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Morphometry, Food and Feeding Biology Study of Tiger Tooth Croaker *Otolithes ruber* (Schneider, 1801) from off Paradeep Coast, Odisha, India

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ABSTRACT: The morphometric food and feeding studies on tiger tooth croaker *Otolithes ruber* from off Paradeep coast was studied. High degree of correlation has been observed in the total length and head length with different morphometric characters except snout length and eye diameter. This indicated that the fish maintained a specific body dimension throughout its life. The distance between the tip of snout and the base of anal fin followed by depth of caudal peduncle have the fastest growth rate while eye diameter shows the lowest growth rate. Any noticeable relation in preference of food was not observed for the *O. ruber* where gut content analysis showed that younger size prefers *Acetes* spp. and larger size for both fish and prawns. The semi digested matter comprised mostly of fish and shrimp was recorded in higher percentage for all the months. The gastro-somatic index of this species was maximum during July(7.85) and August(7.59) and as low as 1.738 in the month of May. Index of preponderance for semi-digested fish (56.9%) was found to be maximum followed by semi digested shrimp (20.2%).

Keywords: Morphometry, food and feeding habit, ruber.

INTRODUCTION

Sciaenids are one of the important demersal fish in the marine landing along the Indian coast accounting for 1.356 lakh tones and second largest group among demersal landing. Out of that Maharastra and Gujarat shares about 69% of total sciaenid catch of India and Gujarat itself accounted for more than half of sciaenid's landing in India. In the recent year with mechanization of boat this unexploited fishery resources has substantially increased. Sciaenids are generally available throughout the year. Peak landing is during September to March. The main states in India contributing to the sciaenid catch are Gujarat, Maharastra, West Bengal, Tamilnadu, Orissa, Andhra Pradesh, and Kerala etc. With a coastline of 480 kms and 2400 sq. km of continental shelf, Orissa is bestowed with a good abundance of demersal fishery resources with maximum sustainable yield of 77,000 tonnes that includes sciaenids, catfishes, pomfrets, ribbon fishes, eels, seer fishes, etc. (John and Sudarsan 1990). Sciaenids contributes on an average 9.23% to the marine fish catch of Orissa in the last 10 years, with a maximum being 13.27% and minimum of 4.94% of total marine landing in the year 2001 and 2020 respectively (Anon., 2001). More than 16 species of sciaenids are exploited off Orissa coast like *Johnius carutta, J. belangerii, J. dusssumieri, J. macrorhynus, J. macropterus, Johnieops vogleri, Otolithes ruber, O. maculatus, O. cuvieri, Otolithoides biauritus, Chrysochir aureus, Protonibea diacanthus, Nibea soldado, N. maculatus, Pennahia macrophthalmus* etc**.** Out of which some are estuarine inshore and deep water in nature. Trawlers exploit mostly sciaenids, which accounts for more than 15% of total catch and to a little extent by mechanized and non-mechanized gill-netters. Hook and line and gill nets are used to catch bigger sciaenids like *P. diacanthus* and *Chrysochir aureus, O. biauritus* etc.

Basically sciaenids are divided into two groups, the bigger sciaenids and lesser sciaenids. The later having a number of species of various sizes. The group Sciaenidae being abundant and rather cheap has received a good deal of attention from many parts of the world including India. Most of the workers who have carried out research in the field of sciaenids have been listed in the review of literature of this document. However, there has been very little work on sciaenids from north east coast of India, particularly from the states of West Bengal and Orissa. Dutt and Thankam (1968) reported that along the east coast of India *Otolithus argenteus, Nibea maculata* and *O. ruber* are common in the seas and estuaries of Orissa and West

Bengal. To the best of the knowledge of the present worker there has been no study on sciaenids from the North-East of India on biology, age, growth etc, after the work done on *Pseudosciaena coibor* from Chilika Lake by (Rajan, 1964). The present investigation is perhaps the first of its kind from Orissa coast. The identity of the stock of sciaenids was based on 14 morphometric characters. Morphometric study is a powerful means for characterizing verities of the same species, which involves recognition of subtle the change of shape, independent of size. Similarly, a food and feeding of *O. ruber* habits was studied along the Paradeep coast.

MATERIALS AND METHODS

Though a good number of investigations have been done on morphometric characters in a number of sciaenid species, the present study is aimed at description of sciaenids *O. ruber* particularly from Paradeep coast of Orissa by analysing all the possible morphomeric characters. Samples of *O. ruber* were collected at random from Paradeep landing centre of Orissa. The eye diameter was measured with a vernier caliper for accuracy. The following morphometric characters were examined to study changes in the body form are total length, standard length, head length, snout length, eye diameter, orbital length, inter-orbital length, predorsal length, prepectoral length, preventral length, preanal length, body depth, caudal depth and pectoral fin length. For the analysis of morphometric characters, linear regression equation was fitted using least square method was used following

The relationships were represented by equation: $y = a + b x$. Where, y is a dependent variable, x an independent variable, a constant (intercept) and b the regression coefficient (slope). The coefficient of correlation (r) was determined in order to know the relationship between two variables.

To study the food and feeding habits, samples were collected once in a week at random from Paradeep landing center of Orissa from January 2018 to December 2019. Fresh specimens were brought to laboratory. Total length and weight were measured using a measuring board and balance respectively. In order to examine the stomach conditions fishes were dissected ventrally. At the same time sex and maturity stages of the fishes were also recorded. Estimation of feeding intensity or feeding Index was based on the extent of distension of stomach and amount of food in it, which was determined by eye estimation. Based on the degree of fullness, the stomach conditions were expressed as Gorged, Full, 3/4th full, ½ full, 1/4th and empty as followed by Pillay (1952). A total of 331 numbers of specimens of *O. ruber* were studied for present investigation. The volume of each food item was measured with a measuring cylinder by volume displacement method. The food items of the stomachs were identified up to the possible generic or species level depending upon the state of food. Sand grains and mud particles found among the food items were not taken into consideration, as sciaenids are bottom feeder. The data obtained were tabulated month wise and length group wise for all the 3 species (20 mm class interval in *O. ruber*) was studied. For evaluating the importance and preference of various food items, Index of Preponderance method (Natarajan and Jhingran 1961) was employed, which was expressed as: $I_i = V_i * O_i / \sum V_i * O_i * 100$ where V_i and O_i are the volume and occurrence index of food items in percentage respectively.

RESULTS AND DISCUSSION

Fresh fish samples brought to the laboratory measured to the nearest 0.1 mm (total length) after washing in tap water and wiping with blotting paper. Later, various morphometric characters were measured and meristic counts were made following standard procedure[3]. Morphometric characters for *Otolithes ruber* were measured and relationships of standard length, head length, body depth, caudal depth, pre-dorsal length, pre-ventral length, pre-anal, pre-pectoral length was worked out against total length. Similarly snout lengths, eye diameter, interorbital distance, orbital length, pectoral fin length were compared against head length. The correlation coefficient was worked out following the method of least square.

A total of 176 specimens in the length range of 147 - 406 mm were measured for morphometric studies and presented in Table 1. Preventral length showed a maximum coefficient of variation (41.06) while eye diameter showed minimum variation (24.84). The statistical analysis like range, mean, standard error and coefficient of correlation of various morphometric characters and their relationship to total length and head length are presented in Table 2. The pre anal length showed maximum degree of correlation followed by caudal depth. The eye diameter showed minimum correlation with head length. The correlation coefficient between different characters ranged from 0.86641 to 0.98927. The distance between the tip of snout and the base of anal fin followed by depth of caudal peduncle have the fastest growth rate while eye diameter shows the lowest growth rate. Similar observations were made by Pillai (1983) from Porto-Novo waters.

Table 1: Statistical estimate of various morphometric characters in *O. ruber*.

Sr. No.	Morphometric Characters	Range (mm)	Mean (mm)	Standard Deviation	Coefficient of Variation
1.	Total length	147 - 406	250.36	77.39	30.80
2.	Standard length	123 - 358	210.31	67.24	31.96
3.	Head length	36 - 100	63.73	19.11	29.98
4.	Body depth	31 - 99	54.07	17.940	33.17
5.	Caudal depth	10 -33	18.20	5.99	32.90
6.	Pre dorsal length	39 - 118	69.20	23.53	34.00
7.	Pre ventral length	37 - 111	68.87	28.28	41.06
8.	Pre anal length	86 - 257	150.16	47.71	31.77
9.	Pre pectoral length	35 - 105	64.80	21.45	33.10
10.	Pectoral fin length	21 - 75	44.16	14.37	32.52
11.	Snout length	10 - 28	15.24	4.45	29.21
12.	Eye diameter	7 - 18	11.71	2.91	24.84
13.	Orbital length	17 - 28	36.51	12.90	35.34
14.	Inter orbital length	12 - 38	22.29	6.47	29.03

Table 2: Relationships between different morphometric characters in *O. ruber*.

Sr. No.	Morphometric Characters	Range (X)	Range (Y)	*Mean* of Y	Standard Error of estimate	Y = a + b X	r
1.	*Standard length and **Total length	147 - 406	123 - 358	210.31	22.559	Y = 4.58566 + 0.82169 X	0.96442
2.	*Head length and **Total length	147 - 406	36 - 100	63.73	2.848	Y = 2.50613 + 0.24452 X	0.94071
3.	*Body depth and **Total length	147 - 406	31 - 99	54.073	4.226	Y = -2.0148 + 0.22402 X	0.97242
4.	*Caudal Depth and **Total length	147 - 406	10 -33	18.20	1.436	Y = 0.5176 + 0.7476 X	0.98137
5.	*Pre dorsal Length and **Total length	147 - 406	39 - 118	69.20	5.714	Y = -4.1261 + 0.2928 X	0.97072
6.	*Pre ventral Length and **Total length	147 - 406	37 - 111	68.87	4.725	Y = -1.05069 + 0.27928 X	0.9777
7.	*Pre anal Length and **Total length	147 - 406	86 - 257	150.16	16.259	Y = 6.81193 + 0.57257 X	0.98927
8.	*Pre pectoral Length and **Total length	147 - 406	35 - 105	64.80	4.492	Y = -2.66282 + 0.26945 X	0.96829
9.	*Pectoral fin length and **Head length	36 - 100	21 - 75	44.16	2.893	Y = -2.43807 + 0.43126X	0.9800
10.	*Snout length and **Head length	36 - 100	10 - 28	15.24	2.817	Y = 2.4704 + 0.2003 X	0.87221
11.	*Eye diameter and **Head length	36 - 100	7 - 18	11.71	1.489	Y = 3.3188 + 0.13165 X	0.86641
12.	*Orbital length and **Head length	36 - 100	31 - 99	54.07	3.453	Y = -4.5901 + 0.4449 X	0.96433
13.	*Inter orbital length and **Head length	36 - 100	12 - 38	22.29	2.064	Y = 2.1033 + 0.3167 X	0.94811

Where ** represents 'X' and * corresponding 'Y' and 'r' is correlation coefficient

The data collected on percentage of occurrence of food from January 2018 to December 2019 has been collected for both male and female of *O. ruber*. A sample of 148 males and 183 females were studied for the food and feeding habits of this species (Table 3 and 4). Marked feeding intensity in relation to month was observed during February, May, August and November; the percentage of full stomach being 37.5, 33.0, 21.43 and 22.22. Similarly, in females, higher percentage of full stomach conditions indicated higher intensive of feeding during June (21.74) September (25.0) and October (28.57). Venkataraman (1960) reported this species as piscivore. According to Vaidya (1960) the post larvae and juveniles are surface plankton feeders and the adults carnivorous feeding on crustacean, teleosts and cephalopods. Suseelan and Nair (1969) reported the fish as an active carnivore on prawns and teleosts. Nair (1979) observed that young ones of *O. ruber* feed largely on zooplankton and pelagic animals at the surface; with gradual change over to teleosts and prawns at bottom with increase in size. Pillai (1983) investigated the food and feeding habit of *O. ruber* from Porto Novo and found the species as carnivorous in nature and shows a selective feeding habit. Fennessy (2000); Passoupathy and Natarajan (1987) reported that *O. ruber* juveniles feed primarily on planktonic crustacean and adults on prawns, fishes, polychaetes, and molluscs. The diet of males and females did not differ significantly.

Table 3 : Monthwise percentage of feeding intensity in male of *O. ruber.*

Months	No. of specimen	High feeding		Moderate feeding		Low feeding	
		Gorged	Full	3/4th full	½ full	¼ full	Empty
January	10	-	-	20.00	30.00	-	50.00
February	16	-	37.50	12.50	12.50	25.00	12.50
March	25	-	4.00	40.00	36.00	-	20.00
April	11	-	-	19.00	27.00	27.00	27.00
May	9	-	33.00	-	11.00	11.00	45.00
June	17	-	11.76	17.66	11.76	29.41	29.41
July	8	-	12.50	62.50	-	-	25.00
August	14	-	21.43	-	14.90	28.57	35.71
September	6	-	-	-	33.33	16.67	50.00
October	10	-	-	-	30.00	20.00	50.00
November	9	-	22.22	22.22	11.12	-	44.44
December	13	-	7.69	15.38	15.38	23.08	38.47
Total	148		16.22	18.92	20.27	12.26	32.42

Table 4: Monthwise percentage of feeding intensity in female of *O. ruber.*

Months	No of specimen	High feeding		Moderate feeding		Low feeding	
		Gorged	Full	3/4th full	½ full	¼ full	Empty
January	15	-	13.34	13.34	20.00	26.66	40.00
February	24	-	12.50	12.50	24.50	12.50	38.00
March	16	-	-	50.00	18.75.00	12.5.00	18.75
April	13	-	-	15.38	7.69	15.38	61.55
May	10	-	20.00	-	20.00	30.00	30.00
June	23	-	21.74	21.74	4.35	8.70	43.47
July	7	-	-	14.24	28.58	-	57.18
August	11	-	9.09	9.09	-	27.27	54.55
September	12	-	25.00	41.67	-	16.67	16.67
October	14	-	28.57	14.29	14.29	7.14	35.71
November	18	-	-	5.56	27.77	16.67	50.00
December	20	-	5.00	20.00	10.00	5.00	60.00
Total	183		11.48	18.58	14.75	13.11	42.08

The study of feeding intensity in relation to length was observed that larger males did not show any trend in feeding intensity but fish in the length range of 151 – 370 mm showed higher feeding intensity except the groups of 211-230, 231-250, 251-270 and 311-330 mm. The female fish with middle length range of 211-350 mm were better fed than smaller sizes and larger length group *i.e.* more than 370 mm (Table 5 and 6).

Table 5: Percentage of feeding intensity in male of *O. ruber* in relation to length.

Length group (mm)	No. of specimen	High feeding		Moderate feeding		Low feeding	
		Gorged	Full	3/4th full	½ full	¼ full	Empty
150 - 170	4	-	70.00	20.64	9.36	-	-
171 – 190	15	-	26.60	-	-	20.00	53.4
191 – 210	11	-	18.18	-	27.27	-	54.55
211 – 230	18	-	-	-	-	-	100
231 – 250	8	-	12.50	-	-	-	87.50
251 – 270	10	-	-	-	-	-	100
271 – 290	27	-	5.50	14.20		54.80	25.50
291 – 310	6	-	-	-	-	-	100
311 – 330	21	-	4.76	-	-	14.29	80.95
331 – 350	6	-	-	33.30	16.60	33.30	16.80
351 – 370	9	-	22.22	-	44.44	-	44.44
371 – 390	5	-	-	20.00	20.00	-	60.00
391 – 410	2	-	-	50.00	50.00	-	-
411 - 430	1	-	-	-	-	-	100
431 – 450	3	-	-	-	66.60	34.40	-
451 – 470	1	-	-	100	-	-	-

Table 6: Percentage of feeding intensity in female of *O. ruber* in relation to length.

Length group (mm)	No. of specimen	High feeding		Moderate feeding		Low feeding	
		Gorged	Full	3/4th full	½ full	¼ full	Empty
131 - 150	2	-	-	100	-	-	-
151 - 170	15	-	60.00	26.70	13.30	-	-
171 – 190	7	-	28.60	57.10	-	14.30	-
191 – 210	17	-	-	-	17.60	29.50	52.90
211 – 230	16	-	12.50	25.00	-	18.70	43.80
231 – 250	8	-	12.50	-	25.00	12.50	50.00
251 – 270	25	-	12.00	20.00	12.00	8.00	48.00
271 – 290	27	-	-	3.70	18.50	3.70	74.10
291 – 310	17	-	5.90	5.90	5.90	11.80	70.50
311 – 330	3	-	-	66.70	-	-	33.30
331 – 350	8	-	12.50	12.50	37.50	37.50	-
351 – 370	1	-	100	-	-	-	-
371 – 390	9	-	-	22.20	-	-	77.80
391 – 410	3	-	33.30	66.70	-	-	-
411 - 430	2	-	-	50.00	-	-	50.00
431 – 450	2	-	-	-	-	-	100
451 – 470	1	-	-	-	100	-	-

The gastrosomatic index (GaSI) was calculated for each specimen to estimate the feeding intensity by making use of the following formula (GaSI: Weight of the gut/Weight of the fish in percentage). The gastrosomatic index of *O. ruber* was maximum during July (7.857) and August (7.598) and moderately high during June (4.962), September (4.9867) and December (4.576) while as low as 1.738 in the month of May (Table 7).

Table 7: Month wise Gastro-somatic index in *O. ruber*.

Months	GSI values
January	2.5588
February	2.3784
March	3.0244
April	2.5752
May	1.7383
June	4.9621
July	7.8577
August	7.5983
September	4.9867
October	2.9911
November	2.8183
December	4.5764

The Index of preponderance was estimated through the observations on the occurrence and volume of different food items from the stomach of 261 specimens collected during the investigation were presented in the Table 8. Index of preponderance for semi-digested fish (56.9%) was found to be maximum followed by semi digested shrimp (20.2%), *Solenocera* spp. (6.63%), *P. stylifera* (5.75%), *Stoliphorus* spp. (3.81%) and lesser sardine (1.74%) with lowest value for *Penaeus* spp. (0.048). It was noticed that occurrence of fish was dominant during the period of investigation. Monthwise index of preponderance is presented in the Table 8. Fish was dominant in the stomach during all the month except the month of July and August when shrimp was predominant food. *Acetes* spp. was maximum during July (26.25%).

Table 8: Index of Preponderance of *O. ruber* (pooled).

Food Item	Occurrence (O)	% of Occurrence(O_i)	Volume (V) in ml	% of Volume (V_i)	$O_i * V_i$	Index Preponderance
Acetes spp.	21	8.04	27.50	1.92	15.43	1.16
Stoliphorus spp.	17	6.51	111.30	7.79	50.71	3.81
Lesser Sardine	11	4.21	78.8	5.52	23.23	1.74
Silver belly	7	2.68	77.5	5.43	14.55	1.09
Squilla	8	3.06	39.50	2.76	8.44	0.63
Goat fish	6	2.29	93.6	6.55	14.99	1.12
Sciaenids	3	1.14	40.00	2.80	3.19	0.24
Solenocera spp.	33	12.64	99.50	6.97	88.10	6.63
P. stylifera	27	10.34	105.5	7.39	76.41	5.75
Sepia spp.	3	1.14	29.50	2.06	2.34	0.71
Loligo spp.	3	1.14	20.6	1.44	1.29	0.095
Flat fish	7	2.68	18.25	1.27	3.40	0.25
Small crab	3	1.14	15.80	1.10	1.25	0.094
Penaeus spp.	2	0.76	12.20	0.85	0.64	0.048
Semi digestive fish	67	25.67	420	29.43	755.46	56.90
Semi digestive Shrimp	42	16.09	238	16.67	268.22	20.20
Total	261		1427.05		1327.59	

Table 9: Monthwise Index of Preponderance of *O. ruber* (pooled).

Food Item	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Acetes spp.	-	-	-	-	-	-	26.25	13.26	-	-	-	-
Stoliphorus spp.	-	2.96	-	-	-	-	-	-	-	-	0.21	7.16
Lesser Sardine	5.39	4.07	2.43	0.96	2.32			4.72			2.79	1.07
Silver belly	-	0.37	0.81	-	-	-	-	-	-	-	-	-
Squilla	-	1.11	3.64	-	-	-	-	-	1.77	-	-	-
Goat fish	-	-	1.38	-	1.55	1.12	-	-	-	0.65	-	-
Sciaenids	-	1.11	-	4.4	-	-	-		-	3.17	-	1.43
Solenocera spp.	-	-	-	2.75	-	2.08			-	1.51	-	-
P. stylifera	-	4.81	2.05	3.71	-	-	6.75	2.24	-	-	-	2.50
Sepia spp.	-	-	-	-	-	-	-	1.82	-	-	-	-
Loligo spp.	-	-	-	-	-	0.16	-	-	-	-	1.89	-
Flat fish	1.17	-	-	-	-	-	-	-	-	-	-	-
Small crab	2.56	-	-	-	-	-	-	-	-	-	-	-
Penaeus spp.	0.87	-	0.81	-	-	-	-	-	-	-	-	-
Semi digestive fish	67.47	52.84	71.87	51.08	82.76	87.04	10.25	30.3	74.82	87.71	79.81	69.7
Semi digestive Shrimp	22.54	21.84	17.01	37.1	13.37	9.6	56.25	47.66	23.41	6.96	15.3	18.14

The month wise composition of food of *O. ruber* studied and a total of 13 types of food items were recorded from the stomachs of this species that included *Stoliphorus* spp., flat fish, goat fish, lesser sardine, silver belly, sciaenids, *Acetes* spp., *Penaeus* spp., *P. stylifera*, *Solenocera* spp., Squilla, small crabs and *Loligo* spp. Monthly percentage composition of different food items in the stomach content of this species is depicted in Table 10.

Table 10.

Length Group	No. of Specimens	Food items															
		***Acetes* spp.**	***Stoliphorus* spp.**	**Flat fish**	**Goat fish**	***Loligo* spp.**	**Lesser Sardine**	***P. stylifera***	***Penaeus* spp.**	**Silver belly**	**Squilla**	**Sciaenids**	***Solenocera* spp.**	***Sepia* spp.**	**Small crab**	**Semi digested fish**	**Semi digested Shrimp**
January	21	-	-	5.71	-	-	20.13	-	1.94	-	-	-	-	-	2.53	50.15	19.5
February	10	-	12.19	-	-	-	17.31	9.33	-	3.72	3.15	8.83	-	-	-	31.12	14.35
March	18	-	-	-	-	-	10.24	5.12	3.48	8.02	14.84	-	-	-	-	39.82	18.84
April	31	-	-	-	-	-	4.07	-	-	-	-	18.35	6.28	-	-	48.42	22.88
May	36	-	-	-	15.42	-	11.14	-	-	-	-	-	-	-	-	57.54	15.90
June	20	-	-	-	10.50	9.75	-	-	-	-	-	-	4.25	-	-	43.00	32.50
July	21	28.3	-	-	-	-	-	-	-	-	-	-	6.28	-	-	23.30	37.12
August	11	15.5	-	-	-	-	17.25	5.35	-	-	-	-	-	-	-	33.65	28.25
September	9	-	-	-	-	-	-	-	-	-	9.50	-	-	-	-	43.25	47.25
October	12	-	-	-	8.15	-	-	-	-	-	9.20	12.5	-	-	-	42.65	27.50
November	10	-	3.33	-	13.32	-	9.67	-	-	-	-	-	-	-	-	40.90	32.78
December	17	-	17.12	-	-	-	3.48	3.48	-	-	-	7.24	-	-	-	52.12	16.56

The present observation on the abundance of prawns as main food elements of younger fishes agrees with the findings of Venkataraman (1960); Nair (1979); Bhuyan *et al.* (2012). The selection of *Acetes* spp. by the small size groups of *O. ruber*, further evidenced by the observations of Bashiruddhin and Nair (1961). The preference of juveniles mainly for the crustacean feed also agrees with the observations of Bapat and Bal (1952); Fennessy (2000). Most of the food and feeding behaviours are in concurrence with the earlier observations made on food and feeding of this species. There is a strong correlation between the food item recorded in the stomachs and occurrence of different food organisms in the water where this species is abundant as assessed from the landing of prey items and the gut content of the fish.

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