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On the population dynamics of two brackish-water Cladocera Podon leuckarti and Evadne nordmanni in Kiel Fjord

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Abstract

Both *Podon leuckarti* and *Evadne nordmanni* play a predominant role in the plankton community of Kiel Fjord in summer. Increase and decrease of the populations were recorded through short-term sampling from May to the beginning of July. Abundance in relation to temperature and salinity, body size, number of embryos per female and the occurrence of permanent eggs were investigated. *Podon leuckarti* reached its peak at the end of May, two weeks earlier than *Evadne normanni*; the maximum abundance was 6500 individuals · m^{-3} and 8900 individuals · m^{-3} respectively. The rapid increase of both populations is characterized by an exponential growth phase. The estimated doubling time ranged from 0.5 to 4.3 days. With increasing temperature, body size and number of embryos per female decreased. An inspection of the stomach content showed that both species apparently had fed mainly on phytoplankton.

Introduction

A characteristic feature of the brackish-water plankton community in the Baltic Sea is the appearance of rotifers and cladocera in early summer (REMANE 1940). Through their parthenogenous mode of reproduction both groups are capable of building up large populations within short periods, thus becoming dominant members of the surface layer plankton.

As far as is known, single-celled plankton organisms (bacteria, phytoplankton and protozooplankton) constitute their main food items, while rotifers and cladocera are themselves prey organisms for fish larvae and juvenile fish. By concentrating organic energy bound to pico-, nano- and microplankton organisms and making it available to consumers on higher trophic levels, rotifers and cladocera occupy a position similar to that of herbivorous and omnivorous copepods in the food web. It is therefore important to study their population dynamics and nutrition in detail.

This paper describes an attempt to follow the population dynamics of two cladocera species *Podon leuckarti* and *Evadne nordmanni* in Kiel Fjord during their main peak in early summer. Some laboratory observations are also noted.

Material and methods

Samples were taken from the quay in front of the Institute from 3.5. – 3.7.1979 at intervals of 1 to 3 days on a total of 42 days, between 9 a.m. and 4 p.m. The water column was vertically sampled from 7 m depth to the surface using a small Apstein plankton net with an aperture diameter of 16 cm and a mesh size of 100 μm. A 100 % filtration efficiency was assumed for this short towing distance. An additional 10 l surface sample was filtered through a 100 μm sieve to check for any accumulation of specimens near the water surface. A 100 ml water sample was taken for phytoplankton analysis. Temperature and salinity were recorded at 1 m intervals with a temperature and salinity probe by Electronic Switchgear, London (accuracy 0.1°C and 0.1‰ salinity).

All the cladocera contained in the sample volume were counted in a Bogorov counting dish and their number calculated per m^3 water volume. Embryos were counted only when the eyes were already pigmented. Body length and body height were measured according to ONBÉ (1974).

Results

Temperature and salinity

Fig. 1 shows the temperature and salinity curves for the sampling period. The main summer rise in temperature occurs in the second half of May with a salinity fluctuating around 15 ‰.

Both parameters indicate the typical stratification of the water column. Fluctuations in temperature are often accompanied by parallel fluctuations in salinity. The decrease in temperature for instance in the middle and at the end of June is accompanied by an increase in salinity, pointing to an upwelling of deeper water. This reduces stratification.

Species abundance

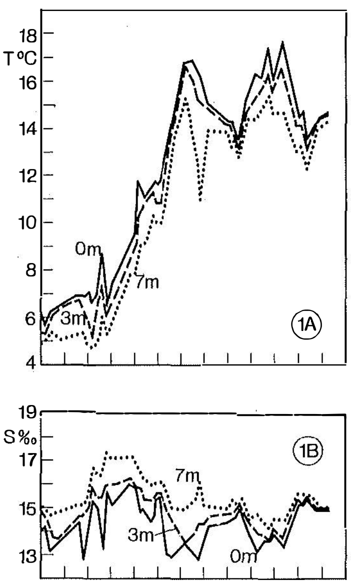
Both species show the same pattern of seasonal abundance (Fig. 2). This is characterized by an initial phase with low numbers followed by a steep increase in population density comparable to the log-phase in phytoplankton cultures. The duration of maximum abundances is comparatively short. Thereafter the populations decline as fast as they grew.

The dip in the maximum abundance curve is probably not a typical feature, since it does not recur in the surface abundance curve. The cause is apparently a change in environmental conditions. The main factor is the exchange of the water masses through upwelling and advection. This can clearly be seen in the abundance curve of *Podon leuckarti*, where the lowest dip point on 5th June coincides with a salinity rise and corresponding temperature drop in the lower part of the water column (compare Fig. 1).

The first specimens of *Podon leuckarti* were already present at the beginning of May when the sampling programme was started. The temperature of the surface layer was then 6°C. The initial phase, before the steep rise in population density began, lasted three weeks, until water temperature had risen to 11°C. The following increase in population density was associated with a rise in water temperature. The period of high abundance lasted from the end of May to the middle of June.

The other species, *Evadne nordmanni*, appeared after a delay of almost four weeks. The first specimens were observed at the end of May at a water temperature of 11°C. Mass development began after a short initial phase of 9 days in early June, reaching its maximum peak a few days later. The average concentration of 8890 individuals · m^{-3} for the 7 m deep water column exceeded that of *Podon leuckarti* with a corresponding value of 6460 individuals · m^{-3} observed two weeks earlier.

The two species apparently succeed each other. *Podon leuckarti* was followed by *Evadne nordmanni* after a delay of two to three weeks. If we suppose the bottom



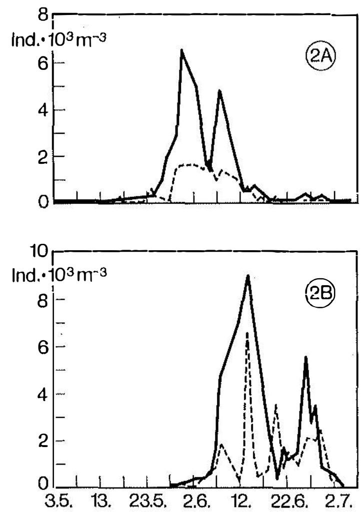


Figure 1

Temperature (A) and salinity (B) of the water column sampled

Figure 2

Abundance of *Podon leuckarti* (A) and *Evadne nordmanni* (B), (———) mean number for the water column, (......) surface concentraction

temperature at the time the organisms first appeared to be the hatching temperature for the resting eggs, we arrive at a temperature of 4.8°C for *Podon leuckarti* and 9.8°C for *Evadne nordmanni*. Thus temperature seems to be the regulating factor for the successive occurrence of the two species.

Growth rate of the populations

Assuming that the abundance curves are not overly influenced by displacement of water masses through advection, we are able to determine the rates of numerical increase for the populations of the two species, at least for the short periods where the populations increase sharply.

The instantaneous rate of numerical increase (r) and the doubling time (t_D) were calculated according to the following equations:

$$r = \frac{\ln N_2 - \ln N_1}{t_2 - t_1} \quad \text{and} \quad t_D = \frac{\ln 2}{r}$$

(N_1, N_2 are the numbers at sampling time t_1 and t_2). The values obtained for 5 distinct growth periods are listed in Table 1.

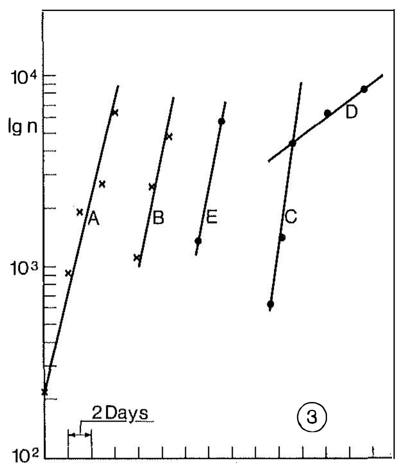
The abundance values (N) for the above periods A – E, plotted on a semilog scale against time (Fig. 3), result in straight lines, indicating that during these periods of maximum increase growth was exponential. The slope of the lines corresponds to the instantaneous growth rates (r) in Table 1.

Table 1

Instantaneous growth rate (r) and doubling time (t_D) for the populations of *Podon leuckarti* and *Evadne nordmanni*.

Species	Growth period			r	t_D (days)	t_D (hours)
Podon leuckarti	A.1.	Peak	(25. 5.–31. 5.)	0.81	0.85	20.4
,, ,,	B.2.	,,	(6. 6.– 8. 6.)	1.02	0.68	16.3
Evadne nordmanni	C.1.	,,	(6. 6.– 8. 6.)	1.37	0.51	12.2
,, ,,	D.1.	,,	(8. 6.–14. 6.)	0.16	4.33	103.9
,, ,,	E.2.	,,	(24. 6.–26. 6.)	0.99	0.70	16.8

The surprisingly high growth rates are explicable by the unusual type of parthenogenesis peculiar to the cladocera. The embryos in the brood pouch of the maternal organism already carry eggs in their own brood pouches. BAINBRIDGE (1958) has termed the newly hatched young „miniature adults'' since they already carry embryos.



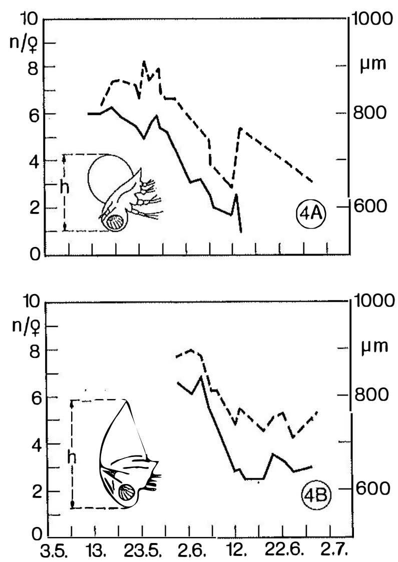


Figure 3

Exponential growth phases of the population of *Podon leuckarti* (x) and *Evadne nordmanni* (●).

A: *Podon leuckarti*	(25.5. – 31.5.)
B: *Podon leuckarti*	(6.6. – 8.6.)
C: *Evadne nordmanni*	(6.6. – 8.6.)
D: *Evadne nordmanni*	(8.6. – 14.6.)
E: *Evadne nordmanni*	(24.6. – 26.6.)

Figure 4

Mean number of embryos per female (———) and mean body height (h) of the females (– – – –) for *Podon leuckarti* (A) and *Evadne nordmanni* (B)

Embryo number

The first females of *Podon leuckarti* with embryos in their brood pouch were observed 9 days after the first appearance of the species. *Evadne nordmanni* required only 3 days to commence parthenogenic reproduction. Both species start their growth period with high embryo numbers, maximum numbers being 7 embryos in *Podon* and 8 in *Evadne*; later the numbers recede (Fig. 4). Minimum numbers observed are 1 for *Podon* and 2 for *Evadne*. The decrease in mean embryo number is also indicated by a decrease in body height, that is, by a lessening in size of the brood pouch (Fig. 4).

Resting eggs

Resting eggs are large fertilized eggs produced singly by sexual females, whereby the neritic cladocera species are able to hibernate on the sea bottom. In *Podon leuckarti*, the formation of resting eggs started as early as during its peak of abundance at the end of May. The highest number of females carrying resting eggs were observed during the second peak in the middle of June. The mean number per m^3 in the water column was 241, equivalent to 5 % of the population.

In contrast to *Podon leuckarti*, only few females with resting eggs were observed in *Evadne nordmanni*. This species differs from the former in showing a second period of abundance in autumn in our area. It is therefore assumed that after the first peak in early summer, parthenogenic females sustain the population in low numbers until the second peak in autumn, when the bulk of resting eggs are produced.

Laboratory observations

Several attempts to feed the cladocera with natural phytoplankton stained with fluorochromes (acridine orange and auramine) and with *Artemia* nauplii failed. Investigation of the stomach content of freshly caught specimens revealed a homogeneous mass without identifiable remnants of prey organisms. The stomach contents, however, were fluorescent like chlorophyll containing algae under a fluorescence microscope. This obervation leads to the assumption that both species had mainly fed on phytoplankton. An examination of the phytoplankton samples showed that microflagellates, the diatom *Skeletonema costatum* and the autotrophic dinoflagellate *Prorocentrum balticum* were the predominant species during the sampling period.

Concluding remarks

The high growth rates observed in both cladocera species are comparable with those of single-celled plankton organisms which have doubling times of a day or less depending on environmental conditions. *Podon* and *Evadne* are thus able to keep pace with their prey organisms. This possibly results in a most efficient energy transfer within the food web.

These conclusions are, however, not reliable as long as we do not really know what these cladocera actually feed on. BAINBRIDGE (1958) has studied the feeding habits of *Evadne nordmanni* by analysing the organisms which were found in the grasp of *Evadne* in preserved samples. Dinoflagellates and tintinnids were the main organisms caught. He also discovered that *Evadne nordmanni*, as is to be expected from their highly developed eyes, feed only during daytime.

Feeding experiments, though difficult to perform with these tiny and tender organisms, are apparently the only means of obtaining more information on this important question.

References

BAINBRIDGE, V., 1958. Some observations on *Evadne nordmanni* Lovén. J. Mar. Biol. Ass. U.K. **37**, 349–370.

ONBÉ, T., 1974. Studies on the ecology of marine cladocerans. J. Fac. Fish. Anim. Husb., Hiroshima Univ. **13**, 83–179.

REMANE, A., 1940. Einführung in die zoologische Ökologie der Nord- und Ostsee. In: GRIMPE and WAGLER (eds.), Die Tierwelt der Nord- und Ostsee, 1–238, Leipzig.