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Spawning Migration of the Horseshoe Crab, *Tachypleus gigas* (Müller), in Relation to Lunar Cycle

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Abstract - Effects of lunar phases and tidal height on the spawning migration of the horseshoe crab, *Tachypleus gigas* (Müller), along the northeastern coast of India were studied. Mature pairs of crabs migrate towards the shore and build their nests in sandy beaches for spawning throughout the year with maximum activity during April-October at highest high tides of the full moon and November-February during new moon phases. The tidal height showed a significant correlation with the number of crabs migrating towards the beach for spawning.

Large numbers of horseshoe crabs have been used in recent years mainly for the preparation of Limulus Amoebocyte Lysate, an important diagnostic reagent prepared from the blue blood (Rudloe 1979). But for occasional references (Anandale 1909; Sewell 1912; Roonwal 1944; Ramarao and Suryarao 1972; Chatterji et al. 1988) very little work on the ecology or biology of the horseshoe crab along the Indian coast has been reported.

Observations on the migration of the horseshoe crab *Tachypleus gigas* (Müller) for breeding purposes in relation to seasonal and lunar phases variation are reported and discussed here.

A marked 200-m transect adjacent to Budhabalanga Estuary at Balramgari (Orissa), northeastern India, was monitored regularly twice a month, coinciding with full and new moon phases from November 1985 to April 1987. The samples were collected one hour prior to and one hour following the predicted high tide.

The Balramgari Estuary experienced mixed semidiurnal tides (two unequal high and two unequal low tides per day). The tidal amplitude was approximately 2 m, reaching its maximum during

full and new moon phases. The breeding activity was more pronounced in daylight high tides than night tides. In the present study, therefore, all the observations were made during daylight hours at highest high tides of full or new moon when breeding activity was strongest.

All the animals in the marked transect were collected, carapace length measured to the nearest 0.1 mm and sex recorded.

A total of 235 females (98-246 mm) and 255 males (111-174 mm) were collected. Salinity, dissolved oxygen, pH and temperature were recorded at the beginning of each observation.

Pairs of *T. gigas* in the mating stage were found in most of the sampled months, reflecting protracted breeding activity throughout the year. Table 1 shows the number and proportion of males and females along the marked transect during full and new moon phases.

The proportions of adult horseshoe crabs (males and females) are represented in Fig. 1. A definite correlation was found in the occurrence of the crab with tidal amplitude and lunar phase. The higher the tidal amplitude, the greater was the occurrence of crabs in the study area. Relatively higher numbers of crabs were found during full moon tides (Fig. 1a) than in new moon tides (Fig. 1b). Significant positive correlations were found between occurrence and tidal height during new moon ($r=0.96$, $P>0.001$) and full moon ($r=0.83$, $P>0.001$) phases.

Maximum numbers of crabs during full moon high tides were encountered in August 1986. While during new moons the maximum occurred in December 1986. Minimum numbers of crabs at full moon high tides were encountered in March 1986 and March-April 1987, while the corresponding new moon minimum was in April-May 1986.

Breeding activity was not observed during the neap tides. The overall sex ratio averaged 1:0.92 (male to female) (Table 1).

The influences of salinity (19.1-29.8 ppt), dissolved oxygen (3.9-6.3 $ml \cdot l^{-1}$), pH (7.0-8.1) and temperature (26.4-33.2°C) on the shoreward migration of the crab were not found to be significant ($P<0.0001$).

The female crabs deposit their eggs in comparatively fine and clean sand at the high water mark of spring tides. As such, the eggs are protected from various predators. Regular shifting of the nesting ground from one place to another has also been observed at

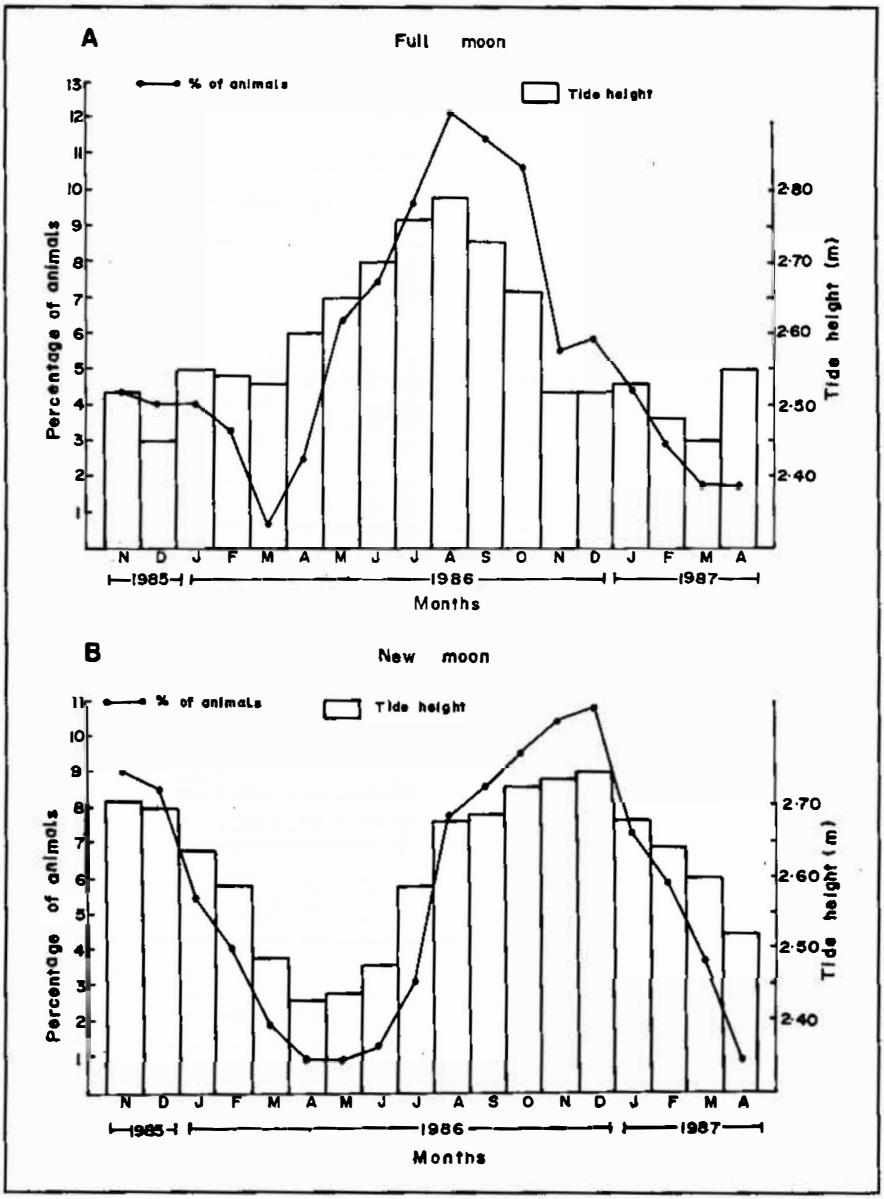

Fig. 1. Relationship between tide height and percentage of crabs collected in different months during (a) full moon tides and (b) new moon tides.

Table 1. Occurrence, abundance and sex ratio in the natural population of the horseshoe crab, *T. gigas* in relation to full moon and new moon phase.

Months	New moon tide			Full moon tide			Sex ratio
	Male	Female	Total	Male	Female	Total	Male:Female
Nov. '85	10	10	20	6	6	12	1:1
Dec. "	10	9	19	6	5	11	1:0.87
Jan. '86	6	6	12	6	5	11	1:0.91
Feb. "	5	4	9	5	4	9	1:0.80
March "	2	2	4	1	1	2	1:1
April "	1	1	2	4	3	7	1:0.80
May "	1	1	2	9	8	17	1:0.90
June "	2	1	3	10	10	20	1:0.91
July "	4	3	7	13	13	26	1:0.94
Aug. "	9	8	17	17	16	33	1:0.92
Sept. "	10	9	19	16	15	31	1:0.92
Oct. "	11	10	21	15	14	29	1:0.92
Nov. "	12	11	23	8	7	15	1:0.90
Dec. "	12	12	24	8	8	16	1:1
Jan. '87	8	8	16	6	6	12	1:1
Feb. "	7	6	13	4	4	8	1:0.90
March "	4	4	8	3	2	5	1:0.85
April "	1	1	2	3	2	5	1:0.75
Total	115	106	221	140	129	269	1:0.92

the study area. The selection of the nesting ground is related to the sediment characteristics (Chatterji et al., unpubl. data).

Lunar phase is reported to influence marine organisms significantly (Barnwell 1968; Saigusa and Hidaka 1978; Rudloe 1979, 1980, 1985; Greenspan 1982). In Delaware Bay, Shuster and Botton (1985) observed that *Limulus polyphemus* started appearing in shallow water during April and reached maximum density during spring tides of May and June. The abundance of the horseshoe crab population in relation to full moon tides has also been reported in Apalache Bay, Florida (Rudloe 1980), and at Sea-horse Key (Cohen and Brockmann 1983).

A definite correlation has been reported between abundance, mating activity (Howard et al. 1984), reproductive behavior (Saigusa and Hidaka 1978; Forward et al. 1982) and lunar phase, and tidal height and sunlight in horseshoe crabs. The reproductive behavior of adult *L. polyphemus* has been found to be greatly influenced by lunar, tidal and circadian rhythms with maximum activity during spring tides, particularly at full moon (Rudloe 1979, 1980). At Sea-horse Key, spawning of *L. polyphemus* has been observed during

daylight high tides (Cohen and Brockmann 1983). Cavanaugh (1975) observed mating activity of the horseshoe crab only after dark at Mashnee Dike, whereas Barlow et al. (1986) concluded that spawning *Limulus* preferred the highest high tides whether they occurred during daylight or at night.

The variation in occurrence of horseshoe crabs on the Balramgari coast indicates the predominance of tidal amplitudes in the seasonal behavioral pattern of the crab. Cohen and Brockmann (1983) and Barlow et al. (1986) have reported a similar positive correlation between the number of *L. polyphemus* and highest high tides on the Gulf of coast of Florida and at Mashnee Dike. The opposite phenomenon has been reported by Rudloe (1980) where maximum numbers of *L. polyphemus* were observed during lowest high tides at Florida.

In the present study, the shoreward migration of juveniles was not observed, which confirms that only mature crabs migrate for breeding purposes. However, juveniles of *L. polyphemus* have been reported to feed actively in the intertidal zone on falling tides during daylight hours in Apalachee Bay (Rudloe 1981).

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References

Anandale, N. 1909. The horseshoe crab, *Tachypleus gigas* (Müller). Rec. Indian Mus. 3:294-295.

Barlow, B., Jr., M.K. Powers, H. Howard and L. Kass. 1986. Migration of *Limulus* for mating in relation to lunar phase, tide height and sunlight. Biol. Bull. 171:310-329.

Barnwell, F.H. 1968. The role of rhythmic systems in the adaptation of fiddler crabs to the intertidal zone. Am. Zool. 8:569-583.

Cavanaugh, C.H. 1975. Observations on mating behaviour in *Limulus polyphemus*. Biol. Bull. 149:419-453.

Chatterji, A., R. Vijayakumar and A.H. Parulekar. 1988. Growth and morphometric characteristics in the horse-shoe crab, *Carcinoscorpius rotundicauda* (Latreille) from Canning (West Bengal), India. Pak. J. Sci. Ind. Res. 31:352-353.

Cohen, J.A. and H.J. Brockmann. 1983. Breeding activity and mate selection in the horseshoe crab, *Limuluus polyphemus*. Bull. Mar. Sci. 33:274-281.

Forward, R.B., K. Lohmann and T.W. Cronin. 1982. Rhythms in larval release by an estuarine crab (*Rhithropanopeus harrisii*). Biol. Bull. 163(2):287-300.

Greenspan, B.N. 1982. Semi-monthly reproductive cycles in male and female fiddler crabs, *Uca pugnax*. Anim. Behav. 30:1084-1092.

Howard, H.A., R.W. Fiordalice, M.D. Camara, L. Kass, M.K. Powers and R.B. Barlow, Jr. 1984. Mating behaviour of *Limulus*: relation to lunar phase, tide height and sunlight. Biol. Bull. 167:527.

Ramarao, K.V. and K.V. Suryarao. 1972. Studies on Indian crabs (Arachnida: Xiphosura). Proc. Indian Acad. Sci. 38:206-211.

Roonwal, M.L. 1944. Some observations on the breeding biology and on the swelling, weight, water content and embryonic movement in the developing eggs of the Moluccan King crab *Tachypleus gigas* (Müller). Proc. Indian Acad. Sci. 20:115-119.

Rudloe, A. 1979. *Limulus polyphemus*. A review of the ecologically significant literature, p. 27-35. *In* E. Cohen (ed.) Biomedical application of the horseshoe crab (Limulidae). Liss, New York.

Rudloe, A. 1980. The breeding behavior and patterns of movement of horseshoe crabs, *Limulus polyphemus*, in the vicinity of breeding beaches in Apalachee Bay, Florida. Estuaries 3:177-183.

Rudloe, A. 1981. Aspects of the biology of juvenile horseshoe crabs, *Limulus polphemus*. Bull. Mar. Sci. 31:125-133.

Rudloe, A. 1985. Variation in the expression of lunar and tidal behavioral rhythms in the horseshoe crab, *Limulus polyphemus*. Bull. Mar. Sci. 36:388-395.

Saigusa, M. and T. Hidaka. 1978. Semilunar rhythms in the zoea-release activity of the land crabs, *Sesarma*. Oecologia 37:103-176.

Sewell, R.B.S. 1912. Capture of *Limulus* on the surface. Rec. Indian Mus. 7:87-88.

Shuster, C.N., Jr. and M.L. Botton. 1985. A contribution to the population biology of the horseshoe crab, *Limulus polyphemus* (L) in the Delaware Bay. Estuaries 8:363-373.

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