African Journal of Biotechnology Vol. 11(22), pp. 6153-6159, 15 March, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.2192
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Food selection preference of different ages and sizes of black tiger shrimp, *Penaeus monodon* Fabricius, in tropical aquaculture ponds in Malaysia

Abu Hena, M. K.[1,2]* and Hishamuddin, O.[3]

[1]Department of Animal Science and Fishery, Faculty of Agriculture and Food Sciences, University Putra Malaysia, Bintulu Sarawak Campus, 97008 Bintulu, Post Box No. 396, Naybau Road, Sarawak, Malaysia.
[2]Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong 4300, Bangladesh.
[3]Department of Biology, Faculty of Science, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

Accepted 9 December, 2011

The investigation of food and food selection preferred by different sizes (PL_{15} to adult) of black tiger shrimp, *Penaeus monodon* Fabricius 1798, was carried out in tropical aquaculture ponds. Post larvae (15.2 ± 3.5 mm) and juveniles (65.2 ± 5.9 mm) foregut contains detritus (unidentified materials) followed by diatoms (*Pleurosigma* sp., *Navicula* sp., *Nitzchia* sp. and *Cosinodiscus* sp.), crustacea and insecta. The subadult (86.4 ± 8.9 mm) and adult (132.0 ± 12.8 mm) shrimp feed on detritus, crustacea, mollusca, annelida, rotifera, insecta and phytoplankton. However, it was found that the food selection preference of *P. monodon* is dependent on the availability of food items in the pond bottom. The tendency to prefer natural food by shrimps was observed when the food was available. The benthic organisms declined at the end of the culture period indicating that the culture species, that is, shrimps preyed on them as living or dead food along with artificial diets and detritus. Shrimps are detritivorous when benthic organisms are scarce. This fact shows that benthic detritus is considered a good food supplement for shrimps since it consists of cellulose, lignin, protein, starch, fats waxes and oils.

Key words: Aquaculture, natural food, *Penaeus monodon*, Malaysia.

INTRODUCTION

Shrimp farming has been rapidly developed from extensive to intensive system in response to the dramatic increase in the economic importance of seafood and the decline in natural stocks due to pollution and over exploitation. Beside the development of culture systems, considerable research finding was implemented to formulate artificial diets (Akiyama and Chwang, 1989; Akiyama et al., 1992; Alava and Lim, 1983: Alava and Pascual, 1987). However, the knowledge of the contribution of natural diets together with artificial diets to shrimp growth in earthen ponds is still scarce.

Many researchers who reported on the diet of *Penaeus* species in coastal areas, adjoining mangrove shore and estuaries (Marte 1980, 1982; Chong and Sasekumar, 1981; El Hag, 1984; Leh and Sasekumar, 1984), suggested that shrimps feed mostly on algae (plant macrophytes and phytoplankton) and meio-benthos. In addition, penaeid shrimp is able to select its food and the feed selection depending on the locality and availability of food items. Panikkar (1952) observed the food of young penaeids in India, while Hall (1962) investigated the food of *Penaeus monodon* in the Straits of Malacca, Malaysia for 35 specimens in the size range of 17 to 33 mm carapace length (CL), and *P. monodon* was found to feed mainly on crustaceans and plant matter. Tiews et al. (1976) observed that *Penaeus merguiensis* feeds mainly on phytoplankton and benthic foraminiferans in Manila and San Miguel Bays of the Philippines.

The stomach content of penaeid shrimp has been studied elsewhere, but the studies were for a selected type of species size (that is, subadult or adult) with carapace length of 17.0 to 69.0 mm. However, very little

*Corresponding author. E-mail: hena@btu.upm.edu.my.

study has been conducted for *P. monodon* in regard to different sizes, that is, body weight, body, carapace and rostrum length from post larvae (PL) to adult in the culture ponds. Keeping these views in mind, this study aimed to investigate the feeding behavior from the PL to adult stage of *P. monodon* during the whole culture period. It is hoped that the present paper will help to give an understanding of the feeding biology and behavior of *P. monodon* in the different life stages of shrimps through out the culture period in tropical aquaculture ponds. Lastly, the findings of this study will help to reduce the aquaculture costs in terms of natural food management and their availability in the culture ponds of the tropics.

MATERIALS AND METHODS

This study was conducted in LPP (Lembaga Pertubuhan Peladang) shrimp farm Malacca, Malaysia (2° 08' 50" N and 102° 24' 00" E). Two culture ponds were selected for this study. Between the two ponds, one pond was three years old and considered as an aged pond (4225 m^2), while the other one was newly constructed by clearing mangroves and considered as a new pond (4355 m^2). The culture ponds were prepared by draining and drying. Surface sludge was removed manually by flashing with hose pipe in the aged pond. Lime was applied at 4.75 t in the aged pond and 3.52 t in the new pond. Tea seed cake (TSC) was used at 0.5 t in the new pond, whereas, no TSC was applied in the aged pond. At the beginning, the pond was filled with about 20.0 to 30.0 cm depth of water, which allowed the growth of phytoplankton and was kept for one week. Water depth was then adjusted to 1 m prior to stocking. Stocking density was 19 PL 15/m^2 both in the aged pond and the new pond. During the culture period, 50% of water was changed once in the aged pond. However, in the new pond 50% of water was changed three times through out the culture period. The water was discharged through a channel to the adjacent water body and refilled through pump from reservoir. A commercial 35 to 40% protein shrimp growout feed (Gold Coin, Singapore) was given at 10% body weight/day for the first month and 4 to 6% for the rest of the culture period. The management of all the culture ponds was controlled and done by the owner of the farm so it was considered as a case study. Therefore, it was not possible to set up any experiment in the pond to maintain all parameters in uniform condition.

Collection of shrimp

Shrimp sample at the various stages of their life cycle was collected at every three-week interval from the culture ponds. A total of 98 shrimps at the different stages from the selected ponds were studied. PL (13.2 ± 4.0 mm) were collected from the supplied hatchery before stocking them into the ponds. Other shrimp samples were collected during every visit from the feeding trial prior to the administering of feed. Collected shrimps were preserved in 10% buffer formalin as soon as possible after collection and brought back to laboratory for further analysis. Morphological characteristics, that is, body weight, body length, carapace length and rostrum length were recorded for each specimen prior to dissection.

Estimation of foregut content

The foregut contents of shrimp were examined for their composition and occurrence. Only the food of anterior chamber of the stomach was considered so as to avoid the food that has been ground as a fine powder by the gastric armature in the posterior chamber. The fullness of the foregut was determined visually and classified as follows: 1, fully swallowed with food; ¾, full, but not swallowed; ½, full; ¼, containing a few but considerable amount of food; 0 - empty with very few amount of fine debris (Chong and Sasekumar, 1981).

The gut from each shrimp (PL_{15} to adult) was opened under a dissecting microscope (LEICA MZ6) and then emptied into 70% alcohol in a Petri dish and thoroughly examined. Gut content were examined microscopically and all identifiable food items were noted in order to determine the percentage of volumetric composition and frequency of occurrence of the food items present. The percentage of volumetric composition of each food item was described according to Thong and Sasekumar, (1984) as the ratio of the volume displaced to the total volume of stomach contents detected by the procedure. The eye estimation method using a grid marking (0.5 x 0.5 cm) was used. The number of squares occupied by each food item was counted and then converted into the percentages of the total number of squares occupied by all the food items.

The percent occurrence of each food item in the foregut was estimated as follows:

(Number of individual food item in the shrimp foregut / Total number of foregut examined for that species) × 100

Food items were identified as far as possible in most cases to the family level following Mori (1964), Chihara and Murano (1997), Arvin (1977), Wickstead (1965), Newell and Newell (1963), Arnold and Birtles (1989), Chuang (1961), Berry (1964 and 1972), Giere (1993), Day (1967) and Fauchald (1977). The food items were classified as unidentified debris (pellets, decaying plant fragments, algae, mangrove roots, grit and unrecognizable material) insecta, rotifera, phytoplankton, crustacean, mollusca, and annelida. In the case of larger stomach, sub samples of the homogenized contents were investigated.

Collection of Benthos

The abundance of macro and meiobenthos was investigated at every three-week interval. Ekman grab sampler covering an area 225 cm^2 was used for macro- benthos collection. Three samples were collected at every three-week interval in a diagonal direction (corner to corner) from each pond. For meiobenthos collection, Ekman grab sampler was brought down into the sediment as slow as possible by using a long wooden bar instead of a rope to avoid the turbulence of pond bottom. Later on, a 2 cm tube core was used inside the Ekman grab to collect meiobenthos (Prof Dr Yoshihisa Shirayama, University of Tokyo, personal communication). All samples were preserved immediately with 10% buffered formalin mixed with one to two drops of rose Bengal. Rose Bengal was used to make the collected specimens to be visible easily during the culture period. In the laboratory, the samples were sieved through a 1000 µm mesh screen to retain macrobenthos and 53 µm mesh screen for meiobenthos. All macrobenthos and meiobenthos were observed and identified under the compound (LEICA Zoom 2000) and dissecting microscope (LEICA MZ6). The organisms were counted and calculated for total amount in m^2 for macrobenthos and 10 cm^2 for meiobenthos.

RESULTS AND DISCUSSION

The frequency of foregut studied in the different ages and sizes of *P. monodon* shrimp in regard to fullness is shown

Table 1. Frequency of stomach studied in the different ages and sizes of *P. monodon* from the aquaculture ponds.

Shrimp size	Stomach fullness					Shrimp studied
	0	¼	½	¾	1	
PL_{15}						
BL 9.5 - 13.0 mm						
RL 1.0 - 2.0 mm						
CL 2.0 - 3.0 mm						
BW 2.2 - 7.3 mg	2	-	9	-	2	13
1st Week (PL_{30})						
BL 16 - 22 mm						
RL 4.0 - 5.0 mm						
CL 4.0 - 5.0 mm						
BW 18.9 - 67.1 mg	1	-	4	2	4	11
4th Week (Juvenile)						
BL 52 - 71 mm						
RL 11 - 13 mm						
CL 11 - 16 mm						
BW 0.963 - 1.59 g	2	-	7	2	2	13
7th Week						
BL 75 - 102 mm						
RL 13 - 18 mm						
CL 18 - 24 mm						
BW 2.51 - 5.99 g	7	-	6	2	2	17
10th Week						
BL 91 - 125 mm						
RL 16 - 24 mm						
CL 22 - 32 mm						
BW 4.31 - 13.18 g	2	3	3	4	3	15
13th Week						
BL 125 - 155 mm						
RL 24 - 35 mm						
CL 31 - 39 mm						
BW 13.38 - 24.39 g	5	3	5	1	3	17
16th Week						
BL 155 - 162 mm						
RL 30 - 34 mm						
CL 41 - 45 mm						
BW 24.81 - 30.81 g	-	1	2	2	7	12

CL, Carapace length; BW, body weight, BL, body length; RL, rostrum length.

in Table 1. The study found that the foregut of shrimp contained a wide variety of food and this depended on shrimp size and age, as well as availability of benthic and pelagic organisms in the ponds. Unidentified debris was common and found in all sizes and ages of foregut of the shrimps throughout the culture period. The percentage of volumetric composition of unidentified debris ranged from 27.72 to 95.01%. Compared to other food items, unidentified materials were found to be in higher amounts during the early stages of the shrimps (PL_{15} to PL_{30}) as these stages prefer to consume plant materials such as algal mat (lablab), small particles and phytoplankton, which may easily decompose into non-defined detritus accumulation that are difficult to identify due to their poor physical state. Phytoplankton present was 54.1% in juvenile shrimps followed by crustacea (9.79 to 28.06%), rotifera (5.26 to 22.66%), annelida (3.88 to 18.67%) and gastropoda (1.01 to 6.03%) at the subadult through adult stage of shrimps (Figure 1 and Plate 1). The volumetric composition in the stomach of adult shrimps (16th week) consisted of 16.24% Mysid. However, it is still unknown whether organisms preyed upon by shrimps were dead or alive before consumption. The large and fast moving organisms were probably not preyed upon, but consumed while dead.

Beside detritus, the other food items consisted of crustacea (mainly copepoda), rotifera and phytoplankton in the foregut of PL_{15} to juvenile shrimp stages (Figure 1). Various earlier researches support this study that detritus is the primary food in shrimp ponds, regardless of the abundance of different live food organisms (Bombeo et al., 1993). Studies by Bombeo et al. (1993) stated that detritus was the common food item in the foregut of PL *P. monodon* followed by copepoda remains and diatoms. Kumari et al. (1978) stated that detritus have higher nutritive energy value than the live phytoplankton and zooplankton. Furthermore, Panikkar (1952) also observed that the food of penaeid shrimps consist of organic detritus, algal materials and microorganisms.

The subadult and adult shrimps' foregut contains detritus, crustacea, annelida, gastropoda and rotifera (Figure 1). Detritus (unidentified materials) ranked the highest in terms of frequency of occurrence in all shrimp gut contents (58.82 to 100%). The percentage occurrence of detritus was increased to 100% at the end of culture period, while other benthic organisms were less in the foregut of shrimps. This fact indicates that the foregut of all the studied shrimps was full with detritus at the end of culture cycle, coinciding with lower amounts of edible benthos in the ponds (Figures 1, 2 and 3). Quasim and Easterson (1974) reported that shrimps were shown to assimilate 93% of estuarine detritus. In the group of crustacea, copepoda was the major food item preyed by all sizes and ages of shrimps throughout the culture period, which cover 16.67 to 90.91% of the occurrence. May be this is due to presence of copepoda throughout the duration of culture period in the ponds. Chen and Chen (1992) stated that PL and juvenile *P. monodon* feed heavily on live zooplanktons which were found to have significantly decreased in ponds after the inoculation of PL shrimps in Taiwan. Rubright et al. (1981) suggested that the transformation of zooplankton populations into detritus could enrich the benthic food chain in culture ponds. Compared to other stages of shrimps (PL_{15} to subadult), the zooplankton fragments were less in the foregut content of adult shrimps indicating that the small size of zooplankton may be the main reason for the rejection of its role as a direct food source for the adult benthic shrimps. Mollusca were present in the foregut of subadult (86.4 ± 8.9 mm) and adult (132.0 ± 12.8 mm) shrimps when they were available in the ponds and were preyed upon by these stages of shrimps.

The present result indicates that subadult and adult *P. monodon* are omnivorous scavengers which feed on variety of benthic materials and organisms, that is, detritus, copepoda, ostracoda, mysidacea, nauplii, insecta, gastropoda, bivalva, ploychaeta, rotifera and phytoplankton, and eat all these food items when they are available in the culture ponds. Hall (1962) found out that the penaeid shrimps consume crustacea, plant matter, annelida, mollusca and small fish in estuarine water. Chong and Sasekumar (1981) stated that organic detritus probably supplement when other preferred food items are inadequate. It is not well known whether shrimps directly utilize detritus, however, unidentified detritus was observed in the foregut. The detritus is known to serve as a substrate for microorganisms, that is, bacteria (Boyd, 1995). However, these microbes are probably more important for the culture species since it consists of cellulose, lignin, protein, starch, fats, waxes and oils (Darnell, 1974; Boyd, 1995). Dall (1968) also suggested that the bacterial colonies might be an important component of diet for penaeid shrimps.

Generally, with the exception of grastropoda, the total benthos abundance in both ponds decreased gradually throughout the culture period (Figure 2). This fluctuation of gastropoda abundance may be due to the rejection of bigger size (1.46 ± 0.67 cm) of *Telscopium telescopium*, which shrimps may be unable to prey upon and consume. The meiobenthos declined gradually as the culture period progressed (Figure 3). However, the selection of food preferred by *P. monodon* depended on the availability of food items in the ponds. The tendency to prefer natural food by the shrimps was found when these organisms were present in the studied ponds. Comparatively, a higher percentage of food items was found in the foregut of the shrimps collected from aged pond since it contained a higher amount of benthic organisms than the new pond (Figures 2 and 3). However, the decrease of overall benthic organisms may be due to the predation of the shrimps throughout the culture period or may because of organic matter input into the ponds from uneaten feed, fecal matters and dead organisms, which produce toxic gases for benthic dwellers as well as for culture species shrimp.

ACKNOWLEDGEMENTS

The authors highly acknowledge the Department of Biology, Faculty of Science and Environmental Studies for providing facilities, and Malaysian Government for providing funds through the project No. 01-02-04-0529-EA001 of Intensification of Research in Priority Areas (IRPA).

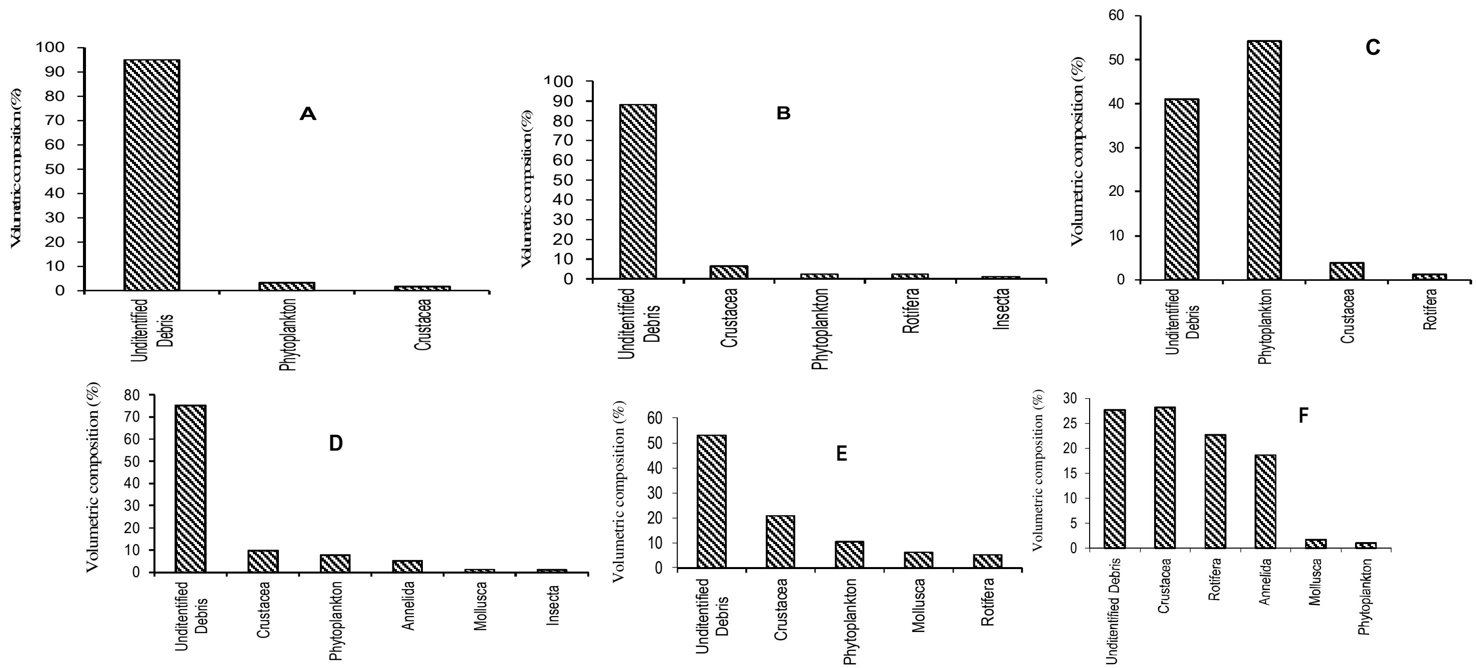

Figure 1. Percentage volumetric composition of different stages of *P. monodon* in aquaculture ponds. [A] PL_{15} (carapace length (CL) 2.0 to 3.0 mm); [B] 1st week PL_{30} (CL- 4.0 to 5.0 mm); [C] 4th week, Juvenile (CL- 11.0 to 26.0 mm); [D] 7th week, subadult (CL- 18.0 to 24.0 mm); [E] 10th week, adult (CL- 22.0 to 32.0 mm); [F] 13th week, adult (CL-31 to 39 mm); [G] 16th week, adult (CL- 41.0 to 45.0 mm).

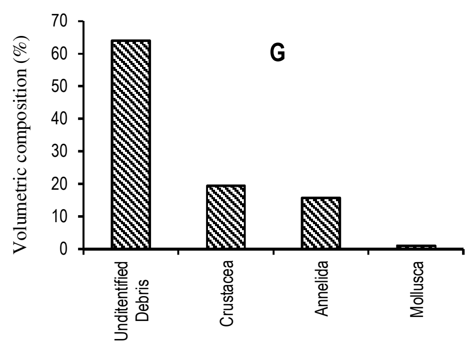

Figure 1. Contd.

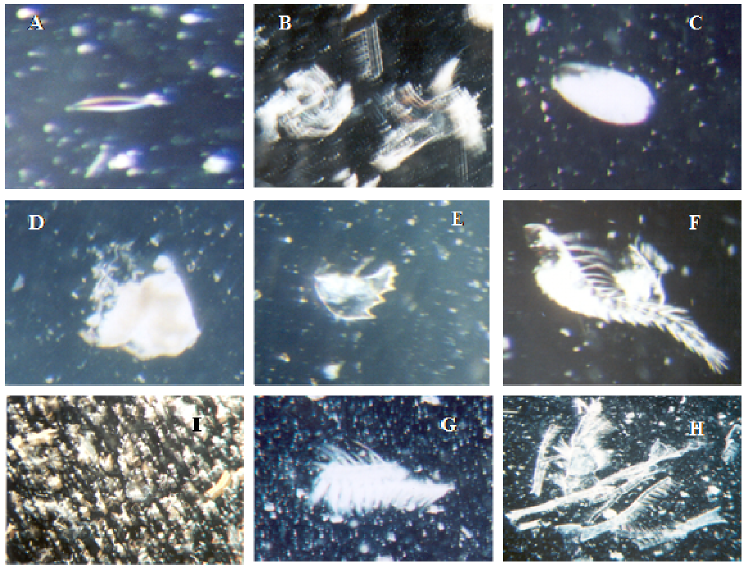

Plate 1. Appendages or body parts of natural food organisms found in the stomach of shrimp during different study periods. [A] Phytoplankton (4th week; x32); [B] crustacean appendages (7th week; x8); [C] ostracodes (7th week; x16;) [D] gastropod (10th week; x20); [E] Crustacean mouth organ (10th week; x16); [F] polychaetes (10th week; x20) [I] Rotifer (13th week; x12); [G] polychaetes (16th week; x10); [H] mysid (Crustacean) appendage (16th week; x10).

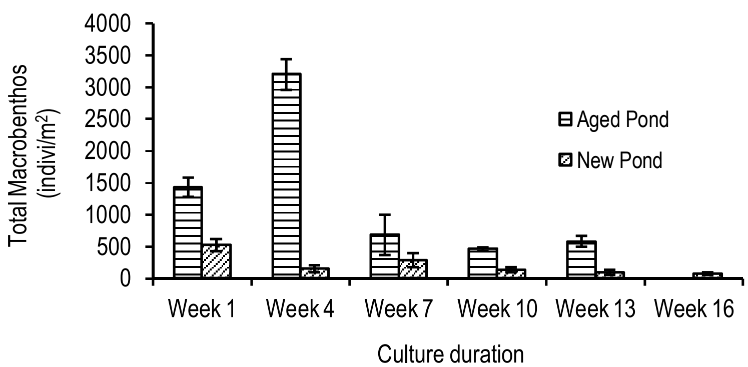

Figure 2. Total macrobenthos populations of *P. monodon* aquaculture ponds throughout the culture cycle.

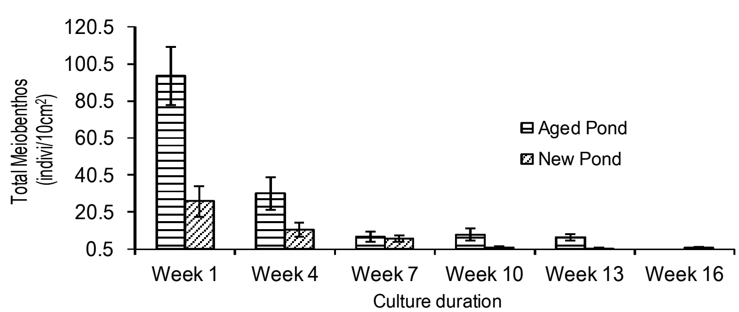

Figure 3. Total Meiobenthos population of *P. mondon* aquaculture ponds throughout the culture cycle.

REFERENCES

Akiyama DM, Chwang LM (1989). Shrimp feed requirement and feed management. *In*: Akiyama DM (Ed.), Proc. of the Southeast Asia Shrimp Farm Manage. Work., Philippines, Indonesia, Thailand, pp. 75-82.

Akiyama DM, Dominy WG, Lawrence AL (1992). Penaeid shrimp nutrition. *In:* Fast AW and Lester LJ (Eds.), Marine Shrimp Culture: Principles and Practices, pp. 535-568.

Alava VR, Lim C (1983). The quantitative dietary protein requirements of *Penaeus monodon* juveniles in a controlled environment. Aquaculture, 30: 53-60.

Alava VR, Pascual FP (1987). Carbohydrate requirements of *Penaeus monodon* (Fabricius) juveniles. Aquaculture , 61: 211-217.

Arnold PW, Birtles RA (1989). Soft sediment marine invertebrates of Southeast Asia and Australia: A guide to identification. *In:* English SA (Ed.), Australian Institute of Marine Sciences, Townville, p. 272.

Arvin PL (1977). Introduction of the common marine zooplankton of Peninsular Malaysia. Division of Fisheries and Marine Science, Universiti Putra Malaysia, Occasional publication No. 1, pp. 23.

Berry AJ (1964). The natural history of the shore fauna of north Penang. Malayan Nat. J. 18: 81-103.

Berry AJ (1972). The natural history of west Malaysian Mangrove Faunas. Malayan Nat. J. 25: 135-162.

Bombeo TI, Guanzon NGJ, Schroeder GL (1993). Production of *Penaeus monodon* (Fabricius) using four natural food types in an extensive system. Aquaculture, 112: 57-65.

Boyd CE (1995). Bottom soils, sediments, and pond aquaculture. Chapman and Hall Publication, New York, p. 348.

Chen YLL, Chen HY (1992). Juvenile *Penaeus monodon* as effective zooplankton predators. Aquaculture, 103: 35-44.

Chihara M, Murano M (1997). An illustration guide to marine plankton in Japan. Tokai University Press, p.1574.

Chong VC, Sasekumar A (1981). Food and feeding habits of white prawn *Penaeus merguiensis*. Mar. Ecol. Prog. Ser. 5: 185-191.

Chuang SH (1961). On Malayan shores. Muwu Shosa, Singapore, p. 225.

Dall W (1968). Food and feeding of some Australian Penaeid shrimp. FAO Fish. Rep. 2: 251-258.

Day JH (1967). A monograph on the polychaeta of Southern Africa. Part 1. Errantia. Part II. Sedentaria.

Darnell RM (1974). Organic detritus in relation to secondary production in aquatic communities. Verh. Int. Ver. Thor. Angew. Limnol. 15: 462-470.

El Hag EA (1984). Food and food selection of the Penaeid prawn *Penaeus monodon* (Fabricius). Hydrobiologia, 110: 213-217.

Fauchald K (1977). The Polychaete worms. Definitions and keys to the orders, families and Genera. Natural History Museum of Los Angles County.

Giere O (1993). Meiobenthology: The microscopic fauna in aquatic sediments. Springer-Verlag, p. 328

Hall DNE (1962). Observation on the taxonomy and biology of some Indo west pacific Penaeida (Crustacea, Decapoda). Fish. Publs. Colon. Off. 17: 1-229.

Kumari LK, Sumitra V, Wafar MVM, Royan JP, Rajendran A (1978). Studies on detritus in a tropical estuary. Ind. J. Mar. Sci. 7: 263-266.

Leh CMU, Sasekumar A (1984). Feeding ecology of prawns in shallow waters adjoining shores. *In:* Proc. of Asian Symp. on Mangrove Environ. Res. Manage. 331-353.

Marte CL (1980). The food and feeding habit of *Penaeus monodon* Fabricius collected from Makato river, Aklan, Philippines (Decapoda Natantia). Crustaceana, 38 (3): 225-236.

Marte CL (1982). Seasonal variation in food and feeding of *Penaeus monodon* Fabricius (Decapoda Natantia). Crustaceana, 42(3): 250-255.

Mori T (1964). The pelagic copepoda from the neighbouring waters of Japan. The Soyo Company Inc. Tokyo, p. 150.

Newell GE, Newell RC (1963). Marine plankton: A practical guide. Hutchinson Educational Limited, London, p. 221.

Panikkar NK (1952). Possibilities of future expansion of fish and prawn culture practices in India. Curr. Sci. 21: 29-33.

Qasim SZ, Easterson DCV (1974). Energy conversion in the shrimp, *Metapenaeus monoceros* (Fabricius), fed on detritus. Ind. J. Mar. Sci. 3: 131-134.

Rubright JS, Harrell JL, Holcomb HW, Parker JC (1981). Response of planktonic and benthic communities to fertilizer and feed application in shrimp mariculture ponds. J World Maricult. Soc. 12: 281-299.

Thong KL, Sasekumar A (1984). The trophic relationships of the fish community of the Angsa Bank, Selangor, Malaysia. *In:* Proce of Asian Symp. on Mangrove Environ. Res. and Manage. pp. 385-399.

Tiews K, Bravo SA, Ronquillo IA (1976). On the food and feeding habits of some Philippines shrimps in Manila Bay and San Miguel Bay. Philippine J. Fish. 14(2): 204-213.

Wickstead JH (1965). An introduction to the study of tropical plankton. Hutchinson Trop. Monographs, p. 160.