Indian Journal of Geo Marine Sciences
Vol. 48 (05), May 2019, pp. 628-634

# Breeding seasonality of *Anodontostoma chacunda* (Hamilton, 1822) off Mangalore coast, Karnataka, India

V.C. Ramya[1], S. Benakappa[1], V. Mahesh[2]*, A.S. Kumar Naik[1], H.N. Anjanayappa[1], & M.E. Vijaykumar[1]

[1]Department of Fisheries Resources & Management, College of Fisheries, Mangalore, India.

[2]Calicut Research Centre of Central Marine Fisheries Research Institute, Kozhikode, India

*[E-mail: mahesh.fishco@gmail.com]

*Received 11 August 2017; revised 09 January 2018*

Clupeids support world's largest marine fishery and dominant pelagic group landing from Indian waters. Even though landings of marine sector increased, the quantity of fish landing is dwindled and fluctuating and capture fish production is dependent on one of the natural biological factors "reproduction". To increase the production potential of marine fisheries, studies on breeding seasonality with reproductive biology of fish is an essential precursor for eco-friendly rational exploitation and sustainable management of fisheries. The present study focuses on some of the important reproductive biology aspects of *Anodontostoma chacunda* along the Mangalore coast for the first time. Six maturity stages were classified based on macroscopic appearance. Gonado-Somatic Index (GSI) indicated protracted spawning which extended from September (2013) to April (2014) with evidence of ova diameter studies as a prolonged spawner. The size at first maturity of *A. chacunda* was estimated at 139 mm (TL) and 141 mm (TL) for male and female, respectively. The overall male-female sex ratio of 1:1.04 was skewed towards female in *A. chacunda* and differed among months and size classes. Fecundity of *A. chacunda* ranged between 2,97,457 to 11,44,871 eggs.

**[Keywords:** Gizzard Shad; Maturity stage; Reproduction; Fecundity; Ova diameter]

## Introduction

Clupeids (Herrings, Shads, Sardines) are important marine forage fish which exhibits shoaling behaviour and dominant pelagic group of fish landed in Indian waters. This group comprises 106 species among 250 species that contribute to pelagic fisheries in Indian coast[1]. Shads are the most common group of clupeid fishes mainly found in coastal and estuarine waters. Some of them are migratory and ascend upstream for spawning, while the others complete their life cycle within coastal waters and estuaries[2]. Different types of gears are employed to exploit shads which include seines, shallow trawls, lift nets, gill nets, and purse-seines. In India, Shads landings were 20,750 tonnes and 56,089 tonnes during 2012 and 2013, respectively[3].

*Anodontostoma chacunda,* an important species of Shads available in Indian coast, commonly known as 'Chacunda Gizzard Shad' in English and locally known as 'Kurandadi/Hole swadi/Swadi' (Kannada), is usually marine coastal inhabitant but ascends rivers to the upper tidal zone, belongs to clupeids. They are mainly characterized by toothless mouth and gizzard like stomach. To continue the increasing trend of promising capture rate of clupeids that accrue for succeeding years, the knowledge about breeding seasonality has profound implications in fisheries management by balancing stock-recruitment relationship without affecting solitary reserve of fish population with securing of breeding sites and closure of fishing. Studies on biology of *A. chacunda* have been reported by Annigeri[4] in Mangalore and Rao[5] from Godavari estuary dating back to four decades. Sketchy observations on reproductive biology are not enough and there is paucity of information on reproductive biology of *A. chacunda* along the Mangalore coast. This study presents the first detailed information on reproductive biology with breeding seasonality of *A. chacunda*, with a view to gain indepth knowledge.

## Materials and Methods

Samples of *A. chacunda* were collected monthly over a period from September 2013 to April 2014 at fish landing center of Mangalore, Karnataka (Fig. 1). A total of 656 specimens were examined for the study. Total length (TL) and standard length (SL) of each individual was measured to the nearest 0.5 mm and total weight of specimen and weight of gonad was measured to the accuracy of 0.01 g using an electronic balance; while the sex was determined by the


Fig. 1 — Map showing fish landing center of Mangalore coast

examination of gonads with naked eye and with the help of binocular microscope (only for female). The sex ratios for different months and size groups were tested for significance by chi-square formula to know the homogeneity of male and female distribution. The size at first maturity ($L_{50}$) was determined logistically by fitting cumulative percentage for male and female considering all maturity stages of fish against size groups of different lengths[6].

Maturity stages were determined based on International Council for the Exploitation of the Sea (ICES) scale with suitable modifications[7]. The spawning periodicity was identified from estimates of the gonado-somatic index (GSI), which illustrated the reproductive cycle over the year at monthly intervals. GSI was calculated by using formula[8,9], GSI = weight of gonad (g)/Weight of fish (g) x 100. Fecundity was estimated gravimetrically using 5% formalin preserved ovaries. Ovaries of the stages IV and V were considered for fecundity estimation. Ovaries were weighed to the nearest milligram while care was taken to remove excess moisture from gonads prior to taking weight using a blotting paper. Small sample of anterior, middle and posterior part from each ovary was removed and weighed as a sub-sample. The number of mature ova in weighed sample were carefully separated from the tissue and counted in a watch glass under the binocular microscope. Absolute and relative fecundity were estimated from the number of mature ova for each individual by using the standard formulas[10]. For ova diameter distribution, a total of 500 ova were measured from each individual fish using compound microscope fitted with ocular micrometer where ocular division had magnification of 0.01 mm to each ocular micrometer division.

## Results and Discussion

*Occurrence of maturity stages in different months*

Classification of maturity stages is a paradigm in fisheries biology for initiation of studies on breeding seasonality with reproductive biology of fish. Based

on gross macroscopic characteristics, gonads were classified into six stages by following standard key for *A. chacunda*. In female, the coloration of ovary noticed was light orange to dark red color from stage I to V with increase in size and prominent network of blood vessels, whereas in male-testes glossy to pinkish color was imparted from stage I to V with development of lobes and blood infusion (Fig. 2, Table 1).

Direct evidence on the spawning period (season) of a species was identified by the occurrence of different maturity stages (especially mature and spent) in various months. A perusal of data on distribution of

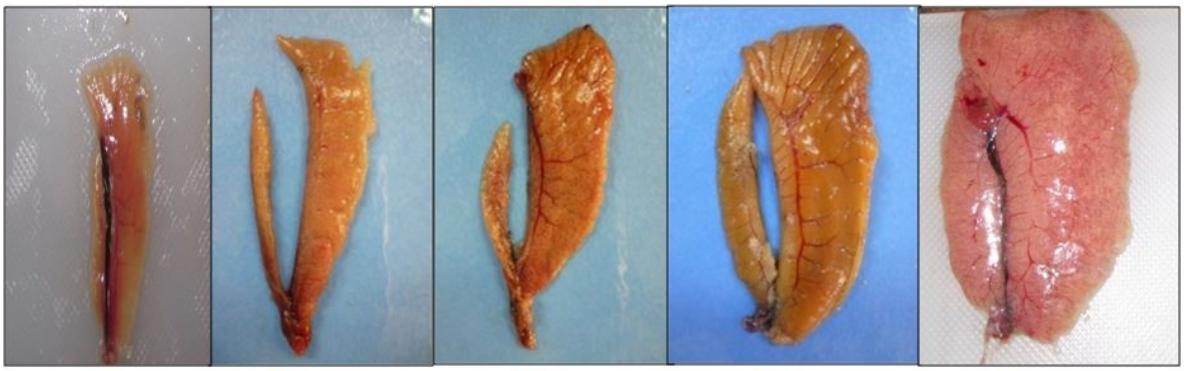


Fig. 2 — Different maturity stages of *A. chacunda* – female

Table 1 ─ Degree of gonadal maturation based on macroscopic and microscopic observations

| | Male | Female | | |
|---|---|---|---|---|
| Maturity stage | Nature and extent of testis in body cavity | Nature and extent of ovary in body cavity | Appearance of ova under microscope | Ova diameter range with a modal value (mm) |
| I (Immature) | Glossy and creamish to light pink, asymmetrical lobes, occupied1/4$^{th}$ of the body cavity. | Small, transparent, light orange to light yellow, occupied less than 1/4$^{th}$ of body cavity. | Very small, transparent, irregular in shape and some being rounded, yolk deposition not yet commenced, transparent with very clear nucleus. | 0.01 - 0.40 (0.01) |
| II (Maturing) | Pale pink to whitish pink with creamish walls, symmetrical lobes, occupied 1/2 of the body cavity. | Translucent, yellowish to orange color, blood capillaries were not distinct, occupied 1/2 of the body cavity. | Opaque and nucleus either visible or invisible, yolk deposition has just commenced, central semi transparent area can be noticeable. | 0.01 - 0.50 (0.05) |
| III (Early mature) | Imparting reddish color, soft and opaque, occupied about 2/3$^{rd}$ of the body cavity. | Orange to reddish color, visible to the naked eye with granular appearance, prominent blood vessels, occupied nearly 2/3$^{rd}$ of the body cavity. | Round and opaque, laden with yolk, transparent with distinct nucleus. | 0.02 - 0.60 (0.30) |
| IV (Late mature) | Imparting pinkish color, soft and brittle, massive and well developed, occupied 3/4$^{th}$ of the body cavity | Dark orange color, occasionally light orange to red color, blood vessels very conspicuous, occupied nearly 3/4$^{th}$ of the body cavity. | Spherical in shape, progression of further yolk deposition, clear perivitelline space and distinct nucleus. | 0.03 - 0.87 (0.50) |
| V (Ripe) | Retaining reddish to pinkish color, voluminous and well developed, occupied full body cavity, | Dark red in color, ovarian wall thin with tightly compacted, predominance of granular appearance, turgid and numerous blood vessels ramified over the surface, blood supply highly vascularised, occupied full length o f the body cavity. | Intra-ovarian eggs large with crystalline transparency, clear and narrow perivitelline space, single oil globule which was free from the follicle. | 0.03 - 0.95 (0.52) |
| VI (Spent) | Not encountered during the study period | | | |

maturity stages shows that almost all stages were present throughout the study period (Table 2). Atleast 3-4 stages of maturity were found in the monthly samples in most of the months. Clark[11] reported that if there is any periodicity in the spawning, all the fish collected at any particular time are expected to belong to same stage of maturity. However, observation on *A. chacunda* did not indicate any such periodicity. Ripe specimens of female *A. chacunda* occurred during the period October (2013) to March (2014) with peak in the month of December (2013), indicating this as a spawning season.

*Length at first maturity*

The timing of sexual maturity is a critical transition where onset of sexual maturity correlated with size of the fish. Cumulative percentage frequencies of male and female were calculated and plotted against different groups presented in Figure 3. The present study revealed that the size at maturity of *A. chacunda* was 139 mm (TL) and 141 mm (TL) for male and female, respectively, the length indicating early maturity may be due to physiological behaviour and thermal regimes which mobilize the fish to attain maturity at faster rate. In the present study, female fish mature later than males may be because of differences in energy requirements for their gonadal development resulting in slower growth of female. This may create recruitment variations by creating gap because when male matures early at a time females were not ready, it abruptly slows down the linkages. Rao[5] in his study on *A. chacunda* from Godavari estuary concluded that specimens were found to be fully mature from 16 to 17 cm onwards.

*Sex-ratio*

Number of male and female proportion may reflect certain change in fish population. Figure 4 and 5 show *A. chacunda* dominant number of male and female occurred in the size group of 140 and 160 mm, respectively. Month-wise dominant number of male occurred in October (2013) and female in February (2014). The chi-square values indicated significant difference in February (2014) with significant difference in size group of 120-140 mm; the overall male and female ratio of 1:1.04 was slightly skewed towards female. The diversity might be due to partial segregation of mature forms, either through habitat predominance or because of school formation thus rendering one sex more easily caught than other[12]. The differences in sex ratio and deviation from 1:1 may be due to gear selectivity in relation to sex differences, physiological activity, fishing pressure, and differential behavior of sexes[13,14]. Similar results were reported by Ghosh *et al.*[15], wherein for the overall sex-ratio varied between 1:1.28 M:F

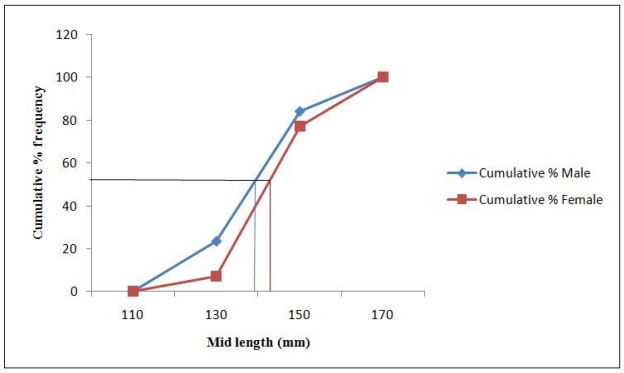


Fig. 3 — Estimation of size at maturity of *A. chacunda* by cumulative percentage frequency method

Table 2 — Seasonal changes in stages of maturity for *A. chacunda*

| Stages | Months of occurrence | |
|---|---|---|
| | Male | Female |
| I (Immature) | September - December, March - April<br>Dominance in September | September - October<br>Dominance in September |
| II (Maturing) | September - April<br>Dominance in September - October, April | September - April<br>Dominance in October |
| III (Early mature) | September, November - April<br>Dominance in November - February, April | September - April<br>Dominance in March - April |
| IV (Late mature) | September, November - April<br>Dominance in March | October - April<br>Dominance in January, April |
| V (Ripe) | November - December, March - April<br>Dominance in November - December | October - March<br>Dominance in November - December, February |
| VI (Spent) | Not encountered during the study period | |

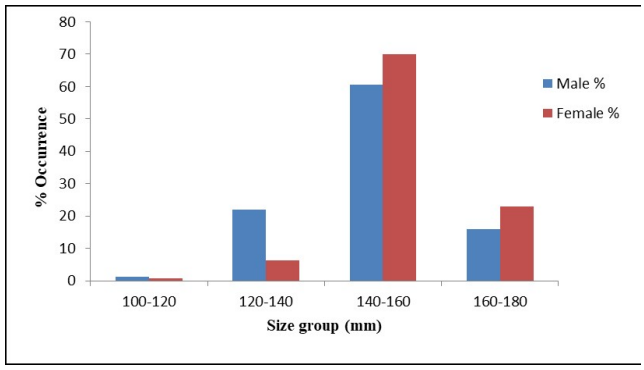


Fig. 4 — Sex ratio of *A. chacunda* in different size groups

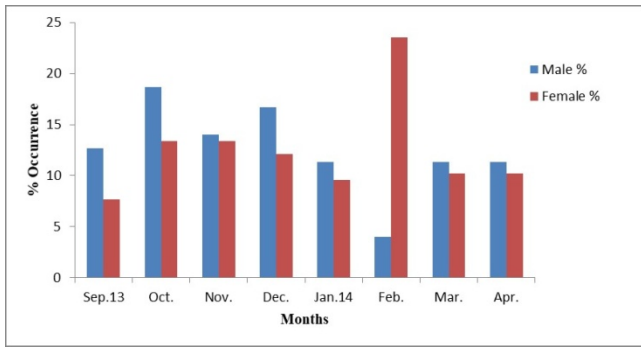


Fig. 5 ─ Sex ratio of *A. chacunda* in different months

*Sardinella gibbosa* and *Sardinella fimbriata* from North-west Bay of Bengal, and 1:1.33 M:F for *Sardinella gibbosa,* and between 1:1.02 to 1:1.025 for *Sardinella fimbriata.* Deshmukh *et al.*[16] reported that *Sardinella longiceps* from Ratnagiri coast exhibited sex-ratio of 1:1.549 (M:F).

*Gonado-somatic index* **(**GSI) values can assess breeding season in two dimensions both qualitatively and quantitatively. The extension of breeding season can be ascertained qualitatively and change in gonad condition (weight) over the season can be determined quantitatively. GSI values, used for indication of intense spawning activity, increase in gonad weight with progress of maturity and spawning; variations in average GSI of mature fish were analyzed to find its relation with spawning. GSI values in Figure 6 shows the average GSI values plotted against months. In female *A. chacunda,* GSI value was the highest (7.51) in December (2013) indicating peak spawning activity and the lowest recorded (1.64) in September (2013) indicating sexual resting period or termination of spawning. Whereas in male, the highest GSI of 2.83 was recorded in March (2014) and the lowest of 1.13 in April (2014). GSI values indicated that *A. chacunda* as a prolonged and protracted spawner in

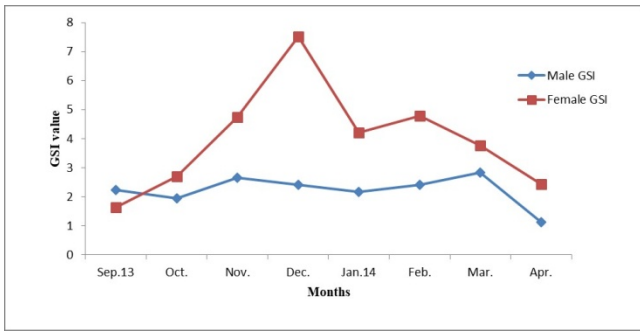


Fig. 6 ─ Monthly variations of GSI of *A. chacunda*

which the breeding season was extended from September (2013) to April (2014). GSI values recorded higher in females than males.

*Fecundity*

Assessment of fecundity has a paramount importance in assessing spawning stock biomass, which can compensate the loss to the fishery and reinforce recruitment process. The focal point for assessment of potentiality of fish population is fecundity. Knowledge about fecundity of a fish is essential for evaluating commercial potentialities of its life stock, life history, potential culture, and actual management of fishery[17]. Figure 7(a,b,c) represents the relation between fecundity of fish with length, weight and ovary weight of fish. The present study revealed the fecundity of *A. chacunda* ranged between 2,97,457 and 11,44,871 eggs with an average of 6,86,717 eggs per individual. In *A. chacunda* linear regression of log fecundity on log ovary weight indicated significant correlation (r=0.88) between the two variables. Similar fecundity results were reported by earlier workers like Panhwar *et al.*[2] who stated that *Tenualosa ilisha* fecundity was 87,267-6,14,482 in the females ranging from 210-350 mm in total length.

*Spawning periodicity and ova diameter studies*

Ova diameter studies have become an integral part of the fishery research. It has been widely accepted that ova diameter studies give reliable evidence on breeding season. The progression of intra-ovarian eggs depicts the spawning periodicity. Figure 8 gives the spectrum of progression of ovadiameter in different maturity stages, the ova diameter from stage I to V ranged between 0.01 to 0.95 mm of *A. chacunda*. This is in conformity with the observation of Annigeri[4] who reported that the egg diameter from immature stage to mature stage ranged from 0.019 mm to 0.95 mm.

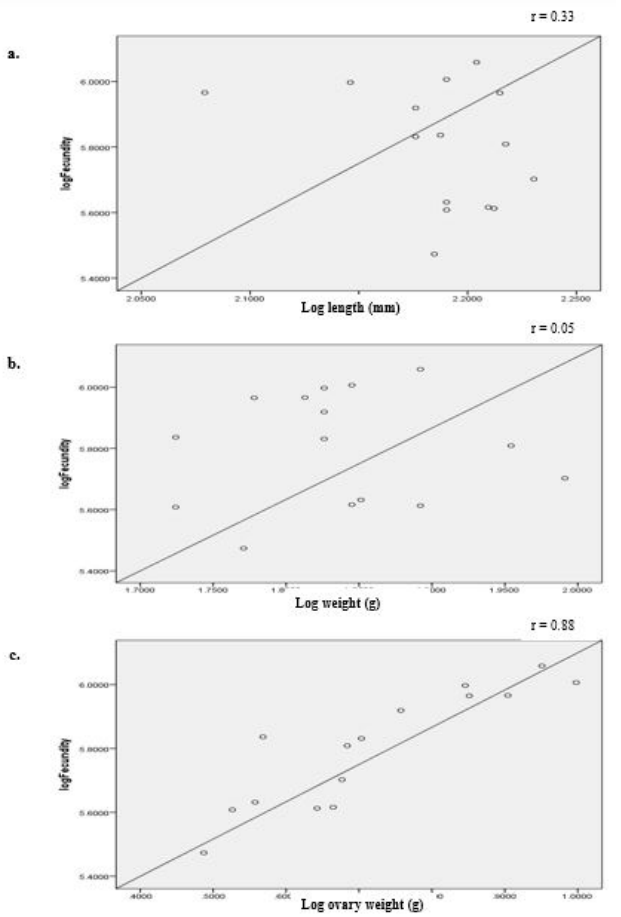


Fig. 7(a, b, c) ─ Linear regression plot of *A. chacunda* representing relation between fecundity of fish with length, weight and ovary weight of fish

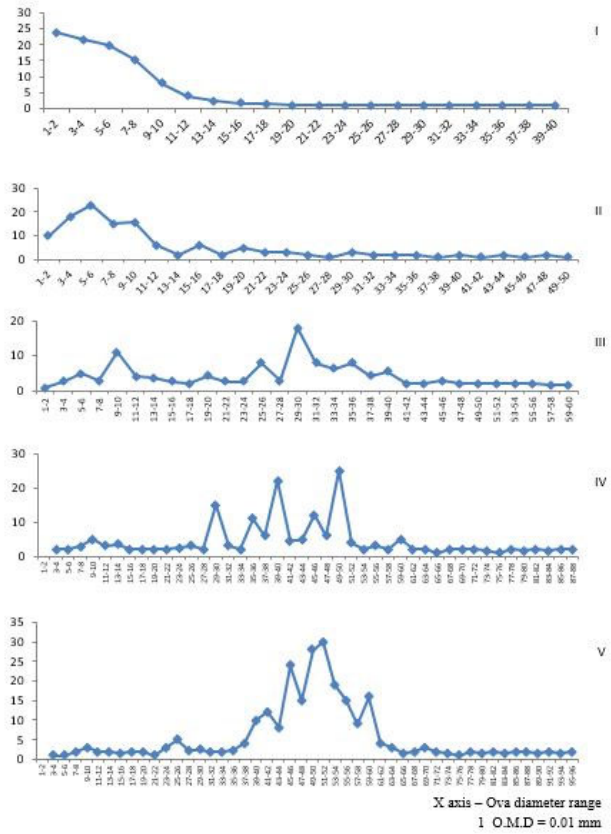


Fig. 8 ─ Ova diameter frequency polygon

The ova diameter study in the present investigation revealed that the presence of multiple groups of eggs in ovaries which were destined to mature and shed periodically by representing unrhythmic spawning bursts could not be sharply differentiated or separated in each stage depicting the prolonged spawning season and indicating fish *A. chacunda* as a continuous spawner. The presence of the highest number of yolked ova in *A. chacunda* mature ovary observed during December (2013), strongly support this as a peak spawning period and confirmed this to be the breeding season. Prabhu[18] also supported the above result by reporting that observation on the spawning period and its duration, as determined by a study of intra-ovarian eggs, would be more accurate if ova represented by various modes studied in relation to different stages of maturity represented by the respective modes in the ova diameter frequency curve and inference made on periodicity of spawning in different species concluded four distinct types of spawning: Type A spawning taking place only once a year during definite short period, Type B spawning taking place only once a year with a longer duration, Type C spawning twice a year, and Type D spawning throughout the year, but intermittently. Presence of more than one batch of eggs in *A. chacunda* was reported by De-jong[19]. Quasim[20] also reported that in Indian Ocean, several species of fish are continuous breeders with prolonged spawning season, lasting 7-9 months in a year.

## Conclusion

The present study on some aspects of reproductive biology with breeding seasonality of *A. chacunda* revealed that females dominate over males in the population and males mature earlier than females. The breeding season extends from September 2013 to April 2014 with a peak spawning activity in December 2013 which was strongly evident by GSI. Ova diameter peaks confirmed that *A. chacunda* is a fractional (batch/multiple) spawner and prolonged spawner with asynchronous oocytes development.

## Acknowledgement

The authors are thankful to the Dean, College of Fisheries, Mangalore, for providing all facilities and support during the study period. This study was a part of M.F.Sc. thesis submitted by the first author to Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka, India.

## References

1 Pillai, N.G.K., Pelagic Fisheries. In: *Handbook of Fisheries and Aquaculture*, edited by S. Ayyappan, (ICAR Publication, New Delhi) 2011, pp. 66-84.

2 Panhwar, S. K., Siddiqui, G. & Ayub, Z., Reproductive pattern and some biological features of anodromous fish Tenualosa ilisha (family: Clupeidae) from Pakistan, *Indian J. Mar. Sci.*, 40 (2011) 687-696.

3 CMFRI, *Central Institute of Marine Fisheries Research Institute Annual report, 2013-2014*, (CMFRI Publications, Cochin, India) 2014, pp. 14-18.

4 Annigeri, G. G., Maturation of the intra-ovarian eggs and the spawning periodicities in few fishes of Mangalore area based on ova-diameter measurements. *Indian J. Fish.,* 10(1963) 23-32.

5 Rao, M. B., Biological studies on the gizzard shad, *Anodontostoma chacunda* Hamilton (Family: Clupeidae), *J. Ma.r Biol. Ass. India*, 7(1965) 89-101.

6 James, P. S. B. R. & Badrudeen, M., Biology and fishery of silver belly *Leiognathus dussumieri* (Val.) from Gulf of Mannar, *Indian J. Fish.,* 28(1981) 154-182.

7 Lovern, J. A. & Wood, H., Variations in the biochemical composition of herring, *J. Mar. Biol. Ass. UK.*, 22(1937) 281-293.

8 James, P. S. B. R., The ribbon fishes of the family Trichiuridae of India, *J. Mar. Biol. Assoc. India,* 226(1967) 25-31.

9 Baragi, V.M., *Biology of Jhonieops osseus (Day) with notes on Sciaenid fishery of South Canara coast*. M.F.Sc. thesis, University of Agricultural Sciences, Bangalore, India, 1977.

10 Garg, S.K., Bhathager, A., Kalla, A. & Jahal, M.S., *Experimental Ichthyology.* (CBS Publication, New Delhi) 2002, pp. 129.

11 Clark., Maturity of California sardine *(Sardina casurulea)* determined by ova-diameter measurements, *Fish. Bull.,* 42(1934) 1-51.

12 Reynolds, J. D., Biology of small pelagic fishes in New Volta lake in Ghana. Pt III. Sex and Reproduction. *Hydrobiol.*, 45(1974) 489-508.

13 Del-Zarka, S. E. & El-Sedfy, H. M., The biology and fishery of *Mugil saliens* (Risso) in Lake Quaran. *Bull. Inst. Oceanogr. Fish.,* 1(1970) 3-26.

14 Bal. & Rao., *Marine fisheries of India*, 1st edtn. (Tata Mc Graw Hill Publisher company ltd, New Delhi) 1984, pp. 29-31.

15 Ghosh, S., Rao, H. M. V., Samithrudu, S., Rohith, P. & Maheshwarudu, G., Reproductive biology of *Sardinella gibbosa* and *Sardinella fimbriata* from North-west bay of Bengal., *Indian J. Mar. Sci.,* 42(2013) 758-769.

16 Deshmukh. A. V., Kovale, S. R., Sawanth, M. S., Shirdhankar, M. M. & Funde, A. B., Reproductive biology of *Sardinella longiceps* along Ratnagiri coast off Maharastra, *Indian J. Mar. Sci.,* 39(2010) 274-279.

17 Lagler, K. F., Opportunity for pre-impoundment studies in fisheries and in hydrobiology related to fisheries of Kafue reservoir, Zambia. *F-Misc*, (1967) 67.

18 Prabhu, M. S., Maturation of intra-ovarian eggs and spawning periodicities in some fishes, *Indian J. Fish.,* 3(1956) 59-90.

19 De-Jong, J.K., A preliminary investigation of the spawning habits of some fishes of Java Sea. *Treubia,* 8 (1939) 199-218.

20 Qasim, S. Z., An appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters, *Indian J. Fish.,* 20(1973) 166-181.