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Some Morphometric Relationship Traits of Talang Queenfish, *Scomberoides commersonnianus* (Lacépède, 1801) from Pakistan

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ABSTRACT

In the current study, 73 samples of *Scomberoides commersonnianus* of different body size with ranges of 20.5 to 56.9 cm were collected from Karachi, Pakistan. Specimens were used to examine some morphometrics as length-weight and length-length relations. To address the parameters, condition factors and their relations with respect to total length, fork length, standard length, head length and width, body girth, dorsal fin base and length, pectoral fin base and length, pelvic fin length, caudal fin length, anal fin width, and length were determined. Results showed highly significant correlation among those parameters, concerning the increase in body weight and total length. For instance, a highly positive correlation was found between body weight and condition factor, while a non-significant relation was detected in total length and condition factor. Furthermore, the b recorded value for the coefficient of regression was 2.53 indicating negative allometric growth pattern in *S.commersonnianus*. Interestingly, the resulted data would hopefully provide significant information of various morphometric parameters of Talang Queenfish (*Scomberoides commersonnianus)* to support zoologists and ichthyologists.

INTRODUCTION

Almost forty-two species of family Carangidae represent the dominant finfish group in Pakistan. *Scomberoides* genus contains three species; namely, *S. tol*, *S. lysan*, and *S. commersonnianus*. Talang queenfish is a significant resource of fishery that is vernacularly called aal and saram **(Panhwar *et al.*, 2014)**. In morphometry, the study of change and variation are addressed in the form of shape and size of organisms **(Websters, 2006).** Traits of the science of fisheries are either hereditable based qualities or separate fish species **(Mir *et al.*, 2013)**. *S. commersonnianus* (Talang queenfish) grows up to a maximum size length of 120cm **(Smith-Vaniz, 1984)** and a weight of 16kg **(International Game Fish Association, 2001)**.

Consequently, the present study was organized to evaluate the morphometrics based relationship of *Scomberoides commersonnianus* collected from Karachi, Pakistan and generate the report on morphometric parameters of the same species particularly for the Arabian Sea.

MATERIALS AND METHODS

Karachi is situated along Karachi Harbor; a natural harbor on the Arabian Sea, on the coast of Sindh province in southern Pakistan**.** Seventy three fish samples of *S. commersonnianus* (Talang Queenfish) were randomly chosen from the Arabian Sea in Karachi, Sindh, Pakistan. Fish was transported safely to Fisheries Laboratory, Institute of Pure and Applied Biology (Zoology Division), Bahauddin Zakariya University, Multan, Pakistan .

Various morphometric measurements of fish specimens showed variability in length and weight. Fish measurement refers to the measuring of the length of individual fish and the weight of various parts of their anatomy. Each sample was weighed using an electric balance (MP3000 Cho, Japan) to the nearest 0.01g separately. The exact estimation of body length from the snout tip to the longer lobe tip of the caudal fin was usually measured with lobes with its midline compressed. This was estimated according to the straight-line measurement, without measuring over the body curve. Measurement of total length was done with the help of a wooden board. The standard and total length were measured from tip of snout to tip of tail and from length of it's terminal side of mouth to caudal fin base. For the measurment of head length distance from snout, the anterior portion to the opercula bones of its posterior edges and head width between their straight distance of eyes was determined. Fin base and length values were noted as pelvic, anal, pectoral, and caudal. The dorsal fin length was adjusted accordingly as the distance from anterior body junction to the most anterior fin tip. In addition, pelvic, pectoral, anal, and dorsal fin base and width of caudal fin were noted accordingly. The used calculation formula of condition factor was as follows

$$\text{Condition factor} = 100 \times W/L^3$$

The weight- length relation is in an exponential form as described by the succeeding formula:

$$W = aL^b$$

While the equation in a form of a log is as follows:

$$\text{Log}W = \log a + b \log L$$

Statistical relations between fish body weight and total length were derived by using linear transformation as reported in the study of **Zar (1984)**.

Fulton's condition factor (K) was determined using the following formula:

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

In addition, the statistical data analyses through regression coefficient were specified by using Microsoft Excel.

RESULTS

A total of 73 samples of *Scomberoides commersonnianus* were collected from Karachi, Pakistan. The range of wet body weight and total body length was 94.50 to 1183g and 20.5 to 56.9cm, respectively. The mean and standard deviation was 605.41±40.57 for weight, while for total length, the value recorded was 40.74±1.42. Those values for different morphometric variables concerning *Scomberoides commersonnianus* are presented in Table (1). The general form shows that the relation between wet body weight and total length is in an exponential form and is expressed as:

$$W=aL^b \text{ or } Y=aX^b$$

X and Y are dependent and independent variables, respectively, in the equation although a and b are intercepts and constants as described in the study of **Le Cren (1951)** as follows:

$$\text{Log } W = \log a + b \log TL$$

Table 1: Values of mean and ranges for various external morphometric parameters of *Scomberoides commersonnianus.* (n = 73)

Morphometric parameters	Mean ± S.E	Ranges
Body Weight (BW)	605.41±40.57	94.50-1183.00
Total length (TL)	40.74±1.42	20.50 –56.90
Condition Factor (K)	0.80±0.02	0.61-1.17
Fork Length (FL)	35.42±1.20	18.10-49.60
Standard length (SL)	34.53±1.18	17.50-48.10
Head length (HL)	7.39±0.17	4.80-9.90
Body Depth (BD)	10.98±0.40	5.20-15.25
Body girth (BG)	21.97±0.79	10.40-30.50
Dorsal fin length (DFL)	5.44±0.22	1.00-7.50
Dorsal fin base (DFB)	14.57±0.44	5.00-19.60
Pectoral fin length (PtFL)	4.57±0.17	2.10-6.80
Pectoral fin Base (PtFB)	1.37±0.04	0.40-1.90
Pelvic fin length (PvFL)	3.61±0.16	0.20-5.20
Pelvic fin Base (PvFB)	0.98±0.04	0.30-1.70
Anal fin length (AFL)	5.09±0.26	0.20-7.50
Anal fin base (AFB)	13.61±0.60	5.30-20.30
Caudal fin width (CFW)	9.21±0.39	0.50-13.80
Eye Diameter (ED)	1.02±0.05	0.40-1.50

Weight-length relationship is expressed as: TL 2.5346 (Table 2) a dLogW = 1.365 + 2.53 log TL (r=0.993) (Table 2).

A regression analysis between weight and total length revealed a highly significant correlation ($P < 0.001$) with log data value (0.996). The b value for the coefficient of regression was recorded 2.53 indicating allometric in relation. The measurement of the relation between total length and wet weight of the body was linear with a highly significant correlation (Table 2).

Growth parameters, mainly length-weight was found to be allometric in *Scomberoides commersonnianus*. Additionally, a highly significant coorelation ($P<0.01$) was detected in the relation between total length with head length, standard length, body girth, head width, body depth, eye diameter, pelvis, anal, dorsal, caudal, and pectoral fin length along with caudal fin width.

Table 2: Regression and statistical parameter of total length with different morphometric parameters for *Scomberoides commersonnianus*.

Correlation coefficient	Parameter relationship		95% CI of 'a'	95% CI of 'b'	R	r^2
	a	b				
W = a + Btl	-540	28.12	-595.68,-484.98	26.82,29.42	0.98***	0.96
K = a + Btl	1.271	-0.012	1.2151,1.3265	-0.0128,-0.0102	0.90***	0.81
FL = a + Btl	0.8071	0.85	0.4018,1.2124	0.8401,0.8591	0.999***	0.998
SL = a + bTL	0.5225	0.83	0.1066,0.9383	0.8250,0.8446	0.999***	0.998
HL = a + Btl	2.61	0.117	2.29,2.94	0.1095,0.1250	0.963***	0.928
BD = a + Btl	-0.3492	0.2782	-0.7018,0.003	0.2698,0.2864	0.99***	0.98
BG = a + Btl	-0.689	0.5561	-1.3952,0.0159	0.5395,0.5727	0.99***	0.98
DFL = a + bTL	-0.5648	0.1474	-1.0678,-0.0618	0.1355,0.1592	0.946***	0.896
DFB = a + bTL	2.68	0.2918	1.6957,3.6665	0.2686,0.3150	0.947***	0.8985
PtFL = a + bTL	-0.1434	0.1156	-0.3493,0.0624	0.1108,0.1205	0.984***	0.9696
PtFB = a + bTL	0.2193	0.0283	0.1107,0.3280	0.0257,0.03083	0.934***	0.8724
PeFL= a + bTL	-0.558	0.1024	-1.0206,-0.0948	0.09146,0.1132	0.911***	0.8316
PeFB= a + bTL	-0.195	0.029	-0.3310,-0.0595	0.02554,0.03193	0.904***	0.819
AFL= a + Btl	-2.08	0.1759	-2.5922,-1.5585	0.16375,0.1880	0.959***	0.9213
AFB= a + Btl	-3.696	0.425	-4.0797,-3.3125	0.4156,0.4337	0.996***	0.992
CFW= a + bTL	-1.4389	0.2613	-2.3427,-0.5251	0.2399,0.2827	0.945***	0.8931
ED= a + Btl	-0.1206	0.028	-0.3047,0.064	0.0236,0.0322	0.699***	0.836

The relation of body weight with their different morphometrics parts revealed that all the parameters increased with an increase in wet body weight. The relationship among these showed highly significant positive correlations between the wet weight of the body and the length of all the external morphometrics parts (Table 2). As the b value is shown in Table (3), all studied parameters based on external morphometric noted a highly

significant correlation with a wet weight of the body. The regression coefficient values 'r' are shown in Tables (4 & 5).

Notably, the relation between total body length and different body variables displayed a highly significant positive correlation. Moreover, all of those factors of different body variables increased with the increase in total body length and showed positive relationship trend. In log total length with external morphometric study indicated a positive trend (Table 2). Analysis of regression between wet weight of body and other different morphometric body parameters increased with the increase in body weight and showed a positive correlation with body weight. In log analysis of body weight with different body parameters, all showed a positive correlation as shown in Tables (4 & 5).

Table 3: Descriptive regression and statistical parameter of log total length with different morphometric parameters for *Scomberoides commersonnianus.*

Correlation coefficient	Parameter relationship		95% CI of 'a'	95% CI Of 'b'	R	r^2
	a	b				
LogW = a +Log bTL	-1.365	2.5346	-1.4451,-1.2858	2.4846,2.5846	0.996***	0.9931
LogK = a +Log bTL	0.6345	-0.4654	0.5549,0.7141	-0.5154,-0.4154	0.9106***	0.8291
LogFL = a + LogbTL	-0.0083	0.9678	-0.0285,0.0119	0.9551,0.9804	0.998***	0.9969
LogSL = a + LogbTL	-0.0369	0.9786	-0.058,-0.0159	0.9653,0.9918	0.998***	0.9967
LogHL = a + Logb TL	-0.0604	0.5798	-0.1245,0.0037	0.5396,0.6200	0.959***	0.9209
LogBD = a + Logb TL	-0.6607	1.0559	-0.7096,-0.6119	1.0252,1.0866	0.992***	0.9852
LogBG = a + Logb TL	-0.3588	1.0553	-0.4077,-0.3098	1.0246,1.0861	0.992***	0.9851
LogDFL = a + Logb TL	-1.2769	1.2437	-1.4967,-1.0571	1.1058,1.3816	0.905***	0.8200
LogDFB = a + Logb TL	-0.1435	0.8121	-0.2959,0.0091	0.7164,0.9078	0.895***	0.8014
LogPtFL = a + Logb TL	-1.0132	1.03820	-1.0694,0.9569	1.0029,1.0735	0.989***	0.9798
LogPtFB = a + Logb TL	-1.2153	0.8402	-1.3557,-1.0749	0.7521,0.9284	0.914***	0.8358
LogPeFL= a + Logb TL	-1.7994	1.4443	-2.3430,-1.2559	1.1032,1.7854	0.707***	0.5001
LogPeFB= a + Logb TL	-2.0233	1.2413	-2.2444,-1.8021	1.1026,1.3801	0.904***	0.8176
LogAFL= a + Logb TL	-2.2300	1.8037	-2.5704,-1.8895	1.5901,2.0174	0.894***	0.7996
LogAFB= a + Logb TL	-1.1148	1.3899	-1.1638,-1.0659	1.3592,1.4207	0.995***	0.9913
LogCFW= a + Logb TL	-1.2516	1.3643	-1.6558,-0.8473	1.1107,1.6180	0.786***	0.6183
LogED= a + Logb TL	-1.6293	1.0073	-1.9020,-1.3566	0.8361,1.1784	0.812***	0.6599

Table 4: Descriptive regression and statistical parameter of body weight with different morphometric parameters for *Scomberoides commersonnianus*.

Correlation coefficient	Parameter relationship		95% CI of 'a'	95% CI Of 'b'	R	r^2
	a	b				
TL= a + BW	20.0083	0.0342	18.9032,21.1134	0.0327,0.0358	0.981***	0.9631
K = a + Bw	1.0248	-0.0003	0.9836,1.0660	-0.0004,-0.0003	0.828***	0.6864
FL = a + Bw	17.7572	0.0292	16.8586,16.6559	0.0279,0.0305	0.983***	0.9662
SL = a + bW	17.1945	0.0286	16.2851,18.1039	0.0273,0.0300	0.982***	0.9642
HL = a + Bw	4.9003	0.0041	4.7259,5.0747	0.0039,0.0044	0.968***	0.9379
BD = a + Bw	5.2346	0.0095	4.8461,5.6232	0.0090,0.0101	0.970***	0.9419
BG = a + Bw	10.4741	0.0190	9.6973,11.2509	0.0179,0.0201	0.970***	0.9419
DFL = a + bW	2.3973	0.0050	2.0577,2.7369	0.0046,0.0055	0.925***	0.8561
DFB = a + Bw	8.4395	0.0101	7.8479,9.0311	0.0092,0.0110	0.942***	0.8883
PtFL = a + Bw	2.1558	0.0040	1.9979,2.3136	0.0038,0.0042	0.972***	0.9454
PtFB = a + Bw	0.7859	0.0010	0.7158,0.8559	0.0009,0.0011	0.915***	0.8379
PeFL= a + Bw	1.4830	0.0035	1.1990,1.7671	0.0031,0.0039	0.898***	0.8064
PeFB= a + Bw	0.3630	0.0374	0.2885,0.4376	0.0009,0.0011	0.912***	0.8334
AFL= a + Bw	1.5016	0.0059	1.1068,1.8964	0.0054,0.0065	0.927***	0.8597
AFB= a + Bw	4.8290	0.0145	4.2767,5.3812	0.0137,0.0152	0.974***	0.9493
CFW= a + Bw	3.8070	0.0089	3.2039,4.4101	0.0081,0.0098	0.925***	0.8562
ED= a + Bw	0.4078	0.0010	0.3108,0.5049	0.0009,0.0011	0.862***	0.7445

Table 5: Descriptive regression and statistical parameter of log body weight with different morphometric parameters for *Scomberoides commersonnianus*.

Correlation coefficient	Parameter relationship		95% CI of 'a'	95% CI Of 'b'	R	r^2
	a	b				
LogTL = a + b LogW	0.5460	0.3918	0.5252,0.5667	0.3841,0.3996	0.996***	0.9931
LogK = a + b LogW	0.3621	-0.1754	0.3000,0.4243	-0.1986,-0.1523	0.873***	0.7623
LogFL = a + b LogW	0.5178	0.3800	0.4997,0.5361	0.3732,0.3868	0.997***	0.9944
LogSL = a + b LogW	0.4952	0.3842	0.4762,0.5143	0.3771,0.3913	0.996***	0.9940
LogHL = a + b LogW	0.2541	0.2280	0.2117,0.2964	0.2122,0.2438	0.959***	0.9210
LogBD = a + b LogW	-0.0891	0.4156	-0.1194,-0.0589	0.4043,0.4268	0.993***	0.9870
LogBG = a + b LogW	0.2126	0.4153	0.1822,0.2429	0.4040,0.4266	0.993***	0.9869
LogDFL = a + b LogW	-0.6003	0.4882	-0.7468,-0.4538	0.4336,0.5428	0.904***	0.8174
LogDFB = a + b LogW	0.2967	0.3194	0.1959,0.3976	0.2818,0.3569	0.895***	0.8018
LogPtFL = a + b LogW	-0.4498	0.4081	-0.4875,-0.4121	0.3940,0.4221	0.989***	0.9793
LogPtFB = a + b LogW	-0.7645	0.3322	-0.8548,-0.6742	0.2985,0.3658	0.919***	0.8452
LogPeFL= a + b LogW	-1.0081	0.5648	-1.3698,-0.6463	0.4300,0.6997	0.704***	0.4956
LogPeFB= a + b LogW	-1.3483	0.4874	-1.4956,-1.2011	0.4325,0.5423	0.903***	0.8155
LogAFL= a + b LogW	-1.2326	0.7020	-1.4669,-0.9983	0.6147,0.7893	0.885***	0.7835
LogAFB= a + b LogW	-0.3586	0.5455	-0.3967,-0.3206	0.5314,0.5598	0.994***	0.9881
LogCFW= a + b LogW	-0.4987	0.5316	-0.7702,-0.2272	0.4304,0.6328	0.779***	0.6072
LogED= a + b LogW	-1.0822	0.3957	-1.2630,-0.9014	0.3283,0.4631	0.811***	0.6589

DISCUSSION

Morphometric analysis is a basic tool to study growth, ontogeny, variation, demographic characteristics, and the taxonomy of different fishes **(Kov & Copp, 1999)**. Analysis based on morphometric character played an important role in the estimation of the relationship between different body parts **(Carpenter *et al*., 1996)**.

Correlation values among the aforementioned different parts indicate that all relations of total length of body with its standard length, head width, and length, body girth, diameter of body, dorsal, pectoral, pelvic, eye diameter, anal fin length, caudal fin width and length showed highly significant correlation. Thus, all the relations with length were significantly correlated among these parameters. In this study, the highly significant correlation for body length with other parameters coincides with studies conducted on *O. mossambicus* fish **(Naeem *et al*., 2011a)**, *T. putitora* **(Naeem *et al*., 2011b)** and on *T. macrolepis* **(Pervaiz *et al*., 2012)**.

The result of length-weight relation showing estimation of 'b' value was found to be in normal range (2.5-3.5), and concurs with that of **Carlander (1969)** and **Froese (2006)**. Analysis of regression coefficient between the weight of the body and its total length helps to understand the growth pattern of fish. Fish shows an ideal value of growth having 'b' value ranging from 2 to 4. If b found was 3 values below or above, a negative or positive allometric growth is hence indicated. Positive allometric growth in case of b>3 fish becomes more in weght with an increase in the size of fish, while negative allometric growth in case of b<3 indicates that fish becomes lighter with increase in body length **Tesch (1968)**. The values of b for length-weight relation in the study was found in usual ranges (from 2.5 to 3.5); a result that is similar to that of **Carlander (1969).** In the current study, the value of b (2.53) showed an allometric growth pattern. It is noteworthy mentioning that, this variation in 'b' value is influenced by various factor such as health, breed, sex, salinity, seasons, maturity, geography, pH, biological factors, dissolved oxygen and time of year **(Bagenal & Tesch, 1978; Muchlisin *et al*., 2010)** and food availability **(Ishtiaq & Naeem, 2016)**. The variation in b value of the same or different species may be related to its sex **(Hile & Jobes, 1940)** and its feeding habit **(LeCren, 1951)**. Additionally, it may also be related to the maturity state of fish **(Frost, 1945)** among the different species in the population **(Jhingran, 1968).**

The results of the present study would be helpful for ichthyologists to compare morphometric relationships of *Scomberoides commersonnianus.*

CONCLUSION

Seventy three samples of *Scomberoides commersonnianus* of different body size with ranges 20.5 to 56.9 cm were collected from Karachi and used for examination of some morphometrics characaters. Condition factor showed highly significant correlation with all parameters, in relation to increase in body weight and total length. A highly significant

positive correlation was found between body weight and condition factor, while a non-significant relation was found in total length and condition factor.

AUTHORS CONTRIBUTION

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REFERENCES

Bagenal, T.B. and Tesch, F.W. (1978). "Age and growth In: Methods for assessment of fish production in fresh waters". 3rd Edition, (ed. T. Bagenal), IBP Handbook 136.–No. 3, Blackwell, Oxford.pp. 101.

Carpenter, K.E.; Sommer Iii, H.J. and Marcus, L.F. (1996). Converting truss interlandmark distances to Cartesian coordinates Advances in Morphometrics Springer. pp. 103-111.

Carlander, K.D. (1969). Handbook of freshwater fishery biology.The lowa State Uni. Press, Ames. IA. 1:752.

Froese, R. (2006). Cube law, condition factor and weight length relationship: history, meta-analysis and recommendations. J. Appl. Ichthyol., 22: 241-253.

Frost, W.E. (1945). The age and growth of eels. (*Angulla angulla*) from the Windermere Catchment area. Part 2. J. Anim. Ecol., 4: 106-124.

Hile, R.and Jobes, F.W. (1940). Age, growth and production of the yellow perch ,*Percaflavescens* (Mitchill) of Saginaw Bay. Trans. Am. Fish. Soc., 70:102-122.

International Game Fish Association. (2001). Database of IGFA angling records until 2001.IGFA, Fort Lauderdale, USA. URL: http://www.fishbase.org.

Ishtiaq, A. and Naeem, M. (2016). Length weight relationships and condition factor for farmed *Catla catla* (Hamilton, 1822) from southern Punjab, Pakistan. Punjab Univ. J. Zool., 31(2): 209-214.

Jhingran, V.G. (1968). Synopsis onbiological data on *Catla catla* (Ham.,1822), FAO Fish synops. 32:1.

Kov, V. and Copp, G.H. (1999). Morphometry of the stone loach *Barbatula barbatula* (L). Do metric characters reflect the species life history thresholds. Environ. 115. Biol. Fish., 56: 105

Lecren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol., 20(2): 201-219

Mir, J.I.; Sarkar, U.K.; Dwivedi, A.K.; Gusain, O.P. and Jena, J.K. (2013). Stock structure analysis of *Labeo rohita* (H amilton, 1822) across the Ganga basin (India) using a truss network system. J. Appl. Ichthyol., 29(5): 1097-1103.

Muchlisin, Z.A.; Musman, M. and SitiAzizah, M.N. (2010). Length weight relationships and condition factors of two threatened fishes, Rasboratawarensis and Poropuntiustawarensis, endemic to Lake LautTawar, Aceh Province, Indonesia. J. Appl. Ichthyol., 26: 949-953.

Naeem, M.; Salam, A.; Baby, R.; Ali, M.; Ishtiaq, A. and Ashraf, M. (2011a). Length–Weight relationship of female population of farmed *Oreochromis mossambicus* in relation to body size and condition factor from Pakistan. International Conference on Bioscience, Biochemistry and Bioinformatics (ICBBB 2011), 26-28, February, 2011, Singapore. pp.360-363.

Naeem, M.; Salam, A.; Ashraf, M.; Khalid, A. and Ishtiaq, A. (2011b). External morphometric study of hatchery reared mahseer (*Tor putitora*) in relation to body size and condition factor, Afr. J. Biotechnol., 10(36): 7071-7077.

Panhwar, S.K.; Qamar, N. and Jahangir, S. (2014). Fishery and stock estimates of Talangqueenfish, *Scomberoides commersonnianus* (Fam: Carangidae) from the Arabian sea coast of Pakistan. Pak. J. Agric. Sci., *51*(4): 1011-1016.

Pervaiz, K.; Iqbal, Z.; Mirza, M.R.; Javed, M.A.; Naeem, M. and Ishtiaq, A. (2012). Length-weight and length-length relationships for wild Indus Mahseer, Tor macrolepis, from Attock, Pakistan, J. Appl. Ichthyol., 28(4): 673-676.

Smith-Vaniz, W.F. (1984). FishBase. World wide web electronic publication. URL: http://www.fishbase.org

Webster, M. (2006). Introduction to Geometric Morphometrics.Department of the Geophysical Sciences, Univ. Chicago.

Zar, J.H. (1984). Biostatistical analysis.2nd edition. Prentice-Hall, Englewood Cliffs, New Jersey, 130pp.