



## Reproductive biology of *Gerres longirostris* Lacepede, 1801 (Perciformes: Gerreidae) in the western Arabian Gulf

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### ABSTRACT

Reproductive biology of the strongspine silverbiddy, *Gerres longirostris* Lacepede, 1801, was studied by examining 1910 individuals collected fortnightly between May 2012 and January 2014 from the western Arabian Gulf, off Saudi Arabia. The samples were identified as 470 males, 1370 females and 70 undetermined. Maximum length observed was 30 and 40 cm (total length TL) for males and females, respectively. Overall sex ratio of males to females was found to be 1:3.1. This sex ratio was significantly different from the normally expected 1:1 ratio ( $p < 0.05$ ). Males constituted more than 50% of individuals measuring less than 20 cm but this male-bias was not significant ( $p > 0.05$ ). Females were significantly greater than males in all size classes between 20 and 34 cm with high significant difference ( $p < 0.05$ ) from the expected 1:1 ratio between sexes. In length classes more than 34 cm, 100% of the fish were females. Size at first sexual maturity was estimated at 19.1 and 19.8 cm TL for females and males, respectively; all fish were mature at 20.7 cm TL. The spawning season coincided with late spring-early summer; gonadosomatic index (GSI) was highest (8.1-8.7 and 2.7-2.8 for females and males, respectively) in the peak season, May-June. GSI seems to peak in both sexes before 2-3 months of reaching the highest temperature. GSI and water temperature (T) were best expressed by a second-degree polynomial equation for both sexes, indicating that water temperature  $> 30.28^\circ\text{C}$  might not be optimal for reproduction of *G. longirostris*.

Keywords: Arabian Gulf, *Gerres longirostris*, Gonadosomatic index, Sex ratio, Size at first sexual maturity

### Introduction

Strongspine silverbiddy, *Gerres longirostris* Lacepede, 1801, is a gerreid inhabiting the Indo-Pacific, ranging from the Red Sea and South Africa to the Marquesas Islands, north to the Ryukyu Islands, and south to Australia (Iwatsuki *et al.*, 2001). Its presence was reported from Arabian Gulf (Carpenter *et al.*, 1997) and the biology of this species has been studied from the western coast of the Arabian Gulf (Hosny *et al.*, 2003) and in the southern Arabian Gulf off the United Arab Emirates (UAE) (Grandcourt *et al.*, 2006). *G. longirostris* prefer sandy and silty grounds and are mostly found among sea grass beds and coral reefs (Sommer *et al.*, 1996; Gell and Whittington, 2002). They attain a maximum length of 44.5 cm total length (TL) (Allen and Erdmann, 2012) and adults are often found in clear coastal waters down to 50 m depth; while juveniles occur in nearshore areas influenced by freshwater (Iwatsuki *et al.*, 2001). Fry stages of about 10 cm in length enter the estuaries and stay until they reach maturity (Cyrus and Blaber, 1984).

Gonadal maturation in teleosts is quantified based on the colour, size and shape of their gonads and are macroscopically classified into different maturity stages.

Different workers have adopted various maturity schemes to classify gonads (Divakaran and Kuttyamma, 2014). The maturation status of fish varies among different habitats and this variation is likely to be due to the diverse environmental conditions. It has been reported that higher temperatures during pre-spawning season favoured rapid maturation of ovaries (Yamamoto and Shiah, 2013).

Studies on the reproductive biology of gerreids are relatively plenty, covering most of their geographical distribution. Jones and Sujansingani (1954); Jhingran (1957), Rao (1970), Patnaik (1971), Kurup and Samuel (1986; 1991), Sivashanthini and Ajmalkhan, (2004), Sivashanthini (2008), Renuka and Bhat (2011) have studied reproductive biology of gerreids in Indian waters. The same has been investigated by Austin (1971) and Etchevers (1978) in Venezuela; by Valdez-Zenil *et al.* (2014) in Mexico; Araujo and Santos (1999) in Brazil; Albaret and Desfossez (1988), Cyrus and Blaber (1984) and Whitfield (1998) in South Africa; Iqbal *et al.* (2007) and Kanak and Tachihara (2008) in Japan; Shutharshan and Sivashanthini (2011) in Sri Lanka; Sjafei and Syaputra (2009) in Indonesia and El-Agamy (1986) and Grandcourt *et al.* (2006) in the Arabian Gulf.

Knowledge on the reproductive biology of a species is regarded as an important contributor in comprehending the dynamics of its population. To the best of our knowledge, there is no previous information on the reproductive biology of *G. longirostris* from the western Arabian Gulf. This paper reports for the first time, on the reproductive biology of this species in terms of sex ratio, size at first sexual maturity, monthly variations in gonadosomatic index and its relation with water temperature.

## Materials and methods

Strongspine silverbiddy *Gerres longirostris*, were surveyed in the catch from commercial fishing operations performed off the coast of Saudi Arabia on the Arabian Gulf, from Salwa in the south up to Khafji in the North (Fig. 1). Biweekly samplings lasted from May 2012 until January 2014. The target was artisanal fishers on Dhows (large fishing boats or Sanbook) and speedboats (Tarrad) operating local fishing gears that are known to catch silverbiddies, *i.e.*, wire traps (Gargoor), fixed gillnets (Manaseb), drifting gillnets (Ghozool) and hook and line (Hadag) (Hosny *et al.*, 2003). From each fishing operation, weight of the total catch as well as the

total weight of silverbiddies were recorded along with geographical location (using a GPS, Garmin gpsmap 276c) and bottom depth (m) as well as water temperature (°C). *G. longirostris*, were then separated from the catch according to fishing gear and samples were then collected at random as a percentage of the catch of silverbiddies, the monthly target sample size being 50 individuals.

In the laboratory, the sex of individuals was determined macroscopically after opening the abdominal cavity. A five-point maturity scale, which is the most commonly used and ideal for most tropical total spawners was adopted as follows: I - immature; II - maturing virgin and recovering spent; III - ripening; IV - ripe and V - spent (Qasim, 1957a, b; Qasim, 1973). Total length (TL) was measured to the nearest mm using digital slide calipers, total weight ( $W_T$ ) and gutted weight ( $W_G$ ) were recorded to the nearest gram (g), while gonad weight ( $G_w$ ) was weighed to the nearest 0.001 g using a precision scale (Cole-Parmer® Symmetry® PR410).

Sex ratio was computed for the whole sample and then against 3 cm fish size class making 8 size classes (TL, cm). We conducted independent  $\chi^2$  tests to determine whether sex ratios differ from the normal 1:1 ratio for the collected sample and for each size class. The probability level was set at 0.05 and Yates's correction factor (Sokal and Rohlf, 1995) was used.

The mean size at first sexual maturity ( $L_m$ ) was estimated for males and females by fitting the logistic function to the proportion of mature fish in a predefined 3 cm (TL) size classes. The mean size at first maturity was taken at a point where 50% of individuals were mature (Restrepo and Watson, 1991).

The reproductive cycle of the fish was determined from monthly changes in the gonadosomatic index (GSI) that was computed as:  $GSI = G_w/W_G * 100$ , where,  $G_w$  is the gonad weight and  $W_G$  is the gutted weight in each sampled individual.

To establish the timing and frequency of spawning, GSI of males and females was plotted separately against the sampling period by month. The monthly mean water temperature in the study area was calculated from data measured *in situ*. Correlations between the monthly mean water temperature and GSI of both males and females were analysed by polynomial and linear correlations.

## Results and discussion

There were 470 males (24.61%), 1370 females (71.73%) and 70 undetermined (3.66%) specimens in the samples collected ( $n = 1910$ ). Males ranged in size between 30 and 16.9 cm TL and had an average size of  $21.61 \pm 2.9$  cm. Females ranged in size between

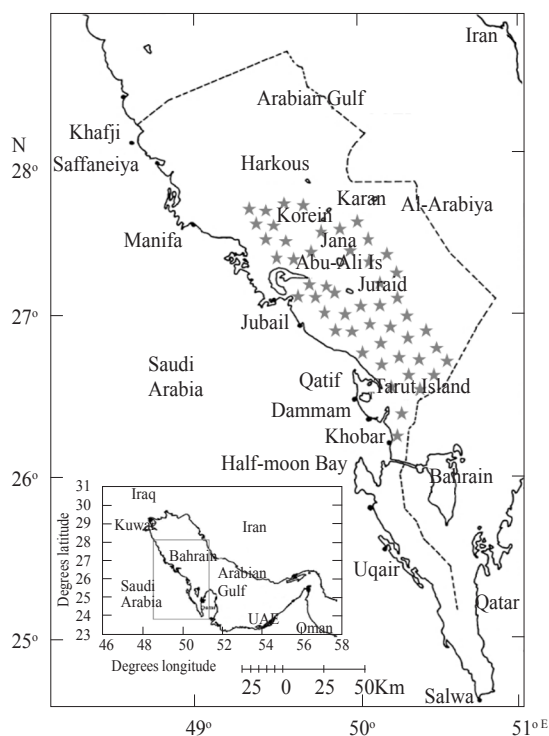


Fig. 1. Map showing major landmarks in the territorial waters of Saudi Arabia on the Arabian Gulf, marked with dashed line (insert shows Saudi territorial waters relative to the Arabian Gulf; blue rectangle shows enlarged area; blue stars mark locations where *G. longirostris* was present in the fishing gears during the study period)

40 and 17.5 cm TL with an average size of 24.7±3.9 cm. Specimens with undetermined sex ranged between 26.4 and 19.3 cm TL and had an average size of 22.3±2.1 cm. The regional record for this species on the southern coasts of the Arabian Gulf, off Abu Dhabi is 33 cm fork length (FL) (Grandcourt *et al.*, 2006) and off Oman is 37 cm TL (Randall, 1995). All samples of *G. longirostris* were only from the catches of wire traps (Gargoores), fixed gillnets (Manaseb) and drifting gillnets (Ghozool).

According to the five-point maturity scale adopted in this study, female gonads and male testis were classified macroscopically and were found to fall under stages I to IV and spent individuals (stage V) were absent in the sampled catch. According to Cyrus and Blaber (1982), mature gerreids leave to spawn in open sea and spent individuals do not return to the shallow waters after spawning. Thus, the absence of spent individuals from our collection could be due to the poor coverage of deeper waters by artisanal fleets.

*Sex ratio*

The ratio of males to females represented in the sample collected for *G. longirostris* during the present study was found to be 1:3.1. This sex ratio differed significantly from the expected ratio of 1:1 ( $\chi^2 = 439.240$ ,  $p < 0.05$ ; Table 1). Such dominance of female over male individuals could be due to behavioural differences between the two sexes (Blaxter and Hunter, 1982). Previously published works on life histories of other gerreids showed sex ratio variations. In *Gerres filamentosus*, the sex ratio was found to be 1:11.4 in Cochin Estuary, India (Kurup and Samuel, 1991) and off Parangipetti coast of south-east India, sex ratio was 1:1 most of the year, but this ratio changed during the spawning season when males outnumbered females (Sivashanthini, 2008). The sex ratio of male and female *Gerres kapas* in Mayangan Coast, Subang, West Java, based on total fish and mature fish were unbalanced and varied between 1:3.1 and 1:9.3, respectively (Sjafei and

Syaputra, 2009). But in the Usumacinta River, Mexico, *Eugerres mexicanus* had a male to female ratio of 1:1.2 (Valdez-Zenil *et al.*, 2014). This variability in the ratio between sexes may be caused by true differences in the composition of the local population or by sampling biases from fishing gears used. In the present study, gillnets tended to capture larger individuals, which were predominantly females, while the wire traps captured smaller size classes that were dominated by males. The overall sex ratio tended to be a function of the relative effort of the fishing gears used. Qasim (1966) suggested that the ponderance 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 addition, Lowerre-Barbieri *et al.* (1996) suggested that the factors controlling the sex ratio within a fish population are gear selectivity, sexual segregation in growth, partial differences of mature fish and behavioral differences during spawning.

Furthermore, the sex ratio of *G. longirostris* among the 8 size classes assigned in the present study indicated that >50% of the fish were males at TL of <200 mm but this male-biased distribution was not significant (Table 1). However, there was a significant ( $p < 0.05$ ) female bias in the length classes >340 mm where 100% were females. The sex ratio analysed by the  $\chi^2$  test for each of the 8 size classes also showed that the number of females was significantly greater than that of males in all the size classes between 200-340 mm with significant difference ( $p < 0.05$ ) from the expected 1:1 ratio between sexes. In accordance to this finding, there was a significant ( $p < 0.05$ ) female bias in the overall male-to-female sex ratio of 1:2.2 in *G. longirostris*, in the southern Arabian Gulf, which was significant for all age categories (Grandcourt *et al.*, 2006). Furthermore, a significant ( $p < 0.05$ ) female bias in the overall sex ratio of 1:1.9 for *Acanthopagrus bifasciatus* and 1:2.2 for *Argyrops spinifer* was observed in the southern Arabian Gulf (Grandcourt *et al.*, 2004). However, the

Table 1.  $\chi^2$  test of the sex ratio in 8 size classes of *G. longirostris* from the western Arabian Gulf off Saudi Arabia

Total length (TL, cm)	No. of fish			Sex ratio (M:F)	$\chi^2$	p
	Male (M)	Female (F)	Total			
16-19	70	60	130	1:0.857	0.623	0.43
20-22	270	400	670	1:1.481	24.837*	6.24E-07
23-25	50	360	410	1:7.200	232.88*	1.40E-52
26-28	50	350	400	1:7.000	223.503*	1.56E-50
29-31	20	110	130	1:5.500	60.931*	5.91E-15
32-34	10	70	80	1:7.000	43.513*	4.21E-11
35	0	10	10	0:1.000	8.100*	4.43E-03
40	0	10	10	0:1.000	8.100*	4.43E-03
Total	470	1370	1840	1:3.089	439.240*	1.58E-97

\*Indicate significant difference

sex ratios in size categories revealed that the female bias was present only at sizes below size at sexual maturation. The sex ratios in size categories above the mean size at first sexual maturity did not differ significantly from unity as revealed from  $\chi^2$  goodness of fit tests (Grandcourt *et al.*, 2004).

#### Size at first sexual maturity

Size at first sexual maturity was considered as the length at which 50% of the individuals were of maturity stage III and this was estimated at 19.1 cm for females and 19.8 cm for males. All males and females were mature at 20.7 cm total length. Similar observation of females attaining sexual maturity at a smaller size than males in gerreids have been made by Sivashanthini (2008) for *G. filamentosus* sampled off Parangipettai (south-east coast of India) and by Sjafei and Syputra (2009) for *G. kapas* in Mayangan Coast, West Java (Table 2).

On the other hand, some studies observed that gerreid males reached sexual maturity at smaller sizes than females. Rao (1970) reported this state for *G. oyena* in the Chilka Lake, Yeeting (1990) in Tarawa Lagoon, Kiribati and Lamtane *et al.* (2007) in Bagamoyo coast, Tanzania and Kanak and Tachihara (2008) in Okinawa Island, Japan. According to Patnaik (1971), 50% of *G. setifer* males matured earlier than females in the Pulicat Lake (Table 2). In *G. filamentosus*, males have been reported to mature earlier than females in Cochin Estuary (Kurup and Samuel, 1991) and in Hong Kong (Sadovy and Cornish, 2000). This early maturity of males was also reported for *G. equulus* in western Kyushu, Japan (Iqbal *et al.*, 2007) (Table 2). For *G. longirostris*, several records

of size at first sexual maturity have been reported in different geographical localities but without reference to sex (Whitfield, 1998; Hosny *et al.*, 2003; Hardman *et al.*, 2008). In southern Arabian Gulf, along the coasts of UAE, males of *G. longirostris* were reported to mature earlier than females (Grandcourt *et al.*, 2006) (Table 2).

In the present study, *G. longirostris* were found to mature at 20.7 cm TL and hence from a managerial point of view it is suggested that capture of *G. longirostris* below 20.7 cm TL should be discouraged.

#### Gonadosomatic index (GSI)

The mean monthly GSI of female *G. longirostris*, whose lengths were  $\geq L_m$  (19.1 cm) were high at 5.3 in May 2012, which reached a peak of 7.45 in June 2012, before declining to 0.7 in July 2012 and then precipitously to 0.59 in December 2012 (Fig. 2). Subsequently, GSI remained at less than 2.2 until March 2013, after which they rose sharply from 3.2 in April 2013 to a well defined peak of 8.1-8.7 in May-June 2013, before sharply declining to 0.6 in August 2013 and then remained in an almost steady state till January 2014. Meanwhile, the trends exhibited by the mean monthly GSI of mature male *G. longirostris*, whose lengths were  $\geq L_m$  (19.8 cm) had the same pattern as described for females, with mean GSI exhibiting well defined peaks of 2.7-2.8 in May-June 2012 and 2.06-2.15 in May-June 2013 (Fig. 2). Thus, it seems that *G. longirostris* spawns during late spring and early summer. This single spawning period supports the argument that seasonal reproductive cycles are common among tropical fish (Robertson, 1990; Sadovy, 1996). However, several gerreid species were

Table 2. Size at first sexual maturity ( $L_m$ ) of gerreids from various studies

Species	Size at 1 <sup>st</sup> sexual maturity ( $L_m$ )		Reference
	Males	Females	
<i>Eugerres mexicanus</i>	17.3 cm (TL)	20.5 cm (TL)	Valdez-Zenil <i>et al.</i> (2014)
<i>Gerres equulus</i>	n.a.	14.1 cm (SL)	Iqbal <i>et al.</i> (2007)
<i>G. filamentosus</i>	14.38 cm (TL)	13.66 cm (TL)	Sivashanthini (2008)
<i>G. filamentosus</i>	11.7 cm (SL)	11.8 cm (SL)	Kurup and Samuel (1991)
<i>G. filamentosus</i>	12.0 cm (SL)	19.0 cm (SL)	Sadovy and Cornish (2000)
<i>G. kapas</i>	11.5 cm	10.5 cm	Sjafei and Syputra (2009)
<i>G. longirostris</i>	n.a.	110 mm (SL)	Whitfield (1998)
<i>G. longirostris</i>	17.4 cm (TL)		Hosny <i>et al.</i> (2003)
<i>G. longirostris</i>	23.8 cm (TL)		Hardman <i>et al.</i> (2008)
<i>G. longirostris</i>	16.3 cm (FL)	20.6 cm (FL)	Grandcourt <i>et al.</i> (2006)
<i>G. longirostris</i>	19.8 cm (TL)	19.1 cm (TL)	Present study
<i>G. oyena</i>	12.8 cm	13.9 cm	Lamtane <i>et al.</i> (2007)
<i>G. oyena</i>	16.4 cm	18.9 cm	Rao (1970)
<i>G. oyena</i>	19.0 cm (FL)	22.0 cm (FL)	Yeeting (1990)
<i>G. oyena</i>	9.2 cm (SL)	10.4 cm (SL)	Kanak and Tachihara (2008)
<i>G. setifer</i>	7.1-8.0 cm	8.1-9.0 cm	Patnaik (1971)

n.a. = Data not available; SL = Standard length; FL = Fork length

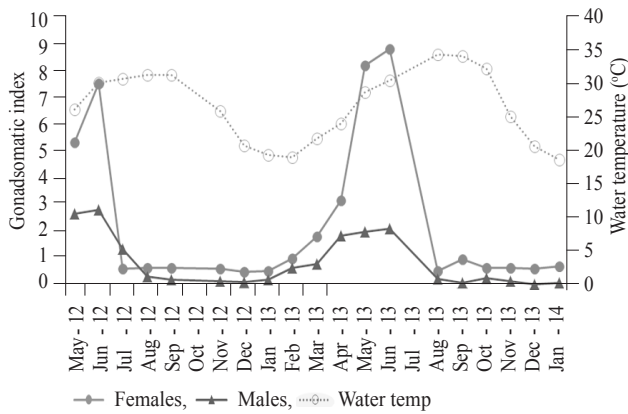


Fig. 2. Temporal variation of the mean gonadosomatic index (GSI) of *G. longirostris* from the Arabian Gulf off Saudi Arabia

observed to have an extended spawning season. In South Africa, Cyrus and Blaber (1984) stated that spawning occurs throughout the year for *G. filamentosus*, *G. rappi* and *G. longirostris*. The same has been reported for *G. filamentosus* in Cochin Estuary (Kurup and Samuel, 1991) and in Parangipettai (Sivashanthini, 2008). *G. setifer* has two defined spawning periods in Tanzania (Lamtane *et al.*, 2007), while *Eugerres mexicanus* has a single defined spawning period in Usumacinta River (Valdez-Zenil *et al.*, 2014). Nevertheless, it seems that within the same narrower geographical location, the spawning season of *G. longirostris* is a single defined one, as it was also reported from the southern Arabian Gulf that it breeds during a single defined period from April to August (Grandcourt *et al.*, 2006).

The mean water temperature was lowest in January-February, ranging between 18.73 and 19.40°C, began to increase in April (24°C), reached the highest in August (34°C) and then continuously decreased from November (25°C) (Fig. 2). The GSI seems to peak in

both sexes by 2-3 months before the highest temperature is reached. The correlation between GSI and water temperature (T) during the period of lowest temperature (January) through the peak recorded temperature (August) were found to be best expressed by a second-degree polynomial equation for both sexes, with an ascending limb from January (19.40°C) to June (30.28°C) and a descending limb from one July and August (Fig. 3). This indicates that water temperature above 30.28°C might not be optimal for reproduction in both females and males of *G. longirostris*. When the ascending limb between January and June, was considered separately, the linear correlation analysis showed positive significant ( $p < 0.05$ ) correlation coefficients of 0.9695 and 0.8491 for females and males, respectively. The linear equations expressing this relation were found to be:

$$\text{GSI} = 0.7531T - 14.026 \text{ in females,}$$

$$\text{GSI} = 0.1556T - 2.3682 \text{ in males}$$

As a management tool, a seasonal closure of the silverbiddies' fishery is thus a requirement during the period from 1 March to 31 July every year. A similar regulation is being enforced in the southern Arabian Gulf, where it is banned during 1 April to 21 July (Grandcourt *et al.*, 2006). The suggested regulation should be backed up by a ban of gargoors used for catching silver biddies, as gargoors have been observed to catch predominantly small sized individuals.

The *G. longirostris* population in the western Arabian Gulf seems to be female biased throughout most of the size range of the adult while, part of the population matures at 20.7 cm total length. As per GSI, *G. longirostris* spawns in a single season annually and its reproductive activity might peak in late spring and early summer. The reproductive activity of *G. longirostris* drastically decreases when the water temperature exceeds 30.28°C.

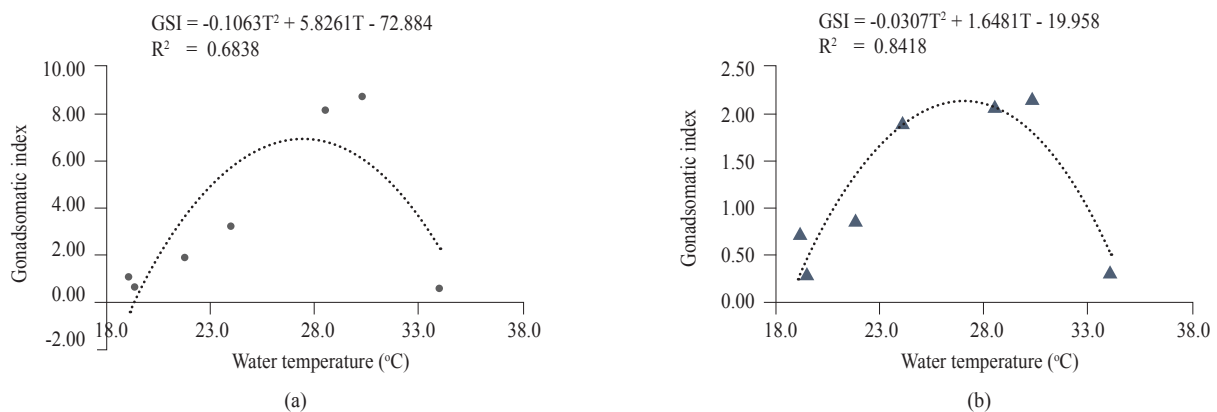


Fig. 3. GSI plotted against water temperature for (a) females and (b) males of *G. longirostris* during winter and early summer (January-June 2013)

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