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Length-weight relationship of six species of *Thryssa* with emphasis on the biology of *Thryssa mystax* from Indian waters

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Original Article

Abstract

The length-weight relationships (LWRs) of six species of the genus *Thryssa* (Cuvier, 1829) with special reference to the relative condition factor, sex ratio, and fecundity of *Thryssa mystax* (Bloch and Schneider, 1801) are reported from Indian water based on two years (2020-2022) study. Six species of *Thryssa* (N = 2023) were analysed, *Thryssa malabarica* (Bloch, 1795), *Thryssa setirostris* (Broussonet, 1782), *Thryssa vitrirostris* (Gilchrist and Thompson, 1908), which showed positive allometry while, *T. mystax*, *Thryssa dussumieri* (Valenciennes, 1848) and *Thryssa polybranchialis* (Wongratana, 1983) had negative allometry. The r^2 value of these six species varied from 0.8 to 0.99. Fulton condition factor for *T. mystax* at different months varied between 0.5-0.82 indicating poor health condition. The sex ratio of male to female *T. mystax* was 1:0.98, which was slightly biased towards the male. Overall sex ratios were found to be non-significant. The fecundity of *T. mystax* ranged from 1219 to 19782 eggs. This study provides basic biological information on the commercially important genus *Thryssa* from Indian waters as a valuable tool to assist fishery management studies.

Keywords: *Condition factor, fecundity, Indian waters, length-weight relationships*

Introduction

Anchovies belong to the family Engraulidae under the order *Clupeiformes* with 17 valid genera including *Thryssa* (Eschmeyer *et al.,* 2017). Genus *Thryssa* is a commercially important pelagic resource in India especially on the southwest and southeast coasts. There are 16 species reported from India and the major gear employed in their fishery are gill net and ring seines. The length-weight relationship is used in fishery biology for estimating an expected weight corresponding to the length. It is used to find the gonadal development and maturity of fish (Wootton, 2012) and also provides the weight corresponding to the given length (Tesch, 1968). The correlation parameter b<3 implies a decrease in condition or elongation with an increase in length, whereas b>3 implies an increase in condition or an increase in height or width with an increase in length (Hile, 1936). The term isometric growth b=3 indicates that the fish is characterized by an unchanging body form (Ricker, 1958). Estimates on the length-weight relationships of *T. mystax* and *T. polybranchialis* were done by Karna (2017). The length-weight relationship of *T. malabarica* (Roul *et al.,* 2017), *T. dussumieri* (Hoda, 1976) and *T. mystax* (Venkataraman, 1956; Abdurahiman *et al.*, 2004) and *T. setirostris* (Patadiya *et al.,* 2021) were also studied. The LWRs of fish are used to estimate growth information and the well-being of fish and also provide information on some biological parameters such as feeding, age, and maturity (Sonwal *et al.,* 2022). The maximum body length of fish may give useful information such as food supply, environmental quality and growth of fish (Hanif *et al.*, 2020; Habib *et al.*, 2021). Condition factor (K) is used to estimate the well-being of fish and helps to determine the seasonal maturity and age of fish (Tesch, 1968). K value 1.6 indicates good condition, K=1 indicates fish with poor health and below 0.80 shows extremely poor growth condition Barnham and Baxter (1998). The K value can be related to the maturity and development of fish. The condition factor can be used to determine fish growth in relation to the environment (Sunaryo, 2021).

The sex ratio is used to study basic information about reproductive potential and to estimate the stock size of a population. It helps to determine the ratio of the male to the female population. Panthulu (1961) reported that the sex ratio was correlated with spawning and behaviour. Gowda *et al.* (2016) determined the sex ratio of *T. mystax* from the Mangaluru coast. Fecundity is the number of mature eggs laid by a female during its spawning season. Studies on the biology of different

marine species were carried out by Venkataraman (1956), Marichamy (1970), Rao (1977), Abdussamad *et al.* (2006, 2010), Ganga and Radhakrishnan (2010), Gowda (2016). Studies on the length-weight relationship, condition factor, sex ratio, and fecundity of genus *Thryssa* from Indian waters are minimal. This study puts forward the length-weight relationship of six species of genus *Thryssa* with particular emphasis on condition factor, sex ratio, and fecundity of *T. mystax* from Indian waters.

Material and methods

Sample collection

Six species of the genus *Thryssa* were collected from the southern coast of India (Kerala, Tamil Nadu and Karnataka) from February 2020 to December 2022 (Fig. 1). For biological studies fresh samples of species *T. mystax* (Fig. 2) were collected every week from three landing sites (Kalamukku, Lat. 09°59'924"N, Long. 76° 14' 564" E, Chellanam, Lat. 09° 47' 950" N, Long 76° 16' 551" E, Neendakara, Lat. 8° 56' 19" N, Long. 76° 32' 25" E of Kerala, India.

The fish were caught by gill net and mini purse seine with 50 mm mesh size at depths ranging from 15 to 20 m. Out of the 2023 specimens collected, 126 *T. malabarica*, 198 *T. setirostris*, 99 *T. vitrirostris*, 249 *T. dussumieri*, 206 *T. polybranchialis* and 1145 *T. mystax* were analyzed. Total length (TL) fork length (FL) and standard length (SL) were measured using a digital vernier caliper with 0.1cm accuracy and the weight (TW) of the fish was taken by an electronic weighing balance with 0.01g accuracy. Species identification was carried out following Whitehead (1972).

Fig. 1. Location of the fishing area on the southern coast of India

Fig. 2. Representative image of *Thryssa* sp.

Length-weight relationship and condition factor

Length-weight relationship of each species was calculated by using the logarithmic transformation of the formula by Le Cren (1951).

$W=aL^b$

$\text{Log } (W) = \text{Log } (a) + b \text{ Log } (L)$…….. (Eq.1)

TL is the total length of the fish in cm, TW is the total weight of the fish in g, (Fig. 2) and 'a' and 'b' are the regression parameters. The 95% confidence interval for a, b, and r^2 values was also estimated. Data were analyzed using Microsoft Office Excel 2016. Analysis of variance (ANOVA) was used to test the significance of regression.

The condition factor (K) of the fish was calculated using Fulton's equation:

$K=100*(W/L^3)$ ……..(Eq. 2)

W is the total weight of the body in g, and L is the total length in cm.

Sex identification and fecundity

A total of 656 specimens of *T. mystax* were collected for biological work and the fish were dissected to remove the gonads and the sex determination was based on gonadal morphology. Gonads were removed, weighed and preserved in Gilson's fluid. Subsamples were taken from the middle portion of the ripped ovary and weighed manually with 0.01g accuracy, and the number of eggs was counted under a stereo zoom microscope. To analyze the monthly difference in numbers between males and females, the sex ratio was calculated by the chi-square formula. The null hypothesis was tested for the results at p (< 0.05) and the degree of freedom as 1. Chi-square (χ^2) verifies the existence of significant differences between the sex ratio of the species, which is commonly expected to be 1:1.

$\chi^2 = \sum (O-E)/E$.....(Eq.3)

where χ^2 is the Chi-square test value, O is the observed value, and E is the expected value.

The fecundity of *T. mystax* was estimated by using the formula (Sinha, 1995).

F (Fecundity) = Total weight of gonad in (g)/weight of sub-sample in (g)*(n) number of eggs in sub-sample.....(Eq.4)

Results

The length-weight relationships were determined for six species of the genus *Thryssa* and the values obtained are represented in Table 1. From the result, it is evident that all the species hold a strong length-weight relationship with the r^2 value nearly reaching 1. The smallest fish observed was *T. polybranchialis* with a minimum length of 8.4 cm and a weight of 4 g. The biggest fish observed was *T. malabarica* with a maximum length of 21.5 cm and weight 65 g. *T. malabarica, T. setirostris,* and *T. vitrirostris* had b >3, indicating a positive allometric growth (Fig. 3). The other three species *T. dussumieri* and *T. polybranchialis, T. mystax,* had b value less than 3 with negative allometric growth (Fig. 4). *T. mystax* had the lowest r value of 0.80 and b value of 1.15 within the length range of 8.4-20.4 cm respectively. Fulton condition factor for *T. mystax* (Fig. 5) was in the range of 0.82 and 0.50 with an average of 0.69 (Table 2), the value being less than 1, indicating poor health condition. The observed sex ratio for the pooled population was 1:0.98 with a chi-square value of 3.84. Only in January (4.5), February (9.1), June (20.6) and September (7.78) the chi-square value was found to be significant; in all the other months, it was non-significant (Table 3).

Fecundity was calculated by observing the female gonads at different maturity stages IV (maturing), V (mature), and VI (spawning). Maturing ovaries are opaque, presence of blood vessels, orange to yellow. Mature ovaries are large, opaque and translucent, blood vessels are rarely present, and orange in colour. The abdomen becomes round, presence of spherical ova and is easily visible by the naked eye. In the spawning stage (Fig. 6), ovaries are found to be large and extended, transparent, presence of oil globules orange to white, large number of spherical ova

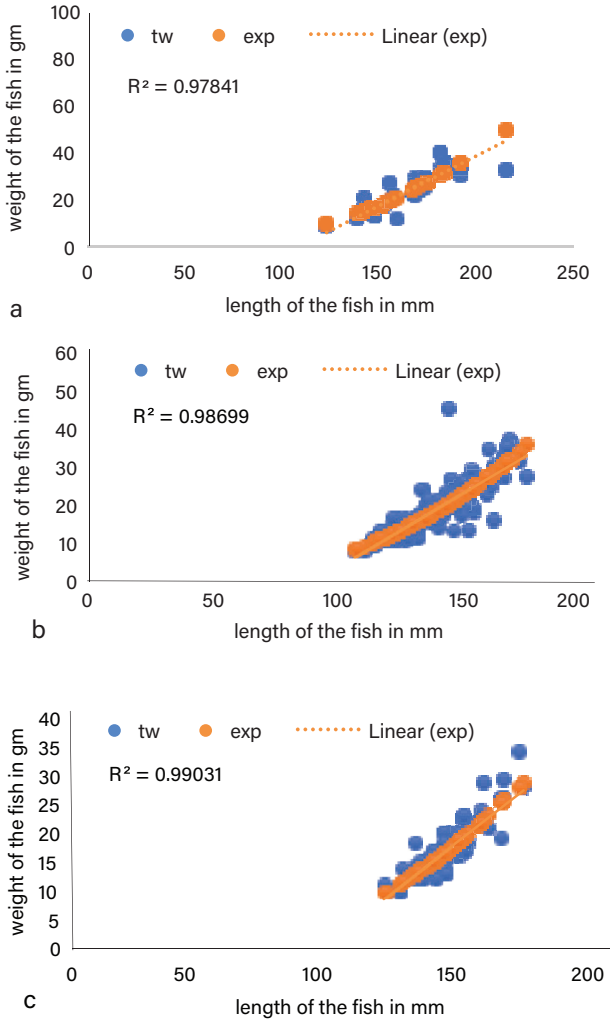

Fig. 3. Length-weight relationship of a) *T. malabarica,* b) *T. setirostris* and c) *T. vitrirostris*

Table 1. Length-weight relationships of *Thryssa* spp. from Indian waters

Species	Number	Total length (cm)		Total leight (g)		b (Regression parameter)	r^2	Growth
		Min.	Max.	Min.	Max.			
T. malabarica	126	12.3	21.5	14	65	3.01	0.98	Positive allometry
T. setirostris	198	10.6	17.4	8	39	3.01	0.99	Positive allometry
T. vitrirostris	99	11.6	16.8	10	28.6	3.01	0.99	Positive allometry
T. dussumieri	249	11	15.4	9.4	27	2.69	0.99	Negative allometry
T. polybranchialis	206	8.4	20.4	4	71	1.51	0.96	Negative allometry
T. mystax	1145	8.4	20.4	7	71	1.15	0.80	Negative allometry

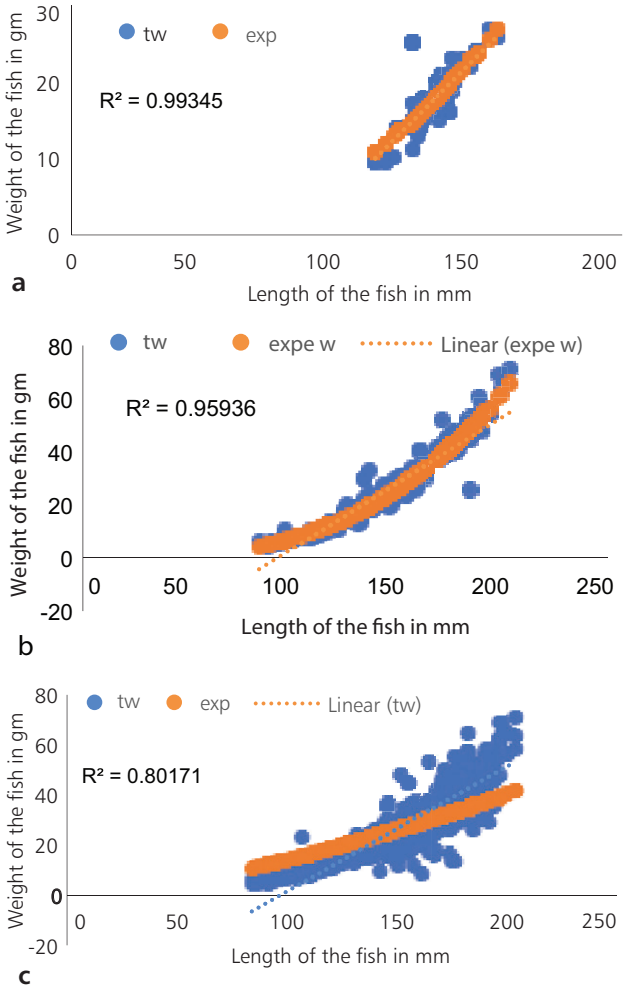

Fig. 4. Length-weight relationship of a) *T. dussumieri,* b) *T. polybranchialis* and c) *T. mystax*

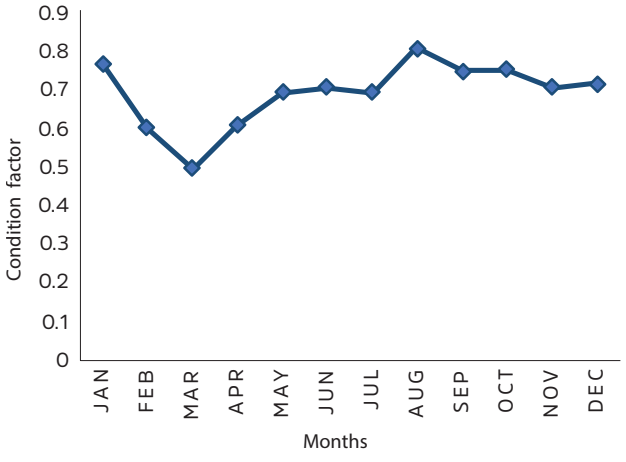

Fig. 5. Graphical representation of month-wise K value of *T. mystax*

are present. The observed fecundity of *T. mystax* (Fig. 7) was in a range of 1219-19,782.

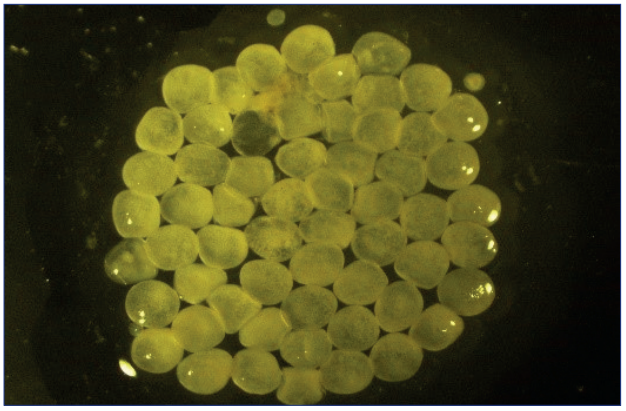

Fig. 6. Microscopic image of matured ova of *T. mystax*

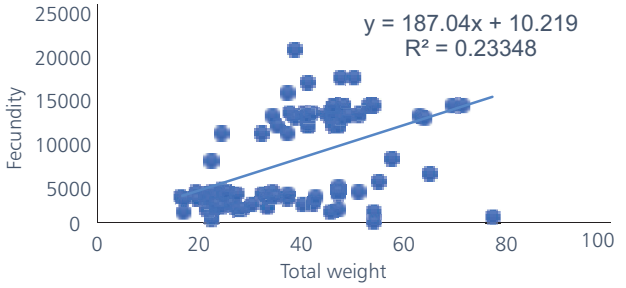

Fig. 7. Relationships of fecundity and weight of species *T. mystax*

Table 2. Condition factor of *T. mystax*

Month	Average
Jan	0.78
Feb	0.61
Mar	0.50
Apr	0.61
May	0.70
Jun	0.71
Jul	0.70
Aug	0.82
Sep	0.76
Oct	0.76
Nov	0.71
Dec	0.72

Discussion

This study presents the LWRs of six species of genus *Thryssa* with special emphasis on the condition factor, sex ratio and fecundity of *T. mystax*. *T. malabarica, T. vitrirostris* and *T. setirostris* had a positive allometric growth pattern and *T. mystax, T. dussumieri* and *T. polybranchialis* showed a negative allometry (Table 1). Except for *T. polybranchialis* and *T. mystax* the estimated b value for all species remained

Table 3. Sex ratio of *T. mystax*

Months	Males (No.)	Females (No.)	Total	Ratio (m: f)	Chi-square	ns/s
Jan	7	1	8	1:0.14	4.5	s
Feb	12	28	56	1:2.33	9.14	s
March	12	9	21	1:0.75	0.43	ns
April	5	1	6	1:0.2	2.67	ns
May	4	1	5	1:0.25	1.35	ns
June	49	9	58	1:0.18	20.69	s
July	6	2	8	1:0.33	2	ns
Aug	3	1	4	1:0.33	1	ns
Sep	154	207	361	1:1.35	7.78	s
Oct	5	2	7	1:0.4	0.99	ns
Nov	6	7	13	1:1.67	1	ns
Dec	68	57	125	1:0.8	0.97	ns
Total	331	325	656	1:0.981	0.05	ns

ns: not significant; s: significant

in the expected range of 2.5-3.5 (Froese, 1998). Similar reports were observed in the length-weight relationship of *T. mystax* from the southern coast of Karnataka (Abdurahiman *et al*., 2004) which found the male population with negative allometric growth. The length-weight relationships of *T. dayi* and *T. malabarica* along the Kerala coast (Roul *et al*., 2017) had positive allometric growth. The estimation of LWRs of *T. mystax* and *T. hamiltoni* revealed that these species had a positive allometric growth (Hoda, 1983; Husaain and Ali, 1987). In the present study, the r^2 value of *T. malabarica* (0.98), *T. setirostris* (0.99), *T. vitrirostris* (0.99), *T. dussumieri* (0.99), *T. polybranchialis* (0.96) and *T. mystax* (0.80) respectively were highly significant ($p < .001$). Karna (2017) observed the LWRs of *T. purava*, *T. polybranchialis* and *T. mystax* from the Chilika lagoon and found that the b values for all the species lies between 3.02-3.32 range and the r^2 value of these three species was greater than 0.95. The LWRs of 45 fish species from the Mini River estuary were observed by Wang *et al.* (2016), and the coefficient of determination r^2 ranged from 0.89 for *T. kammalensis* to 0.95 for *T. dussumieri*.

In the present study, it is evident that the average value of the condition factor for pooled data was less than 1. The lowest K value 0.50 was observed in March and the highest K value in August (0.82), January (0.78), and September (0.76). The proportion relatively increased at the beginning of the month and reached a peak in June and September then gradually decreased. The average value was observed to be 0.69. During these months the presence of matured females was high so the increasing K value can be correlated with the spawning periodicity. The condition factor of *T. hamiltoni* was estimated by Sunaryo (2021), who found that the fish was in good health condition with a K value of 0.74-1.39. Ricker (1975) and Le Cren (1951) reported that the changes in feeding intensity, seasonal changes and fish maturation may influence the deviation from the K value. In the present study, the sex ratio was found to be slightly deviating from the normal 1:1 ratio at different months. The month-wise sex ratio of both female and male populations of *T. mystax* was found to be unequal at 1:0.98. A total number of 331 males and 325 females were observed, and the average Chi-square value of both populations was found to be 0.05 (non-significant). In January, February, June and September the Chi-square value was observed to be significant (4.5, 9.1, 20.6 and 7.7). The total sex ratio of *T. mystax* was observed to be unequal. These monthly variations in sex ratio may be influenced by spawning, feeding habits and migration of fishes (Bal and Rao, 1984). *T. mystax* from the Mangaluru coast revealed that the females and males were in equal proportion (Gowda, 2016).

Fecundity studies on the genus *Thryssa* are minimal. The IV (maturing), V (matured), and VI (spawning) stages of ripe ovaries were observed for analyzing fecundity, and they ranged from 1219 to 19782. Nalluchinnappan and Jeyabaskaran (1991) observed the fecundity of *T. mystax* to range between 13,916 to 22,894 eggs with an average of 18,328 eggs from Tuticorin coast Tamil Nadu. Marichamy (1970) estimated the fecundity of *T. baelama* to be in the range of 1171 to 3356. Hoda (1982) reported that the fecundity of *T. mystax* from the Northern Arabian Sea ranged from 3580 to 24180. The weight of fish had a significant relation with fecundity. Fecundity increases with the increase in weight of fish (Fig. 7), which is also used to determine the spawning time and reproductive potential of fish. The estimated fecundity was different from the previous findings by Kende (2016) in Ratnagiri coast, Maharashtra ranging from 3225 to 24225. Hoda (1976) reported the fecundity

of *T. dussumieri* as 1585-7943. The observed fecundity of *T. mystax* in the present study was lower compared to the reports of Hoda (1982) and Kende (2016). A lower fecundity rate may be caused by the effect of physiological stress and egg attrition (Goldstein, 2022). In conclusion, the present study provides LWR information for six species of genus *Thryssa*, from which three of them showed positive allometry and the rest had negative allometric growth. The K was less than 1 denoting poor health. The overall sex ratio of *T. mystax was* observed to be non-significant and fecundity ranged from 1219 to 19782. This study provides valuable information about the growth of different species of the genus *Thryssa* which can be used as input for fisheries management.

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