Reproductive Biology of the Whipfin Silverbiddy Gerres filamentosus Cuvier, 1829 from the Parangipettai Waters (SE coast of India)

Article · January 2008

CITATIONS
10

READS
520

1 author:

Sivashanthini Kuganathan
University of Jaffna
74 PUBLICATIONS **251** CITATIONS

SEE PROFILE

Asian Fisheries Society, Manila, Philippines
Available online at www.asianfisheriessociety.org

Reproductive Biology of the Whipfin Silverbiddy *Gerres filamentosus* Cuvier, 1829 from the Parangipettai Waters (SE coast of India)

K. SIVASHANTHINI*

Department of Zoology
University of Jaffna
Jaffna, Sri Lanka

Abstract

The developmental stages of the whipfin silverbiddy *Gerres filamentosus* gonads were recorded macroscopically and microscopically. Histological sections of gonads characterized seven stages of ovary and four stages of testes in *G. filamentosus*. Ova diameter in *G. filamentosus* ranged between 12.0 and 501.8 µm. The composite histograms based on the diameters of all oocytes at successive stages of maturation showed three modes in ovaries at stages III, IV, V & VI. Most of the fully ripe ovaries characterized three batches of matured eggs showing that *G. filamentosus* spawns three successive batches within the same prolonged spawning season. Indication of previous spawning was ascertained by the ruptured ovarian follicles and resorbing ovulated ova and atretic ovarian follicles observed during October-February. The silverbiddy males reach maturity at 143.8 mm, while the females at 136.6 mm total length. The annual fecundity varied from 121,700 to 2,062,278 while batch fecundity varied from 171,596 to 740,844 oocytes.

* Tel: +94 21 222 5925; Fax: +94 21 222 2685
E-mail address: sivashanthini@jfn.ac.lk

Introduction

Oocyte development and spawning are two separate events controlled by different physiological mechanisms (de Vlaming 1983). Spawning may be single or serial while oocyte development may be synchronous, group synchronous and asynchronous (Wallace and Selman 1981). Most teleost fish are itereparous i.e. they spawn more than once during their lifespan. In fish, two basic types of spawning have been observed (Longhurst and Pauly 1987): synchronous, where all oocytes develop at the same time inside the ovary and spawn in a single episode; serial or batch spawning with ovaries containing batches of oocytes at different stages of development leading to repeated or multiple spawning (Yamamoto and Yamazaki 1961). Coastal and estuarine teleosts in the subtropics and tropics are characterized with long spawning seasons (Longhurst and Pauly 1987). In Indian waters, most teleosts are prolonged breeders as evidenced by their ovaries containing several batches of ova destined to mature and to be released periodically on maturation (Venkataramanujam and Ramanathan 1994).

Estimates of fecundity, sexual maturity and method of spawning are staples of fishery science and important in the dynamics of the population. In other words, fecundity estimates combined with the estimates of the abundance of eggs in the sea, can be used to estimate the biomass of the stock (Hunter et al. 1992). Knowledge on length at maturity and spawning season detects when and at which length the fish should be protected and therefore it is important for the proper management and conservation of fish stocks.

The most suitable method of determining the reproductive cycle of fishes is to observe the seasonal developmental changes in their gonads (Karlou-Riga and Economidis 1996; 1997). Methods used for identifying spawning seasons of fishes are reviewed by West (1990) who suggested that histological studies while expensive and time consuming, yield the most reliable information on spawning cycles. Histological examination is considered essential for detecting details within the maturation cycle as: maturing fish, partially spawned fish and the presence of postovulatory follicles and atretic oocytes (Hunter and Macewicz 1985a; 1985b; Schaefer 1987; West 1990; Davis and West 1993; Marshall et al. 1993).

The whip fin silverbiddy *Gerres filamentosus* is an economically important demersal fish species, inhabiting the coastal waters of India. *G. filamentosus* Cuvier 1829 are members of the Teleostean family Gerreidae of the order Perciformes. These are popularly called as 'Mojarras', silver-biddies or purse mouths. These are widespread in all warm seas of the Indo-Pacific, from the east coast of Africa through the Indo-Malayan archipelago, South China Sea, Northern Australia and the west Pacific islands also westward to east and South Africa (Froese and Pauly 2000). They spend part of their life cycle in estuaries (Cyrus and Blaber 1982).

Previous studies on the reproductive biology of the whipfin silverbiddy were preliminary (Cyrus and Blaber 1984; Kurup and Samuel 1991). The present study aims towards the estimation of length at first maturity based on the histological sections of gonad tissue, potential annual fecundity, batch fecundity, spawning frequency, annual reproductive cycle and mode of spawning. Such information is valuable for the sustainable management of the gerreid fishery in SE coast of India.

Materials and Methods

The Parangipettai landing center (79^{o} 43′ E longitude and 11^{o} 29′ N latitude) is situated on the northern bank of Vellar estuary where it empties into the Bay of Bengal at about 30 km south of Cuddalore, on the southeast coast of India. Along the Parangipettai coast there are seven fishing villages from Mudasalodai to Pudukuppam extending over a distance of 30 km. Parangipettai waters receive rain from the northeast and southwest monsoons and temperature ranges from 28-36ºC. The depth may vary from 12-15 m. Boat seines and gill nets are the most common gears used to catch silverbiddies. Apart from this, traditional gears such as catamarans, plank-built boats and dugout canoes are also employed for fishing silverbiddies. Whipfin silverbiddies are available throughout the year at the Parangipettai waters. The main fishing season is from April to December.

Random samples of *Gerres filamentosus* were collected from boat seine and gill net catches from Parangipettai and adjacent landing centers (SE coast of India) between September 2001 and August 2003. At least one sample was obtained every week. Sex was determined macroscopi-

cally. For each fish, total length (TL, mm) was recorded to the nearest 1 mm and total weight (TW in g) was weighed to the nearest 1.0 g.

Gonads were weighed to the nearest 0.01g (GW). Nearly all immature and mature gonads were examined macroscopically. Three hundred and fifty five ovaries and two hundred and ninety nine testes were subjected to histological analysis. One gonad was randomly chosen for histological processing and its median portion of about 5-10 mm was removed (Forberg 1982) to avoid possible variation in the developmental stage of oocytes due to their position in the ovary. It was immediately preserved in formal acetic acid (FAA) solution for histological sectioning. In mature females (stages IV-VI), the remaining ovary was placed in modified Gilson fluid for annual and batch fecundity estimation.

Gonads selected for histological processing were placed in FAA for 2-4 weeks. Tissue samples were then rinsed overnight with flowing tap water and placed in 70% ethyl alcohol. Dehydrated tissues were embedded in paraffin, sectioned at 6 µm and stained with Harris haematoxylin and eosin (H&E). Standard histological processing (Ratcliffe 1982) was performed for all samples. The slides prepared were examined by light microscopy with a Nikon Optiphot microscope.

Ovaries were staged on the basis of the most advanced type of oocytes present, regardless of their abundance (Wallace et al. 1987; West 1990; Baelde 1996). The presence of post-ovulatory follicles, migratory nucleus oocytes or hydrated oocytes in ovaries was used to identify individuals that had begun to spawn (Hunter and Macewicz 1985b) or were capable of spawning (Bell et al. 1992). After spawning, residual oocytes and unwanted materials were reabsorbed following a process known as atresia (Hunter and Macewicz 1985a). Atretic oocytes were recognized by their irregular shape, breakdown in fine structure (disintegration of the nucleus and liquefaction of yolk granules) and hypertrophy of the granulosa cells (Davis 1977). As degeneration progresses, it becomes more difficult to distinguish atretic oocytes from advanced degeneration of postovulatory follicles (described as β artesia by Hunter and Macewicz 1985b). Nevertheless, high levels of any atretic material, combined with the lack of hydrated oocytes and post-ovulatory follicles, were used to confirm when spawning had ceased. The presence of alpha (α), beta (β), gamma (γ) or delta (δ) stages of atresia were also recorded. Male gonads were also classified macroscopically and microscopically.

The reproductive season was defined as the period from the appearance of the first active females with yolked oocytes, until the last active females sampled (Hunter and Macewicz 1985a). The percentage occurrence of various maturity stages of ovaries in different months was computed by pooling the data for two years. Maturity stages recognized macroscopically were categorized into four stages. Six individuals were selected for analysis of oocyte size-frequency distributions; three in October and another three in February, representing early and late spawners. The diameter of nearly 500 oocytes from each stage of ovary was recorded.

Length at maturity was analyzed for fish collected from October to February. Females with ribbon-like ovaries (stage I or stage IIa) were classified as immature. Females were considered mature if classified into microscopic stages IIb-VII (Table 1). Males were considered mature if spermatocytes or spermatozoa were present in histological sections (Table 2). Length at maturity was based on 620 females and 714 males (75-279 mm TL). The maturity data were grouped into 25 mm TL size groups and the percentage occurrence of the mature specimens in each size group was calculated. A logistic regression curve was fitted to the data to estimate the length at which 50% of the individuals are mature (L_m) using the non-linear least-squares procedure weighted by the number of fish in each length-class. The form of the logistic equation used was (King 1995):

$$P = 100/ (1 + exp^{[-r (L-Lm)]})$$

where P is the percentage of mature individuals, r is the slope of the curve or the rate of increase in maturity, L_m is length at 50% maturity and L is the 1 cm length class.

Sex ratio was determined from the number of specimens of each sex sampled every month and in every size group. To test the significant deviations from the theoretical 1:1 ratio, the monthly sex ratio values were subjected to chi-square test (Sokal and Rohlf 1981).

To determine the annual spawning season indirectly, the gonadosomatic index (GSI) was calculated by using gonad free weight for each male and female fishes according to the most widely used method in the literature (Cailliet et al. 1986): *GSI = (gonad weight / gonad free total weight)* X 100. A more precise estimate of spawning season was determined from a microscopic examination of gonad stages. The mean GSI for each 25 mm length class interval fish was computed for females of

both species and plotted as box-whisker plots in order to find out the length at spawning.

Table 1. Macroscopic description of the ovary and oocyte developmental stages of *Gerres filamentosus*

Stage	Macroscopic description
I Immature	Small thread-like ovaries; Ovaries pink and translucent
II Early developing	Oocytes not visible; Ovaries pink and translucent
IIa First time developing	Ovary wall thin and transparent
IIb Redeveloping	Ovaries flaccid, ovary wall thick; Ovary pink/grayish to yellow-orange, and opaque
III Developing	Small oocytes becoming visible, still translucent Ovaries sometimes change from pink to yellow-orange
IV Late developing	Small opaque oocytes clearly visible Ovary wall thin and transparent Ovaries occupy 20-100% of length of body cavity
V Ripe	Large transparent (hydrating) oocytes visible Ovaries occupy 70-100% of length of body cavity
VI Running type	Hydrated oocytes very large, almost totally transparent Ovaries occupy 70-100% of length of body cavity
VII Spent & Resting	Some residual oocytes visible within translucent material Ovaries flaccid, grayish ovary wall thickened and wrinkled Ovaries occupy 20-70% of length of body cavity

Table 2. Macroscopic description of the testes of *Gerres filamentosus*

Stage	Macroscopic description
I Immature	Testes very small, flat and thread like
II Mature	Testes flat or round in shape; Testes occupy 20-70% of length of body cavity
III Fully mature	Testes lobed or multi-lobed; Testes occupy 40-70% of length of body cavity Marked groove in the middle of each testis; Free-flowing milt; Testes white sometimes bloodshot
IV Spawning	Testes very bloodshot; Testes occupy 20-50% of length of body cavity Milt sometimes present; Testes pinkish and rubbery as they regress to resting stage

All fecundity estimates were based on fish that had undamaged ovaries and showed no sign of previous spawning in that season (i.e. no

loose, hydrated oocytes in the lumen of the ovary; Watson et al. 1992), no sign of POFs and no sign of major atresia. Initially, portions from five of these fish were dissected from the anterior, median and posterior regions of the gonad and weighed accurately (± 0.001 g). Analysis of variance (ANOVA) was used to compare the number of oocytes per gram between subsamples along the ovaries (in the anterior, median and posterior regions). Since no significant differences (P >0.05) were observed between regions, the median gonad portions were used for estimating fecundity following the gravimetric method (Hunter and Macewicz 1985b).

Annual fecundity was estimated from yolked oocytes (stages IV and V) from samples collected during spawning season. Batch fecundity was estimated from counts of hydrated oocytes in stage VI ovaries. Only females that had stage VI ovaries without POF as confirmed through histological analysis were selected for batch fecundity analysis. The average relative fecundity was measured as the number of oocytes per gram of body weight.

The annual fecundity (F) was related to the total length, total weight, ovary weight of fishes by using the exponential relationship (Bagenal 1967): $F = a X^b$, where a and b are constants and X is the total length, total weight, ovary weight of the fish. After a logarithmic transformation the equation takes its linear form: $Log\ F = log\ a + b\ log\ X$

Relationship of ovary weight-total weight, ovary length-total length, ovary diameter-total length and ovary diameter-ovary length were fitted by the logarithmic transformation of Log Y = log a + b log X (Bagenal 1978), where Y is the dependant variable and X is the independent variable.

Results

A total of 3220 specimens of *Gerres filamentosus* (1632 males and 1588 females) were recorded. The total length (TL) of males ranged from 75 to 279 mm, while that of females ranged from 85 to 260 mm TL. Of the 355 ovaries, 5.0% were in spawning condition (stages V and VI) and 2.0% were spent (stage VII). Of the other 93.0%, 11.0% were yolked (stage IV) and 89.0% were unyolked (stages I-III). Females with developing ova (stages III and IV) were apparent throughout the year, but the main occurrence of spawning and spent females was during October-

February. Some spawning and spent females were recorded throughout the year. A similar occurrence was also observed for the males.

Description of macroscopic and microscopic stages of oocyte development of *G. filamentosus* is given in table 1. Female gonads were categorized into seven oocyte developmental stages based on the occurrence of the most advanced type of oocytes present, regardless of their abundance. Male gonads were classified macroscopically and microscopically as shown in table 2. Male gonads were classified microscopically into four stages. Most of the fully ripe ovaries characterized three batches of matured eggs showing that *Gerres filamentosus* spawn three successive batches within the same prolonged spawning season. Sixteen ovaries were found having α atresia in advanced yolked oocytes. In addition to this, β, δ and γ stages of atresia were also observed throughout the spawning period. The α, β, δ and γ stages of atresia showed similar characteristics to those described for northern anchovy (Hunter and Macewicz 1985b).

Monthly distribution of maturity stages of ovaries is illustrated in figure 1. In females, stages I-III (immature stages) were recorded throughout the year. High percentages i.e. 55, 53 and 51% of immature fishes were recorded in September, July and August, respectively. Lowest percentage (20%) of immature fishes was recorded in February. Stage IV (maturing) fishes were recorded throughout the year. High occurrence (>70%) of stage IV fishes was observed in June. Large percentages of ripe and spawning females (stages V-VI) were observed from October to February with some incidental records in April, June and August. This suggests that the peak spawning period is from October to February. Spent females (stage VII) constituted 15-19% during November to May and 1-2% during July and August. Highest percentage of stage

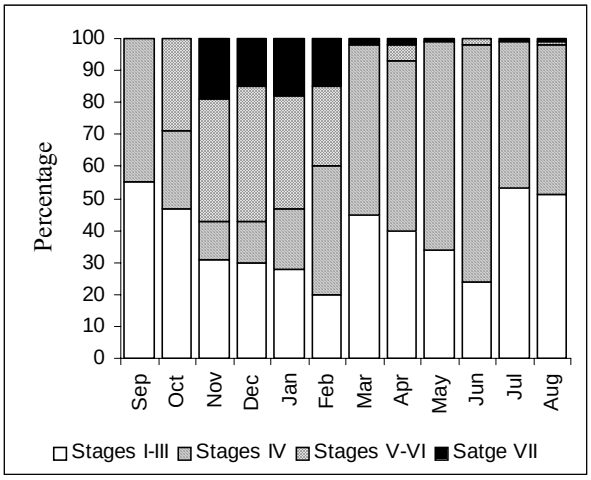

Fig. 1. Monthly percentage maturity stages of female silverbiddy, *Gerres filamentosus* (Prangipettai waters, India).

VII ovaries or post ovulatory follicles emphasized the cessation of spawning during this period thereby suggesting peak period of spawning during October to February.

Size frequencies of the oocytes of *G. filamentosus* in different stages of ovarian development are shown in figure 2. Ova diameter ranged between 12.0 and 501.8 µm. The composite histograms (Fig. 2) based on the diameters of all oocytes found in the six females at successive stages of maturation showed three modes in ovarian stages of III, IV, V and VI. These suggested that the species spawn asynchronously in three batches. In the present study, a continuous oocyte distribution i.e. lack of hiatus between advanced yolked oocytes and less mature oocytes and abundance of yolked oocytes, not decreasing over the spawning season (Hunter and Macewicz 1985a; Hunter et al. 1992) were observed and so indeterminate fecundity is expected in whipfin silverbiddies.

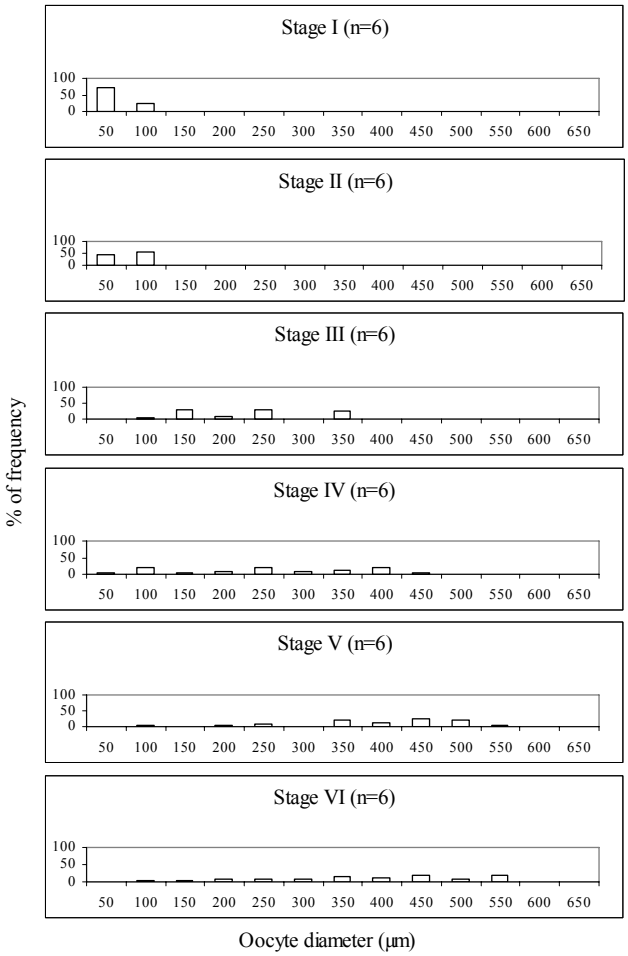

Fig. 2. Frequency distribution of oocyte diameter (µm) of *Gerres filamentosus* for stage I to stage VI ovaries (n: sample size).

No female less than 149 mm had hydrated oocytes or POFs that would have indicated spawning activity. The logistic equation for the maturity ogive of female was,

$$\% \ mature = 100/ (1 + e^{[0.0304 (136.6 - L)]})$$

and for male was,

$$\% \ mature = 100/ (1 + e^{[0.0347 (143.8 - L)]})$$

These indicate that the size at which 50% of males and females were mature corresponds to 143.8 and 136.6 mm total length, respectively. All males and females were mature at 185 mm total length (Fig. 3).

Chi-square values calculated month wise showed that the sex ratio conformed to the theoretical 1:1 in all the months ($P>0.05$) except February 2002, December 2002, January 2003, February 2003 and May 2003. Overall, sex ratio did not vary significantly from an expected 1:1 ratio, with slightly more number of males than females (1.028:1, $X^2=0.0186$, $P>0.05$). The percentage of females in the monthly samples ranged between 32.64 and 62.86% while males ranged between 37.14 and 61.36%. Chi-square values calculated for different length groups showed that the sex ratio conformed to the expected 1:1 in all length groups ($P>0.05$). Overall, sex ratio did not vary significantly from an expected 1:1 ratio (1.027:1, $X^2=0.0186$, $P>0.05$).

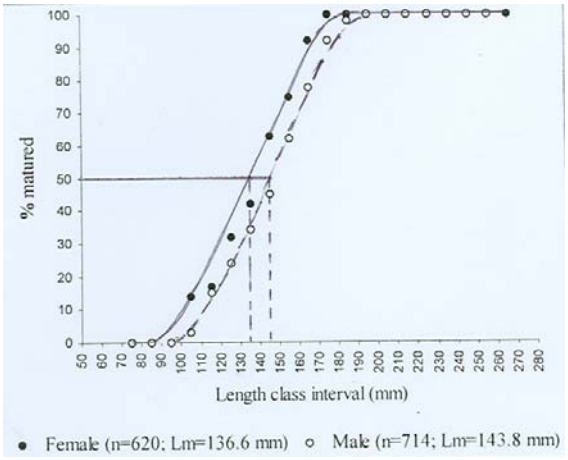

Fig. 3. Estimated (Line) and observed (dots) proportion of mature at length (TL, mm) silver-biddy, *Gerres filamentosus* (Parangipettai waters) (females: • ; males: o).

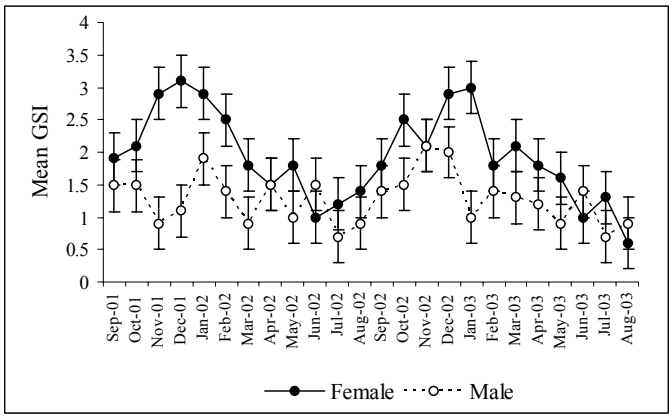

Fig. 4. Monthly variation of male (o) and female (•) silverbiddy, *G. filamentosus* gonadosomatic index (GSI) between September 2001 and August 2003 (Parangipettai waters).

The GSI values indicated *G. filamentosus* to spawn intensively during October-February (Fig. 4). Females in spawning condition usually had a GSI of 2.1- 3.1% in the years 2001-2002 and 1.8-3.0% in the years 2002-2003. Most females greater than 148 mm had a GSI of > 2.5% and some had a GSI of > 2.9%. Generally, the GSI values for spawning females were considerably higher than those for spawning males, which rarely exceeded 1.9%.

The GSI values in spawning fish varied because some individuals had already shed an unknown number of oocytes, resulting in loss of ovary mass (partially spent). The mean GSI increased up to 160 mm length group showing a maximum of 3.1 (Fig. 5). Again it decreased and showed low values in all length groups up to 255 mm. The highest mean value obtained in 160 mm length group suggested the occurrence of fully mature females in

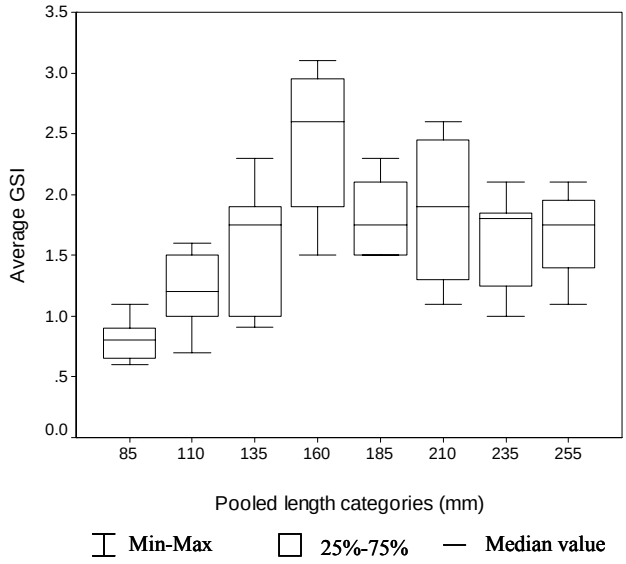

Fig. 5. Length wise GSI of female *Gerres filamentosus.*

this length group. The lower mean values of GSI above 160 mm length group were attributed to the liberation of gametes above this length.

The annual fecundity (F) increased exponentially with total length (Fig. 6), from 121,700 (169 mm TL) to 2,062,278 oocytes (265 mm TL). Annual fecundity varied considerably for a given length, linear regression of the log-transformed data (Table 3) was statistically significant ($F_{1,51}$ = 104.24, P< 0.001, r^2 = 0.6758) yielding the equation:

$$log[F] = 4.04 \; x \; log \; TL \; + 0.5863.$$

Similarly, batch fecundity (BF) which ranged from 171,596 (180 mm TL) to 740,844 65 mm TL) in 9 fishes increased exponentially with total length and the regression for the log-transformed data was,

$log[BF]$ = 3.77 x $log\ TL$ + 0.4833 ($F_{1,8}$ = 75.939, P<0.001, r^2 = 0.9156)

Comparison of these two regressions revealed that most individuals spawned around three batches of eggs each year.

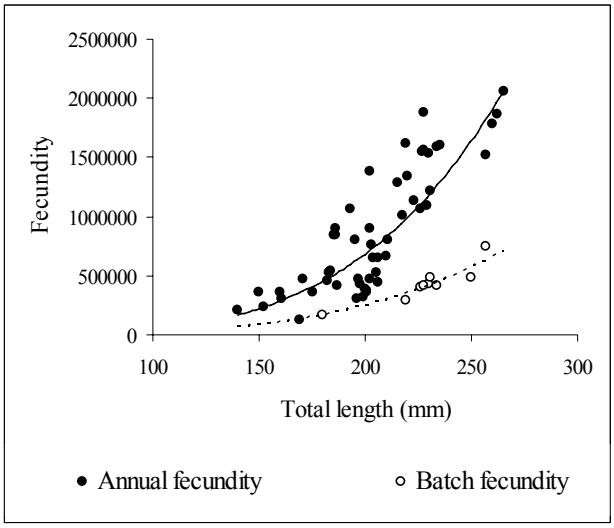

Fig. 6. Annual (o) and batch (•) fecundity of the silver-biddy, *Gerres filamentosus* as functions of total length (TL, mm) in Parangipettai waters.

Table 3. Relationship between fecundity and other independent parameters of *Gerres filamentosus* (AF – Annual fecundity; TL – Total length; BF – Batch fecundity; TW – Total weight; OL –Ovary length; OW – Ovary weight; r - Correlation coefficient; P – level of significance)

Parameters	Logarithmic relationship	n	r^2	P
AF-TL	log[AF]=4.04 x logTL + 0.5863	52	r^2=0.676	7.95 x 10^{-14}
BF-TL	log[BF]=3.77 x log TL + 0.4833	09	r^2 = 0.9156	1.63 x 10^{-41}
AF-TW	log[AF]=1.18x logTW + 3.3882	52	r^2 = 0.6655	1.75 x 10^{-13}
AF-OL	log[AF]=1.08 x logOL + 5.1563	52	r^2=0.3362	1.57 x 10^{-5}
AF-OW	log[AF]=0.48 x logTL + 5.8410	52	r^2=0.5432	2.33 x 10^{-9}

The linear regression of log-transformed fecundity versus log-total weight was statistically significant ($F_{1, 51}$ = 99.48, P< 0.001, r^2 = 0.6655) yielding the equation:

$$log[F] = 1.18 \times log\ TW + 3.3882$$

Exponential and linear equations along with r^2 and P values of the above relationships are given in table 3. Equations for relationships of fecundity-ovary weight and fecundity-ovary length and the relevant regression parameters are also presented in table 3. Parabolic and logarithmic equations for relationships of ovary weight-total weight, ovary length-total length, ovary diameter-total length and ovary diameter-ovary length and r^2 and P values of above relationships for both fishes are presented in table 4.

Table 4. Relationship of ovary weight-total weight, ovary length-total length, ovary diameter-total length and ovary diameter-ovary length of *G. filamentosus* (TL – Total length; TW – Total weight; OL –Ovary length; OW – Ovary weight; OD – Ovary diameter; n – number of observations; r – Correlation coefficient; P – Significance)

Parameters	Logarithmic relationship	n	r^2	P
OW-TW	log[OW]=2.05 x logTW + -4.10	101	r^2=0.553	4.96 x 10^{-19}
OL-TL	log[OL]=1.34 x logTL + -1.1224	101	r^2=0.593	4.83 x 10^{-21}
OD-TL	log[OD]=4.19 x logTL + -5.4575	101	r^2=0.427	1.2 x 10^{-13}
OD-OL	log[OD]=2.42 x logOL + -1.68	101	r^2=0.434	1.1 x 10^{-6}

Discussion

Macroscopic ovarian staging of multiple spawning fishes can be difficult because subtle differences at the cellular level may not be detectable macroscopically (Parrish et al. 1986). However, macroscopic analysis does provide a rapid estimate of maturity and results in a general description of spawning seasons at a reduced cost compared to time-consuming histological methods. West (1990) noted that there have been few attempts to assess the accuracy of macroscopic gonad staging in fishes with histological analysis.

Houde (1989) commented that spawning in the tropics is protracted and occurs in multiple batches, in contrast to spawning in temperate regions where spawning seasons are short. The lack of uniformity in spawning methods within families, and even within genera, suggests an evolutionary plasticity that can respond relatively quickly to the variable

nature of the many different types of estuaries in the subtropics and tropics. An example for this is *G. filamentosus* which spawns in three successive batches from October to February (wet season) in the Cochin estuary in southern India (Kurup and Samuel 1991). In contrast, in KwaZulu-Natal (South Africa), *Gerres* species, including *G. filamentosus*, spawn only once but the spawning season is throughout the year and the fish leave the estuary to spawn (Cyrus and Blaber 1984). Multiple spawning increases the total number of eggs produced in one spawning season and spreads the risk of egg and larval predation over a long period of time. At the same time, it acts to buffer any short-term adverse fluctuations in the abundance of suitable planktonic larval foods.

The size at maturity determined in the present study is 143.8 and 136.5 mm for males and females of *G. filamentosus*, respectively. The size at maturity values of 117 and 118 mm standard length for males and females, respectively, have been recorded for *G. filamentosus* in Cochin estuary (Kurup and Samuel 1991). According to Patnaik (1971) 50% of *G. setifer* males matured at 71-80 mm and females at 81-90 mm in the Pulicat lake. Prabakara Rao (1970) reported that 50% of *G. oyena* males matured at 164 mm and females at 189 mm in the Chilka lake. From the present study, it is recommended from the point of view of conservation that the capture of *G. filamentosus* less than 135 mm should be discouraged. The asymptotic length (L_∞) values obtained for male and female *G. filamentosus* from the Parangipettai waters as estimated by ELEFAN I method (Kuganathan 2006) were 269.0 and 270.0 mm, respectively. Therefore the ratios of L_m/L_∞ for male and female *G. filamentosus* were 0.535 and 0.506. The ratio between mean size at first maturity and asymptotic length for various species of fishes ranged between 0.3 and 0.9 (Beverton and Holt 1957). Cushing (1968) suggested that this ratio is constant for a given family. The results obtained in the present study are in agreement with this statement and fall well within the above range.

Sex ratios vary among published works on life histories of other gerreids such as *G. oyena* (Prabakara Rao 1970) and *G. filamentosus* (Kurup and Samuel 1991). This variability may be due to true differences in the composition of local populations, or it may be an artifact of sampling strategies rooted in seasons covered or gear biases. In the present study, sex ratios did not differ significantly from a 1:1 ratio during most of the months. However the males of *G. filamentosus* were more compared to females during the peak spawning period and such preponderance could be due to migration of females to relatively deeper waters for

spawning or behavioral differences between the two sexes (Blaxter and Hunter 1982). Qasim (1966) suggested that the ponderence of one sex in a population was because of sexual differences in growth rate between sexes. The faster growth rate leads increasingly to less loss from predation and this might influence the sex ratio. In the present study a more or less similar growth rate led the overall sex ratio not to differ significantly from the expected 1:1 ratio.

As fish grow older, ovary weight increases faster with fish length than does somatic weight and therefore the GSI values tend to be higher in the fully matured about to spawn fishes. Another reason for this phenomenon is the weight of hydrated ovaries. Since the weight of hydrated ovaries is two to four or more times that of other maturity stages, the GSI values tend to be higher (Hunter and Macewicz 1985a) just before spawning. Gonad weight has the same ambiguities to detect the other maturity stages as well. For example post ovulatory ovaries differ a little in weight from the earlier stages of post spawning (atretic) ovaries.

The high GSI values recorded from October to February indicated the intense gonadal activity during this period. The macroscopic and histological analysis of gonads in the present study confirmed that the peak spawning period in Parangipettai waters, Southeast coast of India is from October to February. Indication of previous spawning was ascertained by the ruptured ovarian follicles, resorbing ovulated ova and atretic ovarian follicles observed during October-February. A previous study on the GSI of *G. filamentosus* established that they spawned during October-February in the Cochin estuary (Kurup and Samuel 1991).

The exponential value is usually reported as '3' when fecundity is related to length and '1' when fecundity is related to weight (Bagenal and Braum 1978). However, the values may vary from 2.3 to 5.3 for a great variety of fishes (Bagenal and Braum 1978). In the present study, the exponential value is greater than cube (b=4.036, r^2=0.675) when fecundity is related to total length and also greater than '1' (b=1.1809, r^2=0.665) when fecundity is related to weight. According to Bagenal and Braum (1978) changes in the environment such as temperature, salinity and oxygen may also result in significant changes in fecundity. Wootton (1973) suggested that food supply and nutrition affect the number of oocytes produced. Prabhakara Rao (1970) observed the fecundity of *G. oyena* to vary from 104,211 to 1,443,785 eggs in the size ranges of 148-282 mm. The exponent values obtained for length-fecundity and weight-

fecundity relationships of G. *oyena* were 2.43 and 1.872, respectively. The correlation co-efficient between fecundity-length and fecundity-weight were reported as 0.5306 and 0.4421, respectively. Similarly, Patnaik (1971) observed the fecundity of *G. setifer* to vary from 17,293 to 161,505 eggs in the size ranges 88-193 mm. For *G. filamentosus*, Kurup and Samuel (1991) reported fecundity to vary from 64,278 to 387,576 oocytes in the size ranges of 100-148 mm standard length and the exponential values for length-fecundity and weight-fecundity relationships were 3.2563 and 0.9896, respectively, with correlation coefficients of 0.7178 and 0.6906. Thus, it is apparent that the fecundity obtained in the present study for *G. filamentosus* is relatively higher than that of *G. oyena*, *G. setifer* and *G. filamentous* in the Indian waters such as Chilka lake, Pulicat lake and Cochin waters respectively. The weight of the ovaries of fish is mainly influenced by the number of ova contained in them. Many workers reported the increase in fecundity with increasing ovary weight (Bagenal 1967; Varghese 1980).

Recruitment, through reproduction, is the means by which an exploited stock is renewed. If indiscriminate harvesting of a population occurs, the number of fishes that reach maturity is reduced to an extent at which the reproductive capacity of the population is diminished. One way of reducing this possibility is to ensure that minimal fishing pressure is applied to the populations before the fish reach maturity. Often, this is achieved by setting restrictions on mesh sizes used to catch the fish. Since the peak spawning season is from October to February the breeding females of *G. filamentosus* should be protected during this period in order to have the sustainable fishery of gerreids. 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 *G. filamentosus* stocks along the coastal waters of India.

Acknowledgment

Financial Assistance by UGC, New Delhi (Grant number 19-1/2000 -SA II) is greatly acknowledged.

References

Baelde, P. 1996. Biology and dynamics of the reproduction of the blue-eye travella, *Hyperoglyphe antarctica* (Centrolophidae), off Tasmania, southern Australia. Fishery Bulletin 94: 199-211.

Bagenal, T. B. 1967. A short review of fish fecundity. In: The Biological Basis of Freshwater Fish Production (ed. S. D. Gerking), pp. 89-111. Blackwell Scientific, Oxford.

Bagenal, T. B. 1978. Aspects of fish fecundity. In: Ecology of Freshwater Fish Production (ed. S. D. Gerking), pp.75-101. Blackwell Scientific Publication, London.

Bagenal, T.B. and E. Braum 1978. Eggs and Early Life History, In: IBP Hand Book No.3, Blackwell Scientific Publication, Oxford, 106 pp.

Bell, J. D., J. M. Lyle., C. M. Bulman., K. J. Graham., G. M. Newton and D. C. Smith. 1992. Spatial variation in reproduction, and occurrence of non-reproductive adults, in orange roughy, *Hoplostethus atlanticus* Collet (Trachichthyidae), from southeastern Australia, Journal of Fish Biology 40: 107-22.

Beverton, R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations, Fisheries Investment Series 2. UK Ministry of Agriculture and Fisheries: London 19: 533.

Blaxter, J. H. S. and J. R. Hunter. 1982. The biology of clupeiod fishes. Advanced Marine Biology 20: 1-223.

Cailliet, G. M., M. Love and A. W. Ebeling. 1986. Fishes: a field and laboratory manual on their structure, identification and natural history, Wadsworth Press, Belmont, CA, U.S.A, 194 pp.

Cushing, D. H. 1968. Fisheries biology: A study in population dynamics. Madison University of Wisconsin Press, 200 pp.

Cyrus, D. P. and S. J. M. Blaber. 1982. Species identification, distribution and abundance of gerreidae (Teleostei) Bleeker 1859 in the estuaries of Natal, South African Journal of Zoology 17: 105-116.

Cyrus, D.P. and S.J.M. Blaber. 1984. The reproductive biology of *Gerres* (Teleostei) Bleeker 1859 in Natal estuaries, Journal of Fish Biology 24: 491-504.

Davis, T.L.O. 1977. Reproductive biology of the freshwater catfish, *Tandanus tandanus* Mitchell, in the Gwydir River, Australia. I. Structure of the gonads. Australian Journal of Marine and Freshwater Research 28: 139-58.

Davis, T.L.O. and G.J. West. 1993. Maturation, reproductive seasonality, fecundity and spawning frequency in *Lutjanus vittus* (Quoy and Gaimard) from the North West Shelf of Australia, Fishery Bulletin 91: 224-236.

de Vlaming, V.L. 1983. Oocyte development patterns and hormonal involvements among teleosts. In Control Processes in Fish Physiology (Rankin, J.C., Pitcher, T. J. and Duggan, R. T. eds), pp 176-199. Bechenham: Croom Helm, Australia.

Forberg, K.G. 1982. A histological study of development of oocytes in capelin, *Mullotus villosus villosus* (Muller), Journal of Fish Biology 20: 143-54.

Froese, R. and D. Pauly. (Eds.) 2000. FishBase 2000: concepts, design and data sources. ICLARM, Los Banos, Laguna, Philippines. 344 pp.

Houde, E.D. 1989. Comparative growth and energetics of marine fish larvae, in Third ICES Symposium on the Early Life History of Fish, Bergen (Norway), 3-5 Oct. 1988. 191: 479.

Hunter, J.R. and B.J. Macewicz. 1985a. Measurement of spawning frequency in multiple spawning fishes, In: An Egg Production Method for estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, *Engraulis mordax* (ed. Lasker), US Department of Commerce, NOAA Technical Report, NMFS 36: 79-94.

Hunter, J.R. and B.J. Macewicz. 1985b. Rates of atresia in the ovary of captive and wild northern anchovy, *Engraulis mordax*, Fishery Bulletin 83: 119-36.

Hunter, J.R., B.J. Macewicz., N.C. Lo and C.A. Kimbrell 1992. Fecundity, spawning and maturity of female Dover sole *Microstomus pacificus*, with an evaluation of assumptions and precision, Fishery Bulletin 90: 101-128.

Karlou-Riga, C. and P.S. Economidis. 1996. Ovarian atretic rates and sexual maturity of horse mackerel, *Trachurus trachurus* (L.), in the Saronikos Gulf (Greece), Fishery Bulletin 94(1): 66-76.

Karlou-Riga, C. and P.S. Economidis. 1997. Spawning frequency and batch fecundity of horse mackeral, *Trachurus trachurus* (L.), in the Saronikos Gulf (Greece), Journal of Applied Ichthyology, 13: 97-104.

King, M. 1995. Fisheries Biology. Assessment and Management. Fishing News Books, 341 pp.

Kuganathan, S. 2006. Growth and mortality parameters of *Gerres filamentosus* (Cuvier). Proceedings of Jaffna Science Association. Sixth Annual Session (27-29 April 2006): 1(Abstract).

Kurup, B.M. and C.T. Samuel. 1991. Spawning biology of *Gerres filamentosus* Cuvier in the Cochin estuary, Fishery Technology Society, Fishery Technology, Kochin, 28(1): 19 – 24.

Longhurst, A.R. and D. Pauly. 1987. Ecology of tropical Oceans, Academic Press, San Diego.

Macer, T.C. 1974. The reproductive biology of the horse mackerel *Trachurus trachurus* (L.) in the North Sea and English Channel, Journal of Fish Biology, 6: 414-438.

Marshall, J., G. Pullen and A. Jordan. 1993. Reproductive biology and sexual maturity of female jack mackeral, *Trachurus declivis* (Jenyns), in eastern Tasmania waters, Australian Journal of Marine and Freshwater Research, 44: 799-809.

Parrish, R.H., D.L. Mallicoate and R.A. Klingbeil. 1986. Age dependent fecundity, number of spawnings per year, sex ratio and maturation stages in northern anchovy, *Engraulis mordax.* Fishery Bulletin 84: 503-517.

Patnaik, S. 1971. Observations on the fishery and biology of Chilka Jagili, *Gerres setifer* (Hamilton). Journal of Inland Fisheries Society of India 3: 25-43.

Prabhakara Rao, A.V. 1970. Observations on some aspects of the biology of *Gerres oyena* (Forskal) with notes on the fishery of silver biddies of Pulicat Lake. Journal of Inland Fisheries Society of India 2: 85-100.

Qasim, S.Z. 1966. Sex ratio in the fish population as a function of sexual difference in growth rate. Current Science 35: 140-142.

Ratcliffe, N.A. 1982. Practical illustrated histology reader in Zoology, Department of Zoology, University College of Swansea, Mackmillan press Ltd.

Schaefer, M.B. 1987. Reproductive biology of black skipjack, *Euthynnus lineatus*, an eastern pacific tuna, IATTC Bulletin 19: 169-260.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. Oxford and IBH Publishing Co., New Delhi, 172 pp.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry: The Principles and Practice of Statistics in Biological Research. San Francisco, W. H. Freeman and Company, San Francisco. 706 p.

Varghese, T.J. 1980. Fecundity of *Coilia dussumieri* Valenciennes, Proceedings of the Indian National Science Academy B45(1): 114-119.

Venkataramanujam, K. and N. Ramanathan. 1994. Maturation and spawning. In: Manual of finfish Biology, New Delhi: 35-42.

Wallace, R.A. and K. Selman 1981. Cellilar and dynamic aspects of oocyte growth in teleosts. The American Zoologist 21: 325-343.

Wallace, R.A., K. Selman., M.S. Greeley, B.P.C. Jr., Y.W. Lin, R. McPherson and T.R. Petrino. 1987. Current status of oocyte growth. In: International symposium on Reproductive Physiology of Fish, (eds. D. R. Idler, L. W. Crim and J. M. Walsh), Memorial University of Newfoundland: St. John's: 167-177.

Watson, J.J., I.G. Priede., P.R. Witthames and A. Owori-Wadunde. 1992. Batch fecundity of Atlantic mackerel, *Scomber scomberus* L. Journal of Fish Biology 40: 591-598.

West, G. 1990. Methods of assessing ovarian development in fishes: a review, Australian Journal of Marine and Freshwater Research 41: 199-222.

Wootton, R.J. 1973. The effect of size of food ration on egg production in the female three spined-stickleback *Gasterosteus aculeatus* L, Journal of Fish Biology 5: 89-96.

Yamamoto, K. and F. Yamazaki 1961. Rhythm of development in the oocyte of the goldfish, *Carassius auratus*, Bulletin of Faculty of Fisheries, Hokkaido University 12: 93-110.

Received: 23 April 2006; Accepted: 1 June 2007