The juvenile freshwater prawn, *Macrobrachium rosenbergii* (Crustacea-Decapoda) as an effective zooplankton predator

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ABSTRACT

A laboratory study was carried out to examine the effectiveness of juvenile freshwater prawn, *Macrobrachium rosenbergii* (De Man,1879), as a planktonic crustacean predator.

The results showed that large juvenile prawns (body length 4.5-4.8 cm) ingested significantly more zooplankton than did smaller ones (1.1-1.5 c,) when zooplankton density was 5.3 prey /ml . The large juvenile specimens consumed 2705 zooplankton on average, after 12 h, while the medium sized prawn (3-3.5 cm, body length) , medium small (2.1-2.4 cm) and small (1.1-1.5 cm,) size groups ingested 1570, 1440 and 1258 zooplankton respectively. Large prawn consumed prey of larger body size than did smaller prawn .More zooplankton were consumed by the prawn when the zooplankton density was high (8.45-9.8 prey/ml.). The clearing rate (no of zooplankton ingested /no. of zooplankton offered) was, however, lower (69%) when the zooplankton density was high. The results indicate that juvenile *M. rosenbergii* can effectively ingest zooplankton which play an essential role in the food web of the prawn.

Key words: Freshwater prawn, *Macrobrachium rosenbergii*, zooplankton, predation

INTRODUCTION

The natural diets used in culture of larval and juvenile stages of *Macrobrachium rosenbergii* are mostly based on zooplankton, *Artemia* nauplii and microalgae (Lovett and Felder,1988; Rodriguez *et al.* 1994; Kumlu and Jones 1995; Barros and Valenti, 2003).

Gut content analysis suggested that such prawns are epibenthic omnivores once they develop beyond the planktonic larval stages. Many studies (Darnell, 1974; Fenchel and Jorgensen,1977; Rubright *et al.* 1981; Costa and Wanninayake,1986) suggested that, like other epidbenthic decapods, prawns derive most of their nutrients from the environment through various forms of detritus ingestion. For example, the food of a natural population of *M. rosenbergii* with body length between 10.0 and 29.9 cm was mainly detritus, plant and animal matter, of which detritus formed the main food component (Costa and Wanninayake, 1986).

Feeding and fertilization significantly increase shrimp production according to Rubright *et al.* (1981), who found that the best shrimp production occurred in ponds given both feed and fertilizer, followed by feed only, fertilizer only and none. They suggested that fertilizer stimulated the production of chlorophyll and planktonic copepods, while prawn growth derived from feeding directly on planktonic communities is unlikely.

In the present work, the importance of direct contribution of zooplankton to prawn growth was investigated through the laboratory study which examined the effectiveness of ingestion of zooplankton by juvenile *M. rosenbergii*, the effects of prawn size and zooplankton density were the main topics studied.

MATERIALS AND METHODS

This study was carried out in the Invertebrate Laboratory of the Fish Research Station, National Institute of Oceanography and Fisheries at El-Qanater El-KHariya (NIOFA) about 25 Km to the north of Cairo.

Different sizes of the freshwater prawn (Table1) were purchased from the hatchery of Maryot fish farming company (M.F.F.C.) near Alexandria . They were then acclimated in glass aquaria with temperature adjusted at 28±1C° for about one week. The prawns were starved for 30 h before the experiments began. The zooplankton samples were collected 1 day before the ingestion study by using a plankton net (300µm mesh) from ponds and Nile branches in El-Qanater El-Khayria region. Two random specimens were sampled from the zooplankton stock as the control before the ingestion trials began (about 24 h after collection). They were fixed in formalin (20% formaldehyde) and were later sorted and examined for body length frequency distribution.

The ingestion trials for the large prawn size group were carried out in 1L beakers with 700 ml dechlorinated water. Those for other size groups were carried out in 500ml beakers with 350 ml dechlorinated water.

The zooplankton specimens were counted and introduced to the beakers to obtain the desired density. One of the test prawns was then carefully placed in each beaker that was agitated gently with air bubbling. Each trial stayed for 12h. Formalin was then added to each beaker and the prawn was removed. The remaining zooplankton specimens were counted and sorted individually.

Two series of experiments were carried out; the first experiment examined the quantitative effect of prawn size on zooplankton ingestion. The second one investigated the effect of zooplankton (prey) density on ingestion.

In the first experiment, the test prawns were sorted into four size groups (Table 1). The initial zooplankton density was 5.3 animals/ml. In the second experiment, six prawns with a mean body length of 3.5±0.1 cm. and mean body weight of 0.29 g. were tested. Three zooplankton densities were examined namely: 8.45-9.8 animals (prey)/ml, 5.15-5.5 prey/ml and 2.6-2.75 prey/ml. Two prawns were tested at each density "clearing rate" was used to describe the ingestion of zooplankton by the prawn and defined as: clearing rate = (No. of zooplankton ingested /No. of zooplankton offered)×100 (Chen and Chen ,1992).

"Electivity index" used by Wilson (1973) was employed in the analysis. The index was defined as the proportion of zooplankton left over after feeding relative to the proportion before feeding for each size. A value of one indicates that the prawn is gathering zooplankton in proportion to the abundance of zooplankton offered. A value less than one indicates selection. A value greater than one indicates either avoidance or a lower feeding efficiency for that size.

Statistical analysis was done using ANOVA for the difference in the ingestion due to prawn size or prey density.

RESULTS

More zooplankton were ingested by larger prawn (Table 1), the ingestion of zooplankton by different size groups was significantly different($P<0.05$) within 12 h, where the large prawn (4.5-4.8 cm) ingested 2705 zooplankton on average. The mean consumption values of zooplankton during 12h by the medium (3-3.5cm), medium small (2.1-2.4 cm) and small size groups of prawn (1.1-1.5 cm) were 1570, 1440 and 1258, respectively. The large prawn size group ingested significantly ($P<0.05$) more prey than any other size group (Table 1).

Table 1: The body length, body weight and zooplankton ingestion (numbers ingested in 12 h) of four size groups of *Macrobrachium rosenbergii* when the initial prey density was 5.3 prey/ml.

Size group	No. of beakers	Body length(cm)	Body weight(g)	Zooplankton ingestion
Large	1	4.5	0.69	2400
	2	4.8	0.80	3010
				Mean 2705^{a}
Medium	1	3	0.17	1572
	2	3.5	0.25	1568
				Mean 1570^{b}
Medium small	1	2.1	0.10	1225
	2	2.4	0.12	1656
				Mean 1440^{b}
	1	1.1	0.02	1280
Small	2	1.5	0.08	1236
				Mean 1258^{b}

Means with the same superscript are not significantly different ($P>0.05$, Duncan's new multiple range)

In trail two, significantly more zooplankton were devoured by the prawn when the prey density was higher ($P<0.05$). The clearing rate, however, was inversely related to the prey density. UP to 2200 Zooplankton were consumed by the prawn in 12h, when the prey density was 8.45-9.80 prey/ml. The ingestion values were 1450 and 800 zooplankton when the prey density was 5.15-5.5 prey/ml and 2.6-2.75 prey/ml, respectively. Clearing rate was lowest (69%) when the prey density was highest (8.45-9.8 prey/ml). The clearing rate for the 5.15-5.5 prey/ml density was 77.5% and that for the lowest density (2.6-2.75 prey/ml) was 87% (Table 2).

Table 2: Zooplankton ingestion and clearing rate of the freshwater prawn, *M. rosenbergii* at three different densities

Zooplankton densities (prey/ml)	**Clearing rate(%)**	**Number of zooplankton ingestion**
8.45 – 9.8	69	2200
5.15 – 5.5	77.5	1450
2.6 – 2.75	87	800

The zooplankton population used in the study was composed mainly of copepods (*Mesocyclops* sp., *Thermocyclops* sp. and nauplii) and Cladocera (*Daphnia* sp. and *Bosmina longirostris*). The total body length ranged from 400 to 1200 µm for copepod spp. and between 800 to 1500 µm for Cladocera spp.

The stock zooplankton population showed two peaks in terms of relative size frequency: one at 1000 µm, and the other at 1375 µm (Fig. 1). After feeding by the prawn, the 1000 µm peak disappeared indicating strong predation on this size range.

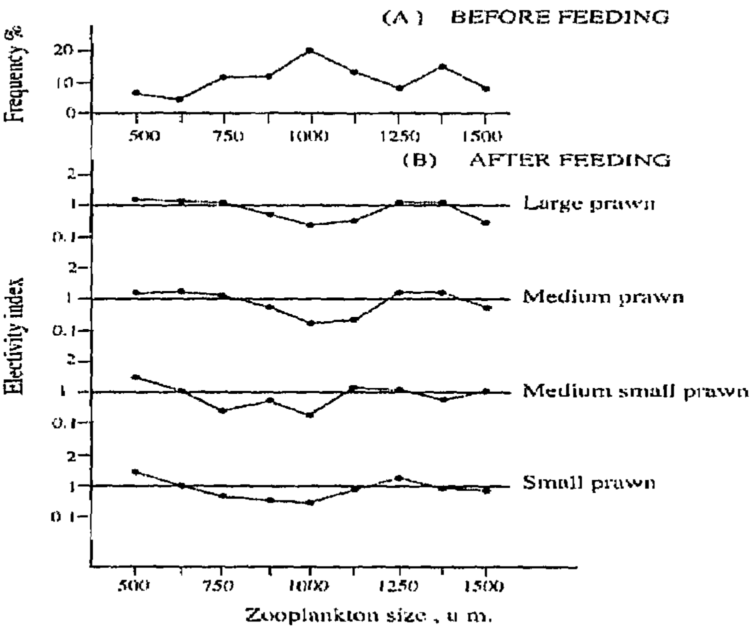

Fig. (1): (A) The frequency distribution of different zooplankton before feeding. (B) The prey size selection (electivity index) on zooplankton by *Macrobrachium rosenbergii* of four size groups in relation to the zooplankton size after feeding.

Prawn of different size groups selected prey of different sizes. The electivity index analysis (Fig. 1B) shows that the larger (large and medium) prawn size groups selected mainly prey with a mean size between 875 and 1125 µm. The smaller (medium small and small) size groups selected mainly prey with a mean size between 750 and 1000 µm.

No correlation could be established for prey size selection and prey density (Fig. 2). The electivity index varied randomly at any given prey density.

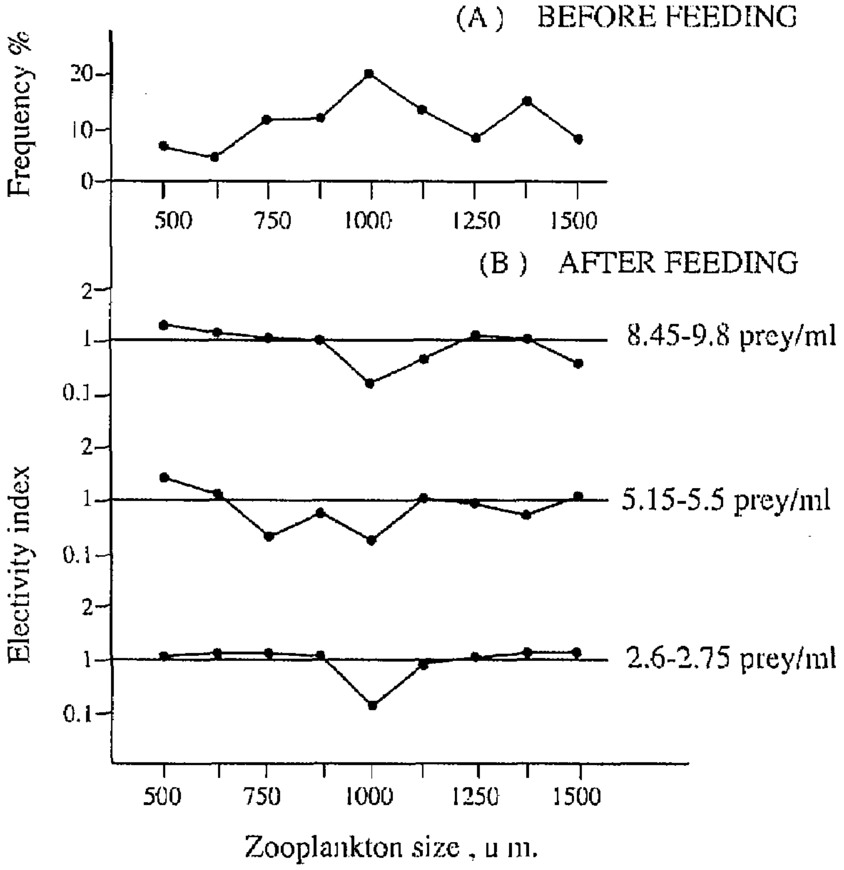

Fig. (2): (A) The frequency distribution of different zooplankton size groups before feeding. (B) The prey size selection (electivity index) on zooplankton of three different densities by *Macrobrachium rosenbergii* (main body length 3.5 +0.1cm.)in relation to the zooplankton size after feeding.

DISCUSSION

In contrast to the general idea that the prawn are mainly detritivore after the last larval metamorphosis, postlarval and juvenile *M. rosenbergii* feed heavily on live zooplankton. The field observations by Chen and Chen (1992) on juvenile *Penaeus monodon* clearly showed a significant decline of zooplankton density in ponds after stocking of postlarval shrimp. Also, Agustin (1999) reared juvenile prawn ,*Macrobrachium borellii* in floating enclosures and found in enclosure that did not receive feeding, a 48.06% decrease of the total zooplankton population mainly copepods and cladocerans, this reduction may be due to an increase in the prawn predation.

In this study, up to 2200 (from the prey density study) to 2650 (from the prawn size effect study) zooplankton were devoured by a starved test prawn in 12 h. Both results strongly indicate the capability of the prawn to use zooplankton effectively as a food source.

There are many publications illustrating the importance of zooplankton derived detritus in the nutrition of benthic or epibenthic animals. Kumari *et al.*(1978) showed that the nutritive value of detritus in terms of available energy was rated higher than that of zooplankton. Shrimp were shown to assimilate 93% of estuarine detritus (Qasim and Easterson,1974). Rubright *et al.* (1981) also suggested that a transformation of zooplankton population into detritus would enrich the benthic food chain in shrimp ponds.Thus, zooplankton alone has not been considered by these authors to be an important food source. The small size of the zooplankton may be the main reason for the rejection of its role as a direct food source for the benthic shrimp.

With respect to the effect of zooplankton as food for *M. rosenbergii*, Tidwell *et al.*(1997) found that prawn fed on zooplankton had satisfied their dietary requirements and supported higher growth and survival rates than those fed on prepared diets. The zooplankton densities tested in this study ranged between 2.6 and 9.8 prey/ml and the starved shrimp might be forced to hunt the zooplankton. Chen and Chen (1992) reared *Penaeus monodon* in grow out ponds where zooplankton probably would not pursue under natural conditions and huge numbers of zooplankton were effectively removed by the shrimp and did not reject the traditional idea that the nutrition of decapods is derived from ingestion of detritus. In an eutrophic environment, such as intensive aquaculture pond, the dense zooplankton population would not be negligible as a food source for the prawn, regardless of prawn size. Shrimp growth via detrital feeding of the decomposing zooplankton is not the only trophic pathway existing in the food web of an intensive aquaculture pond (Chen and Chen, 1992). In the present study, more zooplankton were ingested by larger prawn, that is in agreement with the study on *P. monodon*, where, larger shrimp consumed more zooplankton of larger size than did smaller shrimp(Chen and Chen,1992).

Mortality of zooplankton may occur during the ingestion trial, suggesting that predation could be the result of consuming just the decayed zooplankton and not the live ones. Formalin was added to the experimental vessels when the ingestion trials ended and the zooplankton were examined later, This experimental procedure did not distinguish between dead and live zooplankton. Most of the unused zooplankton in the ingestion trials, however survived for many days in the holding beaker. Even if some deaths occur during the test, the numbers would not be able to match the large numbers that were consumed. Visual observation also confirmed direct catching and feeding on large zooplankton by the test prawn.

The test prawn were starved for 30 h. before the feeding experiment began. Chu and Shing(1986) showed that starvation did not cause any difference in the amount of food consumed by postlarval *Metapenaeus ensis*. The ingestion rate of the unfed shrimp was not significantly different from that of the fed shrimp.

In most other studies comparable to the present one, much younger shrimp were used. Shigueno (1975) reported that larval *P. japonicus* ingested 46 *Artemia* nauplii/day during mysis Ш. to postlarva П stage and 85 nauplii/day between post larva П and postlarva 1V. Gopalakrishnan (1976) stated that the mysid *P. marginatus* showed a maximal ingestion of 510 *Artemia* nauplii/day at afood density of 5 nauplii/ml. Postlarval *P. indicus* were reported to consume 187 *Artemia* nauplii/day when the initial food concentration was 9 nauplii/ day. Barros & Valenti (2003) reported four levels of ingestion during larval development of *M. rosenbergii*. The first level include stages П, Ш and 1V, with average consumption of about 40*Artemia* nauplii/day; the second level includes stages V and V1, with consumption of approximately 55 nauplii/day; the third level includes stages VП and VШ, with consumption of 80-100 nauplii/day. The fourth level includes stages 1X, X and X1 , with the highest values for ingestion. In the present study, juvenile *M. rosenbergii* showed a maximal ingestion of 5300 zooplankton /day.

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