

Some Aspects on Distribution and Biology of the Spinycheek Grouper *Epinephelus diacanthus* (Valenciennes, 1828) from the Arabian Sea off Oman

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Abstract

Spinycheek grouper (*Epinephelus diacanthus*) distribution and biology were studied based on the samples collected during a demersal fish survey conducted by R/V "Al Mustaqila 1" along the Arabian Sea coast of Oman between September 2007 and September 2008. This species was relatively evenly distributed along the coast and occurred in depths from 22 to 182 m with total length range of 6.7–58.1 cm (mean 36.8 ± 0.4 cm SE, $n = 715$), and weight range of 4.0–2575 g (mean 834.4 ± 22.9 g SE). The sizes most commonly encountered groupers ranged between 33 and 39 cm TL. Differences in size between males (mean 38.5 ± 0.6 cm SE, $n = 224$) and females (mean 36.7 ± 0.4 cm SE, $n = 475$) were registered. The length–weight relationship for both sexes combined was $TW = 0.0097 TL^{3.0896}$ ($R^2 = 0.99$). Females were outnumbered males during the survey period where the overall male to female ratio was 1 : 2.13. Ripening and mature males and females were occurred from February to October, and the peak of spawning was found in May–June.

Keywords: Oman, Arabian Sea, *Epinephelus diacanthus*, distribution, size structure, sex ratio, spawning

1. Introduction

The spinycheek grouper, *Epinephelus diacanthus* (Valenciennes, 1828) is a demersal species belonging to the family Serranidae, which are commonly known as groupers, rockcods, and hamours, a group of percoid fishes in the order Perciformes. It is distributed on the continental shelf of the north-western Indian Ocean from the Gulf of Aden to Sri Lanka and Madras (India), but is not known from the Persian Gulf or the Red Sea (Heemstra & Randall 1993), and in the eastern Indian Ocean off Thailand (Chen *et al.* 1980; Monkolprasit *et al.* 1997) and Hong Kong (Ni & Kwok 1999). In Omani waters, the spinycheek grouper occurs on mud and muddy sand bottom from very shallow waters of about 2 m deep down to 110 m (Abdelsalaam 1995).

The groupers are one of the main components of the industrial and artisanal fisheries in tropical and temperate waters and usually have a high price in national and international markets. Groupers are caught by both artisanal and industrial fleets in Oman, but the bulk comes from the artisanal one (about 94%). They contributed about 14% of the demersal fish catch in the artisanal fishery (Anon 2014). Annual landings of groupers in artisanal fishery in Oman from 2004 to 2013 fluctuated between a minimum of 3827 tonnes in 2011 and a maximum of 5825 tonnes in 2009 (mean 4667 tonnes). *E. diacanthus* is an important species among groupers recorded in the catch in Oman, but recently its catch in Omani waters showed a declining trend (Mehanna *et al.* 2013). The species is listed as near threatened in IUCN Red List (Sadovy *et al.* 2008).

Though, detailed studies on the age, growth, reproduction, stock assessment and fishery of the *E. diacanthus* are available from the Indian waters (Chakraborty 1994; Chakraborty & Vidyasagar 1996; Chakraborty *et al.* 2005; James *et al.* 1996; Manojkumar 2005; Premalatha 1989; Rao & Krishnan 2009; Sivakami & Seetha 2006; Sluka & Lazarus 2010; Zacharia *et al.* 1995), information available in Omani waters is limited to the works of McIlwain *et al.* (2006) on reproductive biology and Mehanna *et al.* (2013) on the stock characteristics of this species. As more detailed information on biology and population characteristics of the *E. diacanthus* off Oman's coast is needed to develop strategies for its sustainable exploitation, the present study was undertaken.

2. Materials and Methods

Five seasonal trawl surveys of demersal fish with an average duration of 47 days per survey were conducted by the RV "Al Mustaqila 1" on the continental shelf of Oman in the Arabian Sea between Ras Al Hadd in the north and Yemen border in the south from September 2007 to September 2008 (Fish Resources Assessment Survey of the Arabian Sea Coast of Oman Project). The bottom trawl was used to collect demersal fish on the continental shelf in the 20–250 m depth range. Trawl station positions were selected randomly with a minimum distance of 2 nautical miles in between. Trawl survey tows were carried out during daylight hours only with a towing speed of 3.5 knots, and a standard tow distance of 2.0 nm. Care was taken to ensure that trawls start after dawn and were completed by dusk. The trawl net used was 35 m long headline and 38 m long ground line. The cod-end with a

nominal inside mesh measurement of 40 mm and included an extension section to match with the back end of the trawl and ensure correct filtration.

If a trawl caught less than 20 spinycheek groupers, all specimens were sampled; for trawls in which more than 20 groupers were caught, a random subsample of 20 individuals was taken for biological analysis. For each sampled fish, data on total length (TL) to the nearest 0.1 cm, total wet weight (TW) to the nearest 0.1 g, sex and gonad stage were recorded. A total 715 specimens were analyzed during the study (Table. 1).

Table. 1. Summary table on total number of studied *E. diacanthus* collected from trawl catches in 2007–2008.

Voyage	Date	Trawl survey station (n)	Trawl with <i>E. diacanthus</i> (n)	Number of specimens
Oma0701	17 Sep – 15 Oct 2007	114	27	87
Oma0702	1 Nov – 17 Dec 2007	113	22	215
Oma0801	29 Jan – 18 Mar 2008	131	18	73
Oma0802	19 Apr – 10 Jun 2008	127	30	106
Oma0803	1 Aug – 23 Sep 2008	129	37	234
Total		614	134	715

The gonads of *Epinephelus diacanthus* were assigned to three different maturity stages as suggested by Rao and Krishnan (2009): I – immature, II – maturing, III – mature active/ripe.

Length-weight relationships were estimated separately for males and females and sexes pooled fish using the power equation:

$$TW = a TL^b$$

where, *TW* and *TL* are the total weight and total length respectively, and 'a' and 'b' are the constants to be determined.

The monthly relative condition factor, *Kn* was estimated to understand the condition of the fish as,

$$Kn = TW/aTL^b$$

Where, *TW* = observed weight, *aTL^b* = calculated weight obtained from the length-weight relationship.

The sex-ratio was determined as a percentage of different sexes and tested for the expected ratio of 1 : 1 using a chi² test.

To determine the spawning season the percentage occurrence of different stages of gonads (ovaries and testes) in different months was calculated and plotted.

Statistical tests (ANCOVA, t-test, chi-square test) were carried out with the software package of STATISTICA 10 and map was plotted with the software SURFER 10.

3. Results and Discussion

Spatial distribution

Epinephelus diacanthus was one of the abundant and wide distributed species found in trawl catches during the surveys. The species was relatively evenly distributed along the Oman coast from 16°39' N 53°19' E (Dhalkut) to 21°55' N 53°19' E (Ras Al Hadd) (Fig. 1). About 60% of samples in 2007 and 66% in 2008 were presented from 1 to 5 individuals per trawl.

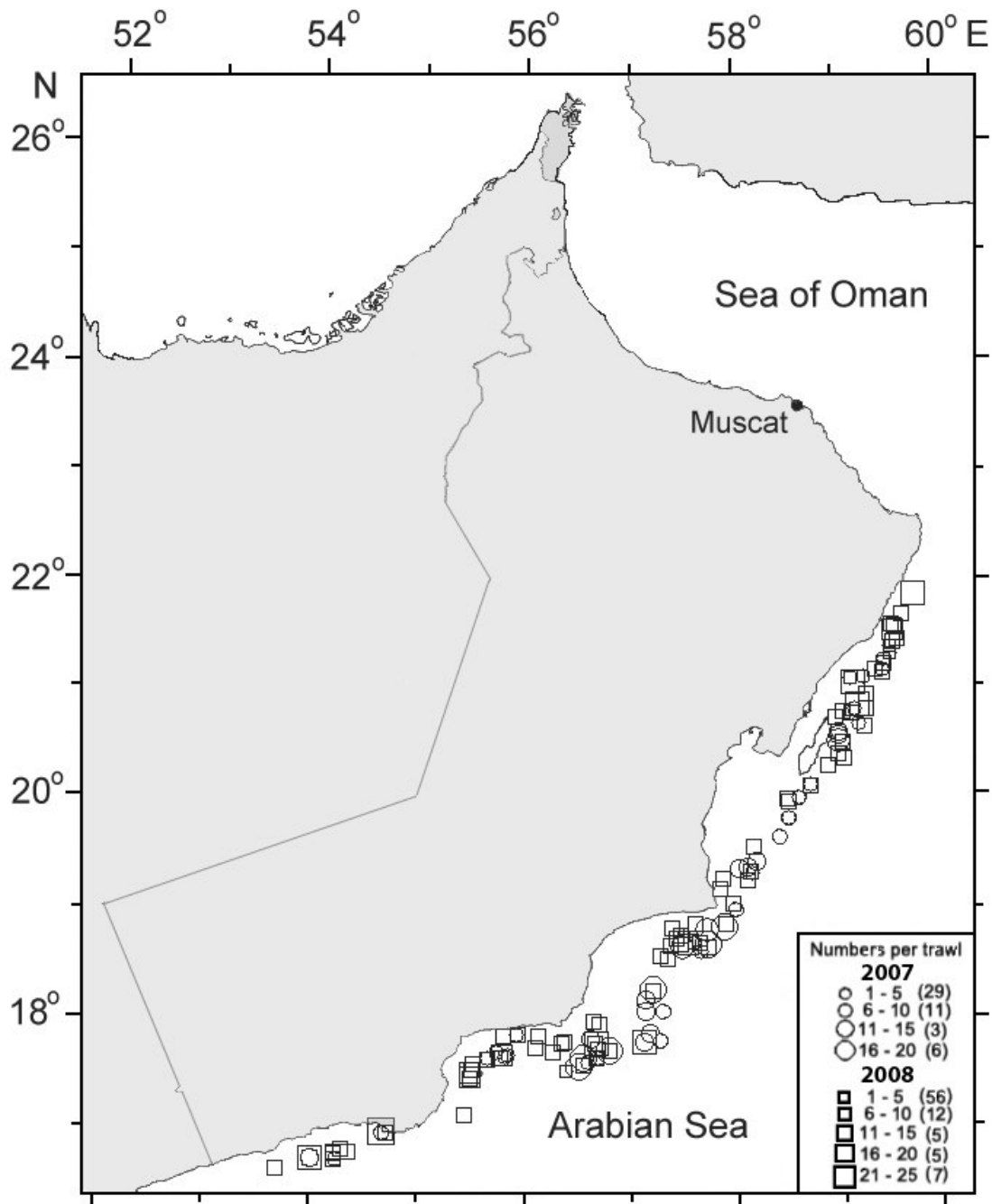


Figure 1. Spatial distribution of *E. diacanthus* during the trawl surveys along the Oman coast of the Arabian Sea in 2007–2008 (in parenthesis is number trawl stations).

Vertical distribution

The spinycheek grouper was caught in depth range from 22 to 182 m. Maximum concentration was recorded between 50 and 90 m (70% of total catch) (Fig. 2). Two specimens were found in trawl catch from depth of 150–153 m and one from depth of 170–182 m.

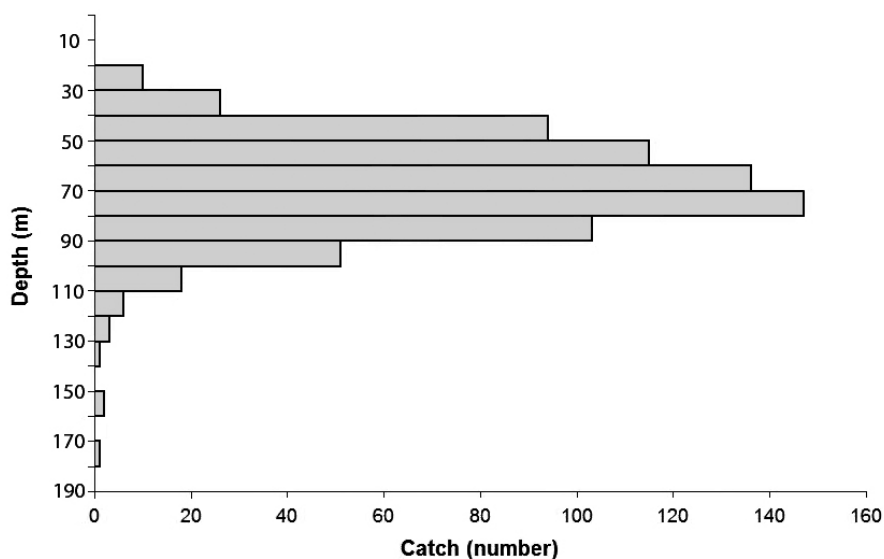


Figure 2. Vertical distribution of *E. diacanthus* during the trawl surveys off Oman in the Arabian Sea in 2007–2008.

It is common that fish juveniles usually distributed in more shallow water than adults did. However, during the survey such difference was not found. Average length of *E. diacanthus* was similar in different depths (Fig. 3). Ten small juveniles (7.6–8.8 cm, 6–8 g) were caught from the depth of 50–55 m. The smallest juvenile (6.7 cm, 5 g) was found in trawl catch between 59 and 77 m.

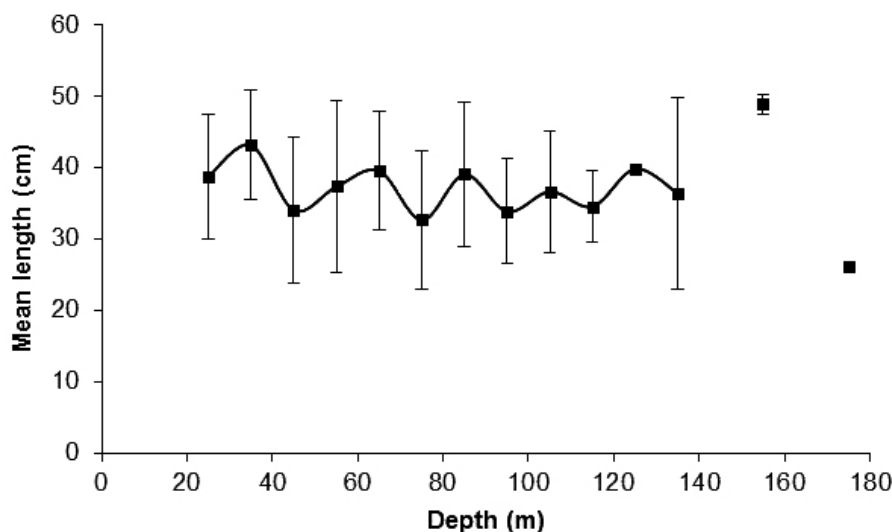


Figure 3. Average length of *E. diacanthus* (with standard deviation) in different depths off Oman coast during the trawl surveys in 2007–2008.

Silas (1969) collected juveniles of this species in Indian waters from 30–60 m and 100–160 m depths. *E. diacanthus* is an important component of demersal fishery off Kerala coast in 63–100 m depth (Talwar & Kacker, 1984). The trawl survey by Sivaprakasam (1986) on Wadge Bank and Gulf of Mannar (India) revealed that *E. diacanthus* was one of the dominant species of groupers, and fishes were most abundant in the 20–50 m depth zone, their abundance decreasing with depth, as also described by Joseph *et al.* (1987); there was no catch of these fishes in the 200–500 m depth zone. De Bruin *et al.* (1995) stated that this species forms large schools on Pakistan muddy trawling grounds at depths of 2 to 50 m. Abdessalaam (1995) indicated that *E. diacanthus* occurs in Omani waters up to 110 m depth. In addition, *E. diacanthus* recorded by an underwater visual census on a hard coral and hard bottom in shallow water (2–12 m) which may be juvenile habitat (Sluka and Lazarus, 2010).

Size composition

While, the total length of the spinycheek grouper in trawl catches ranged from 6.7 to 58.1 cm (mean 36.8 ± 0.4 cm SE), the weight varied from 4.0–2575 g (mean 834.4 ± 22.9 g SE). Ten small juveniles of 7.6–8.8 cm and smallest specimen of 6.7 cm were caught near Masirah Island in September 2007 and August 2008 respectively. Lengths of other individuals were more than 16.1 cm. Overall, four peaks of length classes were recorded: 6–9, 21–24, 33–39 and 45–48 cm (Fig. 4). Individuals less than 20 cm represented about 3%, fish measuring between 25 and 50 cm amounted about 75% from the total number.

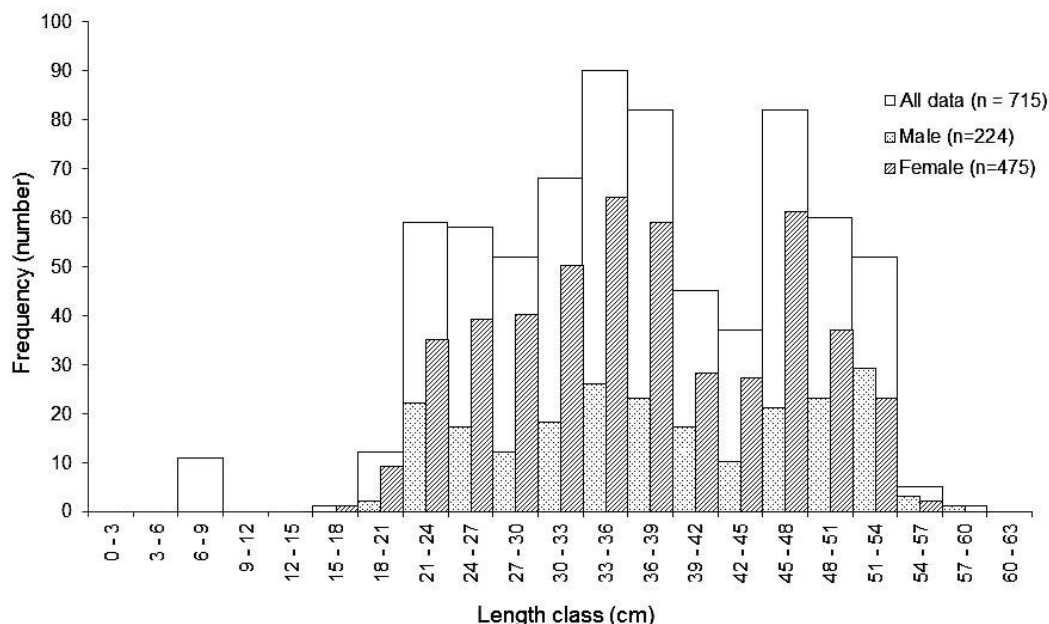


Figure 4. Length frequency distribution of trawled *E. diacanthus* from Omani waters (2007–2008).

During the trawl survey of R/V "Dr. Fridtjof Nansen" the size range of *E. diacanthus* was: 20.5–50.5 cm SL in Pakistan waters in 1983 (Anon 1983); 23.5–53.5 cm FL in Yemen waters in 1985 (Edwards *et al.* 1991). The lengths of the species collected from commercial catches in waters of India in 2000–2003 varied from 5.5 to 49.5 cm TL (Chakraborty *et al.* 2005). Size range of *E. diacanthus* in industrial trawl catches in the Arabian Sea off Oman in 1999–2000 was 26.0–53.2 cm FL (McIlwain *et al.*, 2006).

The previously maximum known total lengths of *E. diacanthus* were 52 cm (Heemstra and Randall 1993), 53 cm (Abdessalaam 1995) and 55 cm (Premalatha 1989; Edwards & Shafer 1991), in the present study, bigger sized fish than mentioned before have been registered.

Size composition of *E. diacanthus* during different months is shown on Fig. 5. Appearance of very small juveniles (6.7–8.8 cm) in August–September maybe explained that this fish was born in spring of the current year. Juveniles with length from 18 to 27 cm were observed in trawl catches in

September–October 2007 and August–September 2008. According to Mehanna *et al.* (2013) the length at first capture of *E. diacanthus* was estimated as 21.8 cm, which is corresponded to an age of one year. Chakraborty (1994) indicated that this species in Bombay waters during first year grows to 22.9 cm, while Manojkumar (2005) calculated the length of one-year-old fish as 24.4 cm.

The length frequency distribution of males and females of *E. diacanthus* was different (see Fig. 5). The males were larger than females, their mean length was 38.5 cm (SE 0.6 cm), and mean weight was 942.9 g (SE 40.7 g), while females had on average 36.7 cm (SE 0.4 cm) and weighed 808.7 g (SE 26.7 g). The largest specimen observed in the study was a male measuring 58.1 cm and weighing 2575 g. Sample variances when tested by t-test showed significant difference at the specified alpha of 0.05.

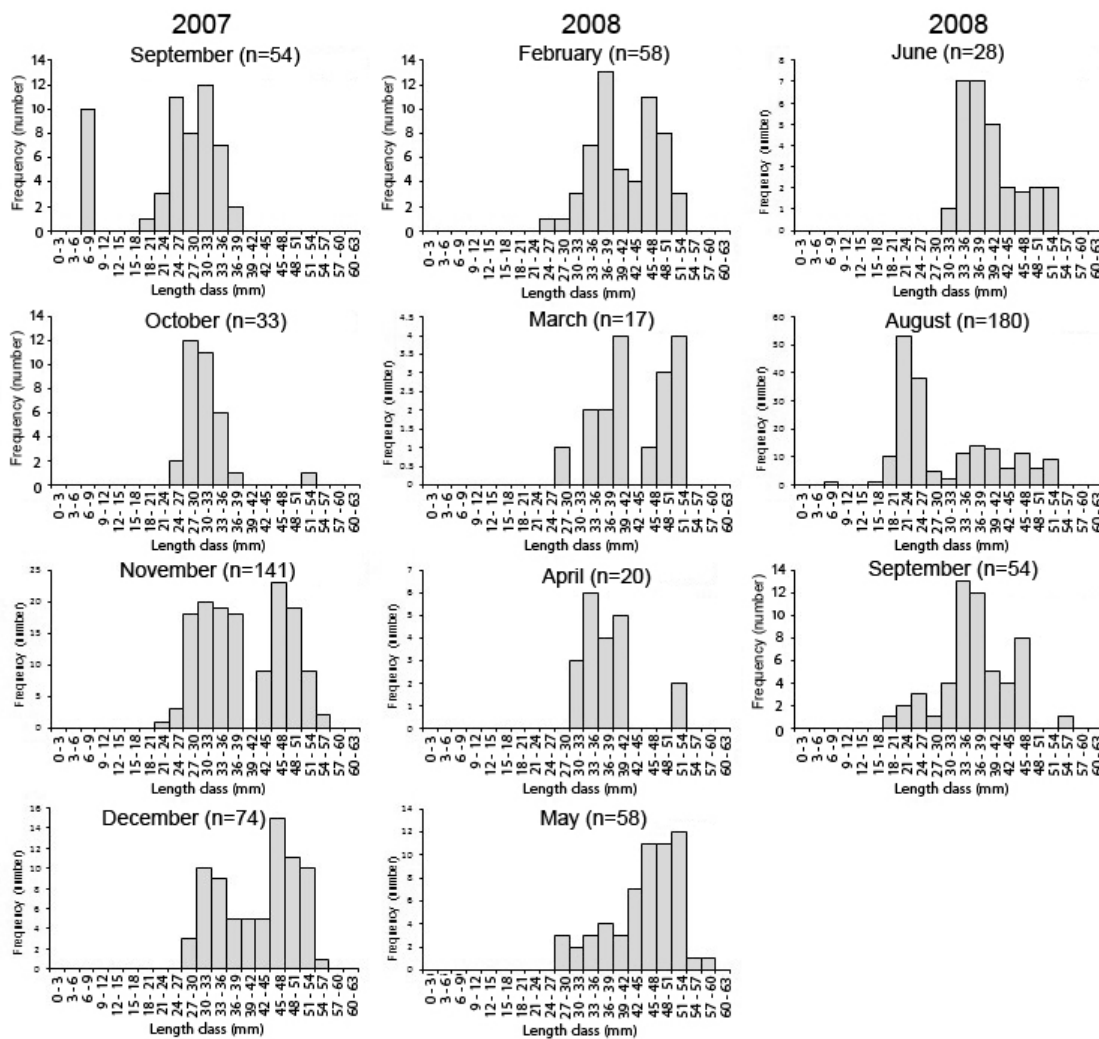


Figure 5. Monthly length frequency distribution of *E. diacanthus* during the trawl surveys along the Oman coast of the Arabian Sea in 2007–2008.

McIlwain *et al.* (2006) reported the similar result where they found that females of the spinycheek grouper had a lower average body size (40.3 cm FL) than males (41.2 cm FL).

Sex ratio

Females dominated in trawl catches during all months of the surveys (Fig. 6). The overall male to female ratio for *E. diacanthus* was found to be 1 : 2.13. Females dominated in all size classes up to 50 cm and their percent varied from 67.1 to 75.0%, while males became dominant after 50 cm (Table. 2).

The sex ratios in different size classes was significantly different from expected ratio 1 : 1 (overall chi-square value = 8.67 at 5% level).

McIlwain *et al.* (2006) also recorded the dominance of females over males with an overall sex ratio of 1 : 2.3 male-to-female in specimens collected in Omani waters during 1999–2000. 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* by Chen *et al.* (1980) 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.

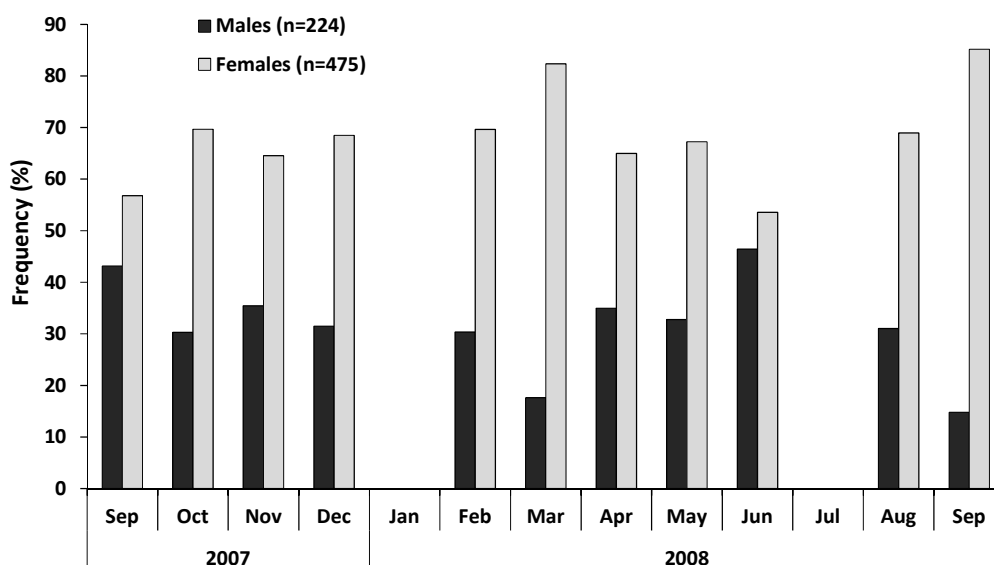


Figure 6. Monthly sex ratio of *E. diacanthus* during the trawl survey in the Arabian Sea in 2007–2008.

Table 2. Sex-ratio in different size groups of *E. diacanthus* in the Arabian Sea of Oman in 2007–2008.

Length class (cm)	No. of females	No. of males	Females (%)	Ratio F : M	Chi-square value
15–20	6	2	75.0	3.0 : 1	2.0
20–25	55	27	67.1	2.04 : 1	9.56
25–30	63	24	72.4	2.63 : 1	17.48
30–35	89	32	73.6	2.78 : 1	26.85
35–40	94	43	68.6	2.19 : 1	18.99
40–45	45	19	70.3	2.37 : 1	10.56
45–50	85	34	71.4	2.50 : 1	21.86
50–55	37	39	48.7	0.95 : 1	0.12
55–60	1	3	25.0	0.33 : 1	1.0
Total	475	223	68.1	2.13 : 1	8.67

Length-weight relationship

The parameters of the length-weight relationships for males, females and all measured fishes of *E. diacanthus* in the current study and from literature are given in Table 3. In the present study, the coefficient (b) was found as 3.0896 for all measured fishes, indicating a positive allometric growth.

The values of an exponent (b) for *E. diacanthus* reported by Premalatha (1989) and Manojkumar (2005) were 2.6117 and 2.82 respectively, which are notably less than the values determined in the present study. McIlwain *et al.* (2006) estimated the regression coefficient (b) as 2.938 for pooled sexes, indicating an isometric growth. The calculated weight at the same length between our and McIlwain *et al.* (2006) formula was very close, but ANCOVA test reveals significant differences in slopes of length-weight relationships at 5% level ($P > 0.05$). The slopes did not differ significantly between the sexes in our study, whereas McIlwain *et al.* (2006) found this significant difference.

Table 3. Parameters of the power equations in relationships between total length and total wet weight of *E. diacanthus*.

Region	Sex	<i>a</i>	<i>b</i>	<i>R</i> ²	Reference
India – Laccadive Sea	Females	0.0498	2.6117		Premalatha (1989)
Yemen – Arabian Sea	Pooled	0.0180	2.940		Edwards & Shaher (1991)
India – Malabar Coast	Males	0.00141	2.74		Manojkumar (2005)
	Females	0.00006	2.89		
	Pooled	0.00009	2.82		
Oman – Arabian Sea	Males	0.0159	2.968	0.93	McIlwain <i>et al.</i> (2006)
	Females	0.0199	2.898	0.95	
	Pooled	0.0176	2.938	0.93	
Oman – Arabian Sea	Males	0.0088	3.1162	0.993	Present study
	Females	0.0076	3.1589	0.990	
	Pooled	0.0097	3.0896	0.093	

Condition factor

The monthly mean condition factor (*Kn*) values ranged between 0.98 and 1.05. The data showed a major peak during April and minor peak during June (no survey was conducted in July) (Fig.7). Based on the available data, it is possible to assume that for *E. diacanthus* the more active feeding occurs in March–April before spawning season.

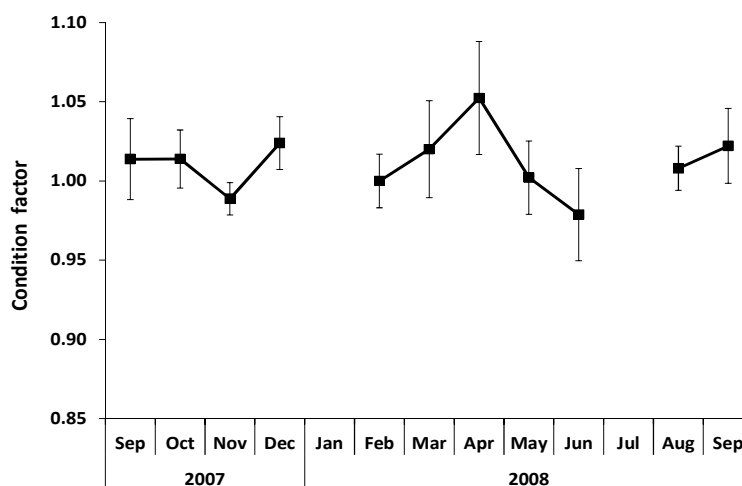


Figure 7. Monthly mean relative condition factor (with confidence limits) of female *E. diacanthus* in the Arabian Sea.

Spawning season

The monthly percentage occurrence of immature (Stage I), maturing (stage II) and ripe (stage III) testes of males and ovaries of females during 2007–2008 was studied to detect the spawning season for *E. diacanthus*. 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 (Fig. 8). The peak of the spawning was in May–June (data for July is absent) This concurs with the findings of McIlwain *et al.* (2006), who 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. Furthermore, Premalatha (1989) suggested spawning season of the spinycheek grouper in India as May–June, while Bapat *et al.* (1982) observed mature and spent adults at a northwest coast of India in September. According to Chen *et al.* (1980) in Taiwan *E. diacanthus* spawns during April–May.

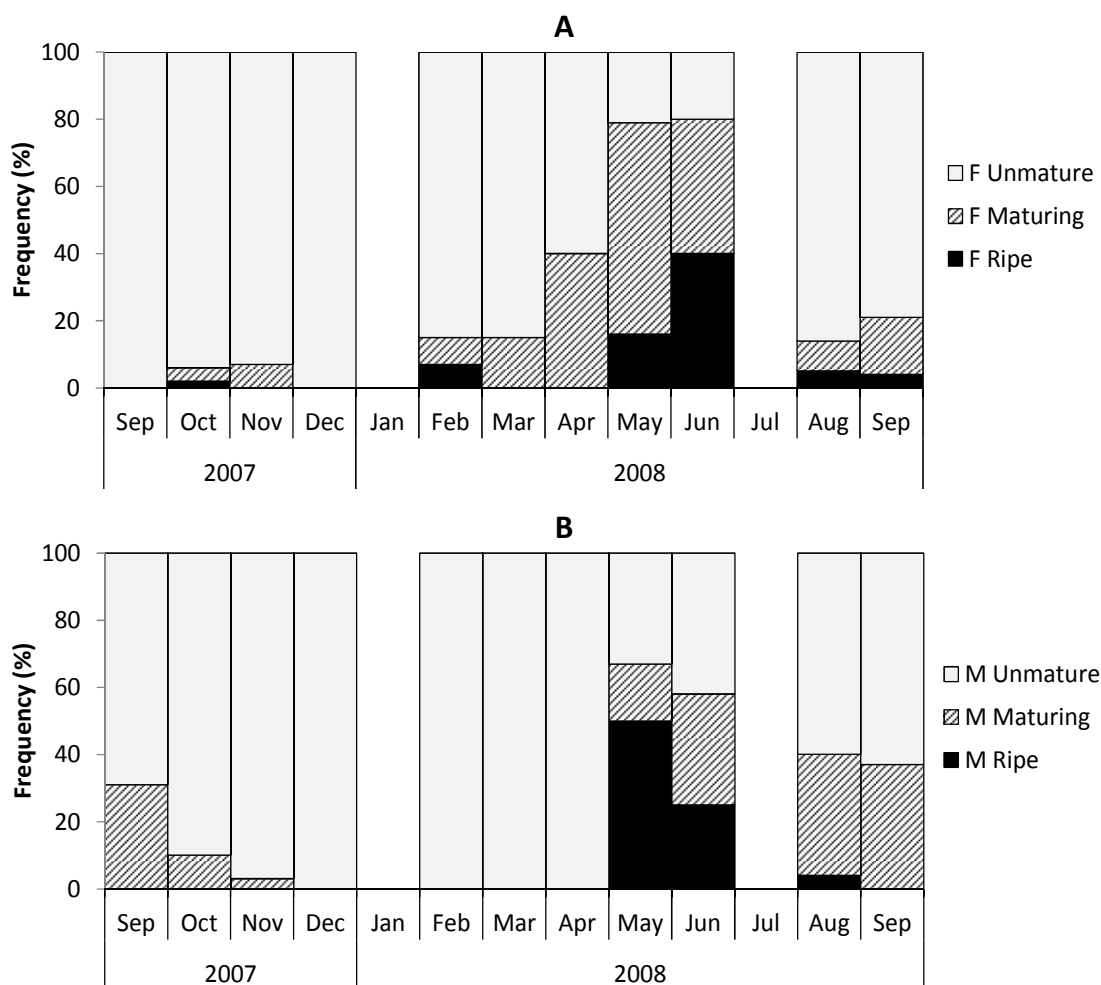


Figure 8. Frequency (%) of unimmature, maturing and ripe females (A) and males (B) of *E. diacanthus* in trawl catches in different months.

4. Conclusion

The results of the study have expanded knowledge about the biology of the spinycheek grouper in the Arabian Sea waters of Oman. *Epinephelus diacanthus*, according to present and previous (McIlwain *et al.* 2006) studies, was one of the most abundant demersal species occurred in all months of a year along the Arabian Sea coast of Oman.

Our finding of *E. diacanthus* in trawl catch from depth of 170–182 m extends information about vertical distribution of the species, which in available literature was reported as 160 m in waters of India (Silas 1969) and 110 m in Oman (Abdessalaam 1995). It is interesting to note that during the surveys were registered significant changes in the seasonal distribution of many fish species, particularly movement from inshore to deeper water, except the spinycheek grouper (McKoy *et al.* 2009). The low oxygen levels recorded in bottom waters during the spring intermonsoon period (April–June) at depths around 100 m and during the SW monsoon period (August–September) at depths >100 m throughout most of the survey area saw catches of the mostly species limited to the shallowest strata. However, *E. diacanthus* appears to be able to tolerate lower oxygen conditions and was taken regularly in the deeper strata on the surveys.

The maximum total length of *E. diacanthus* in the present study (58.1 cm) appeared to be the largest than previously known. However, mean size of the spinycheek grouper in trawl catches in Omani in 2007–2008 was smaller than in commercial catches here in 1999–2000 (McIlwain *et al.* 2006), and in Pakistan trawling ground in 1983 (Anon 1983) and in Yemen in 1985 (Edwards *et al.* 1991) that may be connected with fishing selectivity due to differences in trawl mesh sizes. The comparison of minimum lengths of *E. diacanthus* in commercial trawl catches with literature data on size-at-age testify that its recruitment occurs in the Arabian Sea in August–October, when the one-year-old fish enter the fishery.

In the present study, the abundance of females was more than twice greater than males, which is concurring to the data of McIlwain *et al.* (2006). Also, we observed a change in the sex ratios from females to

males, but at larger sizes than reported of McIlwain *et al.* (2006) and Chen *et al.* (1980).

The values of regression coefficients in length-weight relationships of *E. diacanthus* in different studies exhibit high variations that may be explained by differences in ecological condition of the habitats. Our results were more similar with data obtained by McIlwain *et al.* (2006), which is not surprising, because the investigated fish were from one area. Also, our results confirm the findings of McIlwain *et al.* (2006) about peak of spawning season of the species in Omani waters of the Arabian Sea in May–June.

Nevertheless, the current status of the spinycheek grouper, *E. diacanthus* stock cannot be estimated based on data of the trawl survey of 2007–2008. Government of Oman banned harmful operation of foreign industrial demersal trawlers from June 2011. Therefore, special studies of *E. diacanthus* from fish trap and gill net catches of traditional fishers are needed.

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References

- Abdessalaam, T.Z.S. (1995). Marine species of the Sultanate Oman: An identification guide. Ministry of Aquaculture and Fisheries, Marine Science and Fisheries Centre, Sultanate of Oman. Muscat Printing Press, 412 pp.
- Anon. (1983). Cruise report R/V "Dr. Fridtjof Nansen", Fisheries resources survey Iran, 23 Sept. – 1 Oct. 1983. UNDP/FAO Global Programme GLO/82/001.
- Anon. (2014). Fisheries statistics book 2013. General Directorate of Planning and Development. Fisheries Statistics Department. Ministry of Agriculture and Fisheries, Muscat, 246 pp.
- Bapat, S.V., Deshmukh, V.M., Krishnamoorthi, B., Muthiah, C., Kagwade, P.V., Ramamirtham, C.P., Mathew, K.J., Krishnapillal, S. and Mukundan, C. (1982). Fishery resources of the exclusive economic zone of the northwest coast of India. Bull. Cent. Mar. Fish. Res. Inst., 33, 1–81.
- Chakraborty, S.K. (1994). Age, growth, mortality and stock assessment of *Epinephelus diacanthus* (Valenciennes) from Bombay waters. Bulletin of the Cent. Mar. Fish. Res. Inst., 47, 130–133.
- Chakraborty, S.K. and Vidyasagar, K.D. (1996). Growth, mortality and stock assessment of two perches-moon tail bull's eye *Priacanthus hamrur* Perciformes / Priacanthidae) and thornycheek grouper *Epinephelus diacanthus* (Perciformes / Serranidae) from Bombay waters. Indian Journ. Mar. Sci., 25(4), 312–315.
- Chakraborty, S.K., Biradar, R.S., Jaiswar, A.K. and Palaniswamy, R. (2005). Population parameters of some commercially important fishery resources of Mumbai coast. Central Institute of Fisheries Education, Deemed University, Versova, Mumbai, 63 p.
- Chen, C.P., Hsieh, H.L. and Chang, K.H. (1980a). Age and growth of the grouper, *Epinephelus diacanthus* (Cuvier et Valenciennes) in the waters of northern Taiwan. Bulletin of the Institute of Zoology Academia Sinica, 19(1), 1–9.
- Chen, C.P., Hsieh, H.L. and Chang, K.H. (1980b). Some aspects of the sex change and reproductive biology of the grouper, *Epinephelus diacanthus* (Cuvier et Valenciennes). Bulletin of the Institute of Zoology Academia Sinica, 19(1), 11–17.
- De Bruin, G.H.P., Russel, B.C. and Bogusch, A. (1995). FAO Species Identification Field Guide for Fishery Purposes. The Marine Fishery Resources of Sri Lanka. FAO, Rome, 400 p.
- Edwards, R.R.C. and Shaher, S. (1991). The biometrics of marine fishes from the Gulf of Aden. Fishbyte, 9(2), 27–29.
- Edwards, R.R.C., Ghaddaf, A. and Shaher, S. (1991). The demersal fish stocks and the biometrics of fish on the P.D.R. Yemen shelf of the Gulf of Aden. UNESCO Project 703/PDY/40.
- Heemstra, P.C. and Randall, J.E. (1993). FAO species catalogue. Vol. 16. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. FAO Fisheries Synopsis. No. 125, Vol. 16. Rome, FAO, 382 p.
- James, P.S.B.R., Murthy, V.S.R. and Nammalvar, P. (1996). Groupers and snappers of India, biology and exploitation. In: Arreguin-Sanchez F., Munro, J.L. and Pauly, D. (Eds.), Biology of fishes and culture of tropical groupers and snappers. ICLARM, Conference Proceedings, 48, 106–135.
- Joseph, K.M., Sulochanan, P., John, M.E., Somavanshi, V.S., Nair, K.N.V. and Joseph, A. (1987). Demersal fishery resources of Wadge Bank. Bull. Fish. Surv. India, 12, 1–52.
- Manojkumar, P.P. (2005). Fishery of the spinycheek grouper, *Epinephelus diacanthus* (Valenciennes), off

- Calicut along the Malabar Coast. J. Mar. Biol. Assoc. India, 47(1), 63–69.
- McIlwain, J., Hermosa, G.V., Claereboudt, M., Al-Oufi, H.S., and Al-Awi, M. (2006). Spawning and reproductive patterns of six exploited finfish species from the Arabian Sea, Sultanate of Oman. J. App. Ichth., 22(2), 167–176. DOI: 10.1111/j.1439-0426.2006.00723.x.
- McKoy, J., Bagley, N., Gauthier, S., Devine, J. (2009). Fish resources assessment survey of the Arabian Sea coast of Oman. Technical Report. Ministry of Fish Wealth, Muscat, 77 pp.
- Mehanna, S.F., Al-Marzouqi, A. and Al-Siabi, B. (2013). Stock characteristics and population dynamics of the spiny cheek grouper *Epinephelus diacanthus* (Valenciennes, 1828) from the Arabian Sea, Oman. Turkish Journal of Fisheries and Aquatic Sciences, 13, 127–132. DOI: 10.4194/1303-2712-v13_1_16.
- Monkolprasit, S., Sontirat, S., Vimollohakarn S. and Songsirikul T. (1997). Checklist of Fishes in Thailand. Office of Environmental Policy and Planning, Bangkok, Thailand, 353 p.
- Ni, I.H. and Kwok, K.Y. (1999). Marine fish fauna in Hong Kong waters. Zool. Stud., 38(2), 130–152.
- Premalatha, P. (1989). Fishery and biology of rockcods (Order: Perciformes) from the southwest coast of India. Indian J. Fish., 36(4), 285–291.
- Rao, C.A. and Krishnan, L. (2009). Studies on the reproductive biology of the female spiny cheekgrouper, *Epinephelus diacanthus* (Valenciennes, 1828). Indian Journal of Fisheries, 56(2), 87–94.
- Sadovy, Y., Pollard, D., Russell, B. and Heemstra, P.C. (2008). *Epinephelus diacanthus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011. 2. <www.iucnredlist.org>.
- Silas, E.G. 1969. Exploratory fishing by R.V. Varuna. Bull. Cent. Mar. Fish. Res. Inst., 12, 53–66.
- Sivakami, S. and Seetha, P.K. 2006. Indiscriminate destruction of juveniles of spiny cheek grouper *Epinephelus diacanthus* (Valenciennes) off Quilon, Kerala. Journal of the Marine Biological Association of India, 48(1), 128–130.
- Sivaprakasam, T.E. 1986. A study of the demersal resources of the Wadge Bank and the Gulf of Mannar. Bull. Fish. Surv. India, 15, 1–37.
- Sluka, R.D. and Lazarus, S. (2010). Grouper (Pisces: Serranidae) relative abundance and diversity on the west coast of India. Marine Biodiversity Records, 3: e71 Cambridge University Press DOI:10.1017/S1755267210000606.
- Talwar, P.K. and Kacker, R.K. (1984). Commercial fishes of India, Culcutta, 997 pp.
- Zacharia, P.U., Gupta, A.C. and Mahadevaswamy, H.S. (1995). Exploitation of juveniles of the spinycheek grouper, *Epinephelus diacanthus* by the multi-day trawlers along Dakshina Kannada coast. Marine Fisheries Information Services, Technical and Extension Series, 139, 5–8.

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