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Reproductive biology of the spotted scat *Scatophagus argus* (Linnaeus, 1766) from Mandapam waters, south-east coast of India

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ABSTRACT

Reproductive biology of the spotted scat *Scatophagus argus* (Linnaeus, 1766) was studied by examining 1,659 individuals collected fortnightly between August 1995 and July 1997 from the Gulf of Mannar along Mandapam coast. Overall sex ratio (1:2.2) indicated that the population had significantly higher proportion of females than males (χ^2 test, $p<0.05$). Size at first maturity estimated was 120.5-125.5 mm (males) and 140.5-145.5 mm (females). The spawning season coincided with monsoon months and was observed to extend from June to August (south-west monsoon) with peak in July and from October to December (north-east monsoon) with peak in November. Seven stages of gonadal maturation were established based on macroscopic characteristics *viz.,* immature, developing immature/recovering spent, maturing, mature, advanced mature, ripe and spent. The diameter of ova ranged from 0.10 to 0.75 mm. Fecundity range of 20 females was 1,15,038 in fish of size 235 mm and 265 g to 1,53,661 in fish of size 300 mm and 350 g.

Keywords: Fecundity, Reproductive biology, *Scatophagus argus*, Spawning season

Introduction

The spotted scat, *Scatophagus argus* (Perciformes: Scatophagidae) is a euryhaline teleost found in freshwater, brackishwater and marine habitats. This species is widely distributed throughout Indo-Pacific Ocean (Ni and Kwok, 1999) including the coastal waters from southern India and Sri Lanka to southern Japan and Tahiti (Pinto and Punchihewa,1996). This species is a popular candidate in aquaria (Amarasinghe *et al.,* 2002) and is also an important food fish in South-east Asia (Musikasung *et al.,* 2006). A few attempts have been made to breed them in hatcheries (Chang and Hsieh, 1997; Liao *et al.,* 2001), but most of the seed used in aquaculture are collected from the wild. In Taiwan, this fish has traditionally been used to control algae in ponds (Shao *et al.*, 2004).

Though published reports on the reproductive biology of *S. argus* are available from far-east countries (Barry and Fast, 1992; Khanh *et al.,* 2010; Zeping *et al.,* 2010), no work so far has described the reproductive biology of this species in India. Hence, this study was undertaken to describe the reproductive biology of *S. argus* from the Gulf of Mannar along Mandapam coast of India.

Materials and methods

A total of 1,659 samples were collected through fortnightly random sampling between August 1995 and July 1997 from the commercial catches of artisanal gears such as shore seines, barrier nets, cast nets, gill nets, and special drag nets (*vidu valai*) landed at Mandapam (09º16′43.1″N, 79º09′44.4″E). These gears were operated in and around the coastal waters of Mandapam (Fig. 1). Freshly collected fish were brought to the laboratory in ice boxes and after removing the excess water by blotting, length (to the nearest mm) and weight (to the nearest 0.01g) were recorded for each fish. Fishes were dissected to identify the sex and condition of the gonad. After assessing the stage of maturation, the gonads were weighed (to the nearest 0.001g) and preserved in 4% formalin for subsequent analyses of ova-diameter, fecundity and spawning. Twenty ripe specimens of *S. argus* within the length range of 235 to 300 mm and 265 to 350 g were used for estimating the fecundity. The spawning season was described based on: (i) quantification of maturity stages, (ii) monthly percentage occurrence of fish with gonads in different stages of maturity, (iii) pattern of progression of ova during different months and (iv) variation in gonadosomatic index (GSI). Maturity

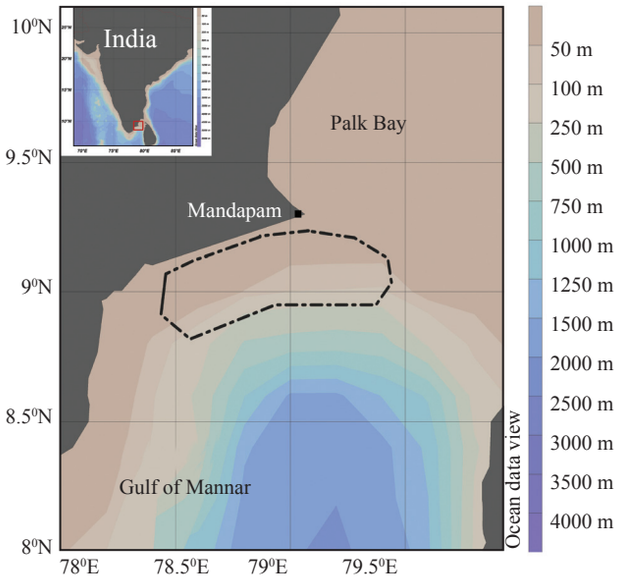

Fig. 1. Map showing the study area

stages were determined following the scale adopted by the International Council for Exploitation of Seas (Lovern and Wood, 1937) with suitable modifications. Based on this, the testis and ovary were grouped into seven maturity stages. Ova diameter measured following the method of Clark (1934) using an ocular micrometer were classified into groups of 50 µm intervals and the prominent modes were recorded from the monthly percentage frequency of each size group. Monthly GSI was determined using the formula: GSI = (Weight of gonad/Weight of fish) x 100 (June, 1953). Size at first maturity was arrived at by plotting the percentage occurrence of mature specimens (stages III and above) against total length. The length at which 50% of the fishes attained maturity was taken as the minimum length at first maturity and was determined using the graphical method (Udupa, 1986). Monthly sex ratio was analysed month-wise in this study. Chi-square test (Snedecor and Cochran, 1967) was employed to test whether the observed ratio between males and females deviated from the expected 1:1 ratio. Spawning season was ascertained by recording the monthly percentage occurrence of gonads in various maturity stages in every month of the study period and the data for the two year period were pooled month-wise and sex-wise. Only fish above size at maturity were considered for this purpose. Fecundity was estimated using the formula: Absolute fecundity = (NxTOW)/SOW, where N = number of eggs in sub-sample, TOW= total ovary weight and SOW=sample ovary weight.

Results and discussion

The gonads are bilobed, united in the middle which open out through a common duct behind the anus. Seven stages of maturation *viz.,* immature, developing/recovering spent, maturing, mature, advanced mature, ripe and spent were recognised in male and female *S. argus* .

Oocyte maturation

The size frequency distribution of oocytes in the stages I-VII of maturity is shown in Fig. 2. In stage I, majority of immature ova measured from 0.10 to 0.12 mm. Progression of a major mode was traced from 0.28-0.31 mm in stage II to 0.64-0.67 mm in stage VI. In stage VII this mode was completely released. A secondary mode was also traced from 0.28-0.25 mm in stage III to 0.37-0.40 mm in stage VII.

Size frequency distribution of oocytes in different maturity stages of *S. argus* indicated that there were 2 batches of ova with modes at 0.64-0.67 mm and 0.37-0.40 mm. Mature ova with modes at 0.64-0.67 mm formed a distinct group followed by a developing batch with the mode at 0.37-0.40 mm, which progressed to 0.43-0.46 mm after the first batch was released and since the fully spent ovary stage had only immature ova, it may be concluded that *S. argus* sheds two batches of ova during the extended spawning season. Based on the results of

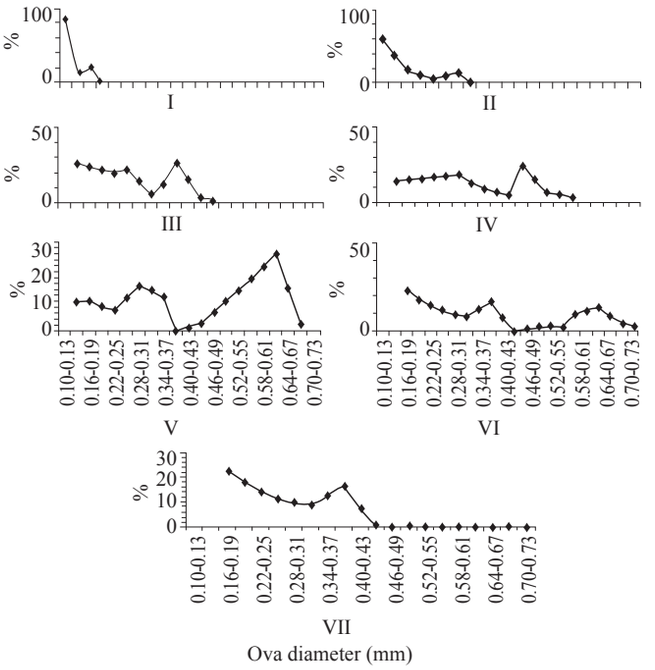

Fig. 2. Ova-diameter frequency polygons of different maturity stages in *S. argus*

size-distribution frequency of oocytes, it appears that *S. argus* fits into type 'C' of Prabhu (1956), breeding twice in a year and category II of Qasim and Qayyum (1961) with ovaries containing more than one group of maturing oocytes. The breeding season was observed to be moderately long. Two distinct modes in oocyte size distribution for mature fish indicate that *S. argus* in Mandapam waters may undergo multiple spawning per season. The breeding period of a fish will be for a definite duration if the mature ova are sharply separated from the stock of immature ova (Hickling and Rutenberg, 1936). However in this study, the secondary mode was not synchronously developed with the mode of maturing oocytes. Species with multiple spawning per year have longer spawning seasons. Ze-ping *et al.* (2010) reported that this fish is capable of multiple spawning during its reproductive period.

Maturity stages of female *S. argus* can also be classified based on the ova diameter range observed in each stage (Table 1) into seven stages of maturation *viz*., immature (0.10-0.2 mm), developing/recovering spent (0.26-0.36 mm), maturing (0.37-0.47 mm), mature (0.43-0.58 mm), advanced mature (0.59-0.69 mm), ripe (0.65-0.75 mm) and spent (0.26-0.36 mm).

Table 1. Size-range of oocytes of *S. argus* in relation to maturity stages

Stage	Range (mm)	Mode (mm)
Immature (I)	0.10 - 0.20	0.12
Developing immature and recovering spent (II)	0.26 - 0.36	0.28
Maturing (III)	0.37 - 0.47	0.39
Mature (IV)	0.43 - 0.58	0.45
Advanced mature (V)	0.59 - 0.69	0.61
Ripe	0.65 - 0.75	0.67
Spent	0.26 - 0.36	0.28
Residual eggs	0.56 - 0.72	0.66

Size at first maturity

Male and female *S. argus* were found to mature at a size group of 120.5-125.5 mm and 140.5-145.5 mm total length (TL) respectively (Fig. 3).

Information on the size of maturation is essential for avoiding over-exploitation of immature juveniles and for ensuring the spawning of the individual fishes at least once in life time. In *S. argus*, the males and females were found to be mature in the size groups 120.5-125.5 mm and 140.5-145.5 mm TL respectively. Size at maturity for female was comparable to the values reported by Barry and Fast (1992) in Philippine waters. However males mature slightly earlier in the Philippine waters. Males attain sexual maturity at a smaller length than females. Similar observations were reported in other species

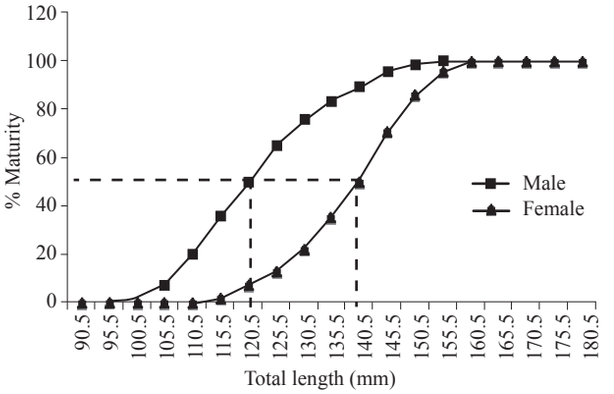

Fig. 3. Size at maturity of *S. argus* off Mandapam

of marine fish such as *Priacanthus hamrur* (Sivakami *et al.,* 2001), *Mugil seheli* (El-halfawy, 2004) and *Sillago sihama* (Shamson and Ansari, 2010).

Maturity stages of gonads

The monthly distribution of different maturity stages of males and females (Fig. 4), indicate that *S. argus* has a protracted breeding season which lasts from June to December with peaks of spawning activity during the south-west monsoon (June-August) and the north-east monsoon (October-December).

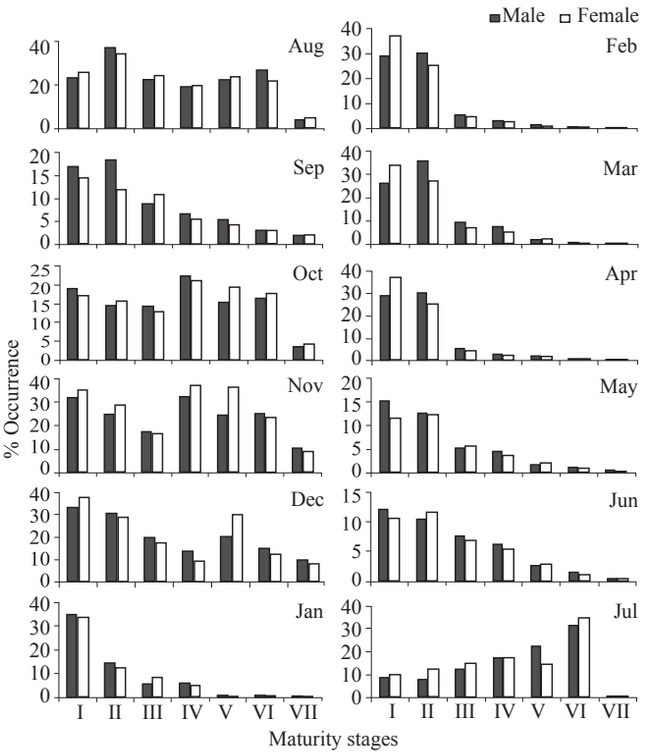

Fig. 4. Distribution of monthly maturity stages of *S. argus* from Mandapam waters (1995-96 and 1996-97 pooled)

Gonadosomatic index

The gonadosomatic index (GSI) values of *S. argus* showed correlation with gonadal maturation (Fig. 5). The monthly GSI values in males ranged from 0.79 and 1.42, while in females, the range was between 3.42 and 8.60. The GSI in females increased from 4.7 in May to the first peak of 8.6 in July, decreased in September and increased again from October to reach the second peak of 7.36 in November. A similar pattern was also observed in males. The GSI values indicated an extended spawning season for *S. argus* in Mandapam waters, with peaks in July (south-west monsoon) and with another peak in November (north-east monsoon).

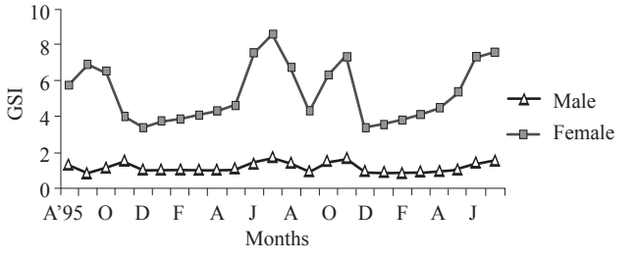

Fig. 5. Gonado-somatic index (GSI) of *S. argus* from Mandapam waters

Sex ratio

The percentage occurrence of females and males is given in Fig. 6. The overall male:female sex ratio was 1:2.2, which significantly differed from the expected ratio (χ^2, $p<0.05$). Females outnumbered males in almost all the months. The overall sex ratio for the pooled observations varied significantly from the expected ratio (χ^2, $p<0.05$), with 2.2 females for every male which is higher than the reported ratio of 1:1.3 by Ze-ping *et al.* (2010) from the South China coastal waters. However, Barry and Fast (1992) noted higher sex ratio of 1:3.1 for the same species from the southern coastal waters of Pannay Island, Philippines. An evaluation of sex ratio in *S. argus* showed that females were dominant in the population. Similar observations of female dominance in *S. argus* were also reported in other waters (Barry and Fast, 1992; Ze-ping *et al.,* 2010). Siddiqui *et al.* (1976) stated that the predominance of females in higher groups might be due to heavy mortality of males in smaller size groups due to either natural death or fishing pressure as they were more active and caught more easily. Females were larger and heavier than males of the same length group. These observations were supported by Jency *et al.* (2008). Females tend to have larger gonads than males with large yolk-rich eggs, whereas males have much smaller gonads that produce numerous smaller sperms (Andersson, 1994).

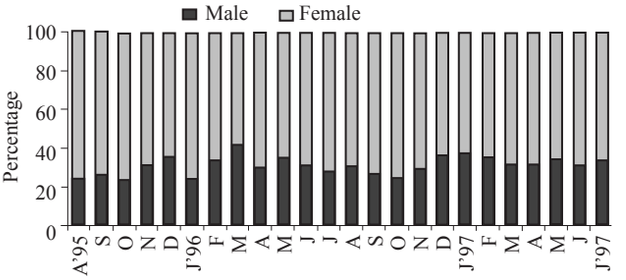

Fig. 6. Proportion of sexes by month in *S. argus* off Mandapam

Fecundity

Knowledge on fecundity is extremely important from the viewpoint of successful exploitation and management of a fishery. In the present study, the estimated absolute fecundity for *S. argus* ranged between 1,15,038 to 1,53,661 ova which is less than that observed by Ze-ping *et al.* (2010) and Barry and Fast (1992). Kennedy *et al.* (2007) and Kjesbu *et al.* (1998) established that the fecundity of fish within a population is known to differ from year to year and also between stocks of the same species.

In the present study, the spawning season established by observing the macroscopic characteristics of the gonads, oocyte diameter frequency distribution and the GSI, showed good agreement indicating that spawning of *S. argus* occurs twice a year, once during the south-west monsoon (June-August) and the other during north-east monsoon season (October-December). Ze-ping *et al.* (2010) found that the breading season of *S. argus* in South China coastal waters extends from April to August with peak between May and July which coincides with breeding season of the fish as observed in the present study. Barry and Fast (1992) also found June-July to be the spawning period of this species in Philippines and suggested that oocyte maturation and spawning are triggered by monsoon.

The results of the present study indicate that *S. argus* spawn twice a year producing large number of eggs. Females dominate over males in the population and males mature earlier than females.

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