EFFECTS OF FEEDING PLANT MATERIAL ON GROWTH AND SURVIVAL OF PINK SHRIMP *FARFANTEPENAEUS PAULENSIS*

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RESUMO

Efeito da alimentação com vegetais no crescimento e sobrevivência do camarão-rosa *Farfantepenaeus paulensis*

Quantidades significativas de material vegetal têm sido encontradas no conteúdo estomacal de juvenis do camarão-rosa *Farfantepenaeus paulensis* que habitam o estuário da Lagoa dos Patos no sul do Brasil. Um experimento em laboratório, com duração de 20 dias, foi realizado para avaliar a sobrevivência e o crescimento de juvenis de *F. paulensis* (0.84 ± 0.24 g; peso médio inicial ± desvio padrão) alimentados com três diferentes dietas vegetais. Os tratamentos alimentares foram: (1) macroalga *Enteromorpha* sp. (Entero); (2) gramínea aquática *Ruppia maritima* (Ruppia); (3) marisma *Spartina* sp. (Spartina); (4) ração comercial (CD); e (5) sem alimento (Unfed). O crescimento e a sobrevivência dos camarões submetidos às dietas vegetais foram similares aos resultados apresentados pelos camarões mantidos sem alimentação (Unfed). Crescimento e sobrevivência significativos somente foram observados no tratamento com ração comercial (CD). Os resultados indicaram que os vegetais testados não são capazes de suportar o crescimento e a sobrevivência de juvenis de *F. paulensis* quando utilizados como única fonte de alimentação. Sugere-se ainda, que a ingestão destes vegetais pelo *F. paulensis*, durante sua fase estuarina, tenha como objetivo o consumo de organismos que se desenvolvem aderidos à estrutura destes vegetais.

PALAVRAS-CHAVE: dieta; *Farfantepenaeus paulensis*; juvenis; vegetais; peneídeo

ABSTRACT

Significant amounts of plant material have been detected in the stomach contents of *Farfantepenaeus paulensis* juveniles inhabiting the Patos Lagoon estuary, southern Brazil. A 20-day long laboratory feeding experiment was performed to evaluate survival and growth of *F. paulensis* juveniles (0.84 ± 0.24 g; mean initial body weight ± sd) fed on three distinct plant diets. The feeding treatments consisted of: (1) macroalga *Enteromorpha* sp. (Entero treatment); (2) seagrass *Ruppia maritima* (Ruppia treatment); (3) saltmarsh *Spartina* sp. (Spartina treatment); (4) commercial diet (CD treatment); and (5) without food (Unfed treatment). Overall, growth and survival of juveniles submitted to plant treatments were similar to the Unfed treatment. Significant growth and survival were observed only in the CD treatment. Results indicated that the plant material tested were not capable to support survival and growth of *F. paulensis* when offered as the sole food source. It could be suggested that the consumption of this plant material by *F. paulensis* during their estuarine phase might be focused on the attached organisms.

KEYWORDS: diet; *Farfantepenaeus paulensis*; juvenile; plant material; penaeid

INTRODUCTION

The pink shrimp *Farfantepenaeus paulensis* is distributed from Ilhéus (14°50'S), Brazil to Mar del Plata (38°30'S), Argentina (D'Incao 1991). As most penaeid shrimps, *F. paulensis* presents two distinct phases in its life cycle: adults spawn offshore and postlarvae enter shallow estuarine waters where they settle on algal and seagrass beds (Dall *et al*. 1990; D'Incao 1991). In southern Brazil, *F. paulensis* postlarvae move into the Patos Lagoon estuary where they grow in the nursery areas before migrating offshore (D'Incao 1991). Intense capture of shrimp juveniles occurs during the migration period and nowadays *F. paulensis* is one of the most valuable species captured in the Patos Lagoon estuary. However, fisheries production has been decreasing annually (Reis & D'Incao, 2000). Therefore, several studies have been performed to develop technology to cultivate *F. paulensis* in ponds (Peixoto *et al*. 2003) and pens, built in the shallow areas of the estuary (Wasielesky *et al*. 2004; Jensen *et al*. 2004; Soares *et al*. 2005).

During growth in captivity, *F. paulensis* presents an intense carnivorous behavior and cannibalism occurs frequently. However, among the natural food items available in the Patos Lagoon estuary, plant material has been documented in the stomach contents of wild (Silva & D'Incao 2001) and cultured (Soares *et al*. 2005) *F. paulensis* juveniles. While estuarine seagrass beds and macroalgae presumably provide protection and food necessary for early shrimp juveniles (Stoner & Zimmerman 1988; Dall *et al*. 1990; Minello & Webb 1997), very little information exists on the direct contribution of plant material to the nourishment of *F. paulensis* either in field or laboratory studies.

The plant material that could potentially be ingested by penaeids includes emergent (e.g. *Spartina*), submerged macrophytes (seagrasses) and algae (Dall *et al*. 1990). In the shallow estuarine areas inhabited by *F. paulensis*, saltmarsh plants (e.g. *Spartina* sp.), seagrasses (e.g. *Ruppia maritima*) and a variety of macroalgae are usually observed (Costa 1997; Seeliger 1997ab), which could provide a nutrition source for wild and reared juveniles. Nevertheless, the nutritional importance of plant material to many penaeids has been questioned (Gleason & Zimmerman 1984; Sullivan & Moncreiff 1990; Bombeo-Tuburan *et al*. 1993; Moss 1994).

The present study evaluated the nutritional value of three types of plant material provided as the sole food source for *F. paulensis* juveniles.

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Mariculture, University of Rio Grande, southern Brazil. Laboratory reared *F. paulensis* juveniles (0.84 ± 0.24 g) (mean initial body weight ± sd) were starved for 20 h before the experiment. Three sources of fresh plant material were used and five treatments (twelve replicates / treatment) were established: (1) macroalgae *Enteromorpha* sp. (Entero treatment); (2) seagrass *Ruppia maritima* (Ruppia treatment); (3) saltmarsh *Spartina* sp. (Spartina treatment); (4) commercial diet (Purina MR35) (CD treatment); and (5) without food (Unfed treatment). *Enteromorpha* was collected daily from the walls of raceway tanks used to rear *F. paulensis* broodstock. Seagrass and saltmarsh samples were collect from Patos Lagoon estuary and maintained in 180 ℓ plastic containers filled with seawater (22 ± 1‰ salinity and 24 ± 1°C temperature). All plant material was washed in clean seawater and attached organisms were removed before shrimp feeding.

To prevent cannibalism, juveniles were reared individually in 5 ℓ plastic containers filled with 4.5 ℓ of filtered seawater. Each treatment was composed of 12 shrimp (replicates). The food items were offered *ad libitum* and plant material was sliced into small (≈ 0.5 cm) pieces. Everyday, faeces and any food remains were removed by siphoning and the water renewal rate was 50 %. Daily observations verified the abundance of food and the occurrence of mortalities.

During the 20 days of the experiment shrimp were exposed to artificial illumination simulating a 12 light/ 12 h dark photoperiod and constant air supply. Temperature and salinity were maintained at 25 ± 1°C and 28 ± 1.7‰, respectively. The experimental containers were maintained partially immersed (⅔) in a shallow bath with heated water. Two heaters with thermostats were placed inside the bath to maintain the water temperature constant. Additionally, a small water pump was used to circulate the warmed water around the containers to homogenize the temperature.

All shrimp were weighed at day 0 (stocking day), day 10 and at the end of the experiment (day 20). A two-way ANOVA (diet*day) was used to analyze differences between dietary treatments over time. Tukey's range test was used to examine the relationship between treatments.

RESULTS

All plant diets were observed to be ingested by shrimp during the experiment. However, after 10 and 20 days of experiment, no significant shrimp growth was observed in the plant treatments as well as in the Unfed treatment ($P > 0.05$) (Fig. 1). Only juveniles submitted to the CD treatment had a significant growth ($P < 0.05$) during the rearing period (Fig. 1).

Mortalities started to be observed after 8 days in the Spartina and Entero treatments (Fig. 2). In the Ruppia and Unfed groups, mortalities were recorded after 13 days of culture (Fig. 2). With the exception of the CD treatment, after 20 days survival was very low in all treatments and no juvenile survived in the Spartina treatment (Fig. 2).

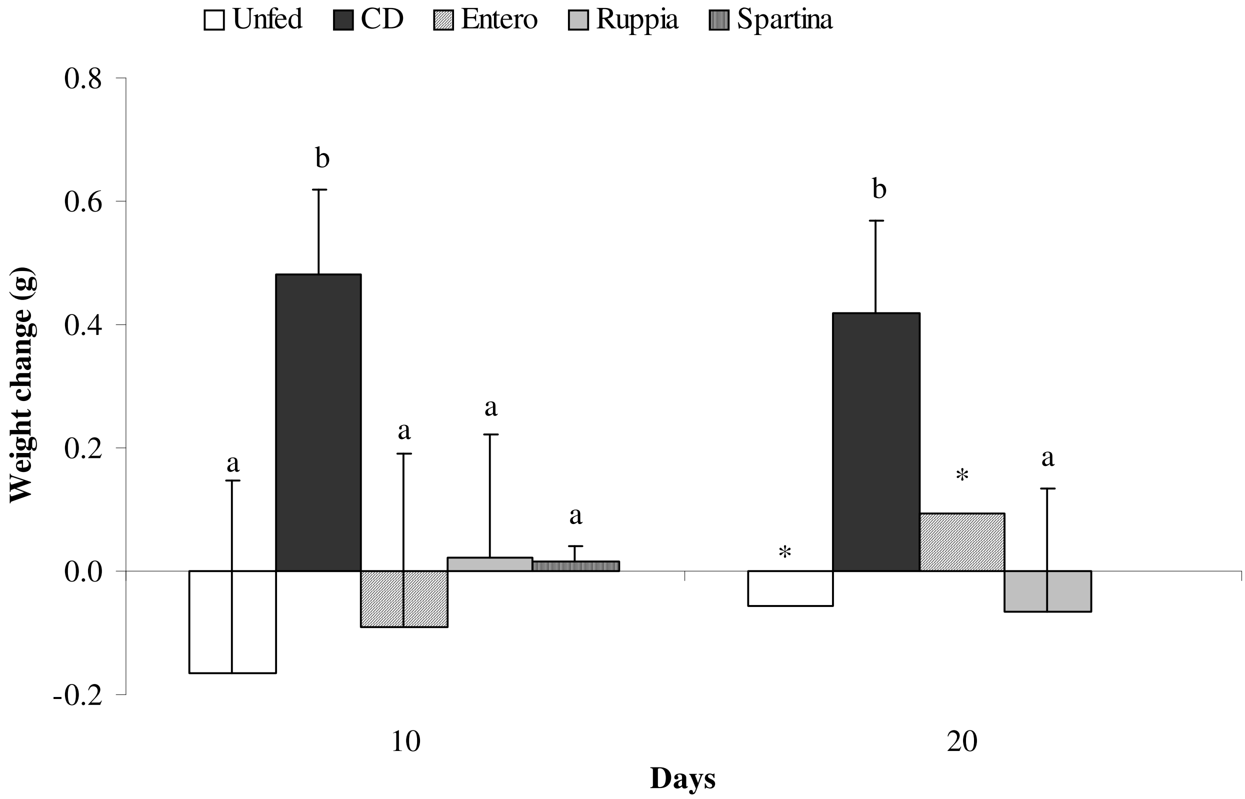

FIGURA 1 – Mean (+ SD) body weigh (BW) changes at day 10 (BW_{10} – initial BW) and day 20 (BW_{20} – BW_{10}) of *Farfantepenaeus paulensis* from each feeding treatment. Common lowercase letters (a; b) denote no significant difference of weight (α = 0.05; Tukey's Multiple Range Test) among treatments in each day. Asterisks (*) denote treatments where only one individual survived. Entero = macroalga *Enteromorpha* sp.; Ruppia = seagrass *Ruppia maritima*; Spartina = saltmarsh *Spartina* sp.; CD = commercial diet; Unfed = without food supply.

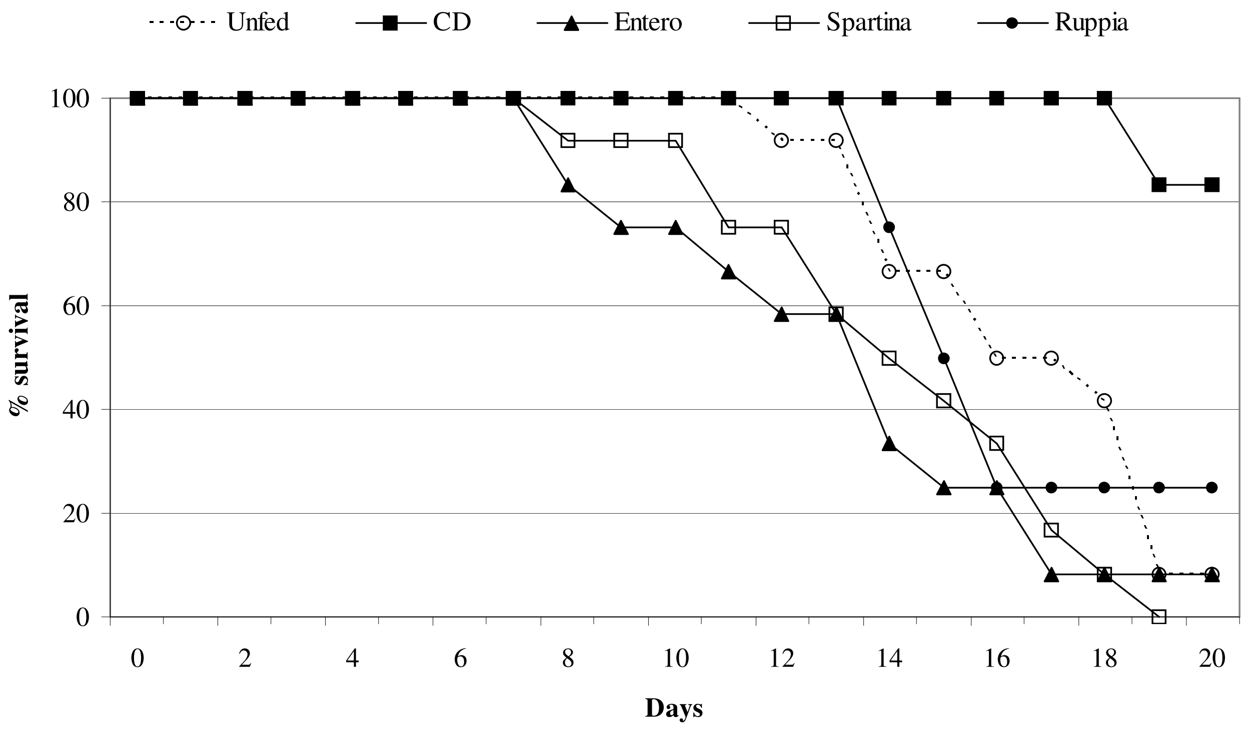

FIGURA 2 – Cumulative mortality (%) of *Farfantepenaeus paulensis* juveniles from each feeding treatment during the experiment period. Entero, macroalga *Enteromorpha* sp.; Ruppia, seagrass *Ruppia maritima*; Spartina, saltmarsh *Spartina* sp.; CD, commercial diet; Unfed, without food.

DISCUSSION

The presence of plant fragments in shrimp stomach contents was reported in the first description of the diet of penaeid species inhabiting estuaries (Williams 1955). The amount of plant material reported in the stomach contents of penaeids varies widely but there is a trend for juveniles rather than adults to ingest plant material (Dall *et al.* 1990). Nevertheless, the direct contribution of plant material for juvenile survival and growth is conflicting (Gleason & Zimmerman 1984; Primavera & Gacutan 1989; Bombeo-Tuburan *et al* 1993; Moss 1994). Although in the present study *Enteromorpha* sp. was observed to be actively consumed by *F. paulensis*, no significant growth was recorded and juveniles started to die even earlier than in the Unfed treatment. This may indicate that shrimp expended more energy trying to digest this plant material than they were able to obtain from it. Faecal examinations in recently settled *F. paulensis* and *Farfantepenaeus brasiliensis* postlarvae suggested that *Enteromorpha* sp. was regularly ingested, but many intact cells were observed which indicated that the starch stored within the cells was not assimilated in the digestive system (Brisson & Pace 1978). Accordingly, neither *Ulva* sp. nor *Enteromorpha* sp. contributed significantly to the growth of *Litopenaeus vannamei*, despite shrimp having ingested large portions of these macroalgae (Moss 1994).

Similar to the Entero treatment, *Spartina* sp. fed shrimp did not grow and started to die before unfed juveniles. Gleason & Zimmerman (1984) observed high survival and weight gain associated with the *Spartina* sp. epiphytes, but *Spartina* sp. detritus alone did not promote growth of *F. aztecus* postlarvae. Accordingly, Sullivan & Moncreiff (1990) suggested that the direct contribution from *Juncus* sp. and *Spartina* sp. appear to be minor in the salt marsh food-webs.

Among the plant materials tested in the present study, *R. maritima* supported *F. paulensis* survival for a longer period, but growth was not significantly different from the Unfed treatment. Seagrasses contain nutritious substances such as starch granules (seeds and rhizomes) and soluble sugars (roots, rhizomes and leaves), especially sucrose (O'Brien 1994). Juveniles of *Penaeus esculentus* from seagrass beds were found to have eaten parts of the seagrass *Zostera capricorni* (O'Brien 1994). Primavera & Gacutan (1989) recorded a survival rate of 100% in *Penaeus monodon* juveniles fed on live *Najas graminea* after 30 days. These authors also observed that *P. monodon* utilized *R. maritima* directly as food, but a poor growth and a survival rate of 58.9% was observed. Fragments of *R. maritima* were observed in the gut contents of *F. paulensis* from the Patos Lagoon estuary (Asmus 1984; Jorgensen 1998), but its assimilation was not determined. Inside the pen enclosures used for *F. paulensis* culture in the Patos Lagoon estuary, the presence of vegetable matter is notably reduced or totally depleted at the end of the rearing cycle. It could be related to the seasonal cycle of plants, bioturbation and / or direct consumption by shrimp. The presence of *R. maritima* inside culture ponds resulted in high growth rates of *P. monodon* (Bombeo-Tuburan *et al*. 1993). However, these authors suggested that this growth might not have been directly due to *Ruppia* but rather to detritus and associated organisms. In accordance, the presence of *R. maritima* inside the pen enclosures could bring some benefits such as diversity of associated organisms and protection against cannibalism. Likewise, presence of plant material must be considered when selecting areas for *F. paulensis* culture inside the estuary.

Overall, growth performance of juveniles submitted to plant material was similar to the Unfed treatment. This result suggests that plant material used in the present work (i.e. *Spartina* sp., *Ruppia maritima* and *Enteromorpha* sp.) are not capable to support *F. paulensis* survival and growth when offered as the only food source. However, this submersed material can be a substrate for microbial colonization and biofilm development that could be eaten by shrimp and / or shrimp preys. Microbial biofilms that develop on submerged substrates are comprised of complex communities of autotrophic and heterotrophic organisms such as bacteria, protozoa, fungi and algae embedded in extra cellular polysaccharide matrix secreted by bacteria (Costerton & Irvin 1981). The biofilm can supply essential elements, such as polyunsaturated fatty acids, sterols, amino acids, vitamins and carotenoids (Thompson *et al*. 1999). For

F. paulensis its importance has been noticed to the enhancement of water quality and as a complementary food source in culture tanks (Thompson *et al*. 2002). Furthermore, biofilms showed to improve shrimp growth in cages in the Patos Lagon estuary (Ballester *et al.* 2003).

The present findings indicate that the plant materials usually ingested by *F. paulensis* during the estuarine phase of their life cycle do not represent a direct food source. However, organisms attached to the submerged plants could be explored by shrimp as an additional nutrients supply. Therefore, further research should be performed regarding this issue.

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