Asian Fisheries Science **13**(2000): 97-104
Asian Fisheries Society, Manila, Philippines
https://doi.org/10.33997/j.afs.2000.13.2.001

The Feeding of Juvenile Grooved Tiger Prawns *Penaeus semisulcatus* in a Tropical Australian Estuary: A Comparison of Diets in Intertidal Seagrass and Subtidal Algal Beds

D.S. HEALES

CSIRO Marine Division
PO Box 120, Cleveland, Qld 4163
Australia

Abstract

Diets of both newly settled (2 to 4.9 mm carapace length) and larger pre-emigrating (5 to 10 mm carapace length) juvenile grooved tiger prawns, *Penaeus semisulcatus*, from two entirely different nursery areas were compared. One site was a subtidal algal bed (*Cauleurpa* spp) inside a narrow mangrove-lined creek, while the other was a wide intertidal seagrass bed (*Enhalus acoroides)* on a straight shoreline in a medium size estuary. Both the newly settled and larger prawns consumed a similar range of prey categories in the two nursery areas. Similar high frequency of occurrence of common dietary items (copepods, diatoms and filamentous algae), were found in both sites. For the small prawns, 13 of the 21 prey categories recorded were common in both sites; while 14 of the 21 prey categories were common in the larger prawns. The small prawns had a lower frequency of occurrence than the larger prawns for most of the prey categories, particularly decapod crustaceans, suggesting a restricted diet for the small juveniles. One common prey item at the seagrass site, an insect larva, was not recorded in the algal site.

Introduction

Juvenile grooved tiger prawns *Penaeus semisulcatus* have been widely studied in Northern Australia, for example at the Cairns Harbour (Coles et al. 1993), around Groote Eylandt (Loneragan et al. 1994), and in the Embley River in the Gulf of Carpentaria (Vance et al. 1996a). These studies identified seagrass beds, both intertidal and shallow subtidal, as important nursery habitats, as well as provided estimates of growth and mortality, and seasonal and annual variations in abundance. Recent work has also shown that, in addition to seagrass beds, subtidal algal beds are likewise very important juvenile nursery areas during the pre-wet season in the Embley River (Haywood et al. 1995).

Although seagrass and algae both provide habitats with a vertical structure that appears necessary for the early life-history stages of tiger prawns, the subtidal algal beds are entirely different nursery habitats from the intertidal seagrass beds. For example, in the Embley River, subtidal algal beds are often found in the middle of small creeks less than 20 m wide, where *Cauleurpa* spp. grow rapidly during the late dry and pre-wet seasons. However, they disappear at the onset of the wet season (Haywood et al. 1995). Consequently, these ephemeral algal beds provide nursery habitats for tiger prawns only during the pre-wet season, whereas the intertidal seagrass beds remain and provide nursery habitats throughout the year (Haywood et al. 1995). Due to faster currents, coarser substrates, higher turbidity, permanent inundation and the ephemeral nature of the algal beds (Haywood et al. 1995), it would be reasonable to expect that the diet of juvenile tiger prawns in this habitat may be different from that of the seagrass habitat.

The diet of newly settled *Penaeus semisulcatus* on an intertidal seagrass bed in the Embley River estuary and the effects of the moult cycle on feeding have recently been described (Heales et al. 1996). However, there is no published information on the feeding of juvenile tiger prawns in the different algal habitats within small creeks, or on the diet of both the newly settled and larger juvenile tiger prawns in these subtidal habitats; nor is there information on whether the diet of newly settled prawns differs from the larger prawns prior to emigration. This study was undertaken to provide information on these topics.

Materials and Methods

Juvenile (2.0-10.0 mm carapace length CL) grooved tiger prawns *P. semisulcatus* were collected from an intertidal seagrass (*Enhalus acoroides*) site and a subtidal algal (*Cauleurpa* spp) site in the Embley river, Queensland, Australia (12° 40' S, 141° 50' E) (see Haywood et al. 1995 for detailed site description). A small beam trawl (1 m wide by 0.5 m high frame with a 2 mm mesh body and a 1 mm mesh codend) was used to collect samples from both sites between 1600 and 2000 h (around high tide) in late October 1994 (pre-wet season). At this time of the year, both the biomass of seagrass and algae, and the densities of postlarval and juvenile prawns are relatively high (Haywood et al. 1995). In this study, prawns were classified into two size groups - small: 2.0 to 4.9 mm CL and large: 5.0 to 10.0 mm CL. Juvenile *P. semisulcatus* found in nursery areas in the Gulf of Carpentaria were mostly less than 10 mm CL (Loneragan et al. 1994, Vance et al. 1996a) indicating that juveniles may begin emigrating off the nursery sites at very small sizes. Newly moulted prawns were not examined in this study. At the seagrass site, 30 small prawns and 24 larger prawns were collected, while 20 and 14 prawns respectively were collected from the algal site.

Prawns were snap frozen in an iced brine slurry at capture. In the laboratory, they were measured and moult staged. Foregut fullness was estimated on a scale of 0 (empty) to 10 (full) using a sorting microscope. Means of foregut fullness were compared using a t-test (SAS Institute Inc. 1989). The contents of the foregut were examined under a compound microscope using the methods described by Heales et al. (1996).

The frequency of occurrence (FOC) for each dietary item was recorded as the percentage of prawns in the sample with at least one of that prey category in its foregut. A Wilcoxon matched-pairs signed-ranks test was used to test for differences in the FOC between the two size groups of juveniles at each site, and also between sites for both size groups (Conover 1971). The mean number of copepods and insect larva (in foreguts of prawns that had eaten these prey), was calculated by dividing the total number of copepod carapaces and insect larva heads by the number of prawns which had at least one of the prey categories in their foreguts. The mean counts for these taxa were compared using a t-test (SAS Institute Inc. 1989).

Some species within the genus *Penaeus* have recently been renamed (Pérez-Farfante and Kensley 1997). However, since we do not agree with the new nomenclature, we have retained the old names for this paper.

Results

There were no significant differences ($p < 0.05$) between the mean carapace lengths (CL) of prawns in the two size groups from the two sites (Table 1). The mean foregut fullness ranged from 6.9 for small prawns in the algal site to 8.9 for the larger juveniles at the seagrass site (Table 1). The consistently high means of foregut fullness indicated that the dietary contents of foreguts could confidently be compared between sites and size classes.

Small prawns

Twenty-one prey categories were recorded in the foreguts of small prawns and 13 of these were common to both sites. An unidentified material which probably consisted of both animal and plant materials, was found in the foreguts of all small and larger prawns, with 100% frequency of occurrence (FOC) (see Heales et al. 1996). No significant differences were detected in the overall pattern of FOC between small prawns from the two sites (Wilcoxon, $t^{17} = 86$, $p > 0.05$). Copepods, diatoms, and filamentous algae (mostly *Polysiphonia*) were very common (FOC > 70%) in the diet of the small juveniles (Figs.1a, b). Ostracods were common in the foreguts of

Table 1. *Penaeus semisulcatus*. Size range, mean size [carapace length (CL) in mm] ± 1 SE, foregut fullness (scale 0-10) ± 1 SE, and sample size (N) of juvenile prawns from an intertidal seagrass and a subtidal algal site in the Embley River estuary in October 1994.

Site	Size range (mm CL)	Mean size (mm CL)	Foregut fullness Scale (0 - 10)	(N)
Seagrass	small (2.0 - 4.9)	4.0 ± 0.3	7.7 ± 0.1	30
(*Enhalus acoroides*)	large (5.0 - 10.0)	6.9 ± 0.3	8.9 ± 0.2	24
Algae	small (2.0 - 4.9)	4.1 ± 0.4	6.9 ± 0.1	20
(*Caulerpa* spp.)	large (5.0 - 10.0)	7.5 ± 0.8	7.9 ± 0.2	14

prawns from both sites (FOC = 30% in seagrass site and 20% in algal site). Insect larvae *Ceratopogonidae (Diptera*) were found in the foreguts only at the seagrass site (FOC = 33%), whereas an unidentified parasite was more common at the algal site (FOC = 65%) than at the seagrass site (10%).

The mean number (± 1SE) of copepods per foregut of small prawns did not differ significantly between the seagrass site (10.4 ± 1.7) and the algal site (11.5 ± 1.4) ($p = 0.7$). The mean number (± 1SE) of insect larva per foregut of prawns at the seagrass site was 1.5 ± 0.2, while none was found at the algal site.

Large prawns

Twenty-one prey categories were recorded in the foreguts of the larger juvenile prawns; 14 of these were common to both sites. No significant difference was observed in the overall pattern of FOC between the two groups of larger prawns from the two sites (Wilcoxon, $t^{19} = 83$, $p > 0.05$). As in the case of the small prawns, the most common items in the diet of the larger juveniles at both sites were copepods, diatoms, and filamentous algae (Figs. 1a, b). Decapod crustaceans also had high FOC - 58% and 71% at the seagrass and algal sites respectively. Again, insect larvae were found only at the seagrass site (Figs. 1a, b).

For those more common prey categories with a FOC > 25%, the larger prawns at the seagrass site had higher FOC than the small prawns - for filamentous algae, insect larvae, ostracods, foraminaferans, decapod crustaceans, unidentified eggs, tanaeids, and thick algae. Similarly for common prey categories (FOC > 25%) at the algal site, larger prawns had much higher FOC for ostracods, decapod crustaceans, polychaetes, thick algae, and gastropods, than the small prawns, although the small prawns had higher FOC for the unidentified parasite.

At the seagrass site, there was a significant difference in the overall pattern of FOC between the smaller and the larger prawns (Wilcoxon, $t^{18} = 18.5$ $p < 0.05$) but not at the algal site (Wilcoxon, $t^{19} = 71$, $p > 0.05$). The mean number (± 1SE) of copepods per foregut of the larger prawns was significantly higher at the seagrass site (17.2 ± 2.2) than at the algal site (5.7 ± 1.2) ($p = 0.0003$). At the seagrass site, the only site where insect larvae occurred, the mean number (2.2 ± 0.3) of insect larva per foregut of larger prawns was higher than that of the small prawns (1.5 ± 0.2) ($p = 0.9$).

Discussion

Although the intertidal seagrass and subtidal algal beds are entirely different in terms of tidal inundation, current flow rates, substrate type, and vegetation, the results of this study suggest that juvenile grooved tiger prawns consumed similar suites of prey categories at both locations. The absence of postlarvae and juvenile tiger prawns from the itinerant algal site during the late wet season reported by Haywood et al. 1995 may simply be

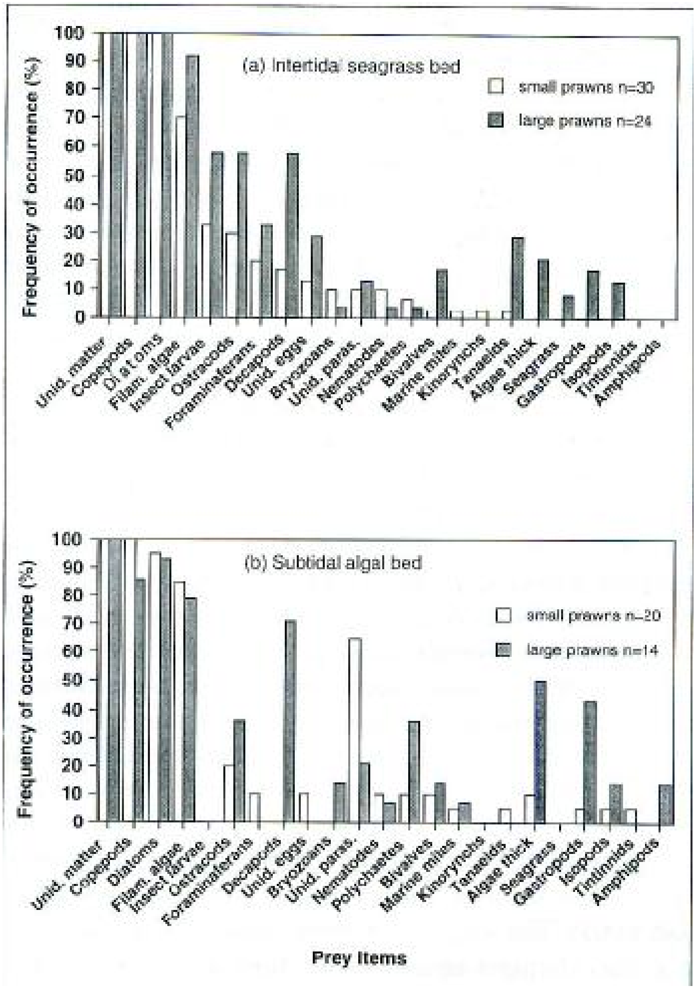

Fig. 1. *Penaeus semisulcatus*. Frequency of occurrence (FOC) (%) of prey items from foreguts of two size groups (2.0-4.9 mm carapace length and 5.0 - 10.0 mm carapace length) of juveniles from (a) an intertidal seagrass bed and (b) a subtidal algal bed.

due to the lack of algal structure and the refuge it provides for the prey. The most common food types at both sites were diatoms, copepods, and filamentous algae, confirming the results of a previous diet study at the seagrass site during the pre-wet season which also found that the FOC for these prey was higher than 70% (Heales et al. 1996).

Diets of juvenile penaeids are similar worldwide and in most cases include diatoms. High FOC of diatoms in juveniles from both the seagrass and algal sites is consistent with this pattern. Diatoms are reported to promote growth in wild-caught postlarval *P. aztecus* reared in a laboratory in Texas, USA (Gleason and Zimmerman 1984). Studies on small juveniles of another tiger species, *P. esculentus*, in Moreton Bay, Australia, also showed that diatoms were very common prey items (O'Brien 1994). However, juvenile prawns eat fewer diatoms as they grow into adults.

The absence of insect larvae from the diets of prawns at the algal site may have been due to the difference in substrate exposure between the intertidal seagrass bed and the subtidal algal bed. In the subtidal algal bed, the substrate is never exposed for the adults to lay their eggs on, but they almost certainly lay eggs on the adjacent intertidal mangrove forest substrate. Insect larvae have been found in the foreguts of juvenile *Penaeus merguiensis*, which inhabit the tropical mangrove-lined creek banks similar to those of the creek in this study (Robertson 1988). *P. merguiensis* juveniles do move up into the forest floor with the flood tide (Vance et al. 1996b) while the juvenile tiger prawns remain in the algal beds in the middle of the creek (Haywood et al. 1995).

Foraminaferans occurred in fewer foreguts (for both size groups of prawns) at the algal site compared to the seagrass site. They were recorded in only 10% of foreguts of the small prawns at the algal site, but were absent in the larger prawns, possibly reflecting reduced prey availability at this site. Other studies have shown that foraminaferans occurred in 54% of foreguts of juvenile Banana prawns (*P. merguiensis*) from the Straits of Malacca (Chong and Sasekumar 1981). These Banana prawns were of similar size (3.2 - 6.3 mm CL) to the juvenile tiger prawns from the present study, and they were collected from similar mangrove-lined nursery habitats.

Changes in diet with increasing prawn size have been found in many penaeid species, see Dall et al. 1990. Similar findings were reported for two size groups (2 to 5 mm CL and 9 to 12 mm CL) of juvenile brown tiger prawns *P. esculentus* (O'Brien 1994). In 15 out of 17 prey categories in that study, (where FOC > 10% for at least one of the groups), the small prawns had lower FOC than the larger prawns. For the other two prey categories, occurrences were almost equal. The vegetative components of the diet of *P. esculentus* in that study also changed as they grew from small (2 to 5 mm CL) to large juveniles (9 to 12 mm CL). A similar result was observed in our study for the prey item, thick algae, where the FOC for larger prawns at both sites was much higher than for the small prawns.

The high FOC of decapod crustaceans in the larger prawns in this study differs from the findings of Wassenberg and Hill (1987) who found none in the foreguts of larger juvenile *Penaeus semisulcatus* (mean size around 15.7 mm CL) from seagrass beds during December around the Groote Eylandt in the Gulf of Carpentaria. Our findings are more consistent with those for small *P. esculentus* from seagrass beds in Moreton Bay, Queensland (O'Brien 1994). That study showed that the FOC of decapod crustaceans in the smaller juveniles (2 to 5 mm CL, FOC 25%) was lower than for the larger juveniles (9 to 12 mm CL, FOC 90 to 100%). In our current study, when decapod crustaceans were found in the foreguts, they usually constituted the majority of the foregut volume, and those that could be identified, were mostly carids.

Although the FOC for copepods was high (86 to 100%) for prawns in both the algal and seagrass sites, and for both small and large prawns, the larger prawns at the algal site ate fewer copepods than the small prawns at this site, and both size groups of prawns at the seagrass site. The reason for this is unclear, unless copepods were less available to the larger prawns at the algal site. It would be expected that as prawns increased in size they would consume fewer of the very small prey items such as copepods. For the larger juvenile (mostly greater than 10 mm CL) *P. semisulcatus* from seagrass beds in the western Gulf of Carpentaria, the FOC for copepods also decreased with increasing prawn size (Wassenberg and Hill 1987). However, O'Brien (1992) reported only a minor drop in the FOC of copepods for *P. esculentus* as they grew from small (2 to 5 mm CL) to larger juveniles (15 to 18 mm CL). Another study of juvenile *Penaeus* spp. in Puerto Rico also reported that the occurrence of copepods in the diet decreased with an increase in prawn size (Stoner and Zimmerman 1988)

Conclusion

Although these two nursery areas are entirely different in terms of inundation, currents, substrates, and the ephemeral nature of the algae at the creek site, the range of prey categories consumed by both size groups of prawns are remarkably similar. Almost two-thirds of the prey categories recorded for each size group were common to both sites. The main difference between the two size groups at each site was the restricted diet for the small juveniles.

Acknowledgments

I thank P. Clymo, B. Hill, N. Loneragan, C. O'Brien, D. Vance and E. Wassenberg for their constructive comments on the manuscript. Funding for this study was provided by the Fisheries Research and Development Corporation of Australia (FRDC grant No. 92/45).

References

Chong, V.C. and A. Sasekumar. 1981. Food and feeding habits of the white prawn *Penaeus merguiensis*. Marine Ecology Progress Series 5:185-191.

Coles, R.G., W. Lee Long, R.A. Watson and K.J. Derbyshire. 1993. Distribution of seagrasses, and their fish and penaeid prawn communities, in Cairns harbour, atropical estuary, Northern Queensland, Australia. Journal of Marine and Freshwater Research 44:193-210.

Conover, W. J. 1971. Practical nonparametric statistics. J Wiley & Sons, New York.

Dall, W., B.J. Hill, P.C. Rothlisberg and D.J Staples. 1990. The biology of the Penaeidae. In: Blaxter, J.H.S., Southward A. J. (eds.) Advances in Marine Biology 27:1-489.

Gleason, D.F. and R.J. Zimmerman. 1984. Herbivory potential of postlarval brown shrimp associated with salt marshes. Journal of Experimental Marine Biology and Ecology 84:235-246.

Haywood, M.D.E., D.J. Vance and N.R. Loneragan. 1995. Seagrass and algal beds as nursery habitats for tiger prawns (*Penaeus semisulcatus* and *P. esculentus*) in a tropical Australian estuary. Marine Biology 122:213-223.

Heales, D.S., Vance, D.J. and Loneragan, N.R. 1996. Field observations of moult cycle, feeding behaviour, and diet of small juvenile tiger prawns *Penaeus semisulcatus* in the Embley River, Australia. Marine Ecology Progress Series.145:43-51.

Loneragan, N.R., R.A. Kenyon, M.D.E. Haywood and D.J. Staples. 1994. Population dynamics of juvenile tiger prawns (*Penaeus esculentus* and *P. semisulcatus*) in seagrass habitats of the western Gulf of Carpentaria, Australia. Marine Biology 119:133-143.

O' Brien, C.J. 1992. Some aspects of the production ecology of *Penaeus esculentus* Haswell (Decapoda: Penaeidae) juveniles. Ph.D. thesis. University of NSW.

O' Brien, C.J. 1994. Ontogenetic changes in the diet of juvenile brown tiger prawns *Penaeus esculentus*. Marine Ecology Progress Series 112:195-200.

Pérez-Farfante, I. and B. Kensley. 1997. Penaeoid and Sergestoid shrimps and prawns of the world, keys and diagnoses for the families and genera. Memoires du Museum National D'Histoire Naturelle. Tome 175.

Robertson, A.I. 1988. Abundance, diet and predators of juvenile banana prawns, *Penaeus merguiensis*, in a tropical mangrove estuary. Australian Journal of Marine and Freshwater Research 39:467-478.

SAS Institute Inc. 1989. SAS/STAT user's guide, Version 6, 4th edn, SAS Institute Inc. Cary, NC.

Stoner, A.W. and R.J. Zimmerman. 1988. Food pathways associated with penaeid shrimps in a mangrove-fringed estuary. Fisheries Bulletin 86(3):543-551.

Vance, D.J., M.D.E. Haywood, D.S. Heales, R.A. Kenyon, N.R. Loneragan and R.C. Pendrey. 1996b. How far do prawns and fish move into mangroves? Distribution of juvenile banana prawns, *Penaeus merguiensis* and fish in a tropical mangrove forest in northern Australia. Marine Ecology Progress Series 131:115-124.

Vance, D.J., M.D.E. Haywood, D.S. Heales and D.J. Staples. 1996a. Seasonal and annual variation in abundance of postlarval and juvenile grooved tiger prawns *Penaeus semisulcatus* and environmental variation in the Embley River, Australia: a six year study. Marine Ecology Progress Series 135:43-55.

Wassenberg, T.J. and B.J. Hill. 1987. Natural diet of the tiger prawns *Penaeus esculentus* and *P. semisulcatus*. Australian Journal of Marine and Freshwater Research 38:169-182.

Manuscript recieved 06 July 1998; Accepted 12 January 2000.