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Study on the growth of three species of silverbellies from the South-East Coast of India

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Growth parameters were estimated for three species of silverbellies from the south-east coast of India, based on samples collected from trawl landings at Kasimedu Fisheries Harbour in Chennai. Asymptotic length L, annual growth co-efficient K and theoretical age of the fish at zero length t_0, were derived as 139.9 mm, 1.41 yr^{-1} and -0.119 yr for *Photopectoralis bindus*, 121.5 mm, 1.525 yr^{-1} and -0.01212 yr for *Secutor insidiator* and 166.65 mm, 1.3 yr^{-1} and -0.0159 yr for *Gazza minuta*. Average daily growth rate ranged between 0.45 mm and 0.13 mm in *P. bindus*, 0.34 mm and 0.03 mm in *S. insidiator* and 0.62 mm and 0.1 mm in *G. minuta*. At the end of the 1st and 2nd year of its life, *P. bindus* attains lengths of 110.5 mm and 132.3 mm, *S. insidiator*, 94.9 mm and 115.6 mm and *G. minuta*, 122.1 mm and 154.5 mm. Longevity was estimated as 2-2.2 yrs for *P. bindus* and *S. insidiator* and 2.4 yrs for *G. minuta*.

[**Keywords:** Growth, *Gazza minuta*, *Photopectoralis bindus*, *Secutor insidiator*, Silverbellies]

Introduction

Growth in an organism is defined as a measurement of body dimension at a given point of time, *i.e.* growth is expressed as a function of age[1]. Information obtained through these studies throw light on the population dynamics of that species as unit stock with reference to a specific geographic habitat. One of the major purposes of a study on growth is to determine the amount of fish that can be produced in terms of quantity (weight) in a body of water in relation to time[2]. Growth parameters are important in estimating food consumption of fish populations[3] and thus, in understanding the role of a particular fish in the ecological trophic network.

Silverbellies, slipmouths or ponyfishes (Family: Leiognathidae, Order: Perciformes) form an important component of the marine fisheries of several countries exploiting the coastal fishing grounds in the Indo-Pacific and the Western Central Atlantic oceans. In India, silverbellies are exploited chiefly by trawl nets, constituting about 80% of their total catch. Tamil Nadu accounts for more than 70% of the silverbellies landed along the Indian coast, followed by Kerala (9.5%), Andhra Pradesh (7.5%) and Gujarat (4.5%). Since silverbellies are an important component of trawl landings all along the Indian coast, it is essential to keep track of the abundance, availability and biological characteristics of these fishes and to assess the stock potential in terms of recruitment and spawning biomass. Several studies on age and growth in different species of silverbellies have been carried out from various parts of the world. The growth parameters for 6 species of silverbellies (genus *Leiognathus*) have been listed[4], based on length frequency analyses, and the interrelationships between mortality and growth parameters in fishes have also been derived[5,6]. Growth parameters of *L. equulus, L. splendens* and *L. bindus* (= *P. bindus*) have been described from different areas of the Indo-Pacific[6-15]. Most studies on age and growth of silverbellies from Indian waters pertain to the east coast of India, describing age and growth of *L. splendens*, *S. insidiator* and *G. minuta* from Porto Novo on the south-east coast of India[16], growth parameters of *L. jonesi* from Mandapam and Rameswaram[17,18], growth dynamics of *L. bindus* (= *P. bindus*) from the Kakinada coast[19], age and growth in *G. minuta* from Porto Novo[20], growth parameters of *S. insidiator* from the Kakinada coast[21], growth

performance of *L. dussumieri, L. berbis, S. insidiator* and *G. minuta* from Tuticorin coast[22] and population dynamics of *L. bindus* (= *P. bindus*) and *S. insidiator* from Visakhapatnam[23]. However, information available from the Chennai coast is scanty. Therefore, in the present study, the age and growth of three species of silverbellies, the orange fin ponyfish *Photopectoralis bindus* (Valenciennes, 1835), the pugnose ponyfish, *Secutor insidiator* (Bloch, 1787) and the tooth pony, *Gazza minuta* (Bloch, 1795), was assessed, based on samples collected from trawl landings at Kasimedu Fisheries Harbour in Chennai.

Material and Methods

Weekly length (Total Length, TL in mm) frequency data collected from commercial trawl landings at Kasimedu Fisheries Harbour (Chennai) during the period from January 2004 to February 2006 were used for the study. On account of trawl ban in May, requisite data were not obtained in May 2004 and May 2005. Due to a temporary halt in fishing activities following the tsunami that struck the Chennai coast on 26th December 2004, data could not be obtained for January and February 2005, either. However, in order to obtain an average annual length composition, data collected in the months of January and February 2006 were used while pooling the month-wise data. The number of samples measured to generate the length frequency distribution was 4465 for *P. bindus*, 1380 for *S. insidiator* and 3163 for *G. minuta*.

Monthly size distribution of *P. bindus*, *S. insidiator* and *G. minuta* were constructed from the weekly length frequency data. Since males and females could not be distinguished externally, the length frequency could not be constructed sex-wise. The frequency was distributed in length classes of 5 mm intervals. The data obtained for each sample was raised to the day's catch and subsequently to the month's catch[24]. Monthly length composition data so obtained was sequentially arranged for two years and used for estimation of growth parameters and age at length.

Identification of cohorts and separation of modes for Modal Progression Analysis was done on the pooled length frequency data of each species by Bhattacharya Method using the FiSAT software package[25]. Mean lengths of the identified cohorts were then used to trace the progression of modes over monthly intervals, and thus the lengths were related to the age difference between the cohorts. Length-at-age data thus generated was used to estimate the von Bertalanffy growth parameters, $L\infty$ and K, for each species using the Ford-Walford plot[26,27] and the Gulland and Holt plot[28]. These estimates were used to arrive at the final values which gave better goodness of fit for the growth curve generated from the restructured length frequency data using the ELEFAN I (Electronic Length Frequency Analysis) programme in the FiSAT Computer package[25].

The von Bertalanffy mathematical growth model expresses length 'L' as a function of age, 't'. The growth curve of a fish can thus be traced from the von Bertalanffy growth equation –

$$L_t = L_\infty [1-e^{-K(t-t_0)}]$$

The value of t_0, the theoretical age at which the length of the fish is '0', was estimated by rearranging the von Bertalanffy equation[29] :

$$-\ln (1- L_t / L_\infty) = -Kt_0 + Kt$$

where K is the slope (= b) and $-Kt_0$ is the intercept (= a) and, t_0 = -a/b. The longevity of each species was estimated using the equation :

$$t_{max} = 3/K$$

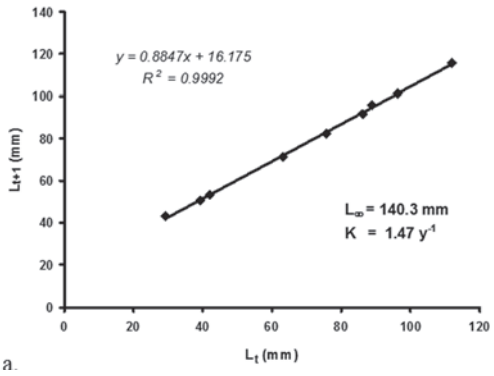
Results and Discussion

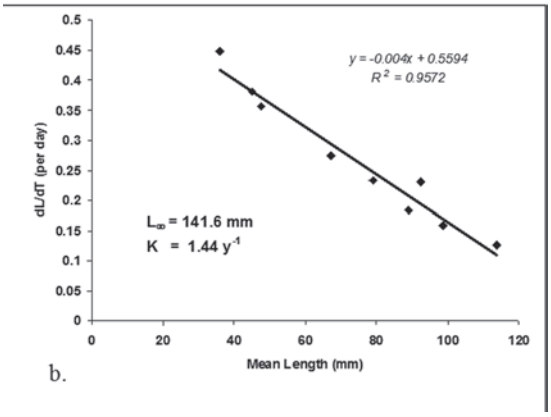
Age and growth in L. bindus

The length range of *P. bindus* in the commercial trawl landings at Chennai during the study period was 10-135 mm and the maximum size recorded (L_{max}) was 133 mm. Mean lengths of the monthly distribution of components separated by Bhattacharya analysis are given in Table 1. Average daily growth rate in *P. bindus* varied from 0.45 mm in fish of 36 mm length to 0.13 mm in fish of 113 mm length. By the Ford-Walford method, the value of $L\infty$ for *P. bindus* was obtained as 140.3 mm and annual growth co-efficient K was obtained as 1.47 yr^{-1} (Fig. 1a). Gulland and Holt plot (Fig. 1b) indicated the values of L_∞ and K as 141.6 mm and 1.44 yr^{-1}, respectively. Value of t_0 estimated by reverse calculation using the von Bertalanffy growth equation was -0.119 yrs. From

Table 1. Mean modal length values (in mm) obtained for *L. bindus* from Bhattacharya Analysis on pooled length frequency data *(Jan 2004 - Feb 2006)*

Month	Mean modal length (mm)					
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
January	39.31	60.29	75.65	99.81		
February	29.19	51.37	63.07	76.42	104.3	
March	74.51	93.7	110.98			
April	60.78	84.02	101.97	115.09		
May						
June	55.5	69.9	104.21			
July	44.21	71.05	83.07			
August	47.07	64.69	79.86	96.47	125.5	
September	18	41.35	60.5	74.55	88.68	105.59
October	18	37.33	74.15	106.77		
November	47.6	74.62	95.14	113.67		
December	20.5	44.28	64.34	84.83		





the output of the ELEFAN I analysis (Fig. 1c), L_∞ and K for *P. bindus* were estimated to be 139.9 mm and 1.41 yr^{-1}, respectively. The von Bertalanffy growth equation for *P. bindus* off Chennai was thus derived as :

$$L_t = 139.9\ [1\text{-}e^{-1.41\ (t\ +\ 0.119)}]$$

Based on this, it is estimated that the fish attains lengths of 81.1 mm, 110.5 mm, 125.1 mm and 132.3 mm at the end of 0.5, 1.0, 1.5 and 2.0 years in its life. The longevity of *P. bindus* was estimated to be 2.04, 2.08 and 2.12 years using K-values obtained by the Ford-Walford, Gulland and Holt and ELEFAN I methods, respectively. Therefore it is concluded that *P. bindus* has a maximum life span of 2 to 2.2 years.

Age and growth in S. insidiator

Length range of *S. insidiator* in the commercial trawl landings at Chennai during the study period was

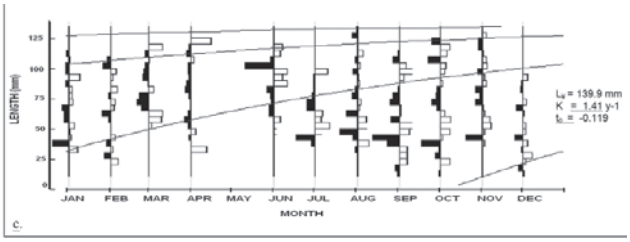


Table 2–Mean modal length values (in mm) obtained for *S. insidiator* from Bhattacharya Analysis on pooled length frequency data *(Jan 2004 - Feb 2006)*

Month	Mena modal length (mm)				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
January	23	44.75	67.55	-	-
February	25.5	55.5	73.8	94.91	-
March	64.16	97.22	105.16	-	-
April	67.55	81.73	-	-	-
May					
June	10.5	28.43	55.5	79.36	94.66
July	64.55	78.75	-	-	-
August	45.5	73.8	-	-	-
September	86.87	104.89	-	-	-
October	25.5	81.4	98.14	-	-
November	63.99	88.15	-	-	-
December	49.45	76.26	95.62	112.06	-

10-120 mm and the L_{max} was 118 mm. Mean lengths of the monthly distribution of components separated by Bhattacharya analysis are given in Table 2. Average daily growth rate in *S. insidiator* varied from 0.34 mm in fish of 53 mm length to 0.03 mm in fish of 110 mm length. By the Ford-Walford method (Fig. 2a) the values of L_∞ and K for *S. insidiator* were obtained

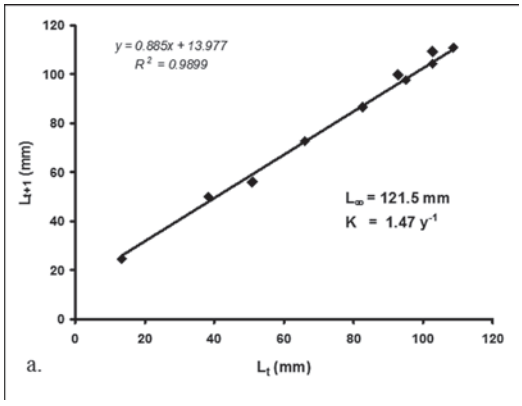
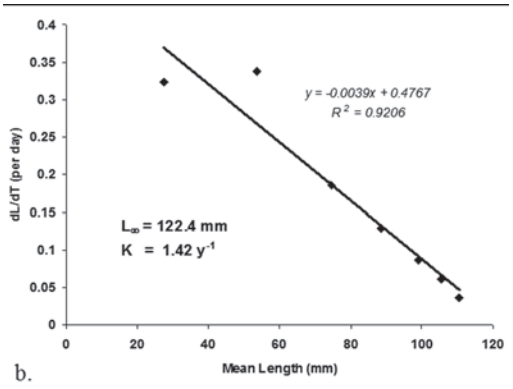
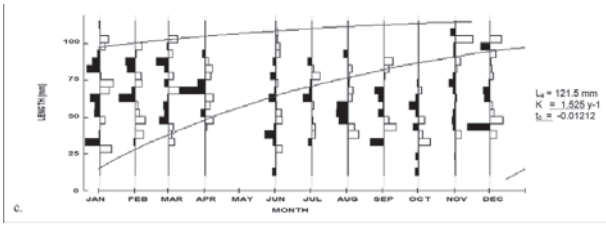


Fig. 1—Estimation of von bertalanffy's growth parameters for Photopectoralis bindus by
a. Ford-Walford method



b. Gulland-Holt method



c.ELEFAN method

as 121.5 mm and 1.47 yr^{-1}, respectively. Gulland and Holt plot (Fig. 2b) indicated the values of L_∞ and K as 122.4 mm and as 1.42 yr^{-1}, respectively. The value of t_0 was estimated as -0.01212 yrs. From the output of the ELEFAN I analysis (Fig. 2c) L_∞ and K for *S. insidiator* were estimated to be 121.5 mm and 1.5 yr^{-1}, respectively. Von Bertalanffy growth equation for *S. insidiator* off Chennai was thus derived as :

$$L_t = 121.5\ [1\text{-}e^{-1.5\ (t + 0.01212)}]$$

Based on this it is estimated that *S. insidiator* attains lengths of 65.1, 94.9, 108.9, and 115.6 mm at the end of 0.5, 1.0, 1.5 and 2.0 years in its life. Longevity was estimated to be 2.04, 2.11 and 2 years using K-values obtained by the Ford-Walford, Gulland and Holt and ELEFAN I methods, respectively. Therefore it is concluded that *S. insidiator* has a maximum life span of 2 to 2.2 years.

Age and growth in G. minuta

The length range of *G. minuta* in the commercial trawl landings at Chennai during the study period was 15-160 mm and the maximum size recorded was 159 mm. Mean lengths of the monthly distribution of components separated by Bhattacharya analysis are given in Table 3. Average daily growth rate in

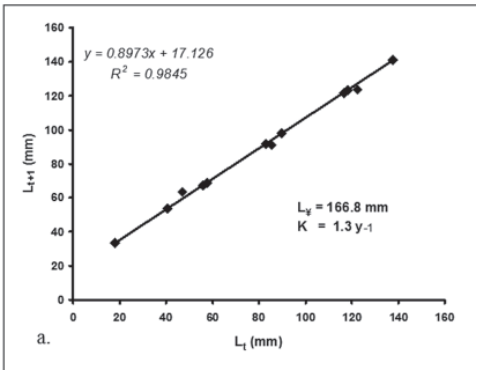
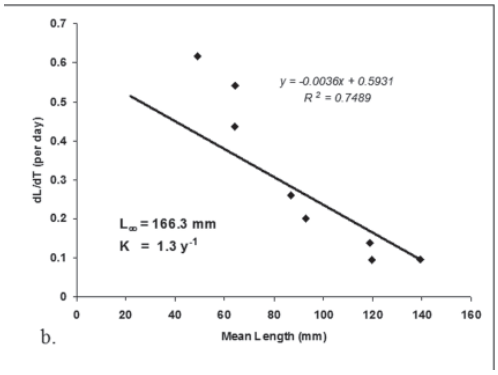


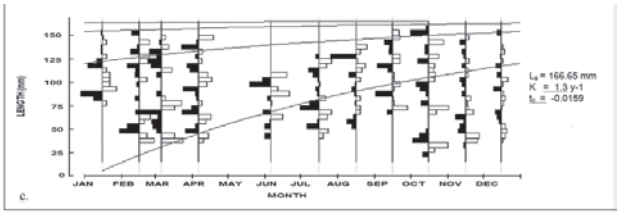
Fig. 2—Estimation of von bertalanffy's growth parameters for Secutor insidiator by
a. Ford-Walford method



b.Gulland-Holt method

Table 3–Mean modal length values (in mm) obtained for *G. minuta* from Bhattacharya Analysis on pooled length frequency data *(Jan 2004 - Feb 2006)*

Month	Mean modal length (mm)				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
January	86.62	119.56	133.93	148.66	-
February	49.96	109.88	133.01	-	-
March	57.55	105.5	122.76	141.62	-
April	49.89	70.3	91.31	117.12	137.96
May					
June	55.5	83	99.55	-	-
July	54.89	75.36	93.2	109.17	-
August	59.63	80.12	95.34	127.57	-
September	81.1	112.25	140.56	-	-
October	40.5	80.63	94.02	121.88	150.5
November	55.87	89.86	103.57	118.2	135.39
December	66.62	92.85	110.13	125.5	-



c.ELEFAN method

G. minuta varied from 0.62 mm in fish of 49 mm length to 0.1 mm in fish of 139 mm length. Values of L_∞ and K for *G. minuta* were obtained as 166.8 mm and 1.3 yr^{-1} by the Ford-Walford method (Fig. 3a) and 166.3 mm and 1.3 yr^{-1} by the Gulland and Holt plot (Fig. 3b). Value of t_0 was estimated as -0.0159 yrs. From the ELEFAN I analysis (Fig. 3c), L_∞ and K for *G. minuta* were estimated to be 166.65 mm and 1.3 yr^{-1}, respectively. Von Bertalanffy growth equation for *G. minuta* off Chennai was thus derived as :

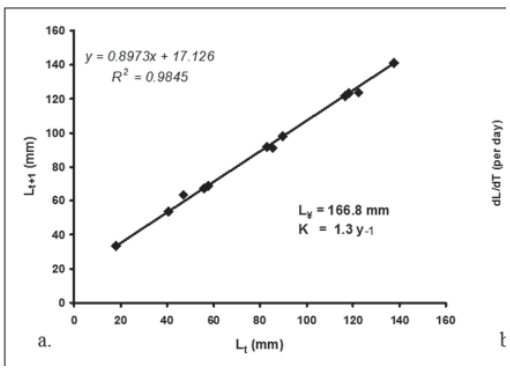
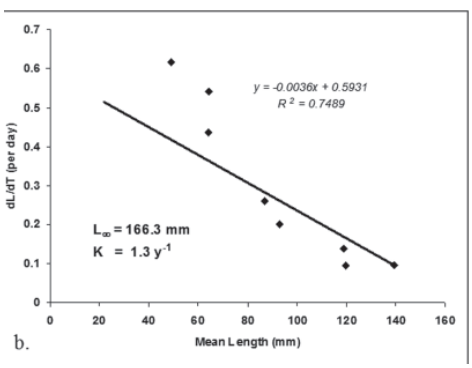
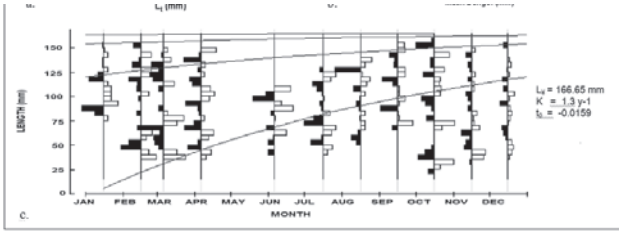


Fig. 3—Estimation of von bertalanffy's growth parameters for Gazza minuta by a.Ford-Walford method



b.Gulland-Holt method



c.ELEFAN method

$$L_t = 166.65\ [1\text{-}e^{-1.3\ (t\ +\ 0.0159)}]$$

From this equation, it was estimated that *G. minuta* attains lengths of 81.3, 122.1, 143.4 and 154.5 mm at the end of 0.5, 1.0, 1.5 and 2.0 years in its life. Longevity was estimated to be 2.31 years using K-values obtained by the Ford-Walford, Gulland and Holt and ELEFAN I methods and therefore it is concluded that *G. minuta* has a maximum life span of about 2.4 years.

Generally in nature, the oldest fish in the stock grows to reach about 95% of the asymptotic length[30,31]. Assuming that the maximum size observed in the fishery is 95% of the asymptotic length, the L_∞ works out theoretically to 140 mm for *P. bindus*, 124.2 mm for *S. insidiator* and 167.4 mm for *G. minuta*. These values conform to the estimates obtained by the Ford-Walford, Gulland and Holt and ELEFAN I methods. Estimates of growth parameters obtained for these species in the present study are listed along with estimates reported from other parts of the Indo-Pacific, for comparison, in Table 4. These results indicate that the asymptotic length ranges between 121 and 167 mm in the case of *P. bindus*, 120 and 140 mm in *S. insidiator* and 135 and 183 mm in *G. minuta*. Among the three species, *S. insidiator* shows the smallest range width. A comparison of the

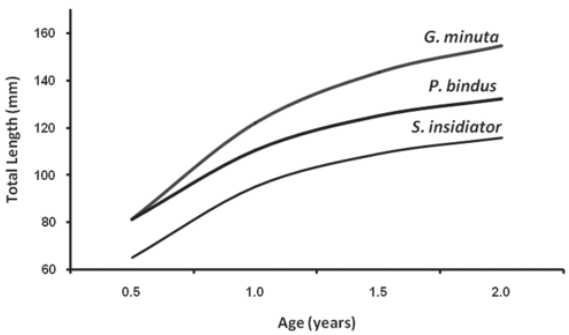


Fig. 4—Comparison of length-at-age of P. bindus, S. isidiator and G. minuta

Table 4–Comparison of growth parameters of *P. bindus*, *S. insidiator* and *G. minuta* from different regions

Species	Growth parameters			Locality	Author & Year
	L_∞ (mm)	K (yr^{-1})	t_0 (years)		
P. bindus	125	1.38		Java	Dwiponga *et al*., 1981
	122	1.3		Calicut	Pauly, 1982***estimated from the data of Balan, 1963*
	121	0.98		Samara Sea	Silvestre, 1986
	158.4	0.58	-0.024	Kakinada	Murty, 1986
	153-167	0.9-0.96		Madras	Murty *et al*., 1992
	154-165	0.77-0.7		Kakinada	-do-
	151-163	0.9-0.95		Visakhapatnam	-do-
	148	0.88		Visakhapatnam	Rajkumar, 2006
	139.9	1.41	-0.119	Chennai (Madras)	Present study
S. insidiator	123	1.2	-0.01	Kakinada	Murty, 1990
	120			Porto Novo	Jayabalan, 1991
	125.5-138	1.22-1.3		Madras	Murty *et al*., 1992
	125-130	1.06-0.85		Kakinada	-do-
	120-130	1.2-0.85		Visakhapatnam	-do-
	122-124	2.5-3.16	-0.018 to -0.0007	Tuticorin	Nagarajan, 2000
	140	0.96		Visakhapatnam	Rajkumar, 2006
	121.5	1.5	-0.01212	Chennai (Madras)	Present study
G. minuta	140	1.1		San Miguel Bay (Philippines)	Ingles and Pauly, 1984
	160	0.8649	-0.02316	Porto Novo	Jayabalan and Ramamoorthi, 1986
	173-183	1.6764-2.0	0.0152 to -0.0019	Tuticorin	Nagarajan, 2000
	135	0.85		Brunei	Silvestre and Garces, 2004
	166.65	1.3	-0.0159	Chennai (Madras)	Present study

length-at-age growth curves of the three species is presented in Fig. 4. From this it is evident that *P. bindus* and *G. minuta* have similar growth rates initially, but by the end of the first year, *G. minuta* attains greater length. *S. insidiator*, on the other hand is smaller and shows lower length-at-age in comparison with the other two species, throughout its life span.

Silverbellies are small to medium-sized tropical fishes with short life spans averaging 1-2 years. In general, short-lived fishes have small L_∞ and high K while long-lived fishes tend to have high L_∞ and low K values[32]. Faster growth rates are also a common feature among tropical fishes in comparison to temperate fishes. Results of the present study indicate that *P. bindus*, *S. insidiator* and *G. minuta* have short life spans, small values of L_∞ and high values of K.

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