

## Diel Variations in Occurrence of Penaeid Larvae in Estuarine & Nearshore Waters of Goa

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Relative abundance of larvae of commercially important penaeid prawns through complete tidal cycles in different seasons was studied in order to determine suitable time and season for large scale seed collections. Larvae and post larvae of 4 species, viz. *Metapenaeus dobsoni* (Miers), *Penaeus merguensis* de Man, *Parapenaeopsis stylifera* (H. Milne Edwards) and *Metapenaeus* sp. were recorded from estuarine collections. In addition to these species, developmental stages of 3 more species, *Metapenaeus monoceros* (Fabricius), *Penaeus indicus* H. Milne Edwards and *Penaeus* sp., were present in the plankton samples collected from an inshore station off Bogmalo. *M. dobsoni* was the most abundant species, followed by *P. merguensis*. In general, post larvae (1301) were more than larvae (1080). Developmental stages of all the species were more abundant in the Mandovi estuary (72.86%) than in the Zuari estuary (27.13%). Diel rhythm, tidal oscillations and different seasons seem to influence variations in the distribution of the stages. Out of the total of 2381 larvae and post larvae recorded from the estuarine stations, 1388 were from the night samples and 993 from the day samples. Maximum ingress of the larvae took place at high tide and during premonsoon months.

INLAND bays and estuaries serve as nursery grounds for several of the marine organisms, including commercially important prawns. Planktonic larvae and early post larvae of penaeids enter estuaries along with the tidal currents. Information on the relative recruitment and abundance of these larvae is essential for predicting success or failure of prawn fisheries in estuarine and nearshore environments<sup>1,2</sup> as well as determination of suitable time for seed collections for aquaculture practices. Considerable work has been done on the seasonal occurrence of larvae and post larvae of penaeid prawns from the Cochin backwaters and nearby areas<sup>1,3-8</sup>. Investigations on some of these aspects on penaeid larvae have recently been carried out from Goa waters<sup>9-11</sup>. Subrahmanyam and Rao<sup>12</sup> and Subrahmanyam and Ganapati<sup>13</sup> have given accounts of larval abundance of penaeids in relation to diel rhythm, lunar periodicity and tides from estuaries on the east coast of India. The present paper deals with the occurrence of larvae and post larvae of commercially important penaeid prawns over full tidal cycles during different seasons in estuarine and nearshore waters of Goa.

### Materials and Methods

Plankton samples were collected from 5 fixed stations, 2 each in Mandovi and Zuari estuaries and 1 from the nearshore region off Bogmalo (Fig. 1). Collections were made by 5 min surface tows with HT net (mouth area 0.25 m<sup>2</sup> and mesh width 0.33 mm) every 3 hr covering the entire tidal cycle. Samples collected between 0600 to 1800 hrs have been considered as day samples (sample Nos. 1 to 4 and 9) and those between 1800 to 0600 hrs as night samples (sample Nos. 5 to 8). At estuarine

stations, collections were made over complete tidal cycle once during monsoon, postmonsoon and premonsoon seasons of 1971-72 whereas at Bogmalo, both horizontal and vertical sampling was carried out over a tidal cycle during Sept. 1973. Samples were preserved in 5% buffered formaldehyde. These were analysed for estimation of penaeid larvae which were sorted out from 20 to 100% of samples depending on their abundance and their number raised to the total. Larvae of different species were identified using larval characters of penaeid prawns described<sup>5,7,14-18</sup>.

### Results

*Species composition and abundance* — Larvae and post larvae of 4 species of commercially important

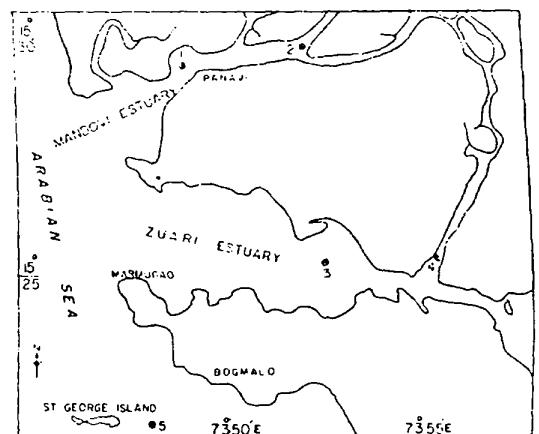


Fig. 1 — Position of sampling stations

penaeid prawns were present in estuarine zooplankton samples. These in their order of abundance were *Metapenaeus dobsoni* (Miers) (61.44%), *Penaeus merguensis* de Man (30.91%), *Metapenaeus* sp. (6.67%) and *Parapenaeopsis styliifera* (H. Milne Edwards) (0.96%). The maximum number of developmental stages were recorded at stations situated nearer to the mouth of the estuary. Out of the total of 2381 larvae and post larvae recorded from both the estuaries, 1735 (72.86%) were from the Mandovi estuary and only 646 (27.13%) from the Zuari estuary. This difference in the abundance of the larval stages in the 2 estuaries may probably be due to the location of the stations. In Zuari estuary, sampling stations were much interior in comparison to those in Mandovi estuary.

**Diel and tidal variations in developmental stages** — Distribution of developmental stages of all the species are influenced by diel rhythm and tidal oscillations. A higher nocturnal abundance of larvae and post larvae was discernible at stations of both the estuaries (Fig. 2). Out of the total of 1080 larvae recorded, 556 (51.48%) occurred in the night samples and 524 (48.51%) in the day samples. Similarly, among the total of 1301 post larvae obtained, as much as 832 (63.95%) were from the night collections and only 469 (36.04%) from the day samples. In general, the post larvae outnumbered the larvae in most of the samples except at the stations nearer to the mouth of the Mandovi estuary where more larvae were recorded during day than in night.

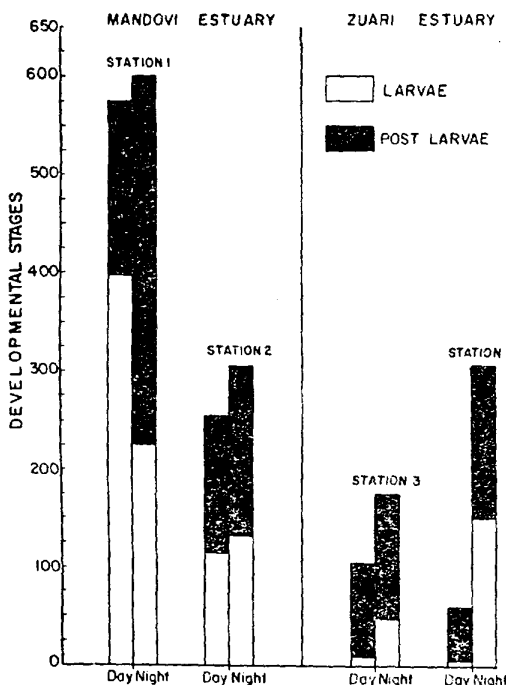


Fig. 2 — Abundance of larvae and post larvae of penaeid prawns in Mandovi and Zuari estuaries in day and night collections

The tides in the Mandovi and Zuari estuaries are of semidiurnal type with the maximum amplitude of about 2 m. Tidal flow during the different seasons seem to have some influence on the larval ingress into these estuaries (Fig. 3). The peak abundance of the developmental stages was recorded during high tide. During monsoon and postmonsoon seasons, large number of larvae and post larvae occurred in the samples at night and high tide periods. The maximum number of the larvae and post larvae in the Mandovi estuary during premonsoon month was also obtained at the flood tide of the day. However, in the corresponding season, tidal effect on larval distribution was not so clear in the Zuari estuary.

**Distribution of larval stages — *Metapenaeus dobsoni*:** Larvae and post larvae of this species are the most abundant in the collections from both the estuaries. Out of 2381 stages of all the species recorded, 1463 belong to *M. dobsoni*. Developmental stages of this species occur more in the Mandovi estuary (1001) than in the Zuari (462). In the distribution of larval stages and diurnal rhythm also, the conditions are different in the 2 estuaries. Post larvae occur in far greater numbers than larvae in the Zuari estuary (Fig. 4), but in the Mandovi estuary, larvae are slightly more (502) than post larvae (499). Developmental stages are more at both the stations of the Zuari estuary during night. On the contrary, their distribution is different at the 2 stations of the Mandovi estuary. At station 1 which is nearer the mouth of the estuary, larvae are more in the day collections (267) than in the night samples (123) but post larvae are more in

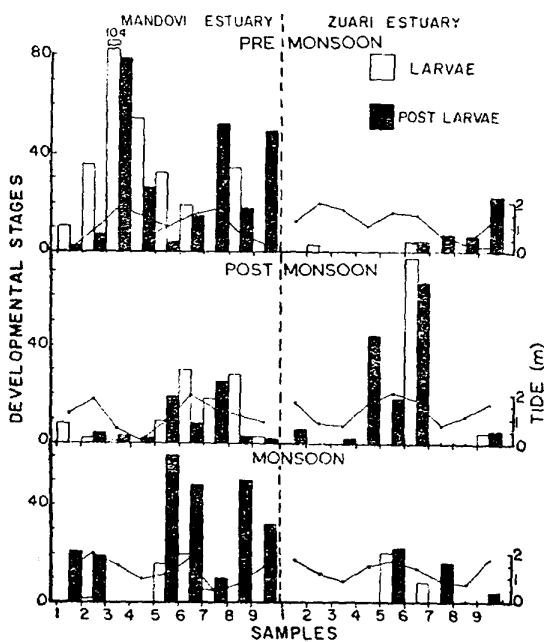


Fig. 3 — Occurrence of larvae and post larvae of penaeid prawns over a complete tidal cycle during different seasons in the two estuaries [Data from 2 stations from each estuary combined]

the night samples (216) than in the day collections (123). This pattern of distribution is altogether reversed at the interior station where larvae occur more in night samples than in day samples.

As evident from the general distribution of total larvae and post larvae in relation to tides, developmental stages of this species too show numerical abundance during high tide. There is also seasonal variation in the occurrence of larvae and post larvae of the species. During monsoon, plankton samples from both the estuaries contain large numbers of post larvae. In the remaining 2 seasons, more larvae have been obtained from the Mandovi estuary and post larvae from the Zuari estuary.

*Penaeus merguensis*: Total number of stages of this species recorded was 737, out of which 403 were post larvae and 334 larvae. The species occurred more in the samples from the Mandovi estuary (577) than from the Zuari estuary (160), being more in numbers in stations located near the mouth. Majority (89.09%) was post larvae in the samples from the Mandovi estuary while in Zuari estuary 71.98% were larvae. As in the case of *M. dobsoni*, this species too occurred more in the night samples than in the day samples. A study of the occurrence of the developmental stages with reference to season indicates that their peak in the Mandovi estuary was during premonsoon months. In the Zuari estuary, these were almost absent in the monsoon and premonsoon seasons (Fig. 5) and present mostly in postmonsoon months.

*Parapenaeopsis styliifera*: This species was represented by only few larvae, no post larval stage being recorded in any of the samples collected and present only in Mandovi estuary. All the 23 larvae were obtained during premonsoon season at station 1 of the Mandovi estuary indicating high salinity preference (av. salinity, 34.85‰). Larvae of this species were more in the day samples (13) than the night (10).

*Metapenaeus* sp.: This species was obtained mostly in the mysis stages. Out of the total of 159 specimens, only 5 were post larvae obtained from the night samples collected from station 1 of the Mandovi estuary. Among the larvae, 90 were noticed in the day collections from the Mandovi estuary while from the Zuari estuary, in a total of 25 larvae, 24 occurred in the night samples. Maximum (93) and minimum (10) of these stages were in samples taken from the Mandovi estuary during premonsoon and monsoon season respectively. Strangely, the abundance of the larvae in the Zuari estuary was noticed during the monsoon season. It may be due to the fact that the Zuari estuary show higher saline conditions almost throughout the year.

Distribution of developmental stages of the 4 species of penaeid prawns during different seasons and in the day and night samples is given in Table 1.

*Occurrence of penaeid larvae at Bogmalo*—In addition to larvae of 4 species of penaeids recorded from the estuarine samples, developmental stages of 3 more species were obtained from horizontal and vertical samples collected from the nearshore station off Bogmalo where average depth is 15 m. The 7

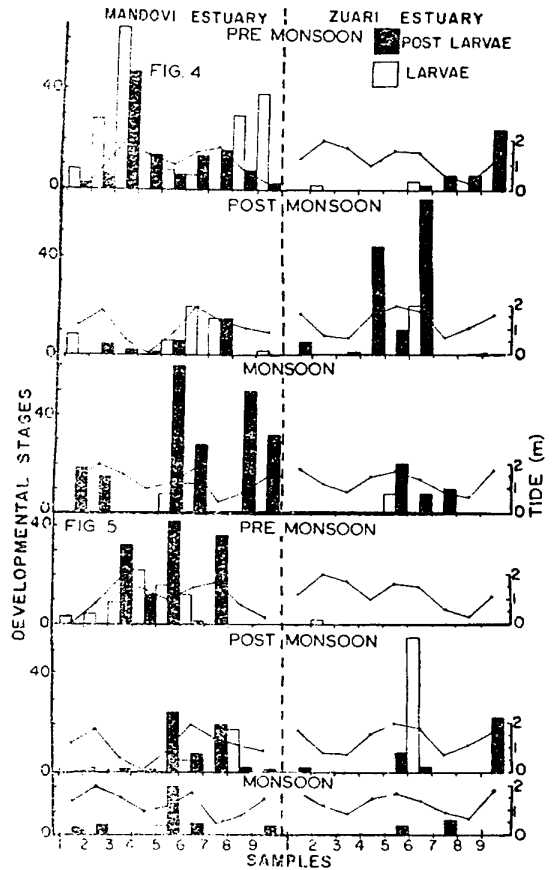


Fig. 4 — Distribution of larvae and post larvae of *Metapenaeus dobsoni* over a complete tidal cycle during different seasons in the two estuaries [Data from 2 stations from each estuary combined]

Fig. 5 — Distribution of larval stages of *Penaeus merguensis* over a complete tidal cycle during different seasons in the two estuaries [Data from 2 stations from each estuary combined]

species in their order of abundance were *Metapenaeus dobsoni* (57.85%), *Penaeus merguensis* (30.03%), *P. indicus* (4.77%), *Metapenaeus* sp. (2.73%), *M. monoceros* (1.84%), *Parapenaeopsis styliifera* (1.74%) and *Penaeus* sp. (1.02%). Larvae and post larvae of all these species were observed to be more in the samples taken in the vertical hauls (60.75%) than in those of horizontal or surface hauls (39.24%). As observed in the estuarine samples, post larvae were more (303) than larvae (283). Also, there is diel variations in the occurrence of these stages at this station (Fig. 6A). In the day collections, more larvae and post larvae were recorded in vertical samples (181) than in the horizontal samples (49) whereas in the night collections they were more in the horizontal samples (234) than vertical samples (122) indicating vertical migration of these larval stages of penaeid prawns to a certain extent. The influence of diel rhythm was evident in both

TABLE 1 — TOTAL NUMBER OF DEVELOPMENTAL STAGES OF FOUR SPECIES OF PENAEID PRAWNS AT 2 STATIONS OF MANDOVI AND ZUARI ESTUARIES DURING DIFFERENT SEASONS

Species	Mandovi estuary								Zuari estuary								
	Station 1				Station 2				Station 3				Station 4				
	Larvae		Post larvae		Larvae		Post larvae		Larvae		Post larvae		Larvae		Post larvae		
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	
MONSOON																	
<i>Metapenaeus dobsoni</i>	0	20	61	138	—	—	—	—	0	16	0	60	0	0	0	0	9
<i>Penaeus merguensis</i>	0	17	11	25	—	—	—	—	0	0	0	12	0	0	0	0	4
<i>Parapenaeopsis stylifera</i>	0	0	0	0	—	—	—	—	0	0	0	0	0	0	0	0	0
<i>Metapenaeus</i> sp.	1	4	0	5	0	0	0	0	0	24	0	0	0	0	0	0	0
POSTMONSOON																	
<i>M. dobsoni</i>	10	35	7	10	2	42	3	32	0	0	94	36	0	40	6	110	
<i>P. merguensis</i>	3	5	3	45	1	41	0	19	0	0	0	4	4	110	7	16	
<i>P. stylifera</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Metapenaeus</i> sp.	0	15	0	0	0	16	0	0	0	0	0	0	0	0	0	0	
PREMONSOON																	
<i>M. dobsoni</i>	257	68	55	68	47	21	86	39	3	8	4	16	0	0	44	16	
<i>P. merguensis</i>	66	48	40	84	25	12	48	84	2	0	0	0	0	0	0	0	
<i>P. stylifera</i>	13	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Metapenaeus</i> sp.	47	4	0	0	42	0	0	0	1	0	0	0	0	0	0	0	
Total	397	226	177	375	117	132	137	174	6	48	98	128	4	150	57	155	

D = day, N = night, — = no observation.

the dominant species, i.e. *M. dobsoni* and *P. merguensis*. Their developmental stages were more in the vertical samples during the day but more abundant in the horizontal samples during night (Fig. 6B). The larvae of *Penaeus* sp. and post larvae of *M. monoceros* were obtained in the day and night samples respectively.

**Discussion**

Both Mandovi and Zuari rivers have wide and perennial connections with the Arabian Sea resulting in regular ingressions of penaeid larvae into these 2 estuaries. Distribution of planktonic stages appears to be influenced by diel phases and tidal fluctuations. Greater abundance of these stages during night is evident in all samples collected during the present study. Nocturnal abundance in the distribution of larvae has been reported from the brackish water systems as well as offshore waters from other areas<sup>12,13,18-22</sup>. In the Gulf of Mexico waters off Galveston, Temple and Fischer<sup>22</sup> have recorded average catches of penaeid larvae almost two times greater at night than during the day.

Vertical migration of larvae of *M. dobsoni* and *P. merguensis* connected with the diel rhythm is observed at Bogmalo. Planktonic stages of both the species occur more in samples collected by vertical hauls at day time and surface hauls during the night. Temple and Fischer<sup>22</sup> studying the vertical distribution of the planktonic stages of

penaeid shrimps have reported these stages extending their distribution into the surface layer either just prior to or after the onset of darkness. A close study of the abundance of larval stages in estuarine samples through the hours of the day and night (Fig. 3) would indicate more or less a similar condition.

Maximum recruitment of larvae and post larvae of different species in the Mandovi and Zuari estuaries is noticed mostly at the high tide periods and comparatively more during the premonsoon season. Rao and Krishnaya<sup>23</sup> have reported that higher number of larval stages of *Penaeus indicus*, *P. monodon* and *P. semisulcatus* enter the Pulicat lake at high tide periods. Thus, it is apparent that the planktonic larvae are recruited into the estuaries more due to the tidal effect.

As reported earlier<sup>10,11</sup> from these estuaries the penaeid larvae are noticed to be distributed, in general, more at stations nearer to the mouth of the estuary. This is more evident in the Mandovi estuary since the sampling stations in this estuary are located nearer to the mouth while in the Zuari estuary they are in the mid reaches. The currents at the mouth of both the estuaries are weaker than at the mid and upstream areas<sup>24,25</sup>. These stronger currents in the mid reaches of the estuaries probably result in an apparent reduction of the penetration of the larvae in the Zuari estuary, the sampling stations in this estuary being in these

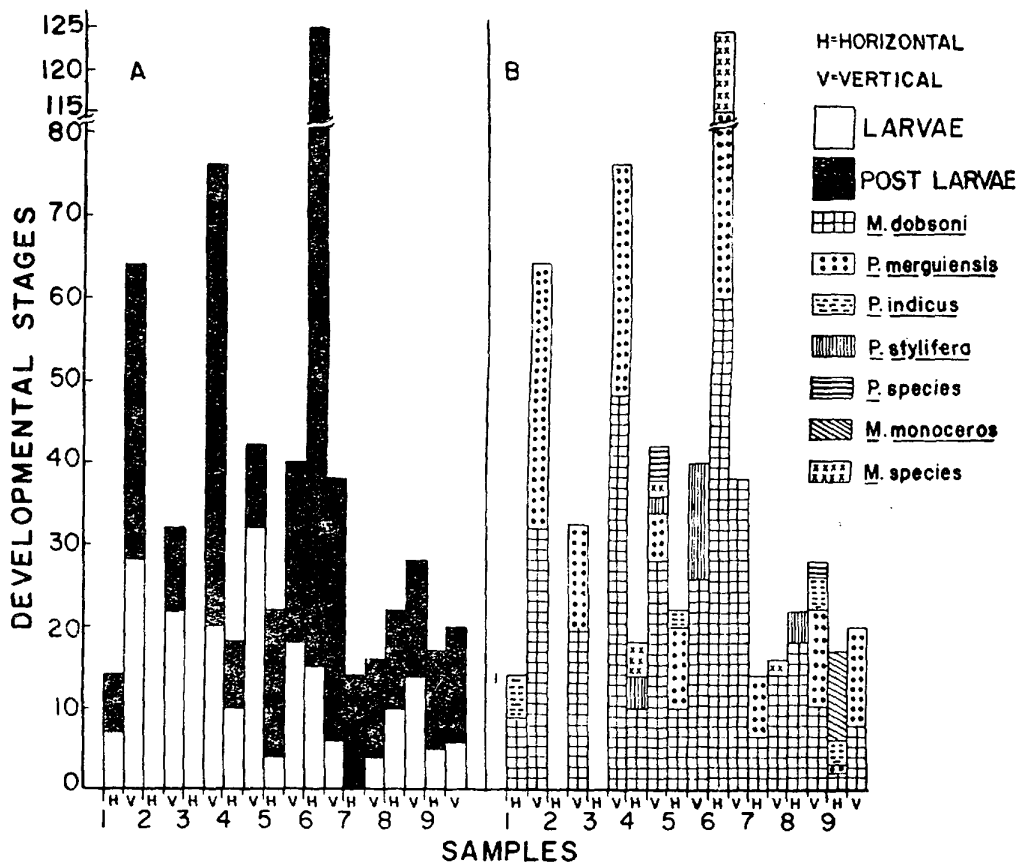


Fig. 6 — Occurrence of (A) larvae and post larvae of penaeid prawns (total) and (B) developmental stages of different species of penaeid prawns at Bogmalo in horizontal and vertical samples

areas. It is also probable that by the time the larvae reach the upstream areas they develop into advanced post larvae and cease to be planktonic, resulting in a lesser representation in the plankton.

The results of the present study, showing abundance of planktonic stages, especially post larval stages of cultivable species of penaeid prawns in certain hours in the diel rhythm and tidal phases would certainly be useful in the context of seed collection from nature for aquaculture of the prawns. It is indicated that these can be collected in large numbers for stocking purposes during premonsoon season at dusktime and high tide periods.

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