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A Study on Length -Weight Relationships and Morphometric Characteristics of Fish Species Belonging to Three Different Families in Chennai Waters, India

KEYWORDS: length- weight relationships, Nemipterus jaopnicus, Upeneus vittatus, Pomadasys maculatus, morphometric and meristic characters.

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ABSTRACT *The present study was aimed to analyse the morphometric and meristic characters for three marine fishes namely Nemipterus japonicus, Upeneus vittatus and Pomadasys maculatus, collected from Chennai, East coast of India. A total of 1500 individuals, 500 for each family were sampled and analysed. Coefficient of determination (R2>0.8 at p <0.001) was recorded for all species indicating significant relationship between length and weight for all the three species. The length-weight relationship Y=aXb fitted to the data collected for the value of parameter 'b' for the 3 families range between 2.646 and 3.043. The pooled data on 14 morphometric and 2 meristic characters were analysed using Canonical discriminant analysis out of which 7 characters (HL (Head Length), BD (Body Depth), WDF (Width of Dorsal Fin), TL (Total Length), PDL (Post Dorsal Length), PDL (Post Dorsal Length), TW (Total Weight) and PPD (Pre Pelvic Distance)) were significantly different*

INTRODUCTION

Three distinct fishes representing 3 families namely *Nemipterus japonicus* (Bloch, 1791) Nemipteridae, *Upeneus vittatus* (Forsskal, 1775) Mullidae and *Pomadasys maculatus* (Bloch, 1793) Haemulidae (all under order Perciformes) were selected to undertake a comparative study on morphometric and meristic characters and, possible relationship thereof. These are commercially important demersal fish species found along the Indian Ocean in depths less than 200 meters. Though they represent different families with various physical shape properties, they are of commercial interest as food fish. Analyzing their morphological characters statistically would provide interesting insights on how the characters and related features change at different growth levels between species.

Length-Weight relationship (LWR) is an important tool in fishery biology (Garcia et al. 1989; Haimovici and Velasco, 2000). Variations in environmental conditions and genetic structure lead to morphological variations among different geographical populations. (Mamuris et al.1998). Morphometric characters are studied in fisheries biology to measure the discreteness and the relationship across various taxonomic categories. There has been a lot of evidence for stock discreteness (Corti et al.1998; Bembo et al. 1996; Haddon and Willis, 1995; Turan, 2000). Keeping the significance of statistics in fishery biology, the present study was carried out to examine the extent of changes in morphomertric characters compared among 3 fish species belonging to 3 morphologically different families from the Chennai waters applying the multivariate technique.

MATERIAL AND METHODS

A total of 1500 fish, in which 500 belonging to each of the three families (Nemipteridae, Mullidae and Haemulidae) were collected randomly from the Kasimedu landing center, Chennai (geographical coordinates of latitude of 13° 5› 0» N and a longitude of 80° 17› 0» E.) from June 2012 to May 2013. Fishes were collected from a number of gears such as gill nets and trawl nets. Collected samples were transported to the laboratory in an ice box to prevent spoilage and then stored in a deep freezer of temperature -15° C. Once thawed, the data were obtained for all morphometric and meristic variables using appropriate tools. LWR was estimated using the equation $W= aL^b$ (Ricker, 1973). The values of constant 'a' and 'b' were estimated from the log transformed values of length and weight based on least square method (Sokal and Rohlf, 1981). All data on LWR of the three different fish species were subjected to t-test analysis and verified to detect the declivity of regression indicating the type of growth *viz.* isomertic (b =3.0), positive allometric (b>3.0) or negative allometric (b<3.0) (Spiegel 1991). Multivariate techniques can be used to exhibit the pattern of differences among samples that simultaneously consider the variation in several characters and thereby, assess the similarities between three species. For our study we used discriminant function analysis (DFA) to combine a selection of body measures in a single classification group. Discriminant analysis (DA) is different from the cluster analysis because prior knowledge of the classes, usually in the form of a sample from each class, is required. The common objectives of DA are (i) to investigate differences between groups, (ii) to discriminate groups effectively, (iii) to identify important discriminating variables, and (iv)to classify new observations into pre-existing groups. Stepwise canonical and discriminant function analyses are commonly used DA techniques, available in the SAS (Statistical Analysis Software) systems STAT module (SAS Inst. Inc. 1999). A total of 16 morphometric and meristic variables namely, SL (Snout Length), ED (Eye Diameter), POL (Post Orbital Length), PDL (Post Dorsal Length), PPD (Pre Pelvic Distance), WDF (Width of Dorsal Fin), HL (Head Length), BD (Body Depth), STL (Standard Length), FL (Fork Length), CPL (Caudal Peduncle Length), PDL (Post Dorsal Length), TL (Total Length), TW (Total Weight), DLFmin (Dorsal Fin Spine minimum) and DLFmax (Dorsal Fin Spine maximum) are used here to demonstrate the features of discriminant analysis in classifying the 3 fish species into species groups.

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RESULTS

The length-weight relationships (LWR) for the three different species under consideration for growth study are summarized in Tables 1a, 1b,and 1c along with their respective power curves - Fig. 1a, 1b,and 1c. From the data collected, the minimum total-length (total-weight) of the three species *N. japonicus, U. vittatus* and *P. maculatus* were 10.5cm, 10.3cm and 11.2cm TL and 13.5 gm, 10.53 gm and 24.77gm minimum total weight respectively. The respective maximum total-length and total-weight observed were 32 cm, 20.3cm, 21.3cm and 264.3gm, 155.37gm, and 161.47gm. The growth parameter 'b' of LWR varied between 2.646 and 3.043. All species considered for the study exhibited only allometric growth type (b<3, b>3). The student's t-test (p<0.001) employed revealed that 'b' was significantly lower than the theoretical value of 3 indicating negative allometric growth. Length increases but no increase in body weight for *N. japonicus*, while the t-test for *U. vittatus* and *P. maculatus* reveals that 'b' was significantly higher indicating positive allometric growth, depicting increase of both length and weight. This observation reveals that length-weight relationship of *N. japonicus* is slightly lower than other two species in terms of growth. The overall growth parameter values were positive and highly correlated with $R^2>0.8$ between fish total-length and total-weight measurements. The correlogram plotted (Fig.2a,2b, and 2c) illustrates only significant values (p <0.001) while insignificant values are left as blank. This points out that morphometric characters of the three species considered have high correlation with Standard Length (STL) and Fork Length (FL). The length subset of other parameters studied were Pre Pelvic Distance (PPD), Post Dorsal Length (PDL) and Head Length (HL) and these parameters had a positive correlation among two species only namely *N. japonicus* and *P. maculatus*. Basically, these fishes have close body shapes but differ in their meristic characteristics. While *N. japonicus* can grow up to 35 cm in length, *P. maculatus* can grow double the size (75 cm). *U. vittatus* is a smaller perciform fish that can grow up to 25 cm TL with varied mersitic and morphometric characters in comparison to the other 2 species.

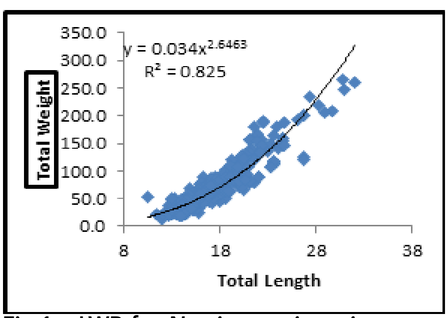

Fig.1a: LWR for *Nemipterus japonicus*

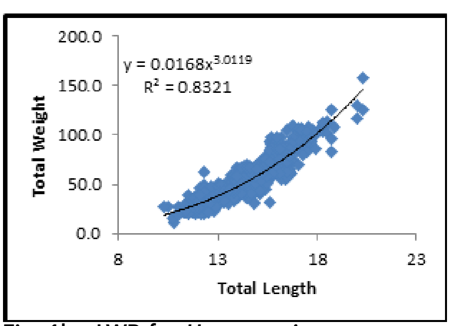

Fig. 1b: LWR for *Upeneus vittatus*

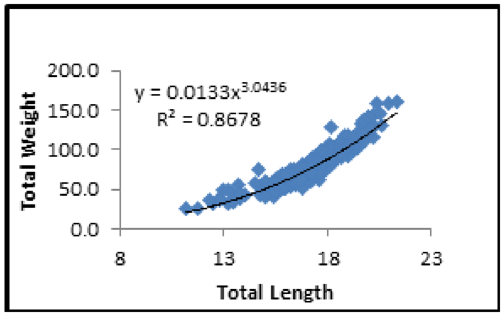

Fig.1c: LWR for *Pomadasys maculatus*

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate	95% Confidence Limits	
Intercept	1	-3.38276	0.15364	-22.02	<.0001	0	-3.68462	-3.08090
LN_TL	1	2.64632	0.05462	48.45	<.0001	0.90830	2.53902	2.75362

Table 1a: Growth parameters for *Nemipterus japonicus*

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate	95% Confidence Limits	
Intercept	1	-4.08595	0.16132	-25.33	<.0001	0	-4.40291	-3.76899
LN_TL	1	3.01188	0.06063	49.68	<.0001	0.91218	2.89276	3.13101

Table 1b: Growth parameters for *Upeneus vittatus*

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate	95% Confidence Limits	
Intercept	1	-4.32108	0.15102	-28.61	<.0001	0	-4.61780	-4.02437
LN_TL	1	3.04356	0.05324	57.16	<.0001	0.93153	2.93895	3.14817

Table 1c: Growth parameters for *Pomadasys maculatus*

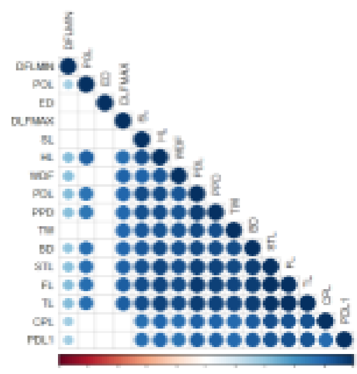

Fig2b: Correlation of morphometric and meristic characters for *Nemipterus*

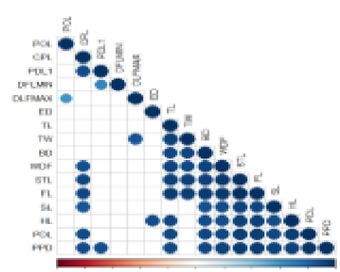

Fig 2a: Correlation of morphometric and meristic characters for *Upeneus*

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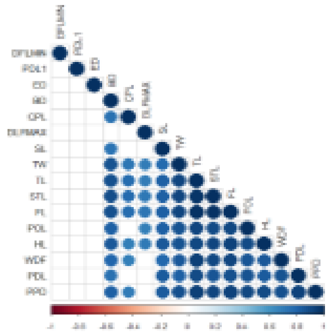

Fig2c: Correlation of morphometric and meristic characters for *Pomadasys*

Multivariate Statistics and F Approximations					
S=2 M=2 N=744.5					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.00483508	2850.22	14	2982	<.0001
Pillai's Trace	1.78620776	1780.78	14	2984	<.0001
Hotelling-Lawley Trace	42.21687649	4493.84	14	2382.2	<.0001
Roy's Greatest Root	37.90014246	8078.14	7	1492	<.0001
NOTE: F Statistic for Roy's Greatest Root is an upper bound.					
NOTE: F Statistic for Wilks' Lambda is exact.					

Table 2. Multivariate Analysis

Wilks' Lambda test is considered here to test and to identify which variable contributes significantly in discriminat function.Table (2) also provides an F- statistic to test the significance of Wilk's Lambda. If the p-value in case is less than 0.0001, we can conclude that the corresponding variable elucidates the particular group will be good.

The discriminating power of DA was adopted for analysis of morphometric and meristic data for the three different species. This was carried out in order to identify the combinations and to determine the variable,which discriminate between two or more naturally occurring groups. The discriminant analysis of the data for the fish groups were highly significant ($p < 0.001$). As per the discriminant analysis, out of 16 morphometric characters, seven are sufficient to discriminate the growth aspect of the three distinct species considered *viz.* HL (Head Length), BD (Body Depth), WDF (Width of Dorsal Fin), TL (Total Length), PDL (Post Dorsal Length), TW (Total Weight), and PPD (Pre Pelvic Distance). Following this, Canonical discriminant analysis was performed on the seven variables and the results are provided in Table. 3. The plot in Fig(3) between first and second total canonical scores indicates the morphometric discrimination of samples of the three different populations and the canonical axes are loaded with the seven parameter values of the fishes. In two dimensions, first and second canonical axes clearly classify the three populations as being separate in their morphometric characters. The first and the second canonical axis explain 89.77% and 10.2% of the variation in the discriminating variables as seen in Table 3.

Canonical Discriminant Analysis

	[illegible]	[illegible]	[illegible]	[illegible]	Eigenvalue	Difference	Proportion	Cumulative	Likelihood Ratio	Approximate F Value	Num DF	Den DF	Pr > F
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	2982	<.0001
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<.0001

Table 3: Canonical Discriminant Analysis

The extracted canonical variable scores can be used to plot pairs of canonical variables in two-dimensional bi-plots (Fig.3) aiding visual interpretation for group differences. Interrelationships among the seven multi-attributes and the discriminations of the three species are presented in Table.4. The first canonical axis which has largest loadings on the seven variables discriminated all three species successfully. The second canonical axis which has moderate size loadings on HL, BD, PDL, TW and PPD discriminated (1) *N. japonicus*, (2) *U. vittatus* and (3) *P. maculatus* species groups moderately. The 3 species are highly different with respect to their individual morphometric characters, as seen by their non-overlapping clusters, but in species (2) and (3), fewer variables have close contact as observed from the plot in Fig. 3.

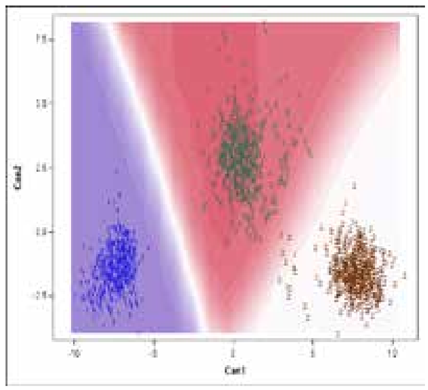

Fig 3: Canonical discriminant analysis - three species (1 *N. japonicus*, 2 *U. vittatus* and 3 *P. maculatus*

Canonical Discriminant Analysis

Total Canonical Structure		
Variable	Can1	Can2
HL	0.550867	-0.033446
BD	0.609607	-0.124583
WDF	0.961649	0.060882
TL	0.433313	0.202629
PDL	0.519011	-0.440530
TW1	0.293267	-0.016398
PPD	0.509046	-0.033771

Table 4: Canonical variate function for the concentration of seven variables in three species from Chennai coast.

DISCUSSION

This unique study is attempted to characterize the morphometric and meristic characters between three different commercially important demersal fish species from the Chennai waters, east coast of India. In most research, the morphometric analysis has been considered as a useful tool for separating the species, population or geographical variant. The condition factor of fish is strongly affected by both biotic and abiotic environmental factors (Saliu, 2001) while factors that may affect the differences in LWR of fish are the quality and quantity of food (Sparre and Venema, 1992), available in a geographical location. Other factors responsible for the differences in parameters of the length-weight relationships are temperature, salinity, food (quantity, quality and size), sex, time of year and stage of maturity (Pauly 1998) varying in seasons. The 'b' values depend on the shape and structure of the species primarily. According to Bagenal and Tesch (1978) and Goncalves et al., (1997), the parameter 'b' unlike the parameter 'a' may vary daily, seasonally and even between habitats. This parameter 'b' could be used to determine the status of the aquatic ecosystem in which the fish live, whether the ecosystem is in good condition or polluted (Luff & Bailey, 2000; Anene 2005). In this study, the morphometric characters on *N. japonicus* have negative allometric growth in length and weight relationships as compared to other two species namely *U. vittatus* and *P. maculatus*.

The work carried out by Edwin Prabakaran *et al*. (2014) on the LWR on *N. japonicus* resulted in higher degree of correlation for ten variables namely SL, PPD, WDF, HL, BD, STL, FL, PDL1, L and W. The study by Raeisi et al. (2012) and Kamaruddin et al. (2012) report on the Length-weights relationships of 3 dominant demersal fishes from Persian Gulf and Malaysia whereas, the spawning periods, sex ratio and length at first maturity were determined for 6 commercially important finfish in Oman by McIlwain et al. (2006). While some research work just focuses on the LWR studies, other research works target the biological parameters for growth. Both approaches are useful for stock assessment, population dynamics and sometimes even valuable to identify migrating populations. In the present study, a comparison between 3 species belonging to the order Perciformes under 3 families revealed allometric LWR for all the 3 species with a coefficient of determination as R^2> 0.80.

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