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Observations on the biology of smooth dwarf monocle bream, *Parascolopsis aspinosa* (Rao & Rao, 1981) from Mangaluru, southwest coast of India

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Original Article

Abstract

Some aspects of biological information is presented here for the little known smooth dwarf monocle bream, *Parascolopsis aspinosa* (Rao and Rao, 1981) (Perciformes: Nemipteridae) based on specimens collected from the bycatch of commercial shrimp trawlers operating in the Arabian Sea off the Karnataka coast. Eight-hundred forty seven specimens measuring 7.4 to 22.8 cm TL, and weighing between 15.0 -216 g total weight were analysed for the study. The length-weight relationships were found to be significantly different between the sexes ($P<0.001$). The coefficients '*a*', '*b*' of the length-weight relationship were estimated as 0.0333, 2.7919 ($r^2= 0.961$) for females and 0.0194, 2.9791 ($r^2= 0.962$) for males and the species follows a negative allometric growth pattern ($b<3$). The fish attains maturity (TL_{50}) at 12.5 cm TL for females and 11.5 cm TL for males. *P. aspinosa* was found to breed throughout the year with peak spawning during August-September and January. The overall sex ratio (M:F) favoured females at the rate of 1:1.15. A seven-stage maturity was found and a progressive increase in the size of the ova was traced to advanced stages of maturity. The total fecundity of *P. aspinosa* ranged from 45,823 (12.3 cm TL; 41g body weight) to 1,56,308 (22.8 cm TL; 216 g body weight) with an average fecundity of 84,367 eggs. Analysis of the stomach contents (%IRI) revealed that *P. aspinosa* mainly fed on *Saurida tumbil* (%IRI=18.2), followed by *Penaeus indicus* (%IRI=16.7), *Loligo* spp. (%IRI=15.2), Squilla (%IRI=6.4), and *Acetes* spp (%IRI=2.7). Other detailed biological observations such as the length composition, sex ratio, and length at maturity (TL_{50}) of *P. aspinosa* are also provided in the study. Since the species has been poorly studied and assessed as Least Concern (LC) in the IUCN red list criterion, it is expected that the biological information from the present study will support the ongoing data generation and help in arriving at management decisions for the species in the future.

Keywords*: Nemipteridae, Smooth dwarf monocle bream, diet, length-weight relationship, length at maturity, fecundity*

Introduction

Karnataka state along the eastern Arabian Sea of the southwest coast of India is very progressive in terms of adopting new fishing methods and now stands third in terms of all Indian marine fish production (CMFRI, 2017). Trawl fishing which is the mainstay of the states marine landing is now predominantly carried out beyond the shelf waters (Dineshbabu *et al*., 2017). As a consequence, demersal resources became the vital component in the marine fish catches in Karnataka with an estimate of 1,85,547 tonnes (t) forming 35% of the total catch (CMFRI, 2017).

Among demersals, threadfin breams belonging to the family Nemipteridae has emerged as one of the important resource after mackerel and oil sardine in the State (CMFRI annual report, 2017-18). The family Nemipteridae comprise 5 genera and 67 species of tropical and sub-tropical Indo-West Pacific nemipterids (Russell, 1990) and *Parascolopsis* (monocle breams) is one among the five genera under this family. The genus can be identified from other nemipterids by the posterior margin of sub-orbital spine weak or absent; no canine teeth on jaws; 4-6 transverse scales on preopercle; second anal spine longer and robust than third spine.

Parascolopsis aspinosa (Rao and Rao, 1981) or Smooth dwarf monocle is one of the important species among the genus *Parascolopis* and is occasionally found along with the landing of threadfin breams by multi-day trawlers, though, in very small quantities. Nemipterids are locally known as "madhumal" in Karnataka. *P. aspinosa* can be distinguished from other *Parascolopsis* species with a black blotch between 7-10 spines, posterior margin of suborbital smooth or few tiny spines. *P. aspinosa* occurs in the deeper shelf to continental waters, at depths between 20-410 m (and up to 500 m), in the Indo-West Pacific (from Persian Sea and Arabian Gulf to Australia and Japan) (Russell and Golani, 1993). The fish is reported from the Indian Ocean including the Persian Gulf; Gulf of Oman, Gulf of Aden, Arabian Sea, Bay of Bengal and the Andaman Sea. Though no major fishery exists for any species of *Parascolopsis*, small catches are taken off the southwest coast of India from trawlers (Radhika pers. observ.). Several studies have been carried out to understand the biology and life-history traits of nemipterid fishes (Zacharia and Nataraja, 2003; Manojkumar, 2004; Joshi, 2005; Kerdgari *et al.*, 2009; Nettely *et al.,* 2016), whereas the only study available on biology of any species of *Parascolopsis* from Indian waters is of Naik (2000) from Goan waters. Other than this work no information is available on fishery or any aspects of the biology of the species from other parts of the country because of the erratic and low volume of landings.

The present investigation, therefore, is aimed to provide preliminary information of *P. aspinosa* on its life history traits such as length composition, length-weight relationship, reproduction and spawning, and diet characteristics based on specimens collected from commercial trawlers operating along the Mangaluru coast, southwest coast of India, off the north eastern Arabian Sea.

Material and methods

A total of 827 specimens (females, 443; males, 384) were collected from trawl net landings at Mangaluru (12° 51′ 10.8′′ N, 74° 49′ 58.8′′ E) fisheries harbour in Karnataka coast (Fig.1) during August 2017 to May 2018. The fishing operations were done in depth range between 30 and 200 m off the eastern Arabian Sea. The fishes were preserved in ice and brought to the laboratory in plastic boxes. The total length (TL) of each specimen was measured to the nearest mm, and the total body weight (TW) to the nearest g and its sex was recorded. The gonads were weighed to nearest 0.001g using a digital balance. The length frequency distributions for each sex were tested to see if data conformed to a normal distribution using Shapiro-Wilk test (Shapiro and Wilk, 1965). Dependent on whether the data were distributed normally or not, inter-gender size differences were then investigated using a two-tailed *t*-test, to ascertain any sex-based differences in landings. Length frequency distribution of females and males was compared using the ms (Chi-square symbol χ^2) test with the length distribution divided into 1.0 cm length class intervals of TL (Cochran, 1952). Sex-ratio was analysed by Chi-square (χ^2) test to determine for any significant deviation from 1:1 (Snedecor and Cochran, 1967). The parameters '*a*' and '*b*' of the length-weight relationships were estimated using the equation proposed by Le Cren (1951): $W = a * L^b$. After logarithmic transformation of the length and weight data, this equation may be expressed as: log TW= log *a*+ *b* * log TL, where TW is the weight of the fish in g and TL is the total length of the fish in cm; '*a*' is the intercept of the regression curve (coefficient related to body form) and '*b*' is the regression coefficient (exponent indicating isometric growth; Froese, 2006). The confidence and prediction intervals were calculated for the length and weight of the fish in the LWR using the following formulae: the confidence interval for the mean response when predictor is x^* is $\hat{y} \pm t^* S\epsilon \sqrt{1/n + (x^* - x)^2 / (n-1)s_x^2}$ and the prediction interval for an individual response when the predictor is x^* is $\hat{y} \pm t^* S\epsilon \sqrt{1 + 1/n + (x^* - x)^2 / (n-1)s^2x}$

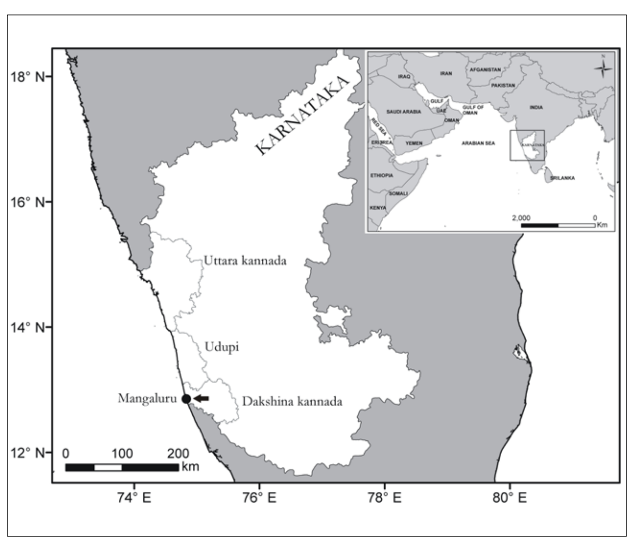

Fig. 1. Map showing Mangaluru fish landing centre, Karnataka, the location from where *P. aspinosa* was collected.

(Montgomery *et al*., 2012). The male and female length-weight relationship was tested for significant difference using the extra sum of squares method involving full and reduced regression models for testing the common slope (parallel lines), while the *F*-statistic was computed to test the difference between the two slopes (Montgomery *et al*., 2012).

Maturity stages in females were classified based on the macroscopic appearance of the ovary following ICES scale (Lovern and Wood, 1937) with appropriate modifications, and microscopic characteristics of ova preserved in 10% neutral buffered formalin. For studying the growth of ova, 600 intra-ovarian egg diameter were measured by taking out small pieces of ovaries from the anterior, middle and posterior regions and the ova teased out on to a glass slide. Intra-ovarian egg diameter was measured by calibrated ocular micrometer with a magnification of 0.016 mm to each ocular micrometer division (O.M.D), which was mounted on the eyepiece of a compound microscope.

Spawning periodicity was estimated from the percentage occurrence of mature ovaries and gonadosomatic index (GSI) during the study period. Individuals with stage III and above were considered as mature. GSI value was calculated following Ellis and Shackley (1997) and tested for statistical significance following Snedecor and Cochran (1967). Fecundity of the fish and correlation analysis for fecundity and total length, body weight and gonad weight of *P. aspinosa* were estimated following Manojkumar (2004).

The TL_{50} for females and males were derived from the following logistic regression, where the proportion, pL, of the fishes that were mature at TL was calculated as: $pL = \{1 + e^{[-\ln(19)(TL - TL_{50})(TL_{95} - TL_{50})]-1}\}^{-1}$, where TL_{50} and TL_{95} are constants and 'ln' is the natural logarithm. Maximum likelihood estimates of the parameters were obtained using the routine SOLVER in Microsoft™ Excel and by calculating the likelihood of immature and mature individuals as 1pL and pL, respectively. The reported estimates of the parameters were determined as the median values derived from 200 sets of randomly re-sampled data, with the same sample size, drawn from the data on the observed maturity status at TL for female and male fishes. The 95% confidence interval was estimated as 2·5 and 97·5 percentiles of the 200 estimates resulting from these re-sampled data (Wood, 2004; White, 2007, Purushottama *et al*., 2017).

Feeding intensity in various months was analysed for determining the feeding periodicity following Manojkumar *et al.* (2015) with some modifications. The data on food and feeding habits were combined since no difference was noticed between sexes. The empty stomach ratio (ESR) was also analysed following Rohit *et al.* (2015).

Based on three indices such as percentage of the wet weight of each food item to the total wet weight of all food items identified (%W), percentage of the number of each food item to the total number of all food items identified (%N), and frequency of occurrence of each food item in the total number of stomachs examined (%F) the relative importance of each prey items were identified using Index of relative importance IRI = (%*N* +%*w*) * %*O* (Pinkas *et al*., 1971; Zacharia and Abdurahiman, 2004). The IRI was expressed as %IRI to allow for a comparison of the values between the prey groups (Cortes, 1997).

Results and discussion

The present study provides essential information on the reproductive biology, length at maturity, length-weight relationship and diet of the sparsely studied smooth dwarf monocle bream, *P. aspinosa* found in the Arabian Sea. Commercial trawlers land smooth dwarf monocles as bycatch along Mangaluru, Karnataka region throughout the year, except during the southwest monsoon when no fishing takes place due to rough weather and uniform fishing ban on mechanized gears.

Out of the 827 specimens collected for the study, females constituted 53.6% (*n*=443) and males 46.4% (*n*=384) with an overall sex-ratio (Male: Female) of 1:1.15. The TL range of females of *P. aspinosa* was 7.4 -22.6 cm TL (mean±S.E =17±0.14 cm) with weight range of 15.4 -216 g (mean±S.E =98.0±2.3 g). Males ranged from 7.5 -22.8 cm TL (mean±S.E =16.5± 0.14 cm) and weight ranged from 15 -211 g (mean±S.E =89.0± 2.30 g) (Fig. 2). 65 unsexed specimens ranged from 11.1-30.8 cm TL (mean±S.E =21.0+ 0.6 cm) and weight ranged 29.0 -500 g (mean±S.E =200+ 15.2 g) was recorded in landing centre. Females were dominant throughout the study period except during November, December, March and April. Results indicated a significant difference (χ^2-test, P<0·05) in overall sex-ratio from the normal 1:1, whereas, month-wise sex ratio recorded as non-significant (P>0·05) except during September and

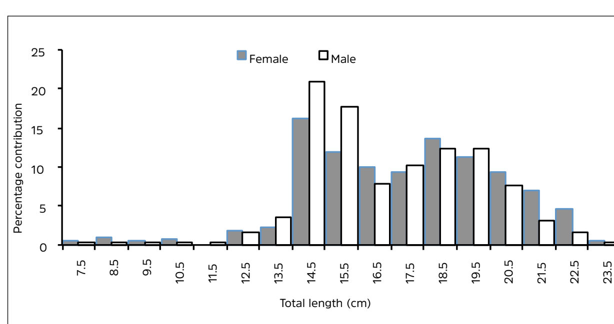

Fig. 2. Total length (TL)- frequency histogram of *P. aspinosa* [Female (■), n = 443; males (□), n =384] studied.

October. It can therefore be inferred that there is no seasonal dominance of a particular sex in *P. aspinosa* occurring in the southwest coast of India. There was also a significant ($P<0{\cdot}05$) dominance of females in larger length groups above 18.5 cm TL, (Table 1 and 2) most due to the migration and differences in growth and behaviour (Nettely *et al.*, 2016). Though *P. aspinosa* is rare in the fishery along the west and east coast of India, its documentation is limited and mostly unreported from many regions. The size range of *P. aspinosa* observed in the trawl net fishery of the Karnataka waters (7.4.0 -30.8 cm TL) differed from those reported from other regions. Naik (2000) examined 511 specimens of both sexes (9.0 -20.5 cm TL, female=272, male=239) in the Goa waters. Karuppasamy *et al.* (2008) observed 5 specimens of both sexes (16.0-18.0 cm TL) in the eastern Arabian Sea at 120 m depth. Mohapatra *et al.* (2013) and Kannan *et al.* (2013) recorded specimens measuring 10.2 cm SL and 14.3 cm TL, respectively from east coast of India. Furthermore, the present study has recorded the largest TL for *P. aspinosa* (30.8 cm TL) to date.

Table 1. Length-wise Chi-square ($\chi 2$) test of sex- ratio of *P. aspinosa* occurring in the coastal waters of Mangaluru, southwest coast of India.

Length-wise Cm (TL)	No. of fish			Sex- ratio (M:F)	χ2
	Total	Male (M)	Female (F)		
6.5 –8.5	8	2	6	1:3.00	2.00
8.5 –10.5	7	2	5	1:2.50	1.29
10.5 –12.5	21	10	11	1:1.10	0.05
12.5 –14.5	243	135	108	1:0.80	3.00
14.5 –16.5	159	74	85	1:1.15	0.76
16.5 –18.5	210	97	113	1:1.17	1.22
18.5 –20.5	129	51	78	1:1.53	5.651*
20.5 –22.5	50	13	37	1:2.85	11.52*
Pooled	827	384	443	1:1.15	4.209*

*significant differences at $P<0.05$

Table 2. Monthly Chi-square ($\chi 2$) test for sex- ratio of *P. aspinosa*

Month	Total	Male (M)		Female (F)		Sex- ratio (M:F)	χ2	P
		n	%	n	%			
August 2017	127	54	42.52	73	57.48	1:1.14	2.843	0.09
September	86	32	37.21	54	62.8	1:1.17	5.628	0.02*
October	97	36	37.11	61	62.9	1:1.17	6.443	0.01*
November	72	39	54.2	33	45.83	1:0.8	0.5	0.48
December	65	38	58.46	27	41.54	1:0.7	1.862	0.17
January 2018	79	33	41.8	46	58.23	1:1.14	2.139	0.14
February	93	41	44.1	52	55.91	1:1.3	1.301	0.25
March	69	37	53.62	32	46.4	1:0.9	0.362	0.55
April	76	45	59.21	31	40.8	1:0.7	2.579	0.11
May	63	29	46.03	34	53.97	1:1.2	0.397	0.53
Total	827	384	100	443	100	1:1.15	4.209	0.04*

The weight of *P. aspinosa* ranged between 15.4 to 216 g in females and between 15.0 to 211 g in males. The equations relating to total length (TL) and weight (TW) consisting of 443 females (7.4 -22.6 cm TL) and 384 males (7.5 -22.8 cm TL) are presented below, thus enabling an approximate weight of the smooth dwarf monocle bream to be estimated from a given total length (Fig. 3a, b). The slopes were found to be significantly different between the sexes ($P<0.001$). The estimated LWR parameters along with the descriptive statistics are given in Table 3.

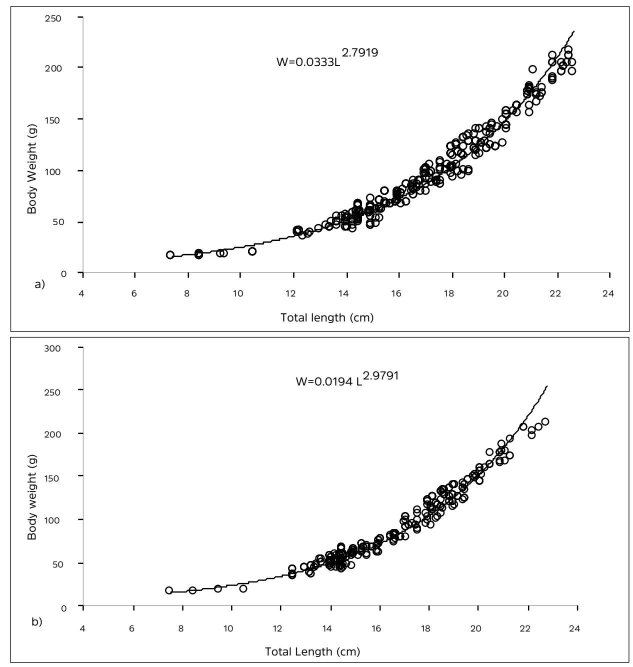

Fig. 3. Length-weight relationship of *P. aspinosa* in the coastal waters of Mangaluru, southwest coast of India. (a) female (b) male.

The parabolic and logarithmic equation for length-weight relationship established for *P. aspinosa* as follows,

Male: $\text{Log } W = \text{Log } 0.0194 + 2.9791 \text{ Log } L (W=0.0194\, L^{2.9791})$

Female: $\text{Log } W = \text{Log } 0.0333 + 2.7919 \text{ Log } L \ (W = 0.0333\, L^{2.7919})$

The value of "*b*" in the length-weight relationship will be "3", if the growth is isometric (Ricker, 1975; Sossoukpe *et al.*, 2013). This cube law relationship is rarely expected, as most of the species change their shape (Hile, 1936). These changes are due to sex, maturity, season and even the time of day due to stomach content (Bagenal, 1978). *P. aspinosa* in the present investigation exhibits a negative allometric growth pattern (ANCOVA, $p<0.05$ and 0.01) at 95% confidence interval, which implies that the fish grows faster in length than in

Table 3. Length-Weight Relationships of *P. aspinosa* in the coastal waters of Mangalore, south west coast of India.

Sex	N	TL range (cm)	BW range (g)	Regression Parameters						Student's t-test		ANCOVA
				a	95% CL of a	b	95% CL of b	SE (b)	r^2	t-stat (b)	p-value	F-stat (b) / p-value
M	384	7.5 - 22.8	15.0-211	0.019	0.018-0.020	2.97	2.83-3.12	0.033	0.96	91.2	3.5E-235**	
F	443	7.4 - 22.6	15.4-216	0.033	0.013-0.035	2.79	2.65-2.93	0.028	0.96	100.2	2.1E-287**	17.9 / 0**
C	827	7.4 - 22.8	15.0-211	0.027	0.026-0.028	2.86	2.71-2.99	0.022	0.96	131	0**	

N, sample size; M, male; F, female; C, combined sex; TL, total lengths in cm; BW, body weight in g; a and b, parameters of length weight relationship; CL, confidence limits; SE (b), standard error of slope b; r^2, coefficient determination; t-stat(b), t-statistic of b; ANCOVA, analysis of covariance; F-stat(b), F-statistic of b; p-value, probability level.
*p< 0.05; **p< 0.01.

fish body weight. There is no degrees of departure found in slope values (*t*-statistic, p>0.05 and 0.01) of both sexes. Naik (2000) reported the coefficients "*a*", "*b*" of the length-weight relationship as 0.017419193, 2.973939837 (r^2= 0.975) for females and 0.022494394, 2.872986425 (r^2= 0.966) for males. The "*b*" values found by this author were almost in agreement with the present investigation.

The average Kn values of each size groups of both the sexes remained low in smaller size classes ranging from 6.5 -7.5 to 9.5 -10.5 cm TL for male and up to 10.5 to 11.5 cm TL for females. Thereafter a slight difference in condition of fish has been observed in 10.5 -11.5 cm TL size class (0.9957) in case of male, whereas, the Kn values increased progressively up to size class 21.5-22.5 cm TL size class (1.059). Naik (2000) also reported similar results for (Kn) values among males which ranged from 0.97457 to 1.14932 in males 0.977624 to 1.0616812 in females. Highest Kn values were recorded for males of 19.0-19.9 cm TL length class. In most of the sizes, the males had higher Kn values than females. The values of Kn decreased from smaller to larger fishes of about 130-139 mm size class, whereas the Kn values increased as they grew further. This trend was noticed up to the biggest size recorded.

Under microscopic observation of ova, seven stages of maturity could be identified. In stage I, the size of the ova ranged from 0.064 mm to 0.144 mm (mode of 4 OMD; 0.064 mm) which shifted to 0.064 to 0.096 mm in stage II with a maximum size of the ova at 10 OMD (0.160 mm). During progressive maturation of gonads to stage III (0.24 mm to 0.304 mm), opaque ova started to appear. At this stage, the ova of 12 OMD (0.192 mm) were found to be numerous and the maximum size of ova was 0.304 mm. At stage IV, opaque ova were predominant, the mode of the largest size of ova being 23 OMD (0.368 mm) and the maximum size attained were 30 OMD or 0.48 mm. As the ovary reaches stage V, ova becomes larger with mode at 0.39 mm and the maximum size of 54 OMD (0.864 mm). At stage VI, the mode was at 0.864 mm, with maximum size attained as 63 OMD (1.008 mm). At stage VII (spent), the size of the ova resembles the immature stages (Table 4).

Table 4. Progression of ova diameter in advanced maturity stages in *P. aspinosa*

Stages of maturity	Description of ova	Mode of largest group of ova (mm)	Maximum size of ova (mm)
I	Immature	0.064	0.144
II	Maturing virgin	0.096	0.16
III	Early mature	0.192	0.304
IV	Late mature	0.368	0.48
V	Matured	0.624	0.864
VI	Ripe	0.848	1.008
VII	Spent	0.096	0.192

In the case of males, differentiation of male maturity stages was found to be difficult due to the tiny appearance of the testis, similar to the observations made by Nettely *et al.* (2016) in Nemipterid fishes from coastal waters of Bintulu, South China Sea. High GSI values were observed during August-September, and January for both sexes (Fig. 4), which subsequently declined in the following months. GSI values were significantly different between months for females (ANCOVA, F=34.01, d.f.=9.422, P<0.05) and males (ANCOVA, F=10.99, d.f.=9.359, P<0.05). Month-wise percentage occurrence of mature gonads followed similar trend for both sexes. The maximum percentage of mature gonads were recorded during September, January and February, which is in concurrence with the GSI values suggesting that *P. aspinosa* breeds throughout the year. This is similar to the generic observations by Baragi and James (1980), that mature fishes occurs throughout the year in most tropical marine fishes as maturation is a continuous

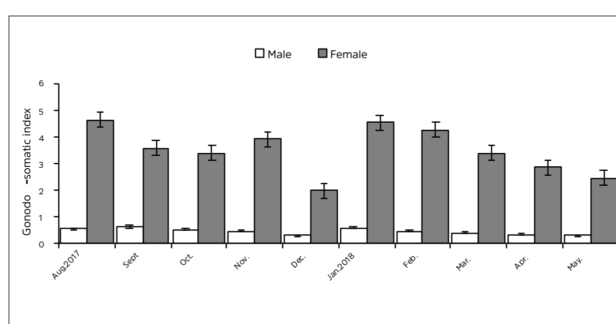

Fig. 4. Month-wise GSI values of female (ANOVA, F=34.01, d.f.=9.422, P<0.05) and males (ANOVA, F=10.99, d.f.=9.359, P< 0.05) of *P. aspinosa* occurring in the coastal waters of Mangaluru, southwest coast of India (Bars indicate ± standard error).

process. Naik (2000) also observed increased GSI values from September to January for *P. aspinosa*. In nemipterids, the GSI of *N. randalli* (= *N.mesoprion*) increased from August to peak during October-November, decreased during January and increased again in later months. However as per Naik, (2000), increase in GSI for *N. japonicus* begins from post-monsoon months, peaking during December-January. GSI values remained highest during the peak spawning of fishes in Indian waters (Pillay, 1958).

The length at maturity (TL_{50}) determined in the present study was 12.5 cm TL for females and and 11.5 cm TL for males of *P. aspinosa* (Fig. 5a & 5b). However, the observation made by Naik (2000) indicated TL_{50} of females as 11.6 cm TL and 11.8 cm TL for males in Goa, west coast of India. It can be concluded from the present study that both sexes of *P. aspinosa* matures at length range of 11.0 cm -13.0 cm TL. The fecundity ranged from 45,823 to 1, 56,308 eggs with an average of 84,367 eggs. The number of ova increased proportionally with increase in length, weight as well as gonad weight of the fish. The correlation analysis of log fecundity and total length (Y=1.7806 + 2.5129 X, r = 0.97), body weight (Y=3.4488 + 1.2162 X, r=0.93) and gonadal weight (Y=3.4015 + 1.6555X, r=0.91) of *P. aspinosa* was arrived at as perfect linear correlation.

P. aspinosa is a carnivorous bottom-feeding fish with preference for the major groups of preys: i) crustaceans ii) fishes iii)

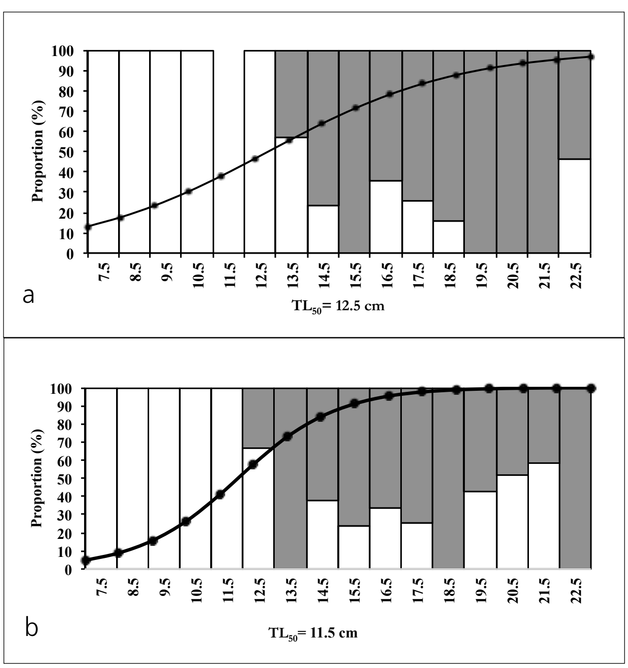

Fig. 5. Percentage frequency of occurrence of immature (□) and mature (■) *P. aspinosa* in sequential total length (TL) classes for (a) females and (b) males. Numbers above each bar represent the sample size in each sequential TL class. Arrows indicate the TL at which 50% of females and males attain maturity (TL_{50}).

cephalopods. Among fishes, *Saurida* spp., *Stolephorus* spp., *Nemipterus* spp. were recorded. Squilla, *Penaeus indicus, Acetes* spp. were accounted among crustaceans and *Loligo* spp. were frequently recorded under cephalopods. Analysis of the stomach contents (%IRI) revealed that *P. aspinosa* fed primarily on crustaceans (48.3%), followed by teleosts (35.2%) and cephalopods (16.5%). Naik (2000) suggested that food of this deep-water species is predominantly formed by crustaceans, as in the case of other nemipterids. Existence of a wide range of crustaceans in the stomach of *N. japonicus* has been reported by earlier workers (Kuthalingam, 1965; Krishnamoorthi, 1971; Karuppasamy *et al.,* 2008; Afshari *et al.,* 2013; Manojkumar *et al.*, 2015).

Percentage of relative importance (IRI) values were *Saurida tumbil* (%IRI=18.2), *P. indicus* (%IRI=16.7), *Loligo* spp., (%IRI=15.2), Squilla (%IRI=6.4) and *Acetes* spp. (%IRI=2.7) for prey items recognized in the study and unidentified crustaceans accounts %IRI=22.4, and unidentified fishes (%IRI=16.7) contributed significantly in the diet of *P. aspinosa*. Smaller quantities of other prey items includes *Nemipterus* spp. and *Stolephorus* spp. (%IRI=0.3 each) (Table 5). In this study, it was observed that juvenile fishes feed mainly on crustaceans, whereas, larger individuals feed mainly on

Table 5. Prey composition of *P. aspinosa* from Mangaluru, southwest coast of India

Prey item	%N	%W	%O	IRI	%IRI
Crustaceans					
Acetes spp.	6.8	5.1	6.2	74	2.7
Penaeus indicus	15.3	17.6	13.9	458.9	16.7
Squilla	9.6	9.2	9.4	176.1	6.4
Other unidentified shrimp	15.9	16.3	19.1	614.8	22.4
Cephalopods					
Loligo spp.	15.3	13.4	14.6	417.8	15.2
Other Unidentified Cephalopods	5.1	4	4	36	1.3
Teleost fishes					
Saurida tumbil	14.8	17.7	15.4	499.9	18.2
Stolephorus spp.	2.3	3	1.5	7.7	0.3
Nemipterus spp.	1.4	2.4	2	7.5	0.3
Other Unidentified fish	14.9	13.7	16	457.8	16.7

teleost fishes which denotes increased piscivorous feeding habits with increase in age of these fishes.

Out of 827 species examined during the study period, 201 stomachs were full (29%), 102 were 3/4th full (13%), 78 were 1/2th full (9%), 139 were 1/4th full (15%) and 307 were found empty (34%) (Fig.6). The high occurrence of empty stomachs may be due to several reasons: absence of favourite food item, condition of the fish or eviction of gut contents during

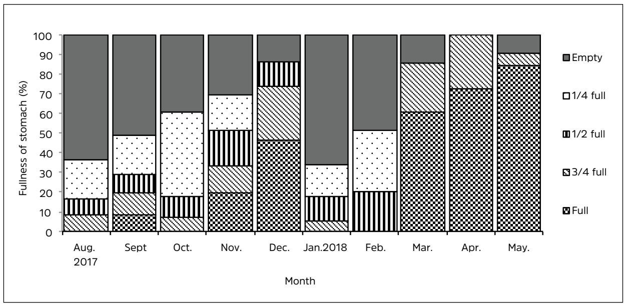

Fig.6. Feeding frequency of *P. aspinosa* in the coastal waters of Mangaluru, southwest coast of India.

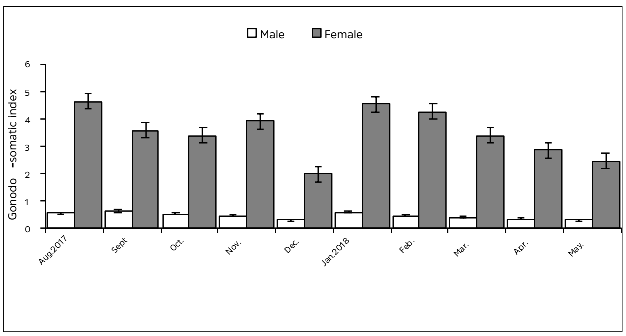

Fig.7. Monthly variation in the Empty Stomach Ratio (%ESR) of *P. aspinosa*

trawl catch or the food might have digested completely and caught before subsequent feeding. ESR values were found higher during August-September and January-February, which can be related with the peak spawning season of these fishes (Fig.7). Naik (2000) suggested that presence of more number of empty stomachs may be mostly due to overcrowding and struggling of fishes while the net was dragged through the bottom and to lesser extent due to the act of pressure and weight on the abdomen when the net is hauled up. It is also mentioned that, proper identification of the gut contents is possible only when there is short gap between feeding and capture and by adaptation of proper execution methods for analysis of gut contents.

The present study deals with fishery biology of *P. aspinosa* along Karnataka coast. This fish is not popular among fish eating community of the state and formed very low percentage among nemipterid catches during the last decade of 21st century. Absence of biological studies hinders in making any assessment or management recommendations along southwest coast of India. Therefore, the present investigation becomes significant as it will help to fill the knowledge-gap on the size distribution, length-weight relationship, maturation and spawning and diet of *P. aspinosa* from Karnataka waters in eastern Arabian Sea. Understanding critical aspects of biology is a prerequisite for sustainable management of harvests and this is particularly important for species such as *P. aspinosa* that are considered as potential candidates for the commercial fishery in the future.

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References

Afshari, M., T. Valinassab, J. Seifabadi and E. Kamaly. 2013. Age determination and feeding habits of *Nemipterus japonicus* (Bloch,1791) in the Northern Oman Sea. Iran. *J. Fish. Sci*., 12 (2): 248-264.

Bagenal, T. B. 1978. Methods for Assessment for Fish Production in Freshwater, 3rd ed. Blackwell Scientific Publication, London.

Baragi, M. V. and P. S. R. B. James. 1980. Reproductive biology of Sciaenid Fish *Johnieops osseus* (Day) from the South Kanara Coast. *Indian J. Mar. Sci*., 9 (1): 19-24.

CMFRI 2017. Annual report 2015-16. Central Marine Fisheries Research Institute, Cochin, 292 pp.

Cochran, W. G. 1952. The χ2 test of goodness of fit. *Ann. Math. Stat.,* 25: 315-345.

Cortés, E. 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. *Can. J. Fish and Aquat. Sci*., 54:726 -738.

Dineshbabu, A. P., Sujitha Thomas and S. Shailaja. 2017. Efficacy of spatial study on catch and effort from fishing vessels for strengthening fisheries management. *J. Mar. Biol. Ass. India*, 59(1): 31-35.

Ellis, J. R. and S. E. Shackley. 1997. The reproductive biology of *Scyliorhinus canicula* in the Bristol Channel, U. K. *J. Fish Biol.,* 51(2): 361-372.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: History, meta- analysis and recommendations. *J. App. Ichthyol*., 22: 241-253.

Hile, R. 1936. Age and growth of *Siscoleucichthys arteli* (Lesueur) in Lake of Three Northern Highlands, Wisconsin. *Bull. U.S. Bur. Fish.,* 48: 209-317.

Joshi, K. K. 2005. Biology and population dynamics of *Nemipterus mesoprion* (Bleeker) off Cochin. *Indian J. Fish.,* 52(3): 315-322.

Kannan, K., L. Ranjith, K. Sureshkumar, S. Mohamed Sathakkathullah, K. John James and M. S. Madan. 2013. Occurrence of *Parascolopsis eriomma* (Jordan and Richardson, 1909) and *P. aspinosa* (Rao & Rao, 1981) from Tuticorin coast. *Mar. Fish. Infor. Serv. T&E Ser.,* 217: 23-24.

Karuppasamy, P. K., K. Balachandran, S. George, S. Balu, V. Persis and N. G. Menon. 2008. Food of some deep sea fishes collected from the eastern Arabian Sea. *J. Mar. Biol. Ass. India*, 50(2): 134 - 138.

Kerdgari, T., S. Valinassab, M. Jamili, R. Fatemi and F. Kaymaram. 2009. Reproductive biology of the Japanese threadfin bream, *Nemipterus japonicus,* in the Northern Perisan Gulf. *J. Fish. Aquat. Sci.,* 4(3): 143-149.

Krishnamoorthi, B. 1971. Biology of the threadfin bream, *Nemipterus japonicus* (Bloch, 1791). *Indian J. Fish*., 18(1-2): 1-21.

Kuthalingam, M. D. K. 1965. Notes on some aspect of the fishery and biology of *Nemipterus japonicus* (Bloch, 1791) with special reference to feeding behaviour. *Indian J. Fish*., 12(2A): 500-506.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in the gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol*., 20: 201-219.

Lovern, J. A. and H. Wood. 1937. Variations in the biochemical composition of herring. *J. Mar. Biol. Assoc. U.K.,* 22: 281-293.

Manojkumar, P. P. 2004. Some aspects on the biology of *Nemipterus japonicus* (Bloch) from Veraval in Gujarat. *Indian J. Fish*., 51(2): 185-191.

Manojkumar, P. P. 2015. Food and feeding habits of *Nemipterus japonicus* (Bloch) from Malabar coast, Kerala. *Indian J. Fish*., 62(1): 64-69.

Mohapatra, A., P. C. Tudu, D. Ray and P. Yennawar. 2013. First report on the occurrence of four fishes of family: Nemipteridae from Digha on the east coast of India. *Rec. Zool. Surv. India*, 113(Part-1): 145-149.

Montgomery, D. C., E. A. Peck and G. G. Vining. 2012. Introduction to Linear Regression Analysis, (Wiley publication, New Jersey), 152 pp.

Naik, S. K. 2000. *Some studies on the biology of Nemipterids of Goa coast.* Ph. D. Thesis, Goa University, Taleigao Plateau, Goa, India, 177 pp.

Nettely, A. H., N. A. Rajaee, M. H. Denil, M. H. Idris, S. M. Nesarul, N. Amin and M. K. A. Hena. 2016. Reproductive biology of *Nemipterus japonicus* (Bloch, 1791) from the coastal waters of Bintulu (South China Sea), Sarawak, Malaysia. *J. Environ. Biol*., 37: 715-724.

Pillay, T. V. R. 1958. Biology of the hilsa *Hilsa ilisha* (Ham.) of the river Hooghly. *Indian J. Fish.,* 5: 201-259.

Pinkas, L., M. S. Oliphant and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. *Cal. Fish Game,* 152: 1-105.

Purushottama, G. B., Thakurdas., V. Ramasubramanian, D. Gyanaranjan, K. V. Akhilesh, S. Ramkumar, S. J. Kizhakudan, V. V. Singh and P. U. Zacharia. 2017. Reproductive biology and diet of grey sharpnose shark *Rhizoprionodon oligolinx* Springer, 1964 (Chondrichthyes: Carcharhinidae) from the northeastern Arabian Sea. *Indian J. Fish*., 64(4):9-20.

Rao, D. M. and K. S. Rao. 1981. A revision of the genus *Scolopsis* cuvier (Pisces: Nemipteridae) with descriptions of two new species from Indian waters. *Proc. K. Ned. Akad. Wet. C*., 84(1): 131-141.

Ricker, W. E. 1975. Computer and interpretation of biological statistics of fish population. *Bull. Res. Board Can*., p. 315-318.

Rohit, P., K. M. Rajesh, G. Sampath Kumar and K. Sahib. 2015. Food and feeding of the ribbonfish *Trichiurus lepturus* Linnaeus off Karnataka, south-west coast of India. *Indian J. Fish*., 62(1): 58-63.

Russell, B. C. 1990. FAO Species Catalogue. Nemipterid fishes of the world. (Threadfin breams, whiptail breams, monocle breams, dwarf monocle breams, and coral breams). Family Nemipteridae. An annotated and illustrated catalogue of nemipterid species known to date. *FAO Fish. Synop.,* 125(12):149 pp. FAO, Rome.

Russell, B. C. and D. Golani. 1993. A review of the fish genus *Parascolopsis* (Nemipteridae) of the Western Indian Ocean, with description of a new species from the northern Red Sea. *Israel. J. Zool*., 39: 337-347.

Shapiro, S. S. and M. B. Wilk. 1965. An analysis of variance test for normality (complete samples), *Biometrika*, 52(3 & 4): 591-611.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical methods, 6th Edn. Oxford and IBH Publishing Co., New Delhi, India.

Sossoukpe, E., F. K. E. Nunoo, P. K. Ofori-Danson, E. D. Fiogbe and H. R. Dankwa. 2013. Growth and mortality parameters of *Parascolopsis senegalensis* and *Parascolopsis typus* (Sciaenidae) in nearshore waters of Benin (West Africa) and their implications for management and conservation. *Fish. Res*., 137:71- 80.

White, W. T. 2007. Catch composition and reproductive biology of whaler sharks (Carcharhiniformes: Carcharhinidae) caught by fisheries in Indonesia. *J. Fish Biol.,* 71(5): 1512-1540.

Wood, M. 2004. Statistical inference using bootstrap confidence intervals. *Significance,* 1: 180 -182.

Zacharia, P. U. and G. D. Nataraja. 2003. Fishery and biology of threadfin bream, *Nemipterus mesoprion* from Mangalore-Malpe. *Indian J. Fish*., 50(1): 1-10.

Zacharia, P. U. and K. P. Abdurahiman. 2004. Methods of stomach content analysis of fishes. In: Winter School on Towards Ecosystem Based Management of Marine Fisheries-Building Mass Balance Trophic and Simulation Models (Mohammed, K.S., ed.), p. 148-158.