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Length-Weight Relationships and Condition of Gerreids (Pisces: Gerreidae) from the Parangipettai Waters (SE coast of India)

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Abstract

The parameters of length-weight relationships were obtained for male, female and unsexed *Gerres filamentosus* and *G. abbreviatus* from the Parangipettai waters (SE coast of India). Covariance analysis for length–weight relationships of males, females and unsexed of both species revealed that there was no significant variation among males, females and unsexed (P>0.05) and hence common formulae of $W = 0.00676 * TL^{3.285}$ and $W = 0.00910 * TL^{3.178}$ were derived for *G. filamentosus* and *G. abbreviatus*, respectively. The relative condition of both fishes showed seasonal variations. In females, low relative condition values were observed during October-February for both species. The highest mean values of average condition factor were recorded from 160 to 185 mm TL in *G. filamentosus* and from 170 to 195 mm in *G. abbreviatus*.

Introduction

Knowledge of length-weight relationship plays a vital role in fisheries biology and population dynamics. It helps in estimating the standing stock or biomass thereby establishing the yield by converting one variable into another as is often done during field studies, calculating condition indices, comparing the ontogeny of fish population from different regions (Petrakis & Stergiou 1995) and in trophic studies (Gonzalez et al. 2003). In

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the field it is easier to measure the length of fish than the weight, therefore the biomass or the stock could be computed only by measuring the length of the fishes. The length weight relationship may also give an idea about the variations from the expected weight for a particular length of fish or fish populations based on fatness, general well being or gonad development.

Gerreids are members of the Teleostean family Gerreidae of the order Perciformes. They are small to medium sized fishes, popularly called as 'Mojarras', 'silverbiddies' or 'purse mouths'. Silver-biddies constitute an important component of the coastal fishery of India, by providing protein and fatty acid rich food for millions of the poorest people. Gerreids are distributed along the west and south coast of India and around Sri Lanka, from the east coast of India through the Indo-Malayan Archipelago to the South China Sea, Papua New Guinea and Northern Australia (Froese & Pauly 2000). Silver-biddies inhabit shallow coastal waters down to a depth of 40 m, predominantly feeding on bottom living organisms (Fischer & Bianchi 1984). These are usually found in small schools along with silverbellies, on sandy bottoms. Gerreids attain a maximum length of 300 mm. Separate statistics are not reported for this species (Fischer & Bianchi 1984).

Six species of gerreids belonging to two genera have been recorded from the Parangipettai waters (Sivashanthini & Subramanian 2003). These are *Gerres filamentosus* (Cuvier 1829), *G. abbreviatus* (Bleeker 1850), *G. oyena* (Forsskal 1775), *G. oblongus* (Cuvier 1830), *G. setifer* (Hamilton 1822) and *Pentaprion longimanus* (Cantor 1850). But the most abundant species throughout the year are *G. abbreviatus* and *G. filamentosus*.

So far, studies have not been done on length-weight relationship of *Gerres abbreviatus* and *G. filamentosus* in the Parangipettai waters. Therefore the present study was undertaken on the size distribution, length-weight relationship parameters and relative condition of *G. abbreviatus* and *G. filamentosus* from the Parangipettai waters.

Materials and Methods

The Parangipettai landing center (79°43´E longitude and 11°29´N latitude) is situated on the northern bank of the Vellar estuary where it empties into the Bay of Bengal, about 30 km south of Cuddalore, on the southeast coast of India. Parangipettai waters is equipped with rain from the northeast and southwest monsoon and the temperature ranges from 28 to 36 ºC. The depth may vary from 12 to 15 m. Boat seines and gill nets are the most common gears used to catch silverbiddies. Apart from this, traditional gears such as catamarans, plank-built boats and dugout canoes are also employed for fishing silverbiddies. Whipfin silverbiddies are available throughout the year at the Parangipettai waters. The main fishing season is from April to December.

Random samples of fishes were collected from Parangipettai and adjacent landing centers (SE coast of India) from September 2001 to August 2003. At least one sample was obtained every week from the Parangipettai fish landing center. Total length (TL) of each fish was measured from the anterior most edge of the lower lip (tip of snout) to the posterior most edge of the caudal fin to the nearest mm using a measuring board. Weight (W) was measured to the nearest 0.1 g using an electronic balance (Roy Electronic Balance) after draining the water from the buccal cavity and wiping the moisture content on the body of fish (King 1996). Fishes with damaged caudal fins were discarded.

If a fish grows isometrically (increasing in all dimensions at the same rate) and doubles in length, its weight will increase in relation to the increase in volume; that is by 8 (or 2^3) times (King 1995). Thus there is a cubic relationship between length (L) and weight (W), which can be represented by the cubic or power curve equation:

$$W = a L^{b},$$

where,
W = weight of the fish
L = length of the fish
b = close to 3 in isometric growth
a = a constant determined empirically.

For comparisons among stocks, a transformation into linear form using logarithms is commonly used, which can be expressed as follows:

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

The value of ‘a’ in the length-weigh relationship is often used as an index of ‘condition’, ‘fatness’ or ‘well-being’ for the fish (Bagenal & Tesch 1978). The condition factor or ponderal index is often used for understanding the changes in weight for length assuming that the length-weight relationship obeys the cube law. The more a fish weighs for a given length, the greater will be its condition factor. An alternative is the relative condition factor which compares the mean weight of fish in a sample with the predicted weight of fish from a generalized length weight relationship. Le Cren (1951) recommended a study on relative condition factor (K_n) in preference to the ponderal index (a) as the latter will be highly influenced by many environmental and biological factors. Relative condition factors calculated from monthly samples, for example, may be used to detect seasonal variations in the condition of fish, which may vary with food abundance and the average reproductive stage of the stock (King 1995).

The parameters 'a' (proportional constant or intercept) and 'b' (exponent) of the length–weight relationship of the form $W = aL^b$ were estimated for unsexed, males and females separately by using the logarithmic transformation log W= log a + b.log L. The regression line was computed by the method of simple least square regression analysis. The 'b' values obtained for unsexed, males and females of *Gerres filamentosus* and *G. abbreviatus* were tested by Student's *t* test to see whether the 'b' values differed significantly from 3 or not (Zar 1983). Student's *t* test was employed by dividing the difference between 'b' and '3' by standard error of 'b'. The regression lines of males, females and unsexed of *G. filamentosus* and *G. abbreviatus* were then analyzed further for significant differences following the General Linear Model Analysis of Covariance (GLMANCOVA) using MINITAB (Version 13) statistical software.

The monthly mean relative condition factor (K_n) for males and females of *G. filamentosus* and *G. abbreviatus* were calculated using the equation:

$$K_n = W/\hat{W},$$

where, K_n = relative condition factor, W = observed weight and $\hat{W}$ = calculated weight (expected geometric mean weight for the observed length) (Le Cren 1951) and plotted against months

The mean relative coefficient of condition for each 25 mm length class intervals was computed for both species without regard to sex and plotted as box-whisker plots in order to find out the variation of condition factor with length.

Results

A total of 1135 specimens (243 unsexed, 471 males and 421 females) of *G. filamentosus* and 1198 specimens (235 unsexed, 462 males and 501 females) of *G. abbreviatus* were analyzed.

Size range

The size (TL) of *G. filamentosus* ranged from 85 to 260 mm (mean ± SD = 141 ± 3.54 mm). Males ranged from 105 to 255 mm TL (mean ± SD = 153.2 ± 3.34 mm), females from 85 to 260 mm TL (mean ± SD = 148.4 ± 3.31 mm), and unsexed ranged from 85 to 131 mm TL (mean ± SD = 104.9 ± 1.0 mm).

The size (TL) of *G. abbreviatus* ranged from 83 to 279 mm (mean ± SD = 150 ± 4.13 mm). Males ranged from 103 to 279 mm TL (mean ± SD = 161.9 ± 3.79 mm), females from 95 to 279 mm TL (mean ± SD = 161.3 ± 3.87 mm) while unsexed ranged from 83 to 135 mm TL (mean ± SD = 104.6 ± 1.04 mm).

Length-weight relationship

The estimates of the regression parameters for males, females, unsexed and pooled data of both fishes obtained by regression analysis are given in table 1. The plots of weight versus length for both fishes are shown in figures 1a and 1b.

The b values 3.264, 3.247 and 3.203 obtained for *Gerres filamentosus* males, females and unsexed respectively, indicated that the fish follows the cube law; its growth is proportionally three-dimensional (n = 471, r^2 = 0.975, 95% CL a = 0.006546-0.008395, 95% CL b = 3.217-3.311 and coefficient of variation = 0.001107 for males; n = 421, r^2 = 0.975, 95% CL a = 0.006457-0.008299, 95% CL b = 3.200-3.293 and coefficient of variation = 0.001154 for females; n = 243, r^2 = 0.926, 95% CL a = 0.006194-0.010605, 95% CL b = 3.088-3.318 and coefficient of variation = 0.003736 for unsexed).

That is, with increasing age, rate of growth in terms of weight in this fish becomes faster than that of its length. Correlation coefficients (r) 0.987 for males, 0.989 for females and 0.962 for unsexed were found to be significant ($p<0.001$) in all instances indicating good correlation between length and weight of *G. filamentosus*.

Table 1. Length-weight relationship parameters of *Gerres filamentosus* and *G. abbreviatus* (N=Number of observation, df=Degrees of freedom, b=Regression exponent, a=Constant, SS=Sum of squares, r=Correlation coefficient, M=Male, F=Female, U=Unsexed, T=Total and Po=Pooled)

Sex	N	df	Length range (mm)	b	a	Errors of estimation		r
						df (residual)	SS (residual)	
				G. filamentosus				
M	471	470	105-255	3.264	0.007	469	1.097	0.987
F	421	420	85-260	3.247	0.007	419	0.911	0.989
U	243	242	85-131	3.203	0.008	241	0.335	0.962
T	1135	1132		-	-	1129	2.343	-
Po	1135	1134		3.285	0.006	1133	2.488	0.991
				G. abbreviatus				
M	462	461	103-279	3.095	0.011	460	1.128	0.987
F	501	500	95-279	3.119	0.010	499	1.571	0.984
U	235	234	83-135	3.037	0.012	233	0.168	0.979
T	1198	1195		-	-	1192	2.868	-
Po	1198	1198		3.178	0.009	1196	3.022	0.990

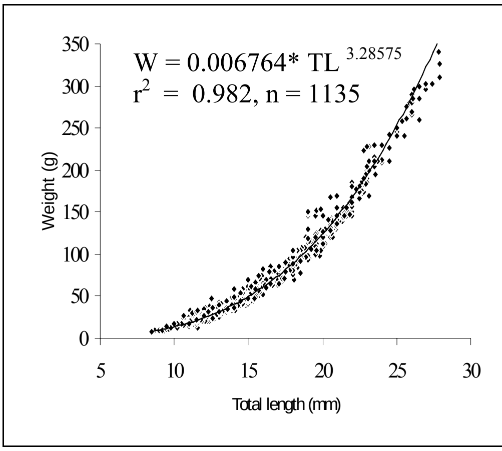

Figure 1a. Scatter diagram of weight versus total length for *G. filamentosus*.

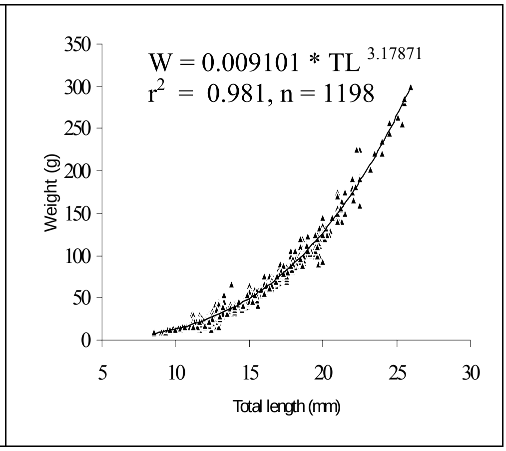

Figure 1b. Scatter diagram of weight versus total length for *G. abbreviatus*.

Comparatively low b values 3.095, 3.119 and 3.037 were obtained for *G. abbreviatus* males, females and unsexed respectively (n = 462, r^2 = 0.974, 95% CL a = 0.010257-0.013213, 95% CL b = 3.049-3.140 and coefficient of variation = 0.001082 for males; n = 501, r^2 = 0.969, 95% CL a = 0.009419-0.012331, 95% CL b = 3.070-3.167 and coefficient of variation = 0.001103 for females; n = 235, r^2 = 0.958, 95% CL a = 0.010069-

0.014757, 95% CL b = 2.955-3.118 and coefficient of variation = 0.002692 for unsexed).

However this species was also found to follow the cube law. Correlation coefficients (r) 0.987 for males, 0.984 for females and 0.979 for unsexed were also found to be highly significant (p<0.001) in all instances indicating good correlation between length and weight of *G. abbreviatus.*

The results of student's *t* test to analyze the significance of variation in the estimates of 'b' for *G. filamentosus* and *G. abbreviatus* from the expected value for the ideal fish (3.0) are as follows:

G. filamentosus:

Males:	(3.264-3.0) / 0.024	= 11.006 Significant (computed $t_{\alpha(2),0.05,470} > 1.965$)
Females:	(3.247-3.0) / 0.023	= 10.436 Significant (computed $t_{\alpha(2),0.05,420} > 1.965$)
Unsexed:	(3.203-3.0) / 0.058	= 3.497 Significant (computed $t_{\alpha(2),0.05,242} > 1.969$)
Pooled:	(3.285-3.0) / 0.013	= 21.702 Significant (computed $t_{\alpha(2),0.05,1134} > 1.96$)

G. abbreviatus:

Males:	(3.095~3.0) / 0.023	= 4.094 Significant (computed $t_{\alpha(2),0.05,461} > 1.965$)
Females:	(3.119-3.0) / 0.024	= 4.831 Significant (computed $t_{\alpha(2),0.05,500} > 1.965$)
Unsexed:	(3.037-3.0) / 0.041	= 0.903 Not significant (computed $t_{\alpha(2),0.05,234} < 1.970$)
Pooled:	(3.178-3.0) / 0.012	= 14.295 Significant (computed $t_{\alpha(2),0.05,1197} > 1.96$)

The regression exponent values obtained for males, females and unsexed of *Gerres filamentosus* and males and females of *G. abbreviatus* were significantly different (P<0.05) from 3 indicating positive allometric growth in all instances whereas the exponent value of 3.037 obtained for *G. abbreviatus* unsexed very close to 3, did not deviate significantly from 3 (P>0.05) indicating isometric growth.

In GLMANCOVA a full rank design matrix was formed from the factors and covariates and each response variable was regressed on the columns of the design matrix. The GLMANCOVA showed the slopes (b) of males, females and unsexed not to exhibit significant interaction (computed $F_{1,1129}$ <3.84, P>0.05 and computed $F_{1,\ 1192}$ <3.84, P>0.05 for *G. filamentosus* and *G. abbreviatus*, respectively).

Further, comparison of regression co-efficient of males, females and unsexed using GLMANCOVA for the regression of log weight on log total length for *G. filamentosus* males, females and unsexed showed the ‘b’ values not to show significant differences (P>0.05). The confidence intervals of ‘a’ for male, female and unsexed of G. *filamentosus* overlap with each other and therefore there is no significant differences between the intercepts. Hence the following common formulae were derived for males, females and unsexed of *G. filamentosus*.

Parabolic equation: $W = 0.00676 * TL^{3.285}$
Logarithmic equation: $\text{Log } W = -2.169 + 3.285 * \log TL$

In *G. abbreviatus* the ‘b’ values of unsexed, males and females did not differ significantly from each other (P>0.05). The confidence intervals of ‘a’ for male, female and unsexed of G. *abbreviatus* overlap with each other and therefore there is no significant difference between intercepts. Thus the following common formulae were derived from the pooled data of males, females and unsexed of *G. abbreviatus*.

Parabolic equation: $W = 0.00910 * TL^{3.178}$
Logarithmic equation: $\text{Log } W = -2.040 + 3.178 * \log TL$

Condition factor

The monthly mean relative coefficient condition values for males and females *G. filamentosus* and *G. abbreviatus* are presented in figures 2a and 2b. The *G. filamentosus* males had relatively higher mean K_n values than females (mean 1.001 ± 0.0359SE and mean 0.0984 ± 0.0403SE, respectively). Relative K_n value for females of *G. filamentosus* decreased gradually from September 2001 and attained a low value during February 2002. Again it increased to 1.01 in March 2002 and attained a very low value in February 2003 with fluctuations in the other months. Slightly higher K_n values were observed in October and December 2002.

In *G. abbreviatus* males also showed relatively higher mean K_n values than females (mean 1.35 ± 0.1024SE and mean 1.275 ± 0.1017SE, respectively). Relative K_n values for females of *G. abbreviatus* declined from October 2001 to December 2001. It rose again and higher values were noticed up to September 2002 except in April and July 2002. Low values were observed during October – February. After this a peak was observed in April 2003. The low K_n values may be an indication of spawning from October to February in both species.

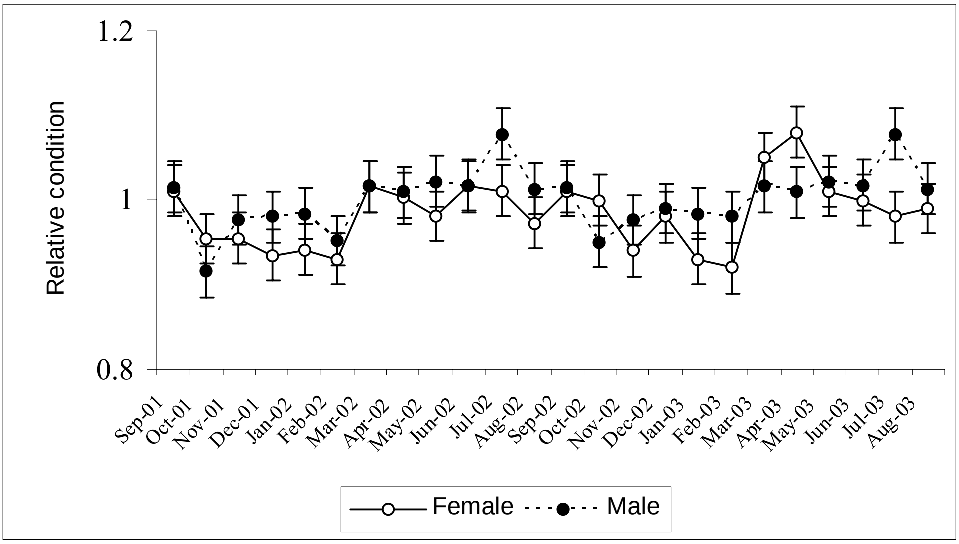

Figure 2a. Monthly mean relative coefficient of condition for male and female *G. filamentosus.*

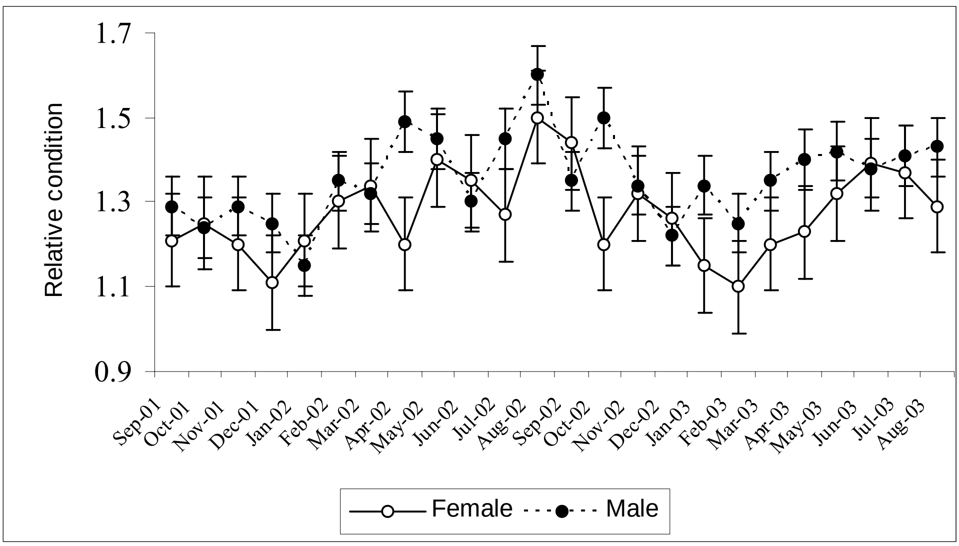

Figure 2b. Monthly mean relative coefficient of condition for male and female *G. abbreviatus.*

The average condition factor plotted against size groups at 25 mm class intervals of length without regard to sex for *G. filamentosus* and *G. abbreviatus* is shown in figures 3a and 3b. The K_n values of different size

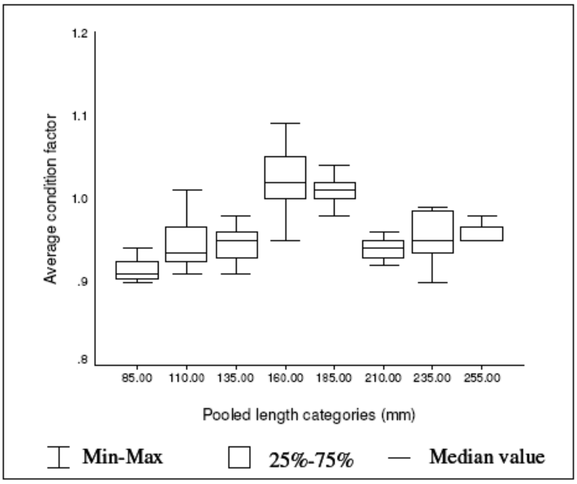

Figure 3a. Average condition factor at different lengths of *G. filamentosus*.

groups gave an idea about the variations in the condition of the fish during its growth. The average K_n values increased with increasing length up to 160 mm in *G. filamentosus* and 170 mm in *G. abbreviatus* showing high feeding activity, normal growth and active maturation. A gradual decrease from 185 mm and a considerable drop at 210 mm in *G. filamentosus* and at 220-245 mm in *G. abbreviatus* showed that these fishes attained the size at first maturity and started breeding. The highest mean values of average condition factor recorded were from 160 to 185 mm TL in *G. filamentosus* and 170-195 mm in *G. abbreviatus*.

Discussion

Allen (1938) pointed out that the exponent coefficient (b) in the length-weight relationship of fishes is usually 3. Later, Carlander (1969) pointed out that the 'b' value is very close to 3.0 but varies between 2.5 and 3.5. If the 'b' value for a fish is 3, the fish grows isometrically; if it is greater than 3, the fish exhibits positive allometry and if it is lower than 3 the fish exhibits negative allometry (Tesch 1968). Fishery biologists also

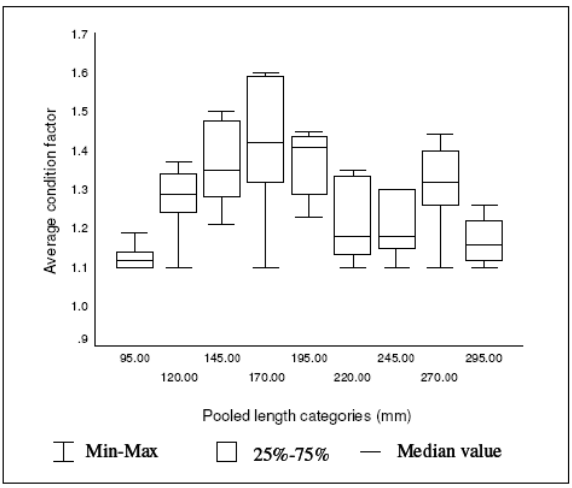

Figure 3b. Average condition factor at different lengths of *G. abbreviatus*.

stated that the ‘a’ and ‘b’ values differ not only in different species but also in the same species depending on sex, stage of maturity, food habits and so on (Qasim 1973; Bal & Rao 1984; Froese 2006). A historical review on length weight relationship and recommendations for users about length-weight relationships, condition factors and relative weight is provided by Froese (2006). The parameters of length-weight relationship of gerreids estimated by various authors from different parts of the world are tabulated in table 2.

Table 2. The parameters of length-weight relationship of gerreids from different regions of the world (TL = Total length, FL = Fork length and SL = Standard length)

Species	Sex	a	b	Range (mm)	Region	Source
Eucinostomus argenteus	Un-sexed	0.0359	2.910	70-153 SL	Colombia	Duarte et al. (1999)
E. currani	Un-sexed	0.0268	2.750	98-209 TL	Brazil	Ruiz-Ramirez et al. (1997)
E. gracilis	Un-sexed	0.0051	3.330	96-190	Brazil	Ruiz-Ramirez et al. (1997)
E. gula	Un-sexed	0.0552	2.750	62-160	Colombia	Duarte et al. (1999)
E. havana	Un-sexed	0.0614	2.770	85-117 FL	Cuba	Garcia-Arteaga et al. (1997)
E .havana	Un-sexed	0.0123	3.230	20-120 FL	Cuba	Claro and Garcia-Arteaga (1994)
E. havana	Un-sexed	0.0128	3.052	12-120 FL	USA	Bohnsack and Harper (1988)
E. jonesii	Un-sexed	0.0923	2.650	85-117 FL	Cuba	Garcia-Arteaga et al. (1997)
E. melanopterus	Un-sexed	0.0128	2.910	31-100 TL	Nigeria	King (1996)
Eugerres brasilianus	Un-sexed	0.0529	2.820	13-300 FL	Cuba	Claro and Garcia-Arteaga (1994)
E. brasilianus	Un-sexed	0.0179	2.906	10-50 FL	Cuba	Claro and Garcia-Arteaga (1994)
E. plumieri	Un-sexed	0.0481	2.930	86-266 SL	Colombia	Duarte et al. (1999)
E. plumieri	Un-sexed	0.00624	2.860	- FL	Venezuela	Claro and Garcia-rteaga (1994)
Gerres cinereus	Un-sexed	0.0147	3.120	130-430 FL	Cuba	Garcia-Arteaga et al. (1997)
G. cinereus	Un-sexed	0.013	2.690	- FL	Cuba	Claro and Garcia-Arteaga (1994)
G. cinereus	Un-sexed	0.0152	3.084	50-260 FL	USA	Bohnsack and Harper (1988)
G. filamentosus	Un-sexed	0.0176	3.059	90-160 FL	Australia	Willing and Pender (1989)
G. filamentosus	Un-sexed	0.0266	2.966	50-230 FL	New Caledonia	Letourneur et al. (1998)
G. filamentosus	Male Female Un-sexed	0.0474 0.0516 0.0153	2.8740 2.8381 2.2558	- - -	India	Kurup and Samuel (1987)
G. oblongus	Male	0.01127	2.9583	103-253 TL	Sri Lanka	Sivashanthini and Abeyrami (2003)

Table 2. The parameters of length-weight relationship of gerreids from different regions of the world (TL = Total length, FL = Fork length and SL = Standard length) (continued)

Species	Sex	a	b	Range (mm)	Region	Source
G. oblongus	Female	0.015319	3.1261	110-253 TL	Sri Lanka	Sivashanthini and Abeyrami (2003)
G. ovatus	Un-sexed	0.0238	2.986	30-190 FL	New Caledonia	Letourneur et al. (1998)
G. oyena	Un-sexed	0.012	3.232	40-200 FL	New Caledonia	Letourneur et al. (1998)
G. oyena	Un-sexed	0.0000068	3.15139	48-295 TL	India	Prabhakara Rao (1970)
G. setifer	Un-sexed	0.0097	3.08729	19-210 TL	India	Patnaik (1971)
Pentaprion longimanus	Un-sexed	0.0291	2.965	70-110 FL	Australia	Willing and Pender (1989)
P. longimanus	Un-sexed	0.0169	2.917	35-150 TL	Indonesia	Pauly et al. (1996)
P. longimanus	Un-sexed	0.0119	3.0	- TL	Philippines	Federizon (1993)

The 'a' and 'b' values obtained for *G. filamentosus* were superimposed in the plot of log 'a' versus 'b' available for *G. filamentosus* and 1300 miscellaneous species in FishBase 2007 for comparison and it is shown in figure 4a. Estimated values in the present study fall well within the range of values reported earlier for *G. filamentosus*. Such a plot is not available for *G. abbreviatus* as the above has not been studied in this species and therefore compared in the plot of *G. filamentosus* (Fig. 4b).

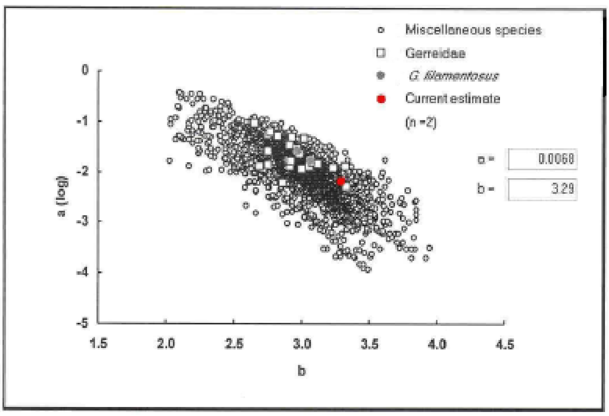

Figure 4a. Plot of log 'a' versus 'b' for *G. filamentosus*

The only previous work available for length-weight relationship of *G. filamentosus* in Indian waters is that of Kurup & Samuel (1987). They reported a 'b' value of 2.874 for males, 2.838 for females and 2.255 for unsexed and were comparatively lower than the values obtained in the present study.

The size variation obtained from the box-whisker plots for *G. filamentosus* and *G. abbreviatus* will be very useful to the fishery managers especially in specifying the minimum size above which these species should be exploited, in determining the mesh size of gill nets and in imposing fishery regulations. Even though *G. filamentosus* and *G. abbreviatus* grow only up to about 300 mm in TL, they have a special place in the market and among the people living in the coastal region of east, southeast and west coasts of India, these are valuable fishes available throughout the year.

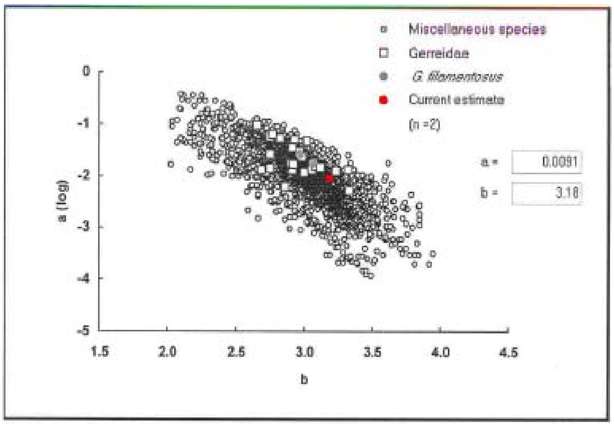

Figure 4b. Plot of log 'a' versus 'b' for *G. abbreviatus*

Acknowledgments

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