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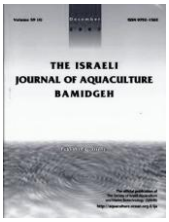

Population Growth of *Bosmina longirostris* Fed *Chlorella vulgaris* and *Scenedesmus subspicatus* in Different Densities

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Abstract

In this study, the effects of the different densities of *Chlorella vulgaris* (0.05 x 10^6, 0.1 x 10^6, 0.2 x 10^6, 0.4 x 10^6, or 0.8 x 10^6 cells/ml) and *Scenedesmus subspicatus* (0.05 x 10^6, 0.1 x 10^6, 0.2 x 10^6, or 0.4 x 10^6 cells/ml) on culture of the water flea, *Bosmina longirostris*, were investigated. The experiment was carried out in a photoperiod of 16 h light:8 h dark at 25±1°C. At the beginning of the experiment, one *B. longirostris* individual (<24 h old) was put into each vessel, and the number of individuals and rate of population increase were determined for 30 days. Increasing the food density increased the number of individuals and the rate of population. The maximum number of *B. longirostris* individuals (7.1±2.08 ind/ml) and maximum rate of population increase (0.2±0.004/day) was in the group fed 0.2 x 10^6 cells/ml *S. subspicatus*. The effect on the number of the individuals was statistically significant (p<0.05).

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Introduction

Among freshwater zooplanktons, protozoans, rotifers, cladocerans, and copepods are numerically more abundant than other groups. In terms of biomass, rotifers and crustaceans (cladocerans and copepods) are often the dominant group (Mangas-Ramirez et al., 2002; Nandini and Sarma, 2002). Because of their high sensitivity to changes in the physico-chemical characteristics of natural water systems, there are sometimes only a few cladoceran species present as dominant groups. For example, *Bosmina*, *Cercopagis*, and *Daphnia* are usually wide-spread in temperate water, while *Ceriodaphnia*, *Moina*, and *Simocephalus* attain higher densities in tropical waters (Mangas-Ramirez et al., 2002).

The most important environmental factors controlling the growth and reproduction of cladocerans are temperature (Benider et al., 2002; Vijverberg and Koelewijn, 2004) and food quantity and quality (Bocanegra et al., 2002; Abrantes and Gonçalves, 2003). Food density is one of the most important and commonly affecting factors for cladocerans both in the field and under laboratory conditions (Nandini and Sarma, 2000).

The effects of food on the dynamics of cladoceran species is a well-researched subject. Most studies focus on *Daphnia* species but some focus on the dynamics of smaller cladocerans such as *Ceriodaphnia*, *Moina*, and *Simocephalus* (Nandini and Sarma, 2000; Mangas-Ramirez et al., 2002; Ovie and Egborge, 2002; Abrantes and Gonçalves, 2003). The aim of the present work was to determine the effect of different densities of two species of algae (*Chlorella vulgaris* and *Scenedesmus subspicatus*) on the population growth of the water flea, *Bosmina longirostris*.

Materials and Methods

Bosmina longirostris were originally isolated from Lake Eğirdir (Turkey). Experimental animals brought from the field were maintained in controlled laboratory conditions for more than six months. Certified strains of *Chlorella vulgaris* (SAG 211-11n) and *Scenedesmus subspicatus* (SAG 54.80) were obtained from Sammlung von Algenkulturen der Universitat Göttingen (SAG, Germany). The algae were mass cultured in transparent 6-l bottles and sub-cultured in 250-ml Erlenmeyer flasks, using autoclaved Bold-Basal medium (Borowitzka and Borowitzka, 1988). Algae harvested during the log-phase were centrifuged and resuspended in autoclaved well water. The density of the stock algal concentrates of each species was estimated using a Neubauer counting chamber.

To assess the effects of food type and densities on *B. longirostris* reproduction, we established 27 treatments based on densities of 0.05×10^6, 0.1×10^6, 0.2×10^6, 0.4×10^6, and 0.8×10^6 cells/ml for *C. vulgaris* and 0.05×10^6, 0.1×10^6, 0.2×10^6, and 0.4×10^6 cells/ml for *S. subspicatus*. Each treatment had three replicates. The experiments were conducted in 30-ml transparent tubes, each with 10 ml of medium containing the specified type and density of algae. Experiments were carried out in 25±1°C, pH 7.0-7.5, and a photoperiod of 16 h light:8 h dark. The inoculation density of *B.*

longirostris was 0.1 individuals/ml. In all cases, experiments started with female neonates less than 24 h old, randomly distributed in the experimental vessels. Following initiation of the experiments, we daily counted the number of living individual animals in each experimental tube and transferred them to test tubes containing fresh medium with the appropriate food levels. The experiments were terminated after 30 days, when most replicates showed a declining trend.

Based on collected data, we derived the rate of population increase per day (r) using the following equation: $r = (\ln Nt - \ln N_0)/t$, where N_0= initial population density and Nt = population density after time t (Nandini and Sarma, 2000). We used one-way analysis of variance (ANOVA) to statistically evaluate the differences between food types and densities on the rate of population increase and peak population abundances of the tested zooplankton. Differences were considered significant when $p<0.05$.

Results

Food density had a significant effect on the population growth of *B. longirostris* for both algal species (Figs. 1, 2). In general, *B. longirostris* grew well on both types of algae, but consistently grew better with *Scenedesmus* than *Chlorella*. The highest *B. longirostris* population density (7.1±2.08 ind/ml) was obtained in the group of fed 0.2 x 10^6 cells/ml *S. subspicatus*. The population density rapidly increased as the *S. subspicatus* density doubled to this level, but further increase did not result in a higher population density. The lowest population growth (1.2±0.12) was recorded at the highest food density of *C. vulgaris*.

Population increase was positively related to feed density. In general, the lowest value (0.106±0.002) was obtained at 0.05 × 10^6 cells/ml *C. vulgaris* while the highest (0.2±0.004) was obtained at 0.2 x 10^6 cells/ml *S. subspicatus*. For both algae, the rate of population increase was significantly lower when density was only 0.05 × 10^6 cells/ml than when the density was at its highest.

Discussion

Our results show that both population growth and the rate of population increase of *B. longirostris* were influenced by food type and density. The effect of food density on cladocerans may be quantified using population growth studies and life-table demography aspects. Further, population growth studies provide information on the effect of food level on individuals of various generations simultaneously occurring in a growing culture (Bocanegra et al., 2002; Nandini and Sarma, 2003).

It commonly occurs in laboratory tests that the population density of cladocerans increases as the algal density increases, up to a certain level (Nandini and Sarma, 2003). In the present work, the peak densities of *B. longirostris* fed *C. vulgaris* and *S. subspicatus* were 4.167 and 7.1 ind/ml, respectively. In a study determining population growth of *B. longirostris* and *B. fatalis* in relation to algal food levels, the peak population growth values

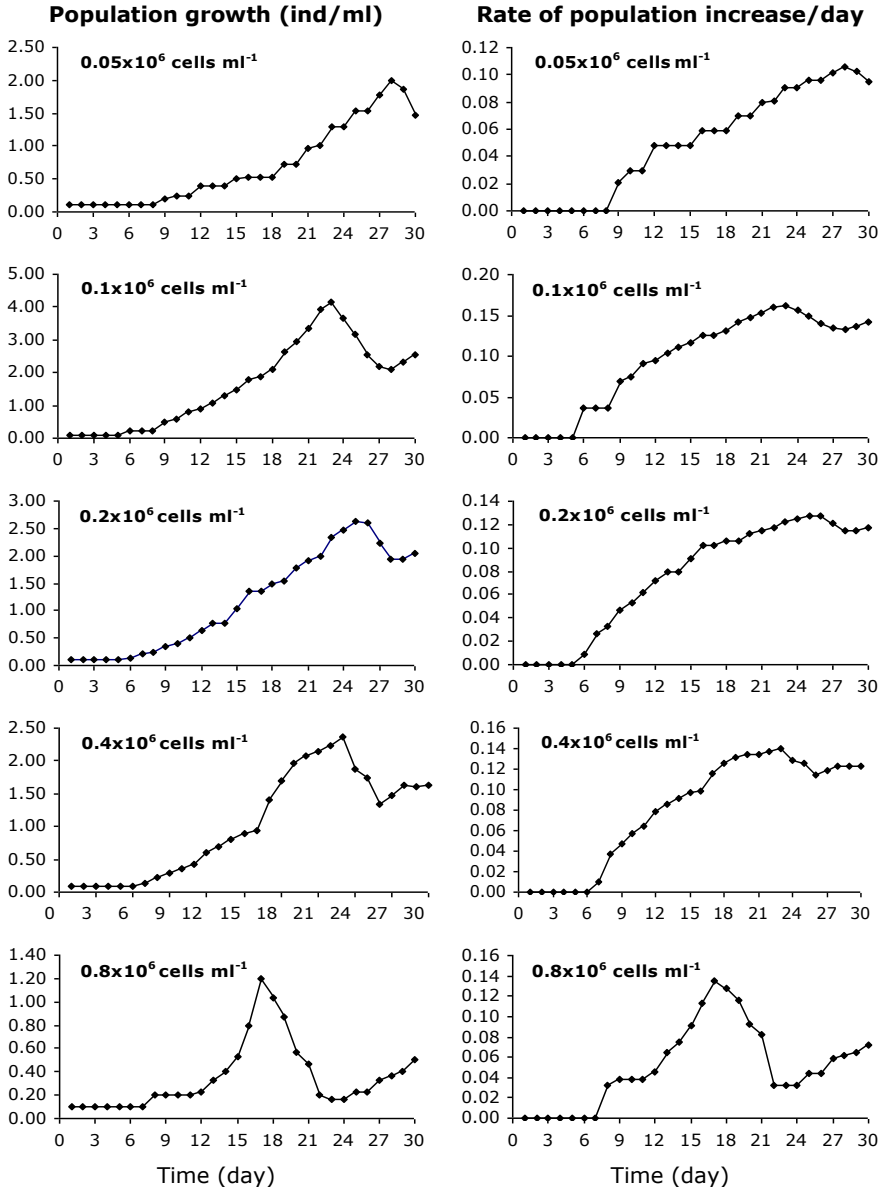

Fig. 1. Population growth and rate of population increase of the water flea, *Bosmina longirostris*, fed different densities of the alga, *Chlorella vulgaris*.

were 455 and 318, respectively, in 100-ml test tubes containing 1.6 x 10^6 cells/ml of *C. vulgaris* (Hanazato and Yasuno, 1987). The peak population growths in our study are in the same approximate range.

The increase in number of *B. longirostris* that accompanies the increasing food density leads to a change in *r* value. The *r* values of cladocerans range

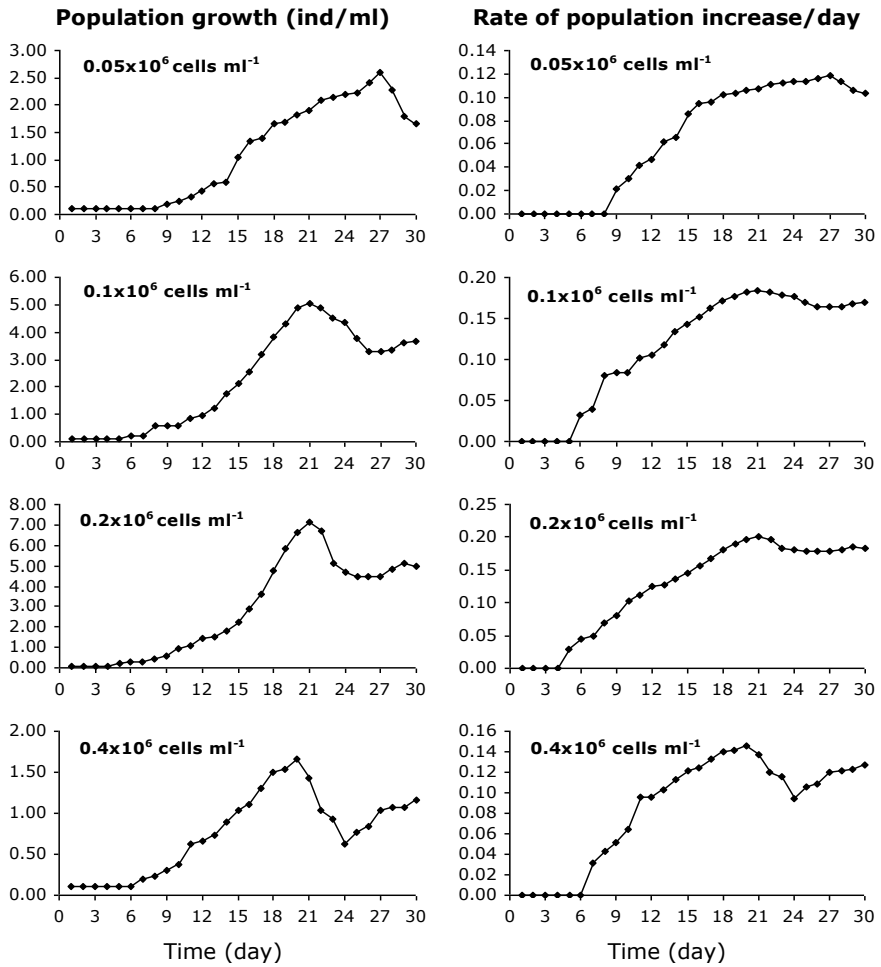

Fig. 2. Population growth and rate of population increase of the water flea, *Bosmina longirostris*, fed different densities of the alga, *Scenedesmus subspicatus*.

0.01-1.5 depending on the species, food type, temperature level, etc. (Nandini and Sarma, 2003). Using the life table demography approach, *r* values range 0.17-0.23 for *Ceriodaphnia cornuta*, 0.54-0.60 for *Moina macrocopa*, 0.09-0.15 for *Pleuroxus aduncus*, and 0.12-0.28 for *Simocephalus vetulus* at food densities of 0.5-4.5 × 10^6 cells/ml and, except for a few species of *Daphnia* and *Moina*, most cladocerans have population growth rates lower than 0.5/d (Nandini and Sarma, 2000). In *Ceriodaphnia dubia* and *M. macrocopa*, *r* values vary 0.14-0.47/d (Flores-Burgos et al., 2003). In the present study, the *r* values for *B. longirostris* varied 0.106-0.2/d, depending

on food type and density, within the range observed for most zooplankton species.

Some rotifers and cladocerans are well-adapted to lower food levels. In such cases, increased algal density can cause a reduction in peak population density and *r* value (Mangas-Ramirez et al., 2002). While small rotifer species are well adapted to low food levels, large species cannot survive and reproduce under such conditions (Stemberger and Gilbert, 1985). Several reasons have been adduced for the inhibitory properties of algal feed at high densities: too high densities can cause zooplankton death by the fouling effect of accumulated feces and uneaten food (Hirata, 1979), by decomposition of the algae's toxic products and secretions (Sarma and Rao, 1990), or by increased effort in food gathering (Nandini and Sarma, 2000). The inhibitory effect of *C. vulgaris* (above 0.1 x 10^6 cells/ml) and *S. subspicatus* (above 0.2 x 10^6 cells/ml) on population growth of *B. longirostris* found in this study could be due to a combination of these factors.

In conclusion, the present study shows that under the culture conditions used in our experiments *S. subspicatus* is a suitable food for the culture of the freshwater cladoceran, *B. longirostris*. Since density and type of algae can be controlled in cladocera culture, the information discovered in this study can be useful for determining efficient aquaculture practices and ecosystem modeling.

Acknowledgements

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