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Bionomics of a lesser known goby, *Stenogobius gymnopomus* (Bleeker, 1853) (Perciformes: Gobiidae) from southern Kerala, India

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Author Contribution: SL was involved in the sample collection, data processing, data analysis and writing the paper. GP involved in the identification of specimens, preparation and correction of manuscript. SDR was involved in design and data analysis of the study.

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Abstract: The biology of a lesser known goby, *Stenogobius gymnopomus* was studied from the freshwater systems of southern Kerala. Dietary analysis showed that *S. gymnopomus* is a euryphagous feeder and an omnivore. Cladocerans, together with fish eggs and scales, constituted the major food items. The minimum size at first maturity for male *S. gymnopomus* is 78mm and for females 72mm. This species was found to be a batch spawner with a prolonged spawning season extending from August to December. Fecundity ranged from 46,323 to 61,291 eggs. Sex ratios revealed that local populations of *S. gymnopomus* are male dominated.

Keywords: Food and feeding, goby, reproductive biology, *Stenogobius gymnopomus*.

INTRODUCTION

The family Gobiidae is a perciform taxon represented by several thousand species which underwent extensive adaptive radiation. Most populations occupy marine, brackish and inland habitats of tropical and temperate regions (Gandolfi et al. 1991). Gobies were in existence in the Eocene (50 million years ago) (Grzimek 1974) and they are considered the 'Lilliputians' of the fish world as most species are under three inches in length and many are under one inch in length. They are bottom dwellers having worldwide distribution. Most gobies inhabit the shallow coastal waters of warmer seas especially on rocky shores, some being left behind as the tide ebbs and they shelter under stones in rocky pools. Others live in burrows in sand or mud or shelter among branching corals (Burton & Burton 1975). A few seek out the brackish water region at the mouth of rivers and only a very few are able to penetrate into absolute freshwaters. Gobioids are experts in concealing themselves, spending most of their time hidden in mud or sand, or in burrows or bores of mangrove stems.

Extensive studies on gobiod fishes are available from many regions of the world (Morawski 1978; Miller 1989; Bouchereau & Guelorget 1997; Horackiewicz & Skora 1998; Chesalin et al. 2004; Borek & Sapota 2005; La Mesa et al. 2005). Studies on Indian gobioid fishes are very few, and those available are restricted mostly to the Large Indian Goby *Glossogobius giuris*, a commercially important fish growing to considerable size. Tandon (1962) studied the feeding biology of the species in the river Ganga. Bhowmick (1963) made a preliminary study of the food and feeding habits of *G. giuris* from Hoogly estuary. Geevarghese (1976) carried out a detailed study of *G. giuris* from Lake Veli, Kerala, India.

As Smith (1959) pointed out, gobioid fishes are not a favourite of most ichthyologists; largely because of their small size and the trouble involved in their collection. Very little is known about this group from Kerala. The present study reports the food and feeding habits and breeding biology of *Stenogobius gymnopomus* from Thiruvananthapuram, Kerala.

MATERIALS AND METHODS

Samples of *Stenogobius gymnopomus* were collected on a monthly basis from the different regions of Pallichal Canal near Arattukadavu, Vellayani, Thiruvananthapuram District (located 11km south of Thiruvananthapuram City) Pallichal canal originates from Neyyar River and joins the Vellayani Lake at the northern border. It has a width of 1.5m and an average depth of 1.75m (Fig. 1). The collection site located between 76^{0}58'30''-76^{0}59'30''E & 8^{0}27'-8^{0}25'30''N. Samples (n = 108) were collected using a cast net over a period of 10 months from July 2006 to April 2007. Samples were anaesthetized at the collection site itself and preserved in 5% neutral formalin for further examination in the laboratory. The length of whole fish was measured to the nearest millimeter and weighed to the nearest gram. The fish was dissected and the gut taken out for dietary analysis. The ratio of gut length to the total length of fish in different size groups was determined. The food composition in each gut was determined using a points and occurrence method as described by Hyslop (1980). Of the 108 specimens, 65 males ranged in length from 61-150 mm and 40 females ranged from 41-130 mm in total length and the remaining three which ranged in length from 30-40.1 mm were too small to determine the sex.

From the intact gut the intensity of feeding was assessed (Geevarghese 1976). Guts were classified as:

Empty - the gut contained practically nothing and its wall was least distended.

Poor - the gut contained little food but no distension of the wall was evident.

Medium - the gut was nearly half full and the wall was slightly distended.

Good - the gut was almost full and the distension of the wall was clearly evident.

Heavy - the gut was gorged with food and the wall was fully distended.

Depending upon the degree of fullness of gut, points were allotted. Subsequently each category of food was sorted out and points were awarded for each food item. The total points thus allotted in a food category in a sample for a particular month were summed and expressed as the percentage of the total points. Combining percentage of occurrence and points, the index of preponderance (I_i) was calculated following Natarajan & Jhingran (1961).

$$I_i = \frac{V_i O_i}{\sum V_i O_i} \times 100$$

Where Ii is the index of preponderance, V_i and O_i represent the percentage volume and occurrence of particular food (i) respectively.

The gonads were carefully dissected and colour, shape and weight of each gonad recorded. A few ripe stage ovaries were preserved in 5% formalin. The percentage occurrence of different maturity stages (males and females separately) were noted and grouped into 10mm interval length groups to indicate the minimum size at maturity. A quantitative assessment of the condition of the gonad, employing the technique of gonado somatic index (GSI), expressing the gonad weight in terms of the percentage of the body weight, was worked out.

$$GSI = \frac{\text{Gonad weight}}{\text{Body weight}} \times 100$$

Sex ratio was calculated as the percentage of males and females in each monthly collection. From the samples of ovaries, sub samples were taken and the eggs counted, and then the fecundity determined (Clark 1934; Prabhu 1956).

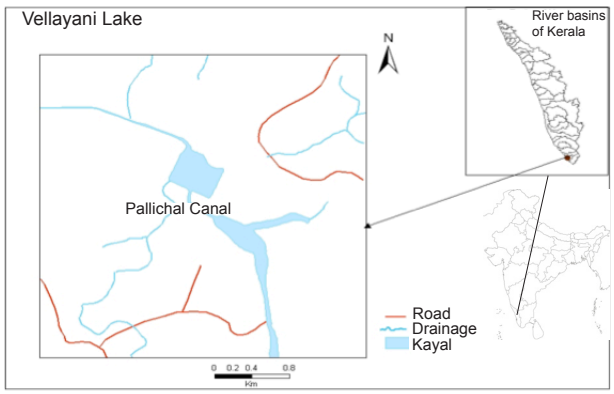

Figure 1. Map showing Vellayani Lake and study area - Pallichal Canal

RESULTS

Major food items and index of preponderance of *S. gymnopomus* is presented in Table 1. *S. gymnopomus* is predominantly an omnivorous fish feeding mainly on cladocerans and fish eggs and scales which are being supplemented with other food materials such as green algae, blue green algae, diatoms, crustaceans, aquatic insects, bivalves, nematodes, polychaetes and detritus.

It was observed that fishes with heavy guts (gorged and full) constituted an annual average of 9.48%. Fishes with heavy guts exceeded the annual average in the months of August, October, November and December and reached its maximum incidence in December. The relation between relative gut length and weight of fish was represented in Fig. 2.

The reproductive parameters of the fish are given in Table 2. Female *S. gymnopomus* less than 60mm were all immature while all fish were matured, when they were 71mm. Fish ≥ 111mm were all in ripe condition. The minimum size for the attainment of maturity for at least 50% of females and males of *S. gymnopomus* is around 72mm (TL) and 78mm (TL) respectively. Therefore

Table 1. Index of preponderance of *Stenogobius gymnopomus*

Food item	Index of occurrence (Oi) ($n_i \times 100 / \sum n_i$)	Index of volume (V_i) ($v_i \times 100 / \sum v_i$)	O_iV_i	Index of preponderance (I_i)
Green algae	6.25	1.8	11.25	1.15
Blue green algae	4.16	1.59	6.61	0.67
Cladocera	12.5	15.38	192.25	19.68
Bacillariophyceae	4.16	6.89	28.66	2.93
Crustacean	10.42	10.53	109.72	11.23
Fish scales and egg	12.5	23.87	298.37	30.55
Polychaete worms	10.42	12.73	132.64	13.58
Nematode worms	6.25	4.13	25.81	2.64
Aquatic insects	8.33	5.03	41.89	4.28
Bivalves	8.33	8	66.64	6.8
Detritus	6.25	5.83	36.43	3.73
Sand grains	8.33	2.91	24.24	2.48
Semi digested food	2.1	1.31	2.75	0.28
Total	100	100	976.5	100

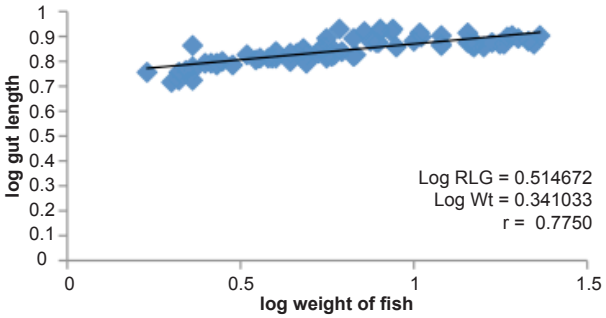

Figure 2. Relation of alimentary canal length with weight of fish

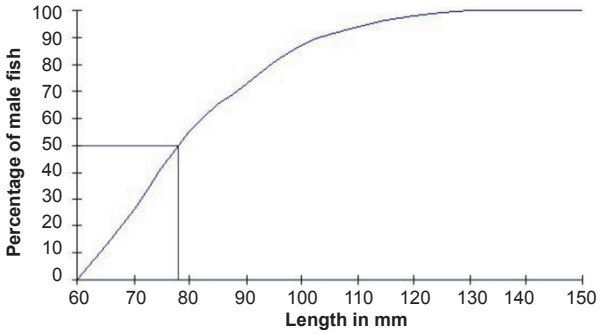

Figure 3. Size at first maturity of male *S. gymnopomus*

Table 2. Reproductive parameters of *S. gymnopomus*

Fecundity	46323 – 61291
Sex ratio (male : female)	1.62 : 1
Size at first maturity male (cm)	61.0
Size at first maturity female (cm)	72.0

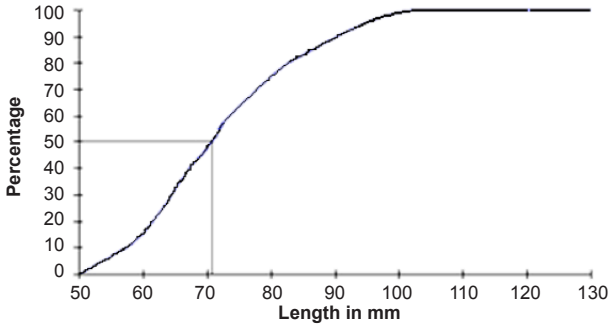

Figure 4. Size at first maturity of female *S. gymnopomus*

females mature at a length smaller than that of males. Size at first maturity of males and females are showed in Figs. 3 and 4 respectively.

High GSI values were obtained for female *S. gymnopomus* from August to October, and December and March months while the lowest GSI values were during November, January to February and April months. From the above mentioned observations it appears that the species is a multiple spawner and spawning season of the species could be from August to December and March months. The eggs represented by different modes and these modes represent distinct stock of ripe ova. This is the ripe stock to be immediately spawned. The next stage of ova represented by a mode was the ripening stock that undergoes rapid maturation and takes the position of first mode as the ripe stock of eggs is eliminated by spawning. Subsequently, the newly ripe ova are extruded during

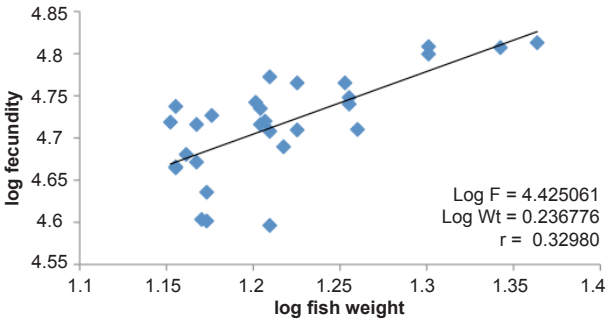

Figure 5. Relation between fecundity and weight of fish

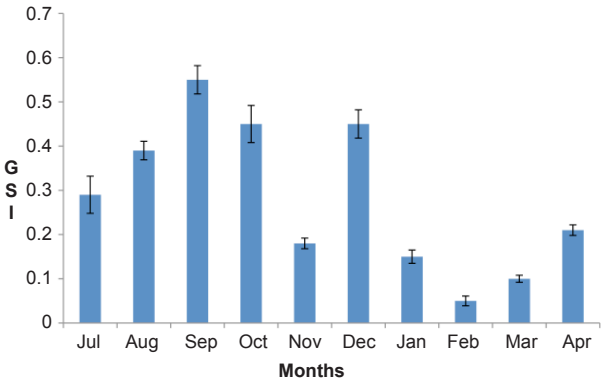

Figure 6. Monthly average of Gonado Somatic Index of male *S. gymnopomus*

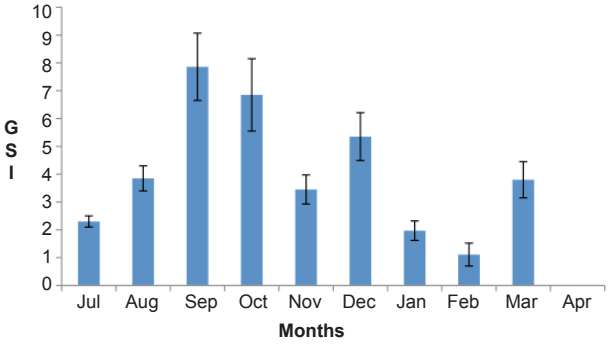

Figure 7. Monthly average of Gonado Somatic Index of female *S. gymnopomus*

the next spawning process which occurs within a very short period. The occurrence of large number of ova of intermediate size between the immature and fully ripe sets of ova in the mature fish itself also indicates the prolonged spawning period of the species. It has been observed that the male to female ratio is around 1.62:1 indicating the dominance of males. From November to February, females dominated over males and in October, males and females were in equal ratio i.e. 1:1. In all other months the sex ratio was skewed in favour of males. Fecundity ranged between 46,323 to 61,291 eggs. The relation between fecundity and weight of fish is represented as Fig. 5. The fecundity and weight of fish was positively correlated. The monthly average GSI against months of male and female are represented as Figs. 6 and 7 respectively.

DISCUSSION

The growth of fish is determined by the combined effects of food quality and quantity. The present study revealed that the main constituents of gut content are filamentous algae, molluscs and worms. This mixed diet composition revealed that the fish is an omnivore. According to Menon & Chacko (1956) fishes feeding on filamentous algae, molluscs, worms, and whose guts contain sand grains in fair proportions are benthic feeders. If this characterization is to be relied upon, *S. gymnopomus* is also a bottom feeder as with most of the gobioid fishes. Sunil (1994) reported that *Stigmatogobius javanicus* and *Eleotris fusca* from Veli Lake in Kerala are also benthic feeders.

Since the food and feeding habits of this species has not been reported previously, a comparison with earlier results becomes difficult. But details are available on the feeding habits of other species of gobioids. Such information shows that they may range from near herbivorous to purely carnivorous, feeding on a wide variety of ingestible organisms from its habitat. It has even been noticed that the same species may consume a variety of food from different localities which means that, some of the gobioid species have no food specificity. Marquez (1960) found *G. giuris* from Philippines to be predominantly herbivorous, feeding mainly on algae. Tandon (1962) found the same species in Varanasi (India) to be carnivorous, feeding mainly on fishes and insects. Geevarghese (1976) recorded the same species in Veli Lake as carnivorous, feeding mainly on fishes and crustaceans. These observations suggest that availability of food in the habitat is the main factor that determines the feeding habits of some gobioids, and that such species have no food specificity. From the observations, it is clear that there is a linear relationship exists between weight of the fish and relative gut length of fish (Kharat et al. 2008).

Breeding in teleosts is characterized by unique specialization, which permits the successful adaptation to diverse environmental conditions. From the data on GSI and monthly distribution of maturity stages it can be assumed that spawning is a continuous process in *S. gymnopomus* and extends for nearly 7 to 8 months in a year. For the period of investigation (July 2006 - April 2007) the peak spawning lasted from August to December. A total absence of mature males and females was noticed in January and February and ripe specimens started appearing from March-April onwards. Other gobioid fishes like *Chasmichthys dolicognathus*

and *Peteragobius esapoides* (Nakamura 1936), *Chaenogobius urotaenia* (Dotu 1955), *Gobius cobitis* (Gibson 1970), *Gillichthys mirabilis* (Barlow & DeVlaming 1972), *Leseurigobius friesii* (Gibson & Ezzi 1978) and a majority of the Pacific species (Barlow & DeVlaming 1972) also have a protracted breeding season. Another gobioid *Aphia minuta* was noticed to spawn at least twice (Caputo et al. 2000). *Gobius niger* (De Casabianca & Kiener 1969) seemed to be an exception for the absence of an extended breeding season.

Results of the ova diameter frequency indicated that the ovary contained two distinctly separated definite batches of eggs and hence the same individual may spawn more than once during a season. Considering the above characters *S. gymnopomus* can be placed in Group IV of Karekar & Bal's (1960) classification (fishes which spawn intermittently over a prolonged period, with ovaries containing batches of eggs which cannot be differentiated from each other) and in category II of Qasim & Qayyum (1961) (fishes having a longer breeding season, with more than one batch of maturing eggs). Tandon (1962), Marquez (1960), Saksena (1976 a,b) and Geevarghese (1976) after studying the reproductive biology of *G. giuris* concluded that the species has an extended breeding season and breeds throughout the year. Saksena (1976 a,b) reported that the spawning period of the species extends from June to September and that this difference in the breeding habit may be ascribed to geographical and environmental variations. In the present observation it is clear that the species is characterizes with prolonged breeding season.

The sex ratio of *S. gymnopomus* in the present study was 1.6:1 favouring males. The ideal sex ratio in natural adult populations of fish is close to 1:1 (Nikolsky 1980). The deviation in sex ratio from the ideal one with a distinct predominance of males may be a contributing factor to the endangered status of *S. gymnopomus*. (Nikolsky 1980). Geevarghese (1976) in *G. giuris* and Gibson & Ezzi (1978) in *L. friesii* also reported similar skewed sex ratios. In *G. giuris*, the male: female ratio was 5:1 and in *L. friesii* it was 1.2:1. The reduction in number of females may be attributed to the fact that the females of *S. gymnopomus* are less hardy and more liable to death due to the dynamics of breeding and also due to their peculiar parental care (Sunil 1994).

Fecundity of similar sized gobies may differ between different species (Miller 1989). In *Sicyopterus japonicus* of 105mm, the fecundity was reported as 224960 eggs whereas in *Neogobius melanostomus* of the same length, the number of eggs produced was 1600. According to Borek & Sapota (2005), fishes which are more vulnerable to predation produce more number of eggs. Fecundity shows a linear relationship with weight of fish. This shows ovary grow in proportion to the body growth. According to Kharat et al. (2008) the non-isometric growth of ovary as compared to somatic tissues can have evolutionary significance. In the present study, it is clear that during spawning period the stomach of a gravid female is normally empty. This arrangement suggests that the fish devotes its entire abdominal space for the growing ovary. On conclusion it can be stated that the *S. gymnopomus* collected from the canals of Thiruvananthapuram area of Kerala, India is an omnivorous, bottom feeder with a skewed sex ratio favouring males. The fish has got a prolonged breeding season and peaks from August to December.

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