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Length Weight relationship of titan triggerfish *Balistoides viridescens* (Bloch and Schneider, 1801) (family: Balistidae) off Thoothukudi coast of Gulf of Mannar, Southeast coast of India (08° 53.6'N 78° 16'E and 08° 53.8'N 78° 32'E) – (36 m)

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Abstract
Length-Weight relationship was studied in Balistoides viridescens, for a period of two years from January 2011 to December 2012. The slope value (b) estimated for Balistoides viridescens of both sexes was found to be 1.0541. The slope value (b) estimated for Balistoides viridescens male was found to be 1.4070 and for female 1.2257. The regression equations calculated for female was Log W = -0.4394 + 1.2257 Log L, and for male Log W = -0.7044 + 1.4070. The correlations coefficient was found to be significant (P<0.01). It was found in tropical waters from about 08° 53.6'N 78° 16'E and 08° 53.8'N 78° 32'E /36 M from Thoothukudi fishing harbour, southeast coast of India. The significant difference between sexes of the species 'F' value was at the 1% level. The b value differed from the ideal cube law of '3' as is with the case of length-weight relationship studied in this species else-where. The slope value was compared here could be very useful for comparison with the balistids species in other geographical locations.

Keywords: *Balistoides viridescens*–length-weight relationship – regression analysis- Population dynamics

1. Introduction
The triggerfish family (Balistidae) is a highly modified and advance group of fish and is well represented throughout the world's ocean with approximately 11 genera and 40 species described [15]. The study of length-weight relationship of titan triggerfish of *Balistoides viridescens* (Bloch and Schneider, 1801) (Family: Balistidae) is having vital importance to fisheries biologists as it serves three purposes. The triggerfish family has review on developments in the taxonomy and systematic of the Tetrodontiformes, focusing primarily on contributions since 1980 [9]. This 412 extant species in the 10 families of living Tetraodontiformes, with the allocation of species and genera as follows: Triacanthodidae including 23 species in 11 genera, Triacanthidae seven species in four genera, Balistidae 37 species in 12 genera, Monacanthidae 102 species in 27 genera, Aracanidae 13 species in six genera, Ostraciidae 22 species in five genera, Triodontidae monotypic, Tetraodontidae 184 species in 27 genera, Diodontidae 18 species in seven genera, and Molidae five species in three genera. [9]. First, it establishes the mathematical relationship between the two variables, length and weight so that the unknown variable can be readily calculated from the known variables in the practical fisheries problem. Secondly, the relative condition can be estimated to assess the general wellbeing of the animals. Finally, it is used in the estimation of potential yield per recruit in the study of their population dynamics.

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The actual relationship between length and weight may part from the cubic value 3 and this may be due to environmental condition in which the animal lives and also due to the physiological condition of the animal. Length-weight relationship studies of any fish species is a pre requisite for the study of its population [11].

The knowledge of the length weight relationship of a fish is essential, since various important biological aspects, viz, general wellbeing of fish, appearance of first maturity, onset of spawning, etc., can be assessed with the help of condition factor, a derivative of this relationship [9]. Moreover, the length-weight of fish is an important fishery management tool

because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relationship between the two [5]. As length and weight of fish are among the important morphometric characters, they can be used for the purpose of fish stock assessment.

The estimation of yield per recruit in prediction models, and in the estimation of biomass from length observations and limited studies has been made on population dynamics. As no work has been done in this species region, in the present study, an attempt has been made to study the length-weight relationship of *Balistoides viridescens*.

2. Materials and Methods

The length frequency and catch data were collected from the Thoothukudi fishing harbor district from January 2011 to December 2012. Monthly length frequency data of the species in the catch data was used to estimate length-weight relationship of *Balistoides viridescens*. Length-weight relationship study was carried out in 91 specimens of *Balistoides viridescens* (Fig 1) ranging from 10 to 581 mm in total length and weight range from 20 – 2.580 kg. The length-weight relationship was calculated by the method of least squares using the equation of [11]: $W = a. L^b$, where W= weight in fish, L total length of fish and 'a' and 'b' is the exponents. The same in the logarithmic form can be written as log W = log a + b log L. Analysis of covariance [19] was employed to find out whether the regression coefficients differed significantly between males and females. The significance of difference in the estimate of 'b' in pooled data of sexes from the expected value of 3 (isometric growth) was tested by the 't' test as given by the formula.

t= b-3/ Sb

b= regression coefficient of log transformed data.

3. Results and Discussion

The maximum length recorded for this species in the Thoothukudi region was 58.1 cm. The reported maximum length for this species is 75 cm [12]. The linear equation was also fitted separately for both sexes. The correlation coefficient derived for the length-weight relationship for both sexes are given in Table.1. The regression equations derived for both the sexes are presented below Table.2.

Male = Log W = - 0.7044 + 1.4070 Log L

Female = Log W = -0.4394 + 1.2257 Log L

Table 1: Statistics in the length-weight relationship of males and females of *Balistoides viridescens*

Sex	N	SX	SY	SX^2	SY^2	SXY
Males	48	99.7567	106.5492	232.1622	265.5424	248.0753
Females	43	101.1109	105.0392	237.9638	256.8133	247.1622

N= Number of fish

SX^2, SY^2, SXY = Sum of squares and product

SX, SY = Sum of logarithmic values of length and weight respectively.

Table 2: Regression data for the length-weight relationship of males and females of *Balistoides viridescens*

Sex	Sum of Squares and Products					
	DF	X^2	XY	Y^2	b	DF
Male	48	232.1622	248.0753	265.5424	1.4070	47
Female	43	237.9638	247.1622	256.8133	1.2257	42

DF: Regression freedom

B: Regression Co-efficient

SS: Sum of Squares

The results showed significant of the both sexes of the species and the 'F' values were found to be significant at 1% level (Table.3). The correlations coefficient was found to be significant (P<0.01). The observed total length plotted against total weight for males and females sexes are presented in (Figure 1 and 2).

Table 3: Test of Significance

Source of Variation	DF	Sum of Square	Mean Square	Observed F
Deviation from individual with in sexes	1	497.7046	497.7046	90.5329
Difference between Regression	90	494.7771	5.4975	
Deviation from Total Regression	91	992.4817		Significant at 1% level

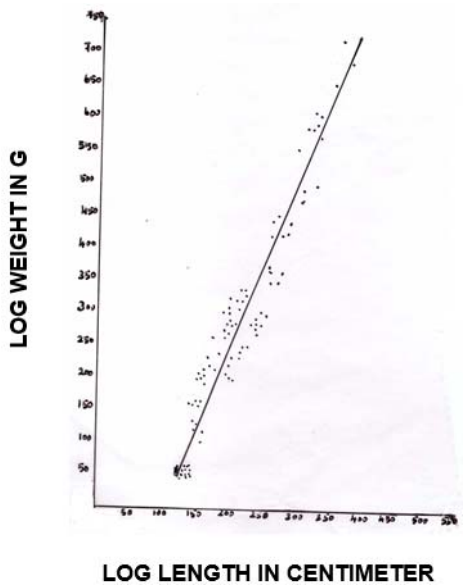

Fig 1: Logarithmic relationship between length and weight of males *Balistoides viridescens*

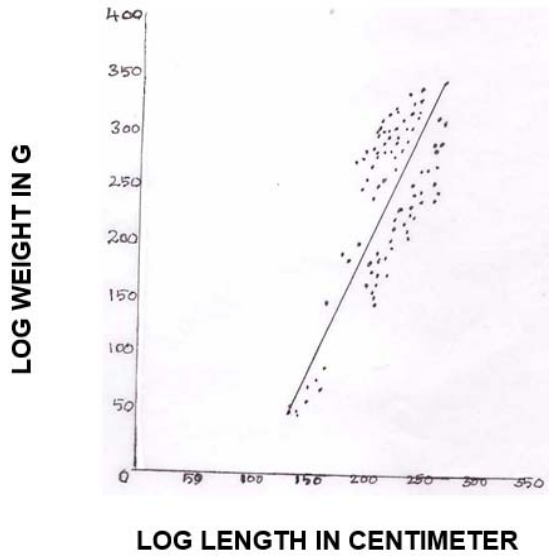

Fig 2: Logarithmic relationship between length and weight of females *Balistoides viridescens*

This relationship indicated a negative allometric growth in *Balistoides viridescens*. The calculated slope value was 1.41 for males and 1.23 for females. The balistid species have revealed that the length-weight relationship, b values obtained ranged from 0.28 t 4.37, where 40.6 of the species exhibited negative allometric growth, 36.9% showed isometric growth while 12.5% showed positive allometric growth [20]. Various *b* values of other balistid species and the *b* value obtained from this study are shown in (Table 4). The current interpretation studies the length weight relationship of *Sufflamen fraenatus*, reported the slope value of 2.73 for both the sexes [18]. The result showed that the length weight of relationship of *Odonus* niger, the calculated slope value was 2.16 for male and female was 2.25 [21]. In fishes, generally the growth pattern follows the cube law [10]. [4] Stated that major deviations from isometric growth are rare. Such cubic relationship for fishes will be valid when the fish grows isometrically. But in reality, the actual relationship between the variables, length and weight, may depart from this, either duet to environmental conditions or condition of fish [11]. According to [13] the value of the exponent 'b' in the parabolic equations usually lies between 2.5 and 4. Depending upon the deviation of 'b' values from '3' fishes can be classified into three groups (i) b= 3 where the body form of fish remains constant at different lengths (isometric) (Allen, 1938), (ii) b<3 when fish becomes more slender as the length increases and (iii) b>3 (allometric) when fish grows stouter with increase of length [7].

Table 4: Maximum age estimates and slope values *b* from the length-weight relationship $W = aL^b$ for males (M) and females (F) of various balistid species

Species	Area	Ageing method	Max. age			*b*			Study
			M		F	M		F	
Balistes capriscus	NEGM	ss	13		12	3.18		3.06	Johnson and Saloman (1984)
	EGM	ss	14		10		2.91[b]		Hood and Johnson (1997)
	SEBC	ss, wv	5		5	3.26	3.29	3.34	Bernards (2002)
	IBT	ss	3		3	2.76	2.78	2.78	Ismen *et al*., (2004)
	PWC	--	--		--		2.34		Mendes *et al*., (2004)
	WCG	ss		11			2.51		Aggrey-Fynn (2009)
B. polylepis	CMM	ss		7			2.66		Barroso-Soto *et al*., (2007)
B. vetula	ACNA	--	--		--		2.87		Robin (1986)[a]
	VI + P	ss		7			2.75		Manooch and Drennon (1987)
Balistapus undulatus	GBR	--	--		--		3.6		Randall *et al*., (1990)[a]
Odonus niger	GMI	--	--		--	2.16	--	2.25	Vaitheeswaran and Venkataramani (2008)
	GBR	--	--		--		3.0		Randall *et al*., (1990)[a]
Balistoides viridescens	GMI	--	--	4	--	1.41		1.23	This study
Rhinecanthus aculeatus	LI	--	--		--		2.41		Murty (2002)
	OIJ	ss, sv	13.5		9.5		2.83		Fabienne Kunzli and Katsunori Tachihara (2012)
R. rectangulus	M	--	--		--		2.96		Myers (1999)[a]
Xanthichthys ringens	ACNA	--	--		--		2.93		Robins (1986)[a]

W weight, *L* fish length, *b* slope value, *ss* sectioned spine, *sv* sectioned vertebra, *wv* whole vertebra, *NEGM* Northeastern Gulf of Mexico, *EGM* Eastern Gulf of Mexico, *SEBC* Southeastern Brazilian Coast, *IBT* Iskenderun Bay Turkey, *PWC* Portuguese West Coast, *WGG* Western Gulf of Guinea, *CMM* Coast of Mazatlan Mexico, *ACNA* Atlantic Coast North America, *VI + P* Virgin Islands and Puerto Rico, *GBR* Great Barrier Reef, *GMI* Gulf of Mannar India, *LI* Lakshadweep India, *OIJ* Okinawa Island Japan, *M* Micronesia

[a] Cited in Vaitheeswaran and Venkataramani (2008)

[b] *b* values obtained from $Y = a + bx$, where Y = log 10 (whole weight), X = log 10 (fork length)

The significant difference between sexes of the species 'F' value was at 1% level. In majority of the fishes the shape and density change with increasing age, which often causes the regression coefficient of weight of length, depart from 3. The present observation is also in agreement with the above view and it can be concluded that the cube formula $W = al^3$ will not be a proper representation of the length-weight relationship for *Balistoides viridescens* as the 't' value is significantly different and the growth is not isometric. [4] Suggest that the value of 'n' is almost always near to 3. Several theories have been advance by a number of workers as to what governs or influences the value of 'n' is dependent and governed by the feeding behavior of fish. Also the size of type of food consumed by the fish seems to have influence on the value of 'n'.

4. Conclusion

In fishes 'b' value is usually '3' in the length-weight relationship, but during growth change in specific gravity of body contour, morphological changes due to age may also cause the coefficient of regression of logarithm on logarithm

of length, to depart substantially from 3.0 [17]. Deviation in the growth rate 'b' observed during the present investigation may be the result of variations in the ecology of the geographical locations or due to changes in the environmental conditions [2]. The parameter b, unlike the parameter a, may vary seasonally, and even daily, and between habitats. Thus, the length-weight relationship is affected by a number of factors, including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat [16]. Others include seasonal variability of the environment and food availability [8], sample size and the length interval within different areas [14]. The LWR parameters may also vary within the same species due to feeding, reproduction and fishing activities [3]. Environmental changes, individual metabolism, sexual maturity and age [6]. Thus, comparing the slope of *Balistoides viridescens* with other Balistidae species, it could be concluded that the slope value is less than 3 for the both sexes of *Balistoides viridescens.*

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