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Study on biology of *Thryssa dussumieri* (Valenciennes, 1848) from the coast of Ratnagiri, Maharashtra, India

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The Dussumier's thryssa, *Thryssa dussumieri* is one of the important component of by-catch of trawl and mini purse seine landings at Ratnagiri. The length-weight relationship indicated the isometric growth in *T. dussumieri* with generalized equation W = 0.0066 L $^{3.1077}$. The month-wise relative condition factor showed two peaks coinciding with peak spawning season. All morphometric lengths showed varying degree of correlation with total length. The qualitative and quantitative analysis of food revealed *Thryssa dussumieri* to be a carnivore, feeding mainly on mysids, copepods, diatoms and juvenile shrimps.The highest GSI value, for females, was observed during March, October, December and January. The male:female ratio was found to be 1:1.4. *T. dussumieri* has got a prolonged spawning season extending from September to April. The absolute fecundity ranged from 3367 to 14130 eggs with an average of 7420 eggs. Length at sexual maturity has been estimated to be 12.8 cm.

[**Keywords:** *Thryssa dussumieri*; Relative condition factor; Feeding and reproductive biology]

Introduction

Anchovies are widely distributed throughout the Indian Ocean, Arabian Sea and the Red Sea[1]. They contribute largely to the fishery industry of the Arabian-Gulf Sea[2]. Of the six species of anchovies recorded from the Arabian Gulf [3], *Thryssa hamiltonii*, *T. dussumieri* and *T. mystax* are the most common species caught from the coastal waters. The Dussumier's thryssa (*Thryssa dussumieri*) is mainly distributed in the Indian Ocean (western coast of India, Pakistan, and Sri Lanka) and Western Pacific (Malaysia, Indonesia and north to Taiwan). It is found in coastal pelagic waters and also in mangroves and adjacent brackish waters[4]. The biological studies on *T. dussumieri* including feeding and reproductive biology were carried out by Venkataraman[5] and Mahajan[6] from west coast; Dharmamba[7] and Sivakumar[8] from east coast of India, and Hoda[9] and Ya et al.[10] from Pakistan and Malaysian coasts, respectively. The production of anchovies in India is estimated at 264891 tonnes, with Maharashtra accounting for 10008 tonnes[11]. The maximum catch is taken by small trawlers and mini purse seiners from depths up to 50 m. Anchovies have less demand in fresh condition but there is considerable market for dried fish and for fishmeal industry. No recent studies pertaining to biology of *T. dussumieri* are reported from Ratnagiri coast apart from studies by Venkataraman[5] and Mahajan[6], reported long back from west coast. There has been large scale urbanization and industralization along the west coast, especially Maharashtra which must have altered the ecology on account of pollutants discharged into the sea. Hence the information on vital activites of the species are important for management of the resource in the changed situation. Therefore, the present study was undertaken to investigate the biological aspects of *T. dussumieri* along the Ratnagiri coast of Maharashtra.

Materials and Methods

The samples were collected from commercial trawl by-catches landed at Mirkarwada fish landing centre in Maharashtra, at weekly intervals during March 2016 to February 2017. The findings are based on the study of 913 individuals of *T. dussumieri* comprising 379 males and 534 females.

The total length of each fish was measured to the nearest 1 mm using a standard measuring board and the body weight was recorded to the nearest 0.01 g using analytical balance. The fish were cut open and the sex and the stage of maturity were noted. Gonads were excised out and the excess moisture was removed by appropriate blotting paper, weighed and

preserved in 5% neutral formalin for further study. The length-weight relationship was estimated using linear regression analysis[13]. Relative condition factor "Kn" was calculated as per Le Cren[14] formula:

$$Kn = W/Wc$$

where, 'Kn' is relative condition factor, W is weight of fish and 'Wc' is estimated fish weight.

A total of 19 morphometric relationships were obtained with respect to total length, using regression analysis. Stomach content analysis was condcuted by using numerical method[14]. Different organisms were identified by using the key given by Newell and Newell[15] and Verlencar and Desai[16]. The number of each item was recorded and expressed as percentage of the total number of all food items in the sample studied. GSI was estimated as per Bal and Rao[17]. The sex of individual fishes was ascertained by examination of the gonads after dissection. Data on sex ratio were analyzed by χ^2 (chi square) test to find the domination of sex, if any. The mean length at sexual maturity (Lm) was estimated as per King[18]. Fecundity was estimated by gravimetric method[19].

Ova diameter of intra-ovarian eggs was measured from small portion of ovary taken from the anterior, middle and posterior region and averaging the values. The development of ova was studied using ocular micrometer. Frequency polygons ova diameter was plotted to acertain the stages of maturity.

Results

Length-weight relationship

Length-weight relationship of three groups, *viz*., male, female and pooled were analyzed separately. The relationship in males and females is estimated to be Log W = -2.2309 + 3.1469 Log L and Log W= -2.1254 + 3.0534 Log L, respectively. The t-test on 'b' values indicated no significant differentce in sexes; isometric growth was seen in males, females and total individuals. Therefore, a generalized length-weight relationship equation was used for total individuals as $W = 0.0066\ L^{3.1077}$.

Relative condition factor

The values of relative condition factor (Kn) were observed in increasing trend during the period from March to September consistently (Fig. 1). A peak was observed in September and further decrease was noted with sudden drop in November. Again values showed an increasing trend with a peak in January and further decrease up to March.

Morphometric relationship

The 19 morphometric characters compared against total length indicated varying degree of correlation ranging from 0.1369 to 0.9863 (Table 1).

Food and feeding habit

The average proportion of the gut content showed that mysids (19.42 %), copepods (13.47 %), diatoms (12.56 %) and juvenile shrimps (9.00 %) formed bulk of the diet, while polychaetes (5.90 %), *Lucifer* spp. (5.69 %), amphipod (4.96 %), isopod (3.73 %), cladocerans (2.56 %), fishes (1.41 %) were noted in small amount. Month-wise composition of food items (Fig. 2) revealed that mysids and copepods were

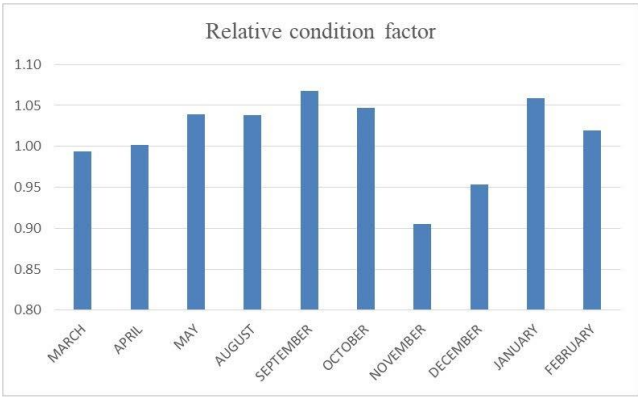

Fig. 1 — Month-wise relative condition factor of *T. dussumieri*

Table 1 — Relation of various morphometric measurements to total length (TL)

Sr. no.	Parameter	Abbreviation	Times in TL	R
1	Fork length	LF	1.1251	0.9863
2	Standard length	LS	1.2285	0.2544
3	Snout length	OU	25.6245	0.6041
4	Eye diameter	OO'	19.9092	0.7040
5	Orbital diameter	Ed	35.6240	0.5794
6	Head length	YJ'	4.8425	0.2283
7	Dorsal base length	DD'	10.8211	0.2183
8	Anal base length	AA'	3.7709	0.8490
9	Pectoral base length	PP'	32.5886	0.5359
10	Pre-dorsal length	UD	2.5684	0.9381
11	Pre-anal length	UA	2.0653	0.2807
12	Pre-pelvic length	UVh	2.9406	0.9245
13	Pre-pectoral length	UPh	4.5654	0.9179
14	Body depth	h	4.3573	0.9289
15	Pectoral height	Ph	6.7378	0.8345
16	Dorsal height	Dh	5.7181	0.1369
17	Anal height	Ah	8.2060	0.2374
18	Pelvic height	Vh	11.3391	0.2408
19	Maxilla length	UJ	3.1280	0.2295

found in all months, with maximum during January and October, respectively. Similarly diatoms, juvenile shrimps, polychaetes, *Lucifer* spp., amphipods, isopods and cladocerans were noted almost in all months. The highest percentage of fishes was recorded in the month of January. Copepods, polychaetes and diatoms were mostly noted in juveniles. *Lucifer* spp, amphipods and isopods were found in moderate percentage in all size groups. Adults prefered mysids, juvenile shrimps and fishes. Copepods (16.00 %) and diatoms (16.71 %) were observed in size groups 8-9 cm and 10-11 cm, respectively. Polychaetes were noted to be maximum (20.00 %) in 8-9 cm size group while fishes were found in maximum quantity (2.71 %) in 13-14 cm size group. During the entire study period, 10.14 % of the stomachs were noted to be full, 6.78 % three quarter full, 18.60 % stomach half full, 44.75 % quarter full and 19.73 % empty. The highest percentage of full stomachs was observed in December. While, empty stomachs were observed in months from September to November.

Gonado-somatic index (GSI)

The values of GSI were found to be the highest during months of March, October, December and January in females while September, October, December, and February in males.

Sex ratio

A total of 913 specimens were examined to estimate sex ratio. The average sex ratio of the males and females was found to be 1:1.4 for the entire study period. Chi-square test indicated significant difference between sexes during the months of August, December, January, February and May. The males were found to be dominant in catches only during May.

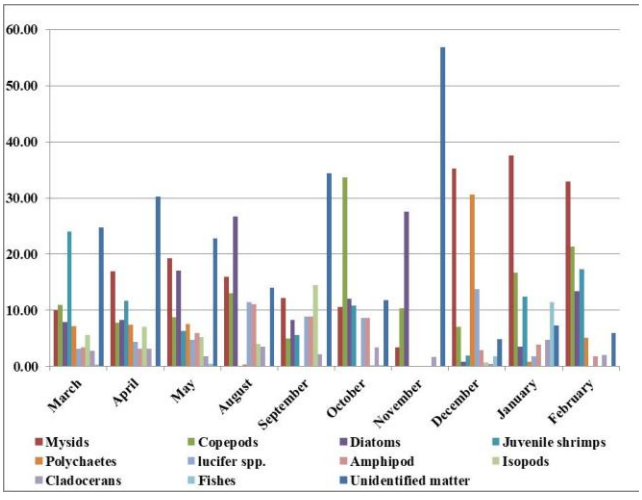

Fig. 2 — Month-wise percentage composition of food items of *T. dussumieri*

Maturity studies

Maturity stages were examined in 508 ovaries (Fig. 3). The maturity stage I (immature) and stage II (developing) were noted mainly during the months of May and August. Stage III (maturing) was observed in September, November, December, January and February. Stage IV (mature) ova were maximum from September to February. The ova in maturity stages V (gravid) and VI (spawning) were observed during September to April. The stage VII (spent) ova were observed during March and April.

Length at sexual maturity (Lm)

In the present study, length at sexual maturity for females was estimated to be 128 mm (Fig. 4).

Fecundity

The absolute fecundity was estimated by studying randomly selected 25 mature ovaries. The fecundity ranged from 3367 to 14130 eggs with an average of 7420 eggs.

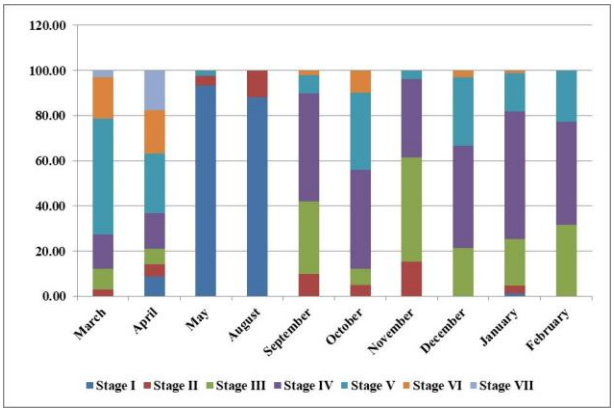

Fig. 3 — Monthly variation in the maturity stages in female of *T. dussumieri*

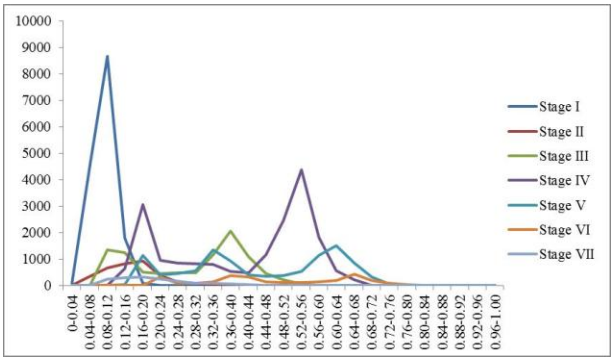

Fig. 4 — Length at sexual maturity of *T. dussumieri* along the Ratnagiri coast

Ova diameter study

The ovaries belonging to the seven maturity stages were selected and the ova diameter frequency polygons were drawn (Fig. 5). The ova in stage I of maturity ranged from 0.01 to 0.16 mm with a mode 'a' at 0.1 mm. The mode 'a' is seen progressing to 0.18 mm at stage II. In stage III, the mode progresses to 0.38 mm. Another mode 'b' is formed at 0.1 mm. The mode 'a' is seen progressing to 0.54 mm and mode 'b' to 0.18 mm in stage IV. The progression of modes 'a' and 'b' continues to 0.62 mm and 0.36 mm respectively in stage V. While another batch of ova with mode 'c' is seen developing at 0.18 mm in stage V. In maturity stage VI, the modes 'a', 'b' and 'c' are progressing to 0.66 mm, 0.38 mm and 0.22 mm, respectively. The spent stage ova ranged from 0.10 mm to 0.42 mm in partially spent females.

Discussion

Length-weight relationship

Accurate length-weight relationship (LWR) is an important information required in the assessment of fish stocks[20-22]. Beverton and Holt[23] reported that cubic relationship between length and weight, b value near to 3.0. Ricker[24] observed that a fair number of species seem to approach this ideal. According to Pauly & Gayanilo[25], for fish, the 'b' values may range from 2.5 to 3.5 indicating results of the present study as valid. The isometric growth in *T. dussumieri* found in present study conforms to the findings of Mahajan[6] from Ratnagiri coast. But conversely, positive allometry was reported by Ya *et. al.*[10] along the Sepang Besar River estuary. The variation in 'b' values within different stocks of *Thryssa dussumieri* and sexes may be due to the factors related to the ecosystem and biological phenomenon such as maturity stages, feeding behaviour and competition for food.

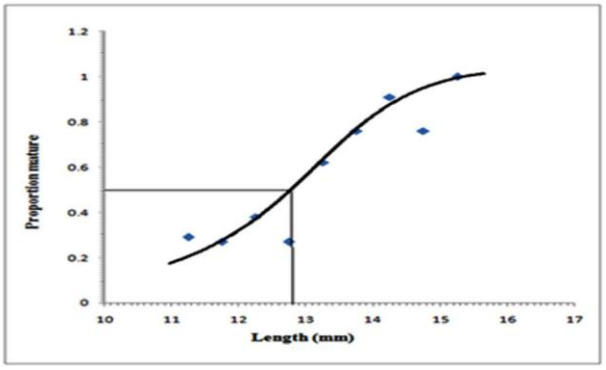

Fig. 5 — Stage-wise oa diameter trend in T. dussumieri

Relative condition factor

The average values of relative condition factor (Kn) showed two peaks during September and January. Availability of more mature individuals is noted in these two months coinciding with peak spawning season. Higher K value indicates better condition. K value is the highest during spawning season hence it can be used to ascertain spawning season/ periodicity[26]. The decreasing values after September and January point to the presence of more spent females in the population. There are no published reports on the study of condition factor in *T. dussumieri* from elsewhere. Masurekar and Rege[27] studied condition factor of *T. hamiltonii* from Bombay waters and reported considerably low values for the months of October-November and April-May. Fluctuations in Kn value might be either related to other parameters like breeding cycle[13,28,29], feeding rhythms[30,31] and the environment[32].

Morphometric relationship

There are no published reports on the study of morphometrics in *T. dussumieri* from elsewhere. Correlation coefficient ranged from 0.1369 to 0.9863 between morphometric characters with total length. Kende[33] reported the correlation of total length against morphometric characters of *T. mystax* to vary from 0.7038 to 0.9966 along the coast of Ratnagiri which appears to be higher than that for *T. dussumieri*. However, the study of morphometrics can aid in comparing the population of the same and/or similarly related species from different regions[34,35].

Food and feeding habit

In the present study, the stomach contents of *T. dussumieri* were noted to be mysids, copepods, juvenile shrimps, polychaetes, *Lucifer* spp., amphipods, isopods, cladocerans and fishes; thereby indicating that *T. dussumieri* is a carnivore; however, it feeds on diatoms also. Based on size percentage composition of food items, it can be concluded that juveniles prefer zooplankton while adults show more preference towards fish. Venkataraman[5] reported that *Thrissocles dussumieri* fed mainly upon prawns, copepods and *Lucifer* sp. along the Malabar Coast. Mahajan[6] reported *T. dussumieri* to be a carnivore fish, feeding mainly on zooplankton of crustacean origin along the Ratnagiri coast. *T. dussumieri* and *T. vitrirostris* are reported to be carnivorous with a preference for planktonic crustaceans along the coast of Porto Novo, Tamil Nadu[8]. The above findings conform the results of

present findings. Other species belonging to the genera *Thryssa* are reported to be carnivores except few by various workers. Venkataraman[36] reported *T. mystax* to be a carnivore, feeding upon penaeid prawns, polychaetes, copepods, *Acetes* sp., decapod larvae and *Lucifer* sp. from Calicut coast. Venkataraman[5] reported that *Thrissocles malabaricus* feeds on penaeid prawns, polychaetes, copepods, *Acetes* sp; decapod larvae and *Lucifer* sp. Similarly copepods along with few cladocerans formed the main diet of *Thrissocles setirostris* along Malabar Coast.

Nalluchinnappan and Jeyabaskaran[27] reported *T. mystax* to be a zooplankton feeder, feeding upon prawn *juveniles*, molluscan larvae, *Acetes* sp., fish eggs, amphipods, polychaetes, and nauplius larvae along Tuticorin coast. Kende[33] reported that *T. mystax* is a carnivore fish, feeding mainly on *Acetes* sp., copepods and fish eggs along the Ratnagiri coast. It is evident from the above studies reported by various authors that most of the species of anchovies belonging to genera *Thryssa* including *T. dussumieri* are carnivorous in feeding habit corroborating the similar finding in the present investigation.

Feeding intensity

Results on the feeding intensity reveal that more individuals with empty to one-fourth full stomachs were noted during October to November, a possible breeding peak observed in the present study. Fall in feeding intensity was thus noted but in few stomachs moderate feeding was also noted. Second spawning peak in the present study possibly takes place during March-April. Feeding intensity was found to be more during December to March, a pre-spawning period. The variation in above feeding intensity was noted in immature as well as mature individuals. In the present study, it is difficult to attribute either the increase or decrease in feeding intensity only to the spawning activity, and other possible reasons may be the seasonal abundance and competition for food. Similar phenomenon was also reported by Kende[33]. As the fluctuation in feeding intensity of mature fish in latter study has not strictly coincided with the spawning it would be rather difficult to conclude whether the fall in the feeding intensity was entirely due to spawning activity of the fish.

Gonado-somatic index

The GSI was noted to be the highest during the months of October to March in females indicating spawning season. The GSI in males also showed more or less similar trend indicating synchronous maturation in both the sexes. In the present study, sudden drop in GSI is noted in November and April thereby suggesting that spawning possibly takes place twice during the spawning season. Based on GSI studies, Mahajan[6] reported that *T. dussumieri* spawns twice a year along Ratnagiri coast. The spawning was noted in the months of October-November and March-April conforming the spawning period reported in the present study.

Hoda[37] reported that *T. mystax* spawns twice in a year, in January to March and from June to July based on gonado-somatic index along the northern Arabian Sea. Hussain and Ali[38] studied the gonado-somatic index of *T. hamiltonii* and *T. mystax* in Khor Al-Zubair, north-west Arabian Gulf. They stated that both species have single, prolonged spawning, extending from December to April, with peak in March. The higher GSI values in males and females in present study correspond to spawning period of *T. mystax* along the Ratnagiri coast[33].

Sex ratio

In the present study, the overall sex ratio between males and females was found to be 1:1.4 with females dominating males ($P < 0.05$). The sex ratio in *T. dussumieri* was reported to be 1.22:1 along the Karachi Fishing Harbour, Pakistan, thereby indicating dominance of females over males[9]. Hoda[37] reported the sex ratio of *T. mystax* to be 1.26:1 from Karachi Fishing Harbour, Pakistan. Mahajan[6] reported the sex ratio of *T. dussumieri* along Ratnagiri coast of Maharashtra as 1:1.3 with females dominating over males. The results of sex-ratio almost conform to the findings by Mahajan[6]. Kende[33] reported that the overall male-to-female ratio in *T. mystax* from Ratnagiri was found to be 1:0.93. He further reported that there was no significant difference in the proportion of male and females in most of the months. The dominance of either sex in catches might be possibly related to the variation in size at first capture, the selectivity of the gear and vulnerability of either sex to capture.

Maturity studies

In present study, the ovaries in advanced stage of maturity were observed in the months of September to April, it can be concluded that *T. dussumieri* having prolonged spawning season extending from September to April along Ratnagiri coast of Maharashtra. Venkataraman[36] stated that *T. mystax* has prolonged spawning season from September to

May along the Calicut coast. The peak spawning activity is reported from November to March. Masurkar and Rege[27] reported *T. hamiltonii* has two distinct spawning seasons one from October to November and the other from late March to May based on maturity studies. Large numbers of mature females of *Thrissina baelama* with ovaries in advanced stages of maturity were noticed during July-August and December-January along Port Blair, Andaman Sea[39]. He reported that spawning season coincided with monsoon season. However, no evidence of spawning coinciding with monsoon is seen in present study.

Length at sexual maturity (Lm)

The length at sexual maturity in *T. dussumieri* was estimated to be 128 mm in present study. The size at first maturity for *T. dussumieri* is reported to be between 10.6-11 cm and 11.6-12 cm for males and females, respectively[6]. The size at first maturity in *T. mystax* from Calicut coast is reported to be in the range of 140-150 mm by Venkataraman[36]. Masurekar and Rege[27] studied maturity and spawning of *T. hamiltonii* along the Bombay coast. They reported that the fish attains sexual maturity at a length of 150 mm. Marichamy[39] reported the length at sexual maturity of *T. baelama* to be 117 mm from Port Blair, Andaman Sea. Hussain and Ali[38] reported that both *T. mystax* and *T. hamiltonii* attain length at sexual maturity at 140 mm along Khor al-Zubair, north-west Arabian Gulf. Nelluchinnappan and Jeyabaskaran[40] reported that *T. mystax* attains the size at first maturity at 122 mm along the Tuticorin coast. The length at sexual maturity in *T. mystax* was stated to be 146 mm along the Ratnagiri coast by Kende[33]. The size at first maturity in present study is relatively smaller than reported for species other than *T. dussumieri* but almost agree with the findings of Mahajan[6]. The difference in size at first maturity may be possibly due to the variation in growth rate and maximum size reached by different species under the influence of varying environmental conditions and food availability.

Fecundity

The fecundity of *T. dussumieri* ranged from 3367 to 14130 eggs with an average of 7420. Marichamy[39] reported that the fecundity of *T. baelama* at Port Blair, Andaman Sea, ranged between 1171 and 3356. The fecundity of *T. dussumieri* is reported to be on an average of 4500 eggs from Ratnagiri coast[6]. Hoda[9] reported the fecundity of *Thryssa dussumieri* ranged from 1585 to 7945 in a fish ranging from 106 to 139 mm in total length from Pakistan coast. Hoda[37] stated that the fecundity of *T. mystax* ranged from 3580 to 24180, with a mean value of 10360 from Karachi Fishing Harbour, Pakistan. The fecundity of *T. mystax* was found to vary from 3225 to 24225 eggs with an average of 12025 eggs per female[33]. The fecundity varies from species to species and within species from region to region in accordance to the reproductive potential of the stocks.

Ova diameter study

Ova diameter studies indicate that *T. dussumieri* spawn more than once in a season, as its ovary contains three batches of ova namely spawning, maturing and developing. The spawning takes place as the first (spawning) batch of eggs is released. While the presence of other peak possibly indicates the release of other batch of ova (maturing) in ensuing months. It is possible that eggs comprising the third peak are not spawned in the same season. From this, it can be inferred that *T. dussumieri* follows a protracted spawning season with the individual spawning twice in a season. Hoda[9] reported that *T. dussumieri* has got a prolonged spawning period and breeds twice in a year based on ova diameter studies along the Karachi Fishing Harbour, Pakistan. Mahajan[6] reported that *T. dussumieri* spawns twice during the prolonged spawning season along the Ratnagiri coast. He further reported that the peak spawning occurred during the months of October-November and again in March-April. Dharmamba[7] reported that *T. dussumieri* spawns twice during a prolonged spawning period extending from February-March to August-September from Lawson's Bay, Waltair. Study of ova diameter inferred that *T. hamiltonii* along Bombay coast has two distinct spawning seasons viz., October to November and March to May[38]. Based on ova diameter studies of *T. baelama* along the Andaman Sea, Marichamy[39] stated that the species spawns twice in a year in a short duration. Based on ova diameter studies Kende[33] reported that *T. mystax* spawns twice in a spawning season along Ratnagiri coast. The findings of ova diameter study in the present study agree with those reported by Dharmamba[7] and Mahajan[6].

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