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Length-weight relationship (lwr), condition factor and seasonal distribution of *sardinella sindensis* (day, 1878) through size frequency variation from the Balochistan Coast, Pakistan

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Abstract
The length-weight relationship and condition factor was investigated from 1000 specimens of *Sardinella sindensis* caught along the Gwadar waters, Balochistan, Pakistan for 3 years from January 2003 to December 2006. The experimental fish size in total length (TL) ranged from 15 to 25 cm (mean ± SD=17.8±1.50) and the body weight (W) of *S.sindensis* range from 40 to 75 g (mean ± SD=50.3±11.28). The value of regression co-efficient obtained for the length-weight relationship was 0.6991.This suggests positive allometry growth from the entire specimens sampled. There was no significant statistical difference in the regression co-efficients. The mean value of condition factor computed for all the specimens of *Sardinella sindensis* was0.87±0.09, indicated that the specimens were moderately healthy.

Keywords: Length-weight relationship, condition factor, *Sardinella sindensis*, Balochistan Coast

1. Introduction
Length-weight relationship (LWR) of fishes are important in fisheries and fish biology because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them [1, 2]. Like any other morphometric characters, the LWR can be used as a character for the differentiation of taxonomic units and the relationship changes with the various developmental events in life such as metamorphosis, growth and onset of maturity [3]. Fulton's condition factor (K) is also widely used in fisheries biology studies. This condition factor is calculated from the relationship equation between the weight of fish and its length, with the intention of describing the condition status of that individual fish [4]. Different values in K of a fish indicate the state of sexual maturity, the degree of food source availability, age and sex of some species [5]. These relationships are also an important tool in fish Base [6]. *Sardinella sindensis* is one of the economically important small pelagic fish species for the local community [7]. The study on the length-weight relationship and condition factor of this species is scanty, which only previously reported by [8] from Manora Channel. However, there was no similar study reported in Balochistan Coast yet, which contributes to the main reason of performing this study. Therefore the obtained result from this study will provide baseline information on length-weight relationship and condition factor of this species from Balochistan Coast.

2. Materials and Methods
2.1 Samples collection
A total of 1000 fish samples were collected from the fishermen catches using gill nets from January 2003 to December 2006. The total length (TL) of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin to the nearest 0.1 mm using measuring board. The weight (W) of each fish was weighted to the nearest 0.01 g using a top loading balance.

2.2 Length-weight relationship (LWR)
The relationship between length and weight of fish was analyzed by measuring length and weight of fish specimens collected the from study area. The statistical relationship between these parameters of fishes was established by using the parabolic equation by [4].

$W = aL^b$
Where,
W = weight of fish in grams
L = Total length of fish in centimeter
a = constant
b = an exponent

2.3 Condition factor (K)
The condition factor (K) of the experimental fish was estimated from the relationship:

$$K = \frac{100\ W}{L^3}$$

Where,
K= condition factor
W= weight of fish
L= length of fish (cm)

4. Results and Discussion
In this study, a total of 1000 specimens of *Sardinella sindensis* were analyzed. The size (TL) of *S.sindensis* range from 15 to 25 cm (mean ± SD=17.8±1.50) and the body weight (W) of *S.sindensis* range from 40 to 75 g (mean ± SD=50.3±11.28). The LWR of these samples were computed as shown in Table 1 to Table 7. These table illustrated the correspondence statistics such as specimen size (TL), specimen weight (W), estimated parameters of LWR (a, b), standard deviation (SD) and co-efficient of determination (r^2). These data are representatives of four seasons (Summer, Winter, Autumn, Spring). Overall, the mean LWR parameters of a = 1.222, b = 2.329and r^2= 0.836 and mean condition factor (K) of *S. sindensis* was 0.87±0.09 throughout the sampling period (Table 6).This result indicates that there was a noticeable difference between the condition factor and length-weight relationships of *S.sindensis*. The highest mean and standard deviation of condition factor values was in the Summer season (K=0.95 ± 0.06) and the lowest mean and standard deviation of condition factor values was in the Winter season (K=0.4 ± 0.08).The most abundant length size of *S.sindensis* was between 17.4-18.4 cm (51%) and smallest length frequency was 21.5-25cm (3.2 %) (Fig.1). the highest weight group was 33-43g and the lowest weight group was 66-118g (Fig.2). The length frequency of *Sardinella sindensis.*(Figures 1-2) indicates that the cyclic relation between intervals and frequency (%) so the frequency (%) distant indicates the increasing trend were. In figure 3 shows a linear regression line has an equation of the form Y = a + bX, where X is the explanatory variable and Y is the dependent variable. The slope of the line is b, and a is the intercept (the value of y when x = 0) and in figure 4, 5, 6 shows the length weight relationship and condition factor of fish. The effective management of any fishery requires considerable knowledge of population parameters such as length-weight relationship. This relationship is very important in fisheries biology because it allows estimation of average weight of the fish of a given length group [9], assess the well-being of individuals and to determine possible differences between separate unit stocks of the same species [10]. The relationship is also important in fisheries management for comparative growth studies [11]. An investigation by [12] found that length-weight relationship (LWR) provides valuable information on the habitat where the fish lives while [13] stressed the Importance of LWR in modeling aquatic ecosystems.

4.1 Conclusion
The information obtained from the present study is believed to become an important knowledge on length-weight relationship and condition factor of *S. sindensis* from Balochistan Coast and also for future comparison in other locations.

Table 1: Seasonal variations of *Sardinella sindensis* in the length-weight relationships ($W = aL^b$). Correlation coefficients(r) and Significance test of differences between means (Student's t-test, p = 0.05).*p<0.05.

Seasons	n	$W = aL^b$	r	a	b
Pre south-west monsoon calm period (Spring)	250	$W=-1.285\ L^{2.380}$	0.821	-9.780	22.656
Post south-west monsoon calm period (Autumn)	248	$W=-1.032^{2.173}$	0.817	-8.446	22.243
North-east monsoon calm period (Winter)	247	$W=-0.792\ L^{1.980}$	0.812	-6.970	21.794
South-west monsoon period (Summer)	255	$W=-1.734\ L^{2.745}$	0.896	-16.163	32.042
Total	1000	$W=-1.222L^{2.329}$	0.836	-20.196	48.149

Table 2: Seasonal variations of *Sardinella sindensis*, mean length (TL), mean weight (W), mean condition (K) values and standard deviation.

Total Length Group	Total			
	n	TL (cm)	W (g)	K
15-17.5	472	16.8±0.64	40.8±3.50	0.8±0.04
18-19	495	18.3±0.34	57.6±6.42	0.92±0.05
21.5-25	33	24.2±1.58	75.5±18.2	0.53±0.15
Total	1000	17.8±1.50	50.3±11.28	0.87±0.09

Table 3: Results of ANCOVA of *Sardinella sindensis* for different groups. Tests between subject effects dependent variable: Weight

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	114672.640	18	6370.702	494.151	.000
Intercept	2531096.100	1	2531096.100	196327.524	.000
Length	114672.640	18	6370.702	494.151	.000
Error	12647.260	981	12.892	-	-
Total	2658416.000	1000	-	-	-
Corrected Total	127319.900	999	-	-	-

a. R Squared = .901 (Adjusted R Squared = .899)

Table 4: Seasonal size frequency variations of *Sardinella sindensis* from Balochistan Coast.

Total Length	n				TL (cm)				W (g)				K			
Group (cm)	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
15.0 -17.5	118	116	118	120	16.88± 0.64	16.89± 0.62	16.87± 0.64	16.89± 0.64	40.60± 4.45	40.60± 2.82	40.70± 3.11	40.50± 4.47	0.84± 0.03	0.84± 0.04	0.84± 0.03	0.84± 0.03
18.0 -19.0	125	125	120	125	18.38± 0.35	18.37± 0.34	18.34± 0.33	18.37± 0.35	58.34± 6.54	56.44± 7.00	56.32± 6.74	59.63± 4.62	0.92± 0.07	0.90± 0.06	0.90± 0.06	0.95± 0.06
21.5 -25.0	7	7	9	10	24.50± 1.32	24.50± 1.32	24.60± 1.16	24.30± 1.47	68.00± 0.00	68.00± 0.00	68.00± 0.00	93.00± 26.35	0.51± 0.20	0.47± 0.09	0.46± 0.08	0.78± 0.15
Total	250	248	247	255	17.80± 1.45	17.85± 1.44	17.87± 1.59	17.90± 1.59	50.20± 10.7	49.36± 9.90	49.20± 9.90	51.90± 14.17	0.87± 0.10	0.86± 0.09	0.86± 0.09	0.89± 0.08

n = number of samples, TL = Total length, W = Weight, K = Condition factor, A = Spring, B = Autumn, C = Winter, D = Summer

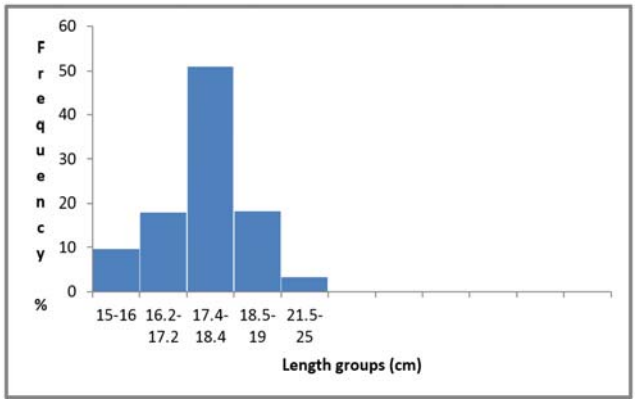

Fig 1: Length frequency distribution of *Sardinella sindensis*

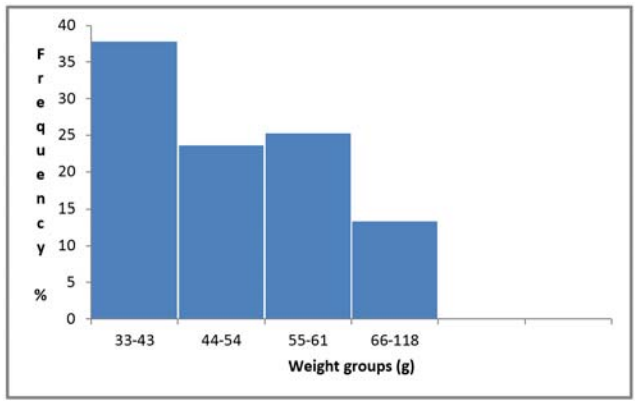

Fig 2: Weight frequency distribution of *Sardinella sindensis*

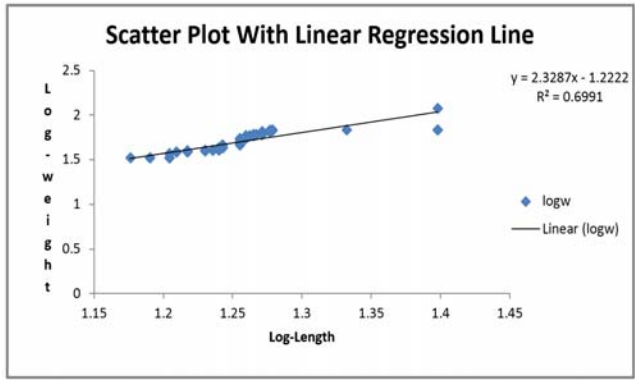

Fig 3: Linear relationship between length and weight of *Sardinella sindensis*

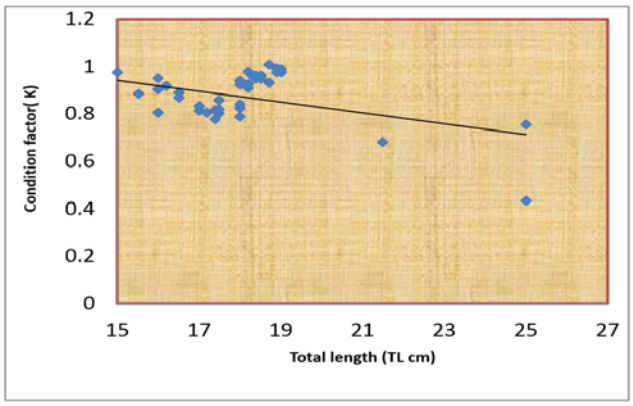

Fig 4: Condition factor and total length of *Sardinella sindensis*

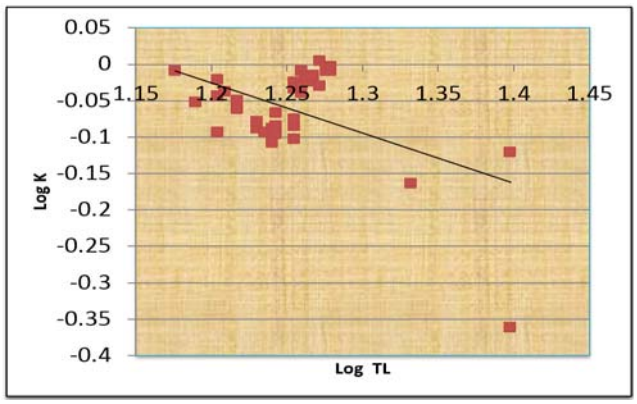

Fig 5: Log Condition Factor and Log total length of *Sardinella sindensis*

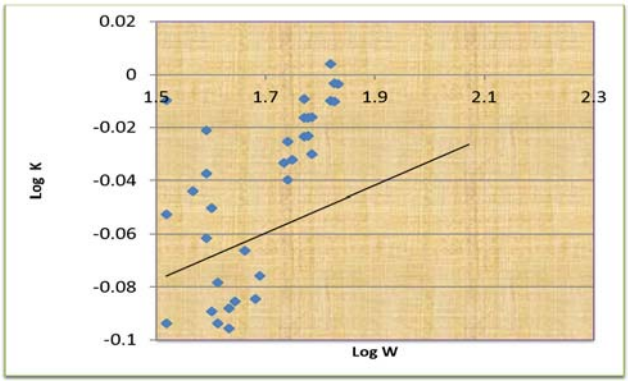

Fig 6: Log condition factor and Log weight of *Sardinella sindensis*

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