

8. Estimation of consumption rates of the predatory cladoceran *Cercopagis pengoi* in laboratory conditions

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SUMMARY

The predatory cladoceran *Cercopagis pengoi*, native to the Ponto-Caspian region, was first found in the Baltic Sea in the early 1990s. There are strong signals from field observations that the population abundance of a dominant native cladoceran *Bosmina coregoni maritima* is depressed and the seasonal abundance dynamics of copepod nauplii has changed after this invasion. Considering the very limited knowledge on feeding habits of *C. pengoi* (largely due to species-specific peculiarities), we conducted a set of laboratory feeding experiments with this species as a predator and several native more abundant mesozooplankton species as a prey. The goal of the current study was to identify potential prey items for *C. pengoi* in the lab conditions and to estimate the consumption rates of the species for various prey taxa at different prey mixtures and densities.

MATERIAL AND METHODS

Specimens of *Cercopagis pengoi* Ostroumov were collected with Juday net (mesh size 90 μm , mouth diameter 0.1 m^2) from upper layers of Pärnu Bay (NE Gulf of Riga) and placed into 3 l containers. In order to reduce the stress, the collected material was quickly (within 1 hour) transported to the lab. In the lab, the animals were separated by means of a wide mouth pipette and placed singly into 1 l containers containing filtered seawater with aeration. Mostly large parthenogenetic females were used. It was carefully inspected that the selected individuals were free of attached detritus or other material and healthy, i.e., freely swimming during a 24-hour period. The young were born at night and these newly born first instar individuals were used in feeding experiments. However, some experiments were carried out with adult, third instar *C. pengoi* parthenogenetic females.

Mesozooplankton for prey were collected from Pärnu Bay simultaneously with *C. pengoi*, pipetted out of the water and placed into filtrated seawater in 2 l containers where they were kept in aerated conditions until feeding experiments.

Experiments were conducted in 1 l vessels at 20 ± 2 °C, allowing only diffuse overhead light. Each container was filled with 0.8 l filtrated seawater where 1 individual of *C. pengoi* was added. There was no aeration during the experiment. Healthy prey (15–50 per vessel) was added to containers. The prey density (ca 10 to 65 thousand individuals m^{-3}) corresponded to that in the field conditions in Pärnu Bay. We visually controlled whether *C. pengoi* individuals were intact at the beginning of the experiments and several times during the experimental terms by observing their swimming behaviour. To prevent food

plankton sedimentation, we also mixed the vessels gently on these occasions. In addition, mesozooplankton swimming caused some turbulence in the flasks.

The duration of the experiments was usually 8 (\pm 4) hours. After the incubation period, experiments were terminated by addition of formalin to all vessels. The contents of experimental vessels were concentrated by reverse filtration (using 60 μ m mesh) and observed using a dissecting microscope to assess predator and prey mortality, as well as the condition of the animals. Prey individuals found trapped within the water surface film were considered as live after the experimental period.

Altogether eight series of experiments, each in 25 replicates, were performed. The following prey was used: *Bosmina coregoni maritima* (P. E. Müller), *Balanus improvisus* Darwin larvae and nauplii and copepodids of *Eurytemora affinis* (Poppe) and *Acartia bifilosa* (Giesbrecht). Control experiments, without predators, were carried out exactly in the same manner as with *C. pengoi*. These were performed with all prey species separately.

Results of the predation experiments (the consumption rate of *C. pengoi*) are expressed as number of prey *C. pengoi*⁻¹ hour⁻¹ consumed. Prey density in experiments is shown per litre (i.e., ind. l⁻¹).

RESULTS

The control experiments (without predator) showed that a prey species-specific approach should be implemented when interpreting the results. On average two individuals of copepod nauplii may have been lost during the experiment whereas for all the remaining diet items the mean potential loss was one. It appears that the share of successful experiments (including those where the predator actually died during the experiment) was relatively high, on average 75% (Table 8.1). The highest rate of unsuccessful experiments was in the case of copepodids (33%), the most successful experiments were those where *B. c. maritima* (80%) or copepod nauplii (82%) were used as prey.

Table 8.1. Number of feeding experiments of *C. pengoi* with various single and mixed diet items

Diet	Total experiments	Successful experiments
<i>Balanus improvisus</i> larvae	20	15
<i>Bosmina coregoni maritima</i>	10	8
Copepodids	61	41
Copepod nauplii	49	40
<i>B. improvisus</i> larvae + copepod nauplii	45	32
Copepod nauplii + copepodids	25	20
Total	210	156

The consumption rate of *C. pengoi* on *B. improvisus* larvae and *B. c. maritima* as single prey is rather similar with the highest value recorded for copepod nauplii and the lowest for copepodids (Table 8.2). The relation of consumption rates and prey densities was studied for *B. improvisus* larvae and copepod nauplii. It was obvious that a higher prey density resulted in an elevated consumption rate. This increase was most evident for copepod nauplii. When copepod nauplii and *Balanus* larvae were given at equal densities (19 prey l⁻¹), copepod nauplii were preferred: consumption rates were 0.42 ± 0.02 and 0.34 ± 0.04 *C. pengoi*⁻¹ hour⁻¹ (mean \pm SE), respectively (Fig. 8.1). When provided with mixed prey items at equal densities (19 prey l⁻¹) *C. pengoi* again consumed copepod nauplii at a higher rate than copepodids (0.51 ± 0.03 and 0.06 ± 0.03 *C. pengoi*⁻¹ hour⁻¹, respectively).

Experiments on the consumption of single prey by *C. pengoi* provided at two different density levels (above and below 30 prey l⁻¹) indicate that (1) the consumption rates do not differ for copepod nauplii and *B. c. maritima*, and (2) the more *B. improvisus* larvae are available, the more they are consumed (Fig. 8.2). Both *C. pengoi* juveniles and parthenogenetic adults consumed at similar rates *B. c. maritima* and copepod nauplii. A substantial difference was observed for *B. improvisus* larvae, who were utilized at a higher rate by adult than by juvenile *C. pengoi* (Fig. 8.3). The above suggests that copepod nauplii and *B. c. maritima*, if available, are the major prey for the *C. pengoi* population.

Table 8.2. Consumption rates of *Cercopagis pengoi* for various diet items

Diet	Consumption rate (number of prey <i>C. pengoi</i> ⁻¹ hour ⁻¹ ; mean \pm SE)
<i>Balanus improvisus</i> larvae	0.73 ± 0.04
<i>Bosmina coregoni maritima</i>	0.66 ± 0.06
Copepodids	0.40 ± 0.03
Copepod nauplii	0.94 ± 0.05

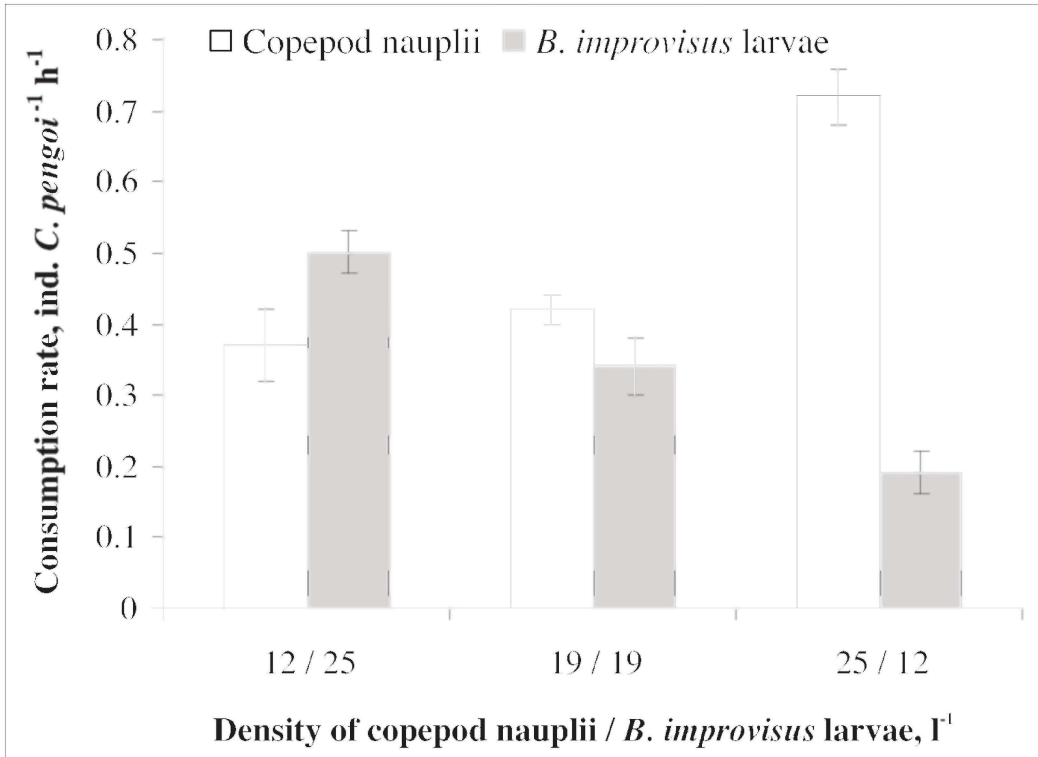


Fig. 8.1. Consumption rate of *Cercopagis pengoi* for *Balanus improvisus* larvae and copepod nauplii (*C. pengoi*⁻¹ hour⁻¹, mean ± SE) at three different mixed prey densities (Γ⁻¹).

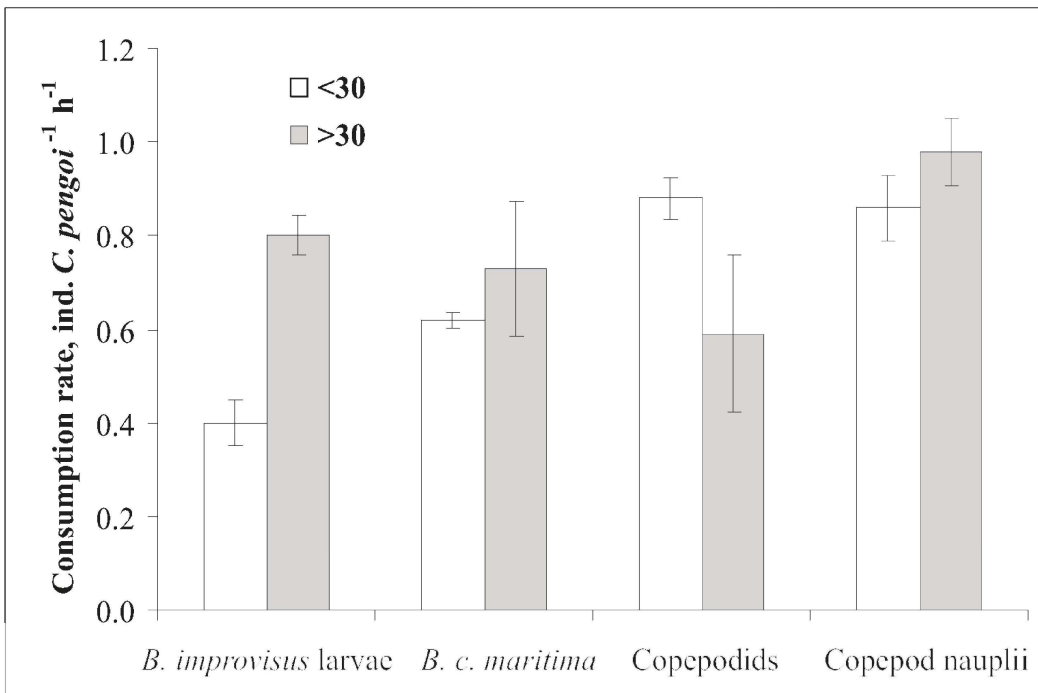


Fig. 8.2. Consumption rate of *Cercopagis pengoi* for various prey taxa (*C. pengoi*⁻¹ hour⁻¹, mean ± SE) at two different single prey densities (Γ⁻¹).

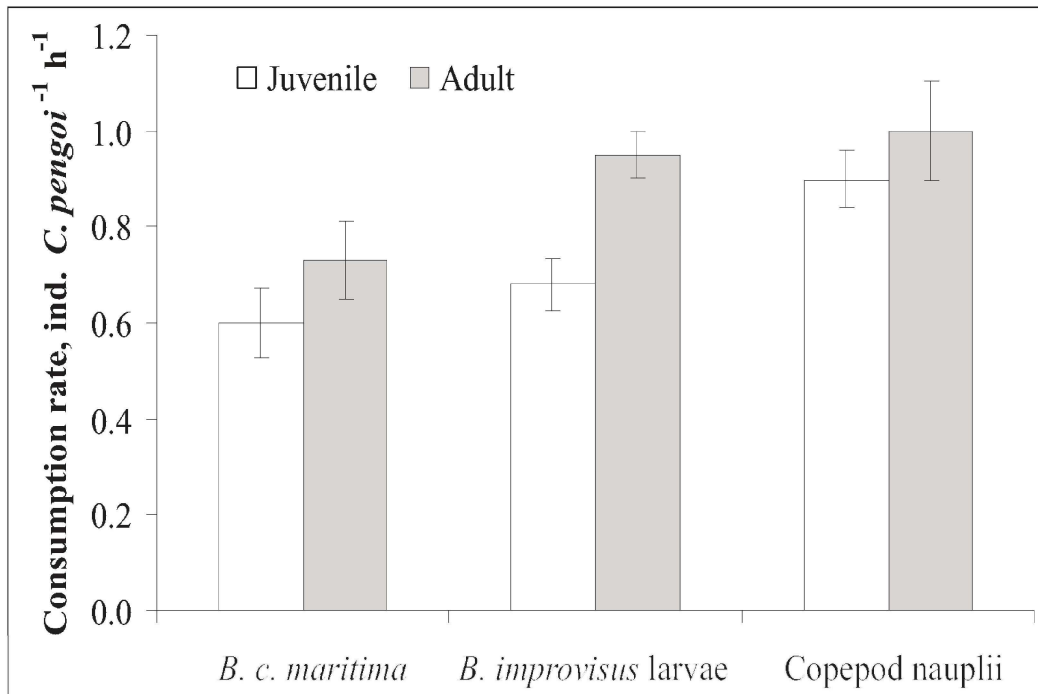


Fig. 8.3. Consumption rates of *Cercopagis pengoi* juveniles (stage I) and adults (parthenogenetic females) ($C. pengoi^{-1} \text{ hour}^{-1}$, mean \pm SE) for different single prey items.

DISCUSSION

Cercopagis pengoi is extremely sensitive to handling and experimental manipulations and survive poorly in captivity (Gorokhova et al., 2005). Still, some short-term experiments have been carried out for studying the feeding habits of the species. For instance, Laxson et al. (2003) proved that *C. pengoi* preys on small-sized mesozooplankton species. Witt and Caceres (2004) estimated potential predator–prey interactions of two predatory cladocerans, *C. pengoi* and *Bythotrephes longimanus*, in lab conditions. However, most studies on the feeding of *C. pengoi* and potential impact of the species on plankton communities are based on field data by using a bioenergetic model (Telesh et al., 2001; Laxson et al., 2003; Thompson et al., 2005; Gorokhova et al., 2005). As data available on the feeding, energetics and physiology of *C. pengoi* are limited, knowledge on another predatory cladoceran – *Bythotrephes* – has been applied (e.g. Yurista & Schulz, 1995).

The prey taxa used in the current study dominate, except *B. c. maritima* in recent years, at various stages of mass development of the *C. pengoi* population. We faced severe difficulties in obtaining the necessary amount of *B. c. maritima* as the species has practically disappeared from the plankton community in the NE Gulf of Riga. According to Gorokhova (1998), the diet of *C. pengoi* contains 60% of copepods (nauplii and copepodids of *Acartia* spp., *E. affinis* and *T. longicornis*), 20% of rotifers (*Synchaeta* spp.) and 20% of cladocerans (*E. nordmannii*). The results of our current laboratory

experiments suggest that *C. pengoi* is able to consume these copepod (and most likely also cladoceran) species whereas the consumption rate is higher in the case of higher prey density.

In their lab experiments Laxson et al. (2003) obtained similar consumption rates of *C. pengoi* for *Daphnia retrocurva* and *Bosmina longirostris*: $2.8 C. pengoi^{-1} \text{ day}^{-1}$. Our results (when calculated to the same time interval) vary between 4.8 (copepodids) and 11.3 (copepod nauplii) $C. pengoi^{-1} \text{ day}^{-1}$ and are thus notably higher than those obtained by Laxson et al (2003). However, the same authors also used bioenergetic modelling and obtained the following consumption rates: 2.1–4.7 for *D. retrocurva* and 7.1–7.5 $C. pengoi^{-1} \text{ day}^{-1}$ for *B. longirostris*. Considering also differences in prey size, it is concluded here that these consumption rates are in good agreement with the results of the current study.