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# Observations on feeding behaviour and survival rates in the estuarine calanoid copepods *Acartia spinicauda* and *Heliodiaptomus cinctus* (Crustacea: Copepoda: Calanoida)

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Experiments were conducted on the calanoid copepods, *Acartia spinicauda* (Acartiidae) and *Heliodiaptomus cinctus* (Diaptomidae) in order to determine food preference and survival rates respectively. Adults of *A. spinicauda* were fed monocultures of *Tetraselmis gracilis* (Chlorophyta) and *Skeletonema costatum* (Bacillariophyta), whereas, adults of *H. cinctus* were fed on five different combinations of phytoplankton feed. Total hourly differences in pigment concentrations indicate that *A. spinicauda* preferred to feed *on T. gracilis* (90.08%) as compared to *S. costatum* (55.87%). A combined feed of *Isochrysis galbana* (50%) and *Chaetoceros* sp. (50%) was found to be most satisfactory in case of *H. cinctus* as there was no mortality till the 8th day and only 57% mortality on the 14th day. However, total mortality occurred on the 15th day. The results indicate that feeds played an important role in determining the survival rates in *H. cinctus*.

Copepods form an abundant group of zooplankton playing a major role in the utilisation of resources produced at primary trophic level and thereby influence the turnover at secondary level in the aquatic food web. Feeding behaviour of copepods has received considerable attention in temperate waters[1-4] but very little is known from the tropics[5]. Such studies in copepods are essential as even closely related algal species may vary in their nutritional potential for any given herbivore[6]. In the present investigation, two separate experiments were designed to understand the food preference of *Acartia spinicauda* (Crustacea: Copepoda: Calanoida), a high saline estuarine copepod and survival rates of *Heliodiaptomus cinctus* (Crustacea: Copepoda: Calanoida), a low saline estuarine copepod. This latter species occurs in the mid reaches of the Mandovi estuary (Goa) during the low saline south west monsoon season[7,8].

For the grazing experiments, healthy adults of *A. spinicauda* were picked using fine capillary tube from the zooplankton samples collected from the Zuari estuary (Goa) in January 1997. They were kept overnight in 250 ml beakers containing aerated GF/F filtered sea water (FSW) of ambient salinity (35 psu) for starving prior to experiment. For the experiments, monocultures of some commonly occurring phytoplankton species[9] were maintained in the laboratory[10]. Phytoplankton cell suspensions were prepared using monocultures of *Tetraselmis gracilis* and *Skeletonema costatum*. About 30 ml of the cultures were added to 720 ml of FSW of ambient salinity. Initial concentrations of chlorophyll *a* and phaeopigments ($\mu g.\ l^{-1}$) were determined fluorometrically using Turner Designs Model 10 fluorometer[11]. These values were treated as zero hour readings. The experimental setup consisted of 500 ml flasks containing 250 ml of the cell suspensions (in triplicates) for each species of phytoplankton. The flasks were covered with black cloth to avoid photosynthesis and phytoplankton divisions. One copepod was introduced into each experimental flask. In order to avoid settling of phytoplankton cells, the flasks were gently swirled every 30 minutes. Total pigment concentration in each flask was determined by removing 10 ml of the cell suspension at hourly interval for 7 hours. The hourly difference in the average total pigment concentration was estimated by subtracting the pigment concentration obtained for the previous hour. This was considered as the hourly rate of consumption by each copepod. The experimental setup was maintained at room temperature (30°C) which was close to the ambient temperature at the time of collection.

Similarly, specimens of the low saline copepod

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*H. cinctus* were picked from the zooplankton samples collected from the Mandovi estuary in August 1997. They were starved overnight in FSW (GF/F) of ambient salinity (17 psu). They were transferred into cell plates of 24 cell wells, each with a capacity of 5 ml. Each cell well was filled with 4 ml of FSW. Five combinations of live phytoplankton feed were prepared using laboratory maintained monocultures of *Chaetoceros* sp., *Isochrysis galbana*, *Tetraselmis gracilis* and *Skeletonema costatum* (Table 1). Cell densities were determined using Neubauer haemocytometer under 10× magnification on Leica inverted microscope. A concentration of $10^4$ cells/cell well/copepod was fed once daily. Six individuals were maintained separately in each cell well for each feed combination. They were transferred daily to new cell plates with fresh FSW and feed. A daily record was kept on mortality. As these specimens were collected during the south west monsoon, the experimental sets were maintained at 20°C (close to ambient temperature) keeping at 10 h:14 h light:dark cycle and lasted till the death of all individuals.

The results indicated that *A. spinicauda* fed relatively more on *T. gracilis* than on *S. costatum* (Fig. 1). The differences in the average total pigment concentration showed that over the entire experimental duration, the feeding was more (90.08%) on *T. gracilis* as compared to *S. costatum* (55.87%). It has been reported[12] that copepods of the genus *Acartia* possess mouth parts that facilitate the capture of larger food particles. This may possibly be true in the present case because *T. gracilis* is larger in size (maximum width 14 µm and length 22 µm) as compared to *S. costatum* (diameter of 22 µm). Also, spiny chain forming diatoms are less readily consumed by the calanoid copepods[13] and *S. costatum* being a chain forming diatom might not have been preferred. Dietary requirements may also be an important factor responsible for selective feeding. Rapid gut filling reported[14,15] in the prestarved copepods was not observed. Feeding pattern differed with the two species of phytoplankton. With *T. gracilis*, an initial decline was followed by a steady increase, with a maximum feeding at 5th hour (0.343 µg. $l^{-1}$ $h^{-1}$) and declined thereafter. On the other hand the trend with *S. costatum* was different. Maximum feeding (0.0290 µg $l^{-1}$ $h^{-1}$) occurred in the initial hour itself with a steady decline over the next two hours. During the subsequent hours the food uptake increased slightly and again decreased towards the end of the experiment. The feeding was found to be neither synchronized nor continuous although food was in plentiful supply in the experimental flasks. Although no such information is available for any other species of copepod from tropical waters, it has been reported[16] that the feeding in salp *Thalia democratica* was also not influenced by the availability of the feed (*Chaetoceros* sp.).

In case of *H. cinctus*, depending upon the feed combinations, 100% survival was observed for about 6-9 days (Fig. 2). In feed A, 50% mortality was observed after 7 days and total mortality occurred on

Table 1—Combination of phytoplankton species used for feeding *Heliodiaptomus cinctus*

| Feed | *Chaetoceros* sp. (%) | *Isochrysis galbana* (%) | *Skeletonema costatum* (%) | *Tetraselmis gracilis* (%) |
|---|---|---|---|---|
| A | 33 | 33 | 0 | 33 |
| B | 0 | 33 | 33 | 33 |
| C | 33 | 33 | 33 | 0 |
| D | 25 | 25 | 25 | 25 |
| E | 50 | 50 | 0 | 0 |

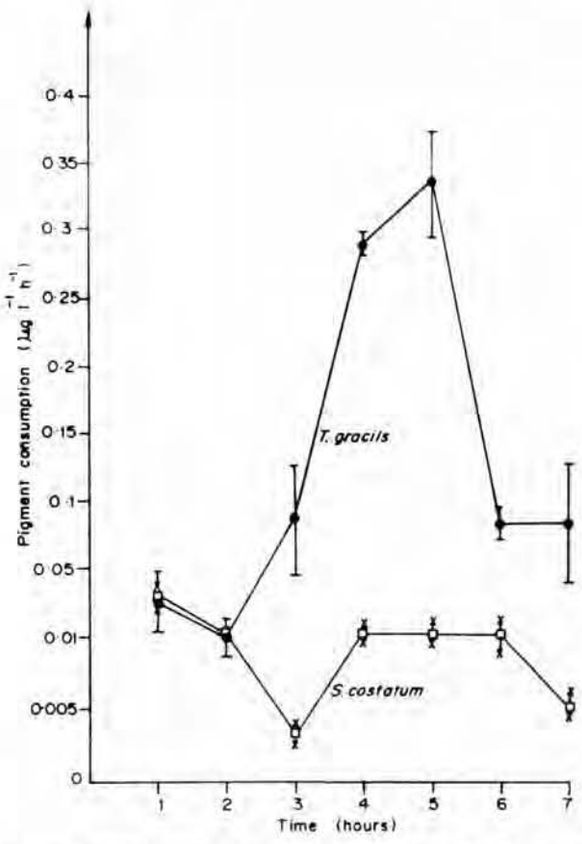


Fig. 1—Hourly consumption of phytoplankton (± SD) by *Acartia spinicauda*

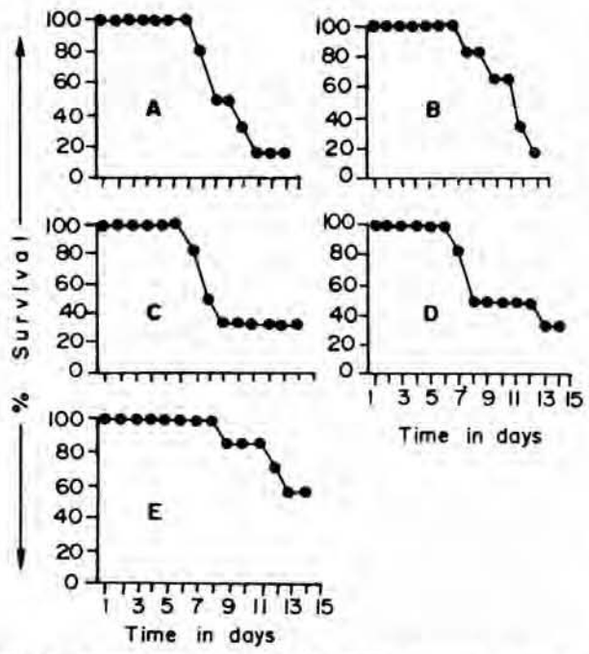


Fig. 2—Percentage survival of *Heliodiaptomus cinctus* in different feed combinations

the 15th day. In feed B, there was a gradual decrease (83.33%) in survival after 7th day and total mortality occurred on the 13th day. A sharp decline in the survival rate between the 6th and the 7th day occurred in feed C and 33% survived till the 14th day. Feed D showed 50% survival on the 8th day and remained steady till the 12th day with total mortality on 15th day. With feed E, survival rate was comparatively better showing no mortality till the 8th day and gradually reduced to 57% by the 14th day. Total mortality, however, occurred on the 15th day. The ANOVA indicated that the feeds played a significant role ($P<0.05$) in the survival of *H. cinctus*. The variations observed with different combinations of feed could either be due to the morphology of the feed and/or its nutritional value. Survival of *H. cinctus* under laboratory conditions for a fairly long period suggests its importance as an amenable planktonic candidate species for laboratory experiments like grazing, bioassay etc. It is apparent that all the specimens used for the experiment belonged to the same stock which resulted in their total mortality on the 15th day in all feed combinations.

These experiments suggest that food preference and feeding strategies may vary from one herbivore to the other depending upon the individual's feeding adaption in relation to the type of food available. All phytoplankton cells may not possess all the nutritional qualities necessary to satisfy the needs of the herbivores. Difficulty in digesting a particular species due to the presence of a thick cell wall may play a significant role in some instances. However, to establish feeding selectivity and rhythm in copepods, detailed studies on all these aspects are imperative.

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