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Population structure and length-weight relationship of *Epinephelus diacanthus* from Ponnani, South India

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Abstract

Groupers in addition to their importance to local economies, are apex predators thought to play important roles in ecosystem function. Ponnani in South West coast of India, has been a good landing centre for a particular species of grouper, *Epinephelus diacanthus*. However, of late the mean length of individual landed has shown a drastic reduction. Most of the fishes caught are either juveniles or sub adults. This paper elucidates the population structure of *E. diacanthus* through length-weight relationship analysis of the fish landings. Results emerging from the present study indicate the dismal condition of the Spinycheek grouper stock along the South Western coast of India. The study also suggests that unless stringent management measures are not implemented to restrict overexploitation of this species, it is likely that the species that has been categorized a 'Near Threatened' under IUCN Red list would soon become 'Endangered'. Being an apex predator in the demersal food web, depletion of stock of *E. diacanthus*, would alter the ecological health.

Keywords: *Epinephelus diacanthus*, juvenile, Ponnani

1. Introduction

Marine biodiversity worldwide is under increasing threat, primarily as a result of overfishing, climate change and habitat destruction. Fishes are more vulnerable owing to the changing fishing patterns, over capacity of fleet in fisheries, use of fishing techniques that harm the environment and fish stocks, excessive quantities of unwanted bycatch, poor control over fishing activities, including illegal fishing and most importantly excessive juvenile fishing. This has become more conspicuous since many fishes are caught before it attains the length at first maturity. The fishes of the subfamily Epinephelinae belonging to the family Serranidae, popularly known as groupers or rock cods constitute an important component of demersal fishery resources of India. On an average, they form 2% of total marine landings in India [7]. They inhabit rocky grounds and coral reef areas along Kerala, Tamil Nadu, Gulf of Mannar, Gulf of Kutch, off Paradeep, and Andaman seas. Off Kerala, the area between 8-13N latitude at depth 60-150 where the bottom is uneven with rock out crops and coralline areas are rich in rock cods and hence are known as "Kalava grounds" [13]. Major species of seranids caught off Kerala are *Epinephelus diacanthus*, *E. malabaricus*, *E. tauvina*, *E. chlorostigma*, *E. bleekeri* [7]. In many fish stocks, high fishing pressure has also led to a marked shift in age structure. In extreme cases especially in groupers the shift is towards younger size class which has resulted in very few reaching spawning age.

Over exploitation and juvenile fishing by using trawl net causes decline in the grouper population. Once over fished, many grouper populations would take several decades to recover. Removal of these large predators can elicit trophic cascades and destabilizes the relative abundance of smaller species. Predator depletions can lead to permanent shifts in marine communities and alternate equilibrium states [8]. The current rate of grouper global exploitation and mortality is arguably so high under current management regimes that unless a renewed initiative is undertaken some species of grouper will become effectively extinct. The collapse and decline of large marine predators can create shifts in biological communities that result in systemic biodiversity losses [4]. Given the vulnerability of some groupers to even modest fishing efforts (due to slow growth rates, late maturity, low fecundity, long life spans, and the close relationship between the number of young produced and biomass), potential recovery of grouper populations to overharvesting would take decades and human decisions regarding groupers are a crucial element of marine-related social science [9].

Epinephelus diacanthus [11] is an important species, which constitutes nearly 90% of the groupers, landed along this region [5]. Earlier studies have clearly shown the over exploitation of this species from the South West coast of India [13] and a large number of juveniles of this species has been encountered as bycatch [10, 18]. Ponnani is a major traditional fish landing centre in Kerala. The total marine fish landings is about 25,000 t per year, of which 10000 t is caught by the mechanised vessels including trawlers and the rest by motorized and non-motorised traditional fishing crafts. Ponnani is one of the landing centres in Kerala where there is continuous landing of *E. diacanthus*. An attempt is made to elucidate the length-weight relationship *E. diacanthus* caught off Ponnani coast with a view to identify the fishing pressure on these economically important fishes.

2. Materials and Methods

Epinephelus diacanthus landed in Ponnani harbour were collected based on random sampling on a monthly basis from August to May. Data on total fish caught and location of the fishing operation was also recorded from the fishermen. Individual length (TL) was measured to nearest cm and total weight to nearest gm of fish were recorded. Around 25 randomly *E. diacanthus* were preserved in ice and transported to MES Ponnani College for assessing the maturity stage. The data on length was grouped into 40 mm class intervals and the raised monthly frequency distribution was used for the growth studies [12]. The relationship between length and weight was determined for pooled data by transforming the values of both variables to logarithmic values and fitting a straight line by the method of least squares. The significance of regression was tested by ANOVA. The regression coefficients for male and female were compared by analysis of covariance (ANACOVA) [15] to establish the variations in the 'b' values, if any, between them. Bailey's t-test [15] was employed to find out whether 'b' value significantly deviated from the expected cube value of 3

$$[t = (b-3)/Sb],$$

Where b = regression coefficient and Sb= Standard error of 'b'. The t-test [15] on 'r' values reveals whether a significant correlation exists between length and weight. The total lengths of the previous ages were back-calculated using Lee's equation. The back-calculated lengths were applied to a Ford and Walford plot to estimate the von Bertalanffy growth parameters (L_{∞} and K).

3. Results and Discussion

Figure 1, The average length class of *Epinephelus diacanthus* collected from Ponnani harbour is shown in Figure. Results clearly indicated that the minimum length class observed in the present was 4.1-8.0 cm and the maximum was 24.1-28.0 cm. These values were comparatively low against previous reports from Western coast of India which have reported value up to 55 cm. In that respect, the fish group caught from Ponnani could be considered as juveniles or sub adults. Maximum represented class interval was 16.1-20.0 cm indicating that most of fish landed in Ponnani have not attained their length at first maturity. The results indicate that the length at first capture was smaller than length at first maturity for this species as recorded in Fish base (28.1 cm TL).

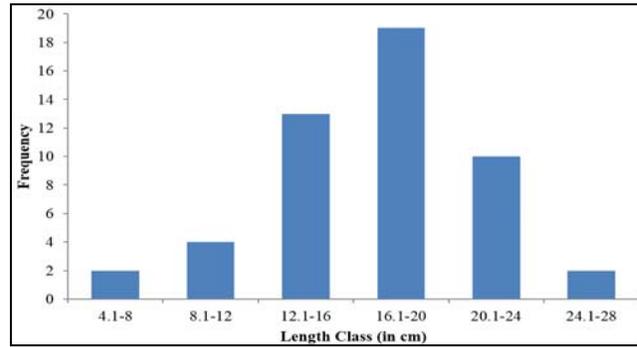


Fig 1: Average length class of *E. diacanthus* landing at Ponnani

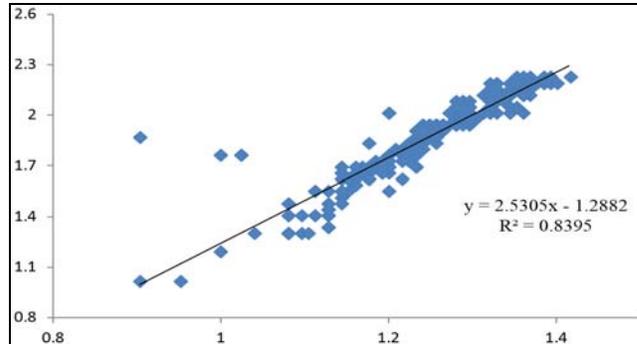


Fig 2: Total length-Weight relationship for *Epinephelus diacanthus*

Result of regression analysis between the total length and weight of all fishes pooled together during the study period is depicted in Figure 2. The length weight relation was estimated as

$$\text{Log W} = -1.288 + 2.53 \text{ Log L} \quad (r=0.9162)$$

Results indicate strong correlation between the two variables with high r value of 0.9162 (Table 1). From the length-weight relationship estimated in the present study, the calculated weight of the juvenile *E. diacanthus* of mean size of 20 cm was estimated at 100.83 gm. Although this value is greater than that recorded by Sivakami and Seetha (2006) [14], compared to the maximum weight this species could attain the value are much lower. Chakraborty (1994) [2] had estimated a growth of 229 mm for the same period from Bombay. Tessa (1994) had observed that *E. diacanthus* in the size group of 231-250 mm had 43% of the individuals in the transitional stage. Therefore, applying the pooled fit of length-weight relationship for males and females of $\text{Log W} = -4.03 + 2.82 \text{ Log L}$ [5] for the species off Malabar coast, the calculated weight of the fish at 244 mm (TL) is 504 g. Hence the present finding clearly indicates that the *E. diacanthus* caught from Ponnani coast is predominantly undersized individuals.

Table 1: Result of Regression Analysis

Regression Statistics	
Multiple R	0.916223
R Square	0.839464
Adjusted R Square	0.838992
Standard Error	0.094014
Observations	342

On further analysis to delineate the significance among the two parameters one-way ANOVA was employed. Results indicate significant ($P < 0.001$) different in the regression coefficient of length and weight. Following this the regression coefficient of the pooled data was tested using Analysis of Co-Variance (ANACOVA) with a view to find out the 'b' value. Results of this stage of analysis are provided in Table 3.

Table 2: Result of one-way ANOVA on length-weight data of *E. diacanthus*

	df	SS	MS	F
Regression	1	15.71420785	15.71421	1777.91**
Residual	340	3.005116759	0.008839	
Total	341	18.71932461		

Table 3: Results on ANACOVA on Regression coefficient of length weight of *E. diacanthus*

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.28817	0.074896701	-17.1994	3.85E-48
log L	2.530493	0.060013671	42.16528	4.2E-137

From the results of ANACOVA the 'b' value calculated was 2.53 ± 0.06 . Subsequently Bailey's t-test was employed to see whether significant the 'b' value had significantly varied from the value 3. Results showed that a t value of -7.823 was calculated, which was higher than the table value. This indicates that the growth pattern of *Epinephelus diacanthus* landing at Ponnani is following an allometric growth pattern. While correlating the earlier results of length class and regression analysis, it could fairly be observed that the stock forming fishing at Ponnani is rather young. This is characterised by allometric growth pattern as well as smaller length groups.

The average total catch registered per month during the study period was 12.38t. During most months of observation this group landed as bycatch and their percentage of occurrence ranged between 6% to 23% in different boats. Thus, it may be concluded that an estimated biomass of 148.56t of fish could have been obtained at the end of the 1st year if the harvested fish were allowed to grow for one year. The von Bertalanffy Growth (VBG) model could not be constructed in the present study since almost all the catch represented a narrow size range. However, with the existing data it was calculated that the L_{∞} for *E. diacanthus* landing in Ponnani is 36.0 and the K value was 0.81. Manoj Kumar (2005) [15] using VBG formula, had estimated a growth of 244 mm during the first year of its life span off Calicut along Malabar Coast.

Table 4: Growth parameters (L_{∞} and K) of *Epinephelus diacanthus* based on historical data from different localities

Locality	L_{∞}	K	Authors
Bombay, India	57.0	0.21	Chakraborty, 1994
Bombay, India	55.8	0.60	Chakraborty <i>et al.</i> , 2005
Calicut, India	51.2	0.65	Manojkumar, 2005
Ponnani, India	36.0	0.81	Present study

While comparing the growth parameters of this species reported by earlier authors from the West coast of the country, it was clearly evident that the length size represented in Ponnani is small and could be considered as juveniles or sub adults. This was confirmed by the VBG and K values. Lower L_{∞} and higher K value shows that this is a fast growing population and hence could be confirmed to be fishes in their early life stage. Alarmingly it is more evident that during the

past 20 years the fish population of this species is continuously shrinking and is represented by low length class fishes (Table 4).

Rao and Krishnan (2007) while studying the maturation pattern of gonads of *Epinephelus diacanthus* recorded that fishes collected from Quilon and Ratnagiri. His observations showed that transition of sex occurred in smaller fishes off Quilon ($TL = 28.1 \pm 0.51$ cm) when compared to the fishes collected off Ratnagiri ($TL = 30.5 \pm 0.74$ cm). This indicate that a protogynous fish such as *E. diacanthus* convert from female to male at 28.1-30.5 cm length. In the present study however, the maximum sized fish encountered was of 25.4 cm. This means that majority of fish caught from Ponnani could not attain the length class appropriate for sex transition. Since the number of males in the population declined considerably due to recruitment overfishing the cause of decline in stock of *Epinephelus* is justified.

Silas (1969) [13] while reporting the capture of juveniles of *E. diacanthus* to the tune of 10 kg (average length of 21.8cm) in experimental trawling conducted off $9^{\circ}33'N- 75^{\circ} 41'E$ had emphasized the need to study the behaviour of Kalava. According to Zacharia *et al.* (1995) [18], since the juveniles of *E. diacanthus* are caught from 30-60 m depth, the young ones abound in the muddy bottom for feeding purpose and stay in fishing ground for 8 months after which they migrate to deeper waters for further growth and breeding. Castro and Huber (2000) [1] opined that groupers being reef fishes have a complex life history consisting of a planktonic larval and benthic juvenile and adult stage. While the planktonic larvae drift with the current, the juveniles settle in shallow areas where they find hiding places and as they increase in size they move to deeper waters [17]. The present study shows a fairly good population of *Epinephelus diacanthus* off Ponnani, similar to those reported elsewhere along South West coast of India. The large number of juveniles of this species landing in Ponnani indicates the region to be good nursery ground for *E. diacanthus*. In the present case, it is possible that the juveniles of *E. diacanthus* were caught accidentally in trawlers from their nursery ground during their settlement phase in the muddy bottom.

Groupers are of great economic importance in tropical and temperate fisheries [6]. However, biological characteristics such as slow growth, late age of maturity, protogynous hermaphroditism and aggregating behaviour make them vulnerable to overfishing. Because of the unique life history pattern, conventional management methods are unsuitable to protect these species. Results emerging from the present study suggest that the grouper catch in the Western coast of India showed a decreasing trend in the last twenty years and some serranid species have become rare in fishery (as reported by earlier authors).

4. Conclusion

The results proved that the stock of *E. diacanthus* from Arabian Sea was overexploited and may not be reproductively resilient enough to recover from declined populations. Being protogynous hermaphrodite in nature, *E. diacanthus* matures as females and later transforms to males through sex reversal when the individual is 4-5 years old. Since most of the fishes were still under this age, the chance for such sex transformation was denied due to exploitation of stock in Ponnani. This was clearly evident with the fact that most of the fish caught were either sub adults or females. For its management, the current exploitation rate must be reduced to

maintain a sufficient spawning biomass as well as the length at first capture should be raised to about 30 cm to give each fish the chance to reproduce at least once in its life span. Also, there is a need to identify and protect the nursery grounds through establishing Marine Protected Areas (MPAs). Besides, it is of great importance to improve the fishery statistics recording system to involve the catch by species especially for those species that have greater economic importance.

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