



Research Article

Volume 14 Issue 2 - September 2021
DOI: 10.19080/OFOAJ.2021.14.555884

Oceanogr Fish Open Access J

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Length-Weight Relationships and Condition Factor of Six Sole Fish species from Coastal Waters of Pakistan

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Submission: June 26, 2021; Published: September 03, 2021

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Abstract

The current study aimed to investigate the morphometric analysis based on length and weight relationships and condition factors of six sole fish species i.e., *Cynoglossus puncticeps*, *C. arel*, *C. quadrilineatus*, *Pseudorhombus javanicus*, *P. elevates*, and *Euryglossa orientalis* belong to three different families Paralichthyidae, Cynoglossidae and Soleidae. Their feeding practices are quite different from other species as they forage mostly on bottom invertebrates, therefore, these species inhabiting in shallow muddy and sandy bottom of the continental shelf along the coast. Sole fish species were collected from five harbors i.e., Karachi fish harbor (KAH), Keti Bandar fish harbor (KBH), Korangi fish harbor (KOH), Ormara fish harbor (OFH) and Pasni fish harbor (PFH) along the coast. The significant variations were observed in morphometric parameters according to fish species. The highest condition factor was evaluated for *E. orientalis* (1.943) and lowest was examined for *C. arel* (0.469). This is the preliminary analysis from Pakistani waters and an addition of some basic information on the biology and growth of sole fish in the marine environment of Pakistan.

Keywords: Length-weight relationship; Fish assemblage; Sole fishes; Pakistan

Introduction

Length-weight relationship has a conspicuous importance to differentiate the biological stock demonstration, to understand by body condition records, figure biomass dependent on length recurrence circulations and for acoustic overviews [1-3]. In spite of its significance and the way that these relationships are effectively acquired, they are normally absent for a few animal types, particularly those that are not economically important [3]. The relationship between length and weight is analyzed on the basis as used to explore information regarding fish condition, factors and examine the nature of the growth of fish, whether isometric or allometric [4,5]. Generally morphometric data likewise interlink between total length and total weight are essential, especially for Eco morphological studies [6,7].

An indispensable job is played by fish in the advancement of a country in spite of the fact that it is the least expensive wellspring of over-the-top nutritive protein. It has other fundamental supplements which are required to human body [8-10]. Length-weight relationship (LWR) is basic instrument in the executives of fishery it is additionally essential in fisheries the board for relative development ponders it gives vital data on the oceanic

natural surroundings numerous devices were utilized in fishery science to separate fish populace, for example, hereditary and morphometric it is broadly used to realize the distinction between fish populace [11-15].

Flat fishes play a vital role in energy pathway, and it is also beneficial for conservation of benthic organisms in a form suitable for human consumption [16]. Since 1930, the relationship between Length-weight was used [17]. It was described with Cubic parabola first. $W=aL^3$ after this procedure, it has been superseded by general parabola. The result of general parabola is much better than cubic parabola $W=aL^b$ $b=2$ to 4 to values will exist a and b they both differ between species, through annual spawning seasons [18]. When b is equal to 3 it means the growth is isometric if it is more than 3 or less than it is termed as allometric growth, thus length-weight relationship (LWR) measurement of any species prerequisite to the study about its population [19].

Fishes impart benefits to human being in plenty ways. It is also essential dietary animal basic protein source in human food [20]. The population of humans has been increasing day by day and it is inversely proportional to animal protein. The fish meat

provides energy and high quality of proteins, which holds all mandatory amino acid in effortlessly digestible; thus, they are worthwhile nutritious sources [21]. The morphometric analysis can also provide the valuable information on aquatic habitat [13]. Differences appeared during the morphometric analysis are important for evaluating the species variation and structure of population on behalf of recognizing stocks [22].

Length-weight relationships of fishes are important tools in fisheries science for the various studied areas i.e., estimation of standard weight of fish species in a given length assemblage [11], growth rate, age and length structures, conversion of growth in-length equations to growth-in-weight in stock assessment models, biomass from length frequency distributions. Length-weight relationship (LWR) considered as an imperative growth index used as a sustainable management tool by fishery biologists. Morphometric relationships among the fish used to assess and determine the possible differences between the different species and stocks of the species [12,23]. Length and weight relationship plays huge role in population dynamics and fishery biologist,

where plenty stock assessment models have been entail using length-parameters.

The review of literature provides few previous studies on these important species (Table 1) Sole fishes from *Cynoglossidae* family are commercial fish in China. Bohai Sea and in east yellow sea [24]. Owing to overfishing, wild population is being decreased and annual output less than 1 ton now [25]. In china sole fishes are commercial fish and also culture able and these are being culture in European countries. These species are reported from both coasts of Pakistan, i.e., Makran coast and Lasbela coast including, Gwadar, jeewani, Ganz, Sur Bandar, Pasni, Ormara, Korangi and Keti Bandar. The present study intended to investigate the morphometric analysis, length-weight relationships, and condition factors of six sole fishes i.e., *Cynoglossus puncticeps*, *C. arel*, *C. quadrilineatus*, *Pseudorhombus javanicus*, *P. elevates* and *Euryglossa orientalis* belong to the three families Paralichthyidae, Cynoglossidae, and Soleidae from coastal waters of Pakistan.

Table 1: Review and record of previous available literature on the species of flat fishes.

Species	Family	Region	'b' value	Reference
<i>Cynoglossus puncticeps</i>	Cynoglossidae	India	3.12	Karna et. al. (2017)
<i>Cynoglossus arel</i>	Cynoglossidae	India	2.92	Jayaprakash (2001)
<i>Cynoglossus quadrilineatus</i>	Cynoglossidae	Iran	3.21	Aghajanpour et.al. (2015)
<i>Pseudorhombus javanicus</i>	Paralichthyidae	India	2.79	Bharadhirajan et. al. (2019)
<i>Pseudorhombus elevates</i>	Paralichthyidae	Iran	3.29	Aghajanpour et. al. (2015)
<i>Euryglossa orientalis</i>	Soleidae	Pakistan	3.02	Hussain et. al. (2010)

Materials and Methods

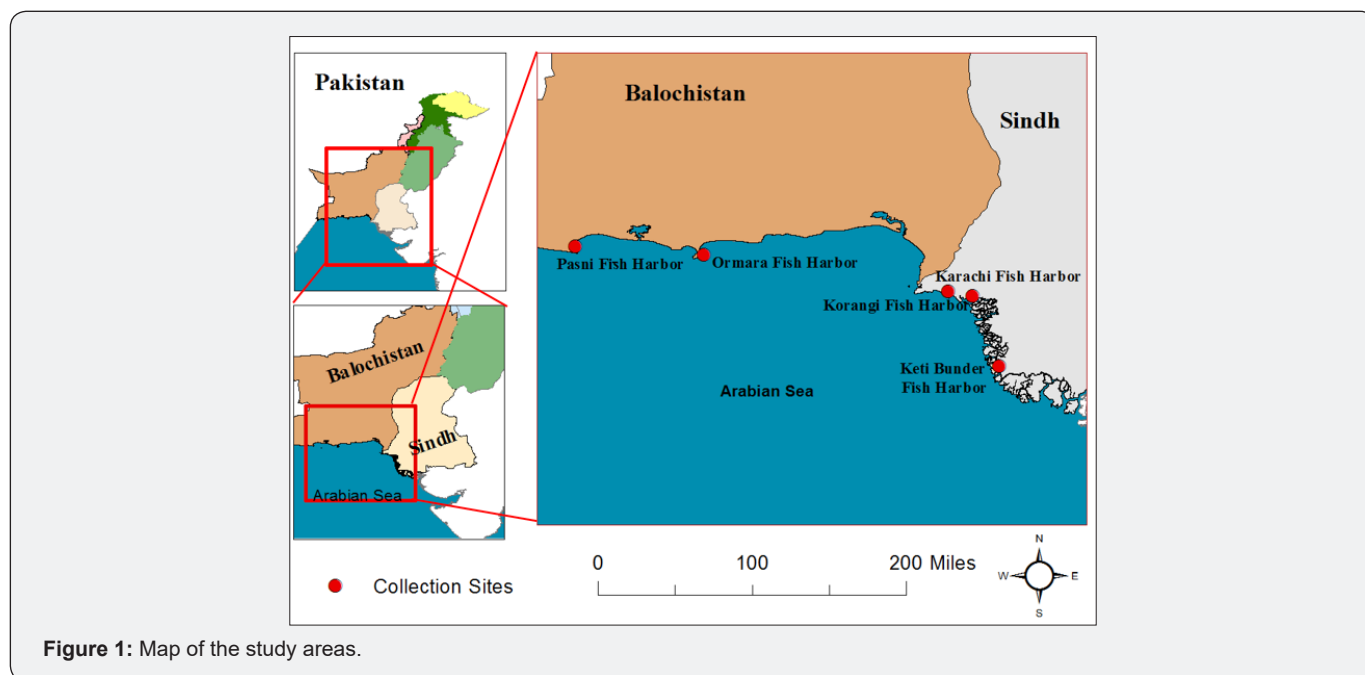


Figure 1: Map of the study areas.

Flat fish sampling was conducted during a whole year of 2018 from five harbors, i.e., Karachi fish harbor (KAH), Keti Bandar fish harbor (KBH), Korangi fish harbor (KOH), Ormara fish harbor (OFH) and Pasni fish harbor (PFH) along the coast of Pakistan (Figure 1)). Fish individuals were identified up to the species level with the help of the fish identification key [26]. A total of 1238 specimens of six species (*Cynoglossus puncticeps*, N=75; *C. arel*, N=216; *C. quadrilineatus*, N=519; *Pseudorhombus javanicus*, N=213; *P. elevates*, N=57; and *Euryglossa orientalis*, N=156) were used in morphometric analysis. Total length (TL) and total width (TW) measured by a stainless scale (nearest 0.1 cm), whereas total weight (TW) measured by using digital weight balance (nearest 0.01 g). Length-Weight, relationship was calculated by following equation given by Le-Cren (1951):

$$W = aL^b$$

Where, W is the weight and L is length of fish individuals, “b” is the allometric growth parameter or slope, and “a” is termed as an initial growth factor (y-intercept). The condition factor (K) is a useful index for monitoring feeding intensity, age, and growth rates defined the well-being of the fish and was obtained using the following formula [27].

$$K = W \times 100 / L^3$$

Statistical Analyses

Morphometric parameters of fishes were analyzed through basic descriptive statistics, which include mean, standard

deviation, minimum and maximum. Analysis of Variance (ANOVA) was used to assess the variations in morphometric parameters regarding fish species and fish harbors and level of significance were accepted at 0.05 probability. Pearson’s correlation analysis (r^2) was used to determine the relationship between morphometric parameters in fishes. Linear regression analysis (r^2) was employed to evaluate the relationship between length and weight of the fishes.

Results and Discussion

The present study provides the Length -Weight relationship (LWR) and relative condition factor (k) of total of six flatfish species (*Cynoglossus puncticeps*, *C. arel*, *C. quadrilineatus*, *Pseudorhombus javanicus*, *P. elevates*, and *Euryglossa orientalis*) from three families (Figure 2), namely Cynoglossidae, Paralichthyidae, and Soleidae. were collected in the current study along the coastal waters of Pakistan. The inter and intra specific variations were observed in the length and weight relationship of studied species of flat fishes in morphometric parameters (Table 2). The morphometric parameters showed significant variations ($p < 0.001$) among the species collected from coastal waters of Pakistan. The total mean length (cm) for all the six studied fishes was significantly varied Whereas, the highest width (cm) was observed for *P. javanicus* (14.09) followed by *P. elevates* (12.85), *E. orientalis* (10.36), *C. puncticeps* (9.77), *C. quadrilineatus* (9.48) and *C. arel* (7.17). The wet weight (g) of studied fishes ranged from 301.6 to 120.5, which was observed highest for *P. elevatus* and lowest for *C. arel* (Figure 3).



Figure 2: Different species of sole fishes collected from Pakistani harbors (1. *Cynoglossus quardilintus* 2. *C. arel* 3. *Pseudorhombus javanicus*, 4. *C. puncticeps* 5. *Pseudorhombus elevates* 6. *Euryglossa orientalis*).

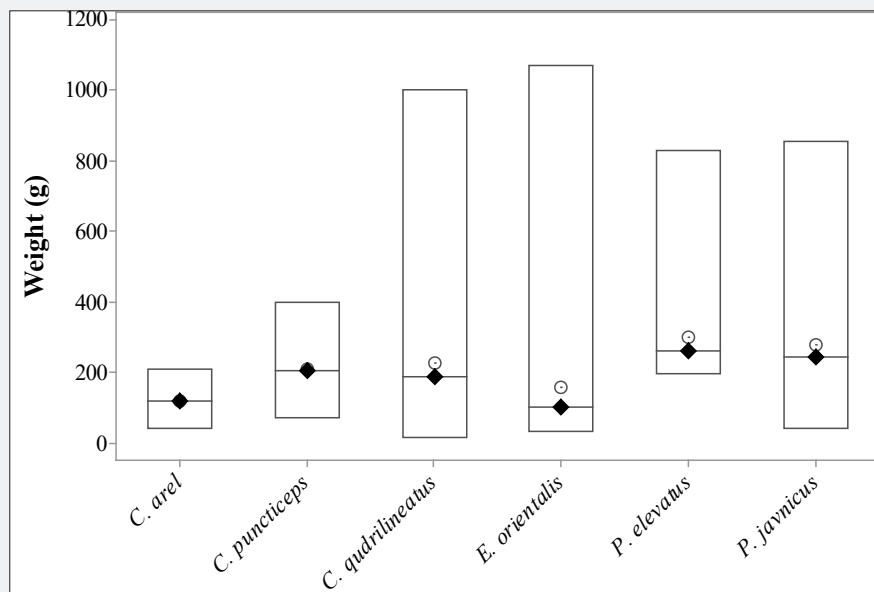


Figure 3: Box plot for length, and weight of the studied flat fish species from coastal waters of Pakistan.

Table 2: The descriptive statistics for the length, weight, and width of Six flat fish species collected during the study.

Species name	Variables	N	Mean	SD	Minimum	Maximum
<i>Cynoglossus arel</i>	Length (cm)	216	28.08	2.61	20	34
	Weight (g)	216	120.5	33.14	40	209
	Width (cm)	216	6.8	2.16	4	9.5
<i>Pseudorhombus elevates</i>	Length (cm)	57	29.8	4.71	24.0	38.5
	Weight (kg)	57	270.4	49.58	199	381
	Width (cm)	57	13.31	0.792	12	15
<i>Euryglossa orientalis</i>	Length (cm)	156	20.32	4.574	9.5	39
	Weight (kg)	156	163.84	146.4	34	1070
	Width (cm)	156	10.32	2.58	5.5	19
<i>Pseudorhombus javanicus</i>	Length (cm)	213	28.72	5.66	15	41
	Weight (g)	213	281.14	176.86	41	855
	Width (cm)	213	14.57	2.802	8	21
<i>Cynoglossus quadrilineatus</i>	Length (cm)	519	32.77	6.37	15	58.5
	Weight (g)	519	221.126	138.9	27	1000
	Width (cm)	519	9.6052	2.4	5	20.3
<i>Cynoglossus puncticeps</i>	Length (cm)	75	30.508	2.98	23	38.5
	Weight (g)	75	205.755	49.63	204	401
	Width (cm)	75	9.7955	1.4	6	13.5

C. quadrilineatus found in abundance from all six species along the Pakistan coast. Among the sole fishes, *Cynoglossus* is genus of flatfish, belong to Cynoglossidae family and can be distinguished by the presence of hook-on snout which is overhanging the mouth. In the current study, the “b” values were observed 2.859 as

compared to the reported values (3.213) from the same fish of the family [28]. The second most abundant species *P. javanicus*, which was also collected from all fish harbors like *C. quadrilineatus*. The significant correlation ($R^2 = 0.83$) evaluated between length-weight relationship. A positive allometry (Figure 4) was observed

with the “b” values (3.043) for *P. javanicus*, is comparable to the reported values 3.207 for the same species [29]. *Cynoglossus arel* was the third most abundant species showed the significant

correlation ($R^2 = 0.68$) between length-weight relationship with a positive allometry (Figure 4).

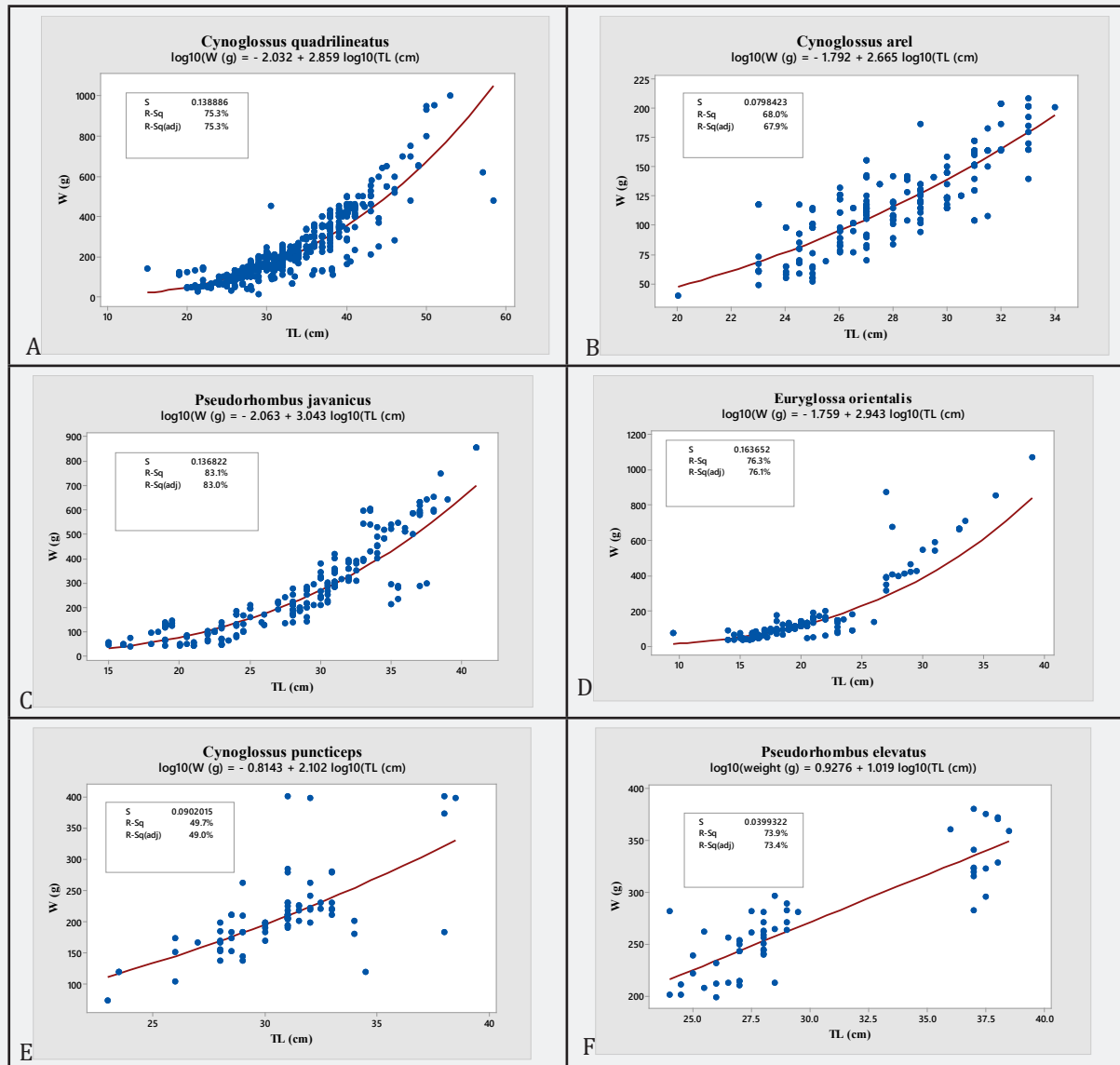


Figure 4: Length weight relationship of six species of sole (A) *Cynoglossus quadrilineatus* (B) *Cynoglossus arel* (C) *Pseudorhombus javanicus* (D) *Euryglossa orientalis* (E) *Cynoglossus puncticeps*(F) *Pseudorhombus elevates*.

In the current study, the observed “b” values (2.859) for *C. arel* can be compared with the previous reported 2.923 values [30]. *Pseudorhombus elevates* belongs to the Paralichthidae family, which is recognized as having 67-74 rays, anal fin with 52-58 rays by its strongly ovoid body with dorsal fin. The specimen of *P. elevates* only procured from Karachi fish harbor along the Sindh coast. The average length, width and wet weight of fish is 29.81 cm, 12.85

cm and 301.6 g, respectively (Table 2). The positive allometry and significant correlation ($R^2 = 0.73$) evaluated between length-weight relationship (Figure 4). In the current study, the “b” values were observed 1.019 as compared to the reported values 3.290 [28]. The average length, width, and wet weight of *C. puncticeps* ranged from 30.11 to 32.44 cm, 9.46 to 10.13 cm and 138 to 204 g, respectively (Table 2).

The significant correlation ($R^2 = 0.49$) evaluated between the length-weight relationship of *C. puncticeps* and showed isometric allometry (Figure 4). In the current study, the observed “b” values were less 2.02 as compared to the reported values 3.12 [31]. Total 156 individuals of *E. orientalis* were collected from two harbors i.e., Keti Bunder and Karachi fish harbors. The significant correlation ($R^2 = 0.76$) evaluated between length-weight relationship and showed a positive allometry (Figure 4). In the current study, the “b” values were observed 2.94 as compared to the reported values 2.927 [32]. *E. orientalis* belongs to Soleidae family; it is a marine fish species. It populates in shallow muddy and sandy extremities of coastal waters and also in brackish water. It feeds on base enduring invertebrates, mainly small crustaceans [33].

The length-weight relationships presented the significant positive correlation for *C. quadrilineatus* ($r^2=0.75$), *C. arel* ($r^2=0.68$), *P. javanicus* ($r^2=0.83$), however, *C. puncticeps* ($r^2=0.49$) showed slight negative correlation. The variations in morphometric parameters among the species most likely due to the ecological conditions of the niche and/or physiological condition of fish [20]. However, some scientists already recognized the factors affect the

distribution and profusion of fish such as spawning rates, supply of food and depth of water, vegetation, breeding grounds and some other factors which have been recommended as major factors and the abundance of numerous families in Lake of Kianji [34].

The results of this study provide useful basic biological information about the most conspicuous species of fish caught in the study area that can also be compared to surrounding areas, The Fulton’s condition factor (K) is an extent as linking the length and weight for a particular fish, therefore it could be influenced by the same factors as Length and weight relationship. It was proposed that if the K value is 1.00, the condition of the fish is poor, long, and thin. A 1.20 value of K indicates that the fish is of modest condition and acceptable to numerous anglers [35]. If the fish would have a K value that is approximately 1.40 or more considered as a good and well-proportioned. The condition factor (K) for the studied species ranged from 0.406 to 1.94 (Table 3), the lowest condition factor was evaluated for *C. arel* that showed the less favorable environmental condition of the area for this species. Similar condition factor was described from coastal waters of Nigeria in Lagos state [36].

Table 3: The estimated average condition factor of all six species of Flat fishes.

Species	Numbers	Condition factor
<i>Cynoglossus arel</i>	216	0.469
<i>Euryglossa orientalis</i>	156	1.943
<i>Pseudorhombus javanicus</i>	213	1.1927
<i>Cynoglossus puncticeps</i>	75	0.7351
<i>Cynoglossus quardilineatus</i>	519	0.6345
<i>Pseudorhombus elevatus</i>	57	1.138

The higher condition factor evaluated for *E. orientalis* at Korangi fish harbor, which showed the favorable environmental condition in the area. Similar condition factor was described from coastal waters of Parangipettai Coast, India [37]. The condition factor (K) of *C. puncticeps* and *C. quardilineatus* was 0.735 and 0.634 respectively (Table 3), showed the moderate favorable environmental condition in the area. Similar condition factor for these species were described from coastal waters of Nigeria from Nkoro River Niger Delta [38]. For the *C. arel* the K value (0.469) showed the poor conditions and similar condition factor was described from coastal waters of Tighra reservoir, Gwalior, throughout May 2012 to April 2013. Tighra reservoir mendacities on 26-12’0” latitude and 78 - 30” E Longitude [39]. The condition factor (K) for *P. elevatus* calculated as 1.138 (Table 3), which showed the favorable environmental condition in the area. Similar condition factor was described from coastal waters of Iran muddy shores of the inter-tidal zone of Bandar Abbas city, Persian Gulf, Iran [40]. The highest (1.927) condition factor (K) was observed for *E. orientalis* (Table 3), which showed the favorable environmental condition in the area.

Based on this criterion, the sampled fishes along the coast were in good and moderate conditions except *C. arel*, However the difference in condition factor could be due to the availability of food organisms at a particular time as well as the difference of development [41]. The present data could not clarify the factors among those described above could have led to these observations. Mean values of length-weight relationship and condition factor were therefore considered to be indicators of the study area regardless the sampling locations. Moreover, in present study, the factors that affect and predictors of the length-weight relationship, such as habitat, seasonal consequence, stomach richness, preservation techniques, adulthood stage, maturity, age, and gender [42,43] were not taken into consideration. Due to such reasons, the estimated length-weight relationship and the values of a and b can be considered as the mean values, as proposed by several authors [44].

The variations in morphometric parameters among the coastal areas probably due to the ecological conditions of the niche and/or physiological status of fish [20]. It is well known that

the functional regression b , value varies according to the body shape of fish and some life history parameters such as maturity, maximum size, growth rate, and others factors like habitat, stomach fullness, health, sex, age, etc., [1,4,45]. The results of this study provide useful basic biological information about the most conspicuous species of fish caught in the study area that can also be compared to surrounding areas, like the Veracruz Coral Reef System National Park [45].

Conclusion

This study aimed to investigate the morphometric analysis, length-weight analysis, and condition factor of six endemic species (*Cynoglossus quardilineatus*, *C. arel*, *C. puncticeps*, *Pseudorhombus javanicus*, *P. elevatus*, and *Euryglossa orientalis*) inhabiting in the coastal waters of Pakistan. The significant variation ($p < 0.05$) was observed in length, width, and weight among the six fish species. The length-weight analysis showed the significant positive relationship in between length and weight of all studied fishes except negative growth relationship *Pseudorhombus javanicus*. The mean condition factor was examined highest for *E. orientalis* and was lowest for *C. arel* that inhabiting in coastal waters of Pakistan. The current study provides the basic information on length-weight relationships and condition factor 'K' for six sole fish species, and it would be utilize in biology and ecology of these fishes to manage the fin fish fishery resources in coastal waters of Pakistan.

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DOI: [10.19080/OFOAJ.2021.14.555884](https://doi.org/10.19080/OFOAJ.2021.14.555884)

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