International Journal of
Life Sciences
International Peer Reviewed Open Access Refereed Journal

Int. J. of Life Sciences, 2018; 6 (2):549-556
ISSN:2320-7817(p) | 2320-964X(o)
UGC Approved Journal No 48951

Original Article Open Access

Fishery and behaviour of banana prawn, *Fenneropenaeus merguiensis* (de Man,1888) around Mumbai waters

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Manuscript details:

Received : 14.03.2018
Accepted : 14.04.2018
Published : 26.04.2018

Editor: Dr. Arvind Chavhan

Cite this article as:
Sushant Mane, Deshmukh VD and Sujit Sundaram (2018) Fishery and behaviour of banana prawn, *Fenneropenaeus merguiensis* (de Man,1888) around Mumbai waters, *Int. J. of. Life Sciences*, Volume 6(2): 549-556.

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Available online on
http://www.ijlsci.in
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)

ABSTRACT

Behaviour of banana prawn, *Fenneropenaeus merguiensis* is investigated from around Mumbai waters. In inshore waters, the species contributed to the penaeid prawn catch at 44% (barrier net) and 0.8% (bag net). In seasonally operated gill nets the entire catch consisted of this species and in trawl nets, the contribution of the species was <1.0%. However in trawl net the catch was very high during March-May from nearshore and offshore waters. The bag nets are operated in areas with strong tidal currents in Mumbai harbour while barrier nets are set along the banks of Karanja, Dharamtar and Rajpuri creeks. Owing to shoaling behaviour (emigrating behaviour towards offshore) the gill nets are operated in shallow nearshore waters at the end of monsoon for one or two weeks. The juveniles of banana prawn feed in shallow depths close to the banks rather than mid-stream waters of the creeks to avoid strong currents, and here they get caught in barrier nets. The large sized sub-adult and adult prawns which remains in the creeks throughout the rainy season (over-wintering population), and instead of emigrating to the deeper marine waters, display shoaling behaviour at the mouth of the creek and nearshore waters during post-monsoon and get caught by gill nets. While moving in shoals, these sub-adult and adult prawns swim in the bottom, churning the soft bottom mud intermittently, probably to escape from predators. Fishermen easily spot these clouds of muddy water in the calm and clear sea and exploit the prawns by setting their gill nets; however this fishery lasts only for a short period.

Keywords: Banana prawn, behaviour, fisheries, feeding, shoaling Mumbai waters.

INTRODUCTION

The marine penaeid prawns belonging to the genus Penaeus exhibit amphibious life cycle with larval stages developing in the open sea, post-

larvae and juveniles growing up rapidly in estuarine waters and adults migrating to offshore waters for spawning (Garcia and Le Reste, 1981). Behaviour of organisms displaying such life pattern often coupled with natural environmental cycles is complicated by their foraging and reproductive migrations which are difficult to investigate in confinement. Nevertheless, some behavioural activities exhibited by them can be inferred from the catching patterns observed in the fisheries and a successful fisherman often gathers knowledge of local movements and distribution from the behaviour patterns (Wardle, 1986).

The prawns belonging to the genus *Penaeus* are commercially important along the Indian coast among which *Penaeus merguiensis* is the prime species next to Indian white prawn *P. indicus*. On the west coast, *Fenneropenaeus merguiensis* occurs along North Kanara, Goa and Maharashtra and exploited by trawlers in the coastal waters and by the artisanal gears in the creeks and estuaries. Although the species contributes about 1-2% to the penaeid prawn landings, it fetches the highest price in local and as well as export markets. It inhabits coastal waters up to 55-60 m depth, where the sea bottom is muddy and sandy. It displays typical life cycle with larval stages in the open sea; the post-larvae enter estuaries and creeks, where they remain for 2-3 months as juvenile and after attaining the pre-adult stage they migrate from shallow inshore and nearshore waters to the deeper offshore waters for spawning.

While observing the fishery of juveniles and sub-adults of *F. merguiensis* in estuarine and coastal waters around Mumbai some interesting patterns of behaviour were noticed. The biological attribute of feeding, reproduction, movements and migration have been analyzed to elucidate the behaviour of the species in the present study.

MATERIAL AND METHODS

The seasonal fishing pattern of *F. merguiensis* was investigated from barrier net landings in Rajpuri creek and trawl landings at Harnai in Ratnagiri district and New Ferry Wharf (NFW) landing centre in Mumbai during January-December 2015. The trawlers at Harnai carried out fishing in nearshore waters (5-30 m depth) while those at NFW in offshore waters (30-90 m depth). In addition, seasonal gill net operation specially carried out for the species in nearshore waters at Cuffe Parade and Worli was also recorded during August-September 2015. The catch and effort data was recorded from 10-20% of the crafts landed on the days of observation, and by taking into consideration total number of units landed and the fishing days in a month, the month-wise catch and effort was estimated. The species-wise catch of penaeid prawns was recorded by eye estimation but sometimes the actual weight of the species in the catch was available at the auctioning places at the landing centres. Catching pattern and the catch of *F. merguiensis* of seasonally operated gill fishery were collected by enquiry from the fishermen at Rajpuri, Cuffe Parade and Worli villages. The catch of the species from 5-6 boats was recorded and estimated for the season.

The analysis of food and feeding was carried by 'volumetric points method' given by Hynes (1950). The prawns were categorised as well fed, moderately fed and poorly fed. For quantitative study of volume and occurrence of food 'Index of preponderance' (Natarajan and Jhingran 1961) was computed and analysed (IP) for food preference of the sexes, areas and also for sex-wise and area-wise mature and non-mature females for comparisons. The intensity of feeding between sexes and maturity condition of females was compared statistically by the test of homogeneity, and between the areas by the test of independence by Friedman's test (Zar, 1999). For comparing the food preference between the sexes and areas, IP of food items was analysed by using non-parametric Spearman rank correlation method (Zar, 1999).

RESULTS AND DISCUSSION

The catching patterns, percentage of *F. merguiensis* in total penaeid prawns and the moth-wise abundance investigated from inshore (creek) nearshore and offshore waters are described below.

***Barrier net fishery*:**

Fishing in Rajpuri creek is mainly artisanal and carried out by means of fixed barrier nets (locally called *Dharan Jal*) operated along the shores and smaller bag nets (locally called *Bokshi* nets) set in the mid-stream of the creek. The barrier nets (60-80 m long) are set during low tide and when the tide rises to the highest water level the upper margin of the net is lifted by the head rope attached to the bamboo stakes thereby creating a barrier in about 1.5-2 m depth along the bank of the creek. During high tide, fishes and prawns which come

close to the shore, probably for feeding get entangled in the nets by the force of the receding water current during ebbing tide. The barrier nets are generally operated at night as the catch of *F. merguiensis* is more during night while fish catches are high during the day.

The estimated annual catch of *F. merguiensis* in Barrier nets at Khamde landing centre in the Rajpuri creek was 5.0 t and the percentage of the species in the total penaeid prawn catch was 43.9%. The highest catch of 1.5 t was recorded in March - 16.6 kg/boat-trip at the catch rate of 7.67 kg/boat-trip. The catch consisted of juvenile and sub-adult prawns. The size of males ranged from 43-148 mm (mean size 92.7 mm) and of females from 48-168 mm (means size 94.8 mm). Smaller sized prawns were observed in March-April (mean sizes 84.3 mm) and in November (85.2 mm) for males and 86.3 mm and 85.0 mm for the females in the respective months. The large sized prawns were recorded in June for both males (mean size 119.2 mm) and females (mean size 125.2 mm) (Fig. 1).

***Bag net fishery*:**

The bag nets are set in the mid-stream of the creeks where the current is high. The nets are anchored by stakes with the mouth facing the ebbing tide; so that when water recedes, it filters through and fishes, prawns etc. are caught in the cod end of the net. Since force of the tidal current is high during spring tides, both barrier and the bag nets are operated only for 4-5 days before and after the new moon and full moon days.

The estimated annual catch of *F. merguiensis* in the bag nets from New Ferry Wharf was only 567 kg and the species contributed to the total penaeid prawns 1.8%. The species was landed from July to December only. The annual catch rate was 0.16 kg/boat that reached the highest (0.6 kg/boat) in September. The bag net catch consisted of sub-adult prawns with males ranging in size from 88-133 mm (mean size 113.2 mm) and of females from 63-143 mm (means size 125.4 mm) (Fig. 1).

***Trawl fishery*:**

Although trawling at both Harnai and NFW is multi-day with continuous fishing operations during day and night, it was found that *F. merguiensis* was mostly caught during day time while other prawn species were caught irrespective of day or night trawling; excepting for, *M. monoceros* that was particularly caught at night.

At Harnai, the annual estimated catch of *F. merguiensis* from nearshore waters was 29.6 t and the share of the species in the total penaeid prawns was 1.6 %. The month-wise catch of the species peaked in March (6.5 t) and the share of the species in total penaeid prawn landings in the month was 8.5%. The annual size range of the species was 108-183 mm for males and 108-233 mm for the females with mean of 144.2 mm for the former and 159.7 mm for the latter. Month-wise size composition showed that the catch was constituted by smaller prawns in March with mean sizes of 129.3 mm for males and 139.3 mm for the females. Larger sizes in the catch were recorded in November for both males (mean size 148.7 mm) and females (mean size 170.9 mm) (Fig. 1).

At New Ferry Wharf the annual estimated catch of *F. merguiensis* from offshore waters was 67 t at the catch rate of 0.03 kg/hr and the share of the species in the total penaeid prawns was 0.6 %. The month-wise catch of the species peaked during March-May (78% of the annual catch). However, the catch rate of the species was highest in August (0.1 kg/hr). At New Ferry Wharf, the catch of *F. merguiensis* consisted of mainly adult prawns. The size of males ranged between 98-183 mm with mean of 143.0 mm while females ranged between 108-238 mm with mean of 161.8 mm. Month-wise size composition showed that the catch was constituted by smaller prawns in March with mean sizes of 136.4 mm for males and 155.4 mm for females. Larger sizes in the catch were recorded in November for both males and females with mean size 150.0 mm and 182.6 mm respectively (Fig. 1).

***Gill net fishery*:**

Highly seasonal, Gill nets were used for the species from late August to middle of September off Chowpatty and Worli village in Mumbai. About 100-150 small, dugout and plank built boats from Cuffe Parade and Worli village operated monofilament gill nets in very shallow waters in depth range of 2-5 m. The nets were operated only during day time and exclusively for *F. merguiensis* for a short period. The fishermen follow realise the presence of huge shoals of prawns by noticing clouds of muddy water in shallow depths and then set the gill nets accordingly.

Although exact catch statistics could not be collected, it is estimated that 20 t of catch of *F. merguiensis* was landed at the catch rate of 3-10 kg/boat in short period of 20 days. The gill net catch mainly consisted of adults

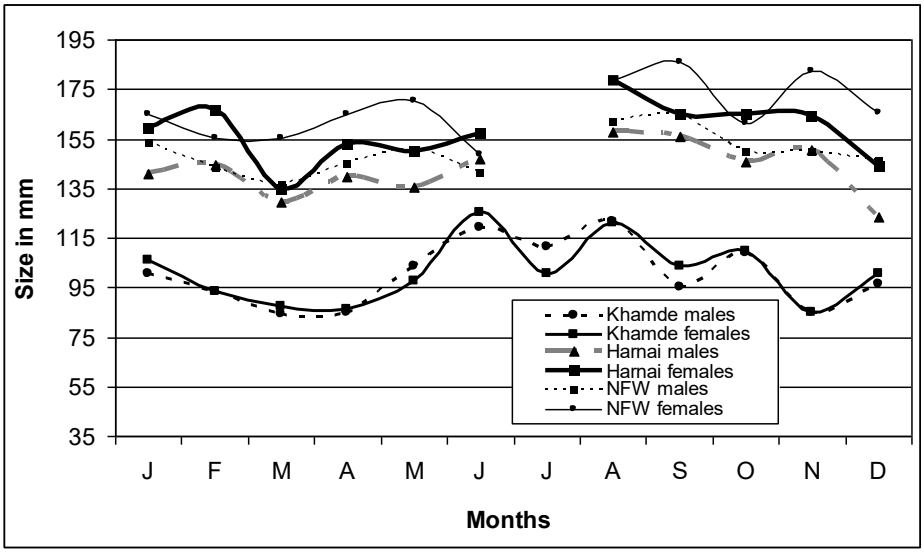

Fig. 1 Month-wise mean lengths of males and females of *F. merguiensis* at all landing centres

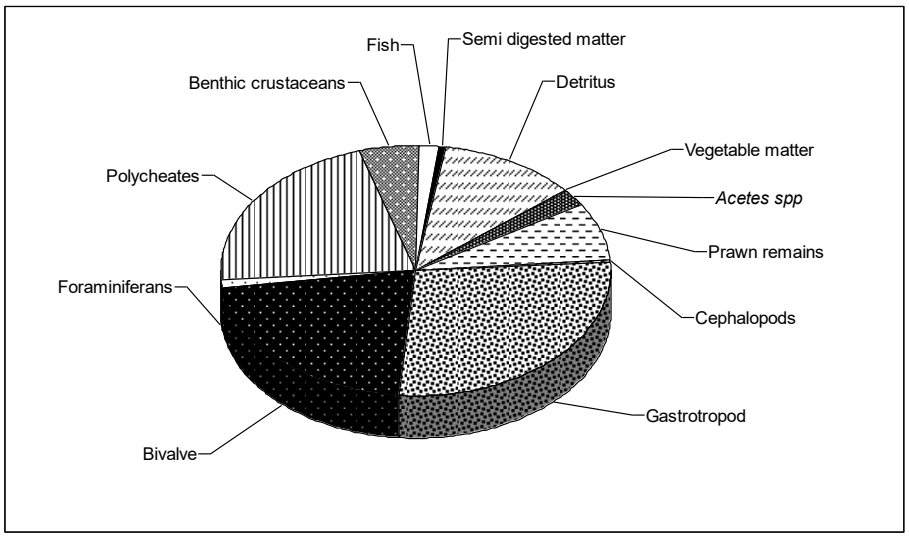

Fig. 2 Index of preponderance of the various food items of *F. merguiensis*

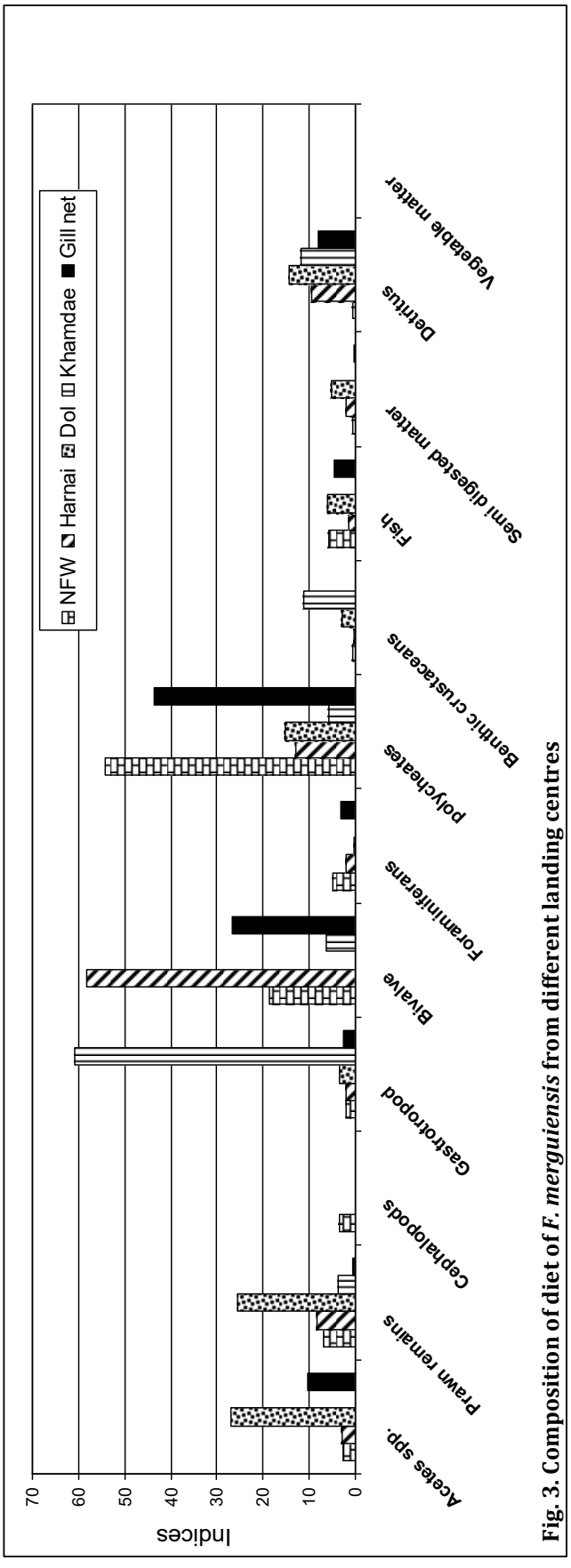

Fig. 3. Composition of diet of *F. merguiensis* from different landing centres

of *F. merguiensis*. The size of males ranged from 153-173 mm and that of females from 163-208 mm with mean lengths 164.6 mm and 185.9 mm respectively (Fig.1).

Feeding intensity:

Area-wise feeding intensity of prawns showed that well fed prawns dominated in estuarine waters (31.7%) than offshore (23.3%), nearshore (22.1%) and shallow nearshore waters (18.3%). The χ^2 test revealed that feeding intensity of prawns was significantly different (*P<0.05*) in the four areas and it may be inferred that prawns in estuarine waters fed better than the rest of the areas, while those in shallow nearshore waters fed poorly. The feeding intensity between the sexes was not significantly different (*P>0.05*) and the sexes fed almost equally in estuarine, nearshore and offshore areas. However, the shoaling prawns in the shallow nearshore waters showed that the feeding intensity of sexes was significantly different (*P<0.05*); the proportion of poorly fed males (77.5%) was higher than females (47.7%). The feeding intensity of mature and non-mature females was also significantly different (*P<0.05*). The proportion of well fed mature females was more than non-mature females which indicated that mature females feed better than non-mature.

Composition of diet:

The diet mainly consisted of gastropods, bivalves, polychaetes, detritus, Prawn remains, benthic crustaceans and *Acetes* spp. Other food items such as fish remains, foraminiferans, Semi Digested Matter (SDM), cephalopods, vegetable matter and nematodes were noticed occasionally. The molluscs collectively formed the single most dominant food item that contributed 50.8% to the entire diet spectrum of the species (Fig. 2).

Since juveniles mainly inhabited estuarine waters and migrated as sub-adults to shallow nearshore waters and subsequently to nearshore and offshore waters as adults, diet in these habitats can be related to their life stages. Comparison of dietary items between the areas by Friedman's test showed that the preference of food in four different areas (χ^2 *0.05, 13=21.026*) was significantly different (*P<0.05*). The food item preferred was polychaetes in offshore, bivalves in nearshore, gastropods in the estuarine waters and polycheates in nearshore low depth waters (Fig 3). Composition of food of mature and non-mature females collected from nearshore and offshore areas showed that both mature and non-mature females devoured high proportion of polychaetes (45.8% and 44% respectively). Comparison

of food items between mature and non-mature females showed significant difference (p<0.05) in the dietary items, which is attributed to higher percentage of molluscs (41.0%) in the diet of mature females than non-mature ones (23.1%).

Behaviour of commercially important species of the genus Penaeus was reported by Racek (1959) to explain short term fluctuations in catch rates of trawlers. In the present study catchability of *F. merguiensis* in spatially different areas with barrier and bag nets in inshore waters and gill nets and trawlers in nearshore and offshore waters respectively showed that behaviour is different in inshore and the open sea waters. Such difference may be attributed to ontogenic difference *i.e*. juvenile phase in estuarine inshore waters and the adult phase in the open sea. The behaviour is largely influenced by intensive foraging in the case of rapidly growing juveniles in the estuarine inshore habitat and the reproductive phase of the adult prawns in the marine open sea waters (Wassenberg and Hill, 1993).

Based on catchability of prawns in relation to behaviour Penn (1984) suggested three types of Penaeus species namely those strongly nocturnal but often inactive or buried at night; generally nocturnal but buried during day and continuously active at night and those rarely buried and almost continuously active. According to Penn (1984), *F. merguiensis* is placed in the third category. In the present study it was noticed that *F. merguiensis* was mostly caught during day time by trawlers. However, such day time activity was not observed in the estuarine inshore waters where the catch of the species in the barrier nets consisted of mostly juveniles. Owing to nocturnal activity of the juveniles, the artisanal fishermen operated the barrier nets only at night. In the inshore waters, *i.e* in the barrier and bag nets it was also intriguing to discover diverse catchability. Better catchability is observed in barrier nets set along the shore with catch rate of 4.44 kg/boat and is poor in the bag nets operated in the mid-stream with catch rate of 0.16 kg/boat. In the mid-stream, the current is swift and as a result there is danger of juvenile prawns being swept away from the creek towards open sea before they reach sub-adult state. Therefore, to avoid this, they move along the banks of the creek in shallow muddy areas. Similar observations were reported by Sheaves *et. al.* (2012) from North east Australian waters. Wassenberg and Hill (1993) observed that juveniles of *F. merguiensis* had significantly more food in their foreguts and feeding took place just after dusk. Similarly in the present study area also, it was observed that *F. merguiensis* forage food at night. In the present study, significantly high feeding intensity by juvenile prawns and their dietary preference for small gastropod (which are more abundant in the inter-tidal area along the banks of the creek) implies movement of juveniles towards the shore. Such foraging incursions towards the banks of the creek make the juveniles vulnerable to the barrier net fishery.

Shoaling behaviour of *F. merguiensis* has been reported (Kirkegaard *et al.,* 1975; Nandakumar, 1988; Pillai *et al*., 1991). According to Nanadakumar (1988), shoaling of the species in Karwar coast occur during June-August and explained that juveniles migrating from the backwaters remain in the coastal waters until they attain the adolescent stage and then move out to the deeper waters. However, from the size structure of the population in nearshore coastal waters in the present study, the mean lengths was 164.6 mm for males and 185.9 mm for females and it is evident from this observation that they are not adolescent but fairly large sized adult prawns. Further, it was also observed that prawns immigrated to the open sea when they attained 100-120 mm size and therefore explanation for the shoaling behaviour of juvenile prawns offered by Nanadakumar (1988) seems to be not so convincing. Along the west coast of Mumbai there are no extensive estuarine backwaters, yet the species exhibited congregation in shallow nearshore waters which are evident from the gill net catches. Therefore, it is concluded that shoaling behaviour of the species is related to not just currents but also to feeding. Marine polychaetes have been proved essential for maturation of ovaries in *P. monodon* (Sudaryono *et al.*, 1995) and *Litopenaeus vannamei* (Wouters *et al.,* 2001). Middleditch *et al*. (1980), opined that *P. vannamei* grown in captivity reached sexual maturity faster when fed on diets similar in fatty acid profiles to that of marine bloodworms. As polychaetes diet enhances rapid maturation of gonads in adult prawns it is possible that the prawns come close to the shore for feeding on polychaetes which are abundant in the nearshore waters. Factors such salinity, rainfall, SST, ocean currents, influx of fresh water, intensity of light may also influence shoaling or 'schooling' behaviour.

In coastal waters of Maharashtra, *F. merguiensis* exhibited two distinct cohorts, one originating from October-December spawning and the other from April-June spawning; the recruits of the former emigrated

from the creeks during March-June and the latter during August-November (Mane, 2007). It is quite likely that late recruits of the former cohort are unable to emigrate from the creeks due to onset of monsoon in late May or early June which reduces the salinity below the threshold level. This behaviour was also observed by Staples and Vance (1985) from Australian waters and according to them large freshwater discharges due to heavy rains causes a physical barrier, preventing emigration. Similar record was also recorded by Sheaves *et. al.* (2012) from North-east Australia. Achuthankutty (1988) reported the absence of juveniles in the estuary during the monsoons in Goa waters, India, similarly Meager *et. al.* (2003), also reported low catches of juveniles during high rainfall from Logan river estuary, Australia. It is interesting to note that females of *F. merguiensis* showed nearly 28% more polychaetes in their diet than males in the offshore waters. The adults periodically form aggregation or 'schools' offshore (Wassenberg and Hill, 1993). According to Tung Hoang *et al.* (2002) the spawning process can be divided into four phases: dormant, pre-spawning, spawning and post-spawning by distinct behaviour of prawn brood stock. The dormant phase was characterized by a quiescent and non-feeding period, whereas movement of prawn brood stock was active during the pre-spawning and post-spawning phases.

The residual population that survives and grows to the adult size remains in the creek until salinity is restored after cessation of monsoon and then commences *en mass* migration to the sea in late August or early September displaying shoaling behaviour. Such population of the species is analogous to the over-wintering population. However, the over-wintering population was found to feed voraciously on polychaetes in the nearshore waters, possibly to hasten gonadal maturation in order to synchronize with their counterparts in the deeper waters for spawning in October-December period. Interestingly, the shoaling adult prawns displayed sifting of mud while feeding which creates a protective cover to escape from the fish predators in the clear nearshore waters (Johnston *et al*. 2007). Fishermen easily spot these clouds of muddy water in the calm and clear sea and exploit the prawns by setting their gill nets; however this fishery lasts only for a short period (Plate 1). Hence it's very evident from the above observations that the species show active shoaling behaviour.

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