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Emigration dynamics of three species of penaeid prawn from backwaters and tidal ponds of Cochin, India

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Abstract

Emigration of three species of penaeid prawn from backwaters and tidal ponds were studied. Considerable diel, tidal, lunar and seasonal fluctuations were observed in emigration process, which was almost nocturnal. Rate of emigration and composition of emigrants varied with time of migration. Large pulses of emigration always coincided with spring tides with major peak during new moon. Seasonal variation was observed with peak emigration of *Penaeus indicus* during monsoon months and that of *Metapenaeus dobsoni* and *Metapenaeus monoceros* during pre-monsoon. Rate of emigration was relatively large from shallow tidal ponds. It correlated directly with the prevailing environmental conditions and juvenile density. Instantaneous rate of emigration was also large in seasonal ponds. The basic stimulus for emigration is the urge for sexual maturation. Coupled with it ecological changes in the habitat have been causing various patterns in migration.

Key words: Emigration dynamics, Penaeid prawn, Brackishwater

Introduction

Penaeids mature and spawn in the open ocean. Early post larvae migrate to shallow coastal waters and backwaters for feeding and nursing. After the nursery phase in the estuarine area they migrate back to sea for their next phase of life; maturation and spawning . The migrating prawns support an extensive artisanal fishery in open backwaters and adjacent tidal ponds. Different authors have investigated the causal stimuli behind penaeid emigration and several factors have been discussed to explain the same (Garcia 1977, Dall 1981, Garcia and Le Reste 1981, Staples and Vance 1986, Laubier, 1989, Benfield *et. al.* 1990). Most of them considered physico-chemical changes in the habitat, lunar periodicity and tidal cycles act as the major stimuli, that evoke emigration in prawns, Barring some information on seasonal shrimp migration based on filter net fishery by Menon (1951), George (1974) and Anon (1982), penaeid emigration was very little understood from Indian waters. So a study was carried out during 1992-2001 to understand more on the causative factors and behaviour of penaeids during their emigration form tidal ponds and backwaters. This paper describes in detail the dynamics of emigration of penaeids from tidal ponds and backwaters and the causal stimuli.

Material and methods

The study was carried out in two each of perennial ponds, deep and shallow seasonal ponds (SPI and SPII) and open backwater sites. Filter nets are 4.5 to 5.0 m long tapering conical nets, made of strong cotton or nylon threads with 0.4 mm meshed code end. Emigration was studied by monitoring the prawn catch in filter nets at fortnightly intervals. Data collections were designed to coincide with different tidal and lunar phases. Biology of the species in the catch and physico-chemical parameters of the tidal ponds and backwaters were also monitored.

Catch details were collected directly on sampling day and from farm registers for the remaining period. Species composition, length, weight and biology of major species were studied. A total of 11,276 specimens of *Penaeus indicus*, 19,782 *Metapenaeus dobsoni* and 2,871 *Metapenaeus monoceros* were used in the study. Number of prawns emigrated from unit pond area was derived from catch and length-weight data. Instantaneous rate of emigration was estimated as the fraction of total prawns recruited into a habitat during the year that emigrated during the same year. Size at emigration was derived from probability curve using length frequency distribution of emigrating population. Multiple regression and analysis of variance were carried out to evaluate and quantify the influence of various physico-chemical and biological factors on emigration. Paired observations were evaluated for significance by hypothesis test for means. Standard procedures were followed in the biological studies and statistical analysis.

Results

Emigrating penaeid population was dominated by *M. dobsoni* followed by *P. indicus* and *M. monoceros*. In perennial ponds, *M. dobsoni* represents 72.2 to 76.6% of the total emigrants and in seasonal ponds between 78.6 to 82.6%. *P. indicus* represents16.7 to 20.8% of the total emigrating population in perennial ponds and 10.9 to 15.4% in seasonal ponds; where as *M. monoceros* represents 4.1 to 4.9% and 3.6 to 5.5% respectively. In backwaters, *M. dobsoni* represents 72.6 to 88.4%, *P. indicus* 10.7-22% and *M. monoceros* 1.4 to 4.4 % of total emigrating population.

Diel periodicity

Emigration occurred only during night hours. Rate of emigration varied during night hours, depending on the time of ebb tide (Table 1). More recruits emigrate, when ebb tide occurred during early hours of the night than late hours. Preference for early hours of night for emigration was more strong in *M. monoceros* (P=0.012, T-5.6421, DF-5), with 60-73% of the total emigration during that time. In *P. indicus* 57.9 to 63.9% (P=0.001, T-=5.6190, DF-5) and in *M. dobsoni* 52.4 to 63.3% (P=0.004, T-4.2381, DF-5) of the emigration occurred during early hours of the night.

Table 1. Dial, tidal and lunar influence on the emigration rate (x 1000 no/ha of habitat area/year) of penaeid prawns (*EN-early hours of night, LN-late hours of night, NM-new moon, FM-full moon, NP-neap tide, SP-spring tide*)

	Time of emigration		Tide phase		Lunar phase	
Species	*EN*	*LN*	*NP*	*SP*	*NM*	*FM*
P. indicus	112-198	64-136	3-5	177-325	104-176	76-154
M. dobsoni	825-945	593-677	40-45	1380-1545	761-919	638-692
M. monoceros	48-72	21-39	1-2	79-98	47-63	27-43

Tidal and lunar periodicity

Emigration varied with tidal and lunar phases, with peaks during spring tides of new and full moon (Table 1). It occurred exclusively during spring tide periods representing 97.2 to 98.8% of the annual emigration in different species. Distinct variation was observed in emigration between new and full moon phases, with large peaks during new moon phase. Hypothesis test for means showed significant variation in emigration between moon phases (P=0.002, T- 8.1146, DF-5). Response of species to lunar stimuli for emigration vary, with strong preference in *M. monoceros* towards new moon phases (P=0.003, T-=7.8437, DF-5). New moon emigration in the species accounted 55.8 to 68.4% of the total emigration. In *P. indicus* it was 53.2 to 59.1% (P= 0.04, T-7.0656, DF-5) and in *M. dobsoni* 50.9 to 59% (P=0.007, T-=3.7581, DF-5).

Seasonal pattern

Emigration rate varied over the season (Table 2). Significant species by variation was also observed in seasonal emigration. Emigration of *P. indicus* was low during post-monsoon (October – January); thereafter it increased gradually to a small peak in April. It decreased marginally in May and then increased to the large peak by August. Post-monsoon emigration accounted 8.5 to 10.6% of the total emigration, pre-monsoon 29.1 to 31.2 and monsoon 58.1 to 62.5%. Ingression-emigration relationship showed that the resultant juvenile population from post-monsoon recruits emigrate during March-May and that from pre-monsoon recruits during June-September resulting in two waves of emigration.

Table 2. Seasonal variation in the species composition (%) of emigrants

Months	*P. indicus*	*P. monodon*	*M. dobsoni*	*M. monoceros*
Jun	30.84	1.29	65.60	2.27
Jul	33.99	0.72	60.62	4.67
Aug	44.62	0.00	53.65	1.73
Sep	28.46	0.00	70.34	1.20
Oct	10.65	0.00	88. 65	0.70
Nov	7.14	0.00	90.50	2.36
Dec	4.45	0.00	95.55	0.00
Jan	5.63	1.26	91.91	1.20
Feb	11.15	0.00	86.44	2.41
Mar	15.20	0.96	77.09	6.75
Apr	14.64	1.69	77.56	6.11
May	21.94	1.08	72.57	4.41

Emigration of *M. dobsoni* and *M. monoceros* were low during post-monsoon, there after it increased gradually to a large peak by April. It declined in May and again increased to a small peak by August. In the former post-monsoon emigration accounted 14.8-19.1% of the total emigration, monsoon 21.6-32.3% and pre-monsoon 52.9 to 59.3%. Juvenile population from post-monsoon recruits produced a major wave of emigration during March-May and pre-monsoon recruits during July-August. In *M. monoceros* pre-monsoon emigration accounted 50.4 to 63.4, monsoon 32.2 to 46.1 and post-monsoon 3.6 to 4.4% of the total emigration. Juvenile population from post-monsoon recruits emigrated during March-April and pre-monsoon recruits during June-August with respective peaks in April and July.

Statistical tests showed that seasonal variation in emigration directly correlated ($P=0.03$ to 0.05) with juvenile abundance in all species, whereas prevailing environmental conditions have no significant influence. Among environmental factors salinity described maximum (48.3 to 54.8%) variation in emigration.

Emigration rate (E)

Emigration was high from seasonal ponds and low from perennial ponds (Table 3). While emigration rate of *P. indicus* was 2,725 no/ha/month from the perennial ponds, it varied between 3,439 and 5,003 no/ha/month from the seasonal ponds. It was high during the monsoon and low during the post-monsoon months. *M. dobsoni* had an emigration rate of 12,410 no/ha/month from perennial ponds and varied between 23,952 and 24,519 from seasonal ponds. It was low for the species during monsoon and high during pre-monsoon months. Emigration of *M. monoceros* was 762 no/ha/month in perennial ponds and between 1,526 and 1,573 in seasonal ponds. It was relatively low during late monsoon and early post-monsoon and high during pre-monsoon months.

Instantaneous rate of emigration (y) is small for all species in perennial ponds and large in seasonal ponds (Table 3). A large value indicated that recruits left the nursery habitats after a short stay and a small value indicated a prolonged stay.

Table 3. Average emigration rate (E) (no/month/ha of habitat area) and instantaneous rate of emigration (y) of penaeid recruits from tidal ponds

Species	Perennial pond		Seasonal pond (SPI)		Seasonal pond (SPII)	
	E	y	E	y	E	y
P. indicus	2,725	1.653	5,003	3.303	3,439	3.534
M. dobsoni	12,410	2.838	23,952	3.920	24,519	5.197
M. monoceros	792	2.174	1,573	2.763	1,526	3.239

Size and age of emigrants

Size and age of the emigrants from perennial ponds were large and from seasonal ponds and backwaters were small (Table 4). Emigrating populations were characterised by unimodal size distribution. Their size and age at first emigration were large from perennial ponds and small from shallow seasonal ponds and backwaters. Size of the emigrants fluctuated over the season with small during August-September and large during March-April. Proportion of small emigrants with size smaller than the size at first emigration were large in the catches from tidal ponds during July-September. In open backwaters small prawns emigrated round the year with large proportion during June and July. They constituted 6.8 to 9.7 % of the annual emigrants from perennial ponds, 23.8 to 30.3% from seasonal ponds and 36.8% from backwaters.

Table 4. Size and age structure of penaeid emigrants from tidal ponds and backwaters

Habitat/ Species	Size range (mm)	Modal Class (mm)	Mean Length (mm)	Mean age (months)	Mean weight (g)	Size at first emigration	Age at First emigration
P. indicus							
Perennial	38-172	100-110	103.9	3.59	8.4	95.8	3.15
Seasonal I	38-148	90-100	100.2	2.74	7.9	86.4	2.15
Seasonal II	38-143	80-90	92.7	2.21		85.5	85.5
Backwater	9-137	80-90	83.6	2.89	6.5	-	-
					4.7		
M. dobsoni							
Perennial	36-105	65-70	66.6	3.4	2.0	62.1	3.0
Seasonal I	32-90	60-65	60.8	2.5	1.6	57.6	2.3
Seasonal II	32-89	55-60	58. 5	2.3	1.5	55.2	2.1
Backwater	27-86	55-60	58.7	2.9	1.5	-	-
M. monoceros							
Perennial	37-120	80-85	79.9	3.1	3.6	78.1	3.0
Seasonal I	34-103	65-70	68.9	2.1	3.1	62.0	1.8
Seasonal II	33-98	65-70	65.5	2.0	2.7	63.6	1.9
Backwater	26-99	65-70	60.42	2.1	2.0	-	-

Statistical evaluation showed that size of the emigrants depends mainly on the habitat conditions ($P=0.0274$ for *P. indicus;* 0.0253 for *M. dobsoni* and <0.01 for *M. monoceros*). It correlated directly with depth, spread area of the habitat and strength of water exchange. Seasonal variations in the size of emigrants was influenced by prevailing environmental conditions, which described 93.4% of the observed variations ($P<0.01$). Salinity described the maximum variation.

Discussion

Considerable similarities were observed in the emigration of penaeids, despite species specific variability on different aspects. Several biotic and abiotic factors are observed to influence and modify emigration. Preference of species for different ecological conditions modifies the composition of emigrants over space and time. Recruits stay for quiet long periods in habitats with stable environment. As perennial ponds offer stable environment, emigrants from that habitat have relatively large size and age and also small value for instantaneous rate of emigration.

Shrimps in general, are active at night and take refuge or stay buried in sediments during day. Reflecting this active rhythm, emigration is almost nocturnal in penaeids. Such diel variation in penaeid emigration has been demonstrated by earlier workers (Garcia 1977, Staples and Vance 1986, Vance 1992, Vance and Staples 1992). After low profile activities during day, prawns become more active by dusk in search of food and to meet other biological requirements. If ebb tide coincides this period more prawns will emigrate. With the advancement of time during night, their activities subside and so relatively few recruits emigrate, if ebb tide occurs late in the night. Biological activities and diurnal rhythm may vary for species and produce species specific variation in emigration.

Prawns emigrate at ebb phase of high tides, with large emigration during spring tides. The most widely accepted explanation for this is strong water currents during spring tide resulting in increased water displacement (Le Reste 1978, Lhomme 1979, Subramaniam 1990, Vance and Staples 1992, Vance 1992, Dumas 2006). Present observations also indicate considerable influence for tide height and current speed on emigration rates. Since, tide and lunar phases of the region are synchronous, spring tides always coincide with new and full moon phases and made it difficult to separate the lunar influence from tidal influence. However, prevailing light levels at the time of emigration will produce variation in emigration. Being nocturnal, activity of prawns will be intense if nights become dark and so large emigrations at new moon phase (Staples and Vance, 1986).

In nature many factors trigger migration in shrimps (Garcia 1977) and may interact as is the case with regard their influence on behaviour (Vance 1992, Vance and Staples 1992). Shrimps being highly sensitive to the environment in which they live, many attribute considerable influence for ecology in eliciting emigration. Some considered declining water temperature as the driving force in emigration (Garcia and Le Reste 1981, Coles and Greenwood 1983, Benfield *et.al.* 1990, Manzano-Sarabia *et.al.* 2007). Seasonal variation in temperature during the present study was very narrow, to have any direct influence on emigration. However, low temperature always coincided with declining salinity and other ecological conditions and so, some synergistic effect with other factors can be expected.

It was seen that, except during periods of extreme habitat disturbances and environmental instability, prawns emigrate selectively, after attaining certain size and developing secondary sex characters only. So it can be assumed that, it may be the biological instincts, which is set in the animals and become active at certain stages of their life, to have most ideal environment to suit their metabolic/physiological requirement is the driving force in emigration. As most of the emigrants were with well-developed secondary sex structures, the biological instinct can be presumed to be the urge for sexual maturation. Coles and Greenwood (1983) and Subramaniam, (1990), suggested onset of sexual maturity coupled with environmental changes as migratory stimuli in prawns. So urge sexual maturation can be considered as the basic stimuli for emigration, whereas factors like habitat environment, competition and predation have only interactive role in modifying patterns and timings.

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