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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR IN *HOLOTHURIA ARENICOLA* (HOLOTHUROIDEA: ECHINODERMATA) FOUND ON TWO ROCKY COASTS OF KARACHI, PAKISTAN

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ABSTRACT: The length-weight relationship and condition factor is determined for *Holothuria arenicola* collected between April 2011 to November 2012 from rocky shores of Manora and Buleji. The maximum total length recorded for this species was 416.0 mm at Manora and 376.0 mm at Buleji. Sex-wise and season wise LWR and slope (b) values revealed the negative allometric growth (b not equal to 3, $P < 0.001$) at both sites. The length-weight relationship in *H. arenicola* during different seasons showed the b value to range between 1.850 to 2.384 at Manora and 2.124 to 2.401 at Buleji. Correlation co-efficient were noticed highly significant for sex and season wise with a good correlation between length and weight. The condition factor (Kn) for *H. arenicola* ranged between1.04 to 1.96 at Manora and 0.87 to 1.8 at Buleji. Analysis of variance showed that there is statistically significant difference between the means of the Kn values in 19 months at Manora (ANOVA, $F = 10.96$; $P < 0.05$) and Buleji (ANOVA, $F = 13.42$; $P < 0.05$) and in various seasons at Manora (ANOVA, $F = 86.529$; $P < 0.05$) and Buleji ($F = 56.285$; $P < 0.05$).

KEYWORDS: *Holothuria arenicola,* length-weight relationship, condition factor Karachi coast, Pakistan.

INTRODUCTION

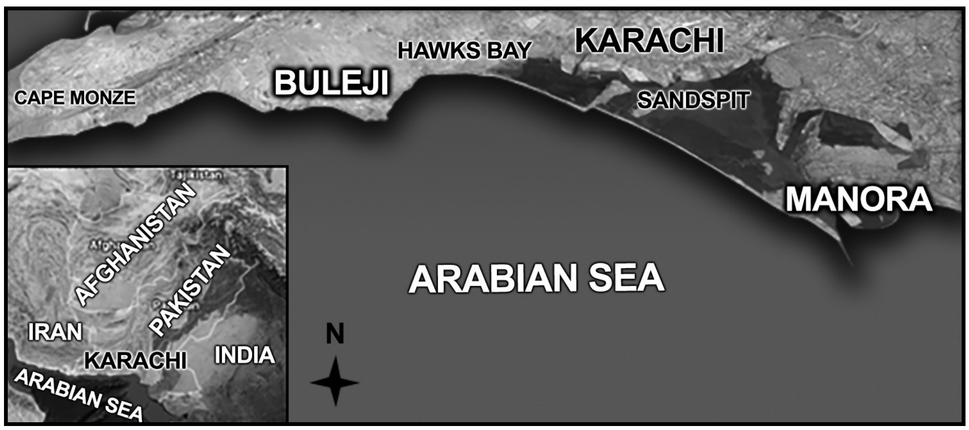
Numbers of studies have been conducted on various biological aspects of sea cucumbers and sea urchins worldwide, while the studies on these organisms in Pakistan have been of taxonomic nature (Hoque, 1969; Tahera, 1992; 1993; 1995; 1996a, b; 1997; 2001 and 2006; Tahera and Kazmi, 1995; 2003; 2005 and 2006; Tahera and Naushaba, 1995; Tahera and Tirmizi, 1995). Therefore, there is a need to undertake more biological and ecological studies on the sea cucumbers and sea urchins which not only play important role in ecosystem but are also economically important.

Growth parameters are required to estimate maximum sustainable yield for any commercial species and to understand the adaptative strategies in these animals (Conand, 1988). Growth is a complex process and is defined as an increase in size over time, in case of sea cucumber it includes length, volume, mass and body composition (Martins, 2005).The length weight relationship is useful in studies of gonad development, rate of feeding, metamorphosis and maturity (Le Cren, 1951; Bolger and Connolly, 1989) as well as in estimation of growth rates, age structure and other aspects of fish/shrimp population dynamics (Tsoumani *et al.*, 2006).

The physiological condition of an animal is related to its evolutionary fitness, therefore, the health status of an animal is considered as an indicator of reproductive success and ability to manage with environmental factors (Cone, 1989, Jones *et al.,* 1999). It is assumed that animals with heavier weight and high condition indices are in better physical condition. One of the best way to analyze the relative condition factor, Kn is to evaluate the relationship between weight and length of a given species and use that data to calculate the fitness status (Cone, 1989).The relative condition of *Isostichopus fuscus* from the Gulf of California, México was found not to vary significantly during the year but showed a parabolic relationship with total length, being highest at the size of first maturity (Herrero-Pérezrul and Reyes-Bonilla, 2008).

The study provides the information on length-weight relationships and variations in condition factor of the sea cucumber, *Holothuria arenicola*, in the coastal waters of Pakistan during different seasons.

Fig. 1. Map showing the collection sites. Scale bar 2 km. Inset shows the coastline of Pakistan.



MATERIALS & METHODS

The samples of *H. arenicola* were collected from the gradually sloping and exposed rocky shores of Manora and Bulejil located on the coast of Karachi (24^{o} 48′N latitude and 66^{o} 59′E longitude), which is about 90 km long and touches the northeastern boundary of Arabian Sea (Fig. 1).

Each month approximately 30-40 individuals of *H. arenicola* were handpicked during 30 minutes of sampling from the allocated area (200 m^2) during the study from April 2011 to November 2012. The less number of individuals were collected in monsoon season (May to September) due to roughness of sea. The sea cucumbers were transported to the laboratory alive in well aerated seawater. In the laboratory the specimens of *H. arenicola* were kept in well aerated seawater with 2.5% $MgCl_2$ and relaxed for 24 hrs,

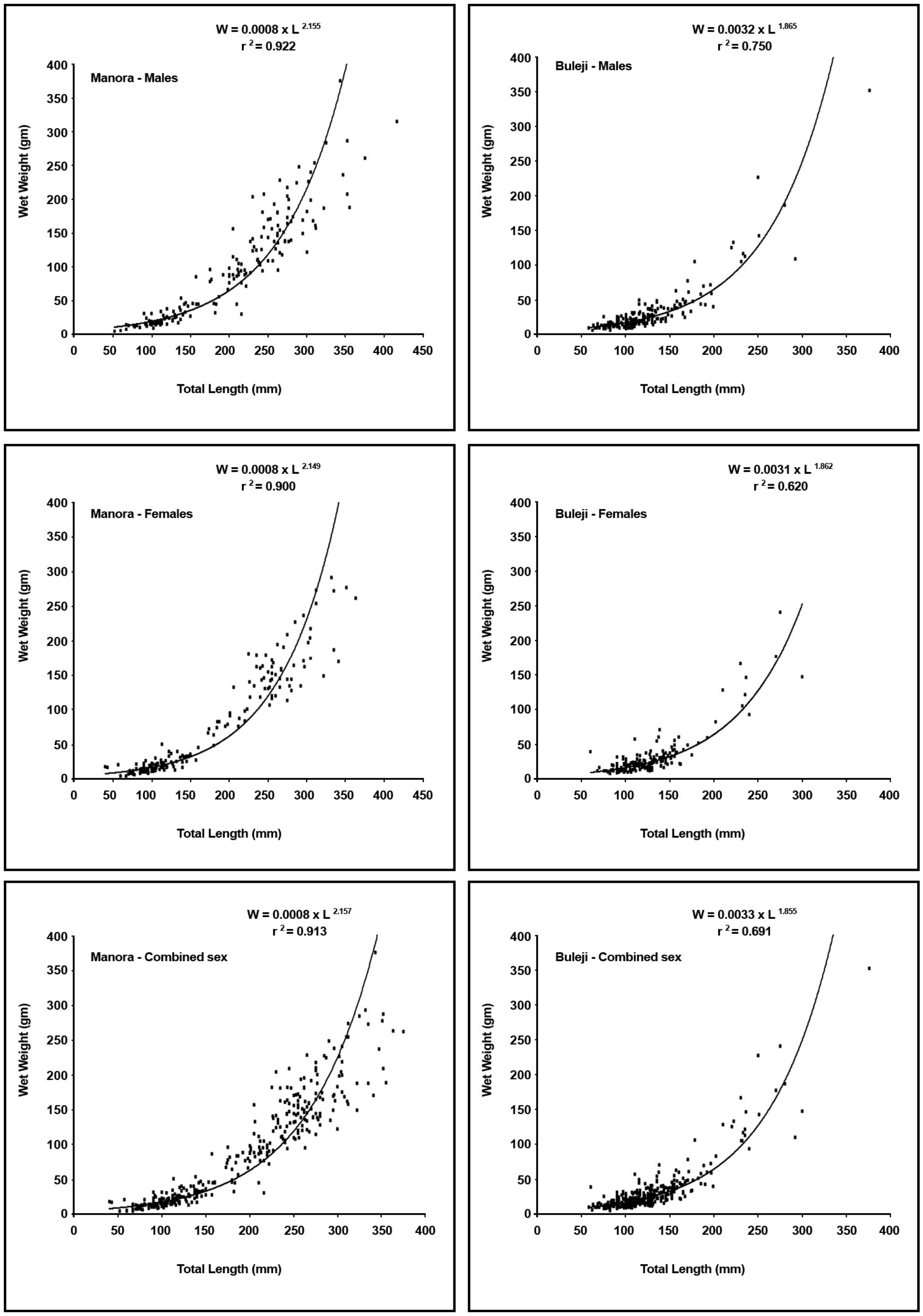


Fig. 2. Relationships between lengths and weights of *Holothuria arenicola* at Manora and Buleji.

after which measurements for total length (TL) was taken from the anus to the center of the tentacle crown (curved length) to the nearest ± 0.1 mm. The wet weight (WW) including the internal organs and coelomic fluid was taken on an electric balance to the nearest ± 0.01gm.

The length-weight relationship was estimated according to the equation $W = aL^b$ (Cone, 1989). The values of *a* and *b* were estimated from the $\log_{10}$ transformed values of length and weight, that is, $\log10W = a + b \log_{10} L$. The Student's t-tests was used to confirm whether *b* values obtained for the length-weight relationship were significantly different from the isometric value (b= 3).

The monthly relative condition factor (*Kn*) of the sea cucumber samples was calculated following Le Cren (1951) as $Kn=W/aL^b$. The *Kn* value was used to compare the condition factor of *H. arenicola* during different seasons. Analysis of variance (α = 0.05) was used to check significance of Kn value in different seasons.

RESULTS & DISCUSSION

Length-Weight relationships:

A total of 748 and 843 specimens of *H. arenicola* were examined from Manora and Buleji, respectively ; their minimum - maximum total length, and wet weight are shown in Table 1. The regression equation were estimated between wet weight vs. total length at Manora (Table 2). Student's t-test showed that growth is allometric (b not equal to 3, $P < 0.001$) for males, females and combined sexes of *H. arenicola*, with negative allometric growth, b values being 2.155 in males, 2.149 in females and 2.157 in combined sex at Manora (Fig. 2). In these relationships the coefficients of determination varied between 0.900 to 0.922 at Manora. Similarly at Buleji the regression equation were estimated for these relationships (Table 2). The t-test showed that *H. arenicola* shows allometric growth (b not equal to 3, $P < 0.001$), with negative allometry, b values being 1.865 in males, 1.862 in females and 1.855 in combined sexes at Buleji (Fig. 2). The coefficients of determination varied between 0.620 to 0.750 at Buleji.

Table 1. Minimum, maximum and mean ± SD (standard deviation) of total length (TL) and wet weight (WW) of *Holothuria arenicola* at Manora and Buleji.

Sites		Mean ± SD	Minimum	Maximum
Manora	TL (mm)	141.2 ± 75.9	27.0	416.0
	WW (g)	51.0 ± 64.8	1.8	375.0
Buleji	TL (mm)	115.7 ± 34.9	38.0	376.0
	WW (g)	23.9 ± 25.5	3.5	352.0

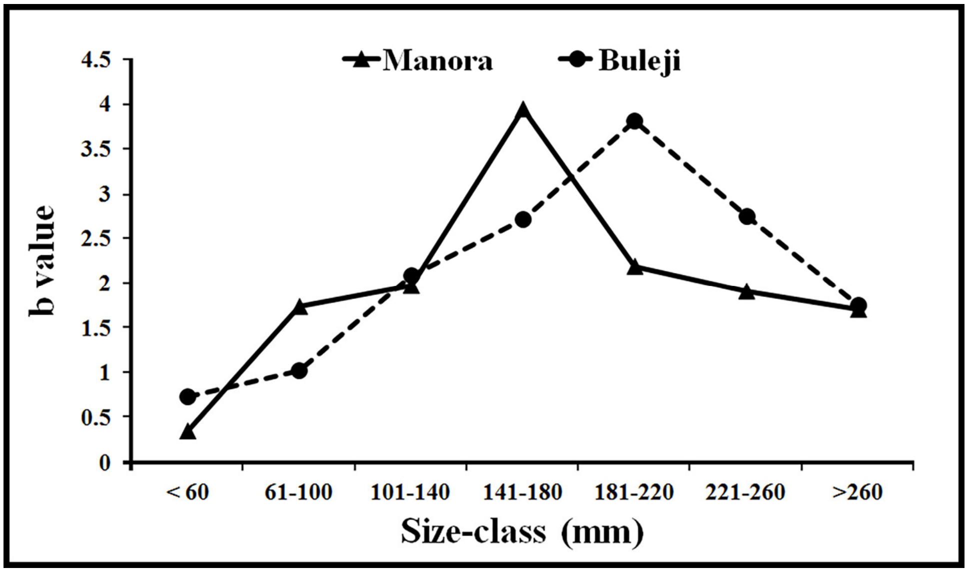


Fig. 3. Variations of b values in different size-classes of *H. arenicola* at Manora and Buleji.

The length weight relationship in *H. arenicola* during different seasons showed the b value to range between 1.850 to 2.384, being lowest in south west monsoon'11 (b = 1.850) at Manora, however, at Buleji the b value being low in autumn inter-monsoon'11 (b = 1.401), south west monsoon'11 (b = 1.754) and south west monsoon'12 (b = 1.730) as compared to other seasons where it ranged between 2.124 to 2.401. The t-test showed that *H. arenicola* grows with negative allometry (b not equal to 3, $P < 0.001$) during different seasons at both sites (Table 3).

The length weight relationships in *H. arenicola* showed the negative allometric growth in all size - classes with the exception in size class 141-180 mm at Manora where the b value was 3.951 which showed a positive allometric growth in this size class (Fig. 3). At Buleji the individuals belonging to size-classes 141-180 and 221-260 mm showed isometric growth and in size-class 181-220 mm a positive allometric growth, that is, in this size-class the increase in weight is faster than length (Fig. 3).

Condition factor:

The condition factor (Kn) calculated for *H. arenicola* ranged between 1.04 to 1.96 at Manora and 0.87 to 1.8at Buleji (Fig. 4). Analysis of variance showed that there is statistically significant difference between the means of the Kn values in 19 months at Manora (ANOVA, $F = 10.96$; $P < 0.05$) and Buleji (ANOVA, $F = 13.42$; $P < 0.05$). Multiple range test showed that Kn value varied significantly in January'12, August'12 and September'12 from remaining months at Manora and in November'11 and July'12 from remaining months at Buleji. Variations of mean condition factor in different seasons that is, spring inter-monsoon (March- April), southwest monsoon (May-September), autumn inter-monsoon (October) and northeast monsoon (November-February) are shown in Fig. 5. Kn values were higher in southwest and northeast monsoons as

Table 2. Morphometric relationships between total length (TL) and wet weight (WW) of the *Holothuria arenicola* population at Manora (N = 748) and Buleji (N= 843). *statistically significant values, P< 0.001.

Sites	Sexes	Intercept 'a'	Slope 'b'	Regression co-efficient 'r^2'	t-test
Manora	Males	0.00087	2.155	0.922	-17.312*
	Females	0.00088	2.149	0.900	-15.821*
	Combined sex	0.00086	2.157	0.913	-23.587*
Buleji	Males	0.00325	1.865	0.750	-14.940*
	Females	0.00309	1.862	0.620	-10.734*
	Combined sex	0.00330	1.855	0.691	-18.282*

Table 3. Length weight relationships of *H. arenicola* during different seasons of the study period from April 2011 to November 2012at Manora and Buleji. r^2, coefficient regression, *a* and *b,* parameters of length and weight equation; Significance *, P< 0.001

Sites	Seasons	Intercept 'a'	Slope 'b'	Regression Co-efficient 'r^2'	t-test
Manora	Spring inter-monsoon'11	0.00313	1.930	0.907	-8.491*
	South west monsoon'11	0.00383	1.850	0.820	-11.015*
	Autumn inter-monsoon'11	0.00078	2.160	0.899	-4.181*
	North east monsoon'11-12	0.00073	2.202	0.936	-8.848*
	Spring inter-monsoon'12	0.00025	2.384	0.931	-7.706*
	South west monsoon'12	0.00027	2.361	0.937	-11.352*
Buleji	Spring inter-monsoon'11	0.00028	2.401	0.913	-2.805*
	South west monsoon'11	0.00634	1.754	0.611	-8.166*
	Autumn inter-monsoon'11	0.03035	1.401	0.697	-6.926*
	North east monsoon'11-12	0.00095	2.124	0.886	-6.307*
	Spring inter-monsoon'12	0.00043	2.257	0.732	-3.963*
	South west monsoon'12	0.00553	1.730	0.652	-13.524*

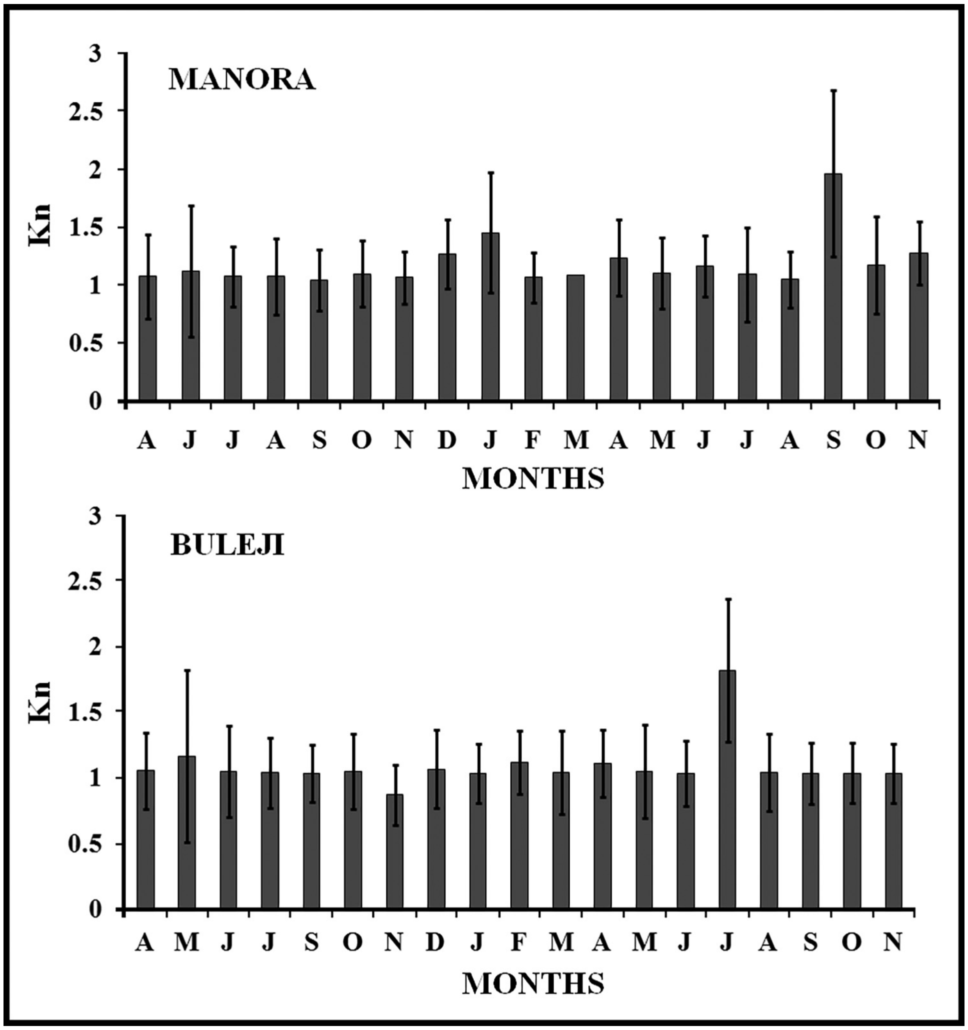


Fig. 4. Monthly relative condition factor (Kn) of *H. arenicola.* Bars indicate mean + SE during the study from April 2011 to November 2012.

compared to spring and autumn inter-monsoons (Fig. 5). Analysis of variance showed a significant difference between the Kn values in various seasons at Manora (ANOVA, $F = 86.529$; $P < 0.05$) and Buleji ($F = 56.285$; $P < 0.05$). Size of *H. arenicola* population in the present study differed at two collecting site, Manora and Buleji with a mean length of 141.2 ± 75.9 and 115.7 ± 34.9 mm, respectively. Mean adult weight also differed being higher at Manora (51.0 ± 64.8 g) than at Buleji (23.9 ± 25.5 g). The larger sized individuals of *H. arenicola* at Manora may be due to the fact that biological diversity is low at Manora as compared to Buleji (Ahmed and Hameed, 1999a, b; Rahman and Barkati, 2012), therefore, probably there is less competition for food and space at

Manora. Growth rates were linked to the availability of food in sea cucumbers (Uthicke and Benzie, 2002) and other echinoderms (Ebert, 1967).

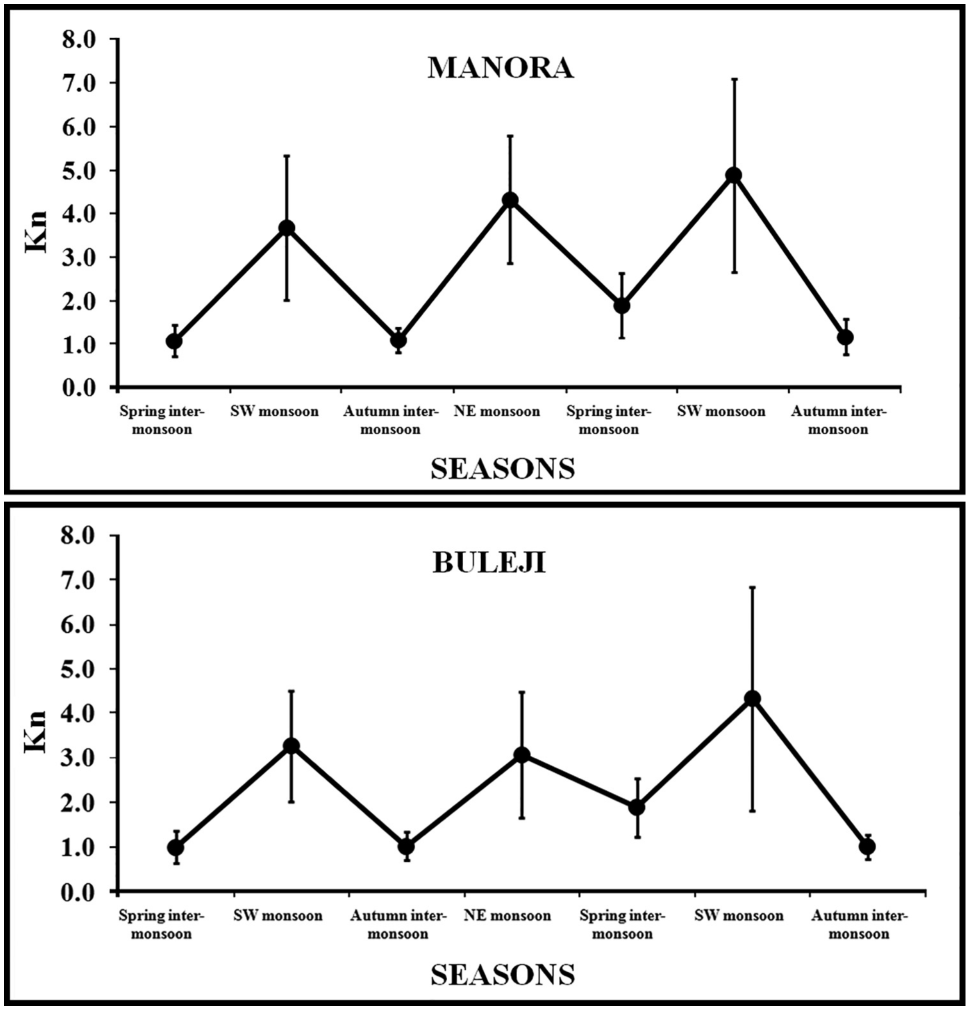


Fig. 5. Seasonal variations in the mean condition factor (Kn) of *Holothuria arenicola*. The vertical lines show standard deviation.

The largest sized specimens of *H. arenicola* found in present study were 41.6 cm at Manora and 37.6 cm at Buleji. The size of *H. arenicola* found in present study is either similar or larger than other *Holothuria* species reported from elsewhere (Table 4), with the exception of *H. fuscogilva* and *H. tubulosa* which were larger in length. The variation in lengths of the same species at different sites may be correlated to the ecological conditions of the habitat, animal physiology (Le Cren, 1951).

Table 4. Maximum body lengths (cm) of sea cucumbersspecies from various sources.

Species	Dissanayake and Stefansson (2007) Sri Lanka	Aumeeruddy and Conand (2007) Seychelles	Kazanidis et al. (2010) Aegean Sea	Kithakeni and Ndaro (2002) Tanzania	Al-Rashdi et al.(2007) Sultanate of Oman	James (1999) Gulf of Mannar, India	Present study Manora Pakistan	Present study Buleji Pakistan
Holothuria atra	35.4	-	-	-	-		-	-
Holothuria fuscogilva	46.2	29.5	-	-	-		-	-
Holothuria nobilis	41.7	27.0	-	-	-		-	-
Holothuria scabra	29.5	-	-	26.5	39.5		-	-
Holothuria edulis	28.5							
Holothuria tubulosa			49.4					
Holothuria arenicola	-	-	-	-	-	20.0	41.6	37.6

Biometric relationships are useful to make conversion of length to weight or vice versa, and then calculate growth parameters. In the present study the weight and length relationships showed negative allometry, that is, the two morphometric variables are not growing at the same rate. Similarly a negative allometric weight-length relationship has been reported in *H. arenicola* from the Mediterranean Sea (Raouf *et al.,* 2000; Abdel Razek *et al.,* 2010). The variations in value of b for length-weight relationships at different sites may be related to environmental factors, physiological conditions of the marine animal, fullness of stomach and gonads stages (Le-Cren, 1952; Ahemed, 1987; Per Spare, 1992; Froese, 1998; Verdiel, *et al.*, 2006).

The condition factor (*Kn*) calculated for *H. arenicola* showed a higher values in southwest and northeast monsoon as compared to spring and autumn inter-monsoons pattern, suggesting different feeding conditions in various seasons. As the coast of Pakistan is under the influence of seasonal monsoonal cycle, two increased primary productivity are expected to occur, one during the northeast monsoon and the other during the southwest monsoon. The highest abundance of phytoplankton was recorded in the south-west monsoon in the coastal waters of Pakistan (Latif *et al.,* 2013; Naz *et al.,* 2013). Similarly, phytoplankton abundance during the south-west monsoon season on northeastern Arabian Sea (Rajagopalan *et al.,* 1992; Parab *et al.,* 2006), northwestern Arabian Sea that extended into the open sea (Brock and McClain, 1992) and in waters of the Indo-Pakistan shelf (Kuz'-menko, 1977) has been reported. The strong southwest early winds during the summer months is due to clockwise surface water circulation in the Arabian Sea (Hastenrath and Lamb, 1979) and nutrient-rich waters along the coast supports high biological productivity during southwest monsoon, i.e., June to September (Nair *et al.*, 1989; Haake *et al.*, 1993; Rixen *et al.*, 1996). A secondary primary productivity peak in the northern basin is initiated when the wind direction reverses due to faster cooling of the continent in fall (Rixen *et al.*, 2005), thus initiating convective winter mixing that provides nutrients for seasonally and regionally enhanced biological productivity (Banse and McClain, 1986; Madhupratap *et al.,* 1996).

The present study provides the baseline information about the population status of *Holothuria arenicola* found in the coastal waters of Pakistan. Population-level information is important for the development of effective management plans for fisheries.

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