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Stomach Contents of the Banana Prawns (*Penaeus indicus* and *P. merguiensis*) in Tammalang Bay, Southern Thailand

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Abstract

The natural foods of *Penaeus indicus* and *Penaeus merguiensis* at Tammalang Bay, Satun Province on the Andaman Coast of southern Thailand were found to consist of seven major items. The frequencies of occurrence were 56-89% bivalves, 44-83% gastropods, 16-71% amphipods, 4-29% polychaetes, 20-44% foraminiferans, 25-52% plant tissues, and 4-23% diatoms. Bivalves and gastropods dominated. Although the frequency of occurrence and numerical composition of these benthic organisms in the diet were similar between shrimp species, they varied depending on seasons. Bivalves and amphipods were more common in shrimp caught in the SW monsoon season (July) than in the NE monsoon season (December). More gastropods and polychaetes were found in December than in July. Based on the frequency of occurrence, foraminiferans, plant tissues, and diatoms seemed to be regularly consumed even though the numerical composition per individual was low.

Introduction

The banana prawns, *Penaeus indicus* and *P. merguiensis*, are economically important marine products of several countries and most consumers prefer them to other penaeids. However, their supplies are mainly from the wild catch which has significantly declined during the last decade. In comparison, the black tiger prawn (*P. monodon*) is gaining popularity because of its greater availability resulting from successful intensive farming. Several private enterprises in Thailand have attempted to culture the banana prawn using techniques developed for farming the black tiger prawn, but the results were not promising. Although there are no published reports available, the

major problem with culturing banana prawns to date is high mortality through as yet unknown causes, likewise many prawns simply disappear from the grow-out pond, also through unknown causes. This was particularly noted at the 5-8 g growth stage, when the prawns are still too small to be considered for export markets. Among several possibilities, improper diet was a likely contributing factor to this mortality.

Information about natural prawn foods and their nutritional characteristics is an essential background for artificial diet formulation. On the basis of stomach content analysis, the natural diets of penaeid prawns in different regions have been reported by a number of authors. However, marked variations in results were noted. Hall (1962) examined 31 *Penaeus* species, and found that all species were omnivorous to some extent, but some species appeared to have specialised diets. Dall (1968) studied five Australian penaeid prawns and proposed that under natural conditions, penaeid prawns are considered to be "detritus feeders" or "omnivorous scavengers". According to Mohamed's review (1970), *P. indicus* fed mainly on crustaceans such as copepods, ostracods, amphipods, tiny decapods and their larval stages, whereas molluscs, polychaetes, echinoderm larvae, hydroids, trematodes and foraminiferans were occasionally found. Wassenberg and Hill (1987) reported that bivalves, gastropods, ophiuroids, crustaceans and polychaetes were the most abundant food items of juvenile and adult *P. esculentus* and *P. semisulcatus*. The authors also suggested that the differences in diet of the prawns could be attributed to differing availability of particular foods. Hill and Wassenberg (1987) demonstrated that *P. esculentus* prefers crustaceans as food over bivalves if a choice is offered. Reymond and Lagardere (1990) reported that juvenile *P. japonicus* seemed to be opportunistic carnivores, with a preference for macrobenthos and chironomids. Recently, Service et al. (1992) demonstrated that *P. setiferus* in microcosms prefers capitellid polychaetes over other macrobenthic taxa.

This study is part of a project to develop a high quality feed appropriate for intensive farming of the banana prawn by studying the nutritional composition of natural banana prawn diets. A preliminary step to this is naturally the determination of the actual diet in the wild of banana prawns, which was undertaken for this study, with special attention paid to the growth stages where high mortality was previously noted. The contents of the foregut were also compared with the natural benthic community in the study areas to make a preliminary assessment of natural foods preferred by the species.

Materials and Methods

Sample collection

Tammalang Bay (6° 30' N, 100° 5' E), Satun Province in southern Thailand, a rich mangrove coastal area with a clay substrate and a major nursery ground for many marine animals, was selected as a study site (Fig. 1). With certain exceptions for academic study, fishing is prohibited within 3 km of the shore, and both *P. indicus* and *P. merguiensis* are abundant and easily netted.

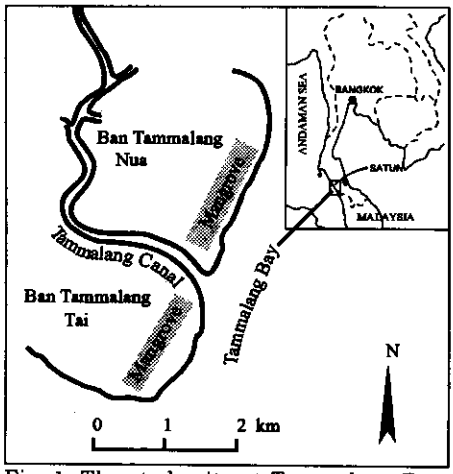

Fig. 1. The study site at Tammalang Bay, Satun Province, Thailand.

To investigate the diversity of the natural diet, samples were collected during the two major seasons of the region, the SW monsoon period in July and the NE monsoon in December 1994. Collections were undertaken during a single day at high tide. To include variations between daytime and nighttime feeding, samples were taken from 14.00-21.00 hours (4 hours of daylight and 3 from dusk to dark). The samples were gathered with a 3.5 cm push net from a small fishing boat at a depth of 2-3 m for about 2 km along the coast. In order to minimize enzymatic digestion of the ingested foods, prawns were successively harvested at 10-15 min intervals, and selected prawns were placed immediately into a -10 °C salt solution (2 kg salt granules + 6 kg ice cubes + 6 l sea water). After 2-3 h in the solution the individual sample was sealed in a plastic bag and refrigerated while waiting to be transported to a freezer in the laboratory. Prawn species were identified according to Grey et al. (1983), Chaitiamvong and Supongpan (1992), and Chaudhari and Jalihal (1993).

Quantification of food materials

Prior to dissection, the carapace length (CL) was measured, the foregut was dissected and the contents were washed into a petri dish for examination under stereo- and compound-microscopes. Only prawn stomachs full or nearly full of identifiable food items were examined. Silt and liquified detritus were excluded. Food items were identified to class or order. Enumeration of food items followed the method of Wassenberg and Hill (1987). The frequency of occurrence and numerical composition of particular food items were calculated as :

Frequency of occurrence = 100 x N_P/N'
where N_P = number of stomachs with a specific kind of food item
N' = total number of stomachs with food

Numerical composition = 100 x p/P
where p = total number of individuals or fragments of a given food item
P = total number of food items

Benthos community

Benthos community at three areas where the samples had been collected were investigated in order to verify the preference of natural foods ingested by

the prawns. Three bottom samples were taken from each sampling site at approximately 200 m intervals with a 0.05 m^2 Tamura's grab in July 1994.

Although several attempts were made to quantify all sizes and species of the benthos, this was not possible due to technical complications. Thus, only macrobenthic fauna could be collected and quantified (while microbenthic and meiobenthic fauna were semi-quantitatively examined) by successively sieving the sediment samples through 3 orders of screens of 5 mm, 1 mm and 0.5 mm mesh. The retained fauna were removed using forceps, fixed in 10% rose bengal formalin solution, then transferred to 70% ethyl alcohol before further identification in the laboratory.

Results

Prawn abundance and identification of food

Penaeus indicus and *P. merguiensis* were more abundant during the SW monsoon season (July) than during the NE monsoon season (December). *Penaeus merguiensis* was more dominant than *P. indicus* during both seasons (Table 1). The carapace length of the shrimps ranged from 1.2-2.8 cm.

The foreguts of 404 (July) and 147 (December) *P. merguiensis*, and 53 (July) and 35 (December) *P. indicus* were examined. Some 84-91% of *P. merguiensis* and 71-91% of *P. indicus* contained food. Prawns with empty stomachs were more often found during the NE monsoon season.

The diversity of natural foods of both species were somewhat similar (12-15 taxa), although *P. indicus* contained fewer food items (Tables 2 and 3). The seven major food items were bivalves, gastropods, amphipods, polychaetes, foraminiferans, plant tissues and diatoms.

Bivalve shells from the foreguts were often found with small soft tissues attached at the umbo while gastropod shells were occasionally found with soft tissues still attached to the helix. Amphipods with head or abdominal parts remaining were recognized. However, most materials were only exoskeleton parts. Polychaete materials found were body parts with parapodia and seta. The jaws were not often seen. Most foraminiferans were found with a complete test. Diatom valves were clearly distinguished, but vascular plants were seen only as cell walls which could not be identified.

Table 1. Composition of banana prawns caught in July and December 1994.

Species	July			December		
	Total catch	Contained food	%	Total catch	Contained food	%
Penaeus indicus	53	48	91	35	25	71
P. merguiensis	404	367	91	147	123	84

Table 2. Stomach contents of *Penaeus indicus* in July and December 1994.

Food item	Frequency of occurrence (%)			Numerical composition (%)		
	July	Dec	Mean	July	Dec	Mean
Bivalvia						
Unidentified species	81.3	56.0	68.6	42.0	23.2	32.6
Gastropoda						
Unidentified species	43.8	76.0	59.9	9.8	40.5	25.1
Crustacea						
Amphipoda	70.8	16.0	43.4	35.1	7.8	21.4
Brachyura	2.1	0.0	1.0	0.1	0.0	0.0
Isopoda	4.2	0.0	2.1	0.2	0.0	0.1
Mysidacea	2.1	0.0	1.0	0.3	0.0	0.2
Foraminifera						
Unidentified species	39.6	20.0	29.8	4.9	5.0	4.9
Polychaeta						
Unidentified species	4.2	24.0	14.1	0.1	4.6	2.4
Bacillariophyceae						
Unidentified diatoms	14.6	4.0	9.3	1.0	1.3	1.2
Others						
Plant tissue	25.0	52.0	38.5	4.0	11.3	7.6
Unidentified eggs	0.0	8.0	4.0	0.0	6.3	3.1
Fish scale	4.2	0.0	2.1	2.6	0.0	1.3

Table 3. Stomach contents of *Penaeus merguiensis* in July and December 1994.

Food item	Frequency of occurrence (%)			Numerical composition (%)		
	July	Dec	Mean	July	Dec	Mean
Bivalvia						
Unidentified species	89.1	72.4	80.7	49.2	34.9	42.0
Gastropoda						
Unidentified species	52.0	82.9	67.5	12.7	37.7	25.2
Crustacea						
Amphipoda	64.3	28.5	46.4	22.7	8.7	15.7
Brachyura	2.7	2.4	2.6	0.1	1.3	0.7
Cirripedia	0.0	0.8	0.4	0.0	0.5	0.2
Copepoda	2.2	2.4	2.3	0.5	0.2	0.3
Isopoda	5.5	0.8	3.1	0.6	0.1	0.3
Mysidacea	0.5	0.0	0.3	0.0	0.0	0.0
Foraminifera						
Unidentified species	43.6	30.9	37.2	6.0	2.7	4.3
Polychaeta						
Unidentified species	7.6	29.3	18.5	1.0	8.7	4.9
Bacillariophyceae						
Unidentified diatoms	22.9	4.9	13.9	2.5	1.1	1.8
Nematoda						
Unidentified species	0.0	1.6	0.8	0.0	0.1	0.1
Others						
Plant tissue	31.6	35.0	33.3	4.0	3.4	3.7
Unidentified eggs	0.0	0.8	0.4	0.0	0.8	0.4
Fish scale	2.2	0.0	1.1	0.7	0.0	0.4

Comparison of diet between prawn species

Bivalve and gastropod shells, and amphipods made up most of the foregut contents of both prawn species. These three groups were commonly found in the diet and at high frequency in both species.

Penaeus indicus had a frequency of occurrence of bivalves, gastropods and amphipods in the gut ranging from 56.0-81.3%, 43.8-76.0% and 16.0-70.8%, respectively (Table 2). *Penaeus merguiensis* had a frequency of occurrence of bivalves, gastropods, and amphipods in the gut ranging from 72.4-89.1%, 52.0-82.9% and 28.5-64.3%, respectively (Table 3). The other four major food groups showed similar frequencies of occurrence and abundance between the two prawn species. Although foraminiferans, plant tissues and diatoms were frequently found in the diet, the percentages of numerical composition were rather low. Cirripedia (barnacle) larva, copepods and nematodes were not seen in *P. indicus* during either season.

Comparison of diet between seasons

The frequency of occurrence and numerical composition of foods showed a seasonal fluctuation, but their trends were the same. Bivalves and amphipods were more common during the SW monsoon season than during the NE monsoon season, while gastropods and polychaetes were more common during the NE monsoon season.

Foraminiferan tests, plant tissue and diatoms also showed seasonal variation in frequency of occurrence but slight numerical difference. Their frequency of occurrence was higher in the SW monsoon season than in the NE monsoon season. Although they were staple food items, the numerical composition in each stomach was low (Tables 2 and 3).

Diversity of benthos

A wide range of benthos was found in the sediment samples including polychaetes, amphipods, bivalves, copepods, crabs (Brachyura), echinoderms, gastropods, nematodes and foraminiferans. Plant tissues were also distributed in all the examined samples. Polychaetes, amphipods and bivalves were the predominant groups.

Discussion

A principal problem of using stomach content analysis to determine natural diets is differential digestion rates for hard and soft tissues that can bias results because identification relies largely upon hard parts. Jones (1968) and Hyslop (1980) examined this problem related to fish stomach contents. Only recently ingested foods were easily identified and large masses of unidentified organic materials were recorded (Schroeder 1983). However, more recent studies on shrimp feeding behaviour showed that *P. esculentus* emptied its foregut

of soft tissue within 1 h (Hill and Wassenberg 1987). Marte (1980) demonstrated that *P. monodon* digests 53% of its soft food within 1 h of feeding. Accordingly, the potential problems of bias resulting from quick digestion in the present study were minimised by immediately chilling the samples to -10 °C within 10-15 minutes of being collected, and the samples were kept thus chilled until the analysis was performed. In many circumstances, the more reliable results could be obtained by combination of the hard parts with soft tissue fragments.

Molluscs, crustaceans and polychaetes are the major natural diets of many penaeid species, including *P. indicus*, *P. merguiensis* and *P. monodon* (Chaitiamvong 1980; Marte 1980; Thomas 1980; Chong and Sasekumar 1981; Moriarty and Barclay 1981; Wassenberg and Hill 1987). In the present study, polychaetes were much less evident than molluscs or crustaceans. This may be because the dominant polychaete found in the area is sedentaria polychaetes, most of which have no hard parts (jaws) (Day 1967), making them hard to be identified. Foraminiferan tests and plant tissue were found in low densities but they occurred in many individuals.

Copepods were seldom found in the gut of *P. merguiensis*. According to Wassenberg and Hill (1987), small copepods were more likely to be consumed by smaller (6-10.9 mm CL) than larger (16-20.9 mm CL) *P. esculentus* caught in the same trawl in Moreton Bay, Australia, possibly explaining this lack in *P. merguiensis* in our study. Food eaten by prawns varies depending on the prey/predator relative sizes and on prawn ecology (Reymond and Lagardere 1990).

The common food items in the guts of *P. merguiensis* in the Gulf of Carpentaria, Australia (Wassenberg and Hill 1993), crustaceans, bivalves, gastropods and polychaetes, were similar to the findings in the present study, though the proportion of each food item was different. There are various factors affecting the penaeid stomach content such as tidal stage (Marte 1980; Wassenberg and Hill 1993), daylight, size of shrimp (Wassenberg and Hill 1987; Wassenberg and Hill 1993), sex (Marte 1980), moult stage (Hill and Wassenberg 1992), geographical location and availability of food items, seasonal change (Wassenberg and Hill 1987; Moriarty and Barclay 1981), prey/predator relative size (Reymond and Lagardere 1990) and shrimp preference (Wassenberg and Hill 1987; Hill and Wassenberg 1992). However, these factors were not taken into account because it aims to formulate a practical diet for culture of *P. indicus* and *P. merguiensis* whereas most of these factors are not important in farm conditions. In addition, some feeding behaviours leading to applicable shrimp feeding regime will be further studied.

Our study shows that *P. indicus* and *P. merguiensis* are predators of some benthic invertebrates. The frequencies of occurrence in the diet seem to vary seasonally (more seasonal study is needed to confirm this). The main food items are more variable during the SW monsoon season than during the NE monsoon season. The major food items also change due to the seasonal variation of the benthos community structure. Further study on the chemical composition of ingested foods should be useful for formulating a practical diet for farming these penaeid prawns.

Although the results from this study on the benthos community were not quantitatively verified, they suggested a positive correlation between the frequency of occurrence of food items in the foregut of the banana prawns and the predominant groups of the benthos community. However, a major exception was echinoderms, which were frequently found in the sediments but were not observed at all in the prawn foreguts of the study. Also, polychaetes, which were the dominant group in the sediments, were found in low numbers and frequency of occurrence, although, as noted above, this may be due to the fact that these particular polychaetes have no hard body parts, which may hasten their digestion.

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References

Chaitiamvong, S. 1980. The biology of penaeid shrimps of Thailand. In : Report of the Workshop on the Biology and Resources of Penaeid Shrimps in the South China Sea Area-Part 1. During 30 June - 5 July 1980, held at Kota Kinabulu, Sabah, Malaysia. pp. 64-69. FAO/UNDP, Manila, Philippines.

Chaitiamvong, S. and M. Supongpan. 1992. A guide to penaeoid shrimps found in Thai waters. Australian Institute of Marine Science, Townsville, Australia.

Chaudhari, K.J. and D.R. Jalihal. 1993. A field key to the seed of penaeid prawns along the Konkan Coast (west coast of India). Crustaceana 65: 318-335.

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

Dall, W. 1968. Food and feeding of some Australian penaeid shrimps. FAO Fisheries Report Series 57: 251-258.

Day, J.H. 1967. A monograph on the Polychaeta of Southern Africa. Part I and II. Trustees of the British Museum (Natural History). London.

Grey, D.L., W. Dall, and A. Baker. 1983. A guide to the Australian penaeid prawns. Northern Territory Government Printing Office, Darwin, Australia.

Hall, D.N.F. 1962. Observations on the taxonomy and biology of some Indo-West- Pacific Penaeidae (Crustacea, Decapoda). Colonial Office Fishery Publications No. 17. Her Majesty Stationery Office, London.

Hill, B.J. and T.J. Wassenberg. 1987. Feeding behaviour of adult tiger prawns, *Penaeus esculentus*, under laboratory conditions. Australian Journal of Marine and Freshwater Research 38: 183-190.

Hill, B.J. and T.J. Wassenberg. 1992. Preferences and amount of food eaten by the prawn *Penaeus esculentus* over the moult cycle. Australian Journal of Marine and Freshwater Research 43: 727-735.

Hyslop, E.J. 1980. Stomach contents analysis - a review of methods and their application. Journal of Fish Biology 17: 411-429.

Jones, R.S. 1968. A suggested method for quantifying gut contents in herbivorous fishes. Micronesica 4: 369-371.

Marte, C.L. 1980. The food and feeding habit of *Penaeus monodon* Fabricius collected from Makato River, Aklan, Philippines (Decapoda: Natantia). Crustaceana 38: 225-236.

Mohamed, K.H. 1970. Synopsis of biological data on the Indian prawn Penaeus indicus H. Milne Edwards, 1837. FAO Fisheries Report No. 57(4): 1267-1288.

Moriarty, D.J.W. and M.C. Barclay. 1981. Carbon and nitrogen content of food and the assimilation efficiencies of penaeid prawns in the Gulf of Carpentaria. Australian Journal of Marine and Freshwater Research 32: 245-251.

Reymond, H. and J.P. Lagardere. 1990. Feeding rhythms and food of *Penaeus japonicus* Bate (Crustacea, Penaeidae) in salt marsh ponds: role of halophilic entomofauna. Aquaculture 84: 125-143.

Schroeder, G.L. 1983. Stable isotope ratios as naturally occurring tracers in the aquaculture food web. Aquaculture 30: 203-210.

Service, S.K., R.F. Feller, B.C. Coull and R. Woods. 1992. Predation effect of three fish species and a shrimp on macrobenthos and meiobenthos in microcosms. Estuarine, Coastal and Shelf Science 34: 277-293.

Thomas, M.M. 1980. Food and feeding habits of *Penaeus semisulcatus* de Haan at Mandapam. Indian Journal of Fisheries 27: 130-139.

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.

Wassenberg, T.J. and B.J. Hill. 1993. Diet and feeding behaviour of juvenile and adult banana prawns *Penaeus merguiensis* in the Gulf of Carpentaria, Australia. Marine Ecology Progress Series 94: 287-295.

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