observed during this experiment between the experimental rotifer *B. rotundiformis* and copepod *A. borneoensis* (Fig. 1A and 1B). However,