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Studies on reproductive biology of *epinephelus diacanthus* (Valenciennes, 1828) off Saurashtra region, Gujarat

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Abstract
In the present work the overall sex ratio for *E. diacanthus* was 1: 2.06. Females dominated in all size classes up to 45 cm and their per cent varied from 54.55 to 76.64%, while males became dominant after 45 cm. *E. diacanthus* spawned throughout the year with the peak in August-December. The size at 50% of *E. diacanthus* matured in the population was 262 mm. Absolute fecundity of *E. diacanthus* ranged from 58,806 during April to 2, 24, 640 in August. The average fecundity determined for the study period of one year was 1, 25, 253. The estimated ova size of *E. diacanthus* ranged from 252 to 384 µm. Month wise GSI was calculated and it was found to be higher in September, October, November and December.

Keywords: *Epinephelus diacanthus*, grouper, reproductive biology, veraval

Introduction
In general *E. diacanthus*, members of Family Serranidae is an Indian Ocean species found on the continental shelf of the northern Indian Ocean from the Gulf of Aden to Sri Lanka and India [1]. The species is possibly found off Specific India, Iran, Oman, Pakistan, Sri Lanka, Yemen and Iraq [2]. The natural habitat of *E. diacanthus* is on mud or muddy sand bottom at the depths of 10 to 120 m [1]. These species are major targets of artisanal, recreational and commercial fisheries [1] [3]. It occurs within trawl catches ranging in India from 250 to 500 m [4]. Juveniles abound the mid-shelf waters for feeding for eight months before migrating to the deeper waters for further growth and breeding [5].

Groupers are top predators, sedentary in character; most of them are strongly territorial, typically long- lived and slow-growing and many assemble in large numbers to spawn. These characteristics contribute to their over-exploitation and consequently they have become endangered by recent fishing operations. The loss of groupers can have a serious effect on local ecosystems, since these fish play an important role in the structure of rocky bottom and coral reef communities [6]. The biology of groupers is a major factor in their susceptibility to heavy and unregulated fishing and biological information is essential for management purposes. Studies of reproductive and biological aspects such as length at first maturity and fecundity facilitate the development of management strategies such as minimum size limit and assessing fishery resilience [7].

There is no considerable information available on *E. dicanthus* caught off Saurashtra coast regarding its sex ratio, maturity, spawning season, food and feeding habits, length-weight relationship and population dynamics. The present investigation was helping us to know the maturity status of the species in different seasons, which will be helpful in knowing the status and profile of body components. The results of the present study will help in devising strategies for managing the fishery of this particular resource at a healthy and sustainable level.

Materials and Methods
The present study was conducted along the coastal waters at Veraval (21º 35' N, 69º 36' E), which is situated along the western coast of Gujarat, India. The study was conducted from January 2016 to December 2017 i.e., for two year. Multi stage stratified random sampling method (developed by CMFRI) was followed for estimating the monthly and annual catch of *E. diacanthus* landed by trawlers at Veraval landing Centre. From the fishes stratified into multi stage size groups, 25 *E. diacanthus* were collected randomly from different areas on a weekly basis. Take the total/standard length.

Abdomen of the fishes was cut opened to get their gut and gonads. The gut was cut for the collection of dietary components present in it and also for their identification, recording the number of items belonging to each category, their weights and volume of each category (ml). Collected ovaries were preserved in 5% formalin. The weight (g) and the status (stage III and above) of the gonads were recorded. Moreover, three pieces of the ovary weighing 1 g each from the anterior, middle and posterior portions of the ovary were taken and examined for the number of ova present in them to determine the fecundity [8]. The ova diameter (um) in each sub sample of the ovary was studied under a stereo zoom microscope [9].

In the statistical analysis Month wise sex ratio of the species was determined and Chi-square test was performed to test the homogeneity of male and female distribution in the population [9]. Maturity was observed based on the stages of gonad [8] and the size at first maturity was determined by plotting the percentage of sexually matured specimens (stage III and above) against their standard body length. The distribution of ova diameter in each sub-sample of the ovary taken from the anterior, middle and posterior regions of the ovary was studied under a stereo zoom microscope [9].

Fecundity was determined following the gravimetric method by preserving ovaries in 5% formalin. Fecundity was worked out by raising the number of ova in all the sub samples of the matured and ripened ovary (stage V and VI) to the total ovary weight. The ovary sub samples were obtained from the anterior, middle and the posterior regions of the ovary [8].

Gonado Somatic Index (GSI) was determined by the formula given below [10].

$$GSI\% = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \text{x } 100$$

Results and Discussion

Sex Ratio

Sex ratio was calculated in every month for males and females of *E. diacanthus* and Females were dominated in trawl catches during all months (Fig. 1). The overall sex ratio for *E. diacanthus* was 1:2.06. Females dominated in all size classes up to 45 cm and their per cent varied from 54.55 to 76.64%, while males became dominant after 45 cm (Table 1). The sex ratio in different size classes was significantly different from expected ratio 1:1.

Females of *E. diacanthus* have outnumbered males for most size and age classes [11], which were similar to the present study findings, reported herein above. The dominance of females over males with an overall sex ratio of 1:2.3 male-to-females in specimens collected in Omani waters during 1999–2000 [12]. However, the dominance of females was found between 24 and 36 cm FL compared with more males between 40 and 48 cm FL. Studies on Taiwan's population of *E. diacanthus* was showed that this species is a protogynous hermaphrodite with female changes sex into male. They reported that the change in sex occurs at the 2–3 year age classes, the intersexual fish occur within 2 to 6 year-old classes, and males became dominant after 4 years old [13].

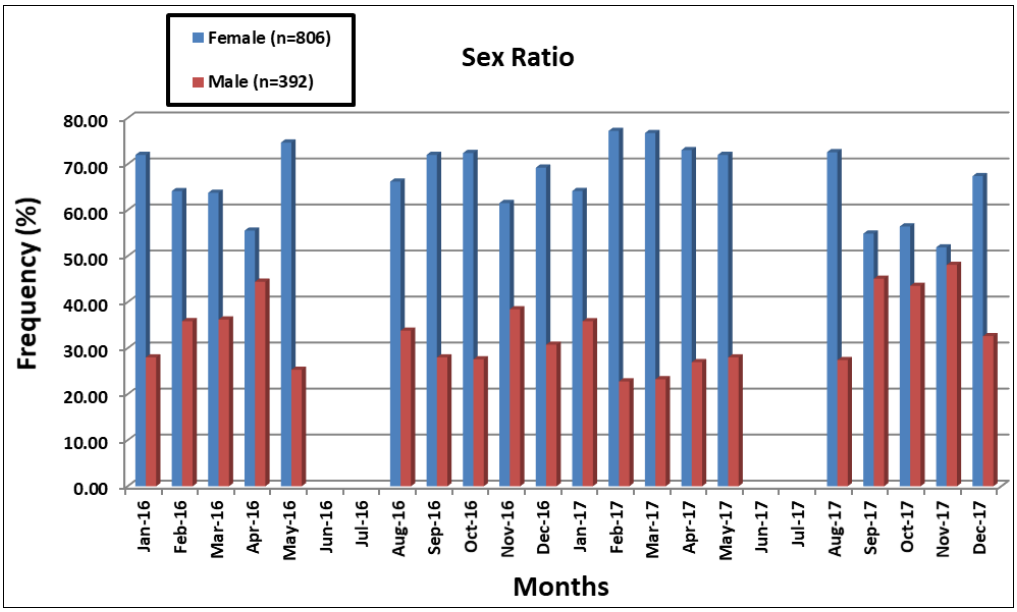

Fig 1: Monthly sex ratio of *E. diacanthus* (2016-2017).

Table 1: Sex-ratio in different size groups of *E. diacanthus* (2016-2017).

Length class (cm)	No. of females	No. of males	Total	Females (%)	Sex Ratio
10-15	105	32	137	76.64	3.28
15-20	295	154	449	65.70	1.92
20-25	239	109	348	68.68	2.19
25-30	109	53	162	67.28	2.06
30-35	31	20	51	60.78	1.55
35-40	18	12	30	60.00	1.50
40-45	6	5	11	54.55	1.20
45-50	2	4	6	33.33	0.50
50-55	1	3	4	25.00	0.33
Total	806	392	1198	67.28	2.06

Maturity

Sexual maturity of individuals was studied by observing the different developmental stages of ova, which were distinguished by microscopic and macroscopic stages of ovary. Immature stages (I & II) were observed in all the months except in August, whereas mature stages (III, IV, & V) were observed in all the months. But, spent condition (VI & VII) was observed in August to November.

This concurs with the findings which suggested spawning season of the spinycheek grouper in India as May-June [14], while mature and spent adults at a northwest coast of India in

observed September [15]. In Taiwan *E. diacanthus* spawns during April-May [13]. It is known that *E. diacanthus* are fractional spawners having extended spawning periods.

Spawning

E. diacanthus spawned throughout the year with the peak in August-December (Fig. 2). This is supported by the fact that the spawning percentage was higher during August, September, October, November and December and whereas it was the least in May. Higher gonadosomatic index of 1.004 to 3.062 during the former four months and the ova of largest size of 384 µm observed in September are also in conformity with the spawning season.

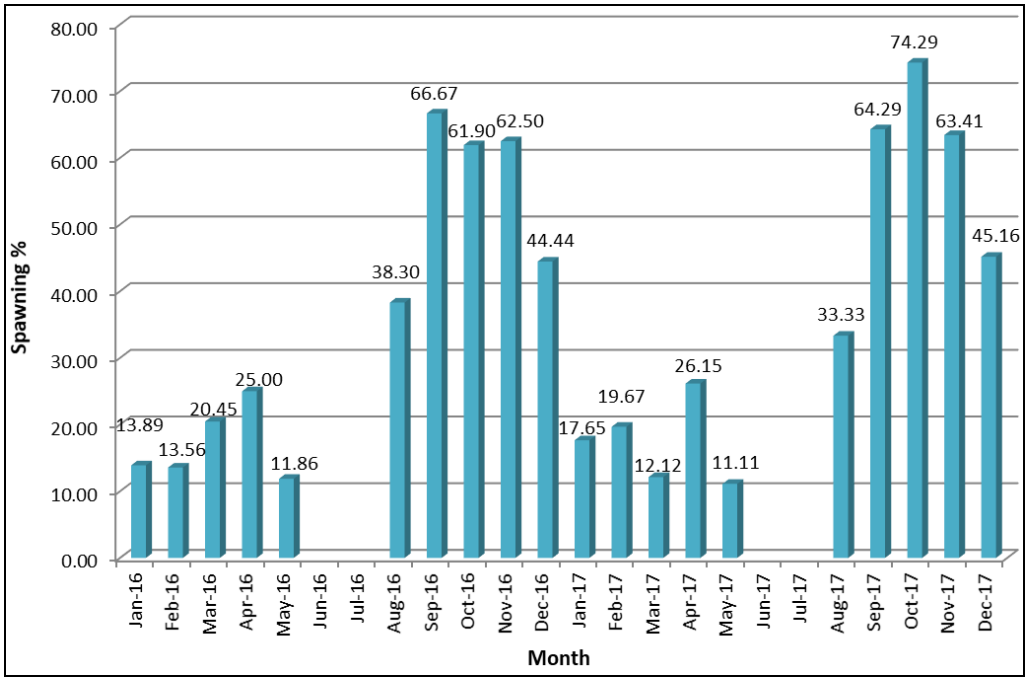

Fig 2: Month wise percentage of spawning females of *E. diacanthus*

This concurs with the findings in which, observe that Ripe males and females were found in October 2007, February, May-June and August-September 2008, that can testify prolonged period of *E. diacanthus* spawning [11]. In other study found that higher GSI values for females of *E. diacanthus* in May and June and highest percentage of females with running gonads in May, and determined spawning season of this species in May-June [16]. Furthermore, Premalatha suggested the spawning season of the spinycheek grouper in India as May-June [14], while Bapat *et al.* observed the mature and spent adults at a Northwest coast of India in September [15]. According to Chen *et al.* in Taiwan *E. diacanthus* spawns during April-May [13].

Length at Maturity

The size at 50% of *E. diacanthus* matured in the population was 262 mm. Individuals with this body length were observed in all the months except in January and March. The size at which 25% and 75% of the fish matured in the population was 184 and 369 mm respectively (Fig. 3).

This concurs with the findings in which observed based on 530 specimens collected in 2000-2001 in Oman, 87.2% and 71.7% of the fish sampled were mature females and males, respectively. In Oman, sizes of first maturity for female and male *E. diacanthus* were found to be 39.2 mm FL and 42.5 mm FL, respectively [12]. Furthermore, Chen *et al.* were found that the minimum size of maturity was estimated to be about 125 mm SL in Taiwan [13].

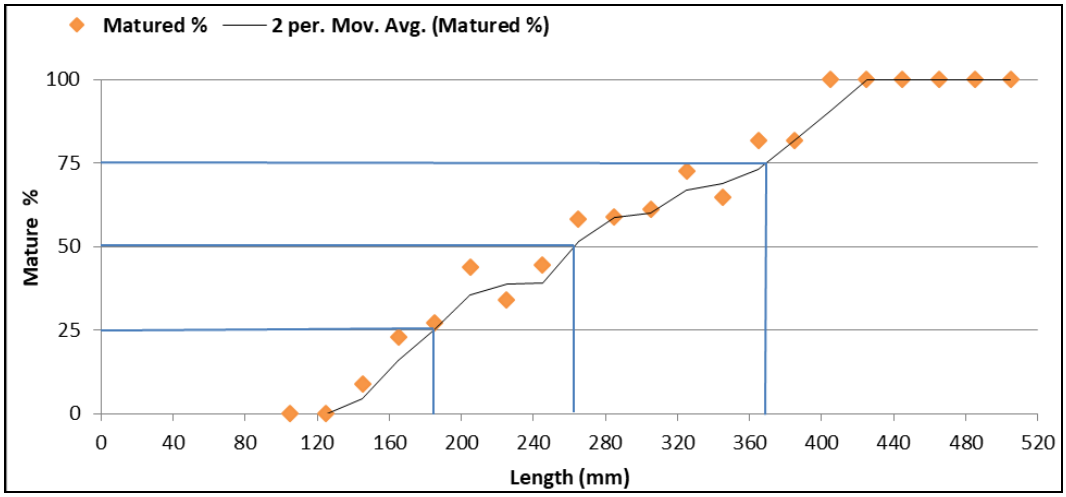

Fig 3: Percentage of mature females at different sizes of *E. diacanthus*

Fecundity

Absolute fecundity of *E. diacanthus* ranged from 58,806 during April to 2, 24, 640 in August (Table 2). The fecundity per gram of body weight was the highest in November (915) and the last of in January (298). The average fecundity per gram body weight was 630. The average fecundit y determined for the study period of one year was 1, 25, 253. There was the peak season of the fecundity observed from August to December (Fig. 4 and 5).

Fecundity of fishes is usually determined from the number of ova of the mature group in the ovary. Rao and Krishnan were determined the fecundity of *E. diacanthus* from the examination of 25 specimens. The fecundity of *E. diacanthus* varied from 13,100 to 1, 45, 700 with an average of 75, 547ova [17]. Tessy reported that the average fecundity of *E. diacanthus* was 57,458 and the highest fecundity was 1, 65, 000 [18]. Chen *et al.* have found that fecundity of *E. diacanthus* in the Pacific Ocean ranged from 63,000 to 2, 33, 000 [13]. In present study the Absolute fecundity of *E. diacanthus* was observed to vary from 58,806 to 2, 24, 640 concurred with previous studies.

Table 2: Fecundity per gram body weight of *E. diacanthus*

Month	Fecundity/g body weight	Fecundity
Jan-16	311	64688
Feb-16	401	89824
Mar-16	652	73676
Apr-16	486	58806
May-16	809	97889
Aug-16	652	80848
Sep-16	768	100608
Oct-16	902	184910
Nov-16	666	217782
Dec-16	402	133464
Jan-17	298	75096
Feb-17	452	92208
Mar-17	701	102346
Apr-17	450	70142
May-17	796	125768
Aug-17	702	224640
Sep-17	812	208684
Oct-17	868	197904
Nov-17	915	207705
Dec-17	551	98078
Average	630	125253

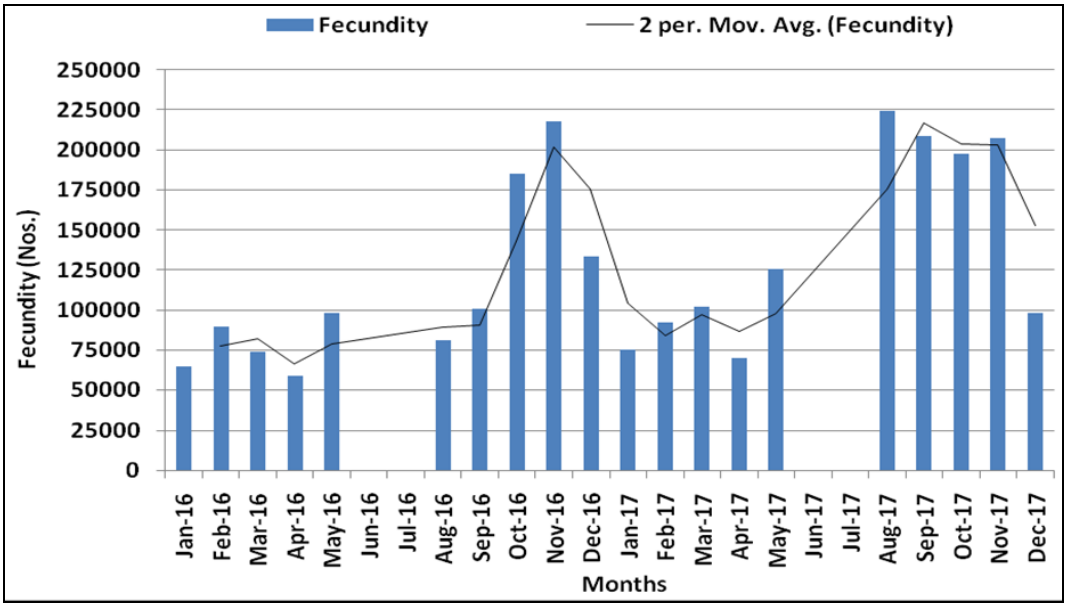

Fig 4: Month wise fecundity of *E. diacanthus*

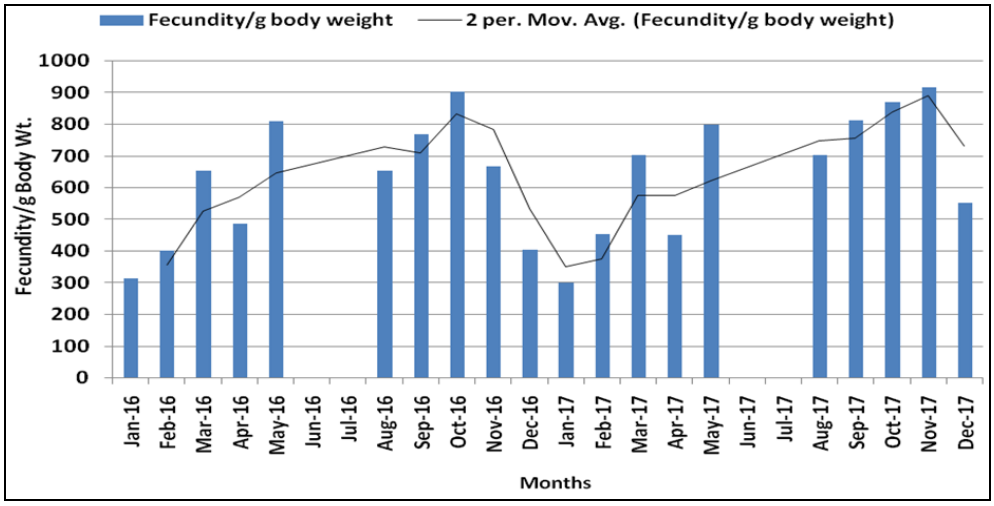

Fig 5: Month wise fecundity per gram body weight of *E. diacanthus*

Ova Diameter

The estimated ova size of *E. diacanthus* ranged from 252 to 384 µm (Table 3). The mean size of the ova was higher in September (384 µm) and October (372 µm) and the least in February (252 µm). The percentage frequency of the ova diameter was estimated and it revealed that the maximum number of ova were in the size category of 351-400 µm (Fig. 6). The above results are similar to the observations made by Yeh *et al.*, who noticed that in *Epinephelus tukula*, oocyte diameter increases from immature stage (120 µm) to ripe stage (552 µm), which is very similar to *E. diacanthus* [19]. The egg diameter of *Epinephilus morio* was found to be less than 1mm [20]. Brule and Deniel also observed similar trend in oocyte cyclic development in the immature oocyte (54 µm) to ripe oocytes (897 µm) in red grouper, *E. morio* [21]. Furthermore, Rao and Krishnan were found the largest oocyte diameter was 650 µm in ripe stage ovary of *E. diacanthus* [17]. Tessy also has observed the largest oocyte diameter as 600 µm in *E. diacanthus* [18]. Powell and Tucker reported eggs of 0.92 mm diameter in *E. striatus* [22].

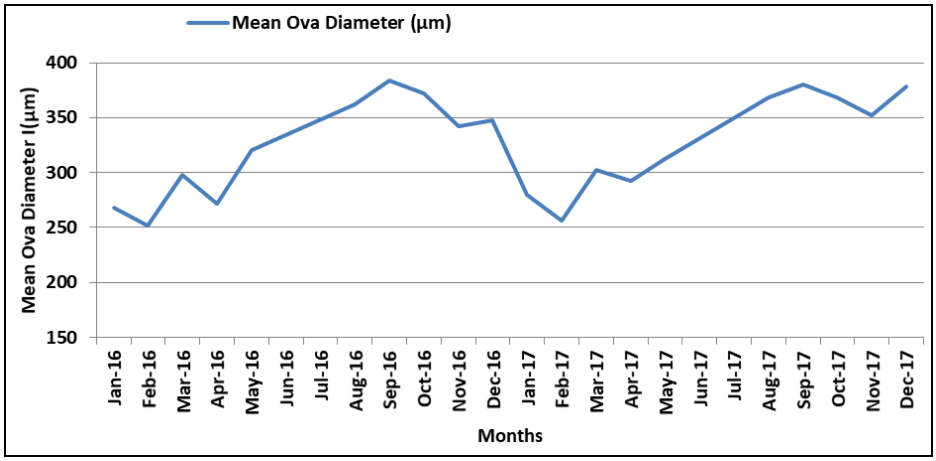

Fig 6: Monthly variations in ova diameter of *E. diacanthus*

Table 3: Frequency of ova diameter of *E. diacanthus*

Ova diameter (µm)	No. of ova	% of frequency
101-150	11	1.27
151-200	27	3.13
201-250	55	6.37
251-300	101	11.70
301-350	132	15.30
351-400	146	16.92
401-450	122	14.14
451-500	99	11.47
501-550	76	8.81
551-600	74	8.57
601-650	16	1.85
651-700	4	0.46

Gonadosomatic Index (GSI)

Month wise GSI was calculated (Fig. 7) and it was found to be higher in September, October, November and December (2.081, 2.604, 3.042, 2.982 respectively), whereas it was lower January (0.098) and February (0.071).

This concurs with the findings of Abdulaziz *et al.*, who observed ripe males and females were found in October 2007, February, May–June and August–September 2008, that can testify prolonged period of *E. diacanthus* spawning [11]. Furthermore, McClanahan *et al.* found higher GSI values for females of *E. diacanthus* in May and June and highest percentage of females with running gonads in May, and determined spawning season of this species in May–June [16]. Moreover, Premalatha suggested spawning season of the spinycheek grouper in India as May–June [14], while Bapat *et al.* observed mature and spent adults at a northwest coast of India in September [15]. According to Chen *et al.* in Taiwan *E. diacanthus* spawns during April–May [13]. This confirms that the breeding of this species in the present study site and elsewhere were high in September to November.

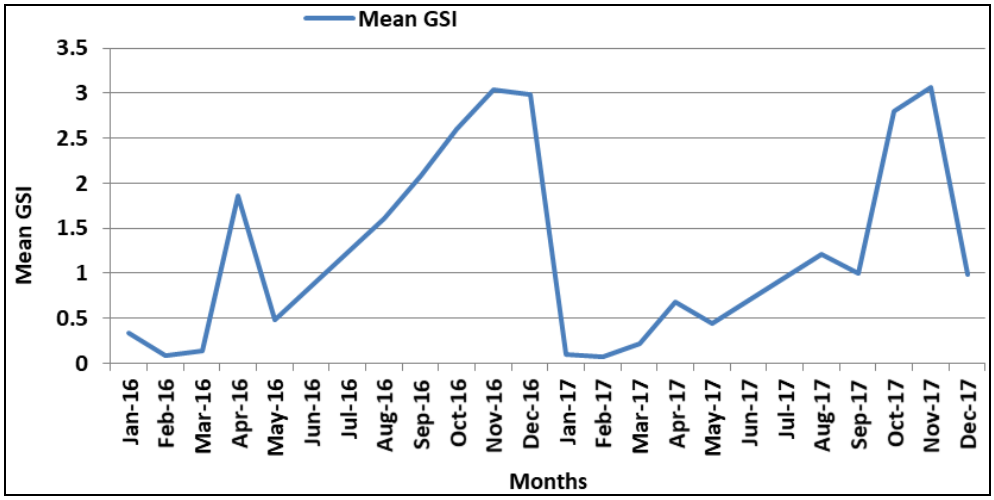

Fig 7: Gonado-Sometic Index of *E. diacanthus*

Conclusions

This study aims to describe the reproductive biology of *Epinephelus diacanthus* off Saurashtra region, Gujarat. Results show that the *E. diacanthus* have longer spawning season from August to December. They sexual maturity of *E. diacanthus* is 262 mm. The findings from this study can be used to develop suitable management practice for groupers such as establish close season during spawning and formulate the suitable mesh size regulation especially for trawl net to protect fish below the size at first maturity.

References

1. Heemstra PC, Randall JE. Groupers of the World. (Family Serranidae, Subfamily Epinephelinae). FAO Species catalogue 16. Rome. 1993; 1-382.
2. Sadovy Y, Pollard D, Russell B, Heemstra PC. *Epinephelus diacanthus.* In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011. 2008; 2. <www.iucnredlist.org>.
3. Craig MT, Sadovy de MY, Heemstra PC. Groupers of the World: A field and market guide. Graham's town, South Africa: CRC Press, NISC. 2011; 1-424.
4. James PSBR, Srirama chandra V, Murthy VS, Nammalwar P. Groupers and snappers of India: Biology and exploitation. ICLARM Conference Proceedings, International Center for Living Aquatic Resources Management, Campeche, Mexico. 1996; 48:106-136.
5. Zacharia PU, Gupta AC, Mahadevaswamy HS. Exploitation of juveniles of the spinycheek grouper, *Epinephelus diacanthus* by the multi-day trawlers along Dakshina Kannada coast, CMFRI, Kochi. 1995; 139:9-12.
6. Aburto-Oropeza O, Erisaman B, Valdez-Ornelasy V, Danemann G. Commercially important serranid fishes from the Gulf of California: Ecology, fisheries and conservation. Ciencia y Conservacion 2008; 1-23.
7. Armswoth PR. Effects of fishing on a protogynous hermaphrodite. Canadian Journal of Fisheries and Aquaculture Science. 2001; 58:568-78.
8. James PSBR, Gupta TR, Shanbhogue SL. Some aspects of the biology of ribbonfish *Trichiurus lepturus* (Linnaeus). Journal of Marine Biological Association of India. 1978; 290(1 & 2):120-137.
9. Narasimham KA. Mortality, spawning and sex ration of the ribbonfish *Trichiurus lepturus* (Linnaeus) off Kakinada. Journal of Marine Biological Association of India. 1994; 36(1&2):199-204.
10. Kume S, Joseph J. Size composition and sexual maturity of Gill-fish caught by Japanese long line fishery in the Pacific Ocean east of 130 degrees west. Bulletin of Fr Sears Fisheries Research Laboratory. 1969; 2.
11. Abdulaziz AM, Mikhail C Said AS. Some aspects on distribution and biology of the Spiny cheek grouper *Epinephelus diacanthus* (Valenciennes, 1828) from the Arabian Sea off Oman. Journal of Biology, Agriculture and Healthcare. 2015; 5(18):39-49.
12. McIlwain J, Hermosa GV, Claereboudt M, Al-Oufi HS, Al-Awi M. Spawning and reproductive patterns of six exploited finfish species from the Arabian Sea, Sultanate of Oman. Journal of Applied Ichthyology. 2003; 22:167-176.
13. Chen CP, Hsieh HL, Chang KH. Some aspects of the sex change and reproductive biology of the grouper, *Epinephelus diacanthus* (Valenciennes, 1828). Bulletin of Institute of Zoology Academia Sinica. 1980; 19:11-17.
14. Premalatha P. Fishery and biology of rock cods from the southwest coast of India. Indian Journal of Fisheries. 1989; 36(4):285-291.
15. Bapat SV, Deshmukh VM, Krishnamoorthi B, Muthiah C, Kagwade PV, Ramamirtham CP *et al.* Fishery resources of the exclusive economic zone of the Northwest coast of India. Bulletin of Central Marine Fisheries Research Institute. 1982; 33:1-81.
16. McClanahan TR, Verheij E, Maina J. Comparing the management effectiveness of a marine park and a multiple-use collaborative fisheries management area in East Africa. Aquatic Conservation. 2006; 16(2):147-165.
17. Rao CA, Krishnan L. Studies on the reproductive biology of the female spiny cheek grouper, *Epinephelus diacanthus* (Valenciennes, 1828). Indian Journal of Fisheries. 2009; 56:87-97.
18. Tessy KL. Studies on the biology of cultivable species of *Epinephelus* from the southwest coast of India. Ph.D. Thesis, Cochin University of Science and Technology. 1994; 1-219.
19. Yeh SL, Dai QC, Chu YT, Kuo CM, Ting YY, Chang CF. Induced sex change, spawning and larviculture of potato grouper, *tukula*. Aquaculture. 2003; 228:371-381.
20. Moe MA. Biology of the red grouper *Epinephelus morio* (Valenciennes) from the Eastern Gulf of Mexico. Florida department of natural resources, Marine Research Laboratory, Professional Papers Series 10, Florida. 1969.

21. Brule T, Deniel C. Biological research on the red grouper (*Epinephelus morio*) from the Southern Gulf of Mexico. In: Arreguin F. Sanchez, Munro, JL, Balgos, M. C. and Pauly, D. (Eds.), Biology, Fisheries and Culture of tropical groupers and snappers. International Center for Living Aquatic Resources Management, Conference Proceedings. 1996; 48:28-42.
22. Powell AB, Tucker JWJ. Egg and larval development of laboratory reared Nassau grouper *Epinephelus striatus* (Pisces, Serranidae). Bulletin of Marine Science. 1992; 50(1):171-185.