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Length weight relationship and biology of *Thryssa setirostris* (Broussonet 1782) from the coast of Thoothukudi, Tamil Nadu, India

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Original Article

Abstract

The present study reports length-weight relationship and biological aspects of *Thryssa setirostris* from Thoothukudi coastal waters during the period September 2016 to July 2017. *T. setirostris* is an important trawl by-catch landing at Thoothukudi. The largest size observed for *T. setirostris* was 14.5 cm total length, weighing 22.74 g. The value of growth constant a= 0.0107 and b= 2.8801. The overall ratio of males and females was 1:1. Minimum size of maturity of the species was 11.3 cm and more than 50% of species were found to be mature at 11.5 cm. Fecundity ranged from 3057 to 16395 ova in fish measuring 11.4 to 13.9 cm in total length respectively. The von Bertalanffy growth parameters $L\infty$, K and t_0 were 15.02 cm, 1.40 and -0.1365 respectively. The estimated total instantaneous mortality co-efficient (Z) of *T. setirostris* was 4.60 and the fishing mortality co-efficient (F) was 1.83. The species is under-exploited along the Thoothukudi coast.

Keywords*: Thryssa setirostris, age, growth and mortality parameter, reproductive biology*

Introduction

Anchovies are typically marine coastal and schooling fishes, occurring in all seas from about 60° N to 50° S (Whitehead *et al*., 1988). They belong to the family Engraulidae under order Clupeiformes with 151 species and 17 genera (Eschmeyer *et al*., 2017). This group includes famous fisheries like Peruvian anchovy, Californian anchovy and Japanese anchovy. Anchovies are forming significant catch of the marine fish landed along the coastal states of India and also known as whitebaits or the whitebait anchovy in the southern states of India; common name applied to the fishes of the genera, *Stolephorus* Lacepede 1803 and *Encrasicholina* Fowler, 1938 (Luther *et al*., 1992; Gopakumar and Pillai, 2000; Jayaprakash, 2003). 34 species of anchovies were reported from Indian waters belonging to five genera, viz., *Stolephorus*, *Coilia*, *Setipinna*, *Thryssa* and *Encrasicholina* (Gopi and Mishra, 2015). Most anchovies are marine rarely occurring in freshwater but around 17 species are freshwater, occasionally entering brackishwater (Nelson, 2006).

Length-weight relationship (LWR) is an important factor in the biological study of fish and their stock assessments (Santhoshkumar *et al*., 2014). The study helps to determine mathematical correlation between two variables and to calculate the variation from the expected weight for length

of the individual fish (Le Cren, 1951). In general, an increase in length of the fish implies that there is an increase in the body weight. In tropical and subtropical waters the growth fluctuation is more frequent in fishes due to variation in seasons, multiple spawning and food composition (Shingadia, 2014). The length weight relationship of *Thryssa dayi* and *Thryssa malabarica* (Roul *et al.*, 2017), *Thryssa dussumieri* (Hoda, 1976), *Thryssa purava and Thryssa polybranchialis* (Karna, 2017) and *Thryssa mystax* (Venkataraman, 1956; Abdurahiman *et al.*, 2004; Bandana *et al.*, 2017; Karna, 2017) were studied. Length-weight relationship of other anchovies such as *Stolephorus commersonnii* (Abdurahiman *et al.*, 2004; Nair *et al.*, 2015), *S. waitei* and *Encarsicholina devisi* (Luther, 1990; Luther *et al.*, 1992 and Rohit and Gupta, 2008) were studied from the Indian coast. Studies on the biological aspects of different *Thryssa sp.* along the Indian coast are limited to, *T. purava* (Marichamy, 1970, 1972) and *T. mystax* (Venkataraman, 1956). The growth and mortality parameter of *T. dussumieri* (Mahajan, 1983; Pawase *et al.*, 2018) and *T. mystax* (Kende, 2016) along Ratnagiri coast were studied.

Information on length - weight relationship and biological aspects of *Thryssa setirostris* is available from other region of Indian coast (Palekar and Karandikar, 1952; Hoda, 1976; Hoda, 1983; Hussain and Ali, 1987; Rao, 1988; Abdurahiman *et al.*, 2004; Rohit and Gupta, 2008; Nair *et al.*, 2015; Karna, 2017; Roul *et al.*, 2017; Pawase *et al.*, 2018). However, information on age, growth, mortality parameters, reproductive biology and fishery of *T. setirostris* is lacking along the coast of Thoothukudi in Gulf of Mannar region of India. Therefore, the present study was undertaken to investigate some biological aspect and length- weight relationship of the species along the coast.

Material and methods

A total of 547 anchovy specimens were collected on weekly interval from Threspuram (8°48′ N, 78°9′ E) Thoothukudi fishing harbor (8°47′ N, 78°9′ E), Punnakayal (8°38′ N, 78°7′ E) and Veerapandiyapattinam (8°31′ N, 78°7′ E) sampling centers along the Thoothukudi coastal waters of Tamil Nadu coast of India from September 2016 to July 2017 (Fig. 1). Collected specimens were brought to the laboratory and species confirmed according to Fischer and Bianchi (1984) and Whitehead *et al.* (1988) (Fig. 2).

The data on total length (length from tip of snout to tip of caudal fin) and weight of fish was recorded. Length was measured to nearest 0.1 cm and weight to nearest 0.1 g. The length-weight relationships were estimated from the allometric formula proposed by Le Cren (1951).

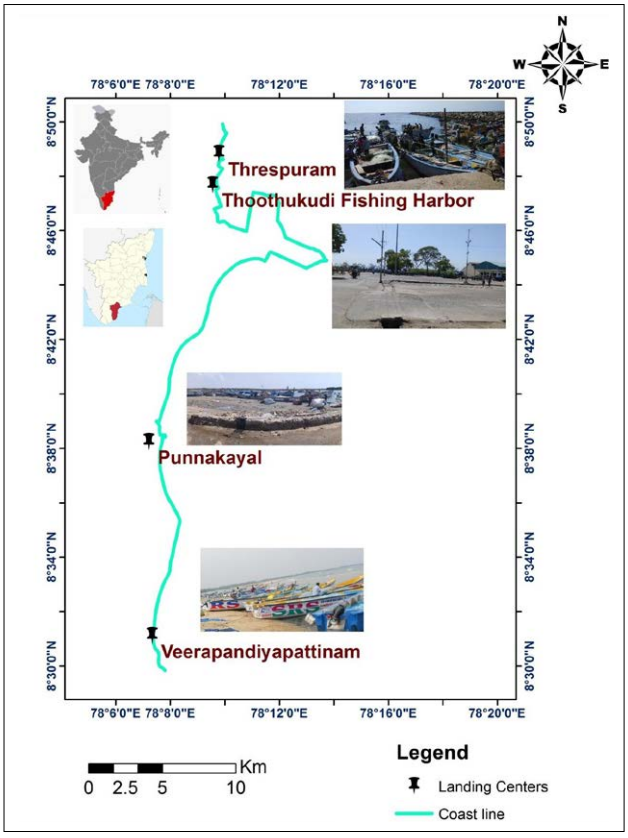

Fig. 1. Fish landing centers along the Thoothukudi Coast

Fig. 2. *T. setirostris* collected from the Thoothukudi coast

$W = aL^b$

Where W = weight in grams, L = total length in centimetres, 'a' is a scaling constant and 'b' the allometric growth parameter.

Algorithmic transformation was used to make the relationship linear:

Log W = Log a + b * Log L

Maturity stages were determined based on the macroscopic appearance, size of gonads (relative length and weight) in relation to body cavity (Venkataraman, 1956).

Stage I, 'Immature': testes bilobed, asymmetrical, thin, whitish, transparent stripes extending less than half the length of the body cavity. Ovaries were bilobed, asymmetrical, thin-walled, whitish, extending less than half the length of the body cavity. Oviducts thin and long. Ova whitish, transparent, traces of yolk discernible under high power.

Stage II, 'Developing': testes elongated, whitish, asymmetrical, transparent, and extending a little more than half the length or body cavity. Ovaries enlarging, asymmetrical, extending half the length of body cavity. Ova small, yolk visible under low power.

Stage III, 'Maturing': testes more enlarged than before, opaque, asymmetrical, extending about 2/3th length of body cavity. Blood vessels spread on surface. Ovaries more enlarged than before, granular appearance, asymmetrical, extending more than half the length of body cavity. Ova visible to the eye.

Stage IV, 'Mature': testes enlarged, massive, asymmetrical, extending about ¾ or more of the length of body cavity. Blood vessels spread on the surface. Ovaries creamy, anterior and occasionally yellowish, asymmetrical, extending to about 3/4th length of body cavity. Granular appearance, blood vessels spread on the surface. Ova visible to the eye.

Stage V, 'Matured': testes massive, well developed, and extending about the entire length of body cavity. Viscous fluid is present. Ovaries creamy, asymmetrical, extending more than 3/4th length of body cavity- Ova large and transparent.

Stage VI, 'Running': testes same as in the stage V, extending over the entire length of body cavity. Ovaries creamy or yellowish, asymmetrical, extending over the entire length of body cavity. Ova large, can be extruded after considerable pressure on belly.

Stage VII, 'Spent': testes shrunken, flabby, reduced in size, extending about half the length of body cavity. Ovaries dull red or reddish, shrunken, extending about half the length of body cavity. Few large ova present.

For determining the length at first maturity, fish in stage IV and V were considered as mature. The length group at which more than 50% of the fish attained maturity was considered as length at first maturity.

Fecundity of fish is described as seasonal spawning potential and alternatively is defined as the number of eggs ripening between current and next spawning period in a female (Zamidi *et al*., 2012). Fecundity is calculated as the number of eggs carried by the female. For the estimation of fecundity, eggs of each ovigerous females were weighed manually to the nearest 0.01 g and counted manually under the magnifying lens. The average number of eggs in the sub samples was then multiplied by the total weight of the egg mass to obtain the total number of eggs for an individual.

$F = nG/g$

Where F= fecundity, n= number of eggs in subsample, G= weight of gonad and g= weight of subsample.

In order to find whether any relationship exists between fecundity and length of fish and weight of fish, the observed values were plotted in scatter diagram. The relationship was estimated using the least square method. Regression equation of length and weight in relation to fecundity were described as follows (Varghese, 1980):

$\text{Log } F = a + b \log L$ and $\text{Log } F = a + b \text{ Log } W$

Where F = fecundity, L= length of fish and W = weight of fish

von Bertalanffy growth parameters like asymptotic length ($L\infty$) and growth coefficient (K) were estimated using the ELEFAN I (Electronic Length Frequency Analysis) module of FISAT software (Gayanilo *et al*., 2005). $Lt = L_{\infty} (1 - e^{-k(t-t0)})$ Where $L\infty$ = asymptotic length, K= growth coefficient t = age at given length and t_0= age at length zero

Pauly and Munro's (1984) growth performance index (φ') was computed (phi-prime $\varphi' = \log K + 2 \log L\infty$) using Von Bertalanffy growth parameters K and $L\infty$. The t_0 value was calculated using the formula (Pauly, 1980)

$\log (-t_0) = -0.3922 - 0.2752 \log L\infty - 1.038 \log K$

Total instantaneous mortality rate (Z) was estimated by length converted catch curve method using FiSAT. Natural mortality (M) was estimated by Pauly's (1980) equation considering the mean annual habitat temperature (29.5 ^{0}C), $L\infty$ and K for *T. setirostris*. The co-efficient of fishing mortality (F) was derived using the relationship $Z = F + M$. The exploitation rate (E) was obtained by dividing F by Z (Gulland, 1979).

Results

Among the collected specimens, the smallest size recorded was 8.9 cm TL with 4.98 g weight, largest size was 14.5 cm TL with 22.74 gm weight and average size of 11.4 cm. The number of specimen in different length group is shown in Fig. 3.

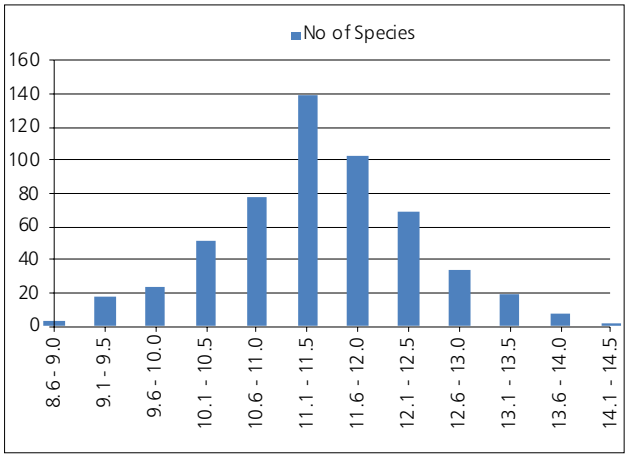

Fig. 3. Number of *T. setirostris* in different length group

The relationship between the total length and weight of *T. setirostris* was calculated. The parabolic and logarithmic equations were as follows

$W = 0.0107\ L^{2.8801}$; $Log\ W = -1.9706 + 2.8801\ Log\ L$

where a = 0.0167 and b = 2.8801. The 'b' value was less than the ideal 'b' (3) value which means the *T. setirostris* exhibits negative allometric growth pattern based on student's t test. The curve for the length weight relationship is presented in the Fig. 4. The coefficient of determination is 0.93, which indicates a significant relation between the length and weight of the species.

The sex ratios of population have been used as an indicator of the population's ability to sustain ongoing recruitment. The average sex ratio of *T. setirostris* was 1:1 (Male: Female). For the estimation of size at first maturity in *T. setirostris* fish having maturity stage IV and above stages were taken as mature fish. We observed that all specimens were immature up to 10.0 cm in *T. setirostris*. Mature fishes were recorded for the first time at 11.3 cm size group and more than 50% of species were found to be mature at 11.5 cm.

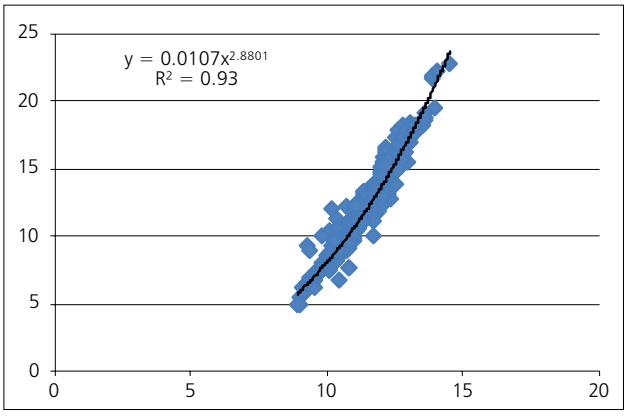

Fig. 4. Length-weight relationship of *T. setirostris*

Number of ova were counted from the ovaries of specimens belonging to IV or VI stages of sexual maturity and were used for fecundity estimation of *T. setirostris*. Fecundity varied from 3057 ova in a fish measuring 11.4 cm (TL) and 13.15 g weight to 16395 ova in fish of 13.9 cm (TL) and 21.83 g weight. In order to find whether any relationship exists between fecundity and length and weight of fish, the observed values were plotted in a scatter diagram (Figs. 5 and 6). The relationship was estimated by using the least square method. A regression equation of length and weight in relation to fecundity of *T. setirostris* were described as follows:

$Log\ F = 0.0006 + 3.8713\ Log\ L$, ($R^2 = 0.2802$)

$Log\ F = 0.6568 + 0.9782\ Log\ W$, ($R^2 = 0.1766$)

Where F = fecundity, L = Total length of fish and W = weight of fish. The fecundity of *T. setirostris* in relation to length and weight of fish indicates that the fecundity of the species does not indicate any correlation between the parameters.

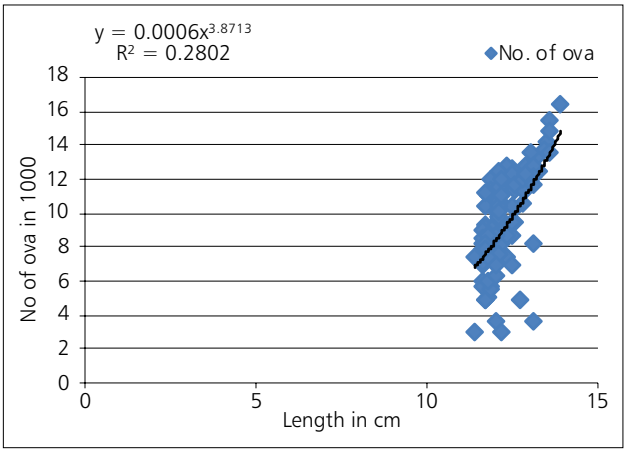

Fig. 5. Fecundity of *T. setirostris* in relation to length of fish

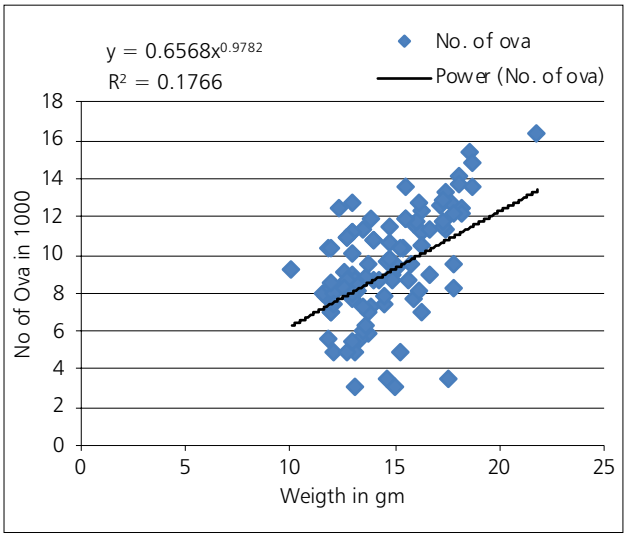

Fig. 6. Fecundity of *T. setirostris* in relation to weight of fish

Table 1. Estimated lengths at different age of *T. setirostris* by fitting Von Bertalanffy growth parameters

Age (t) (years)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Length at given age (in cm)	8.9	12.0	13.5	14.3	14.6	14.8	14.9	15.0

The growth parameters, asymptotic length (L∞) and growth coefficient (K) were estimated using the ELEFAN I programme. The asymptotic length (L∞) was estimated as 15.02 cm and growth co-efficient (K) was 1.4. The length at first capture (Lc) was estimated to be 10.74 cm. The estimated t_0 value was -0.1365, thus the von Bertalanffys equation is derived as: $L(t) = 15.02 * [1- \exp^{\{1.4\,[t - (-0.1365)]\}}]$. Based on the von Bertalanffy growth parameters the estimated length at different ages for species are given in Table 1 and growth curve of species by fitting von Bertalanffy growth parameters represented in Fig. 7.

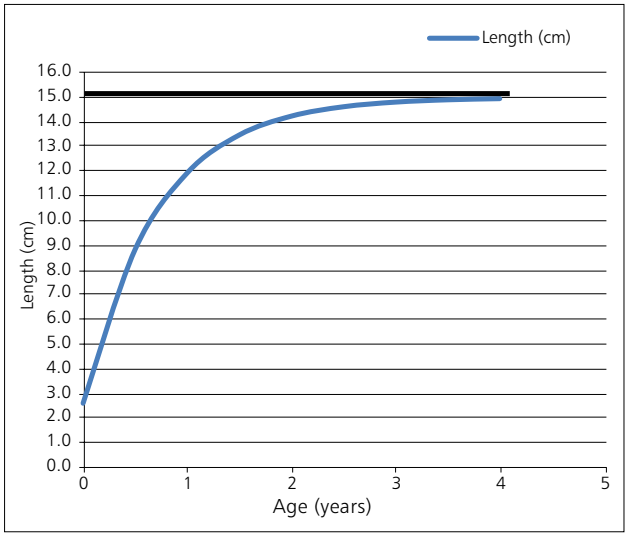

Fig. 7. Growth curve of *T. setirostris*

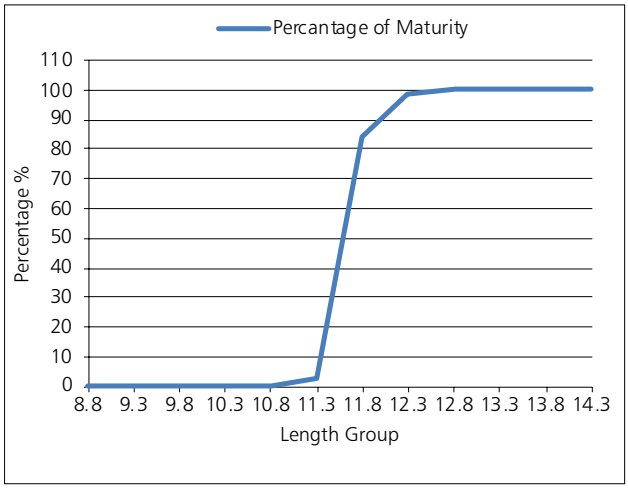

Fig. 8. Length converted catch curve of *T. setirostris*

The estimated total mortality coefficient (Z) value of *T. setirostris* by length converted catch curve method was 4.60 (Fig. 8) and the natural mortality (M) estimated through Pauly's empirical formula was 2.77. The fishing mortality co-efficient (F) was 1.83 and the estimated exploitation ratio was 0.40.

Discussion

In the present study, the largest size observed was 14.5 cm in total length, which is lower than the earlier reports of Munroe and Nizinski (1999) from Western Central Pacific. The length weight relationship of an ideal fish precisely follow the cube law and the value of exponent 'b' in the cube law will become exactly 3 if the fish retains the same shape and specific gravity and grows isometrically during their lifetime (Nair *et al.*, 2015). Allan (1938) reported that such an ideal fish with b value 3 is very difficult to observe in the natural environment. The change in the b value mostly reflects the change in the body form when the weight of the fish is affected by environmental factors likes temperature, food supply, and spawning condition (Nair *et al.*, 2015). Length weight relationship (LWR) is used for estimating the weight corresponding to a given length, and condition factors are used for comparing the condition, fatness, or well-being of fish, based on the assumption that heavier fish of a given length are in better condition (Froese, 2006).

The estimated b value of *T. setirostris* was within the range 2.5-3.5 as per Froese (2006). The estimated slope value (b value) of *T. setirostris* was 2.8801 which indicates that species exhibits negative growth pattern. Similarly Bandana *et al.* (2017) also observed negative allometric growth for *T. mystax* along the Portonovo coast, Tamil Nadu. The earlier reports on estimation of length-weight relationship of *T. dayi*, *T. hamiltonii, T. malabarica* and *T. mystax* revealed that these species exhibit positive allometric growth pattern (Hoda, 1976; Hoda, 1983; Hussain and Ali, 1987; Abdurahiman *et al.*, 2004; Roul *et al.*, 2017). Karna (2017) reported positive allometric growth pattern for *T. purava*, *T. polybranchialis* and *T. mystax* from Chilika lagoon. A positive allometric growth was also reported for other anchovies such as *S. commersonnii*, *S. indicus*, *S. waitei* and *E. devisi* (Rao, 1988; Luther, 1990, Abdurahiman *et al.*, 2004; Rohit and Gupta, 2008; Musarratulain *et al.*, 2015). Length weight relationship of *C. dussumieri* along the Indian coast exhibit negative allometric growth (Amin and Zafar, 2004; Shingadia, 2014).

The previous studies of Rao (1988) stated in *S. devisi* a significant dominance of male observed during the months of January, March, October, November and December. Gadgil (1967)

reported that males were dominant in the higher length groups in *C. dussumieri*, because the female migrates to offshore grounds at smaller size. Marichamy (1970) reported that the females formed high percentage in most of months for *T. baelama*. Present study indicated that there is no significant variation in sex ratio (1:1) for *T. setirostris*. Length at first maturity of *T. setirostris* was estimated at 11.5 cm TL. The size at first maturity for *T. dussumieri* was 12.5 cm from Pakistan coast (Hoda, 1976), *T. hamiltonii* 14.6 to 15.5 cm from Bombay waters (Masurekar and Rege, 1960), *T. purava* 17.0 cm (Palekar and Karandikar, 1952) and for *T. mystax* was 14.0 to 15.0 cm (Venkataraman, 1956) and 14.0 cm from northern Arabian Sea (Hoda, 1982) indicate that these species mature in larger size groups than *T. setirostris*. *T. bealama* attain first maturity at size, 11.7 cm from Andaman waters (Marichamy, 1970) which is slightly higher than *T. setirostris* in the present study.

The fecundity of *T. setirostris* was 3,057 ova in a fish measuring 11.4 cm (TL) to 16,395 ova in fish of 13.9 cm (TL). The length and weight of fish shows nearly significant correlation with fecundity. The estimated fecundity of *T. setirostris* in the present study was higher compared to earlier reports of *T. baelama* (Marichamy, 1970) and *T. dussumieri* (Hoda, 1976) and lower compared to *T. hamiltonii* (Masurekar and Rege, 1960), *T. mystax* (Hoda, 1982) and *T. purava* (Palekar and Karandikar, 1952).

In the present study, estimated growth parameter of *T. setirostris* was 15.02 cm ($L\infty$) and 1.4 per year (K). The asymptotic length ($L\infty$) for *T. setirostris* was lower, where growth coefficient (K) was higher compared to findings of other workers for different species of *Thryssa* such as *T. dussumieri* (Mahajan 1983; Pawase *et al*., 2018), *T. mystax* (Kende, 2016) along Ratnagiri coast and *T. vitirirostris* along Mozambique coast and Safala Bank respectively (Sousa and Gjosaete, 1987 and Mualeque and Santos, 2011). The t_0 was estimated to be -0.1365 year. The earlier reports on t_0 for *T. dussumieri* was 0.0185 year (Mahajan 1983), 0.0048 year (Pawase *et al*., 2018) -0.0036 year for *T. mystax* (Kende, 2016). t_0 has got smaller positive or usually smaller negative value.

The natural mortality of *T. setirostris* was higher than *T. dussumieri* (Pawase *et al*., 2018), *T. mystax* (Kende, 2016) and *T. vitrirostris* (Mualeque and Santos, 2011); the total mortality of *T. setirostris* compared to *T. dussumieri* (Pawase *et al*., 2018) and *T. mystax* Kende (2016) was lower and compared to *T. vitrirostris* was higher. The earlier studies on exploitation of *T. dussumieri* and *T. mystax* stated that this species are overexploited along the Ratnagiri coast where as the present study indicates that *T. setirostris* was under exploited along the Thoothukudi coast. Similarly, Santhoshkumar *et al.* (2011) and Vasantharajan *et al.* (2017) stated that *Nibea maculata* and *Lethrinus lentjan* were under-exploited in this region.

$Z/K = 1$ is considered as a thumb rule for a stock to be growth dominated. Whereas, if it is more than 2, it is considered as mortality dominated. Z/K was found to be 3.29 for *Thryssa setirostris* in the present study indicating the stock of the species as mortality dominated. The M/K ratio which should usually fall in the range of 1.0-2.5 (Beverton and Holt, 1959) often becomes a tool for verifying the accuracy of the estimate of natural mortality. In the present study, natural mortality (M) is estimated to be 2.77 giving M/K ratio of 1.98, which is within the range of 1.0-2.5 suggested for fishes.

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