Indian J. Fish., 60(3) : 23-26, 2013

Reproductive cycle and maturity stages of *Johnius carutta* Bloch, 1793 off Visakhapatnam, south-east coast of India

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ABSTRACT

A total of 3,406 gonad samples of *Johnius carutta* caught off Visakhapatnam (during 2008-'09), were analysed to study the reproductive cycle and maturity stages. Seven maturity stages were observed in the gonads. Spawning season was assessed based on gonado-somatic index and monthly occurrence of matured females based on the general appearance of gonads, its relative length to the abdominal cavity and developmental stages of ova. Monthly distribution of ripe (stage VI) and spent (stage VII) females were considered for ascertaining the probable spawning season. The restricted brief spawning period lasts for three months from February to April and the species spawn only once in a year. The peak breeding activity was observed in the month of February (26.64%) followed by March (18.62%) and April (15.38%) in which high gonado-somatic index (GSI) values (February 3.50%; March 3.46%; April 2.74%) were recorded. Spent females were observed from June to December with peak in the month of August (13.78%) and October (10.80). The size at first maturity was estimated at 17.5 cm in females. The fecundity varied from 35,650 to 1, 96,496 in individuals of 140 to 217 mm and its mean fecundity rcorded was 81,290 ± 5014 (n=38).

Keywords: Fecundity, Gonads, Maturity stages, Sex ratio, Spawning season

Introduction

Sciaenids contributed to 5.65% to the total marine fish production in India during 2010 (CMFRI, 2010). The species *Johnius carutta* is one of the commercially important sciaenid fish occurring in the trawl catches off Visakhapatnam. In Andhra Pradesh, among finfishes, pelagic (56.7%) and demersal (25.5%) resources are the two major contributors. Sciaenids (4.5%) formed the dominant group among demersal resources during 2000-06 (Rao *et al.,* 2008). Maturity and spawning habits of sciaenid fishes have been studied earlier in respect of *J. carutta* and *Johnius dussumieri* (Rao, 1964; Murty, 1979; Vivekanandan, 1985), *Johnius (Johnieops) vogleri* (Murty and Ramalingam, 1986) and *Johnius macrorhynus* (Telvekar *et al.,* 2006). The information available from the earlier investigations on the reproductive biology of *J. carutta* by Rao (1964), Murty (1979) and Vivekanandan (1985) from Visakhapatnam, Kakinada and Madras respectively are very limited. Hence, a detailed study on reproductive biology of this commercially important sciaenid fish was undertaken.

Materials and methods

Random samples of *J. carutta* collected from the departmental Research Vessel CIFTECH-1 operated within 35-40 m depth range off Visakhapatnam during the period from January, 2008 to December, 2009 were used for the study on reproductive parameters. Sexwise, 1,718 samples (length range: 11.0-23.6 cm) were males and the remaining 1,688 were females (length range: 11.6-24.5 cm). Gonad color, size, shape, length in relation to the length of body cavity and microscopic appearance of ova were the main factors taken into consideration to estimate the maturity stages and spawning period of females. In the present study, a scale of seven stages in either sex was identified as per ICSE scale (Lovern and Wood, 1937). For estimation of spawning period, additionally gonado-somatic index (GSI) values were calculated using the method of June (1953) and Yuen (1955). Size at first maturity and fecundity was estimated based on the cumulative percentage frequencies of sixth stage gonads of 0.5 cm size interval groups and were plotted at which 50% attained maturity (Sendecor, 1956). The sex ratio was tested for their equality in different months and length groups using chi-square test. The relationships between fecundity and total length, body weight and ovary weight were statistically determined by regression analysis.

Results

Maturity stages in male and female

Stage I (Immature/virgin): Testes long, transparent, colourless or grey, narrow, thread like extending up to

1/3rd of body cavity which were observed during June-January with peak in August (68.42%) and September (81.46%). In virgins, ovary thin, light pinkish, thread like, extending to ½ of body cavity. In recovering spent, it was broad extended to 2/3rd of body cavity and observed in the months of July (72.51%), August 79.86%) and September (81.82%).

Stage II (Maturing): Testes flattened, translucent pale white color extended less than ½ of the body cavity and was seen for ten months except March, April with peak during November (49.46%) and January (50.00%). Ovary extended 2/3rd length of body cavity. Semi-opaque oocytes were closely arranged and seen in October (52.84%), November (67.95%) and December (60.38%). Ovary of recovering spent was slightly fleshy, light yellow.

Stage III (Late maturing/developing): Testes pale white colour, opaque with blood capillaries and occupy ½ of body cavity; increased volume and weight was seen for eleven months except April with peak in December (37.93%). Ovaries become longer, broader light yellow; blood vessels seen distantly on the wall of ovary; occupied 2/3rd length of body cavity; opaque ova were visible. In recovering spent, ovary looked sac like and was observed for 11 months except in September, with peak in May (58.82%), January (38.96%) and December (23.27%).

Stage IV (Early mature/developed): Testes appeared reddish-white; no milt produced under pressure and occupied about 2/3rd of ventral cavity. Specimens with stage IV gonad occurred during December-August with peak in the month of March (28.39%) and April (31.82%). Ovary was broad, long, slightly dark yellow and attained 3/4th length of body cavity. Network of blood vessels with numerous capillaries on ovary wall was conspicuous. Stages III, IV were seen in January (15.58%), February (18.78%), March (38.30%) and April (46.15%).

Stage V (Mature/gravid): Testes white in colour and attained maximum length of the ventral cavity. Drops of milt produced under pressure was seen during December-July with peak in February (42.11%), April (36.36%) and March (27.10%). Thin walled ovary become dark yellow and extended beyond 3/4th length of body cavity. Ova were visible, thickly packed and dominated in February (42.79%), March (26.60%) and April (26.92%).

Stage VI (Ripe/spawning): Testes milky white in colour, showed further increase in weight and volume and almost extended to the anterior body cavity. Milting even under slight pressure, dominated in March (45.26%), April (35.48%) and May (31.82%). Ovaries become bright golden yellow and occupied entire length of the body cavity. Ripe ova were visible through the ovary wall. Stages of V, VI dominated in February (26.64%), March (18.62%) and April (15.38%).

Stage VII (Spent): Testes flaccid, with weight and volume reduced due to excessive discharge of sperm and appeared thin, slender and translucent. Observed during June-November and peaked in July (11.64%). Ovary was shrunken, flaccid, wrinkled and seen with partly filled left over ova and observed during June-December ranging between 0.63% (December) to 13.78% (August).

Spawning season

Based on the monthwise occurrence percentage, brief spawning season was estimated from February to April. The ripe gonads (stage VI) in either sex were dominated continuously from February to April (ripe ovary in February 26.64%, March 18.62%, April 15.38%; stage VI testes in February 45.26%, March 35.48%, April 31.38%). High GSI. values were observed in February (3.50%), March (3.46%) and April (2.74%) which further substantiates that the ripe gonads dominated during the same period of February-April. But, the GSI values during May (2.49%) was on par with those observed during February (3.50%), March (3.46%) and April (2.74%). From the result it appears that spawning season of *J. carutta* probably lasts for four months.

Sex ratio

The sex ratio between females and males was estimated at 1:1.02. Females dominated from January to May and in December, whereas males dominated from June to November. The chi-square test value (0.041898) was far below the table value at 5% level clearly suggesting both the sexes were equally represented. Males dominated in the smaller length groups (11.0-15.9 cm) whereas females dominated in larger length groups (16.0-24.9 cm).

Length at first maturit:

Females attained first maturity slightly earlier than males. Fifty percent of stage VI ripe females attained first maturity at 17.5 cm, whereas males attained at 17.7 cm (Fig. 1). The population of *J. carutta* attains first maturity at 17.7cm when both the ripe stage gonads viewed together. The smallest size of male and female that attained maturity

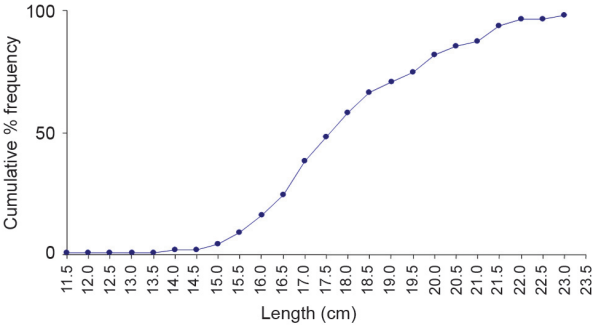

Fig. 1. Length at first maturity in female *Johnius carutta* (17.5 cm)

was at 13.0 cm (0.65%) and 11.50% (0.91%) respectively. Maximum number of males (96.73%) and females (98.18%) attained maturity at 20.5 and 23.0 cm respectively.

Fecundity

Ripe ovary contains only one group of ova, therefore, for estimation of fecundity, only ripe gonads were considered. Fecundity of *J. carutta* estimated from 38 females of length ranging from 14.0 to 23.6 cm varied from 35,650 to 1, 96,496 with a mean fecundity of 81,290 ± 5014. Results of regression analysis of fecundity in relation to three variables of ovary weight (OW), body weight (BW) and total length (TL) indicated that fecundity increased at the rate of 0.7851, 0.6344 and 0.1764 times of the OW (R^2 = 0.904), BW (R^2 = 0.4533) and TL (R^2 = 0.191) respectively.

Gonado-somatic index (GSI)

The mean GSI values fluctuated between 0.28 in August to 3.50 in February. Increased GSI values were reported from January to May with a distinct peak during February-April. Peak GSI values coincided with peak spawning period thus showing a close relationship between the two. High GSI values in 14 -17 cm length groups, particularly during February-April were a clear indication of peak reproductive activity in those length groups during spawning season (Fig. 2).

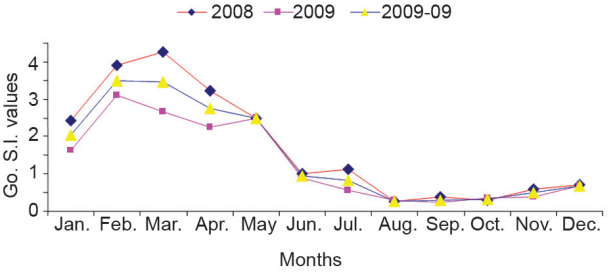

Fig. 2. Gonado-somatic index of *Johnius carutta* in different months during 2008-'09

Discussion

The species *J. carutta* spawns only once in a year for a brief period of February-April during which high GSI values and high occurrence percentage of ripe ovary were recorded. The value registered in May (2.49%) was on par with those observed during February-April, which suggests that the spawning period appears probably for four months from February-May. Rao (1964) reported single spawning season but for four months from January-April based on ova diameter studies but marginally different spawning periods were reported by Luther *et al.* (1988) (January-March) and Rajkumar *et al.* (2004) (March-May) from Visakhapatnam. In contrary, Murty *et al.* (1988) reported protracted spawning period (January-June) of six months from Kakinada, whereas Vivekanandan (1985) estimated brief restricted period of June and July from Madras. The estimated brief spawning season (February-April) was in agreement with the earlier observations (Rao, 1964; Luther *et al.,* 1988; Rajkumar *et al.,* 2004) from Visakhapatnam but differed from the results of protracted (Murty *et al.,* 1988) and restricted (Vivekanandan, 1985) spawning season from Kakinada and Madras respectively. However, spawning season of *J. carutta* varied from place to place and spawning period in majority of sciaenids was restricted to a brief period which breed only once in a year particularly during pre-monsoon along the east coast (Vivekanandan, 1985; Rao *et al.,* 1992). From the present results and those of earlier from Visakhapatnam, Kakinada and Madras waters; it can be seen that spawning season of this species varied from place to place and also marginally differed within Visakhapatnam over a period of time. This deviation can be attributed to sample size as well as influence of environmental factors and availability of quality food.

In the present study, females dominated during January-May and June-November in case of males. Sex ratio between female and male was 1:1.02, but males (1718) are marginally higher in number than females (1688). Murty *et al.* (1979) reported that males dominated during July-August and females showed predominance during September-December from Kakinada with a sex ratio of 1:1 during January-May which was incidentally the spawning season of this species. In the present study, males showed predominance up to 15.9 cm and from 16.0 to 24.9 cm females dominated. In Kakinada males dominated up to 13.9 cm and after this length females dominated (Murty, 1979). Partial segregation of mature forms through habitat preference or due to difference in growth rate (Reynold, 1974); faster growth rate which leads to less loss from predation (Qasim, 1966); migration or behavioural difference between sexes, environmental conditions and fishing (Polonsky and Tormosova, 1969; Bal and Rao, 1984) were the possible factors which influence the sex ratio. Chi-square test results (0.041898) indicated no significant difference between sexes in different months indicating equal distribution of females and males.

The size and age at first maturity depends on the nature of the environment in which the population of concern lives (Moyle and Czech, 2000). Smaller sciaenids attain maturity at the end of one year at the size of 150-170 mm, whereas in larger ones (*Otolithoides brunneus*) it is after attaining the size of one meter (Rao *et al.,* 1992). In the present study, males and females attained maturity at 17.7 and 17.5 cm at which, their age was assessed at ≥1.5 and ≤1.6 years respectively. The estimated size at first maturity (17.5 cm) in the present study was close to the one estimated (17.0 cm) by Luther *et al.* (1988) from Visakhapatnam;

but differed from the other earlier estimates at 14.0 cm by Vivekanandan (1985), 15.5 cm by Murty *et al.* (1988) and 15.4 cm by Rajkumar *et al.* (2004) from Madras, Kakinada and Visakhapatnam waters respectively. This deviation could be attributed to the sampling process, influence of environmental factors and availability of food supply.

Generally fecundity in sciaenids varied in different species and ranged from few thousands to 2-3 lakhs whereas in large species such as *Protonibea diacanthus* it might extend up to six lakhs (Rao *et al.,* 1992). Rajan (1968) reported the fecundity of smaller sciaenid species of *Pseudosciaena coiter* from Chilka Lake ranged from 2.7 to 5.6 lakhs. Total number of mature eggs of *J. carutta* in the present study varied from 35,650 to 1, 96,496 and the mean fecundity of 38 specimens was estimated at 81,290±5014. In general, fecundity increases with the increase in the size of female and influenced by fertility, frequency of spawning, parental care, egg size, population density and environmental factors (Bagenal, 1978). Linear relationship was seen in *J. carutta* between fecundity and ovary as well as body weight which suggests that fecundity increases at the rate of 0.7851 and 0.6344 times respectively; regression analysis values (R^2 = 0.904; R^2 = 0.4533) further corroborate this linear relationship. Linear relationship between fecundity and ovary weight was reported by Rao (1963) in respect of the sciaenid species *Pseudosciaena diacanthus*. However, the linearity between fecundity and total length (0.1764 times) in the present study was insignificant (R^2 = 0.191).

Acknowledgements

Authors are grateful to Dr T. K. Srinivasa Gopal, Director, CIFT, Cochin for according permission to publish this paper.

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Date of Receipt : 14.03.2012
Date of Acceptance : 09.04.2013