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LENGTH-WEIGHT RELATIONSHIPS AND CONDITION FACTOR OF THE SEA URCHIN *ECHINOMETRA MATHAEI* (ECHINOIDEA: ECHINODERMATA) ON BULEJI ROCKY SHORE OF KARACHI, PAKISTAN

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ABSTRACT: The length frequency, length-weight relationships and variation in condition factor was studied in the population of *Echinometra mathaei* (Blainville, 1825) found on the rocky shore of Buleji, Karachi, Pakistan during the period from April 2011 to November 2012. The test diameter (length) in *E. mathaei* ranged from 19.0 and 77.2 mm with mean test diameter of 46.6 ± 6.3 mm. The modal size-class in the population of this species was 41-50 mm. The total wet weight ranged from 13.3 to 121.6 g with a mean of 50.1 ± 18.3 g and showed the modal size class of weight to be 31–40 g. Sex-wise and season-wise length weight relationship (LWR) showed negative allometric growth trend (b not equal to 3, $P < 0.001$). The condition factor (Kn) estimated for *E. mathaei* ranged between 0.95 to 1.06 in males, 0.99 to 1.04 in females and 0.98 to 1.02 in pooled sex at Buleji. Analysis of variance indicated that there is statistically no significant difference between the mean of the Kn values for pooled sex in 14 months (ANOVA, $F = 0.332$; $P > 0.05$). However, analysis of variance showed a significant difference between the Kn values in different seasons at Buleji (ANOVA, $F = 59.57$; $P < 0.05$).

KEYWORDS: Length-weight relationship, condition factor, *Echinometra mathaei*, rocky shore, Karachi.

INTRODUCTION

The increasing interest in the study of sea urchin population is due to two reasons: Firstly, as they play primary role in maintaining the equilibrium in sublittoral community (Sala *et al.* 1998, Williamson *et al.* 2000; Williamson and Steinberg, 2001) and secondly due to its economic importance (Palacin *et al.* 1998, Williamson *et al.* 2000). From the coastal waters of Pakistan four species of sea urchins: *Echinometra mathaei, Echinostrephus molaris, Stomopneustes variolaris*, *Temnopleurus toreumaticus* and one species of sand dollar C*lypeaster rarispinus* have been reported (Tahera, 1993). The study on population dynamics and reproduction of *Echinometra mathaei* has been reported earlier (Siddique, 2015).

Length-weight relationships have been used commonly for the estimation of weight from the length of an animal since in the field weight measurements are time-consuming process (Sinovcic *et al.* 2004). The length weight relationship is useful in studies of gonad maturity, estimation of growth rates, age structure and estimation of biomass and stock assessment (Le Cren, 1951; Pauly, 1993; Froese, 2006).

Condition factor (Kn) of an animal is related to its fitness and which in turn is considered as an indicator of reproductive success and ability of an animal to cope with environmental factors (Cone, 1989, Jones *et al.* 1999). The animals with increased weight and high condition factor are in better physical condition. The relationship between weight and length of a given species can be utilized to evaluate the condition factor and the fitness status (Cone, 1989).

The present study was undertaken on the length frequency, length-weight relationships and variation in condition factor in the population of *Echinometra mathaei* (Blainville, 1825) during different seasons in the coastal waters of Karachi, Pakistan.

MATERIALS AND METHOD

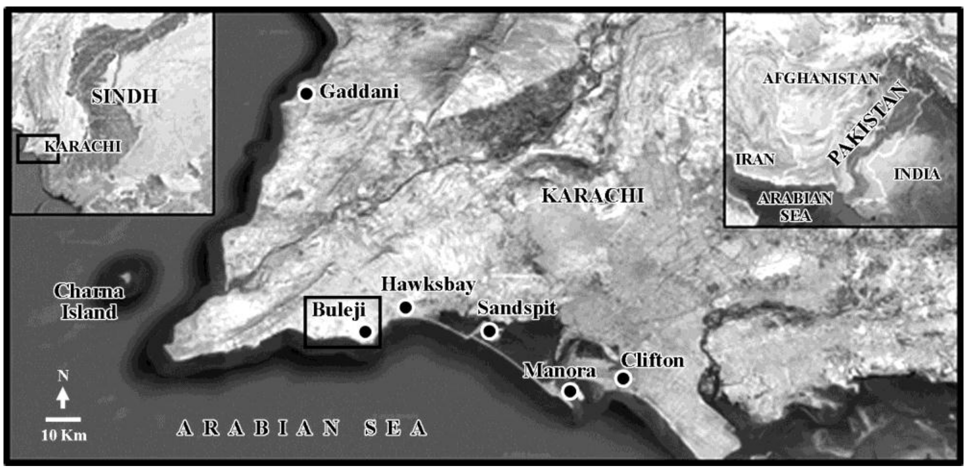

Fig. 1. Map of study area.

Sampling and measurements: The sea urchin, *Echinometra mathaei* were found at the lowest tide mark in the low tidal zone on the rocky shores of Buleji (Fig. 1). For collection of sea urchins an area of 100 meter in length (parallel to sea) and 10 meters in width was selected and the sampling was done from the same area every month on low tides (-0.1 to -0.5 m tide). During 19 months of study period from April 2011 to November 2012, it was possible to do the sampling of sea urchins in 14 months only. During the period from June to August (monsoon season) due to roughness of sea, no specimen could be collected. In other months approximately 30 individuals of *E. mathaei* were handpicked and brought live in well-aerated container to the laboratory. In the laboratory, after taking various measurements the animal was sacrificed. The test diameter (TD) was measured to the nearest ±0.01mm by the vernier caliper to the widest part of each sea urchin. Similarly, the height of test (TH) was measured (Pais *et al.*, 2006). The wet weight (WW) was taken on an electronic balance to the nearest ± 0.01g after leaving the sea urchins for few seconds on absorbent paper for stabilization of weight (Fig. 2).

Length-weight relationships and condition factor: The length-weight relationship was estimated using equation W = aLb (Cone, 1989). The values of a and b were estimated

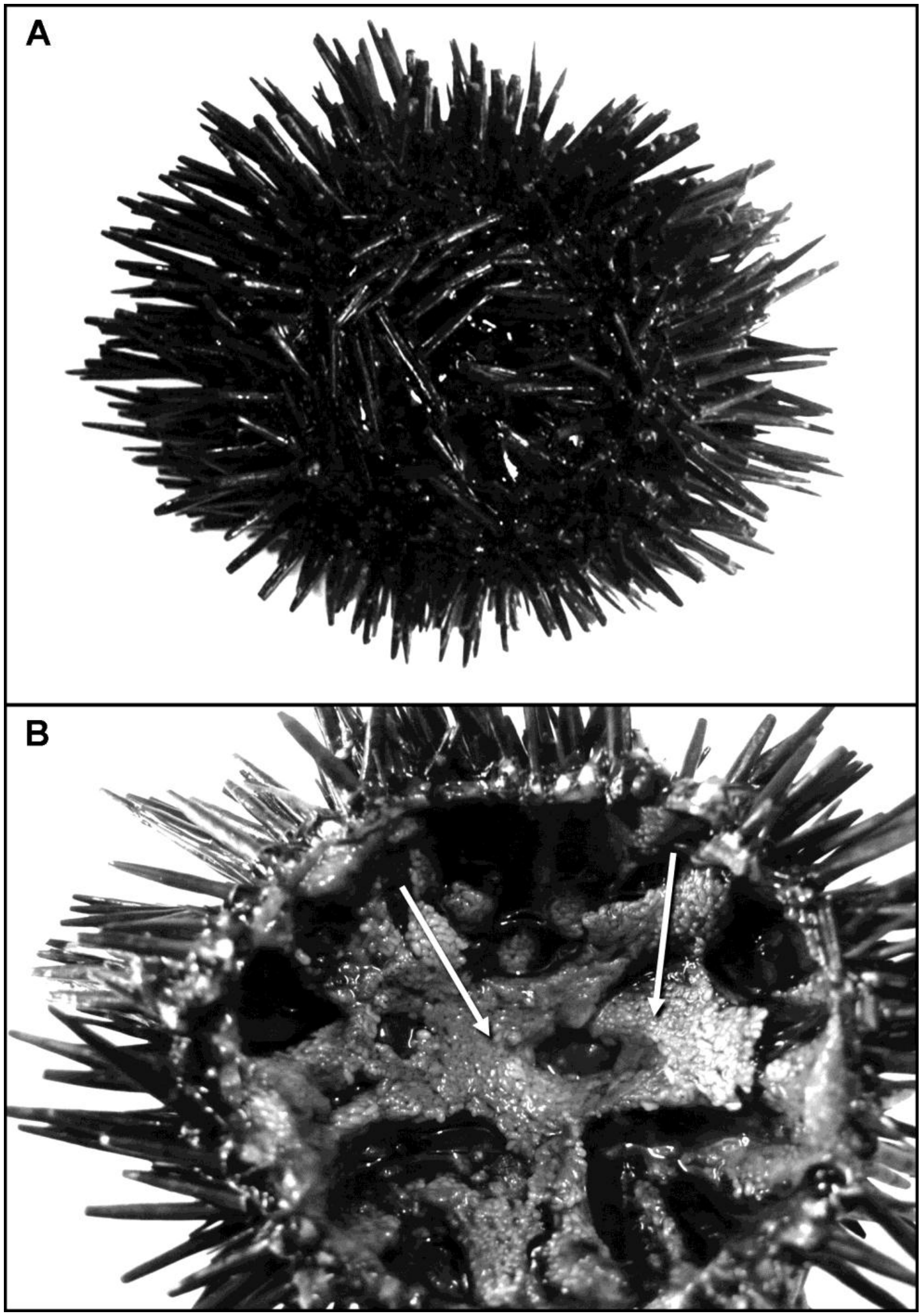

Fig. 2. Photographs of sea urchin: A, Specimen of *Echinometra mathaei*; B, Internal organs of sea urchin, arrow indicates gonadal acini.

from the log10 transformed values of diameter and weight, that is, log10W = a + b log10 L applying a linear regression analysis (Zar, 1996). The Student's t-tests was used to confirm whether *b* values obtained in the linear regression were significantly different from the isometric value ($b = 3$).

The monthly relative condition factor (Kn) of the sea urchin samples was calculated following Le Cren (1951) as Kn=W/aLb. The Kn value was used to compare the condition factor of *E. mathaei* during different months and seasons. To find out the significance of Kn values in different seasons analysis of variance ($\alpha = 0.05$) was used. The seasons were divided into spring inter-monsoon (March-April), south west monsoon (May to September), autumn inter-monsoon (October) and north east monsoon (November to February).

RESULTS AND DISCUSSION

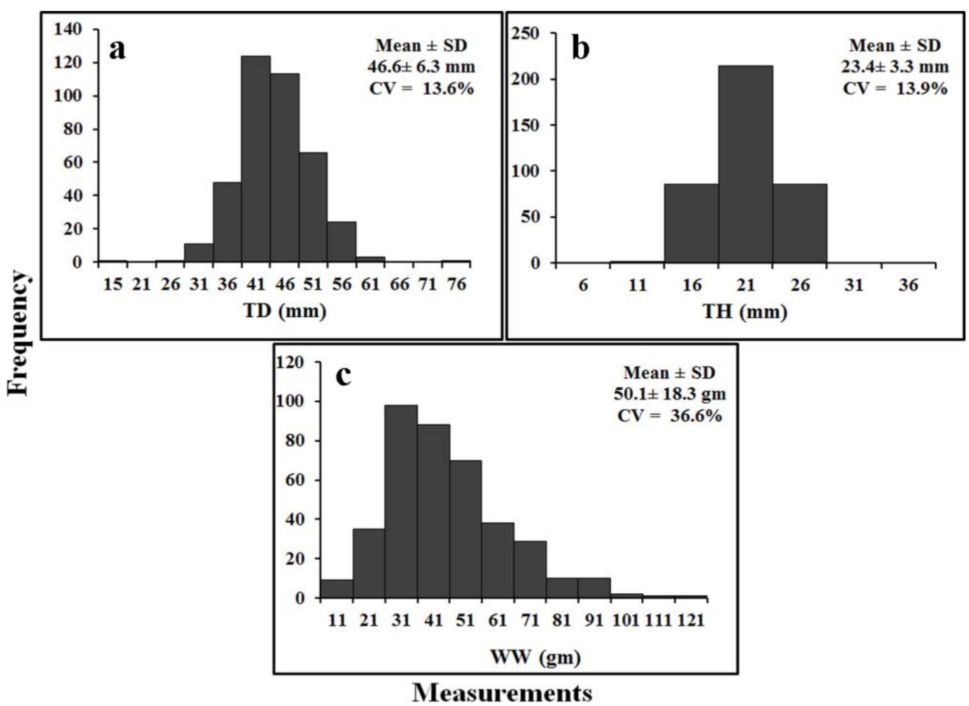

Fig. 3. Frequency distributions of measurements for sea urchin *Echinometra mathaei*, A total of 391 sea urchins were measured during the study period from April 2011 to November 2012 on Buleji rocky shore. a, TD distribution; b, TH distribution; c, TW distribution. (TD = test diameter; TH = test height; WW = wet weight; SD = standard deviation and CV = coefficient of variation in percentage).

Length frequency distribution: The frequency distributions of test diameter (TD), test height (TH) and wet weight (WW) were analyzed (Table 1 and Fig. 3). The test diameter in *E. mathaei* ranged between 19.0 and 77.2 mm with mean test diameter of

46.6 ± 6.3 mm (Table 1). The modal size-class in the population was 41-50 mm (Fig. 3a). The test height ranged between 9.5 and 40.1 mm with mean test height of 23.4 ± 3.3 mm (Table 1 and Fig. 3b). The WW frequency distribution had a mean of 50.1 ± 18.3 g (Table 1 and Fig. 3c) and showed the modal size class to be 31-40 g. The maximum coefficient of variance (36.6%) was observed in the WW frequency distribution.

Table 1. Minimum, maximum and mean ± SD (standard deviation) of test diameter (TD), test height (TH) and wet weight (WW) of *Echinometra mathaei* at Buleji.

	Mean ± SD	Minimum	Maximum
TD (mm)	46.6 ± 6.3	19.0	77.2
TH (mm)	23.4 ± 3.3	9.5	40.1
WW (g)	50.1 ± 18.3	13.3	121.6

Length-weight relationships: The regression equations were estimated between wet weight and test diameter and between wet weight and test height for males and females separately and for pooled sex too. The test diameter- wet weight relationship in *E. mathaei* corresponding to the logarithmic form was W= 0.006+2.347 TD (r^2= 0.853) for males, W= 0.004+2.466 TD (r^2= 0.840) for females and W= 0.005+2.401 TD (r^2= 0.846) for pooled sex (Table 2 & Fig. 4). The values of b (2.34 to 2.46) indicated negative allometric growth trend in *E. mathaei* (Table 2).

In estimate of the test height-wet weight relationship the exponent ‘b’ (slope) values ranged from 2.30 to 2.33 in both sexes (Table 2 & Fig. 4). Correlation co-efficient ‘r’ ranged from 0.894 to 0.908 which is highly significant at $P<0.001$ level (Table 2).

Test diameter-wet weight relationship in *E. mathaei* showed that the b values ranged between 1.925 to 2.814 during different seasons, the lowest value of b = 1.925 was recorded in south west monsoon 2011 and highest value of b = 2.814 was observed in spring inter-monsoon 2011 (Table 3). A negative allometric growth was observed in sea urchin during different seasons thus deviating significantly from the theoretical value of 3 (Table 3).

Condition factor: The condition factor (Kn) estimated for *E. mathaei* ranged between 0.95 to 1.06 for males, 0.99 to 1.04 for females and 0.98 to 1.02 for pooled sex at Buleji (Fig.5). Analysis of variance indicated that there is statistically no significant difference between the mean of the Kn values for pooled sex in 14 months (ANOVA, F = 0.332; P > 0.05). The mean condition factor for pooled sex varied from 1.00 to 3.33 during different seasons. The highest Kn value of 3.33 was recorded in northeast monsoon

Table 2. Result of sex wise regression analysis and Student's t-test for the test diameter-weight relationship of *E. mathaei* from April 2011 to November 2012 at Buleji. (r = coefficient correlation; r^2 = coefficient regression; *a* and *b* = parameters of length and weight equation; A- = Negative allometry; * = P< 0.05 and ** = P< 0.001).

Sites	Sexes	Logarithmic transformation	Intercept 'a'	Slope 'b'	Correlation Co-efficient 'r'	Regression Co-efficient 'r²'	t-test
Buleji	Male	Log W= 0.006+2.347*Log TD	0.005854	2.347	0.924**	0.853	-8.633
	Male	Log W= 0.034+2.303*Log TH	0.033897	2.303	0.908**	0.824	-8.44
	Female	Log W= 0.004+2.466*Log TD	0.003677	2.466	0.916**	0.840	-7.372
	Female	Log W= 0.030+2.334*Log TH	0.030444	2.334	0.894**	0.710	-8.468
	Pooled sex	Log W= 0.005+2.401*Log TD	0.004736	2.401	0.920**	0.846	-11.547
	Pooled sex	Log W= 0.032+2.316*Log TH	0.032368	2.316	0.901**	0.812	-12.123

Table 3. Result of season wise regression analysis and Student's t-test for the test diameter-weight relationship of *E. mathaei* from April 2011 to November 2012 at Buleji. (r = coefficient correlation; r^2 = coefficient regression; *a* and *b* = parameters of length and weight equation and * = P< 0.001).

Site	Seasons	Intercept 'a'	Slope 'b'	Correlation Co-efficient 'r'	Regression Co-efficient 'r^2'	t-test
Buleji	Spring inter-monsoon'11	0.001285	2.814	0.984	0.967	-1.352*
	South West monsoon'11	0.029651	1.925	0.861	0.742	-7.023*
	Autumn inter-monsoon'11	0.006605	2.316	0.973	0.947	-6.726*
	North East monsoon'11-12	0.003846	2.444	0.927	0.859	-6.408*
	Spring inter-monsoon'12	0.001099	2.784	0.964	0.930	-2.141*
	South West monsoon'12	0.001443	2.706	0.984	0.969	-3.917*

2011-12 and lowest was recorded in autumn inter-monsoon 2012 (Fig. 6). Analysis of variance showed a significant difference in the Kn values during different seasons at Buleji (ANOVA, F = 59.57; P < 0.05).

In the present study the test diameter of *E. mathaei* mostly ranged between 35 to 55 mm which is similar to the test diameter of *E. mathaei* reported by Ebert (1982) from Hawaii (30 to 50 mm), Western Australia (30 to 60 mm), Seychelles (30 to 50 mm) and Kenya (30 to 60 mm) and larger than the test diameter reported from Israel (10 to 30 mm) and Enewetal Atoll (10 to 40 mm). Another species of *Echinometra, E. oblonga* varied in diameter from 10 to 40 mm at Hawaii (Ebert, 1982).

Among the fishes and invertebrates the value of the exponent (b) as 3 for the length-weight relationship showed that the growth in weight is isometric with the length, while b value different from 3 showed that the growth is allometric. Allometric growth may be negative (b < 3) or positive (b > 3). In the present study the b value of 2.4 is less than 3 thus showed a negative allometric growth in *E. mathaei.* In another sea urchin *Diadema setosum*, much lower b value of 1.90 has been reported from Malaysia (Rahman *et al.* 2012)

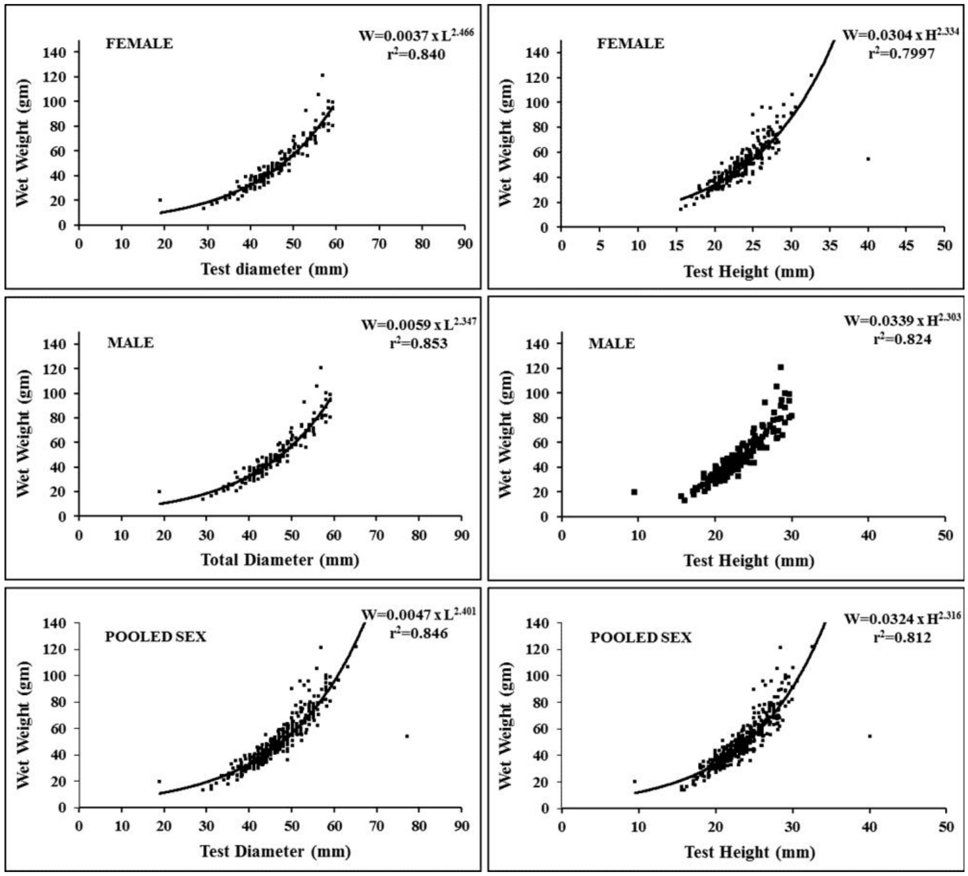

Fig. 4. Relationships between test diameter-wet weight and test height-wet weight of *Echinometra mathaei* at Buleji.

and b = 1.85 in *Paracentrotus lividus*, from Bistrina Bay, Croatia (Tomsic *et al.* 2010). The different factors which influence a negative allometric growth in sea urchins may be the environmental parameters and feeding habits (Cone, 1989, Jones *et al.* 1999; Rahman *et al.* 2012). The condition factor (Kn) estimated for *E. mathaei* presented higher values in north east monsoon as compared to remaining seasons, suggesting different feeding conditions in various seasons. According to Oni *et al.* (1983) condition factor is not constant for a species or population over a time interval and might be influenced by both biotic and abiotic elements. Condition factor of ≥1 showed a good level of feeding and proper environmental conditions (Ujjania *et al.*, 2012). Our results showed that the condition factor ranged from 1.00 to 3.33 in different seasons suggesting that though the feeding conditions are suitable for *E. mathaei* in all seasons but particularly more favourable in north east monsoon followed by south west monsoon.

The present study provides the baseline information about the population status of *Echinometra mathaei* found in the coastal waters of Pakistan, which may utilize for the effective management plans for this species.

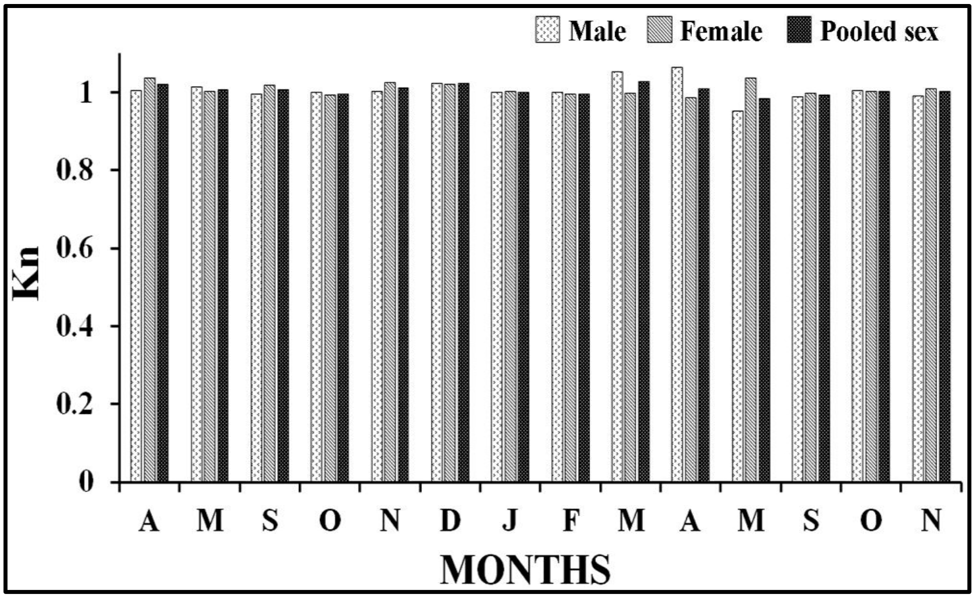

Fig. 5. Monthly relative condition factor (Kn) of *E. mathaei* during the study from April 2011 to November 2012.

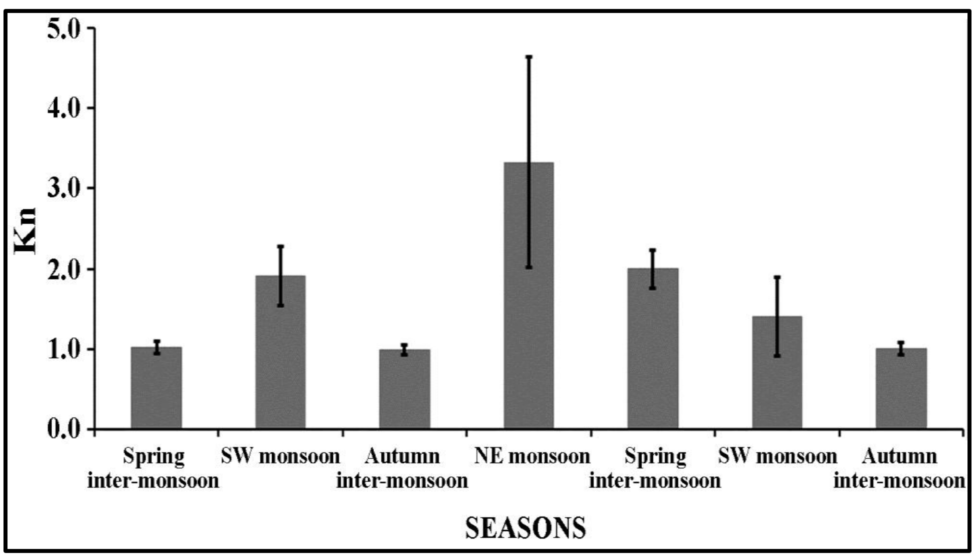

Fig. 6. Seasonal variations in the mean condition factor (Kn) of *Echinometra mathaei*. The vertical lines show standard deviation.

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