Feeding Habits of Decapod Crustaceans

Yahya Bakhtiyar[1*], Imtiaz Ahmed [1] and Seema Langer[2]

[1]Department of Zoology, University of Kashmir, Srinagar- 190006, J and K, India
[2]Department of Zoology, University of Jammu, Jammu- 180006, J and K, India
***Corresponding Author: yahya.bakhtiyar@gmail.com**

Abstract
Any aquaculture enterprise to be a success requires an investment of time, effort and resources. Important linkages for efficient finfish and shellfish production are scientific knowledge, organization, managerial efficacy etc. Besides these mammoth scale negotiations there are certain fundamental and immensely important countenance which are essential for the success of any commercial culture. Among others, one of the fundamental aspects is gathering knowledge about the feeding ecology, feeding habits and food preferences of cultivable fin fish and shell fish species. The knowledge of the feeding helps in decreasing the mortality of the cultivable organism. Current knowledge about the feeding ecology of prawns and shrimps is reviewed, with particular reference to their feeding habits based on different methods of gut content analysis with indices such as index of preponderance, index of relative importance, point method, occurrence percentage or frequency of occurrence and volume etc.
Keywords: Feeding Habits, crustaceans, aquaculture, finfish and shellfish production,

Introduction

Considerable published information regarding the feeding ecology of prawns and shrimps is available but still the work on their exact feeding ecology, habit and preference for their choicest food needs to be carried out. There are still many aspects which are not fully understood. It is substantial to have the knowledge about the diet of an animal in its habitat in order to be aware of its nutritional requirements and its interaction with other organisms. Therefore, the studies to evaluate identify and quantify the resources that specie uses (with the help of gut content analysis) provides information on those selected from the choices available from the environment (Williams, 1981). This paper attempts to review the state of knowledge of prawn and shrimp's feeding ecology for the awareness of the budding researchers working in the related field.

Feeding ecology of decapod crustaceans

Chopra (1939) has mentioned that prawns eat all types of food including both living and dead whatever comes in their way. Similarly, Pannikar (1952) has also mentioned that the food of young penaeids consists of algae, minute organisms and organic detritus. According to Gopalakrishnan (1952) *Penaus indicus* feeds mainly on vegetable matter and crustaceans, but its di*et al*so includes molluscs, foraminiferans, polychaetes, hydroids, trematodes and echinoderm larvae. Dall (1968) claimed the Penaeids to be omnivorous scavengers or detritus feeders. Tiews (1976) observed *P. merguiensis* to feed mainly upon phytoplankton and benthic foraminiferans. Lee *et al.* (1980) made field observations on *Macrobrachium* species and confirmed its omnivorous habit through enzyme studies. They further stated that the diet of *Macrobrachium* species include aquatic insects and larvae, algae, nuts, grains, seeds, fruits, small molluscs and crustaceans, fish flesh and fish offal and other animals. They also found the species to be cannibalistic. Chong and Sasekumar (1981) studied the food and the feeding habits of the white prawn (*Penaeus merguiensis*) and found them to be carnivorous-detritivorous, feeding mainly upon large crustaceans and also on organic detritus. Hag (1984) suggested that Penaeid prawn *Penaeus monodon* juveniles feed mainly upon algal material while adults are observed to be opportunistic in their feeding showing preference towards animal protein.

Many workers have observed crustacean decapods to be important predators in tropical coastal environments (Nelson, 1981; Preston *et al.*, 1992 and Heales *et al.*, 1996). Leber (1985) found that areas colonized by aquatic vegetation are important habitats for shrimps, as they get refuge and food by virtue of its fauna associated to the aquatic macrophytes. Growth of red king crab has been extensively studied both by laboratory rearing (Gray, 1963; Weber, 1967; Matsura and Takeshita, 1989). Feeding and growth of red king crab (*Paralithodes camtschaticis*) were studied by Zhou *et al.* (1998) under laboratory conditions. Davis *et al.* (2005) conducted feeding studies on South African mud crab *Scylla serrata* larvae and found that though mud crab larvae were able to thrive well on the *Artemia* nauplii but it was further recorded by them that the overall development, survival and successful metamorphosis was enhanced by the inclusion of rotifers in the food.

The presence of unrecognizable debris during gut analysis of decapods is suggestive of major role of soft parts in their diet (Williams, 1955). The observations made in this context revealed that *Macrobrachium rosenbergii* is an omnivore that feeds mainly on various plant and animal matter (Mary, 1957; Ling, 1969). Bhimachar (1965) and Raman (1967) also recorded *Macrobrachium rosenbergii* to be bottom feeder and an omnivore, its juveniles consuming more diatoms than adults. Further, Bhimachar (1962) found that immature species are mostly found with empty stomachs as compared to mature specimens. Rao (1967) has reported that *Macrobrachium rosenbergii* shows cannibalistic food habits and even eats its own moults and dead eggs. Phytoplankton and benthic macroinvertebrates have been detected in the stomach of decapods including crabs (Muntz *et al.*, 1965); *Macrobrachium carcinus* (Lewis *et al.*, 1966); *Macrobrachium rosenbergii* (Ling, 1969); cray fish (Caine, 1975); *Palaemon* (Inyag, 1978); *Macrobrachium idella* (Jayachandra and Joseph, 1989); Palaemon (Guerao, 1995); *Macrobrachium borelli* (Collins and Paggi, 1998); *Palaemonetes argentinus* (Collins, 1999); *Aristaeomopha foliacea* (Bello and Pipitone, 2002); *Acetes paraguayensis* (Collins and Williner, 2003).

Subramanayam (1963) studied the stomach contents of *Metapenaeus affinis* and found that its diet was predominated by bottom dwellers such as nematodes, foraminiferans and molluscs. The studies on food content of prawns inhabiting the backwaters of Cochin were conducted by George (1972) who reported that small crustaceans form major food items of juveniles, while only a small portion of stomach content consisted of unidentified objects and debris. Abel and Blum (1977) investigated the ecological aspects of freshwater decapod crustaceans. Investigations regarding food and feeding of *Penaeus monodon* have been carried out by several workers (Hag, 1984; Baskar *et al.*, 2013) who reported the animal to be an omnivore preferring crustacean in particular. While studying the feeding habits of *Macrobrachium dobsoni*, *Macrobrachium affinis*, *Macrobrachium monoceros*, *Penaeus monodon* and *Penaeus indicus*, Kuttayama (1974) reported that the food of prawn in general, consist of varying amounts of organic matter mixed with sand and mud. Many workers (Edwards, 1978; Cortes, 1995) have advocated that the diet of prawn includes several elements of benthic community. According to Cohen *et al.* (1976) the zoea of *Macrobrachium* does not ingest phytoplankton and requires animal food for its growth.

Studies on the food and feeding habits of shrimp suggest that their juveniles feed upon zooplankton, *Artemia* nauplii and microalgae (Emmerson, 1984; Yufera *et al.*, 1984) while the adults are epibenthic detritivores, derieving their nutrients from the various forms of detrital ingestion (Darnell, 1967; Rubright *et al.*, 1981). Similarly, both laboratory and field studies were conducted by Chen and Chen (1992) to study the predatory behaviour of juvenile, *Penaeus monodon* upon zooplankton sps. They came up with the view that while *Penaeus monodon* can affectively ingest fairly more zooplankton as compared to their smaller counterparts.

Feeding rhythms and diet of *Farfantepenaeus paulensis* were studied by Soares *et al.* (2005). They observed that the shrimp showed an omnivorous feeding behaviour. Among prey organisms, polychaetes and tanaids were the main groups recorded. Further, consumption of detritus and plant material decreased as shrimp grew. Collins (2005) conducted trophic studies on two freshwater prawns viz. *Macrobrachium borelli* and *Palaemonetes argentinus*. It was found that both prawns consumed similar food items, but differed in their feeding times.

Macrobrachium Borelli stomach fullness was greater during night than day, whereas *Palaemonetes argentinus* foraging activity occurred by day time.

Biology and ecology including the feeding behaviour of shrimp *Aristeus antennatus* has been studied by many workers (Sarda and Demestre, 1987; Cartes, 1994) and it has been observed that *Aristeus antennatus* feeds on highly diverse prey and it is a highly predatory and active species, feeding continuously (Cortes, 1995). Further, the work of Maynon and Cartes (1997) on the daily ration of shrimp *Aristeus antennatus* indicates that it is a benthic but mobile species, preying mainly upon detritvores or small predators. While studying the ingestion rate and feeding behaviour of the peppermint shrimp, *Lysmata wurdemanni* in laboratory, Zhang *et al.* (1998) found that the shrimp consumed significantly more food than at 25^{o}C. It was also observed that the ingestion rate increased with increasing food concentration in all larval stages and development.

Similar studies related to the food and feeding habits of shrimps have been worked upon in *Aristeomorphs foliacea* (Rainer, 1992, Pipitone *et al.*, 1994; Cortes, 1995; Bello and Pipitone, 2002), *Penaeus esculentus* (Wassenberg, 1990), *Acetes paraguensis* (Collins and Williner, 2003), rose shrimp, *Parapenaeus longirostris* (Kapiris, 2003) and in *Acetes intermedius* (Chiou *et al.*, 2005).

The typical carnivorous habit of decapods has been secondarily modified by detrital or planktivore feeding (Nicol, 1932). Prawns inhabiting the benthic region not only feed on living animals and vegetable matter available nearby but also on dead organic matter. Food is grabbed by chelae of thoracic legs and taken into mouth whereas maxillipedes help in further cutting and driving it towards mandibles, where the food is finely mascerated into finer particles fit for swallowing (Villadolid and Villaluz, 1951). Due to diversified diet found for both Penaeidae and Palaemonidae, several studies have been developed aiming at the role of these consumers in the regulation of the meso and macrofauna of aquatic environment (Bell and Caull, 1978; Nelson, 1981, Leber, 1985; Posey and Hynes, 1991).

According to Collins (1999) the palaemonid (*Palaemonetes argentinus*) is omnivorous grazing on phytoplankton and preying upon slow moving benthic macroinvertebrates. Feeding habits of grapsid *Metopograpus thukuhar* were investigated and observed the grapsid to be an opportunistic feeder with a certain degree of behavioural plasticity.

Collins and Wiliner (2003) while examining the stomach content of *Acetes paraguayensis* (Hansen) from two lakes categorized them as omnivorous, feeding mainly on members of littoral-benthic and lotic communities e.g. Algae, rotifers and microcrustaceans (copepods and cladocerans). Oligochaeta and Diptera larvae were found as alternative food sources when available. The food selection as well as the preference of *P. monodon* depends upon the availability of food items in the pond bottom with preference for natural food when available. Shrimps tend to be detritivores when benthic organisms are scarce gaining nutrients from cellulose, lignin, protein, starch, fats, waxes and oils extracted from detritus. The food of *Solenocera choprai* as studied by Dineshbabu and Manisseri (2009) comprised of decapod crustaceans, unidentifiable mass, fish remains, shells of mollusca, polychaete worms, sand, foraminiferans and small crustaceans (other than decapods) in the decreasing order of abundance. In case of adults the annual index of preponderance revealed preference for decapod crustaceans, detritus and fish remains respectively. In case of females the major component of the food comprised of decapod crustaceans. Annual feeding intensity of adult *S. choprai was* found to be highest in February and lowest from June to December. Feeding intensity was found to be highest in immature females followed by spent females. Jimoh *et al.* (2011) found *Macrobrachium vollenhovenii* as omnivorous detritivore feeding on a variety of plankton species e.g. chlorophyta, euglenophyta, xantophyta, chrysophyta, cladocera, copepoda, protozoa, dinoflagellate, diatoms, insect parts and unidentified food items, with chlorophyta and diatoms forming the most important food items. Baskar *et al.* (2013) while studying the food and feeding habits of *Penaeus monodon* found that the Polychaetes were found to be the most predominant food items as evidenced by the presence of setae, jaws, and occasional

body fragments in the preventriculus on the basis of highest Index of Preponderance (IOP) followed by Prawns, Fishes, Detritus, sand, other crustaceans, Molluscs, Forminiferans, and Minor crustaceans. The index of preponderance, index of relative importance, Gastro Somatic index and feeding intensity were found to be higher during monsoon as compared to summer months. The study suggested that *Penaeus monodon* as carnivorous mainly feeding on animal food items irrespective of size. Bakhtiyar *et al.* (2014) categorized *M. dayanum* as detriti-omnivore feeding on both animal and plant matter with detritus as dominant food item. The study was based on the observation of the total 480 specimens of *Macrobrachium dayanum* (*M. dayanum*) categorizing them into four categories based on size and sex. Out of total 480 analyzed specimens 214 (44.58%) guts were found to be empty while about 266 (55.41%) contained food. The frequency of empty stomachs was found to decrease with increase in size. Index of preponderance revealed that detritus was the dominant food item of *M. dayanum* followed by algae. The second most dominant food item i.e. algae was found to decrease with increase in size of animal. After detritus and algae other important food items were found to be insects, sand, annelids, macrophytes, molluscs, unidentified matter, crustacean and rotifers. Lima *et al.* (2014) studied the diet items of *M. carcinus* from Amazon River estuary throughout the year by the analyzing stomach contents. The results indicated that *M. carcinus* be considered as omnivorous species with more animal component as found in other Macrobrachium species. The stomach content analysis was carried out by using the frequency of occurrence (FO), methods of points (MP) and feeding index (FI) revealing that the prawns fed on detritus, animals and plant fragments as the most important food items. *Ratosquilla anomala* was found to be a carnivore by Prasad and Yedukondala (2015) feeding on fishes, crustaceans, cephalopods, plant material, polychaetes, molluscs, and echinoderms in decreasing order. The index of preponderance and index of relative importance was found to be higher during monsoon as compared to other season whereas the food was not found to vary within different size groups with no marked variation in food composition between males and females was recorded.

Similar studies regarding the feeding ecology of Decapoda have been carried out in *Macrobrachium rosenbergii* (Barros and Valenti, 2003a, b; Mohanty, 2003); *Macrobrachium hainanense* (Mantel and David, 2004); *Penaeus duorarum*, *Paraenaeopis atlantica*, *Penaeus kerathurus*, *Penaeus notialis*, *Paraenaeopis longirostris* (Bello-Olusoji *et al.*, 2005); *Macrobrachium lamarrei* (Sharma and Subba, 2005); *Penaeus esculentus* (Hill and Wassenberg, 2006); grooved tiger shrimps (Maslamani *et al.*, 2007); *Macrobrachium amazonicum* (de Araujo and Valenti, 2007); *M. vollenhovenii* (Abayomi *et al.* 2011); *Macrobrachium dayanum* (Bakhtiyar *et al.*, 2012); *Farfantepenaeus subtilis* (Silva *et al.*, 2012); *Crangon hakodatei* (Maher *et al.*, 2013); *Macrobrachium brasiliense* (Melo and Nagasaki, 2013); *Parapontophilus occidentalis* (Hendrickx and Papiol, 2015).

References

Abayomi, A., Jimoh, E., Clarke, O., Olusegun, O. W. and Haleemah, B. A. 2011. Food and feeding habits of the African river prawn (*Macrobrachium vollenhovenii*, Herklots, 1857) in Epe Lagoon, southwest Nigeria. ***International Journal of Fisheries and Aquaculture*. 3**: 10-15.

Abel, L. G. and Blum, N. 1977. Ecological aspect of freshwater decapod crustaceans of the Perlos, Archipelago, Panama**.** ***Biotropica***. **9**: 239-252.

Bakhtiyar, Y., Lakhnotra, R. and Langer, S. 2014. Natural food and feeding habits of a locally available freshwater prawn *Macrobrachium dayanum* (Henderson) from Jammu waters, North India. ***International Journal of Fisheries and Aquatic Studi es*. 2(3):** 33–38.

Bakhtiyar, Y., Samyal, A., Kumari, A. and Langer, S. 2012. Studies on the food preferences of *Macrobrachium dayanum* and *Labeo rohita* under laboratory condition. ***International Journal of Fisheries and Aquaculture Sciences*. 2(3):** 199-206.

Barros, H. P. and Valenti, W. C. 2003b. Ingestion rates of Artemia nauplii for different larval stages of *Macrobrachium rosenbergii*. ***Aquaculture*. 217**: 223–233.

Barros, H. P. and Valenti, W. C. 2003a. Food intake of *Macrobrachium rosenbergii* during larval development. ***Aquaculture*. 216 (1-4):** 165–176.

Baskar, S., Narasimhan, N., Daniel, G. S., Ravichelvan, R., Sukumaran, M. and Anandaraj, T. 2013. Food and Feeding Habits of *Penaeus monodon* (Fabricius) from Mallipattinam Coast in Thanjavur Dist, Tamil Nadu, India. ***International Journal of Research in Biological Sciences***. **3(1):** 1-4.

Bell, S. S. and Coull, B. C. (1978). Field evidence that shrimp predation regulates meiofauna. ***Oceologia.*** **35**:141-145

Bello, G. and Pipitone, C. 2002. Predation on Cephalopods by the giant red Shrimp *Aristaeomorpha foliacea*. ***J. Mar. Biol. Ass. U. K.*** **82:** 213-218.

Bello, O. A., Afunmiso, M. O. and Bankole, Y. M. 2005. Some aspects of the feeding habits of commercially important Penaeids from part of Fao fishing Zone 34. ***Journal of Animal and Veternary Advances***, **4(10):** 818-824.

Bhimachar, B. S. 1962. Information of prawn from Indian Waters-synopsis of biological data. ***Proc. Indo-Pacif. Fish. Coun.*** **10(11):** 124-133.

Bhimachar, B. S. 1965. Life history and behaviour of Indian prawns. *Symp*. On Prawn Fish. *Soc*. *of Fish Technol*., (India), ***Fish. Technol.*** **2:** 1-11.

Caine, E. A. 1975. Feeding and masticatory structures of six species of the cray fish genus *Procambarus* (Decapoda: Astacidae). ***Forma et Funtico***. **8:** 49-66.

Cartes, J. E. 1994. Influence of depth and Season on the diet of the deep-water aristeid *Aristeus antennatus* along the continental slope (between 400 to 2300 m) in the Catalan Sea (western Mediterranean). ***Mar. Biol***. **120:** 639-648.

Chen, Y. L. L. and Chen, H. Y. 1992. Juvenile *Penaeus monodon* as effective zooplankton predators. ***Aquaculture,*** **103:** 35-44.

Chiou, W. D., Hwang, J. J., Cheng, L. Z. and Chen, C. T. 2005. Food and Feeding habit of Taiwan maxiuma shrimp *Acetes intermedius* in the coastal waters of South western Taiwan. ***Fisheries Science***, **71:** 361-366.

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

Chopra, B. N. 1939. Some food prawns and crabs of India and their fisheries. ***J. Bombay Nat. Hist. Soc.*** **4 (2):** 221-234.

Cohen, D., Finkel, A. and Sussman, M. 1976. On the role of Algae in Larviculture of *Macrobrachium rosenbergii*. ***Aquaculture.*** **8:** 199-207.

Collins, P. A. 2005. A coexistence mechanism for two freshwater prawns in the Parana River Flood plain, Argentina. ***Journal of Crustacean Biology***. **25(2):** 219-225.

Collins, P. A. and Paggi, J. C. 1998. Feeding ecology of *Macrobrachium borelli* (Nobili) (Decapoda: Palaemonidae) in flood valley of river Parana, Argentina, ***Hydrobiologia.*** **362:** 21-30.

Collins, P. A. and Williner, V. 2003. Feeding of *Acetes paraguayensis* (Nobili) (Decapoda: Sergestidae) from the Parana River, Argentina. ***Hydrobiologia.*** **493:** 1-6.

Collins, P.A. 1999. Feeding of *Palaemonetes argentinus* (Decapoda: Palaemonidae) from an oxbow Lake of the Parana River, Argentina. ***Journal of Crustacean Biology***. **19(3):** 485-492.

Cortes, J. E. 1995. Diets of and trophic resources exploited by bathyal penaeidean shrimps from the western Mediterranean. ***Marine and Freshwater Research***. **46:** 889-896.

Dall, W. 1968. Food and feeding of some Australian Penaeid shrimp. *FAO Fish*. *Rep*. **57:** 251-258.

Darnell, R. M. 1967. Organic detritus in relation to the estuarine ecosystem. p. 376-380. In: ***Estuaries*** (G. H. Lauff ed.), A. A. A. S. Publication.

Davis, J. A., Wille, M., Hecht, T. and Sorgeloos, P. 2005. Optimal first feed organism for South African mud crab *Scylla serrata* (Forskal) larvae. ***Aquaculture International.*** **13 (3):** 187-201.

deAraujo, M. C. and Valenti, W. C. 2007. Feeding habit of the Amazon River prawn *Macrobrachium amazonicum* larvae. ***Aquaculture.*** **265(1)**: 187-193.

Dineshbabu, A. P. and Manisseri, J. K. 2009. Food and feeding of the ridgeback shrimp, *Solenocera choprai* Nataraj, along Karnataka coast. ***Indian Journal of Fisheries***. ***56*****(1):** 21-26.

Edwards, R. R. C. 1978. Ecology of a coastal lagoon complex in Mexico. *Estuar*. *Coast*. *Mar*. *Sci*. **6:** 75-92.

Emmerson, W. D. 1984. Predation and energetics of *Penaeus indicus* (Decapoda: Penaeidae) larvae feeding on *Brachionus plicatilis* and *Artemia nauplii*. ***Aquacultur****e*. **38:** 201-209

George, M.J. 1972. ***On the food and feeding habits of Metapenaeus monoceros (Fabricius***). Fishing News (Book) Ltd., London. 178 pp.

Gopalakrishnan, V. 1952. Food and feeding habits of *Penaeus indicus*. ***M.Edw. J. Madras Univ.*** **22 (10):** 69-75.

Gray, Jr, G.W. 1963. Growth of mature female king crab. ***Alaska Department of Fish and Game Information.*** **26:** 1-4.

Guerao, G. 1995. Locomotor activity patterns and feeding habits in the prawn *Palaemon xiphias* (Crustacea: Decapoda: Palaemonidae) in Alfacs Bay, Ebro delta (Northwest Mediterranean). ***Marine Biology.*** **122:** 115-119.

Hag EI, E. A. 1984. Food and food selection of the Penaeid prawn *Penaeus mondon* (Fabricius). ***Hydrobiologia* 110(1):** 213-217.

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.

Hendrickx, M. E. and Papiol, V. 2015. Insights on the biology and ecology of the deep-water shrimp *Parapontophilus occidentalis* (Faxon, 1893) (Crustacea: Caridea: Crangonidae) in the eastern Pacific with notes on its morphology. ***Zootaxa*, 4007(3):** 370-388.

Hill, B. J. and Wassenberg, T. J. 2006. Preferences and amount of food eaten by the prawn *Penaeus esculentus* over moult cycle. ***Australian Journal of Marine Freshwater Research***. **43(4):** 727-735.

Jayachandra, K. V. and Joseph, N. Y. 1989. Food and feeding habits of slender river prawn, *Macrobrachium idella* (Hilgendorf, 1898) (Decapoda, Palaemonidae). ***Mahasagar*. 22:** 121-129.

Jimoh, A. A., Clarke, E. O., Whenu, O. O. and Adeoye, H. B. 2011. Food and feeding habits of the African river prawn (*Macrobrachium vollenhovenii*, Herklots, 1857) in Epe Lagoon, southwest Nigeria. ***International Journal of Fisheries and Aquaculture.* 3(1):** 10-15.

Kapiris, K. 2003. Feeding ecology of *Parapenaeus longirostris* (Lucas, 1846) (Decapoda: Peaneidae) from the Ionian Sea (Central and Eastern Mediterranean Sea). ***Sci. Mar*. 68(2):** 247-256.

Kuttayama, V. J. 1974. Observations on the food and feeding of some penaeid prawns of Cochin area. *J. Mar. Biol. Ass. India*. **15(1):** 189-194

Leber, K. M. 1985. The influence of predatory decapods, refuge and microhabitat selection on seagrass communities. ***Ecology*, 66(6):** 1951-1964.

Lee, P. G., Blake, N. J. and Rodrick, G. E. 1980. A quantitative analysis of digestive enzymes for the freshwater prawn *Macrobrachium rosenbergii*. ***Proc. World Maricult. Soc***. **11:** 392-402.

Lewis, J. B., Ward, J. and McIver, A., 1966. The breeding cycle, growth and food of the fresh water shrimp *Macrobrachium carcinus* (Linnaeus). ***Crustaceana*. 10(1):** 48-52.

Lima, J. D. F., Garcia, J. D. S. and Silva, T. C. D. 2014. Natural diet and feeding habits of a freshwater prawn (*Macrobrachium carcinus*: Crustacea, Decapoda) in the estuary of the Amazon River. ***Acta Amazonica.* 44(2):** 235-244.

Ling, S. W. 1969. The general biology and development of *Macrobrachium rosenbergii*. ***FAO. Fish. Rep***. **57:** 589-606.

Maher, I., Song, K. J., Park, H. M. and Oh, C. W. 2013. Feeding ecology of the sand shrimp *Crangon hakodatei* Rathbun, 1902 (Decapoda: Crangonidae) in the East Sea of Korea. ***Animal Cells and Systems***. **17(1):** 44-52.

Mantel, S. K. and David, D. 2004. Growth and production of a tropical predatory shrimp, *Macrobrachium hainanense* (Palaemonidae), in two Hong Kong streams. ***Freshwater Biology*. 49:** 1320–1336.

Mary, J. C. 1957. Bionomics and life history of *M. rosenbergii* (deMan). ***Bull. Res. Inst. Univ. Kerala*. 5(1**): 93-102.

Maslamani, A. I., Vay, Le L., Kennedy, H. and Jones D. A. 2007. Feeding ecology of the grooved tiger shrimp *Penaeus semisulcatus* De Haan (Decapoda: Penaeidae) in inshore waters of Qatar, Arabian Gulf. ***Mar. Biol*. 150:** 627–637.

Matsura, S. and Takeshita, K. 1989. Longevity of red king crab, *Paralithodes camtschatica*, revealed by long-term rearing study. In: Proceedings of the International Symposium on King and Tanner Crabs, ***Alaska Sea Grant College Program Report*. 90-104:** 181-188.

Maynon, F. and Cartes, J. E. 1997. Field estimation of daily ration in deep-sea Shrimp *Aristeus antennatus* (Crustacea: Decapoda) in the western Mediterranean. ***Mar. Eco. Prog. Ser***. **153:** 191-196.

Melo, M. S. D. and Nakagaki, J. M., 2013. Evaluation of the feeding habits of *Macrobrachium brasiliense* (Heller, 1862) in the Curral de Arame stream (Dourados/Mato Grosso Do Sul, Brazil). ***Nauplius*. 21(1):** 25-33.

Mohanty, R. K. (2003). Food preference and feeding habit of fish (*Catla catla*, *Labeo rohita*, *Cirrhinius mrigala*, *Cyprinus carpio*) and freshwater prawn (*Macrobrachium rosembergii*) in rice field refuge. ***Indian Journal of Animal Sciences***, **73(11):** 1293-1296.

Muntz, L., Ebling, F. J. and Kitching, J. A. 1965. The ecology of Lough Inc XIV. Predatory activity of large carbs. ***Journal of Animal Ecology***. **34:** 315-329.

Nelson, W. G. 1981. Experimental studies of decapod and fish predation on seagrass macrobenthos. ***Marine Ecology Progress Series*. 5:** 141-149.

Nicol, E. A. T. 1932. Feeding habits of Galatheidea. ***Journal of the Marine Biological Association of the United Kingdom*. 18**: 87-106.

Pannikar, N. K. 1952. Possibilities of further expansion of fish and prawn culture practices in India, ***Curr. Sci.* 21**: 29-33.

Pipitone, C., Badalamenti, F., Cuttitta, A., D'Anna, G. and Gristina, M. 1994. Preliminary results on the diet of *Aristaeomorpha foliacea* in the Sicilian Strait (Central Mediterranean Sea). p. 47-48. In: ***Life cycles and fisheries of the deep-water red shrimps, Aristaeomorpha foliacea and Aristeus antennatus*** (M. L. Bianchini and S. Ragonese, eds.). NTR-ITPP Species Publication.

Posey, M. H. and Hynes, A. H. 1991. Complex predator-prey interactions within an estuarine benthic community. ***Ecology*. 72:** 2155-2169.

Prasad, R. and Yedukondala R. P., 2015. Studies on food and feeding habits of *Oratosquilla anomala* (Tweedie, 1935) (Crustacea: Stomatopoda) represented in the shrimp trawl net by- catches off Visakhapatnam, east coast of India. ***European Journal of Experimental Biology***, **5(8):** 43-48.

Preston, N. P., Burford, M. A., Coman, F. E. and Rothlisberg, P. C. 1992. Natural diet of larval *Penaeus merguiensis* (Decapoda: Penaeidae) and its effect on survival. ***Marine Biology.* 113**: 295-302.

Rainer, S. F. 1992. Diet of prawns from the continental slope of north-western Autralia. ***Bulletin of Marine Science*. 50:** 258-274.

Raman, K. 1967. Observations on the ishery and biology of giant freshwater prawn, *M. rosenbergii* (de Man). ***Proc. Symp. Crustacea, Mar. Biol. Ass. India***, II: 649-669.

Rao, K. S. 1967. Reproductive cycles and lipid levels of Leiognathus splendens (Cuv.). ***J. Mar. Biol. Ass. India***. **9(2):** 303-322.

Rubright, J. S., Harrel, J. L., Holcomb, H. W. and Parker, J. C. 1981. Response of planktonic and benthic communities to fertilizer and feed applications in shrimp mariculture ponds. ***J. World Maricult. Soc*. 12:** 281–299.

Sarda, F. and Demestre, M. 1987. Estudio biologico de la gamba *Aristois antennatus* (Risso, 1816) en el Mar Catalan (NE de Espana). ***Invest. Pesq*. 51(1):** 213-232.

Sharma, A. and Subba, B. R. 2005. General Biology of Freshwater Prawn. *Macrobrachium lamarrei* (Milne-Edivards, H.) of Biratnagar, Nepal. ***Our Nature*. 3:** 31-41.

Silva, P. F., Medeiros, M. D. S., Silva, H. P. A. and Arruda, M. D. F. 2012. A study of feeding in the shrimp *Farfantepenaeus subtilis* indicates the value of species level behavioral data for optimizing culture management. ***Marine and Freshwater Behaviour and Physiology***. **45(2):**121-134.

Soares, R., Peixoto, S., Wasielesky, W. and D'Incao, F. 2005. Feeding rhythms and diet of *Farfantepenaeus paulensis* under pen culture in Patos lagoon estuary, Brazil, ***Journal of Experimental Marine Biology and Ecology*. 322(2):** 167-176.

Subramanayam, C. B. 1963. Notes on bionomics of penaeid prawn *Metapenaeus affinis* (Milne Edwards) of Malabar coast. ***Ind. J. Fish*. 10(11):** 11-22.

Tiews, K. 1976. On the food and feeding habits of some Philippine shrimps in Manilla Bay and San Miquel Bay. ***Phillippine Journal of Fisheries*. 14:** 204-212.

Villadolid, D.V. and Villalauz, D. 1951. Cultivation of Sugpo (*Penaeus monodon* Fabricius) in Phillipine. ***Phillip, J. Fish*. 1(1):** 68-78.

Wassenberg, T. J. 1990. Seasonal feeding on *Zostera capricorni* seeds by Juvenile *Penaeus esculentus* (Crustacea: Decapoda) in Moreton Bay, Queensland. ***Australian Journal of Marine and Freshwater Research*. 41(2):** 301-310.

Weber, D. D. 1967. Growth of the immature king crab Paralithodes cemtschatica (Tilesius). ***International North Pacific Fisheries Commision Bulletin*. 21:** 21-53.

Williams, A. B. 1955. A contribution of the life histories of commercial shrimps (Penaeidae) in North California, ***Bull. Mar. Gulf. Carrib*. 5(2):** 116-146.

Williams, M. J. 1981. Methods for analysis of natural diet in Portunidae crabs (Crustacea: Decapoda: Portunidae). ***Journal of Experimental Marine Biology and Ecology*. 52:** 103-113.

Yufera. M., Rodriguez, A. and Lubian, L. M. 1984. Zooplankton ingestion and feeding behaviour of *P. kerathurus* larvae reared in the laboratory. ***Aquaculture*. 42:** 217-224.

Zhang, D., Lin, J. and LeRoy Creswell, R. 1998. Ingestion rate and feeding behaviour of the Peppermint Shrimp *Lysmata wurdemanni* on *Artemia nauplii*. ***Journal of the World Aquaculture Society*. 29(1):** 97-102.

Zhou, S., Shirley, T. C. and Gordon, H. K. 1998. Feeding and growth of the Red King crab *Paralithodes camtscharicus* under laboratory Condition. ***Journal of Crustacean Biology***. **18(2):** 337-345.