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# Distribution, Abundance and Population Ecology of *Ashtoret lunaris* (Forskel, 1775) and *Matuta planipes* Fabricius, 1798 from the Sonmiani Bay (Lagoon), Pakistan

**Noor Us Saher[1], Zunaira Amanat[2], M. Asif Gondal[3] and Naureen Aziz Qureshi[4,*]**

[1]*Centre of Excellence in Marine Biology, University of Karachi, Karachi 75270, Pakistan.*

[2]*Department of Zoology, Federal Urdu University of Arts, Science and Technology, University Road, Karachi, Pakistan.*

[3]*Department of Biosciences, COMSATS Institute of Information Technology, Park Road, Islamabad, Pakistan*

[4]*Government College Women University, Faisalabad, Pakistan*

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**NUS designed the study, performed the experiments and wrote the article. MAG helped in field and lab work. ZA helped in statistical analysis. NAQ helped in preparation of manuscript.**

**Key words**
***Matuta planipes*, *Ashtoret lunaris*, Sonmiani Bay, Sexual maturity, Population biology.**

## ABSTRACT

*Matuta planipes* and *Ashtoret lunaris* were collected as a part of by catch of gillnet deployed for shrimps from April 2005 to March 2007 in Sonmiani Bay waters (Miani Hor lagoon). *M. planipes* was found abundantly in Sep. 2005, Nov. - Dec. 2005 and Dec. 2006 (93.3%, 94.7%, 92.3% and 87 % respectively). *A. lunaris* was found in abundance during May 2005 (85.7%) and Aug. 2005 (81.8%). Male specimens of both species (*M. planipes*: $\chi^2 = 245.4$, $P < 0.005$) and (*A. lunaris*: $\chi^2 = 99.4$, $P<0.005$) were significantly more than females throughout the study period. There was a significant difference in size of male and female crabs within sexes; (*M. planipes*: $t = -4.93$, $P < 0.005$) and (*A. lunaris*: $t = -2.92$, $P<0.005$). Various morphometrical relationships were demonstrated that the males of *M. planipes* and *A. lunaris* were larger in size and heavier than females (4.34g ± 0.9g; 14.86 ± 6.8g and 3.87g ± 0.6g; 11.66 g ± 5.4 g) respectively. There was a negative allometry for both male and females of *M. planipes* and *A. lunaris* for length and weight relationship. The estimated carapace size at onset of sexual maturity was 3.2 cm and 3.3 cm for males and females of *A. lunaris* whereas, males and females of *M. planipes* had sexual maturity carapace size 3.1 cm and 3.2 cm in lagoon waters of Sonmiani bay.

## INTRODUCTION

*Matuta planipes* Fabricius, 1798 (reticulated moon crab) and *Ashtoret lunaris* (Forskal, 1775) (flower moon crab) are two commonly occurring species of sub-family Matutinae (De Haan, 1835) in Pakistani waters belonging to family Calappidae (Tirmizi and Kazmi, 1986). Galil and Clark (1994) revised the genus *Matuta* (Weber, 1795) and re-designated the *Matuta lunaris* as *Ashtoret lunaris*.

These two species are common inhabitant of the surf zone of tropical sandy shores and have a widespread distribution which extends from the Red Sea to South Africa, Asia, and Australia (Chappgar, 1957; Sankarankutty, 1962; Guinot, 1966; Vannini, 1976; Perez, 1990). Despite their common occurrence, there have been very few published studies on the ecology and biology of these crabs (Perez, 1990; Varadharajan *et al*., 2012). They are nocturnal, found in sandy shallow benthic zone (2-4 m). However, Richmond (1997) has reported them from deep waters also. They feed on small shellfish, worms and other animals *e.g.* small crabs at night (Tan and Ng, 1988; Hazlett, 1997). Some investigators declared them as a predator of flat fishes (Thomassin, 1974; Hossain *et al*., 2002; Fatima, 2003; Saitoh *et al*., 2003).

These crabs are not the real mangrove crabs but can be found in open areas of sandy to muddy tidal flats in front of the mangroves and often associated with them (Shukla *et al*., 2013). These crabs are found from the intertidal zone to 10-15 m in depth widely in the Indo-Pacific region (Sakai, 1965) and play an imperative role in the ecology of sandy shores. These crabs are also commercially important and used as food in many tropical and subtropical countries but in Pakistan, the fishermen usually throw back in the waters when these crabs caught in a net or included in the trash.

Growth in animals is often accompanied by changes in proportion as well as in size, *i.e.* some body parts grow at a different rate than others. This phenomenon is called

* Corresponding author: naureenaziz.qureshi@gmail.com; noorusaher@yahoo.com
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relative or allometric growth. Due to the rigid exoskeleton and consequent discontinuous growth, crustaceans have been extensively used for the relative growth analyses (Hartnoll, 1972). The relative growth in crustaceans has been widely studied by numerous authors, mainly because the rigid exoskeleton of these animals allows accurate measurements (Huxley and Richards, 1931; Weymouth and Mackay, 1936; Pinheiro and Fronsozo, 1998). Review of literature shows no previous work on the biology and the ecology of *Matuta* and *Ashtoret* species along the coast of Pakistan except for a little work related to the length-weight relationship of *Matuta* species from the Karachi coast (Fatima, 2003). This is the first attempt to study the population biology and ecology of commonly occurring species of family Matutidae from the coastal areas of Pakistan. Due to the ecological importance of *Matuta* species, this study was aimed to determine the morphometric relationships within species along the coast of Pakistan.

## MATERIALS AND METHODS

*Study site*

The Sonmiani Bay (locally called as Miani Hor) is a lagoon and an important marine fishing center along the coast of Pakistan. It remains the site of brisk fishing activities on the Makran coast throughout the year, evidently due to its nearness to Karachi and also because marine lagoons are generally characterized by high productivity. It is situated 90 km away from Karachi on the eastern most part of Balochistan coast. It is located at the latitude of 25° 27' 431'' North, and the longitude of 66° 33' 700'' East, approximately (Fig. 1). It is a 60 km long and 7 km wide tortuous body of water, which is connected to the sea by 4 km wide mouth. The seasonal rivers, Porali and the Windor, enter into the bay near the study area. In Balochistan, the mangroves are restricted to three localities *e.g.*, Miani Hor, Kalmat Khor and Gawader Bay. The only significant area that contains extensive mangrove stands is a Sonmiani Bay in Balochistan (Saifullah and Rasool, 1995; Rasool *et al*., 2002).

*Field study*

*M. planipes* and *A. lunaris* crabs were collected from the Apr. 2005 to Mar. 2007 as bycatch during the gill net fishing for fisheries survey project in Sonmiani bay. In Sonmiani, the fishermen throw them a side or fling back to water during sorting of catch. The gill net collections were made fortnightly during every month. The net was deployed from the commercial fishing boat with the help of commercial fishermen. Three hauls of twenty to twenty five minutes each, were made at every sampling event. The crabs trapped in each haul were immediately weighted, placed separately in polythene bags and kept on ice for transfer to the laboratory for further analysis. Samples for the hydrographic parameters (salinity, temperature and pH) were also collected at each visit. Salinity was measured with a refractometer (ATAGO, S-mill USA), temperature and pH, with a field pH meter (Hanna 8314) at each sampling event.

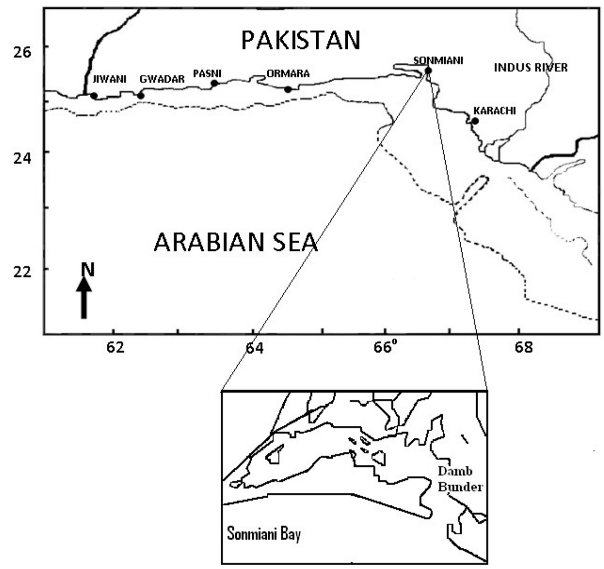


Fig. 1. Coastline of Pakistan showing the location of Sonmiani Bay (Miani Hor) Lagoon.

*Laboratory study*

The collected crab's samples were brought to the laboratory. Later the crabs were sorted, identified up to species level by using the identification keys of Tirmizi and Kazmi (1986) and Galil and Clark (1994). Crabs of both species were sexed into male and female crabs by the shape of their abdominal flaps. The morphometric measurements of different parts of the body, carapace width (CW), chelae length (Ch. L) and total body (Carapace length) length (TL) of crabs were measured to the nearest 0.1 cm (Fig. 2) and total body wet weight was measured up to 0.01g.

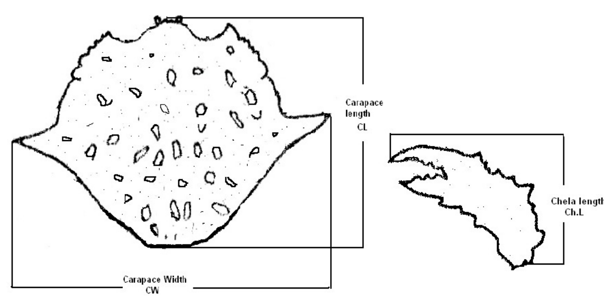


Fig. 2. Diagrammatic presentation of *Ashtoret lunaris* (Forskal, 1775) Morphometric measurements (TL, Carapace length CW, Carapace width and Ch. L., Chela length).

*Statistical analysis*

Analysis of variance (ANOVA) with nested treatment arrangement was carried out by using the statistical package Minitab (Version 15.0) for differences between seasons in the abundance of crabs. Test of significance was accepted as significant at alpha = 0.05 for statistical analyses. Monthly data were grouped into seasons following Saher and Qureshi (2011), wherein December, January and February are defined as northeast (NE) monsoon, March, April and May are defined as pre-monsoon period. June, July and August are defined as the south west (SW) monsoon period, September, October and November as post-monsoon period, to observe the seasonal variability.

Chi Square ($\chi^2$) test was calculated to study the sex ratio at Sonmiani Bay with the help of following equation:

$$x^2 = \sum \frac{(O - E)^2}{E}$$

Where, O was the observed value, and E was the expected value of that species.

All *Matuta* crabs were sorted into four groups *i.e.*, young males, adult males, young females and adult females. Young and adult crabs were sorted according to the examination of secondary sexual characters, such as pleopod morphology, free abdomen and distinct cheliped development in adult male crabs as compared to young male and convex abdomen (forming an incubator chamber) in adult females. The relative frequency of all males, non-ovigerous females and ovigerous females (%) in each size class was plotted and fitted as a sigmoid curve following the result of the logarithmic equation.

$$y = \frac{1}{1 + e^{r}(CW - CW^{50})}$$

Where, $CW^{50}$ was the carapace width at which 50% of the individuals attain sexual maturity, and r was the slope of the curve. The adjusted equation was fitted by the least squares regression method (Vazzoler, 1996; Bertini *et al*., 2001; Saher and Qureshi, 2011; Amanat and Qureshi, 2011).

The relative growth was studied by using power function $Y = aX^b$ and was the equation linearized by logrithmic transformation.

$$\log Y = \log(a + bX)$$

The CW and TL were used as independent variables (X) and whereas, all other body dimensions were considered as the slope "b" of the equation is the allometric constants that express the analogy between two variables, then it is used to determine a growth coefficient for males and females. The pattern of the growth established for length and weight relationships was characterized as positive allometry when $b > 3$, negative allometry $b < 3$ and isometry $b = 3$ (Hartnoll, 1982).

**Table I.- Seasonal variations (mean± SD) and range of air temperature, water temperature, Salinity, pH and density of *A. lunaris* and *M. planipes* collected from Sonmiani waters during April, 2005 to March, 2007.**

| Season | N | Air Temp. (°C) (min-max) | Water Temp. (°C) (min-max) | Salinity(°/oo) (min-max) | pH (min-max) | *Ashtoret lunaris* (min-max) | *Matuta planipes* (min-max) |
|---|---|---|---|---|---|---|---|
| Pre Monsoon (2005) | 3 | 29.33±1.52 (28.0-31.0) | 27.80±2.44 (25.0-29.5) | 34.20±3.83 (30.0-37.5) | 7.5±0.55 (7.2-8.2) | 13.3±12.8 (4-28) | 4.7±4.6 (0-12) |
| SW Monsoon (2005) | 4 | 30.80±2.88 (28.4-34.0) | 30.73±1.41 (29.2-32.0) | 33.00±3.61 (30.0-37.0) | 8.3±0.86 (7.3-9.0) | 15.5±13.6 (2-30) | 11.5±18 (0-38) |
| Post Monsoon(2005) | 3 | 30.66±1.15 (30.0-32.0) | 27.66±1.52 (26.0-29.0) | 35.00±1.73 (34.0-37.0) | 8.5±0.17 (8.3-8.6) | 8.7±8.3 (2-18) | 2±2 (0-4.0) |
| NE Monsoon (2005-06) | 5 | 26.16±0.76 (25.5-27.0) | 19.67±2.31 (17.0-21.0) | 39.00±1.00 (38.0-40.0) | 8.3±0.33 (8.1-8.7) | 21.7±16.5 (2-43) | 35.3±40.4 (2-94) |
| Pre Monsoon (2006) | 2 | 31.50±0.70 (31.0-31.5) | 27.25±4.60 (24.0-30.5) | 37.50±0.70 (37.0-38.0) | 7.4±0.06 (7.3-7.4) | 201±9.9 (194-208) | 125±24 (108-142) |
| SW Monsoon (2006) | 2 | 26.55±2.62 (24.7-28.4) | 27.85±1.20 (27.0-28.7) | 36.00±1.41 (35.0-37.0) | 6.8±0.06 (6.8-6.9) | 4.0±5.6 (0-8) | 19.0±24.0 (2-36) |
| Post Monsoon (2006) | 3 | 27.00±3.00 (24.0-30.0) | 27.20±5.63 (21.0-32.0) | 41.33±5.13 37.0-47.0) | 7.6±0.24 (7.3-7.8) | 64.0±50.9 (28-100) | 42.0±53.7 (4-80) |
| NE Monsoon (2006-07) | 3 | 22.57±1.91 (21.0-24.7) | 23.33±4.51 (19.0-28.0) | 41.00±2.65 (39.0-44.0) | 7.8±0.23 (7.5-8.0) | 60.7±18.1 (40-74) | 33.3±30.4 (6-66) |
| Pre Monsoon (2007) | 1 | 30.50 (30.5-30.5) | 31.60 (31.6-31.6) | 38.00 (38.0-38.0) | 8.0 (8.0-8.0) | 18.0 (18-18) | 20.0 (20-20) |

The best fit linear regression equation was calculated using least square method to determine the relationship between morphometric variables (Teissier, 1960; Hartnoll, 1982; Qureshi and Kazmi, 1999) and growth was considered isometric when 0.9 < b < 1.1 (Castiglioni and Negreiros-Fransozo, 2004; Saher and Qureshi, 2011).

## RESULTS

*Hydrographic parameters*

Seasonal variations in air temperature, water temperature, salinity and pH were observed and presented in Table I. The mean air temperature (28.8 ± 3.14$^o$C) with ranges from (22-34$^o$C) and mean water temperature (25.9 ± 4.1) with ranges from (17-31$^o$C) were observed during the study period. The highest temperature was recorded during the summer months (May - Jul) and the lowest temperature during winter months (Nov - Jan). The salinity was observed in the range of 30 - 47 ppt, and pH of 6.8 - 9.0. The seawater surface salinity and pH were found high (40.5 $^o/_{oo}$) and 8.5, respectively (Table II).

*Distribution and abundance*

The catch sizes varied with the months and showed a seasonal pattern (Fig. 3). Monthly percent distribution showed that both species were found throughout the study period except in the months of May, Jun. and Sep. 2006. Whereas in the month of July (2005, 2006) only *A. lunaris* species were found. Monthly percent distribution showed that the highest number of *M. planipes* was found from Aug. 2005 to Feb. 2006 and Dec. 2006 to Feb. 2007, whereas, *A. lunaris* abundance was observed from March to August and again in the month of October throughout the study period. The significant variations were observed in the seasonal distribution of *M. planipes* ($F_{3,23}$ = 5.76, P=0.004) but *A. lunaris* ($F_{3,23}$= 2.62, P=0.075) showed no significant variations among seasons.

*Sex ratio*

In both species *M. planipes* and *A. lunaris*, males were collected in higher numbers as compared to females throughout the study period except in a few months (Table III). Total 451 specimens of *M. planipes*

**Table II.- Monthly total percent abundance and distribution of male and female individuals of *Matuta planipes* and *Ashtoret lunaris* caught from Sonmiani Bay, (April, 2005 to March, 2007).**

| Month | Percent *Matuta planipes* | Percent *Ashtoret lunaris* | *Matuta planipes* | | *Ashtoret lunaris* | |
|---|---|---|---|---|---|---|
| | | | % Female | % Male | % Female | % Male |
| Apr. 05 | 30.0 | 70.0 | 33.3 | 66.7 | 28.6 | 71.4 |
| May. 05 | 14.3 | 85.7 | 0.0 | 100.0 | 0.0 | 100.0 |
| Jun. 05 | 38.7 | 61.3 | 10.5 | 89.5 | 41.7 | 58.3 |
| Jul. 05 | NC | 100.0 | NC | NC | 0.0 | 100.0 |
| Aug. 05 | 70.7 | 29.3 | 24.1 | 75.9 | 25.0 | 75.0 |
| Sep. 05 | 93.3 | 6.7 | NC | NC | 14.3 | 85.7 |
| Oct. 05 | 42.9 | 57.1 | NC | 100.0 | 75.0 | 25.0 |
| Nov. 05 | 94.7 | 5.3 | NC | NC | NC | 100.0 |
| Dec. 05 | 92.3 | 7.7 | NC | NC | NC | 100.0 |
| Jan. 06 | 63.2 | 36.8 | 16.4 | 83.6 | 30.8 | 69.2 |
| Feb. 06 | 76.5 | 23.5 | 25.6 | 74.4 | 25.0 | 75.0 |
| Mar. 06 | 40.6 | 59.4 | 18.3 | 81.7 | 29.8 | 70.2 |
| Apr. 06 | 35.8 | 64.2 | 66.7 | 33.3 | 41.2 | 58.8 |
| May. 06 | NC | NC | NC | NC | NC | NC |
| Jun. 06 | NC | NC | NC | NC | NC | NC |
| Jul. 06 | NC | 100.0 | NC | NC | 100.0 | NC |
| Aug. 06 | 18.2 | 81.8 | 0.0 | 100.0 | 11.1 | 88.9 |
| Sep. 06 | NC | NC | NC | NC | NC | NC |
| Oct. 06 | 25.9 | 74.1 | 50.0 | 50.0 | 10.0 | 90.0 |
| Nov. 06 | 50.0 | 50.0 | 20.0 | 80.0 | 50.0 | 50.0 |
| Dec. 06 | 87.0 | 13.0 | 10.0 | 90.0 | 33.3 | 66.7 |
| Jan. 07 | 72.5 | 27.5 | 91.9 | 8.1 | 0.0 | 100.0 |
| Feb. 07 | 50.7 | 49.3 | 38.2 | 61.8 | 66.7 | 33.3 |
| Mar. 07 | 47.4 | 52.6 | 11.1 | 88.9 | 10.0 | 90.0 |

NC, not collected.

**Table III.- The descriptive statistics for *Matuta planipes* and *Ashtoret lunaris* for various morphometrical variables (Sonmiani Bay, April, 2005 to March, 2007).**

| Variable | Sex | No | Mean ± SD | Range |
|---|---|---|---|---|
| ***Matuta planipes*** | | | | |
| CW (cm) | F | 93 | 3.8 ± 0.6 | 2.6-5.3 |
| | M | 358 | 4.3 ± 0.9 | 2.1-11.5 |
| TL (cm) | F | 93 | 2.7 ± 0.4 | 1.8-3.7 |
| | M | 358 | 3.1 ± 0.5 | 1.2-6.5 |
| Wt. (g) | F | 93 | 9.1 ± 4.2 | 2.4-21.6 |
| | M | 358 | 12.9 ± 5.3 | 1.3-30.9 |
| Ch. L (cm) | F | 93 | 1.8 ± 0.5 | 1.1-4.9 |
| | M | 358 | 2.1 ± 0.5 | 0.9-6.0 |
| ***Ashtoret lunaris*** | | | | |
| CW (cm) | F | 151 | 4.2 ± 1.0 | 1.7-5.9 |
| | M | 318 | 4.5 ± 0.8 | 2.2-6.9 |
| TL (cm) | F | 151 | 3.4 ± 2.0 | 1.1-21.6 |
| | M | 318 | 3.1 ± 0.5 | 1.5-4.70 |
| Wt. (g) | F | 151 | 11.6 ± 5.4 | 2.6-27.1 |
| | M | 318 | 14.8 ± 6.8 | 1.7-39.9 |
| Ch. L (cm) | F | 151 | 1.9 ± 0.3 | 0.7-3.0 |
| | M | 318 | 2.1 ± 0.4 | 0.8-4.4 |

CW, carapace width; Ch. L, cheliped length; TL, total length of carapace; Wt. wet weight.

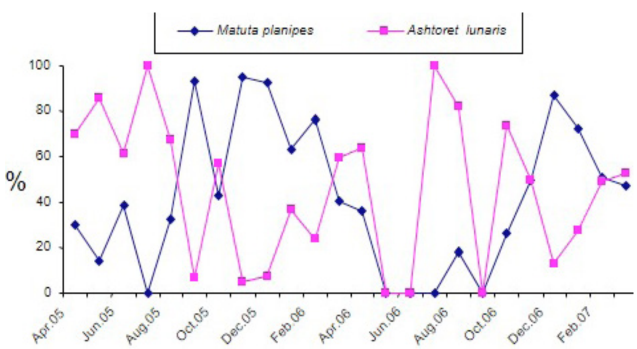


Fig. 3. Monthly percent occurance of *M. planipes* and *A. lunaris* in the coastal waters of Sonmiani bay (Apr. 2005 - Mar. 2007).

were collected in which 93 specimens were females and 358 males, whereas, 469 specimens of *A. lunaris* in which 151 were females and 318 were male individuals. The comparison of male and females showed that the sex ratio showed significant deviations from 1:1 ratio for the *M. planipes* ($\chi^2$ = 245.4, P < 0.005, DF = 15) and for *A. lunaris* ($\chi^2$ = 99.4, P < 0.005, DF = 18), respectively.

*Size variations*

In the present study two species of Matutidae showed size variations in different body parts within the species and sexes. The males of *M. planipes* and *A. lunaris* (12.9 ± 5.3g; 14.8 ± 6.8g, respectively) were heavier than the females (9.09 ± 4.2g; 11.6 ± 5.4 g, respectively). There was a significant difference in the size of male and female crabs of *M. planipes* (t = -4.93, P < 0.005, DF =169) and *A. lunaris* (t = -2.92, P < 0.005, DF = 228), respectively. In *M. planipes,* the total length of carapace (measured along the mid line vertically from the tip of rostrum to posterior margin of the carapace) in males (3.06 ± 0.5 cm) were greater as compare to females (2.75±0.4 cm), whereas in *A. lunaris* males were smaller (3.16±0.5 cm) than females (3.42 ± 2.0 cm).

*Length-weight relationship*

The relative growth between TL and its relationship with wet wt. of the body for *M. planipes* and *A. lunaris* is presented in Table IV. In *M. planipes* the relative growth showed the higher value of slope 'b' for the male (b = 2.70) as compared to female (b = 2.64), whereas *A. lunaris* showed the higher value of slope 'b' for females (b = 2.84) as compared to males (b = 2.75). *M. planipes* and *A. lunaris* showed negative allometry for both males and females. The other morphometrical characters (CW, Ch.L) also showed the highest values in males as compared to females in both *M. planipes* and *A. lunaris* species (Table IV).

*Size-weight relationship*

The size and weight relationship between CW and wet wt. of the body showed negative allometry for both (*M. palnipes* and *A. lunaris)* species. The higher value of slope 'b' for *A. lunaris* was observed in females (b = 2.48) as compared to males (b = 2.32), whereas in *M. palnipes* higher value of slope 'b' were observed in males (b = 2.61) as compared to females (b = 2.35) (Table IV).

*Carapace-Chela length relationship*

The size-length relationship between CW and Ch.L of *A. lunaris* and *M. planipes* are presented in Table IV. The relative growth showed the negative allometry for *A. lunaris* and isometric allometry for *M. planipe*s. The size-length relationship showed no difference within the sexes of *A. lunaris* (b = 0.84; b = 0.87) and *M. planipes* (b = 1.00; b = 0.91), the value of slope 'b' were almost same for male and female, respectively. The length-length relationship between TL and Ch.L of both species showed that the relative growth had an isometric allometry for *A. lunaris* and *M. planipes* species with higher value of slope 'b' in males (b = 1.07; b = 1.06) as compare to females (b = 0.98; b = 0.97), respectively. These relationships shows no

**Table IV.- The regression analysis of different morphometrical parameters of two Matutidae species of Sonmiani Bay (April, 2005 to March, 2007).**

| Relationship | Species | Sex | N | LogY=loga+logbX | $R^2$ | F | Allometry |
|---|---|---|---|---|---|---|---|
| Length-weight TL vs. Wt. | *Ashtoret lunaris* | F | 151 | = -0.298 + 2.84 xlog | 85.6 | 742.02 | -ve |
| | | M | 318 | = -0.243 + 2.75 xlog | 82.1 | 1461.81 | -ve |
| | *Matuta planipes* | F | 93 | = -0.237 + 2.64 xlog | 69.6 | 213.04 | -ve |
| | | M | 358 | = -0.228 + 2.70 xlog | 85.8 | 2150.61 | -ve |
| Size-weight CW vs. Wt. | *Ashtoret lunaris* | F | 151 | = -0.567 + 2.48 xlog | 83.7 | 613.02 | -ve |
| | | M | 318 | = -0.405 + 2.32 xlog | 74.4 | 882.58 | -ve |
| | *Matuta planipes* | F | 93 | = -0.469 + 2.35 xlog | 72.7 | 213.26 | -ve |
| | | M | 358 | = -0.572 + 2.61 xlog | 84.2 | 1768.08 | -ve |
| Length-Length TL vs. Ch.L | *Ashtoret lunaris* | F | 151 | = -0.176 + 0.984 xlog | 83.3 | 591.75 | 0 |
| | | M | 318 | = -0.214 + 1.07 xlog | 73.6 | 817.23 | 0 |
| | *Matuta planipes* | F | 93 | = -0.184 + 0.976 xlog | 72.1 | 196.22 | 0 |
| | | M | 358 | = -0.196 + 1.06 xlog | 83.0 | 1505.42 | 0 |
| Size-Length CW vs. Ch.L | *Ashtoret lunaris* | F | 151 | = -0.277 + 0.871 xlog | 77.2 | 397.03 | -ve |
| | | M | 318 | = -0.233 + 0.841 xlog | 57.3 | 392.48 | -ve |
| | *Matuta planipes* | F | 93 | = -0.294 + 0.915 xlog | 76.0 | 240.54 | 0 |
| | | M | 358 | = -0.315 + 1.00 xlog | 77.4 | 1057.30 | 0 |

difference within species ‘b’ values of males and females of both species and were nearly same.

*Sexual maturity*

The growth curve in juvenile and adult phases differed in all the regressions. The size at which 50% of the population of *M. planipes* was morphologically mature is shown in Figure 4 and of *A. lunaris* in Figure 5. The result of the logistic equation of *A. lunaris* showed that approximately 50% of male crabs were sexually mature at the size of carapace width 3.2 cm, whereas for females this proportion was found in the size of carapace width 3.3 cm. Thus, the estimated size at onset of sexual maturity was 3.2 cm and 3.3 cm for males and females, respectively. In *M. planipes* the results of the logistic equation showed that approximately 50 % males were sexually matured at the size of the carapace width reached 3.1 cm and in females, the size was 3.2 cm. Thus the estimated size of *M. planipes* at the onset of sexual maturity was 3.1 cm and 3.2 cm for males and females, respectively.

## DISCUSSION

This study showed the monthly distribution and abundance of *M. planipes* and *A. lunaris* in the Sonmiani Bay (Miani Hor). The two species were found almost throughout the study period varying in number in each month and showed significant seasonal variations in the distribution. Monthly and seasonal variations in species abundance may be related to oceanographic changes in the

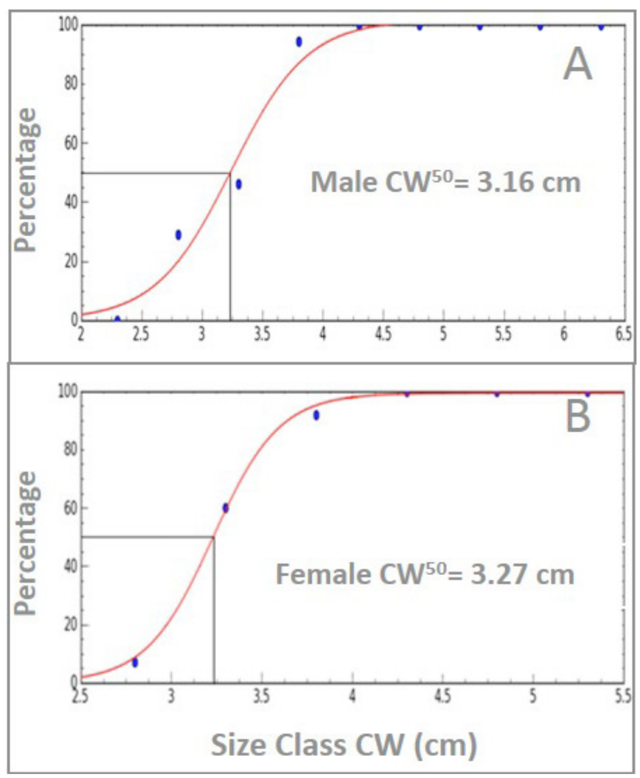


Fig. 4. The growth curves (A, male; B, female) showing the size of carapace of 50% popultion of *M. planipes* attained sexual maturity in Sonmiani bay (Apr. 2005 - Mar. 2007).

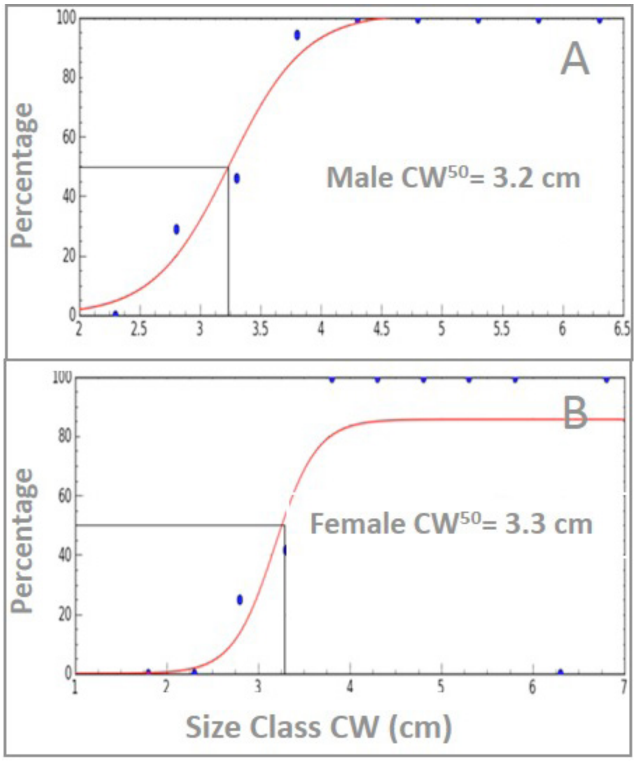


Fig. 5. The growth curves (A, male; B, female) showing the size of carapace of 50% population of *A.lunaris* attained sexual maturity in Sonmiani bay (Apr. 2005 - Mar. 2007).

lagoon and the temperature was found to be a significant factor influence on the distribution of both species. Variations in temperature determine the spatial and temporal patterns resulting in distribution and abundance of species around the world (Thomas et al., 2000; Delaney, 2003). The temporal or spatial abundance pattern of these two co-occurring species varies among populations likely as a result of temperature changes. There was an expressive reduction in the temperature during winter that may have influenced the both species distributions, agreed with the study of De Carvalho *et al*. (2010), as related to the distribution of *Persephona lichtensteinii* and *P. punctata* (Brachyura, Leucosiidae) was associated with the temperature in the Brazil region. The biochemical and physiological kinetics determine the survival, growth, and reproduction of any species, which remain in conjunction of environmental temperature and probably this interactive phenomenon determines that when and where a certain species can survive and thrive (Wethey, 1983; 1984; Thomas *et al*., 2000; Hochachka and Somero, 2002).

The overall sex ratio was female-biased. The variations from the 1:1 ratio resulted from sexual differences in the spatial and temporal distribution and mortality of organisms (Wada *et al*., 2000), also dependant on differential life span, migration, longevity of each sex, food restriction, utilization of different habitats, differential production of gametes and growth rates (Wenner, 1972). Emmerson (1994) and Lardies *et al*., (2004) suggest that deviations from the 1:1 ratio can internally regulate the size of a population by affecting its reproductive potential. Sexual dimorphism was also observed in the present study. The males of both species attain larger sizes than females, agrees with the study of De Carvalho *et al*. (2010). Males attain larger size as compared to females in *Persephona lichtensteinii* and *P. punctata*. Lopez Greco *et al*. (2000) and Mantellato *et al*. (2003) suggested that females may have reduced somatic growth, compared to males because they concentrate on their energy budget for gonad development. Moreover, males may reach larger sizes for successful competition for copulation with more than one female since larger male *Ocypodid* crabs may have greater chances of obtaining females for copulation and win more intraspecific fights (Henmi, 1992).

In relative growth of crabs, carapace width is one of the key measurements used as an independent variable, it showed significant physiological changes that occur throughout their lifespan (Castiglioni and Negreiros-Fransozo, 2004). The relative growth in crustaceans has been studied extensively using the morphometric data (Hartnoll, 1982). In the present study CW and TL were used as an independent variable in length-weight relationship (TL - Wt.), size-weight relationship (CW-Wt.), length-length relationship (TL- Ch.L) and size-length relationship (CW- Ch.L) showed no significant difference within the sexes for both species. The slope of regression lines showed lesser difference for males and females in both species. The length-weight and length-length relationship showed positive allometry for two species except female of *M. planipes* that showed negative length-weight relationship, whereas size-length and size-weight relationship showed positive allometry for both male and female crabs of *M. planipes* whereas for male and females of *A. lunaris* showed negative size-length relationship. Can *et al*. (2007) reported a negative allometric growth pattern both in males and females of *C. aestuarii*. The presented length-weight and size-weight morphometrics will enable biologists to accurately estimate the wet weight and size for both species based on a single measured value of the carapace of the specimen. Weight-size relationships can provide useful information about the increase in weight of a population and this parameter could also be important for comparative studies between populations (Mori *et al*., 1990; Kocak *et al*., 2011).

Both growth and reproduction are life history mechanisms that compete for energy resources. Increase in a component is associated with a decrease in the other, characterizing the relationship known as a trade-off (Hartnoll, 1985; Haefner and Spaargaren, 1993; Llodra, 2002; Begon *et al*., 2007). Consequently, the resource distribution for growth and reproduction should be optimized over the life so it has a higher reproductive success. The lack of significant difference in maturation size between the sexes in both species reported in this study was also observed in *Persephona* species by De Carvalho *et al*. (2010) and *P. mediterranea* by Bertini *et al*. (2010). However, differences in $W_{50}$ between males and females were recorded in several brachyuran crabs. Some species such as *Callinectes ornatus* (Ordway, 1863) (Mantelatto and Fransozo, 1996; Baptista *et al*., 2003), *C. danae* (Smith, 1869) (Branco and Masunari, 2000) and *Goniopsis cruentata* (Latreille, 1803) (Moura and Coelho, 2004), males acquire the sexual maturity at larger body size than that of females. However, *Hepatus pudibundus* (Herbst, 1785) (Reigada and Negreiros-Fransozo, 1999), *Necora puber* (Linnaeus, 1767) (González-Gurrirán and Freire, 1994) and *Maja squinado* (Herbst, 1788) (Sampedro *et al*., 1999), were not recorded for evident differences in maturity size between the sexes. Females can reach maturity at a smaller size than males when they invest more energy to egg production and males allocate more energy for somatic tissue production (Mantelatto and Fransozo, 1996).

Small changes in $W_{50}$ can be caused by individual genetic variations, food availability, the presence of competitors, predators and many other factors that exist in the habitat. In contrast, the occurrence of significant variations between sexes and congeneric species may be due to differences in reproductive strategy of organisms (Hartnoll, 1985; Llodra, 2002; Begon *et al*., 2007).

## CONCLUSIONS

The pronounced seasonal variations were observed in the distribution and abundance of *M. planipes and A. lunaris* and the change of temperature observed the key influential factor for these changes. The maximum size of the male of both species was larger than females, the males of both species, attain the earlier sexual maturity than females crabs as evident in most of the Brachyuran crabs. The size in which the sexual maturity is reached and how it is determined are important aspects of the biological cycle of decapods and it can be determined through the study of reproductive aspects, whereas morphometric techniques can indicate allometric changes in size related to the external morphological maturity. Crustacean would be able to mate when attain such size. Traditionally two criteria have been utilized to determine such size: the first was directly related to reproduction of gonad development, spermatheca analysis, presence of ovigerous females and spermatophores in males and the other was based on morphometric data. It was assumed by various authors that only one technique is not enough to define the size at the sexual maturity, which is basically determined by genetic information of each species and influenced by environmental factors in its distribution area.

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*Statement of conflict of interest*

Authors have declared no conflict of interest.

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