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Biometric analysis of brushtooth lizard fish *Saurida undosquamis* (Richardson, 1848) from Mumbai waters

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Abstract

The aim of the present study was to investigate the relationship between various morphometric measurements and meristic counts, and to establish the length-weight relationships (LWRs) and length-length relationships (LLRs) of Saurida *undosquamis* based on specimens collected from New Ferry Wharf landing centre of Mumbai coast during September 2013 to June 2015. The morphometric variables for the species under study exhibited high level of correlation with each other. Based on present study results, the fin formula of *S. undosquamis* in Mumbai water can be written as $B_{13\text{-}15}$, $D_{11\text{-}13}$, $P_{13\text{-}15}$, V_9, $A_{10\text{-}11}$, $C_{18\text{-}20}$, $L_{47\text{-}53}$. Different values of regression coefficient (b) and correlation coefficient (r) in LLRs illustrates that different organ grows differently. The values of the regression coefficient *b* in the LWRs equations ($W = aL^b$) were 2.90, 3.04 and 2.99 for male, female and pooled individuals respectively indicating an isometric growth with high correlation coefficient (r^2). These parameters are useful for evaluating the relative condition of fish as well as for subsequent biological and population based studies.

Keywords: *Saurida undosquamis*, morphometric measurement, meristic counts, Length-weight relationships, length-length relationships

1. Introduction

The correct identification of fishes was an essential pre- requisite in the study of biology, fishery and distribution of the concerned species [1]. Morphometric and meristic parameters are the primary source of information for distinguishing the species taxonomically. These features have been widely used to separate different morphotypes and to identify different stock units [2, 3, 4]. Nevertheless, phenotypic markers are more suitable for studying short-term environmentally induced variation, which is perhaps most suitable for fisheries management [5]. Relationships between different morphometric measurements can also provide a useful conversion factor [6]. Similarly, length-weight relationships of fishes are considered as an important tool for understanding fish growth and it allows the estimation of the average weight of fish of a length group by applying mathematical relationship of fishes where it poses practical difficulty in weighing the fish mostly during field surveys and onboard vessel [7]. Inter-conversions of these two variables are required for estimating standing stock, yield, biomass of fish populations which is essential for formulating management plan [8]. Moreover, the length weight relationships are also helpful in comparing growth condition of different stock units [9] as well as different species under same taxon [10, 11].

Globally the family Synodontidae comprises of 57 species under four genera [12] and these species were reported from east coast of Africa, Madagascar and Red Sea coast, Pakistan, India, Srilanka, Maldives, Thailand, Philippines, China, Korea and Japan [13]. Of the total 13 species under genus *Saurida* reported from the Indo- Pacific region, nine species are known to occur in the Indian waters [14, 15, 16, 17, 18, 19]. These demersal resources are considered as supporting fishery and having a very good demand in the fresh and as well as dry condition due to its good meat quality and high nutritive value. In Mumbai, lizardfishes are locally known as chor bombil and the fishery is dominated by three species viz. *Saurida tumbil, S. undosquamis,* and S. *gracilis. S. undosquamis,* commonly known as brushtooth lizardfish inhabits in muddy bottoms of continental shelf down to about 100 m deep [20]. Even though few studies have already conducted on morphometric, meristic and length-weight relationship

S. undosquamis [1, 16, 21, 22, 23], but there is no report on morphological and meristic characters of this species from Mumbai waters. Therefore, the present study was an attempt to investigate the relationship that exists between various morphometric measurements and meristic counts and to establish the length-weight relationships (LWRs) for the species under study collected from Mumbai waters, India.

2. Materials and Methods

During the present study, specimens were collected on weekly basis from commercial trawl catches at New ferry wharf landing centre (18^0 57′30″N, 72051′02″E) of Mumbai coast during September 2013 to June 2015. All the morphometric measurements and meristic counts were recorded according to the method given by Hubbs and Lagler [24]. The morphometric measurements were measured using a digital Vernier calliper with 0.1 cm accuracy and measurements over 300 mm were measured using fish measuring board and scale. Total body weight (TW) was determined by an electronic weighing balance with 0.1 g accuracy for each species. The morphometric characters measured were total length (TL), standard length (SL), head length (HL), pre-adipose fin length (PADL),pre-dorsal length (PDL), pre-pectoral length (PPL), pre-ventral length (PVL), pre-anal length (PAL), Body depth (BD), caudal length (CL), caudal width (CW), pectoral length (PL), ventral length (VL), Head height (HH), adipose fin height (ADH),dorsal height (DH), anal height (AH), head depth (HD), eye diameter (ED), inter-orbital width (IOW), vertical mouth opening length (M_V) and horizontal mouth opening length (M_H). Pair wise linear regression of log-transformed morphometric variables with log-transformed standard length and head length were also carried out and regression coefficient was assessed for studying allometric growth pattern of the variables under study. Meristic counts studied in the present investigation include number in dorsal, pectoral, ventral, anal, caudal fin rays, branchiostegal rays and lateral line scale.

Length-weight relationships (LWRs) were calculated for males, females and pooled individuals separately using the equation, $TW = aTL^b$ given by Le Cren [25] and the relationship was also expressed in the logarithmic form as: Log TW = Log a + b LogTL, where TW = total weight of fish in g, TL =Total length of fish in cm, "a" and "b" are intercept and regression coefficient, respectively. The coefficient of correlation "r" was estimated in order to know the relationship between these two variables. The analysis of covariance (ANCOVA) was carried out in order to test the difference between the slopes of the regression lines of males and females at 1% and 5% level of significance, following the method described by Snedecor and Cochran [26]. A student t-test was performed to test deviation of "b" value from that of "3". t = (b-3)/Sb, where, Sb= Standard error of 'b' = and Sb = √ (1/(n-2))*[(Sy/Sx)2-b2], where Sx and Sy are the standard deviations of x and y respectively. The calculated t-value was compared with t-table value for (n-2) degrees of freedom at 5% and 1% level of significance. All the above mentoned statistical analysis were carried out by using MS-Excel.

3. Results and Discussion

3.1 Morphometric and Meristic

In the present study, 280 specimens were examined for morphometric and meristic study. Descriptive statistics of twentyone morphometric variables such as range, mean, median, standard error, standard deviation and co-efficient of variation are presented in table 1. Highest coefficients of variation (CV) were observed for body depth (31.005%) while lowest for vertical mouth opening length (14.63%). A Pearson correlation matrix for 21 morphometric variables showed significant correlation between these variables with highest observed correlation among SL, TL, PADL, PDL, PPL, PVL, PAL, HL (r > 0.9) while CL and VJL were found to be least correlated with other morphometric variables. Likewise growth in M_H, HH, IOW,ED in relation to per unit change in head length were faster than vertical mouth opening length (M_V).Moreover M_V was less correlated with all other morphometric variables.

The morphometric variables for the species under study showed a very wide range as, coefficients of variation (CV) was high for most variables. It indicates samples in the present study were fully representative of all size groups. However ED is showing significant correlation with total length (r=0.78) as well as with head length(r=0.78) which revealed that eye diameter increases with increasing in length in *S. undosquamis*. According to Fernald, in most of the teleost fishes, the eyes continue to grow throughout the life without any obvious changes in visual capability which is found to be agreement with present study [27].

Table 1: Statistical estimates of various morphometric characters in *S. undsquamis*

Morphometric characters	Range (mm)		Mean (mm)	Standard error	Standard deviation	Coefficient of variation (%)
	Min.	Max.				
Total Length	128	310	185.29	1.97	32.72	17.66
Standard Length	109	267	159.86	1.74	28.95	18.11
Head Length	24.7	68.5	38.57	0.44	7.44	19.29
Pre adipose fin Length	45	115	67.37	0.77	12.75	18.93
Pre- dorsal Length	88	212	125.48	1.38	22.94	18.28
Pre-pectoral Length	22	68	40.25	0.46	7.74	19.23
Pre-Ventral Length	42	100	60.39	0.67	11.21	18.56
Pre Anal Length	82	195	117.98	1.25	20.86	17.68
Caudal Length	3.3	15.9	6.64	0.09	1.57	23.66
Head height	10	32.2	14.83	0.20	3.38	22.79
Body depth	12.1	67	20.15	0.37	6.25	31.00
Caudal width	6.1	22.1	9.43	0.11	1.94	20.53
Pectoral length	11.5	40.8	24.04	0.27	4.48	18.66
Ventral length	13.2	47.6	26.71	0.27734	4.61	17.25
Adipose fin height	13.9	68.9	32.56	0.38	6.30	19.36
Dorsal height	2.8	12.2	5.73	0.08	1.42	24.75
Anal fin height	10.2	27.6	16.14	0.16744	2.78	17.23
Eye diameter	4.5	10.5	6.57	0.06	1.09	16.53

Inter orbital length	4.4	15	7.91	0.13	2.25	28.43
Vertical mouth opening	19	38.2	27.81	0.24	4.072	14.64
Horizontal mouth opening	19	50.3	26.86	0.29	4.88	18.18

The descriptive Statistics *viz*. minimum, maximum, mode, frequency for all the seven meristic traits are presented in Table 2 which revealed that *S. undosquamis* possess 11-13 dorsal fin rays, 13-15 pectoral fin rays,10-11 anal fin rays,18-20 caudal fin rays,13-15 branchiostegal rays and 47-53 scales on lateral line, while pelvic fin ray (9) remain constant in all individuals. Based on present study, the fin formula of *S. undosquamis* in Mumbai water can be written as B $_{13-15}$, D $_{11-13}$, P $_{13-15}$, V $_{9}$, A $_{10-11}$, C$_{18-20}$, L $_{47-53}$. A comparison of meristic characters of *S. undosquamis* with findings of earlier workers is presented in Table 3. Though most of the characters can be compared with that of earlier studies, the only difference is the presence of 13 pectoral fin rays and 18 to caudal fin rays. Pectoral fin rays ranged from 13-15 in the present study while it was reported as 14-15 by earlier studies [14, 16, 28, 29]. However, only in 3 specimens pectoral fin rays were counted as 13. Likewise caudal fin rays varied from 18-20 while it was reported as 19 in earlier studies by Day [14]. Nevertheless, most of the meristic counts are coming within range of earlier reports. The meristic counts were more robust than their other morphometric counterparts as the meristic characters get fixed at the time of embryonic stage [30].

Table 3: Statistical estimates of various meristic characters of *S. undsquamis*

Meristic	N	Median	Mode	Freq. of mode	Range	
					Min.	Max.
Dorsal fin rays	280	12	12	235	11	13
Anal fin rays	280	11	11	166	10	11
Pectoral fin rays	280	14	14	190	13	15
Pelvic fin rays	280	9	9	280	9	9
Caudal fin rays	280	19	19	230	18	20
Branchiostegal rays	280	14	13	223	13	15
Lat. Line scale	280	50	48	160	47	53

Table 4: Comparison of Meristic characters of *S. undosquamis* with earlier reports.

Authors	Dorsal fin rays	Anal Fin rays	Pectoral fin rays	Pelvic Fin rays	Caudal fin rays	Branchiostgal Rays	Lat. Line scale
FAO [28]	11-12	-	14-15	9			45-52
Rao [16]	11-13	10-13	14-15			14-15	46-49
Talwar and Kacker [29]	11-13	10-13	14-15	9		13-16	
Day [14]	11-13	10-11	14-15	9	19		53-64
Muthiah [22]	10-12	-	13-15	13-15		14-15	44-50
Present Study	11-13	10-11	13-15	9	18-20	13-15	47-53

3.2 Length-length relationships (LLRs)

Length-length relationships (LLRs) by pair wise linear regression of log transformed morphometric measurements (Y variable) against the log transformed SL (X variable) showed a regression coefficient *b* value of near unity for TL, HL, PADL, PDL, PPL, PVL, PAL, PAL, ADH, DH, PL, PL, CW, PAL, AH clearly indicating the isometric growth of these variables in relation to standard length, whereas a lower value of *b* was observed for PL(0.89), CL(0.67) and PAL(0.77) revealing negative allometric growth. Similarly, higher value of *b* was observed for BD (1.26) showing positive allometry with standard length (Table 2). Likewise, log transformed measurements of head region (Y variable) *viz.* HD,IOW,ED,M_V, M_H when regressed against the log transformed HL (X variable) showed a regression coefficient *b* value of near unity for HH while a lower value of *b* was observed for ED, VJO, HJO and a higher value of *b* was observed for IOW. It clearly indicates the isometric growth of HH in relation to head length while others shows allometric growth. High correlation coefficient (>0.9) was observed for TL, PDL, PADL, PVL and PAL while lowest was for CL (R^2=0.29).

The result of LLRs reveals simple log linear relationship between variables. Length–length relationship (LLR) is very important for fisheries management and for comparative studies of population growth [31]. An established log-linear relationship between standard length and other morphometric variables can give good conversion factors for all variables. The regression coefficient (b) reveals high degree of homogeneity within the population. Beside this, Different regression coefficient (b) and correlation coefficient (r) illustrates that different organ grows differently. So far, few studies has been done on the relationship between mouth openings and body length of marine fishes. In the present study, the direct relationship between mouth opening (both M_V, M_H) and head length as well as between mouth opening (both M_V, M_H) and standard length indicates that different sizes of *S. undosquamis* may feed on all different sizes of prey items nearby according to its own body size. Similar findings were for observed for goatfish *Parupeneus barberinus* in which a log-linear relationship was described by Lukoschek & McCormick between both vertical mouth opening and horizontal mouth opening with total length [32]. Moreover, total length was also found to have linear relation with vertical mouth opening for John dory *Zeus faber* [33]. However, comparing various aspects of prey morphology with predator size can give a better insight into probability and efficiency of different prey items for *S. undosquamis* of particular size.

Table 3: Length–length relationships for *S. undosquamis* from Mumbai waters

Equation	Regression parameters		95% Cl of *a*	95% Cl of *b*	r^2
	a	b			
LogTL = a + b × LogSL	0.30	0.97	0.24 to 0.367	0.96 to 0.98	0.99
LogHL = a + b × LogSL	-1.45	1.01	-1.65 to -1.25	0.96 to1.04	0.90
LogPADL = a + b × LogSL	-1.00	1.027	-1.12 to -0.88	1.00 to 1.05	0.96
LogPDL = a + b × LogSL	-0.21	0.99	-0.30 to -0.13	0.98 to 1.01	0.98
LogPPL = a + b × LogSL	-1.45	1.01	0.97 to 1.057	0.97 to 1.05	0.88
LogPVL = a + b × LogSL	0.97	0.99	-1.14 to -0.80	0.96 to 1.03	0.93
LogPAL = a + b × LogSL	0.14	0.97	0.24 to -0.05	0.95 to 0.99	0.97
LogCL = a + b × LogSL	-1.55	0.67	-2.191 to 0.92	0.55 to 0.80	0.29
LogHH = a + b × LogHL	-0.79	0.95	-1.02 to -0.55	0.89 to-1.02	0.76
LogMBD = a + b × LogSL	-3.45	1.26	-4.01 to 2.90	1.16 to 1.38	0.65
LogCW = a + b × LogSL	2.71	0.98	-2.98 to -2.44	0.92 to 1.03	0.83
LogPL = a + b × LogSL	-1.37	0.90	-1.76 to 0.98	0.82 to 0.97	0.65
LogVL = a + b × LogSL	-0.77	0.80	-1.101 to 0.45	0.74 to 0.86	0.69
LogADH = a + b × LogSL	-1.18	0.92	-1.51 to 0.85	0.85 to 0.98	0.74
LogDH = a + b × LogSL	-3.13	0.95	-3.73 to -2.54	0.84 to 1.08	0.48
LogAH = a + b × LogSL	-1.99	0.93	-2.31 to -1.66	0.86 to 0.91	0.75
LogM_V = a + b × LogSL	0.77	0.50	0.36 to 1.18	0.42 to 0.58	0.35
Log M_H = a + b × LogSL	1.52	0.55	1.27 to 1.77	0.46 to 0.62	0.41
LogED = a + b × LogHL	0.58	0.67	-0.82 to -0.36	0.61 to 0.740	0.61
LogIOW = a + b × LogHL	-2.66	1.29	-2.98 to -2.35	1.20 to -1.38	0.76
LogM_V = a + b × LogHL	1.55	0.48	1.28 to 1.83	0.41 to 0.56	0.37
Log M_H = a + b × LogHL	0.15	0.86	-0.01 to -0.31	0.82 to 0.90	0.85

3.2 Length-weight relationships (LWRs)

Altogether 472 specimens in size range (12.8-31 cm TL, 12 - 214 g TW) were analysed for studying length-weight relationships (LWRs) of *S. undosquamis* collected from Mumbai waters, north-west coast of India. The length-weight relationship equation is based on 153 males (in the length range of 13.5 to 26.6 cm and weight 14 to 117g) and 319 females in length range of12.8 to 31 mm and weight range of 12 to 214 g. The relationships between total length (TL) and total weight (TW) for *S. undosquamis* can be expressed as follows: $TW=0.005748*TL^{3.04}$ for female and $TW = 0.0084*TL^{2.90}$ for male. The same relationship can be represented in logarithmic form such as Log TW = -5.15+3.04 Log TL (R^2 = 0.92047) for Female and Log TW = -4.74 + 2.90 Log TL (R^2 = 0.8492) for Male. Since the analysis of covariance did not show significant difference (at 1 % and 5% levels) between sexes, a combined relationship was considered for *S. undosquamis* in Mumbai water as : $W=0.006576*L^{2.99}$ as well as in logarithmic form as Log TW = - 5.0207 +2.9932 Log TL (R^2 = 0.9042). Scatter Plot of exponential relationship of *S. undosquamis* (male, female and pooled) is depicted in Fig. 1 (a, b and c). The calculated value of "t" for the student's t-test was not found to be significant at 1% and 5% level indicating isometric growth for *S. undosquamis*.

Table 5: Comparison of regression lines of length-weight relationship of males and females of *S. undosquamis* in Mumbai waters

Source	d.f.	ssx	ssy	spxy	Reg. coef	Deviations from regression				
						d.f.	S.S.	M.S	F	Prob
Within										
Males	152	2.74	27.39	7.95	2.90	151	4.33	0.029		
Females	318	7.21	72.34	21.92	3.039	317	5.71	0.018		
						468	10.04	0.021		
Pooled	470	9.95	99.74	29.87	3.00	469	10.08	0.021		
Difference between slopes						1	0.037	0.037	1.74	0.19
Total	471	10.51	104.34	31.47		470	10.089			
Between adjusted means						1	0.0086	0.0086	0.40	0.52

*F value is not significant at 1% level.

In the present study, the value of "b" (3.04, 2.90, and 2.99 for female, male and pooled sexes respectively) was found within the expected range of 2.5-3.5 described by Froese [9] and in all the cases the b values were very close to 3. Generally, the regression coefficient value, b=3 indicates that the fish grows symmetrically or isometrically otherwise it is allometric growth [9].The values of regression coefficient "b" in length weight relationships of *S. undosquamis*, reported by various authors from different parts of the world were compared in Table 6. It indicates that in most of the studies, estimated value of exponent (b) is very close to 3. The earlier investigations on the length-weight relationships (LWRs) of the species under study in Indian waters include those of Rao from Indian water [21], Muthiah from Karnataka waters [1], Rajkumar *et al*. from Visakhapatnam water [22] and Raje *et al*., from Mumbai water [23]. In the present study, the estimated value of regressionon coefficient (3.04, 2.90, 2.99 for female, male and pooled sexes respectively) can be compared with the findings of Rajkumar *et al*. [22] and Rao [21], while Muthiah estimated little higher value (b=3.306) [1]. Nevertheless they did not find any significance difference between the sexes in length weight relationship which is found to be agreement with present study. Raje *et al*., reported significant difference between sexes for *S. undosquamis* in Mumbai waters [23]

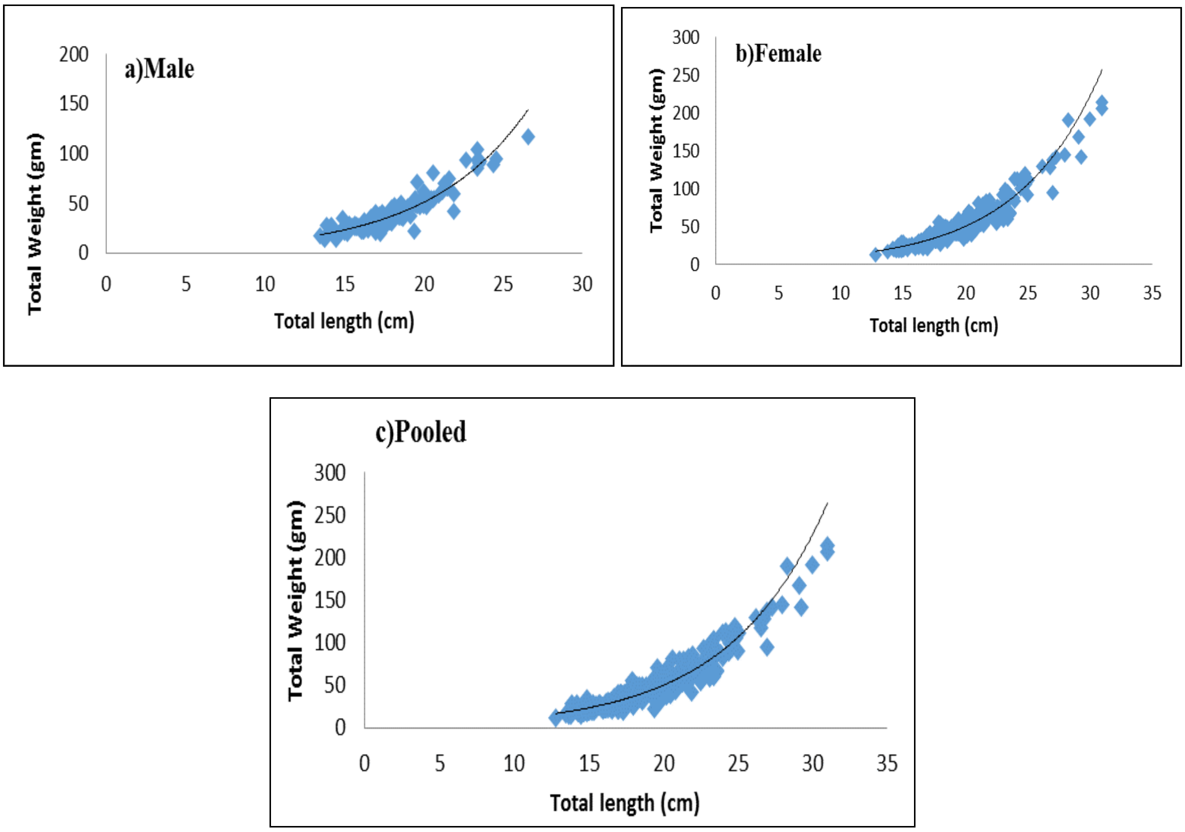

Fig 1: Power length-weight relationship of *S. undosquamis*

Table 4: Comparison of length-weight relationship of *S. undosquamis* with earlier reports

Authors		A	B
Rao [21]	India	0.0058	3.030
Ambak *et al.* [34]	South China Sea	0.0053	3.242
Muthiah [1]	Karnataka, India	0.0000013	3.306
Mater and Torcu [35]	Turkish coasts	0.383	2.617
Tureli and Erdem [36]	Turkish coasts	0.127	3.022
Can *et al.* [37]	South coast of Iskenderun Bay	0.0117	2.797
Abdallah [38]	Alexandria, Egypt	0.003	3.3
Rajkumar *et al.* [22]	Visakhapatnam, India	0.000003	3.102
Cicek *et al.* [39]	Turkish coasts	0.004	3.086
Sangun *et al.* [40]	Turkish coast	0.0039	3.159
Tevfik Ceyhan *et al.* [41]	Gokova Bay, Turkey	0.0046	3.109
Gokce *et al.* [42]	Iskenderun Bay, Turkey	0.01	2.8
Wang *et al.* [43]	Beibu Gulf, NS China Sea	0.0097	3.05
Wang *et al.*[44]	Northern South China Sea	0.956	3.043
Kalhoro *et al.*[45]	Pakistan	0.008	3.00
Present study	Mumbai,India	0.006	2.99

Likewise value of slope "b" was compared with the findings in different localities other than India which indicates closely similarity with most of the studies [34, 36, 39, 40, 41, 43, 44, 45]. However, Mater and Torcu from Turkish coasts [35], Gokce *et al.*from Iskenderun Bay, Turkey [42], Can *et al.* from South coast of Iskenderun Bay [37] obtained lower value of "b" when compared to the present study. Geographical variation, in length weight relationship, has already been documented by earlier workers for different fishes [46, 47] and molluscs [48]. The small differences in length weight relationship of fish at different places may be because of geographical and ecological differences, seasonal fluctuations, environmental parameters and as well as sampling limitations such as physical conditions of the fish at the time of sample collection, sex gonad development and nutritive conditions, number of individuals examined in study, different observed length ranges during the study etc [9, 49, 50].

4. Conclusion

Studies on morphometry measurements and meristic counts can be used for comparative taxonomic study of family Synodontidae. The regression coefficient (b) in LLRs revealed high degree of homogeneity within the population and The regression coefficient (b) in LWRs indicated isometric growth pattern for the species *Saurida undosquamis* from Mumbai coast. Present study has provided baseline information on LLRs and LWRs analysis which could be useful for subsequent biological and population based studies on *Saurida undosquamis.*

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