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Dynamics and production of a natural population of *Brachionus plicatilis* (Rotatoria, Monogononta) in a eutrophicated inner coastal water of the Baltic

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Abstract

The dynamic and production of a natural population of the rotifer *Brachionus plicatilis* (O.F. MÜLLER) were studied by regular field sampling at routine stations in the shallow Darss Zingst estuary, southern Baltic (3–7 ‰ S). Investigations of the horizontal distribution revealed significant population growth during the summer months at salinities above 3 ‰ S and at those stations characterized by high eutrophication. The first individuals hatch from resting eggs in May. Significant reproduction occurs from June to September, when temperatures are above 15° C. Mixis rates were highest during the exponential growth phase. Instantaneous rates of growth, birth, and mortality were estimated. Mean P/B ratios for the growing season were high (around 0.7 d^{-1}) and were in the range of values obtained from mass cultures in the field under subtropical conditions. In Barther Bodden annual biomass production for 1982 was 1.1 g fw · m^{-3}. In its natural habitat, *B. plicatilis* serves as a food source for fish juveniles and the mysid *Neomysis integer*, the seasonal dynamics of the rotifer population were not significantly affected by predators.

Introduction

The monogonont planktonic rotifer *Brachionus plicatilis* is known as a thermophile euryhaline cosmopolitan (KINNE 1977, DUMONT 1983). Due to its widespread use as a live food source in aquaculture (e.g. THEILACKER and McMASTER 1971, KINNE 1977), it is one of the best investigated rotifer species. Although there are many investigations on laboratory cultures, only a few ecological studies exist on natural populations, especially in boreal coastal waters. To make use of the broad genetic variability of natural populations of *B. plicatilis* for selection of optimal mass culture strains, a better knowledge on field populations is necessary.

This note presents data on the population dynamics of *B. plicatilis* in the chain of shallow eutrophicated boddens south of the Darss Zingst peninsula (southern Baltic, GDR) where it can contribute a significant part to total zooplankton production (ARNDT 1986).

Material and methods

For the study of distribution patterns and annual fluctuations, sedimented formalin-preserved samples were analyzed under an inverted microscope. Rotifer dynamics were investigated by integrated sampling, performed weekly with a 5 l HYDROBIOS sampler. Filtered (> 56 μm) and formalin preserved (4 %) samples were counted for females, males, and all egg types under a light microscope (160 x magnification). Males and male-eggs were registered only qualitatively. Parameters of population dynamics were roughly estimated according to formulas by EDMONDSON (1965) and PALOHEIMO (1974): $r = (\ln N_o - \ln N_t) / t$; $b = \ln (E+1) / D$; $d = (b_o+b_t) / 2 - r$, where r is the instantaneous growth rate, b is the instantaneous birth rate, d is the instantaneous death rate, N_o is abundance of amictic females at time O, N_t is abundance at time t, E is the egg ratio of subitaneous eggs per amictic female, and D is the development time of the eggs. Total abundance and percentage of amictic females (mixis ratio in %) were estimated by assuming the same mixis ratio for egg-bearing and non egg-bearing females. Since the aim of the study was to analyze seasonal trends, rather than daily changes in population growth, the calculation of the parameters was carried out using gliding averages of abundances. The generalized equation for temperature-dependent development time of rotifer eggs of BOTTRELL et al. (1976) was used for estimations of D.

Production (P) was estimated according to EDMONDSON (1974): $P = E/D \cdot N \cdot W$, where W is the individual biovolume of a female.

Food selectivity of *Neomysis integer* (3 females in each of 4 replicates, exp. 1–4) was determined in 100 ml dishes containing freshly caught *B. plicatilis* from the Warnow estuary. Index of food selectivity D (JACOBS 1974) by *Neomysis* was estimated by comparing abundances of 4 size classes of *Brachionus* before and after a feeding period of 40 minutes.

Results and discussion

A) Distribution: *B. plicatilis* is found at several places along the G.D.R. coastline in the southern Baltic. Mass occurrence was observed during summer in the inner coastal waters around Rugia (SCHWARZ 1962/63), in the Warnow estuary, in the Darss Zingst estuary, and in the Wismar Bight. In the Darss Zingst estuary, we found remarkable annual fluctuations of abundance (Fig. 1). The occurrence of *B. plicatilis* in Darss Zingst estuary (Fig. 2) confirms its characterization as a polythermal euryhaline species (cf. KINNE 1977). It was only found at salinities above 3 ‰ S, high abundances were registered just slightly above this limit. This is below the salinity optimum of other populations (RUTTNER-KOLISKO 1972, BLANCHOT and POURRIOT 1982). The rare occurrence of *B. plicatilis* at

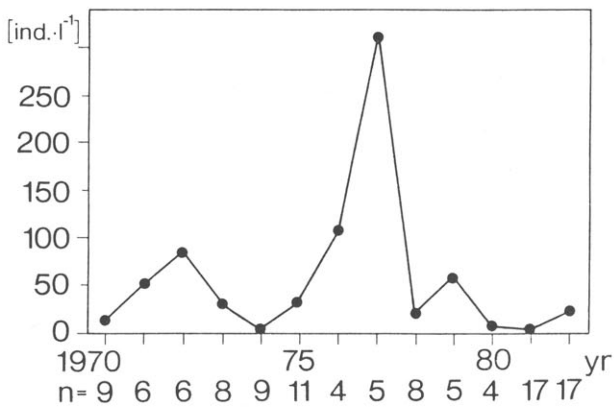

Figure 1

Annual fluctuations of mean abundances of *Brachionus plicatilis* in Barther Bodden during the growing season (June to September; pooled data of routine sampling from SCHNESE, HEERKLOSS and ARNDT unpubl.; n indicates the number of samples per season)

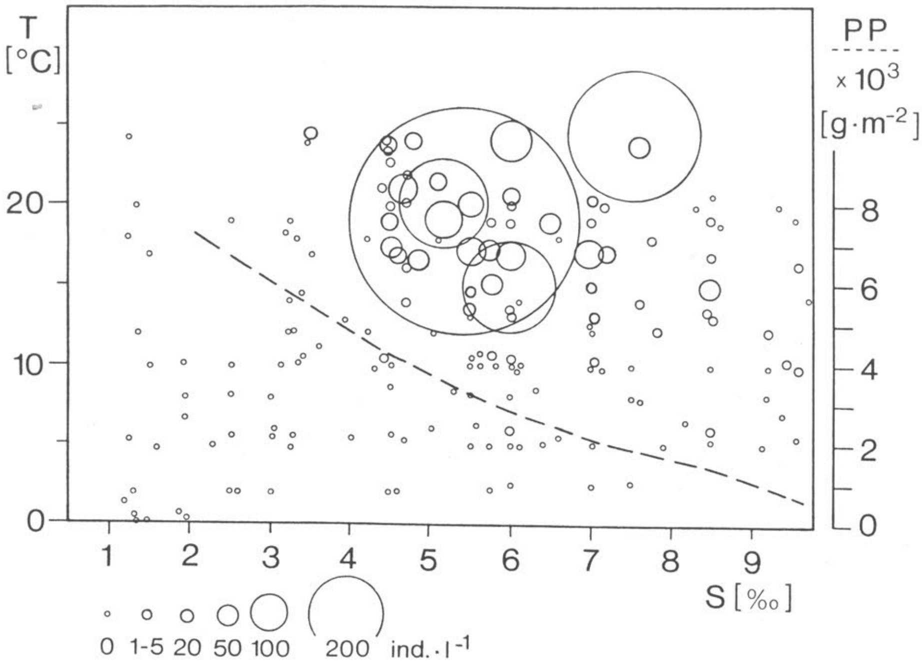

Figure 2

Abundances of *Brachionus plicatilis* (open circles) in relation to temperature and salinity in the Darss Zingst estuary, southerr H. Arndt: Dynamics and production of a *Brachionus* population CHNESE, HEERKLOSS and ARNDT unpubl.; dashed line indicates annual mean primary production at standard stations of the estuary after GEORGI 1985)

higher salinities in the oligotrophic outer parts of the inlet is possibly due to low food concentrations, since studies on laboratory cultures have shown that this species requires high food concentrations for optimal growth (e.g. KINNE 1977). Annual fluctuations of abundances in Barther Bodden are most probably not determined by one major factor, but are the result of the combined influence of temperature, salinity, food concentration, and predation pressure.

B) Population dynamics: Detailed investigations on the population dynamics of *B. plicatilis* in Barther Bodden were carried out in 1982 (Fig. 3, 4). Resting eggs hatched from the sediment at the end of May, when water temperatures rose quickly from 10 to 15° C. Significant egg production occured only above 15° C. Peaks in egg production in early June and August corresponded to maxima in water temperature. Mictic females were found only during mass development in early August. Mixis ratios were low (< 30 %). Maximum values of the instantaneous growth rate were about 0.32 d^{-1} (values in early June were influenced by the hatching of resting eggs). This value is significantly lower than values obtained from studies under optimum laboratory conditions (e.g. SNELL et al. 1983), but lies in the range of values known from mass cultures in the field (e.g. JAMES et al. 1983). Negative death rates at the end of May are the result of population recruitment from resting eggs. The second peak of negative death rate may also be caused by recruitment from resting eggs due to a decrease and renewed rise of water temperature at the end of June.

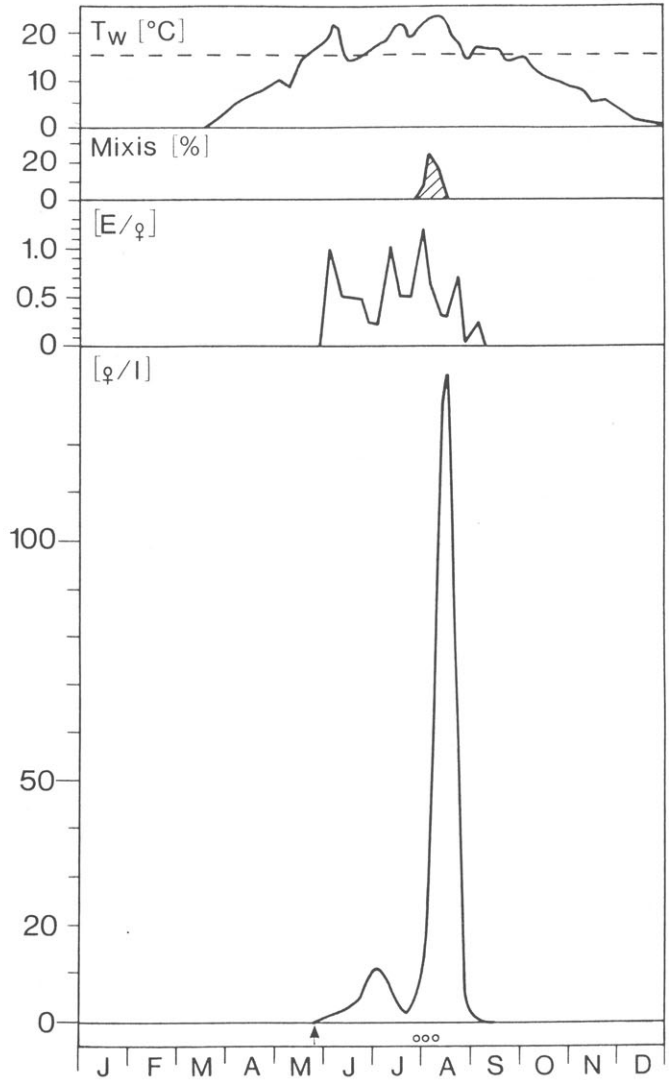

Figure 3

Population dynamics of *Brachionus plicatilis* in Barther Bodden in 1982 (Mixis ratio as percentage of mictic females in relation to total number of females; egg ratio as subitaneous eggs per amictic female; abundance of all females; arrow indicates observed hatching of resting eggs in the plankton; circles indicate occurrence of males and resting eggs)

Since there were constantly high food concentrations during summer (> 15 g fw · m^{-3} phytoplankton biomass, BÖRNER pers. comm.), food should not have been a limiting factor to this euryphageous (cf. POURRIOT 1977) rotifer in Barther Bodden. The most important factor regulating seasonal dynamics seems to be water temperature. Temperature

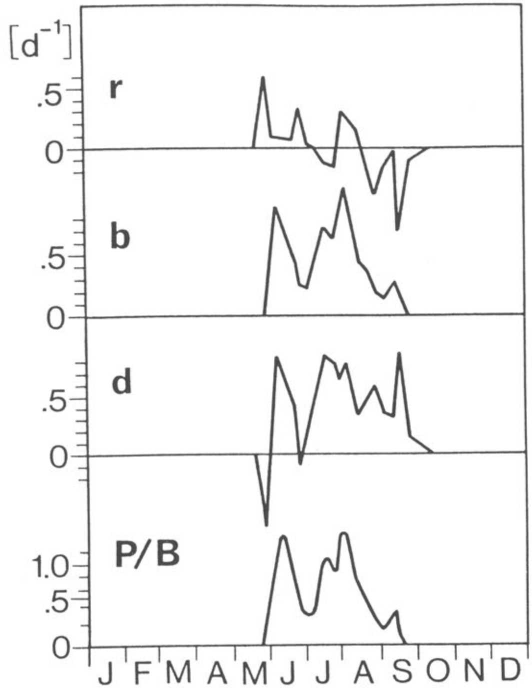

Figure 4
Growth rate (r), birth rate (b), death rate (d), and productivity (P/B) of *B. plicatilis* in Barther Bodden in 1982

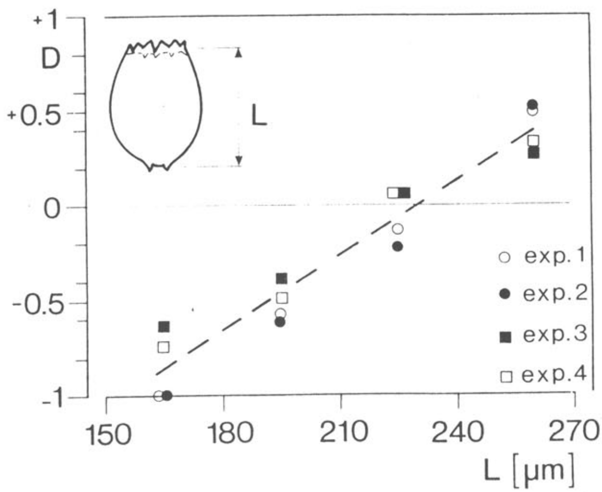

Figure 5
Indices of food selectivity (D) of *Neomysis integer* fed on a mixture of four size classes of *B. plicatilis*. Symbols refer to 4 diffeerent experiments.

requirements (> 10–15° C) for the hatching of resting eggs and for significant egg production of the *B. plicatilis* in Barther Bodden are in accordance with studies on laboratory cultures (e.g. BLANCHOT and POURRIOT 1982, PASCUAL and YUFERA 1983). Peaks in egg production corresponded very well to increases in water temperature.

C) Production: P/B-estimates for the *B. plicatilis* population revealed values greater than 1.0 d^{-1}, but the mean was 0.69 d^{-1} (see Fig. 4). The results show that this field population could be as productive as laboratory populations. Total production in 1982 was about 1.1 g fresh weight per m^{-3}.

D) Predators: Gut content analysis revealed that the omnivorous rotifer *Asplanchna*, most fish juveniles, smelt, herring, and especially the mysid *Neomysis integer* are consumers of *B. plicatilis* in Barther Bodden. During a mass development of *B. plicatilis* in the Warnow estuary in 1982 roach juveniles fed exclusively on this species. In early summer 1983, fish juveniles in the shore region of the Darss Zingst estuary consumed about 44 % of the daily *B. plicatilis* production (DEBUS and ARNDT 1984). Taking into account the predation pressure by *Neomysis* (cf. JANSEN et al. 1983), more than 100 % of the daily production was lost due to predation at this time. Furthermore, feeding experiments using the visually feeding predator *Neomysis integer* showed that within a population of *B. plicatilis*, larger rotifers are selectively consumed (Fig. 5), and egg bearing females are also preferred within the size classes (unpubl.). These two facts enhance the impact of predation. Although *B. plicatilis* is a preferred food item of planktivores of the Darss Zingst estuary, compared to the small rotifer species, estimations of total predation pressure (cf. ARNDT 1986) showed that only about 8 per cent of the total annual rotifer production is consumed by higher trophic levels. Thus the impact of predators should be considered when looking at local or short-term variations in rotifer abundance, but it cannot explain seasonal dynamics.

Conclusions

In boreal waters, even at very low salinities (4–7 ‰ S) field populations of *B. plicatilis* can reach reproductive rates similar to those found for optimized laboratory cultures. An explanation for this may be the advantageous conditions in Barther Bodden: 1) Salinities lie above values which are critical for reproduction (ca. 3 ‰ S); 2) The shallowness of the investigation area (mean depth 1.8 m) makes it possible for warm temperatures to extend down to the bottom (during summer often above 20° C); 3) High concentrations of bacteria and phytoplankton during summer (generally above 20 g fw · m^{-3}) obviously meet the required food concentrations. Whether or not there is a population of *B. plicatilis* especially adapted to lower salinities, which could be of interest for aquaculture in brackish waters, has still to be investigated.

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