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Food and feeding of the ribbonfish *Trichiurus lepturus* Linnaeus off Karnataka, south-west coast of India

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ABSTRACT

Trichiurus lepturus samples landed by trawl boats at Mangalore Fishing Harbour were collected regularly from January, 2008 to December, 2012. Stomach of 4,581 ribbonfishes ranging in size from 40 to 110 cm total length (TL) were analysed to study their feeding habits. Prey mainly belonged to three major taxonomic groups *i.e.,* fishes, crustaceans and cephalopods. Index of relative importance (IRI) values were higher for fishes followed by crustaceans and cephalopods. *Acetes* sp., *Stolephorous devisi, Loligo* sp., *Saurida tumbil, Sardinella longiceps* and *Decapterus russelli* were the major food items. Juveniles of *T. lepturus* and unidentified fish as well as shrimp remains were found occasionally in the gut indicating cannibalistic behaviour. Higher feeding intensity in terms of stomach fullness index (SFI) was observed during April, June and October and lower values during November and December. The monthly change in the empty stomach ratio (ESR) varied from 66.58% in September to 79.14% in June. Generally higher values of ESR were noticed during March to August and lower values during September to February.

Keywords: Feeding, Index of relative importance, Mangalore, Prey, Ribbonfish, *Trichiurus lepturus*

Introduction

The ribbonfish *Trichiurus lepturus* is a cosmopolitan coastal pelagic fish inhabiting warm and warm temperate shelf waters in various parts of the world (Nakamura and Parin, 1993). Ribbonfish is one of the most important pelagic fish of the Indian Exclusive Economic Zone forming 6.2% of the total catch (CMFRI, 2013). On account of its demand for export to China and other south-east Asian countries (Khan, 2006) a targeted fishery for this resource is prevalent in all the coastal states. In Karnataka, the ribbonfish fishery which formed 6.2 to 12.4% of the total trawl catch during the study period, is sustained mainly by a single species, *Trichiurus lepturus.*

Ribbonfishes are top predators and thus play an important role in controlling populations of lower trophic level species including fish, crustaceans and cephalopods (Yan *et al.,* 2011). Therefore, knowledge of the feeding habits and ecological interactions of ribbonfishes and their prey is essential for the management and conservation of the fishery resources and marine ecosystem. There has been considerable research addressing diet of ribbonfish with regard to biological interaction, diet overlap and ontogenetic and seasonal diet variations off South America (Martins and Haimovici, 1997; Martins *et al.,* 2005; Bittar and Beneditto, 2009) and in China Seas (Wei, 1980; Zhang, 2004; Chiou *et al.,* 2006; Lin *et al.,* 2006; Liu *et al.,* 2009; Yan *et al.,* 2012). However, studies on food and feeding of ribbonfish and on its seasonal variation are limited in Indian waters (James, 1967). This study aims to examine the feeding habits, seasonal variations and ontogenic preferences of *T. lepturus* exploited by trawlers based at Mangalore, Karnataka over a period of five years from January, 2008 to December, 2012.

Materials and methods

The study area was in the Arabian Sea, off the south-west coast of India between lat. 11.84° - 15.552° and long. 73.387° - 75.274°) (Fig. 1). The coastline is influenced by the two major river run off (Nethtravathi and Gurupur rivers) of Mangalore during the monsoon season (June to September). *T. lepturus* samples landed by the trawlers were collected on a weekly basis from the Mangalore Fishing Harbour. A total of 4,581 individuals were collected between January, 2008 and December, 2012 and analysed for their gut content.

Fresh specimens were weighed (g) and measured for their total length (cm). The fish was then cut open and the entire stomach was carefully removed for further detailed analysis. Sex and stage of gonad maturity were also recorded for each fish. The total weight of the stomach content was taken and recognisable stomach contents were identified to the lowest possible taxon and the number of food items counted. The partially digested fish and shrimp remains were grouped as unidentified fish and shrimp respectively. Each food item was weighed to the nearest 0.1 g.

Feeding periodicity was determined by analysing the feeding intensity and the empty stomach ratio. Stomach fullness index (SFI) was used to measure the degree of feeding intensity (Chiou *et al.*, 2006). SFI was calculated as: SFI = [weight of the stomach contents/ (body weight - weight of the stomach contents)] × 100. The empty stomach ratio (ESR) was calculated as the percentage of the number of specimens with an empty stomach, of the total number of specimens examined.

The total length (TL) of the *T. lepturus* specimens examined in the study ranged between 40 and 110 cm. To determine variations if any in the feeding activity and diet composition of ribbonfish of different size groups, three categories were defined: (i) 40-60 cm TL; (ii) 61-80 cm TL; and (iii) 81-100 cm TL. Since only 5 specimens of >100 cm TL were available in the sample, they were not considered for the comparisons. The mean SFI of different TL size specimens were compared.

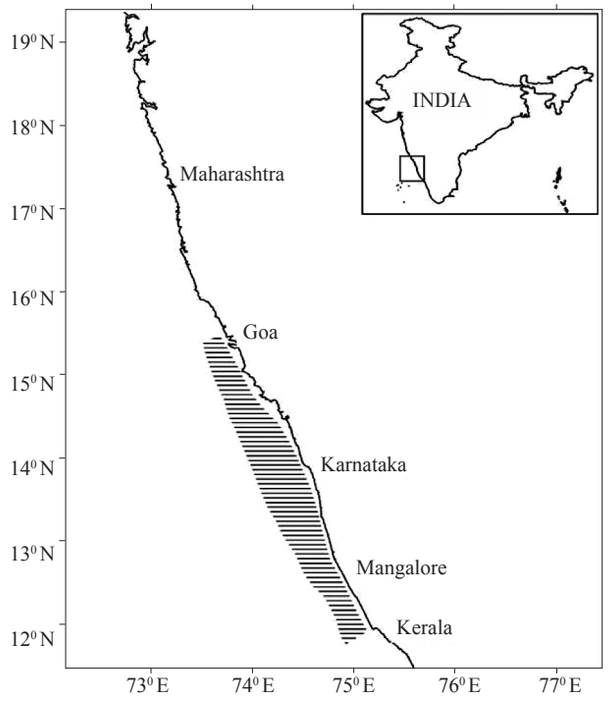

Fig. 1. Study area: location with shading showing the sampling area

The relative importance of each prey item in the diet and their seasonal variations were analysed (Pinkas *et al.,* 1971) on the basis of three indices: (i) percentage of wet weight of each food item to the total wet weight of all food items identified (%W); (ii) 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 index of relative importance (IRI) was calculated as: IRI = (%N+%W)×%F. Student's *t*-test analysis was applied to test the differences in the SFI between sexes of varied size classes.

Results

A total of 4,581 samples were collected during the study period (Table 1). The size ranged from 40 to 110 cm TL and 71.99% (n=3,298) stomachs were empty. The high incidence of empty stomach condition may probably be due to involuntary forced expulsion of food items during their struggle to escape from the trawl net. Prey mostly belonged to three major taxonomic groups: (i) fishes; (ii) crustaceans; and (iii) cephalopods (Fig. 2). Fishes were the most dominant prey item, both by occurrence (73.68%) and weight (73.47%) followed by crustaceans which dominated by number (61.45%) (Table 2).

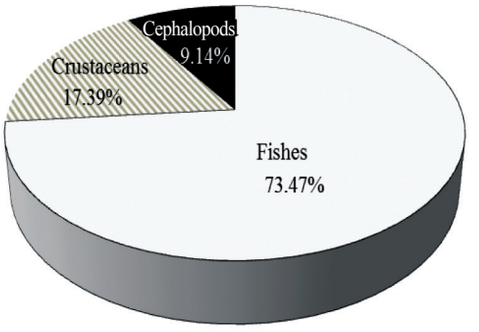

Fig. 2. Major prey group constituting the diet of *T. lepturus*

The percentage IRI values were 61.38, 35.35 and 3.27 for fish, crustaceans and cephalopods respectively (Table 2). Among fishes, *Stolephorous devisi, Saurida tumbil, Sardinella longiceps* and *Decapterus russelli* were the major food items. Among crustaceans, *Acetes* sp. was the major prey groups. *Oratosquilla nepa* and crabs too contributed to the food contents but were found in very less quantity. Cephalopod was

Table 1. Sampling year and month, sample size and total length of ribbonfish landed at Mangalore Fisheries Harbour by trawler.

Years	2008		2009		2010		2011		2012	
Months	Sample size	TL Range (cm)	Sample size	TL Range (cm)	Sample size	TL Range (cm)	Sample size	TL Range (cm)	Sample size	TL Range (cm)
January	169	44-104	173	40-92	-	-	83	40-88	106	54-98
February	98	52-102	56	56-78	-	-	94	46-100	127	42-108
March	71	48-98	67	46-94	-	-	152	52-100	120	42-98
April	148	41-88	113	54-90	69	40-94	84	54-102	43	58-112
May	101	40-76	146	44-96	85	46-92	114	42-98	131	44-98
June	71	42-78	35	44-86	77	48-94	30	60-86	30	60-82
July	-	-	-	-	-	-	-	-	0	
August	88	42-88	-	-	68	54-86	110	42-88	64	58-92
September	121	46-96	-	-	122	46-96	90	46-84	104	50-94
October	96	50-96	-	-	113	48-110	80	52-86	127	48-94
November	149	50-88	-	-	143	50-92	127	52-88	50	54-88
December	50	52-108	-	-	97	60-100	114	52-94	75	48-84
Annual	1162	40-108	590	40-96	774	40-110	1078	40-102	977	42-112

- : No specimens were sampled, TL - Total length

Table 2. Percentage frequency (%F), percentage number (%N), percentage volume (%V), and Index of relative importance (IRI) of each food item in the diet of *T. lepturus* in the coastal waters of Mangalore, south-west coast of India.

	%F	%N	%W	IRI	% IRI
Fish (species pooled)	73.68	35.96	73.47	1446.62	61.380
Stolephorous devisi	26.74	10.82	11.62	642.14	27.246
Unidentified fishes	22.16	9.37	16.67	544.73	23.113
Sardinella longiceps	4.39	2.56	7.62	62.68	2.660
Saurida tumbil	4.37	2.06	8.63	65.85	2.794
Decapterus russelli	3.40	3.02	7.74	43.61	1.850
Bregmaceros sp.	2.98	1.58	3.26	47.03	1.995
Nemipterus randalli	1.95	1.00	2.24	7.68	0.326
Rastrelliger kanagurta	1.87	1.48	5.64	17.58	0.746
Platycephalus sp.	1.17	0.64	0.60	2.61	0.111
Muraenesox sp.	1.02	0.67	0.69	2.93	0.124
Priacanthus hamrur	0.65	0.26	4.04	5.07	0.215
Lagocephalus inermis	0.61	0.24	0.77	1.15	0.049
Cynoglossus sp.	0.56	0.25	0.34	0.67	0.028
Thryssa sp.	0.44	0.23	0.67	0.77	0.033
Leiognathus sp.	0.32	0.11	0.04	0.13	0.006
Fistularia petimba	0.29	0.07	0.16	0.25	0.011
Megalaspis cordyla	0.25	0.62	1.26	0.82	0.035
Trichiurus lepturus	0.18	0.04	1.18	0.35	0.015
Johnius sp.	0.12	0.03	0.20	0.07	0.003
Sphyraena sp.	0.10	0.87	0.03	0.47	0.020
Odonus niger	0.06	0.01	0.07	0.02	0.001
Psenus sp.	0.05	0.03	0.00	0.01	0.001
Crustaceans (Species pooled)	19.92	61.45	17.39	833.18	35.352
Acetes sp.	9.47	58.09	12.52	735.18	31.194
Unidentified shrimps	9.74	3.16	4.59	97.70	4.145
Crabs	0.45	0.13	0.20	0.21	0.009
Oratosquilla nepa	0.26	0.08	0.08	0.09	0.004
Cephalopods (Species pooled)	6.40	2.59	9.14	77.02	3.268
Loligo sp.	6.07	2.31	8.93	76.69	3.254
Octopus sp.	0.28	0.20	0.20	0.31	0.013
Sepia sp.	0.05	0.08	0.02	0.02	0.001

*Values are means of five years (2008 - 2012)

represented by *Loligo* sp., *Octopus* sp. and *Sepia* sp. with a dominance of *Loligo* sp. IRI values (%) indicated that *Acetes* sp. was the most dominant food item followed by *S. devisi, Loligo* sp., *S. tumbil, S. longiceps* and *D. russelli.* Other recognisable prey items were found in very small numbers. Unidentified fish and shrimp remains too contributed considerably to the food but could not be accounted for under any major group. An interesting observation was the presence of *T. lepturus* juveniles occasionally in the gut, though in small quantity (% IRI =0.015).

Results of *Student's t test* analysis showed that SFI values between sexes for each size category of fish were not significantly different In general, the mean SFI values were higher for females compared to males (Fig. 3). The feeding intensity of medium sized fishes (61-80 cm TL) was lower than the smaller (40-60 cm TL) as well as larger fishes (81-100 cm TL) (Fig. 3).

The monthly seasonal change in the feeding intensity in terms of SFI is depicted in (Fig. 4.) SFI values were higher during April, June and October and lower in November and December. The monthly change in empty stomach ratio varied from 66.58 in September to 79.14 in June. Generally higher values of ESR were noticed during March to August and lower values during September to February (Fig. 5).

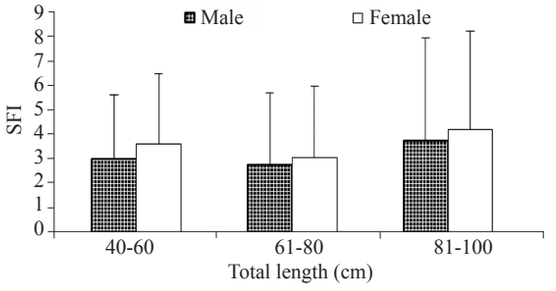

Fig. 3. Stomach fullness index (SFI) for different size classes of *T. lepturus* (vertical bars indicate ± standard deviation)

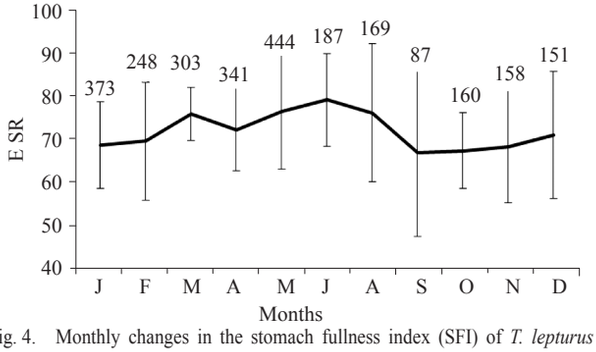

Fig. 4. Monthly changes in the stomach fullness index (SFI) of *T. lepturus* (Bars indicate ± standard deviation. Number of specimens examined is given above each bar)

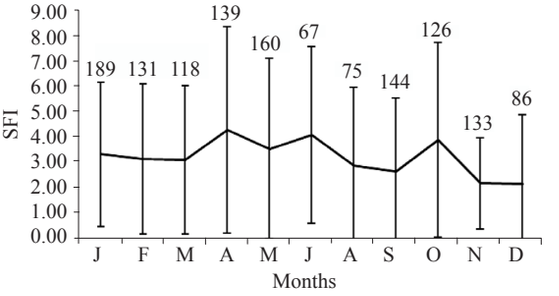

Fig. 5. Monthly changes in the empty stomach ratio (ESR) of *T. lepturus* (Bars indicate ± standard deviation. Number of specimens examined is given above each bar)

Discussion

T. lepturus samples were collected from trawl boats throughout the year except during July when the monsoon ban as a management measure was in force (45-50 days between middle of June to middle of August) along Karnataka coast.

Stolephorous spp., was the most important prey item in the diet of *T. lepturus* in our study with the highest percent weight (%W) and percent frequency (%F) of all the prey types identified. Incidentally, *Stolephorous* spp. was one of the largest components of the commercial catch in Arabian Sea off Karnataka and contributed to 1.7% of the total marine fish landings during 2011 (CMFRI, 2012). The shrimp, *Acetes* sp. was the dominant prey having highest percent number (%N) and index of relative importance (IRI) of all prey types identified. *Acetes* sp. formed more than 75% of the total non-penaeid shrimps landed annually in India (Nair *et al.,* 1983). The other important diets that occurred in fairly good quantity and almost all through the year were *Loligo* sp., *S. tumbil, S. longiceps, Bregmaceros* sp., *D. russelli, R. kanagurta* and *N. randalli.* All these are major components of the commercial catch along Indian coast. Similar type of feeding habit with, small sized fishes such as *Stolephorous* sp., *Leiognathus* sp., *S. longiceps*, *Acetes* sp., shrimps and *Loligo* sp., has been reported in *T. lepturus* from both west and east coasts of India (Prabhu, 1955; James, 1967) and other countries. The euphausid, *Euphausia pacifica* and amphipods were the primary prey in the east China Sea and in the Yellow Sea (Zhang, 2004) whereas *Benthosema pterotum* and *Bregmaceros lanceolatus* were the primary diet component in the ribbonfish collected from south-western Taiwan (Chiou *et al.,* 2006). The chief prey of ribbonfish was the anchovy, *Engracilis encrosicolis* in the Egyptian Mediterranean (Bakhaum, 2007). While the squid *Loligo plei* formed the major prey item in northern Rio de Janeiro, Brazil (Bittar and Beneditto, 2009), the carangid *Decapterus maruadsi* was the most important diet component of ribbonfish in South China Sea (Yan *et al.,* 2012).

Cannibalism in ribbonfish has been described in several earlier studies, with percentage weight (% W) ranging from 17.3 (Zhang, 2004) to 25.2 (Liu *et al.,* 2009), 35.2 (Lin *et al.,* 2005) for the east China Sea, compared to 11.9% W for the Yellow Sea (Zhang, 2004) and 21.6% W in the South China Sea (Yan *et al.,* 2012). However, the cannibalism in the present study was comparatively very low (1.18%W) and similar to the cannibalism of *T. lepturus* in coastal waters of south-western Taiwan (0.5%W) (Chiou *et al.,* 2006). Cannibalism has frequently been suggested as a strategy to transfer energy from smaller to larger individuals (Santos and Haimovici, 1997) and one of the factors regulating population size (Lovrich and Sainte, 1997; Koester and Moellmann, 2000). Many studies found that cannibalism increases when the population was abundant. In contrast, cannibalism would not be expected when other food sources are sufficient (Casas and Paz, 1996).

Fishes with empty stomach condition dominated the catch during the present study period. The presence of high percentage of empty stomachs is characteristic of piscivorous fishes (Faltas, 1993; Juanes and Conover, 1994). Similar findings with higher proportion of empty stomachs in ribbonfishes were reported from Vishakapatnam (Reuben *et al.,* 1997), Kakinada (Abdussamad *et al.,* 2006), Arabian Sea and Northern Bay of Bengal (Ghosh *et al.,* 2014) in India; Egyptian Mediterranean Coast (Bakhoum, 2007) and Beibu Gulf of South China Sea (Yan *et al.,* 2012).

Feeding intensity in terms of SFI varied considerably, reaching its peak in April and June and its low value in November and December. *T. lepturus* spawns in late spring or at the onset of south-west monsoon (May-June) in the Arabian Sea region (Bapat *et al.,* 1982; Al-Nahdi *et al.,* 2009). Thus the spawning period of ribbonfish in the Arabian Sea coincided with the period of greater feeding intensity, which may reflect that the fish require more energy during spawning than during other phases. Earlier studies have clearly pointed out that the reproductive activity is one of the highest nutritional demands of the ribbonfish *T. lepturus* (Martins *et al.,* 2005; Chiou *et al.,* 2006). The feeding intensity showed positive correlation with maturation stage while ESR showed negative correlation, suggesting that feeding increase with gonad development (Yan *et al.*, 2012). However in our study, the higher values of ESR (May-June) coincides with higher values of feeding intensity. This could indicate that some of the ribbonfish in the group were immature and their spawning may not be in the peak spawining period. Earlier studies have reported that the presence of ripe gonads during months other than May-June indicates ribbonfish spawns throughout the year (Al-Nahdi *et al.,* 2009). The breeding season in *T. lepturus* is variable (Martins and Haimovici, 2000; Yan *et al.,* 2011) and can be seasonal (Chiou *et al.,* 2006) or occur throughout the year (Martins and Haimovici, 2000; Al-Nahdi *et al.,* 2009). Supporting this, the second peak of SFI values observed in the present study during October coincides well with the lowest values of ESR during September-October (Fig. 4 and 5). This indicates the possibility of maturation and breeding of some of the ribbonfish in the population during September-October. The earlier studies reported two spawning seasons, one during May-June and another during November-December in the east coast of India (Thampi *et al.,* 1968). Similarly, Reuben *et al.* (1997) reported two spawnings during March-May and August-November in Vishakhapatnam waters. Detailed report on the spawning of *T. lepturus* along the west coast is lacking but a similar pattern is expected along the west coast of India also.

The present study on the food and feeding of *T. lepturus* indicates that these fishes are voracious feeders feeding on all groups with a higher preference for finfishes. The study has also thrown light on the role of feeding intensity with spawning and the important role of *T. lepturus* in the food chain. This information is important particularly in developing an ecosystem based approach for fishery management along Karnataka coast.

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