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Growth Characteristics of Slender Silver-biddies *Gerres oblongus* (Pisces: Perciformes) from the Jaffna Lagoon, Sri Lanka

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ABSTRACT

The present study was carried out to understand the growth parameters of the slender silver biddy *Gerres oblongus*. Growth parameters of *G. oblongus* such as asymptotic length (L_∞), growth coefficient (K) and age at zero length ('t_0') were estimated through the appropriate routines of the FiSAT II software from the length frequency data. The optimized values for K and L_∞ obtained by the ELEFAN I routine was 1.0 year^{-1} and 29.4 cm. The estimated 't_0' value was -0.151. The Powell-Wetherall plot gave a Z/K value of 3.851. The estimated growth performance index (Ø) was 2.93. The von Bertalanffy's growth equation for *G. oblongus* can be expressed as L_t = 29.4 [1-exp {-1.0 (t+0.159)}]. Estimated longevity for *G. oblongus* calculated from Pauly's equation was 2.84. The growth parameters obtained in the present study are useful fundamental indicators for the population dynamics studies of the *G. oblongus*.

Key words: Population dynamics, asymptotic length, growth coefficient, *Gerres oblongus,* von Bertalanffy's growth equation

INTRODUCTION

Slender silver biddies are members of the Teleostean family Gerreidae of the order Perciformes (Froese and Pauly, 2011). These are valued as delicious and medicinal important ones. These are popularly called as 'Mojarras' or Gerreids (Sivashanthini, 2009). These comprise small to medium sized, strongly compressed fishes characterized by a pointed snout and a highly protrusible mouth (Nelson, 1994). They occur over muddy and sandy bottoms in estuaries and hepersaline lagoons (Cervigon *et al*., 1993). These are distributed widely in the northern region of Sri Lanka and support coastal fishery of northern Sri Lanka, significantly. Gerreids play an important role not only as human food equipped with protein and fat but also used as animal feeds, particularly as fishmeal. Currently, gerreids stocks in Northern region of Sri Lanka are not assessed and managed; no studies were performed on stock assessment or age and growth estimation for this species, so far from the Jaffna lagoon.

Mainly sirahu valai is the major gear used to catch the gerreids in the Jaffna lagoon, Sri Lanka. But these types of fish were also caught along with other food fish in gill nets, cast nets and seines. Sirahu valai is a deep water trap net set at depths of 4-6 m. It is fixed by fishermen on a semi-permanent basis. Fishermen drive long timber poles about 4-5 m in length into the lagoon bed every 2-3 m. These poles are fixed as framework on to which net walls are fixed. The components of the gear generally are a long leader, a "C" shaped play ground and one or more traps.

The length of the leader depends on the side of the installation and extends up to about 100 m. The webbing used is 12 mm mesh of 12 ply. The leader which guides the fish into the playground area is usually positioned perpendicular to the length of the shore. Trap is generally in the form of a semi circle having a radius of about 6-8 m while the distance between the two widest points in the playground could be 10-12 m. The webbing for the playground and for the cod end is 12 to 16 mm mesh of 12 to 15 ply. The uppermost region of the collection trap is netted with 12 mm mesh size net so as to avoid escapement of large fish to the exterior of the trap. This procedure is followed by the fishermen at Jaffna lagoon.

Growth characteristics of fishes are important part of population dynamics and essential parameters to take serious decision on the management issues of any fishery. Age refers to the quantified period of time the fish lives whereas, growth is the definite size change of fish between certain periods of time (DeVries and Frie, 1996). The age and growth parameters of fishes provide indispensable data understand the dynamic of ichthyological populations; also they give an important indication on the fisheries management and on the level of their exploitation (Beamish and MacFarlane, 1987). The fishing pressure exerts on a particular fish population can be estimated from the fundamental data for growth parameters. Therefore, it is essential to study the growth parameters of fish at different locations before recommending management measures.

With the progress of fishery research, different methods have been evolved for determining the age of the fish in an open system. These methods may be broadly classified into direct (counting of year rings on hard parts such as scales and otoliths) (Cailliet *et al.*, 1986; Cailliet, 1990; Gallagher and Nolan, 1999; McFarlane *et al.*, 2002) and indirect methods (conversion of length frequency data into age composition) (Gayanilo and Pauly, 1997). Nowadays, estimation of age and growth parameters in tropical fishes hopefully achieved by microcomputer program packages such as Length-based Fish Stock Assessment (LFSA) (Sparre, 1987), COMPLEAT ELEFAN (Gayanilo *et al.*, 1988), MULTIFAN (Fournier *et al.*, 1990), LFDA (Holden and Bravington, 1991) and FiSAT (Gayanilo and Pauly, 1997).

Information available on the age and growth parameters of gerreids which could be used as fundamental data to investigate population dynamics in northern waters of Sri Lanka is meager. Therefore, the present study was carried out to investigate maximum size and age and growth parameters of *Gerres oblongus* of Jaffna lagoon based on length frequency data with a view to obtain basic scientific information of gerreid fishery.

MATERIALS AND METHODS

Fish samples for the present study were collected from the commercial sirahu valai catches of Pasaioor, Kurunagar, Kakkaithevu and Ponnalai landing centres (Fig. 1) at weekly intervals from July 2007 to June 2009. At least one landing centre was visited per week. The collection site, Jaffna lagoon is situated in the northern province of Sri Lanka holds an area of 412.8 km^2 and is one of the largest shallow water body (Somasekaram, 1997). It is situated between 79° 52' E to 80° 38' E longitude and 9° 26' N to 9° 46' N latitudes (Somasundarampillai, 2002).

Gerreid samples mainly caught by sirahuvalai were identified into species and total length measurements were taken for all possible *G. oblongus* to the nearest 1 mm at the landing centres in order to arrange in to length frequency data.

The length frequency data were grouped sex wise into 2 cm class intervals, sequentially arranged for two years and used for estimation of growth. As the length frequency data obtained

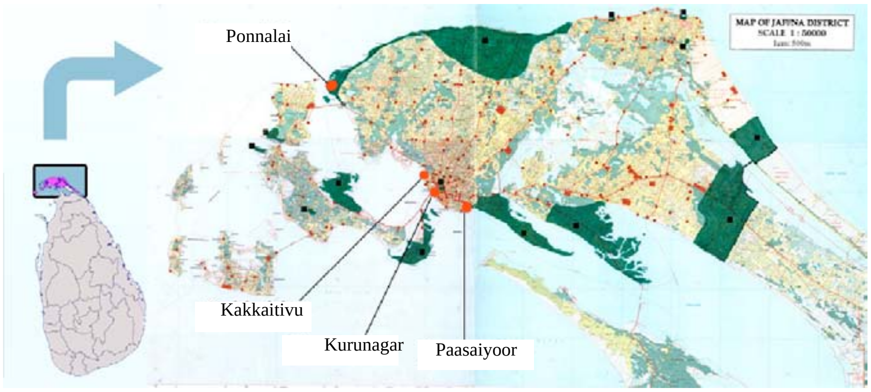

Fig. 1: Sampling sites of *Gerres oblongus* from the Jaffna lagoon, Sri Lanka-Kakkaithevu, Kurunagar, Pasaioor and Ponnalai

from different gear cannot be simply pooled, the length frequency data of *G. oblongus* from the sirahu valai catches were analyzed using ELEFAN I routine of FISAT II software (Gayanilo and Pauly, 1997). The following stepwise procedures were adopted to estimate L_∞ and K and for correction of length frequency data for mesh selection as per literature (Sparre and Venema, 1992; Amarasinghe and De Silva, 1992; Amarasinghe, 2002).

- Preliminary estimation of asymptotic length (L_∞) and growth coefficient (K) using the initial estimates of L_∞ estimated by Powell Wetherall method
- Estimation of an initial value for asymptotic length (L_∞) and Z/K (Z = total mortality and K = growth coefficient) using the Powell-Wetherall method (Powell, 1979; Whetherall, 1986)
- Preliminary estimation of asymptotic length (L_∞) and growth coefficient (K) using the initial estimates of L_∞ estimated by Powell Wetherall method
- Estimation of probabilities of capture by detailed analysis of left ascending part of the catch curve using the preliminary estimation made on the asymptotic length (L_∞) growth coefficient (K) and computed t_0
- Correction of the original length frequencies using probabilities of capture (Pauly, 1986a-c) for incomplete selection for length classes smaller than the first fully selected length through appropriate routine
- Estimation of best optimized estimates of L_∞ and K through ELEFAN I routine (Gayanilo and Pauly, 1997) from the corrected length frequency data

Estimation of L_∞ and K

Powell-Wetherall method: Length frequency data were first analyzed by Powell-Wetherall method (Powell, 1979; Whetherall, 1986) by identifying the smallest length fully recruited by the gear. This method is based on the following equation of Beverton and Holt (1959).

$$Z = K x \left\{ \frac{(L_\infty - L_{mean})}{(L_{mean} - L')} \right\} \tag{1}$$

where, L_{mean} is the mean length of fish of length L' and longer, L' is "some length for which all fish of that length and longer are under full exploitation", Z is the total mortality and K is the growth co-efficient. As L' can take any value equal to and above the smallest length under full exploitation, Eq. 1 can give a series of estimates of Z, namely one for each choice of L'. This makes it possible to turn Eq. 1 into a regression analysis with L' as the independent variable. A series of algebraic manipulations shows that Eq. 1 is equivalent to:

$$L_{mean} - L' = a + b*L' \tag{2}$$

where,

$$Z/K = -(1+b)/b \text{ and } L_\infty = -a/b \tag{3}$$

or,

$$b = -K/(Z+K) \text{ and } a = -b*L_\infty \tag{4}$$

Thus, plotting L_{mean}-L' against L' gives a linear regression from which 'a' and 'b' can be estimated and hence L_∞ and Z/K, of which Eq. 2 represents the simplest approach. The asymptotic length (L_∞) and the ratio of the coefficients of mortality and growth (Z/K) values were estimated by this method.

ELEFAN I method: Length frequency data were analyzed by Electronic LEngth Frequency ANalysis, a computer based method (Pauly and David, 1981; Pauly, 1987) using the appropriate routines. This method attempts to combine the logic of the Peterson method (Pauly, 1983) and that of modal progression analysis with a minimum of subjective inputs. L_∞ and K values were obtained by this method.

L_∞ and K values were obtained through the four options such as, curve fitting by eye, response surface analysis, scan of K values and automatic search routine. In this method the growth parameters L_∞ and K were estimated following the von Bertalanffy growth equation. The equation for growth in length is given by:

$$L_t = L_\infty (1 - \exp^{-K(t-t_0)}) \tag{5}$$

where, L_t is the length at age t, L_∞ the asymptotic length, K the growth coefficient and t_0 theoritical age at which fish would have had zero length if they had grown according to the above equation. The most optimized L_∞ and K values were obtained by ELEFAN I-automatic search routine and the restructured length frequency histograms were also obtained.

Estimation of growth performance index: The growth performance index (Ø) was computed using the following equation (Pauly and Munro, 1984):

$$\phi = \log_{10} K + 2\log_{10} L_\infty \tag{6}$$

Estimation of t_0: As ELEFAN cannot estimate the t_0 value from the length frequency data, a very aproximate value of 't_0' was estimated by substituting the L_∞ (in cm) and K (year^{-1}) in the following equation (Pauly, 1983):

$$\log(-t_0) \approx -0.3922 - 0.2752 \log L_\infty - 1.038 \log K \qquad (7)$$

where, -0.3922, -0.2752 and -1.038 are constants derived from 153 triplets of t_0, L_∞ and K selected from the compilation of length growth parameters such as to cover a wide diversity of taxa and size.

Estimation of longevity: Longevity was obtained from the following equation (Pauly, 1983):

$$t_{max} = \frac{t_0 + 3}{K} \qquad (8)$$

where, t_{max} is the approximate maximum age the fish of a given population would reach.

RESULTS

A total of 3782 specimens of *G. oblongus* ranging from 4.0 to 27.5 cm were analyzed for the age and growth studies.

Estimation of L_∞ and K

Powell-Wetherall method: The analysis of length frequency data by the Powell-Wetherall method (Fig. 2) gave an initial estimate of L_∞ value of 30.08 cm.

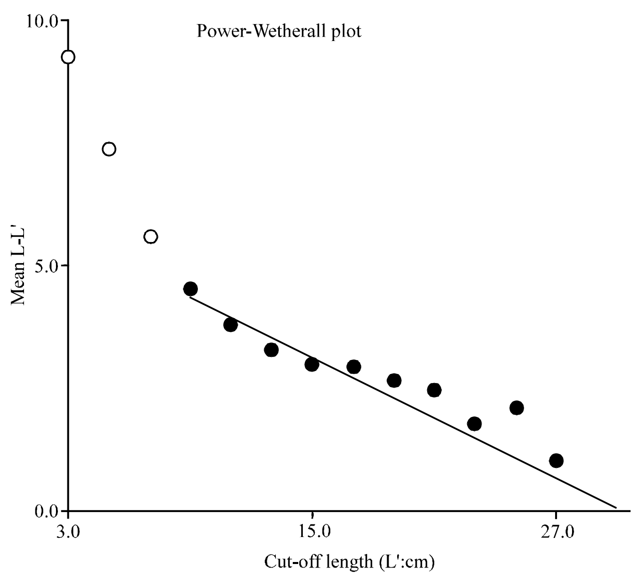

Fig. 2: Powell-Wetherall plot of *G. oblongus* (r = -0.953; regression equation, Y = 6.20+(-0.206) *X; Z/K value = 3.851)

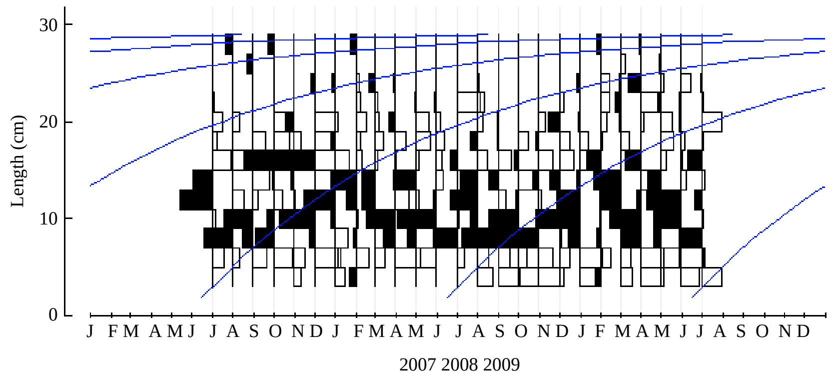

Fig. 3: Growth curve of *G. oblongus* drawn using ELEFAN I programme

ELEFAN I method: The optimized values for K and L_∞ obtained by the ELEFAN I was 1.0 year^{-1} and 29.4 cm, respectively. The goodness of fit index (R_n) for the obtained K and L_∞ value was 0.183. Usually, the R_n value ranges between 0 and 1 in the ELEFAN-FiSAT package. The oscillation parameter (C) and winter point were assumed to be 0 as it is a tropical species. The non seasonalized restructured length frequency histogram with growth curve is shown in Fig. 3.

Estimation of growth performance index: The estimated growth performance index (Ø) was 2.93.

Estimation of t_0: The estimated t_0 value was -0.159.

The von Bertalanffy's growth equation for *G. oblongus* can be expressed as:

$$\text{Male}: L_t = 29.4[1 - \exp\{-1.0(t + 0.159)\}] \quad (9)$$

Estimation of longevity: Estimated longevity for *G. oblongus* calculated from Pauly's equation is 2.84.

DISCUSSION

Age and growth parameters of the slender silver-biddies *G. oblongus* were not reported in Sri Lanka and this is the first study to estimate those parameters. However few research works were carried out for congeners of *G. oblongus* in different countries of the world. The growth parameters L_∞ and K values estimated for gerreids in world waters are presented in Table 1.

Notable examples for similar studies are for *G. filamentosus* from Parangipettai waters, South India (Sivashanthini, 2009), for *G. abbreviatus* from Parangipettai waters, India (Kuganathan, 2006), for *G. setifer* from Parangipettai waters, India (Sivashanthini and Khan, 2004), for *G. oyena* from Tanzania waters (Benno, 1992), for *G. filamentosus* from Ambaro bay (Pauly, 1978) etc.

Apart from the above mentioned studies several studies have been carried out to investigate the age and growth parameters of fish and fish related organisms. When considering cephalopods there are two similar studies one is for Octopus, *Octopus aegina* from Mandapam Coastal Waters (Palk bay), Southeast Coast of India by Ignatius *et al.* (2011), another one for squid, *Sepioteuthis lessoniana* from the Jaffna lagoon, Sri Lanka by Charles and Sivashanthini (2011).

Table 1: The growth parameters estimated for gerreids from different regions of the world TL-Total Length, FL-Fork length, M-Male, F- Female, U-Unsexed

Species	Sex	L_∞ (mm)	K (year^{-1})	t_0 (year^{-1})	Region	Source
Gerres abbreviatus	M	278 TL	1.30	-0.1236	Parangipettai South India	Kuganathan (2006)
	F	282 TL	1.36	-0.1175		
Gerres filamentosus	M	269 TL	1.55	-0.05515	Parangipettai South India	Sivashanthini (2009)
	F	270 TL	1.68	-0.05067		
Gerres filamentosus	U	219 TL	2.616	-	Madagaskar, Ambaro bay	Pauly (1978)
Gerres filamentosus	U	269 TL	1.788	-	Madagaskar, Ambaro bay	Pauly (1978)
Gerres filamentosus	U	329 TL	0.756	-	Madagaskar, Ambaro bay	Pauly (1978)
Gerres oyena	U	182 TL	1.1	-	Tanzania	Benno (1992)
Gerres setifer	M	174 TL	1.19	-0.0817	Parangipettai South India	Sivashanthini and Khan (2004)
	F	175.5 TL	1.26	-0.0775		
Pentaprion longimanus	U	155	0.94	-	Australia	Cabanban (1991)
Pentaprion longimanus	U	137	1.12	-	Indonesia	Sadhotomo (1983)
Pentaprion longimanus	U	156	0.80	-	Indonesia	Sadhotomo (1983)
Pentaprion longimanus	U	134	1.77	-	Indonesia	Sadhotomo (1983)
Pentaprion longimanus	U	142	1.8	-	Indonesia	Sadhotomo (1983)
Pentaprion longimanus	U	160 TL	1.1	-	Malaysia	Chan and Liew (1986)
Pentaprion longimanus	U	158 FL	1.00	-	Philippines	Corpuz *et al.* (1985)
Pentaprion longimanus	U	172 FL	1.03	-	Philippines	Corpuz *et al.* (1985)
Pentaprion longimanus	U	170 FL	1.59	-	Philippines	Ingles and Pauly (1984)

Among the teleost fish age and growth parameters of *Tenualosa ilisha* were studied by several authors in Bangladesh by Rahman *et al.* (2000), Ahmed *et al.* (2008) and Haldar and Amin (2005), in Iran by Roomian and Jamili (2011). Meanwhile age and growth studies were performed for *Harpodon nehereus* (Ham-Buch) from the neritic water of Bangladesh by Amin (2001), for african butter catfish, *Schilbe mystus* in South-Western Nigeria by Adedolapo (2007) and for green jack *Caranx caballus* in the Mexico coast by Gallardo-Cabello *et al.* (2007). From the above mentioned studies it is obvious that biology or age and growth parameters of *G. oblongus* species have not been studied so far around the world waters and there is a necessity to analyze this species for proper management. Even though several other studies were pointed out age and growth parameters obtained have not been compared with that of *G. oblongus* in the present study as these examples have different body plan, life span and metabolic rate.

Literature review shows that the estimated values of L_∞ for different species of gerreids differ at different instances and also for the same species it differs at different times. It clearly expresses the variation of maximum length for different species of gerreids according to different geographical location (Sivashanthini and Khan, 2004; Pauly, 1978) and in different season (Pauly, 1978). Pauly (1978) calculated L_∞ values of 219, 269 and 329 mm for *G. filamentosus* at different time or season in Ambaro Bay. In an incidental study of *G. setifer*, it has been mentioned that from the length frequency studies *G. setifer* grew to about 110 mm when one year old and 175 mm when two years old whereas the maximum size collected was 225 mm (Patnaik, 1971). In the present study calculated L_∞ value for *G. oblongus* is 294 mm which is comparatively higher than other species of gerreids. It may be due to feasible geographical location, potential food supply and subsequently high growth rate occurred due to all feasible external as well as internal characteristics for *G. oblongus*.

The K value obtained is also awfully differing few of the previous records of congeners of this species. For example in a study by Pauly (1978) for *G. filamentosus* collected from Madagaskar, Ambaro bay the K value recorded as 2.6, 1.7 and 0.7 at different time (Table 1). Sivashanthini (2009) recorded K values of 1.45 and 1.50 for male and female *G. filamentosus*, respectively collected from Paragipettai waters, South India. In a similar study with *G. abbreviatus* collected from Paragipettai waters, South India K value of 1.3 and 1.36 for male and female, respectively were recorded (Kuganathan, 2006). These values are not in consistent with that of the present results that is these are obviously higher than the growth rate obtained in the present study. The variation could have been attributed due to different metabolic rate, energy transfer rate, food intake rate, trophic level etc. for this species. However taking into consideration the L_∞ and life span obtained in the present study the growth rate found to be more appropriate.

However K value obtained is in consistent with the study for *G. setifer* collected from Paragipettai waters, South India (Sivashanthini and Khan, 2004) where the authors recorded K values of 1.19 and 1.26 for male and female, respectively. Also it is in consistent with the K value of 1.1 obtained for *G. oyena* collected from Tanzania waters (Benno, 1992).

The 't_0' for *G. oblongus* was not known so far. The 't_0' values calculated in the present study from Pauly's empirical equation (Eq. 7) is higher than the values calculated for other species of gerreids for example *G. filamentosus* (Sivashanthini, 2009), *G. abbreviatus* (Kuganathan, 2006) and *G. setifer* (Sivashanthini and Khan, 2004). The variation of this value is due to the different values calculated for L_∞ and K since the Pauly's equation for estimation of 't_0' solely depends on L_∞ and K.

The growth parameter estimates obtained as L_∞ (29.4) and K (1)for *G. oblongus* was plotted on an 'auximetric' plot (Fig. 4) available in FishBase 2011 (Froese and Pauly, 2011) representing the log K versus log L_∞ values of 1300 species for which the above values are known. This was done to know the agreement of the estimated values (Fig. 4) with the known values. From the figures it can be observed the estimated values of the present study fall within the range of previously recorded values for congeners of this species. No work has been done on *G. oblongus* so far and therefore the values were plotted in the graph of *G. filamentosus* (Fig. 4).

Gunderson (1997) pointed out that high turnover rates or production per biomass (P:B) ratios derived from high annual growth rate of a fish. Fast growth rates, small asymptotic lengths indicate that the fish species in these waters mature early in life and have a short life span (Sparre and Venema, 1992). The life span reported for *G. filamentosus* in Madagascar waters was 1.6 years (Pauly, 1978). The result obtained in the present study for *G. oblongus* is 2.84 which is extremely higher than the life span of *G. filamentosus* collected from Madagascar waters. Perhaps it is due to the low growth rate recorded for *G. oblongus* in the present study.

The results obtained in the present study for *G. oblongus* shows the value for growth performance index (Ø) is 2.93. This value is lower than the growth performance index (Ø) estimated for *G. filamentosus* (Sivashanthini, 2009), *G. abbreviatus* (Kuganathan, 2006) and *G. setifer* (Sivashanthini and Khan, 2004) from the Parangipettai waters, South India. Even it shows comparatively low growth performance index, this species could also be considered as a fast growing species based on the value obtained.

Quantifying growth rate in fishes by fitting the von Bertalanffy asymptotic growth model to mean lengths at age derived from the otolith data is also an efficient method in fishery biology (Pitcher and Hart, 1982). However, this method is expensive and will not be effective for tropical fishes, for which the growth rings overlap. Therefore, length-frequency analysis becomes the

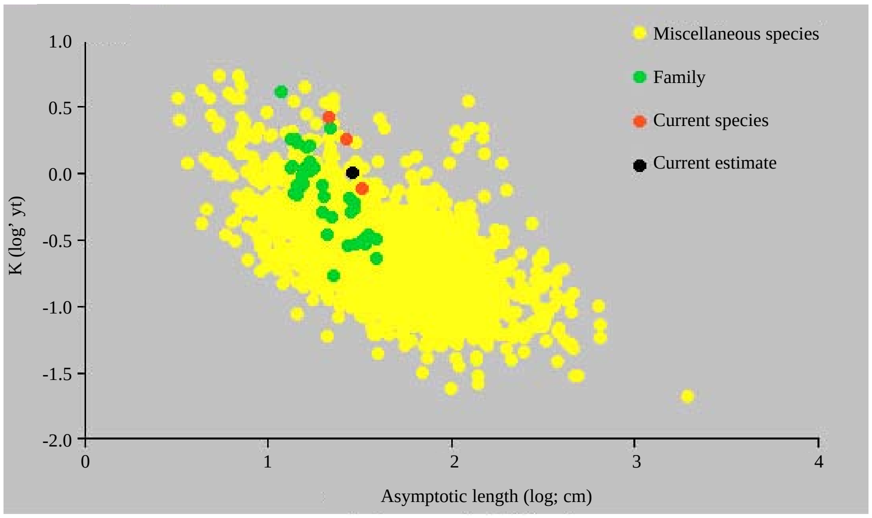

Fig. 4: Auximetric plot for *Gerres oblongus* and Gerreidae [n = 3 mean K = 1 Linf = 29.4] (The values obtained for *Gerres oblongus* plotted as black dot)

effective technique to quantify growth for tropical fishes. The growth parameters obtained in the present study are useful fundamental indicators for the population dynamics studies of the *G. oblongus*.

CONCLUSION

From the present study it is evident that the optimized values for K and L_∞ obtained by the ELEFAN I routine was 1.0 year^{-1} and 29.4 cm, respectively. The estimated 't_0' value was -0.151. The estimated growth performance index (Ø) was 2.93. The von Bertalanffy's growth equation for *G. oblongus* can be expressed as L_t = 29.4 [1-exp {-1.0(t+0.159)}]. Estimated longevity for *G. oblongus* calculated from Pauly's equation was 2.84.

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