

Lunar, diel and tidal variability in penaeid prawn larval abundance in the Mandovi estuary, Goa

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Prawn larvae were studied to determine suitable lunar and tidal phases and time for large scale seed collection for prawn aquaculture. Larvae and postlarvae of 8 commercially important species were observed in the surface and bottom zooplankton samples. These were in order of abundance, *Metapenaeus dobsoni* (Miers), *M. affinis* (H. Milne-Edwards), *M. monoceros* (Fabricius), *Parapeneopsis stylifera* (H. Milne-Edwards), *Penaeus merguensis* De Man, *P. indicus* H. Milne-Edwards, *P. monodon* Fabricius and *P. semisulcatus* De Haan. The mysis stages were dominant. Water temperature and salinity variations were meagre and do not seem to influence larval abundance. However, lunar phases, diel cycles and tidal oscillations influenced their occurrence. The preponderance of protozoa and mysis stages was noticed in samples taken during day time while postlarvae were common at night. Total ingress of penaeid prawn larvae was more during full moon and high tide compared to new moon and low tide periods.

Prawns of family Penaeidae are of considerable importance in the fishery of the coastal and estuarine waters of India¹. Their larvae ingress with tidal currents into estuarine and backwaters for feeding and growth. They later return to the coastal and marine habitats for spawning. The variations in the intensity of larvae recruitment determine the success of prawn capture fisheries in any particular region. The seasonal and diel recruitment patterns of penaeid prawn larvae in the estuaries of Goa were studied²⁻⁴. The influence of lunar phases on penaeid prawn larval abundance in the estuaries along the east coast of India was documented^{5,6}. Information is not available on the influence of lunar phases on ingress of larvae and postlarvae into the estuarine ecosystems along the west coast except in Cochin backwaters⁷. The present paper deals with the relative occurrence and abundance of protozoa, mysis and postlarval stages of penaeid prawns during lunar, diel and tidal phases in the Mandovi estuary, Goa.

Materials and Methods

The study was carried out over entire tidal cycles during full moon (5-6 March 1985) and new moon (21-22 March 1985) periods at a station (2 km leeward from the mouth region) in the Mandovi estuary, Goa (lat. 15°30'N; long. 73°50'E). Surface and bottom (5 m depth) zooplankton samples were taken with HT net (mouth area 0.25 m² and mesh-

width 0.3 mm) fitted with a calibrated flowmeter. The sampling was done at every 2 h interval covering the entire tidal cycle. Penaeid prawn larvae were sorted from 25 to 100% of the sample. Their numbers were raised to total and given as 100 m⁻³. The larvae of each species were further sorted into 3 protozoa, 3 mysis and postlarval stages and identified⁸. Water samples were taken simultaneously along with zooplankton for measurements of temperature and salinity. To study diurnal variability the zooplankton and water collections made between 0600 to 1800 and 1800 to 0600 hrs were considered arbitrarily as day and night samples respectively.

Results and Discussion

Temperature and salinity variations over the entire diel cycles were not much (Table 1). The prevailing hydrographical conditions over the diel cycles do not seem to influence the larval abundance (Table 1) as reported earlier³. Larval stages of 8 penaeid prawn species were encountered. The protozoa, mysis and postlarval stages occurred in varying numbers (Table 2). Five eggs and 2 nauplii were obtained in the surface zooplankton sample taken at 1100 hrs on full moon day. Their number being negligible, these were not included in the total counts. The larval stages of various species recorded in the order of abundance were *Metapenaeus dobsoni* (36.2%), *M. affinis* (29.44%), *M. monoceros*

(12.25%) *Parapeneopsis stylifera* (7.06%), *Penaeus merguensis* (4.76%), *P. indicus* (4.69%), *P. monodon* (2.96%) and *P. semisulcatus* (2.64%). Based on total larval counts, the mysis stages were abundant (48.91%), followed by protozoa (34.68%) and postlarvae (16.41%). Amongst the protozoa stages (Table 2) highest and lowest abundance were recorded for protozoa III and protozoa II respectively. The protozoa I were invariably present except for *M. monoceros* in bottom samples taken during full moon. The protozoa I of *M. affinis* were common but those of *P. semisulcatus* were poorly represented during both the lunar phases. The protozoa II of *M. monoceros*, *P. merguensis*, *P. semisulcatus* and *P. stylifera* were not recorded in zooplankton samples collected during full moon but were present in varying numbers in new moon collections, except for *P. merguensis*. The protozoa III were numerous and occurred invariably in all samples. The maximum and minimum occurrence were recorded for *M. affinis* and *P. semisulcatus*. Among the mysis stages, highest and the lowest population density were recorded for mysis I and mysis III respectively. The poor occurrence of mysis III could be that when the larvae reach this stage they sink to the bottom to take up the benthic mode of life. The occurrence and abundance (no. 100 m⁻³) of mysis stages were also influenced by the lunar phases, being comparatively more in zooplankton samples taken during full moon (14249) than during new moon period (3003). The mysis stages of *M. dobsoni* were common while those of

P. monodon were poorly represented and were not observed in surface collections taken on the new moon (Table 2). Earlier studies⁵⁻⁷ on the influence of lunar phases on ingress rates of penaeid larvae into the Indian estuarine ecosystems dealt mainly with the postlarval stages. No data is available for comparison with regard to protozoa and mysis stages from the Indian waters. However, Cockcroft and Wooldridge⁹ reported that mysis I of *Macropetasma africanus* was the dominant constituent of penaeid prawn larval population during full moon in the Algoa Bay, S. Africa. During the present study the postlarvae of *M. dobsoni*, *M. monoceros*, *P. stylifera*, *P. semisulcatus*, *P. merguensis*, *M. affinis*, *P. monodon* and *P. indicus* were obtained in order of abundance. Kuttyamma⁷ reported that the postlarvae of *M. dobsoni* were dominant and those of *P. indicus* were poorly represented in zooplankton collections from the Cochin backwaters. The postlarvae were encountered almost in all the collections, particularly during the new moon phase. It was reported that the larvae were abundant in collections during new moon⁹. Subramanyam and Rao¹⁰ observed no definite trend in the occurrence and abundance of postlarvae in samples collected coinciding with the full moon and new moon days. The numerical abundance of larvae varied with the type of haul, being abundant in the surface (61.92%) compared to bottom hauls (38.08%). In general the protozoa and mysis stages were common in the surface samples. The postlarvae were generally more in bottom collections during full moon. The postlarvae of

Table 1—Environmental parameters and total penaeid prawn larvae during fullmoon and newmoon periods (values in parentheses are of bottom samples)

Time of collection (hrs)	Full moon period			New moon period		
	Temperature (°C)	Salinity (× 10 ⁻³)	Larvae (no. 100m ⁻³)	Temperature (°C)	Salinity (× 10 ⁻³)	Larvae (no. 100m ⁻³)
1100	28.1(27.6)	33.8(34.0)	3889(539)	29.8(29.5)	34.7(34.8)	1625(1023)
1300	28.3(27.8)	33.6(33.8)	1096(879)	30.0(29.6)	34.7(34.7)	586(638)
1500	28.0(27.9)	33.6(33.5)	663(478)	29.7(29.5)	34.2(34.6)	110(384)
1700	27.9(28.1)	31.4(31.2)	351(106)	29.3(29.5)	33.8(33.5)	117(115)
1900	27.9(27.9)	32.6(32.8)	180(0)	29.3(29.3)	34.0(33.8)	32(183)
2100	27.6(27.5)	32.7(33.0)	605(639)	29.1(29.0)	34.0(34.0)	967(152)
2300	27.4(27.3)	33.0(33.4)	1171(674)	29.0(28.9)	34.4(34.6)	908(419)
0100	27.4(27.3)	33.2(32.2)	1189(1293)	28.8(28.6)	34.2(34.4)	266(206)
0300	27.2(27.1)	33.2(32.9)	2443(1027)	28.9(28.6)	34.0(34.2)	1666(414)
0500	27.4(27.5)	33.1(32.7)	370(425)	29.1(29.0)	34.2(34.4)	190(239)
0700	27.6(27.4)	33.4(33.2)	109(460)	29.3(29.0)	34.3(34.5)	37(106)
0900	27.7(27.5)	33.6(33.8)	173(396)	29.5(29.1)	34.5(34.6)	997(824)
1100	28.0(27.6)	33.6(33.9)	1814(1548)	29.6(29.3)	34.5(34.6)	191(146)

M. affinis and *M. monoceros* were abundant in surface collections irrespective of the lunar phase (Table 2).

Diel and tidal variations—Population density of larvae of penaeid prawn species varied with tidal cycle (Table 3). The larval stages of *Metapenaeus dobsoni*, *M. monoceros* and *M. affinis* were common in surface and bottom zooplankton samples collected during day. The postlarvae of genera *Penaeus* and

Parapeneopsis (Table 3) were abundant in surface samples taken at night. Nocturnal abundance in the distribution of penaeid larvae was reported from other areas^{5,10-12}. Higher occurrence of postlarvae in night collections in the Mandovi estuary was also reported³. Mandovi estuary is a tide dominated coastal plain estuary with semi-diurnal tides and with maximum amplitude of about 2 m. The tidal flow

Table 2—Occurrence of different larval stages of penaeid prawns (no. 100 m⁻³) in the Mandovi estuary during full moon and new moon periods (numbers in the parentheses are of bottom samples)

Species	Larval stages						
	PI	PII	PIII	MI	MII	MIII	PL
Full moon period							
<i>Metapenaeus dobsoni</i>	338 (181)	0 (14)	269 (96)	769 (812)	2031 (524)	1234 (791)	910 (1099)
<i>M. affinis</i>	527 (514)	39 (0)	594 (365)	1855 (813)	1621 (525)	137 (117)	148 (53)
<i>M. monoceros</i>	168 (0)	0 (0)	505 (62)	86 (226)	371 (155)	406 (234)	176 (120)
<i>Penaeus indicus</i>	118 (32)	15 (3)	203 (0)	39 (134)	0 (66)	23 (35)	0 (31)
<i>P. monodon</i>	95 (53)	27 (0)	261 (78)	39 (7)	0 (3)	0 (7)	7 (0)
<i>P. merguensis</i>	55 (35)	0 (0)	96 (43)	96 (124)	19 (188)	0 (57)	46 (106)
<i>P. semisulcatus</i>	35 (7)	0 (0)	19 (18)	58 (35)	19 (42)	31 (35)	56 (66)
<i>Parapeneopsis stylifera</i>	223 (177)	0 (0)	74 (21)	117 (92)	19 (81)	19 (92)	60 (95)
New moon period							
<i>Metapenaeus dobsoni</i>	242 (221)	165 (0)	366 (266)	399 (196)	113 (99)	223 (116)	902 (392)
<i>M. affinis</i>	586 (286)	0 (44)	403 (458)	432 (296)	66 (199)	84 (33)	121 (80)
<i>M. monoceros</i>	198 (98)	44 (26)	593 (305)	48 (80)	0 (0)	87 (39)	117 (79)
<i>Penaeus indicus</i>	179 (32)	79 (33)	286 (136)	14 (26)	14 (0)	14 (26)	88 (26)
<i>P. monodon</i>	117 (40)	36 (13)	15 (66)	0 (0)	0 (0)	0 (12)	132 (36)
<i>P. merguensis</i>	109 (81)	0 (0)	132 (120)	7 (6)	14 (0)	29 (46)	141 (116)
<i>P. semisulcatus</i>	69 (13)	0 (6)	102 (53)	0 (0)	0 (0)	16 (0)	154 (134)
<i>Parapeneopsis stylifera</i>	347 (126)	102 (52)	143 (86)	29 (93)	14 (26)	14 (93)	207 (89)

PI-III = Protozoa 3 stages, MI-III = Mysis 3 stages, PL = Postlarvae

seems to influence larval ingress with abundance during high tide (Table 4). The peak occurrence was obtained at 1100 and 0300 hrs, coinciding with the spring tide periods. The larvae and postlarvae of *M. dobsoni*, *P. indicus*, *P. monodon* and *P. merguensis* were abundant in the collections. Subramanyam and Rao¹⁰ observed that the incursion of postlarvae of *P.*

indicus, *P. monodon* and *P. semisulcatus* was maximum during high tides at full moon and new moon periods. Staples and Vance¹³ reported increased immigration of postlarvae of *P. merguensis* into estuaries on alternate spring tides. Rothlisberg and Church¹⁴ recorded enhanced larval ingress into estuarine environment within the first few hours of

Table 3—Occurrence of penaeid prawn larvae (no. 100m⁻³) in the Mandovi estuary over tidal cycle and during full moon and new moon periods (numbers in parentheses are of bottom samples)

Species	Collection time (hrs)												
	1100	1300	1500	1700	1900	2100	2300	0100	0300	0500	0700	0900	1100
Full moon period													
<i>Metapenaeus dobsoni</i>	1969 (163)	353 (355)	195 (248)	137 (35)	133 (0)	176 (284)	488 (355)	312 (266)	605 (301)	254 (124)	47 (347)	62 (135)	820 (904)
<i>M. affinis</i>	1445 (216)	373 (269)	293 (124)	78 (35)	31 (0)	254 (195)	508 (106)	468 (407)	664 (301)	58 (142)	31 (21)	15 (92)	703 (479)
<i>M. monoceros</i>	398 (46)	234 (234)	78 (106)	78 (0)	0 (0)	136 (71)	78 (195)	195 (0)	315 (71)	0 (36)	8 (14)	16 (0)	176 (24)
<i>Penaeus indicus</i>	31 (60)	39 (7)	0 (0)	0 (0)	0 (0)	0 (0)	19 (18)	58 (177)	195 (0)	0 (0)	0 (0)	18 (21)	38 (18)
<i>P. monodon</i>	0 (11)	78 (0)	39 (0)	0 (0)	0 (0)	0 (0)	39 (0)	39 (35)	176 (0)	0 (17)	0 (0)	39 (85)	19 (0)
<i>P. merguensis</i>	0 (25)	0 (0)	19 (0)	39 (0)	0 (0)	39 (0)	39 (0)	0 (355)	176 (142)	0 (0)	0 (0)	0 (14)	0 (17)
<i>P. semisulcatus</i>	12 (11)	0 (7)	0 (0)	0 (18)	8 (0)	0 (18)	0 (0)	98 (0)	19 (106)	19 (18)	0 (0)	23 (7)	39 (18)
<i>Parapeneopsis stylifera</i>	34 (7)	19 (7)	39 (0)	19 (18)	8 (0)	0 (71)	0 (0)	19 (53)	293 (106)	39 (88)	23 (78)	0 (42)	19 (88)
Total	3889 (539)	1096 (879)	663 (478)	351 (106)	180 (0)	605 (639)	1171 (674)	1189 (1293)	2443 (1027)	370 (425)	109 (460)	173 (396)	1814 (1548)
New moon period													
<i>Metapenaeus dobsoni</i>	102 (173)	102 (106)	22 (80)	55 (43)	11 (43)	498 (46)	498 (179)	205 (66)	293 (169)	132 (53)	37 (53)	396 (259)	59 (20)
<i>M. affinis</i>	220 (226)	132 (265)	44 (132)	11 (6)	7 (30)	176 (40)	102 (106)	44 (60)	568 (126)	29 (93)	0 (40)	308 (259)	51 (13)
<i>M. monoceros</i>	278 (139)	59 (106)	29 (26)	22 (6)	0 (20)	59 (20)	102 (13)	73 (66)	238 (46)	29 (66)	0 (6)	161 (80)	37 (33)
<i>Penaeus indicus</i>	322 (106)	88 (26)	0 (40)	0 (10)	7 (10)	0 (13)	15 (8)	44 (0)	183 (13)	0 (0)	0 (0)	15 (53)	0 (0)
<i>P. monodon</i>	146 (60)	29 (0)	0 (13)	0 (0)	0 (0)	29 (0)	44 (7)	0 (7)	37 (13)	0 (7)	0 (0)	15 (60)	0 (0)
<i>P. merguensis</i>	161 (173)	102 (40)	15 (13)	22 (0)	0 (30)	0 (13)	59 (86)	0 (0)	73 (7)	0 (0)	0 (0)	0 (7)	0 (0)
<i>P. semisulcatus</i>	59 (20)	15 (13)	0 (0)	7 (0)	0 (20)	59 (13)	29 (0)	0 (0)	128 (20)	0 (7)	0 (0)	0 (33)	44 (80)
<i>Parapeneopsis stylifera</i>	337 (126)	59 (132)	0 (80)	0 (50)	7 (30)	146 (7)	59 (20)	0 (7)	146 (20)	0 (13)	0 (7)	102 (73)	0 (0)
Total	1625 (1023)	586 (688)	110 (384)	117 (115)	32 (183)	967 (152)	908 (419)	366 (206)	1666 (414)	190 (239)	37 (106)	997 (824)	191 (146)

Table 4—Diel and tidal variations in abundance of penaeid prawn larvae (av.no. 100 m⁻³) at a station in the Mandovi estuary during full and and new moon periods (numbers in parentheses are of bottom haul)

Species	Full moon period					New moon period				
	D	N	LT	RT	HT	D	N	LT	RT	HT
<i>Metapenaeus dobsoni</i>	512 (312)	328 (222)	195 (79)	300 (315)	1228 (259)	86 (122)	273 (93)	93 (48)	169 (93)	300 (176)
<i>M. affinis</i>	420 (176)	330 (192)	68 (88)	189 (210)	976 (161)	109 (134)	154 (76)	20 (49)	148 (107)	161 (166)
<i>M. monoceros</i>	140 (75)	121 (62)	39 (18)	129 (69)	238 (120)	84 (56)	83 (38)	25 (36)	73 (45)	190 (76)
<i>Penaeus indicus</i>	18 (15)	45 (32)	0 (0)	39 (25)	25 (39)	61 (33)	41 (7)	0 (5)	37 (17)	168 (57)
<i>P. monodon</i>	25 (14)	42 (9)	0 (8)	43 (13)	19 (5)	27 (19)	18 (6)	0 (3)	21 (13)	95 (33)
<i>P. merguensis</i>	8 (8)	42 (83)	19 (0)	26 (59)	19 (12)	43 (33)	22 (23)	11 (0)	21 (12)	110 (130)
<i>P. semisulcatus</i>	10 (9)	24 (18)	10 (18)	21 (13)	6 (6)	18 (21)	36 (10)	3 (3)	27 (20)	44 (10)
<i>Parapenaeopsis stylifera</i>	22 (34)	60 (53)	29 (53)	47 (49)	17 (3)	71 (67)	60 (16)	0 (31)	51 (39)	198 (73)

D = Day, N = Night, LT = Low tide, RT = Receding tide, HT = High tide

the flood tide. The results of the present study have indicated abundance of planktonic stages, especially the postlarvae of cultivable species of penaeid prawns in certain hours of diel and tidal phases.

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