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Research Article

REPRODUCTIVE CHARACTERISTICS OF GREENBACK MULLET, *LIZA SUBVIRIDIS* (VALENCIENNES, 1836) FROM PARANGIPETTAI WATERS (SOUTHEAST COAST OF INDIA)

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ABSTRACT

In this study reproductive characteristics of the Greenback grey mullet, *Liza subviridis* from Parangipettai waters (Southeast coast of India) were examined; especially, the gonado somatic index (GSI), length at first sexual maturity (L_{50}) and fecundity (volumetric method) were calculated. The gonadosomatic index (GSI) indicated that this species follows group-synchronous breeding pattern and spawns twice in a year. The peak spawning season of *L. subviridis* in Parangipettai waters was found to be February and March. The minimum length at first sexual maturity (L_{50}) was found to be 131 mm and 145 mm for males and females respectively. With respect to sex ratio females were caught more in numbers than males throughout the study period. However the sex ratio analyzed month-wise indicated homogenous distribution during most of the months. The overall sex ratio (1:1.2) deviated significantly from the expected 1:1 ratio (X^2 =10.97, P <0.005). The fecundity ranged from 1 to 7.9 lakhs oocytes. The relationship of fecundity with total length, body weight and gonad weight showed highly significant correlation. The average fecundity of the *L. subviridis* observed in the present study was 4.46 lakhs eggs. The implications from this study suggest that proper conservation of stock and substantial production for future is ensured for this species in Parangipettai waters.

Keywords: Mullets of India, Gonadosomatic index, Sex ratio, Fecundity, Reproduction.

INTRODUCTION

Mugilids are distributed widely in estuarine and coastal waters of all tropical and temperate areas of the globe (Thomson, 1997; Nelson, 2006). Mugilids generally exhibits iteroparous reproductive strategy (Brusle, 1981, Fender de Andrade-Talmelli *et al.*, 1994) and possess great number of oocytes (Greeley *et al.*, 1987, Okumuş and Başçnar, 1997). Mullets tend to produce numerous small eggs that are pelagic and typically possess a group-synchronous pattern of ovarian development which is characterized by two different size classes of oocytes present in mature ovaries with a relatively short spawning season. During spawning they release the larger class of oocytes in current breeding season and smaller oocytes are reserved inside for forthcoming breeding seasons (Chan and Chua, 1980, Render *et al.*, 1995, Kendall and Gray, 2008). Mullets exhibit dioecism and hence fertilization occurs externally (Thomson, 1997).

Fecundity is the number of maturing eggs in females prior to spawning (Bagenal and Braum, 1978). It differs from species to species according to various factors such as age, length, weight, environment etc. Fecundity estimations are vital aspects of fishery science. Unavoidably, they will be estimated for every species of economic importance because of their significance in the population dynamics and also it helps to predict the biomass of a stock (Hunter *et al.*, 1992).

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Mullets are targeted commercially all around the globe (Ibáñez-IbaÑez-Aguirre and Gallardo-Cabello, 2004) and also cultured widely (Sivalingam, 1975, Lee and Ostrowski, 2001). Moreover mullets serve as most important forage fishes of estuaries and act as major source of food for upper-level piscivores (McDonough and Wenner, 2003). Therefore, the reproductive biology of various species of Mugilidae has been well studied across the globe. On the contrary, Studies on the biological aspects of Indian mugilids are sparse and only *Mugil cephalus* has been well established. Therefore an attempt has been made to investigate the reproductive characteristics (such as length at first maturity, annual reproductive cycle, gonado-somatic index, peak season of breeding and synchronous or asynchronous spawning) of *Liza subviridis* in Parangipettai waters (Southeast coast of India) which serves as the excellent breeding ground and abound with mullets.

MATERIALS AND METHODS

Specimens of *L. subviridis* were collected from Vellar estuary and Annankoil fish landing centre at Parangipettai (Lat. 11°29′25.55″N, Long. 79°45′38.62″E) during May 2011 - April 2012. The specimens were brought to the laboratory and abdomen of fishes was cut open to expose the gonads for identification of sexes. In each fish, total length (TL in cm) was measured to the nearest 1mm using a measuring board and total weight (TW in gm) was taken to the nearest 1.0 g by an electronic balance. ICES (International Council for Exploration of the Sea) scale of gonadal maturity (Lovern and Wood, 1937) was adopted in the present study with suitable modifications as suggested by Hoda (1986).

The Gonado-somatic index (GSI) was calculated as described by Rowe and Thorpe (1990) using the following formula:

$$GSI = \frac{\text{Gonad weight (g)}}{\text{Total body weight (g)}} \times 100$$

Length at first maturity (*Lm*) using adjusted proportion of mature by King (1995) was adopted. For Fecundity (F) estimation, only V stage ovary was taken into consideration.

Fecundity was estimated by the gravimetric method (Bagenal and Braum, 1978) using the following formula:

$$F = \frac{nG}{g}$$

where F = fecundity
n = number of eggs in sub-sample
g = weight of eggs in sub-sample and
G = weight of both ovaries.

Fecundity model was fitted after a logarithmic transformation of the variables.

The sex ratio was calculated and the homogeneity in the distribution of male and female was tested using the following Chi-square formula:

$$X^2 = \sum \frac{(O-E)^2}{E}$$

where X^2 = Chi-square
$\sum$ = Sum
O = Observed frequency and
E = expected frequency.

RESULTS

Gonado-somatic index (GSI)

The development of gonads and the general growth of the fish are closely associated. Gonad increases geometrically during spawning period and stops at the ripe condition. Naturally, GSI also increases until the gonads reach ripe condition and this index declines sharply after spawning. The GSI calculated separately for both males and females (monthly mean values) are plotted in Figure 1. Values of gonado-somatic index showed high values during September - October 2011 and February – March 2012. The index was low during May 2011 to July 2011. The gonado-somatic index values indicated two breeding seasons in a year. The higher GSI values obtained during September, October, February and March indicated high spawning activity during these months.

Length at sexual maturity

To determine the size at maturity (Lm), fishes were assorted sex-wise into different size groups and the percentage occurrence of mature males and females in each size group was then plotted and fine-tuned with the adjusted proportion for both males and females to find out the accurate length at first maturity (Figures 2-3). The value of length at sexual maturity is usually qualified at a particular percentage level. The 50% level in maturity curve, which may be taken to represent the mean length at which maturity is attained, was 146 mm for males and 155 mm for females. The adjusted proportion of ripe showed the males to mature at 131 mm and females at 145 mm. Thus males seem to attain sexual maturity earlier than females in both the methods.

Fecundity

The fecundity enumerated ranged from 1 lakh to 7.92 lakhs in the size range of 131-265 mm. The average fecundity of *L. subviridis* observed in the present study was 4.46 lakh eggs.

a. Relationship between fecundity and total length

The relationship between fecundity and total length of *L. subviridis* was correlated and the equations obtained are given below and also depicted in Figure 4 (A-B).

1) Based on observed values:

$F= 153225 + 14637x\ TL$ ($r^2 = 0.9728$)

2) Logarithmic equation:

$Log\ F = 5.2971 + 1.2406x\ Log\ TL$ ($r^2 = 0.9788$)

The correlation coefficient ('r') value between fecundity and standard length was found to be highly significant. Thus the present study showed that the number of ova increased with the increase in length of fish (at the rate of 14637 eggs per unit increase in length).

b. Relationship between fecundity and total weight

Relationship between fecundity and body weight of the fish also showed linear relationship [Fig. 5(A-B)]. The regression equations of fecundity against body weight (w) are:

1) Based on observed values:

$F= -354016 + 64095x\ TW$ ($r^2 = 0.9908$)

2) Logarithmic equation:

$Log\ F = 1.9768 + 4.9145x\ TW$ ($r^2 = 0.9852$)

The correlation co-efficient ('r') value for fecundity and body weight relationship was found to be highly significant indicating high degree of correlation between the two variables. From the equations it was inferred that the number of ova increased by 64095 eggs per unit increase in body weight of the fish.

c. Relationship between fecundity and ovary weight

The relationship between fecundity and ovary weight (mg) of *L. subviridis* is represented in Fig.6 (A-B). The relationship between fecundity (F) and ovary weight (OW) can be expressed as:

1) Based on observed values:

$F= -99622 + 78203x\ OW$ ($r^2 = 0.9441$)

2) Logarithmic equation:

$Log\ F = 5.7366 + 0.7701x\ Log\ OW$ ($r^2 = 0.945$)

The correlation co-efficient ('r') value between fecundity and ovary weight was also found to be highly significant indicating a high degree of correlation between these variables.

Sex ratio

The number of males and females examined each month, percentage of males and females, ratio of females per 100 males, chi-square values and their significance are given in Table 1. Monthly sex ratio indicated wide fluctuations. Females were caught more in numbers than males throughout the study period except July 2011 and December 2011. However, the ratio conformed to the expected 1: 1 during most of the months with an exception during October 2011(X^2=5.2972, $P < 0.05$) when it deviated significantly from the expected 1: 1. The overall sex ratio deviated significantly from the expected 1:1 ratio(X^2 =10.97, $P < 0.005$).

Table 1. Month -wise sex ratio of *Liza subviridis* during May 2011-April 2012.

Months	Male	Female	Total	Male %	Female %	Ratio M:F	Chi-Square value	P-value
May- 2011	59	77	136	43.38	56.61	1:1.3	2.3823	>0.05
June	70	80	150	46.66	53.33	1:1.1	0.6666	>0.05
July	64	56	120	53.33	46.66	1:0.9	0.5333	>0.05
August	55	70	125	44	56	1:1.3	1.8	>0.05
September	76	93	169	44.97	55.02	1:1.2	1.71	>0.05
October	60	88	148	40.54	59.45	1:1.5	5.2972	<0.05
November	92	113	205	44.87	55.12	1:1.2	2.1512	>0.05
December	83	71	154	53.89	46.1	1:0.9	0.935	>0.05
January- 2012	76	98	174	43.67	56.32	1:1.3	2.7816	>0.05
February	73	81	154	47.4	52.59	1:1.1	0.4155	>0.05
March	66	78	144	45.83	54.16	1:1.2	1	>0.05
April	61	71	132	46.21	53.78	1:1.2	0.7575	>0.05
Total	835	976	1811	46.10	53.89	1:1.2	10.97	<0.005

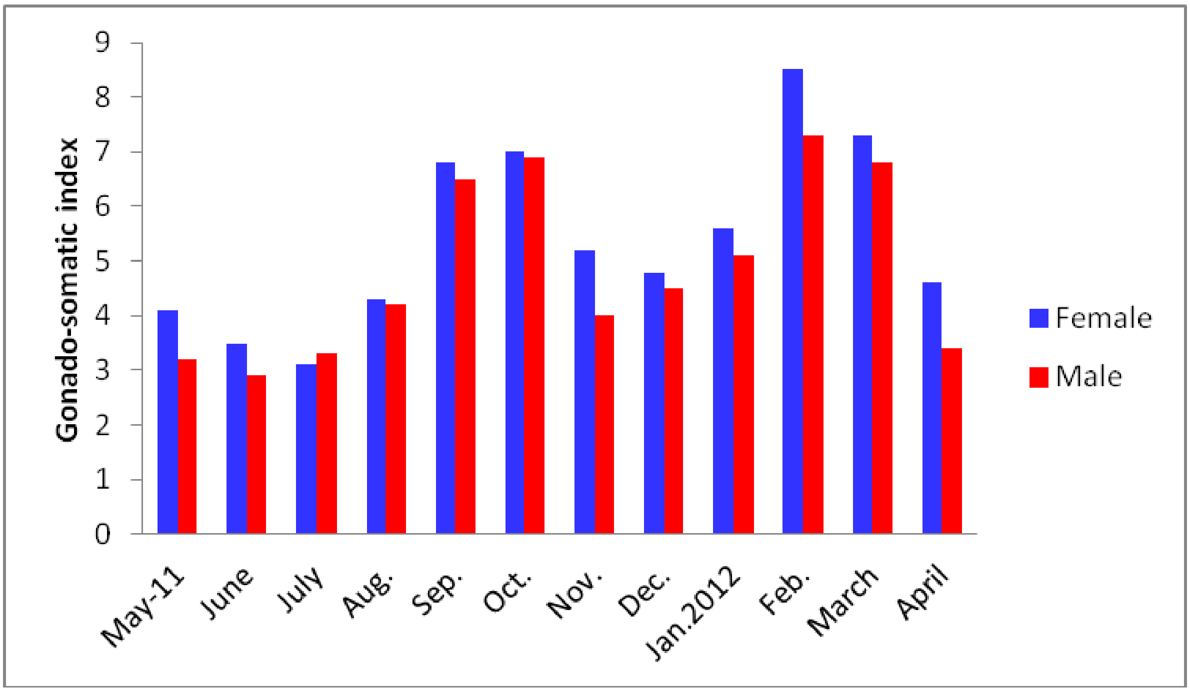


Figure 1. Gonado-somatic index of *Liza subviridis*.

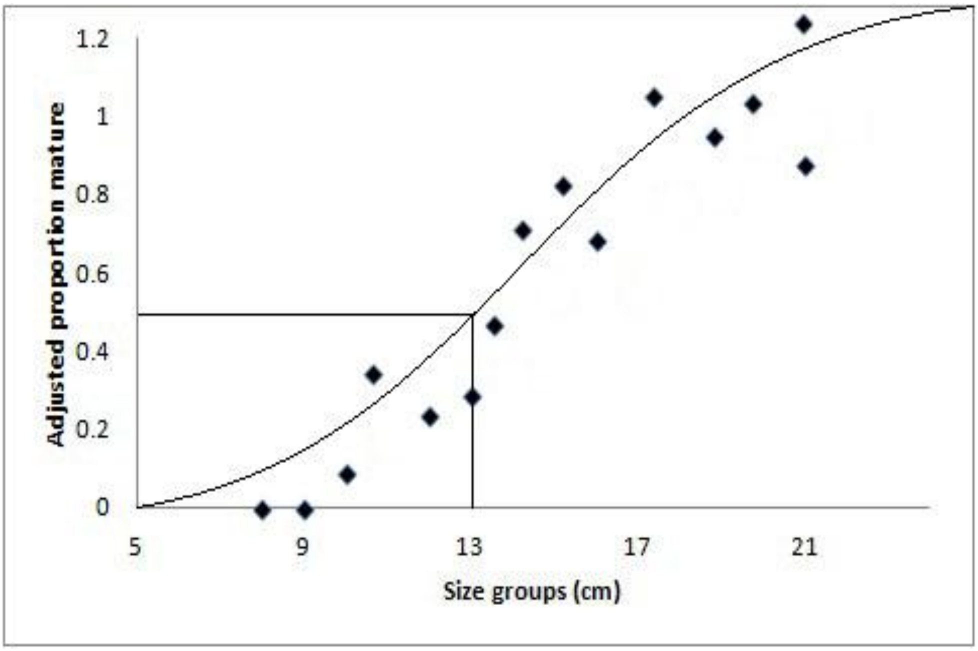


Figure 2. Size at first maturity of male *Liza subviridis* (using adjusted proportion).

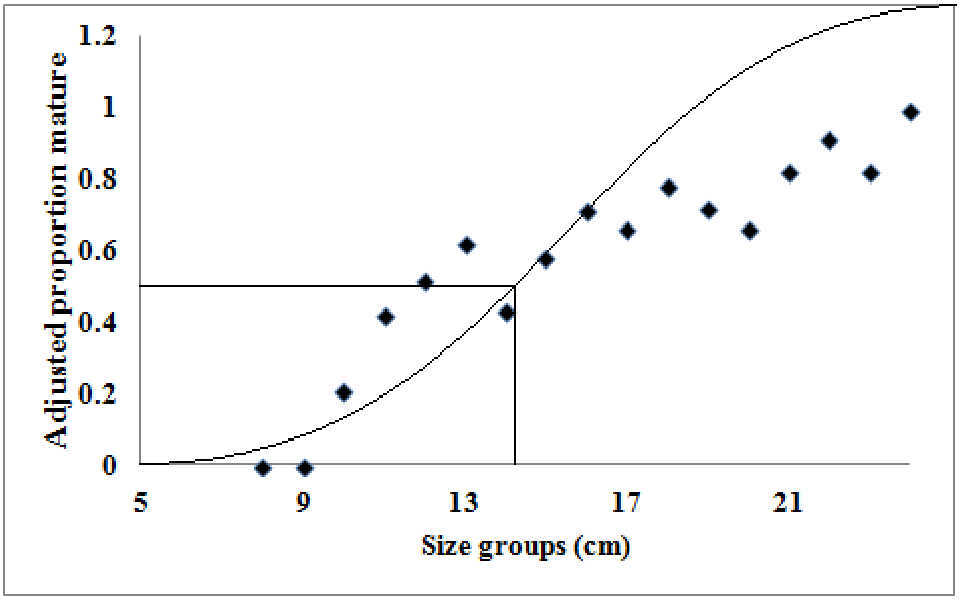
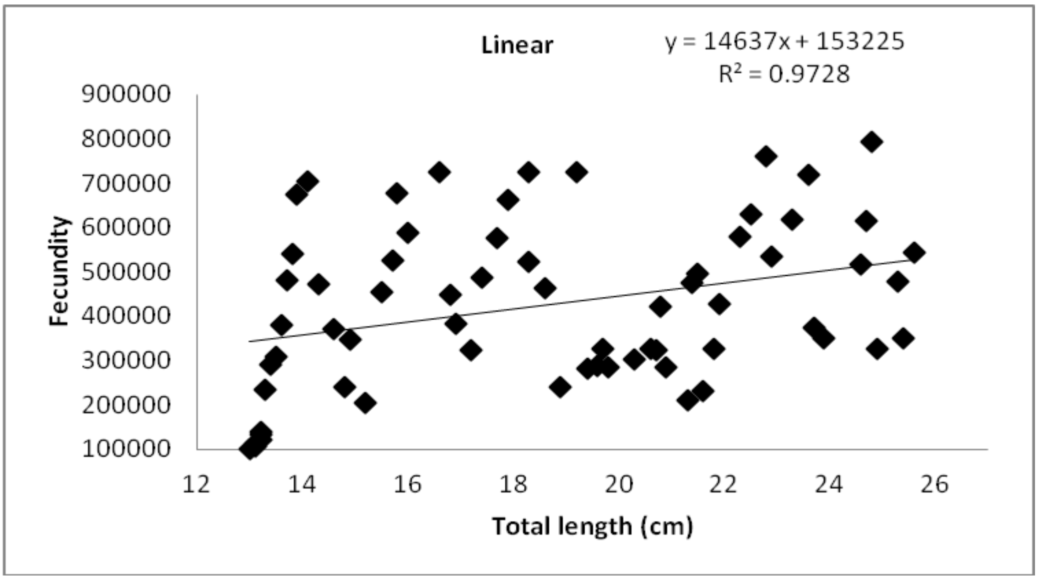
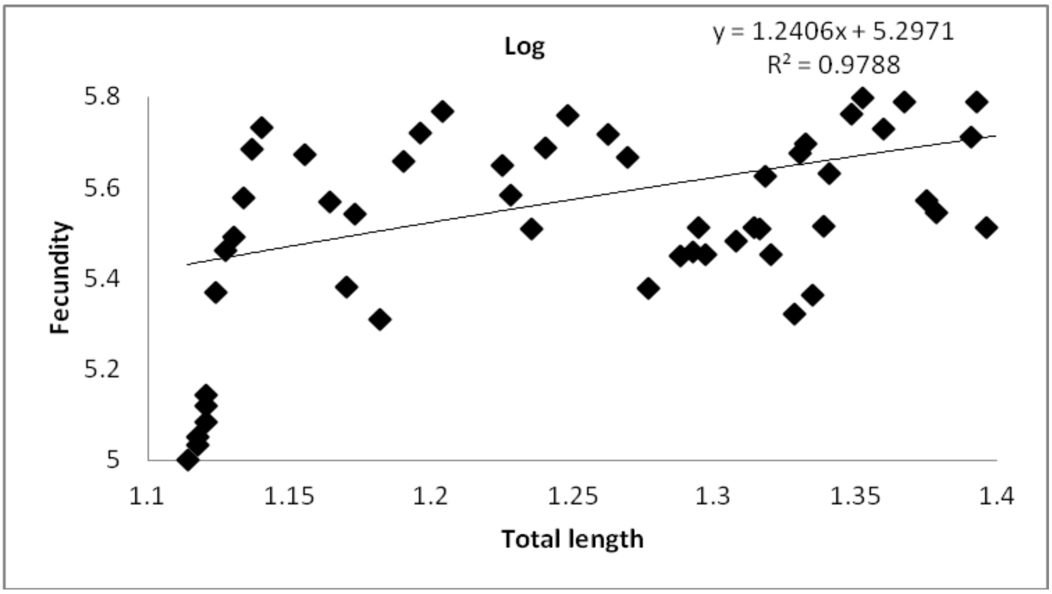


Figure 3. Size at first maturity of female *Liza subviridis* (using adjusted proportion).

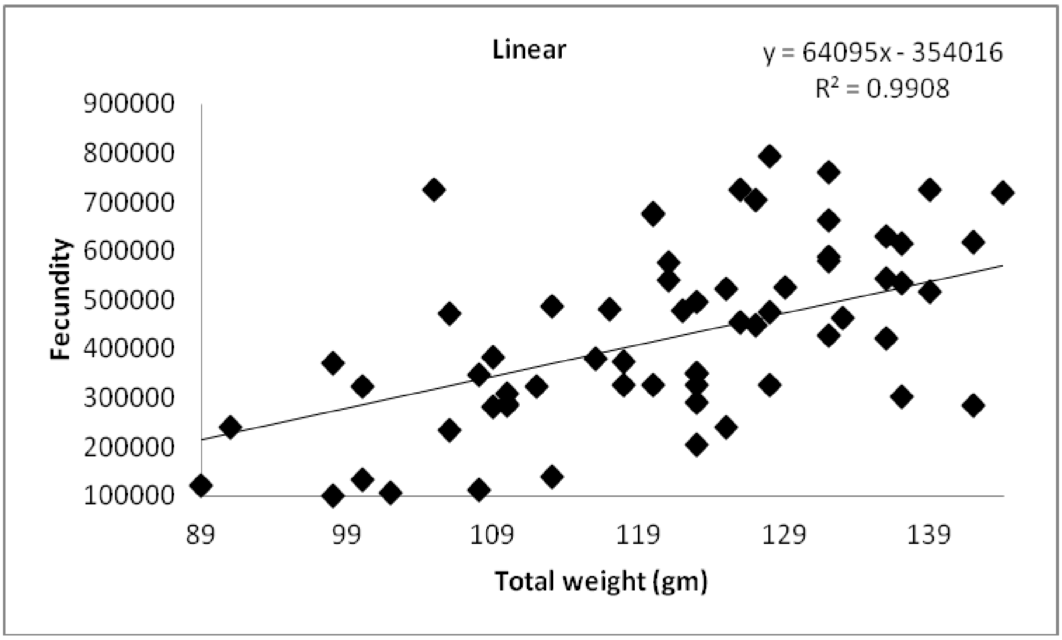


A

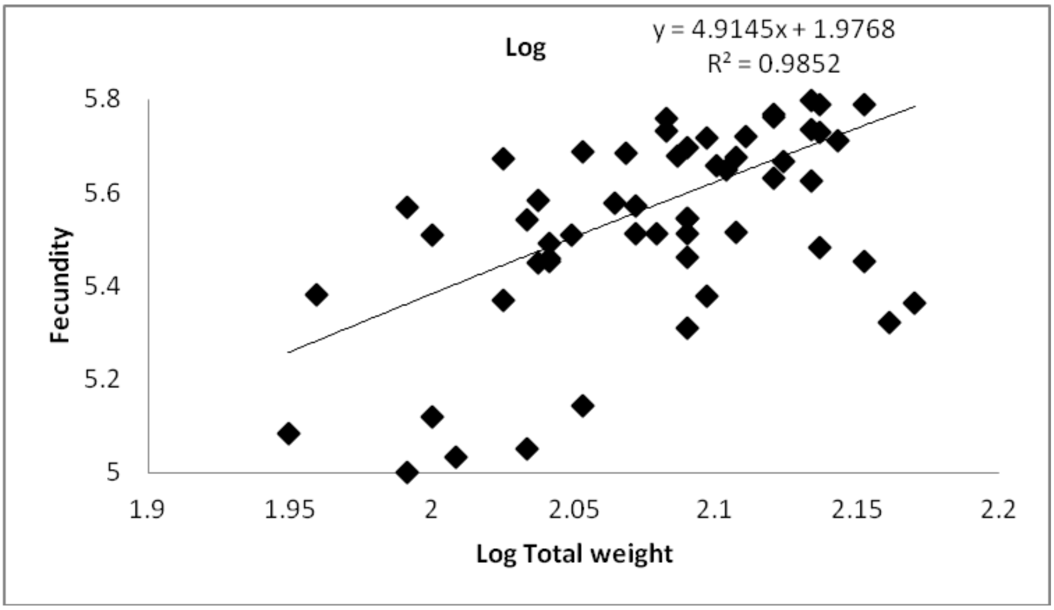


B

Figure 4. Relationship between fecundity and total length in *Liza subviridis* by linear (A) and logarithmic (B) trend lines.

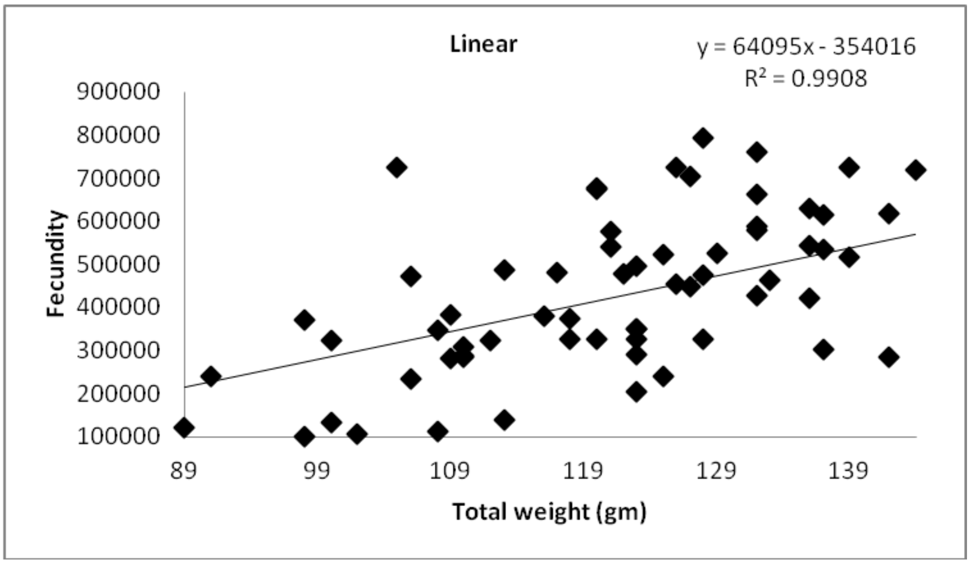


A

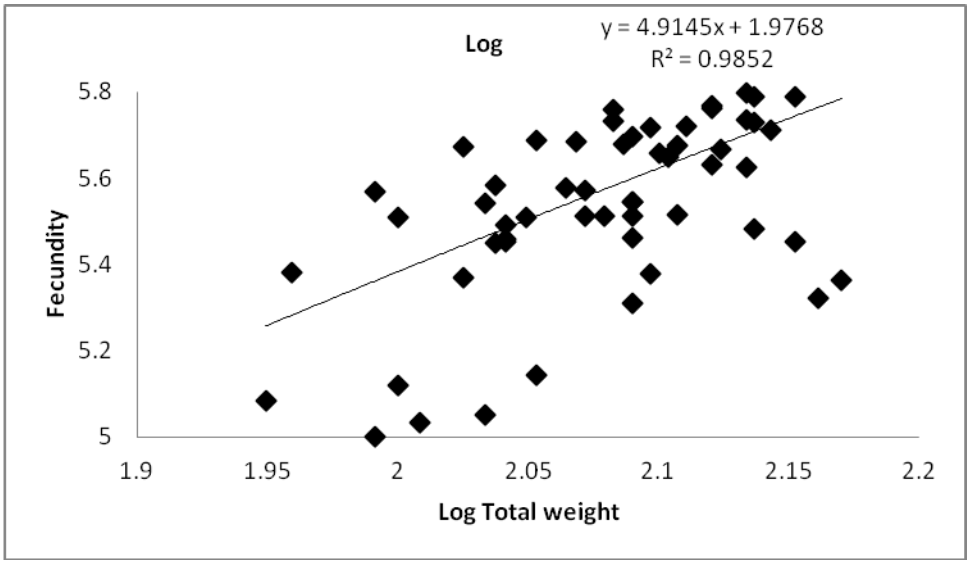


B

Figure 5. Relationship between fecundity and total weight in *Liza subviridis* by linear (A) and logarithmic (B) trend lines.



A



B

Figure 5. Relationship between fecundity and total weight in *Liza subviridis* by linear (A) and logarithmic (B) trend lines.

DISCUSSION

The homogenous distribution of the grey mullets has long been established, though individual cases of hermaphroditism have been reported (Kesteven, 1942; Johnson, 1954; Stenger, 1959; Moe, 1966). In *L. subviridis* not a single case of hermaphroditism was encountered during the present study. All the fishes examined possessed gonads of a distinct sex. While maturing ovaries and testes can be macroscopically differentiated, gonads of immature fish can be sexually differentiated only microscopically. Externally, differentiating the sexes is difficult, except in mature fish as secondary sexual characters are not present and the genital papillae in both sexes do not appear to show much distinction to the naked eye. While it is tempting to suggest that male fish generally have a more slender body shape, differentiation based on this criterion is both arbitrary and unsatisfactory. However microscopic examination of both testes and ovary at different maturity stages after macroscopic scrutiny showed that the latter is not arbitrary but instead provides a useful, faster and convenient method of determining the maturity of the fish.

The monthly variations in GSI offer not only an additional proof regarding the duration of spawning, but also indicate the major phases of the reproductive cycle. Among the various stages of maturity, stage V gonads started occurring during September – October and January – March. The high proportions of stage V gonads and high GSI values were recorded during the above periods clearly showed the spawning period of this species. Identical patterns were observed in both the sexes. This species was found to spawn twice in a year as evident from the gonado-somatic index. The spawning season for *L. subviridis* in Parangipettai coast was found to be February and March. The wide range in gonado-somatic indices observed during the spawning season indicated group-synchronous breeding pattern.

Size at first maturity of other species of mugilids indicates wide variations. *Liza ramada* in Suez canal matured at 140 mm and 160 mm for males and females respectively (El-Halfawy *et al.,* 2007), 264 mm and 240 mm in case of male and female *Mugil curema* in Brazilian waters (De Oliviera *et al.,* 2011). Even within the more widely studied grey mullet, *M. cephalus*, the reported size at first maturity was in the range of 230 - 400 mm in males and 240 - 415 mm in females (Broadhead, 1953; Erman, 1959). However the results of size at first maturity from the present study (131 mm in males and 145 mm in females) were in close agreement with the previously reported values of *L. subviridis* from Southern Iraq which is 137 and 142 mm for males and females respectively (Al-Daham and Wahab, 1991). On the contrary, the same species in Thailand waters was found to mature at 116 and 170 mm for males and females respectively (Chunhapen, 1994). The reason behind the wide fluctuations for the same species might be due to temperature of waters and other environmental factors as Thomson (1963) opined that grey mullets mature earlier in warmer waters than in cold waters. The minimum length at which 50% of the males and females attained sexual maturity (L_{50}) in the present study was found to be 146 and 155 mm respectively. King (1995) opined that this method overestimates the size at first maturity. Instead he suggested the use of adjusted proportion of maturity percentages. This was followed in the present study and the values were found to be lower (131 mm and 145 mm for males and females respectively). In view of its importance in fisheries management, this method is found to be advantageous over the first method. In a properly managed fishery where the fishermen exploit only the fishes above the size at first maturity, they stand to gain as they can fish up to these sizes (131 mm and 145 mm of males and females respectively) rather than 146 and 155mm in males and females respectively. That way the fishermen stand to gain from the adjusted proportion method rather than the old and conventional method.

The relationship between fecundity and length is, generally, found to be curvilinear in fishes. Kesteven (1942) observed positive increase in ova number with increase in total length of grey mullets. Similar trend was observed in the present study. The fecundity of *L. subviridis* in Parangipettai waters ranged from 1 to 7.92 lakhs oocytes in the size range of 131 – 265 mm. Al-Daham and Wahab (1991) observed the fecundity to vary from 1.3 to 2.9 lakhs oocytes for the same species ranging from 182 to 243 mm total length in Shatt Al- Basrah canal, an estuary in southern Iraq. Fecundity of different stocks of the same species can be used for racial discriminate studies. Different races have characteristic fecundities and egg size so that the racial origins of fishes can be determined from egg counts and a population can be identified as a homogenous unit or as a mixture of different stocks (Sivashanthini *et al.,* 2008).

Chi-square analysis showed that the sex ratio differed significantly from the hypothetical ratio of 1:1 in the month of October. The annual average male: female sex ratio in the present study was found to be 1:1.2 and same value recorded from Thailand coast (Chunhapen, 1994). Higher ratio of 1:1.4 was reported by Al-Daham and Wahab (1991) in southern Iraq. The present values agrees with the previous findings reported elsewhere and the above implications in terms of the potential effect on the reproductive capacity of the stock would support management decisions and ensure the long-term viability of *L. subviridis* stocks along the Parangipettai coast and coastal waters of India.

CONCLUSION

The results of the present study provides important information on the reproductive biology of *L. subviridis* and forms the benchmark data that will be helpful for future studies on the biological aspects of Indian mugilids. Further studies on the reproductive characteristics such as the spawning frequency and fecundity from different spawning grounds along the Indian coast of the same species as well as other mugilids are necessary for a clear understanding of the reproductive strategies of Indian mullets.

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