Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2014 JNAS Journal-2014-3-11/1268-1274
ISSN 2322-5149 ©2014 JNAS

Evaluation of some feeding indices *of Atrobucca nibe* in the Northern Oman Sea

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ABSTRACT: In this paper the Vacuity Index (VI), Fullness Index (FI) and Food Preference Index (FPI) for the stomach contents of *Atrobucca nibe* were evaluated to assess the quantity and kind of food which this fish consumes in the north-west Oman Sea. A total of 251 fish specimens were collected twice per season from fishing lanternfish trawlers as by-catch of lanternfish from January 2012 to February 2013. The minimum and maximum total length was measured as 20-21 and 42-43 cm, respectively with mean length of 29.4 cm. The stomachs of 70 of them were full and semi-full and 181 were empty. The overall average Vacuity Index was 72.1 and the seasonal averages were 80.0, 88.6, 55.6 and 70.7 for autumn, winter, spring and summer respectively. Overall Fullness Index was 27.9 with seasonal averages of 20.0, 11.4, 44.4 and 29.3 in autumn, winter, spring and summer respectively. The main stomach contents were fish esp. flatfishes, crustaceans (esp. shrimp & crab), and isopods. The resulting Food Prevalence Indices were for fish 92.2, and crustaceans 32.2 with the main food of lanternfishes, minor food of crustaceans and other food items as random feeds. In overall, the results show that this fish is a relatively abstemious species which consume fishes and crustaceans as a major food.

***Keywords*:** *Atrobucca nibe*, Feeding, Food Preference, Vacuity and Fullness Indices, Oman Sea

INTRODUCTION

The Oman Sea with an area of 94000 km^2, and a depth reaching 3400 m, connects the Persian Gulf to the Indian Ocean through the Arabian Sea. It is located in the subtropical zone lying almost entirely between the latitudes of 24° and 30°N and longitudes of 57° 00′E to 61° 25′E (Fig.1). Average annual rainfall contributes between 3 and 8cm per year (Reynolds, 1993).

The entire water column is well mixed and lies within the photic zone. However, primary productivity for Oman Sea is apparently only in average, being higher than most of the Red Sea but lower than the Arabian Sea (Sheppard ., 1992). The bottom topography is mostly flat and featureless, dominated by soft sediments and a few rocky substrates in the Oman Sea.

Next to oil, fisheries are the second most important natural resource, and the most important renewable natural resource, in the study area (Carpenter ., 1997).

The waters of Persian Gulf and Oman Sea are environmentally unique with an unusual faunal assemblage (Carpenter ., 1997). There are numerous commercially exploited fish species which includes the black mouth croaker (*Atrobucca nibe,* family: Sciaenidae). This species is caught as one of the most important commercial by-catch of lanternfish fishery by industrial trawlers (Valinassab, 2011; Salarpouri ., 2014).

The black mouth croaker is new recorded commercial resources in the north-west of Oman Sea and the high amount biomass of them was found amongst trial-commercial fishing of lanternfishes. The most important myctophid species in the area is the skinnycheek lantern fish *Benthosema pterotum*, which is distributed throughout the Oman Sea (Gjosaeter & Tilseth, 1983; Johannesson &Valinassab, 1994). These myctophids feed on zooplanktons (e.g. copepods, euphausiids, ostracods) and, in turn, represent a major food resource for deep water and pelagic fish, thus acting as important link between secondary producers and upper trophic levels such as black mouth croaker (Hussain, 1992; Ishihara & Kubota, 1997).

A. nibe inhabits from coastal, 45 m to offshore waters to more than 250 m depth (Saski, 2001). In addition to the Oman Sea, it has been reported from western Indian Ocean, Mozambique, South Africa, India, China, Japan, and Philippine. It is also distributed in the northern areas of Australia to southern parts of Indonesia. It has been reported to reach a maximum length up to 47.5 cm (Salarpouri ., 2014) and specimens up to 42.5 cm are commonly caught in the fisheries.

Figure 1. Black mouth croaker, *Atrobucca nibe* (available at www.fishbase.com)

There are very few published studies on feeding of this species in the study area however Khadem-Sadr (2011); Valinassab . (2011) and Salarpouri . (2014) have assessed the feeding habits of *A. nibe* from the Oman Sea. They report that this species is an active predator, feeding generally on lanternfishes (*Benthosema pterotum*), small fishes, and crustaceans (crabs and shrimps).

This study conducted qualitative and quantitative analysis of stomach contents to determine the seasonal prey composition and feeding intensity of *Atrobucca nibe* in the north-west Oman Sea.

MATERIALS AND METHODS

The study was conducted in the sampling areas off Hormuzgan province, Oman Sea in southern Iran (Fig. 1). The study area extends between l longitudes 57º01'E and 58º30'E. Depths ranged from 150 to 300 m. A total of 251 fish specimens were collected from fishing lanternfish trawlers, as by-catch of lanternfish, from January 2012 to February 2013. Samples were obtained from each area twice per season by scientific observers on board of commercial trawlers. Samples were taken at pre-selected random fishing stations. The seasons corresponded to the quarters of the year i.e. winter is January to March etc.

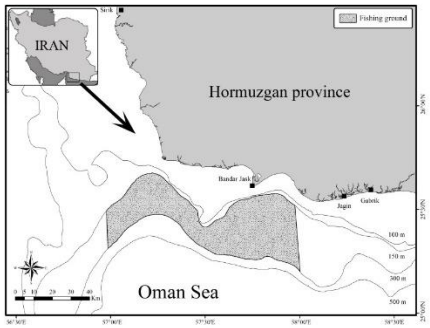

Figure 2. Map of study area in the north-west of Oman Sea

The specimens collected at sea were subsequently analyzed in the laboratory. The intact specimens were measured for total length (mm) and body weight (g). An abdominal incision was made to determine sex of the specimen and to extract the digestive tract. The stomach and intestine were weighed and then emptied and the stomach contents were preserved in 10% formaldehyde solution for further microscopic examination and identification of prey items. Stomach contents were identified in two stages, first they were sorted to higher taxa (e.g. fishes, crabs, shrimps, etc). Further identification within each taxonomic group was done following appropriate taxonomic identification guides (Fischer & Bianchi, 1984; Smith & Heemstra, 1986; Asadi & Dehghani, 1996; Carpenter ., 1997; Randall, 1997; Wolfgag, 1986; Sadeghi, 2003) and with the assistance of specialist experts for each group. Identified prey items were weighed to 0.01g precision.

To estimate the relation between total length (L) and total weight (W), the variables were log-transformed to meet the assumptions of normality and homogeneous variance. A linear version of the power function: $W = aL^b$ was fitted to the data. Confidence intervals (CI) were calculated for the slope to see if it was statistically different from 3.

Two feeding indices, vacuity index and food preference index, were calculated for each seasonal sample as well as overall (annual) index. The Vacuity Index (VI) reflects the frequency of feeding, i.e. the fraction of the population having food in the digestive tract and is defined (Euzen, 1987) as:

$$VI = \frac{E_S \times 100}{T_S}$$

Where:
E_S = number of empty stomach samples
T_S = Total number stomach samples.
The intensity of feeding as indicated by the VI is interpreted as:

- Edacious species $0 \le VI < 20$
- Relatively edacious species $20 \le \mathrm{VI} < 40$
- Moderate feeder $40 \le \mathrm{VI} < 60$
- Relatively abstemious $60 \le \mathrm{VI} < 80$
- Abstemious $80 \le \mathrm{VI} < 100$

Seasonal and sex based differences in VI were tested pairwise using two-sample Z-tests of proportion (REFERENCE) at p=0.05.

The second index relates to the relative importance of different prey groups in the diet using a Food Prevalence Index defined (Euzen, 1987; Biswas, 1993; who called it Food Preference Index) as:

$$FP_j = \frac{NS_j \times 100}{Ns}$$

Where:
NS_j = total number of individual prey of species *j* in all samples (stomach and intestine)
Ns = Total number of samples containing food.
If $FP_j < 10$ then species *j* is considered to be negligible in the diet. For FP_j between 10 and 50, species *j* is considered a minor prey species and if $FP_j > 50$ then species *j* is a main diet item.

RESULTS AND DISCUSSION

Results:

A total of 251 specimens of black mouth croaker (Atrobucca nibe) were collected from the selected sampling areas. The total length varied from 19.0 to 41.0 cm, while the total weight ranged between 63.5 and 788.3 g. and the resultant equation (Fig. 3) was: $W = 0.008\ TL^{3.062}$ ($R^2 = 0.96$).

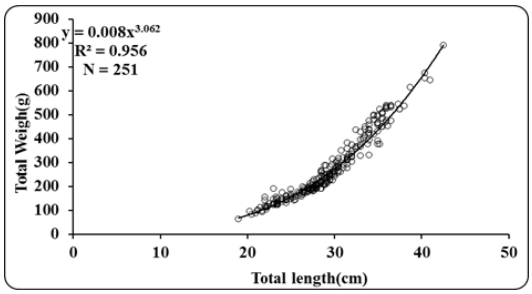

Figure 3. The length-Weight relationship for Atrobucca nibe in the northern Oman Sea

Overall there were 181 empty stomachs (VI = 72.1 %) in total (Table 1). VI was higher in the summer, autumn and winter; and there was no significant seasonal difference between them. VI was lower in the spring. The differences between the high VI seasons (summer, autumn, winter) and the low VI season (spring) were highly significant ($P < 0.05$).

Table 1. Seasonal sample numbers (N) and Vacuity Index (VI) in Atrobucca nibe overall and partitioned by sex in the northern Oman Sea (2012-2013)

Season	N (total)	Vacuity Index	Male		Female	
			N	VI	N	VI
Spring	81	55.6	40	67.5	41	43.9
Summer	41	70.7	20	70.0	21	71.4
Autumn	85	80.0	16	93.8	69	76.8
Winter	44	88.6	17	94.1	27	85.2
Total	251	72.1	93	77.4	158	43.9

Comparison of VI between males and females showed no significant difference over the entire year (P > 0.05). Also, the overall Fullness Index (FI) for both sexes was calculated as 27.9% in total with the highest amount for Spring Season with value of 44.4 % in total.

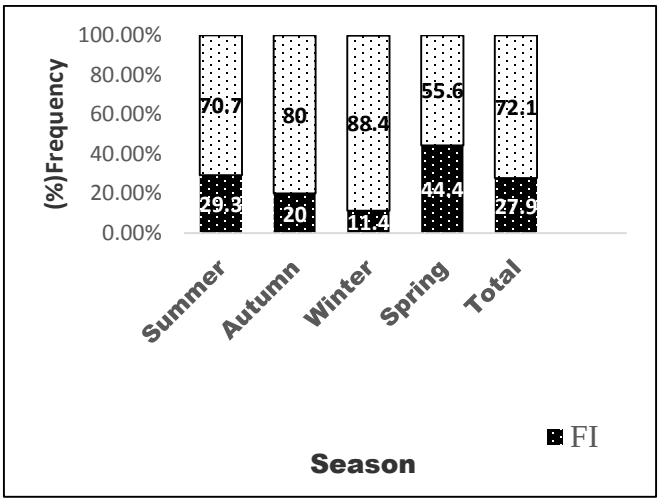

Figure 4. The seasonal changes of VI and FI in Atrobucca nibe in the northern Oman Sea

On the other hand, the seasonal changes of GaSI was estimated with the highest and lowest values for summer and spring-autumn, respectively (Table 2).

Table 2. The mean GaSI for Atrobucca nibe in the northern Oman Sea (2012-2013)

Season	Spring	Summer	Autumn	Winter	Whole Year
Number	36	12	17	5	70
Min	0.03	0.09	0.03	0.08	0.03
Max	12.09	13	6.41	8.87	13.00
Mean	2.04	2.24	0.88	2.76	1.84
SE	0.4	1.07	0.39	1.61	0.32

lanternfishes, Benthosema pterotum, are the only diet item for which the FP index (67.7%) exceeded the threshold (>50) to be considered a main diet item. It was important in the diet year-round being the highest or second highest FP in all seasons. Minor diet groups were shrimps with FP = 29.2%. The FP for all other groups, nempiterids, isopods, crabs, flatfishes & other bony fishes, was less than 10% making negligible contributions to the diet (Table 2).

Table 3. Food Prevalence (FP) Index for different types of the Consumed food by Atrobucca nibe in the northwest Oman Sea waters (2012-2013)

	Spring	Summer	Autumn	Winter	Whole year
Food type	n = 13	n =43	n = 17	n =39	n = 112
Isopoda	2.9	-	-	-	1.5
Crab	2.9	-	-	-	1.5
Lanternfish	61.8	83.3	68.8	66.7	67.7
flatfishes	2.9	-	-	-	1.5
Nemipterids	14.7	-	18.8	33.3	13.8
Other bony fishes	11.8	16.7	-	-	9.2
shrimp	32.4	8.3	37.5	33.3	29.2

Discussion

Understanding of fish nutrition habits requires extensive field and laboratory studies to infer the main sources of nutrition for a species. Even then, feeding studies such as this one can identify the prevalence of food items but it is not possible to assess the diet preferences of fish without detailed complementary studies to estimate the range and abundance of potential food items available in their natural environment. It is clear that food habits such as frequency of feeding or size and species of prey, are constrained by the evolutionary history leading to the species body shape and digestive system.

Based on the result of the analysis of length-weight relationship of A. nibe from this study, it is shown that the growth pattern of A. nibe was positive isometric (b = 3.062). Previous study by Salarpouri . (2014) on length-weight relationship A. nibe in the northern Oman Sea waters showed that the b value was 3.07 for males (positive isometric) and 2.93 for females (negative isometric) and it could be caused by the competition of black mouth croaker populations among themselves as well as the competition with other aquatic species. So, in this present study, the b value which is positive isometric and it can be concluded that the habitat and environment is such in a good condition for the A. nibe to live. In Indian waters the b-value for length-weight relationship equation was estimated as b=3.213 (Murty, 1980). The recorded maximum length was measured 42.4 cm, meanwhile this value was reported 38.0 cm in previous study (Khadem-Sadr, 2012).

In this study black mouth croaker (A. nibe) was shown to be a relatively abstemious feeder from the overall estimate of VI of 72.1%. This is consistent with results from Salarpouri . (2014) who estimated annual VI to be 77% i.e. also in the relatively abstemious range. Seasonal patterns in this study were also consistent with Salarpouri . (2014) with moderate feeding in winter, autumn, & summer and dropping to relatively abstemious in spring simultaneous with spawning season.

The A. nibe is a carnivorous species with the main food item of fishes and amongst them the lanternfishes are the main food with Fp value of 67.7% and it is in agreement with findings of Valinassab . (2011); and Salarpouri . (2014) in the Oman Sea; and Apparao (1989) in India waters. Shrimps with Fp= 29.2% are the next most important food item (Table 3). The distribution pattern of black mouth croaker is in the dense area or main fishing ground of lanternfishes in the north-west of Oman Sea (Valinassab ., 2011). The feeding habit of A. nibe in the India waters show that the main food were identified as different fishes consist of Opisthopterus sp. , Uranoscopus sp. , Cynoglossus sp. , Anchoviella sp. , Bregmaceros sp. , Pseudosciaena sp. , Trichiurus sp. and Caranx sp. and different crustaceans consist of Acetes sp. , Penaeus sp. , Metapenaeus sp. , Solenocera sp. and Squilla sp. (Apparao, 1989).

The capability of rapid digestion which may contribute to the high values estimated for VI. The speed of digestion also makes detailed taxonomic identification less achievable. In this study, sample collection was carried out during daylight hours only. If A. nibe feeds more heavily at night the daytime sampling may have resulted in many stomach contents being highly digested or stomachs being empty. Further study to determine the diurnal pattern of feeding would clarify this issue. The in detailed identifications (as species or genus) of stomach contents of black mouth croaker revealed the food items of Benthosema pterotum (Myctophidae family), Nemipterus japonicus (Nemipteridae family), Saurida tumbil (Synodontidae family), Cynoglossus puncticeps (Cynoglossidae family) and two families of Hippolytidae and Penaeidae from shrimp group; and from isopods family of Cymothoidae (Cymothoa exigua). Also it is noteworthy to be mentioned that the Anisakis worms have been observed several times both inside and outside of the stomach but they cannot be considered as food item but they are assumed to be exoparasite with no harm for further human consumption of black mouth croaker flesh, in agreement with findings of Khadem-Sadr (2011).

Salarpour . (2014) reported that there is an inverse relationship between spawning and feeding in this fish species. During spawning the gonads, but especially ovaries, grow substantially larger, generally filling the body cavity. This displaces and limits the size of the digestive tract in turn limiting fish feeding.

Our results indicate that crustaceans, almost entirely B. pterotum, are the single major food group and minor groups include shrimps, isopods and other bony fishes. Other groups observed in the diet data are considered negligible. Valinassab . (2011) and Salarpouri . (2014) have consistently identified fish (Fp=92.5%) and shrimps (Fp=22.5%) as important food groups. The in detailed identifications were reported as the following food items: family Myctophidae (Benthosema pterotum, Fp=70%), family Acropomatidae (Acropoma japonicum, Fp= 17.5%), family Champsodontidae (Champsodon capensis, Fp= 5.0%), family Nemipteridae (Nemipterus japonicus, Fp= 2.5%), families Clupeids and …(Fp= 12.5%) and from crustaceans (mainly shrimps) the main identified food items were from family Hippolytidae (Axhippolysmata ensirostris, Fp= 10.0% and Latreutes sp. Fp= 7.5%), and from cephalopods two species of Sepia pharaonis and Uroteuthis duvaucelii with Fp= 5.0%) were observed amongst stomach contents of black mouth croaker. In total, it can be concluded that the identified food items in A. nibe is completely in agreement with findings of Valinassab . (2011) and Salarpouri . (2014); but has some differences with

the reported results from India waters in which it can be due to ecological differences between Oman Sea with north-eastern Indian Ocean of India waters; and also availability of foods items in the habitat (Nikolski, 1963; Abdel ., 1993).

The amount of food digestion is dependent on the type of feeding agent, fish species, temperature and the rate of swallowed feed is different (Bond, 1979). The presence of identifiable remains from shrimps and crabs in the intestine indicates less complete digestion of them in comparison with food items which were observed in the stomach only. This suggests that the chitinous exoskeletons of crustaceans persist longer in the digestive tract and consequently may be over-represented in the identified remains.

As an overall conclusion, the A. nibe, black mouth croaker, is a carnivorous and relatively abstemious species. They select their food items according to amount of availability, with preference of fishes, in their habitats.

ACKNOWLEDGEMENT

The authors would have special thanks for Captain and personnel of different commercial Fishing vessels, lanternfish trawlers, for all helps for collecting the samples. Also we are grateful to the reviewers of the manuscript for all technical advises in which makes a serious work to provide more valuable publication.

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