



ORIGINAL RESEARCH PAPER

Zoology

EFFECT OF ENVIRONMENTAL FACTORS ON THE REPRODUCTION OF MARINE CRAB, *PORTUNUS SANGUINOLENTUS*

KEY WORDS: Environmental factors, Temperature, Rainfall, Photoperiod, Crab.

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ABSTRACT

India has vast marine as well as freshwater resources having immense potential to be utilized for aquaculture too. Marine resources of India cover sea area along a coastline of 8185 km. In addition there are other related resources comprising backwaters, impoundment, lagoons and estuaries, besides mangroove. In all 1.42 million ha of these water a substantial part of which is beyond coastal regulation zone (CRZ) could be developed for undertaking sustainable and environment friendly coastal aquaculture, similarly inland water in the form of 14 large, 44 medium and many small rivers, 1.2 lakh ha. of irrigation canals, 2.90 million ha. of lakes and reservoirs, 1.30 million ha. of beds and direct water bodies and 2.85 million ha. of ponds and tanks can offer sizeable area for taking up aquaculture activities. Manmade activities such as addition of sewage, suspended solids, and heavy metals affect adversely the ecosystem. These man-made activities, as well as changes in environmental parameters, apart from sources thermal discharge and radioactive substances, affect the balance of ecosystem. Seasonal variations in the environmental factors such as temperature, rainfall and photoperiod affect biotic community and are closely related to species survival. But effluents released by thermal power station in this area affected the productivity of economically important crustaceans. Therefore efforts are made to understand the effect of these environmental factors on reproduction of marine crab, *Portunus sanguinolentus*. Maximum temperature caused quick maturation of gonads. Maximum values of light hours resulted in successful gametogenesis increasing the gonadal indices of female crab. During rainy season, maximum number of ovigerous females were found in the collection.

INTRODUCTION:

Dahanu is a place on Indian west coast at 125 Km away from Mumbai between 19°, 58' North longitude and 72°, 42' East latitude. The BSES, thermal Power Station, Nuclear Atomic Centre Tarapur and industrial area are nearby Dahanu. The survey of decapod crustacean of Dahanu coast is the major part of the study undertaken since decapod crustaceans, prawn, crab and lobster are commercially important due to their high nutritional contents. The success of a species depends on the viability of eggs and rate of development of eggs. Of course a variety of environmental factors such as temperature, rainfall, and photoperiod are closely related to species survival. But the effluents released by thermal power station in this area affected by productivity of economically important crustaceans therefore, efforts are made to understand the effect of environmental factors on the reproduction of marine crab, *Portunus sanguinolentus*. The reproduction of marine as well as freshwater invertebrates are controlled by environmental factors directly or indirectly (Giese and Pearse, 1974). Narayanswami (1982) observed physical characteristics of the coastal water between Navapur and Umbharat west coast of India. Jaiswal and Loveker (1991) studied impacts of environment in freshwater crab, *Barytelphusa cunicularis*. Santhanam (2002) observed studies on ecology, experimental biology and live food suitability of copepod *Oithona rigida* Giesbrecht from Parangipettai coastal environments. Gopakumar (2004) observed life table parameters of *Brachionus plicatilis* and *B. rotundiformis* in relation to salinity and temperature. Ananthan (2004) observed environmental characteristic of Ariyankuppam estuary and Verampattinam coast of Pondicherry. Eswari et al. (2004) studied estuarine copepod abundance and diversity in relation to environmental variables southeast coast of India. Water temperature exerts a major control over the distribution and activities of marine organism population, because certain warmth is essential for reproduction and growth. Lowe (1961) showed that the lowered temperature tend to slow maturation of oocytes while elevated temperature caused quick maturation followed by disintegration of the oocytes in *Cambarellus shufeldti*. Aiken (1969) stated that when both temperature and photoperiod were in proper proportion, the complete maturation took place. Green et al. (1994) studied the effect of temperature on crustacean larvae. Reigada et al. (2000) studied the effect of water temperature on maturity of *Hepatus pudibundus*. The depth exerted an important influence on the biological patterns of deeper water species, with reasonability of reproductive processes increasing in deeper dwelling species. Tyler and Albert (2001) observed the effect of temperature on reproduction cycle of tanner crab, *Chionoecetes bairdi*. Diaz et al. (2005) described effect of salinity and temperature on thermal tolerance of brown

shrimp *Farfantepenaeus azetecus*. Rainfall is one of the factors, which plays an important role in determining the reproductive and spawning period. Pillai (1981) reported that the rainfall influenced reproduction, spawning and release of young ones of *Paratelpusa hydrodromous*. In *Caridina weberi* rainfall regulated the reproductive cycle (Reddy, 1980). Rajyalakshmi (1980) described the relationship between rainfall and reproduction. However, Anger (1995) stated that heavy rainfall did not visibly influence larval growth or development in the crab *Armasas miersii*. Goswami (1996) observed role of rainfall in the variation of biotic and abiotic characters of coleroon estuarine system. Rajsekar (2005) studied the effect of rainfall and salinity on the population density of phytoplankton in coleroon estuary. The natural photoperiod i.e. the rhythm in recurring alternation of illumination (light hours in 24 hrs i.e. a day) is very important in regulating daily and seasonal periodicities in animals. Terrestrial animals and aquatic mammals respond to change in temperature and photoperiod and are influenced by these factors. Gardner and Maguire (1998) studied the effect of photoperiod and light intensity on survival, development and cannibalism of larvae of Australian giant crab, *Pseudocarcinus gigas* (Lamarck). Rosenkranz et al. (2001) observed effects of water temperature and wind on year class success of tanner crab, *Chionoecetes bairdi*. The environmental factors such as temperature, rainfall, and photoperiod are closely related to species survival. But the effluents released by thermal power station in this area affected by productivity of economically important crustaceans therefore, efforts are made to understand the study of these environmental factors. The plankton helps in growth of crustacean and other aquatic animals directly or indirectly. Hence it is essential to study environmental parameters.

MATERIAL AND METHODS: The temperature of the water was determined by use of mercury thermometer more accurately. The readings were taken twice a month and the mean value was calculated. Similarly the environmental temperature was noted everyday and mean was calculated to determine temperature of month. The rainfall near the spot of collection for two years i.e. 2002-2004 was recorded in observatory. The readings were taken from Government Office records. The correlation between rainfall and reproductive cycle was determined. The hours of light in a day was recorded by taking help of almanac. The sunrise and sunset timing were noted and hours of light in a day were calculated. Thus the range of light hours in the month was determined for two years, to understand its role in reproduction.

RESULT: The environmental temperature and water temperature values in the year 2002 and 2003 are given in fig. 1 to 4. It has been

observed that March onwards there was increase in both temperatures. The environmental temperature ranged between 18.5°C to 37.5°C in the year 2002 and 19.2°C to 38.2°C in the year 2003. The water temperature varied from 16.2°C to 34.2°C in the year 2002 while it was 17.3°C to 35.9°C in the year 2003. The temperature affected maturation of gonads in *Portunus sanguinolentus*. Maximum temperature caused quick maturation of gonads whereas minimum temperature slowed the maturation of gonads. In the month of April, 2002 the maximum temperature of water ranged between 24.7 to 34.2°C, hence the gonad maturation in male and female crab *Portunus sanguinolentus* was seen. In crustaceans, the photoperiod influenced the process of gametogenesis. The maximum light hours resulted in successful gametogenesis. The maximum light hours in the year 2002 was in July (13.10 - 13.90) and in the year 2003 was in June (13.10 - 13.12). These maximum values of light hours increased the gonadal indices of female crab. In Maharashtra monsoon starts in the middle of June. The heavy rainfall observed in June to September 2002 (Monsoon season) was 472.9 mm, 29.63 mm, 142.5 mm and 72.1 mm respectively. During June 2003 to September 2003 it was 143.3 mm, 176.3 mm, 127.9 mm and 60.8 mm respectively. During this period maximum ovigerous females were found in the collection. The reproductive phase during monsoon may be for survival dispersal and acceleration of moulting cycle in the larvae of *Portunus sanguinolentus*.

Table - 1: Monthly correlation between various environmental factors and gonadal index of male and female in crab, *Portunus sanguinolentus* during the year 2002.
(Mean of four observations in a month)

| Month | Gonadal index - S.D. | | Environmental Temperature (°C) | Water Temperature (°C) | Range of day light in hours | Rainfall in mm |
|-----------|----------------------|-------------|--------------------------------|------------------------|-----------------------------|----------------|
| | Female (10) | Male (10) | | | | |
| January | 0.86 ± 0.01 | 0.73 ± 0.01 | 18.5 - 26.1 | 16.2 - 24.3 | 11.02 - 11.12 | Nil |
| February | 1.39 ± 0.01 | 0.91 ± 0.02 | 19.0 - 27.0 | 17.5 - 26.0 | 11.25 - 11.40 | Nil |
| March | 1.22 ± 0.09 | 1.06 ± 0.02 | 22.1 - 30.6 | 20.5 - 28.5 | 11.55 - 12.11 | Nil |
| April | 2.09 ± 0.01 | 1.14 ± 0.06 | 26.5 - 37.5 | 24.7 - 34.2 | 12.27 - 12.41 | Nil |
| May | 2.65 ± 0.02 | 1.90 ± 0.01 | 25.3 - 34.8 | 21.8 - 30.5 | 12.55 - 13.05 | Nil |
| June | 3.28 ± 0.07 | 2.27 ± 0.04 | 28.0 - 32.5 | 23.5 - 28.3 | 13.11 - 13.13 | 472.9 |
| July | 4.17 ± 0.01 | 2.87 ± 0.02 | 25.8 - 30.0 | 24.8 - 27.6 | 13.10 - 13.90 | 29.63 |
| August | 2.40 ± 0.02 | 3.74 ± 0.12 | 25.0 - 28.8 | 23.1 - 26.3 | 12.49 - 12.36 | 142.5 |
| September | 1.73 ± 0.01 | 1.49 ± 0.03 | 25.6 - 29.5 | 24.0 - 28.8 | 12.28 - 12.05 | 72.1 |
| October | 1.41 ± 0.03 | 0.72 ± 0.01 | 24.5 - 33.1 | 21.2 - 30.4 | 11.49 - 11.33 | Nil |
| November | 1.26 ± 0.01 | 0.95 ± 0.02 | 23.4 - 32.5 | 20.7 - 29.9 | 11.20 - 11.08 | Nil |
| December | 1.08 ± 0.02 | 0.83 ± 0.07 | 20.1 - 29.0 | 18.1 - 27.3 | 10.59 - 10.56 | Nil |

Table - 2: Monthly correlation between various environmental factors and gonadal index of male and female in crab, *Portunus sanguinolentus* during the year 2003.
(Mean of four observations in a month)

| Month | Gonad index - S.D. | | Environmental Temperature (°C) | Water Temperature (°C) | Range of day light in hours | Rainfall in mm |
|-----------|--------------------|-------------|--------------------------------|------------------------|-----------------------------|----------------|
| | Female (10) | Male (10) | | | | |
| January | 0.80 ± 0.03 | 0.66 ± 2.02 | 19.2 - 26.5 | 17.5 - 24.8 | 10.57 - 11.04 | Nil |
| February | 1.29 ± 0.01 | 0.85 ± 0.06 | 20.0 - 28.5 | 17.3 - 24.0 | 11.15 - 11.29 | Nil |
| March | 1.43 ± 0.01 | 1.03 ± 0.01 | 23.4 - 34.5 | 21.2 - 30.4 | 11.44 - 12.59 | Nil |
| April | 2.08 ± 0.02 | 1.10 ± 0.01 | 27.5 - 38.2 | 25.3 - 35.9 | 12.15 - 12.31 | Nil |
| May | 2.62 ± 0.05 | 1.47 ± 0.03 | 26.7 - 36.7 | 25.0 - 34.8 | 12.45 - 12.58 | Nil |
| June | 3.19 ± 0.02 | 2.06 ± 0.05 | 28.6 - 33.0 | 24.5 - 30.3 | 13.10 - 13.12 | 143.3 |
| July | 4.28 ± 0.02 | 2.72 ± 0.02 | 26.2 - 30.4 | 22.9 - 28.7 | 13.07 - 12.57 | 176.9 |
| August | 2.94 ± 0.02 | 3.37 ± 0.01 | 25.9 - 30.9 | 23.2 - 26.5 | 12.46 - 12.31 | 127.6 |
| September | 2.46 ± 0.01 | 1.58 ± 0.02 | 26.0 - 30.0 | 24.6 - 27.3 | 12.71 - 12.59 | 60.8 |
| October | 1.64 ± 0.01 | 0.66 ± 0.02 | 26.5 - 33.6 | 24.3 - 30.0 | 11.45 - 11.30 | Nil |
| November | 1.27 ± 0.20 | 0.87 ± 0.05 | 23.6 - 32.8 | 23.0 - 29.4 | 11.17 - 11.05 | Nil |
| December | 1.16 ± 0.04 | 0.70 ± 0.03 | 21.5 - 28.8 | 20.3 - 26.8 | 10.88 - 10.32 | Nil |

Fig.1. Monthly average environmental temperature of collection spot during the year 2002

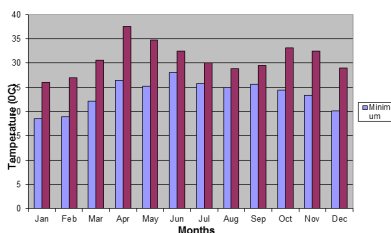


Fig.2. Monthly average environmental temperature of collection spot during the year 2003

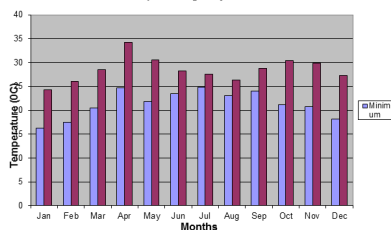


Fig.3. Monthly average water temperature of collection spot during the year 2002

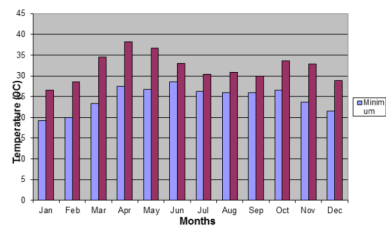


Fig.4. Monthly average water temperature of collection spot during the year 2003

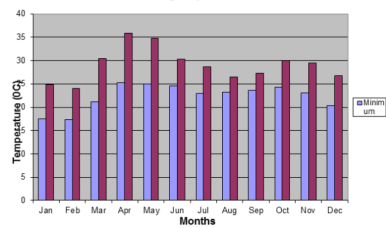


Fig.5. Monthly average rainfall of collection spot during the year 2002

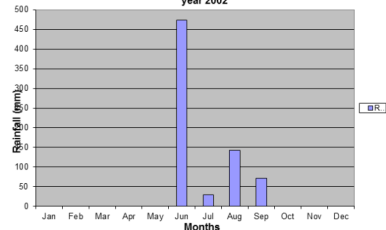
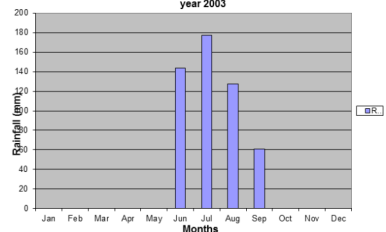


Fig.6. Monthly average rainfall of collection spot during the year 2003



DISCUSSION:

The ecological parameters viz rainfall, photoperiod, temperature etc. played major role in determining the reproductive cycle and breeding behaviour in crustaceans (Vishwanathan, 1992). Schuh and Diesel (1995) described the impact of ecological conditions on breeding behaviour and larval development in sesarimid crab, *Armases miersii*. Many physiological activities in aquatic organisms are under the influence of temperature. In spite of its importance in physiological and ecological consequences on living system the information at hand is limited (Kinne, 1964). Atmosphere temperature during seasonal cycle is superimposed by the conditions such as (Welch, 1952; Hutchinson, 1957) time of collection, topography of water (Ganapati, 1956) and solar radiation (Munawar, 1970), which have an impact on the atmospheric temperature. In present study the maximum atmospheric temperature during summer was in the range of 37.5°C to 38.2°C (2002 and 2003). The similar observations have been reported by several workers (Chourasia and Adoni, 1985; Ramanibai and Ravichandran, 1987; Ambasht and Shardendu, 1989; Ghosh and George, 1989; Fasihuddin and Kumari 1990 and Mahajan and Kanhere, 1995). Temperature reflects on the dynamics of living organisms (Chandler, 1942). Water temperature depends upon the depth of water body, besides solar radiation, climate and topography. It has been observed that no other single factor has so much profounded direct or indirect influence on physico-chemical, biological, metabolic and physiological behaviours of aquatic ecosystem than temperature (Welch, 1952). The temperature of water depends upon various factors like climate, sunlight, light intensity and light penetration. Water temperature is generally minimum during the early hours of morning and reaches maximum value in the afternoon, showing diurnal fluctuations. The season variations of water temperature influence greatly on the variations in crustaceans. In the present

investigation the maximum water temperature peaks were recorded in May 2002 and April 2003. The water temperature values continuously rises from February to April 2002 and 2003. Water temperature values decrease during monsoon period June to August 2002 and 2003. The atmospheric temperature was slightly more than the water temperature. Generally, the seasonal changes observed in the water temperature were always correlating with similar behaviours of atmospheric temperature. The water temperature is the main factor of influence of the survival of juvenile crab, *Scylla serrata* (Wang et al., 1998). In summer the water temperature was increased due to environmental temperature and long day length and decrease during winter season due to shorter photoperiod and decreased environmental temperature. The light hours were maximum from May to August, which resulted in a successful gametogenesis. In spawning period, (June to August) gonadal maturations was influenced by photoperiod (Han et al, 1993). Temperature and photoperiod play an important role in the process of gametogenesis. Long photoperiod along with rise in temperature i.e. from January to April coincided along with maximum number of ovigerous females in collection (Mirajkar et al., 1984). Menakar (1971) observed that the photoperiod is employed in animals as a seasonal clue to initiate and terminate the annual reproductive cycle. The total light or total darkness may have indirectly suppressed active ovarian growth by inhibiting the light-dark cycle dependent processes. Goswami and Padmavathy (1996) observed that the northeast monsoon rainfall played a major role in the variations of biotic and abiotic characters of coleroon estuarine system. The recorded maximum SST during summer season could be attributed to the dry weather condition and clear sky high primary productivity was observed during summer season because of high salinity, surface water temperature, high population density of phytoplankton (Rajasekar et al. 2000, Senthilkumar et al. 2002). In the present investigation it has been observed that photoperiod controlled the reproduction of *Portunus sanguinolentus*. The reproductive activity was initiated by influence of photoperiod at an appropriate time. Therefore, offspring were released in monsoon season. This season is suitable for survival and distribution of larvae of crab. in crab *P. sanguinolentus*, the development of eggs and spawning correlated with rainfall for the best survival of young ones. Hence, the rainfall plays an important role in reproductive cycle of crustacean.

SUMMARY: Gonad maturation was influenced by temperature. Higher temperature caused quick maturation of gonads, whereas lower temperature slowed the maturation of gonad. Photoperiod controlled the reproductive activity of crab. Reproductive activity was initiated by the influence of photoperiod. The maximum light hours from June to August resulted in successful gametogenesis. The rainfall was essential for the release, survival, dispersal and acceleration of moulting cycle in larvae of crab. The present research work gave the knowledge about the crustacean's species available in Dahanu region. The lack of information about species and catching only some commercially important crab species and neglecting other could account for the falling marine catch. Dahanu is a rural area as well as tribal area and the aquaculture is limited to only few commercially important species such as tiger prawn and lobster in this region. The present research work is very useful to encourage and take up the 'aquaculture' activities in the rural area to support socio-economic development.

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