Dietary preference and feeding ecology of Bloch's gizzard shad, *Nematalosa nasus*

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ABSTRACT

Dietary preference and feeding ecology of *Nematalosa nasus* (Bloch, 1795) in Chilika lagoon, India, was investigated through analysis of prey items in the guts and that in the habitat. Of the 230 taxa identified from the habitat in plankton samples from the lagoon, thirty five taxa were recorded from the guts of the fish. Index of Relative Importance showed 80% of the food comprised of microplankton groups *viz*. Foraminifera (35.79%), Chlorophyceae (20.52%), Bacillariophyaceae (12.30%), Cyanophyaceae (6.53%), other plant matter (3.65%) and Euglenophyaceae (0.76%). The fish is a generalized feeder on microplankton, with specialization on foraminiferans and Chlorophyaceae in Chilika lagoon. Diet composition varied significantly with seasons. Prey type selectivity showed, preference to *Gyrosigma*sp. (α_i-0.98, e_i-0.85), *Synedra* sp. (α_i-0.47, e_i-0.71), *Tabellaria* sp. (α_i-0.58, e_i-0.47) and *Ulothrix* sp. (α_i-0.06, e_i-0.34) during monsoon and post-monsoonseason. *Ammoniabeccarii*α_i-(0.77 e_i-0.98), *Campylodiscus* sp. (α_i-0.04e_i-0.17) and *Microspora* sp. (α_i-0.18e_i-0.76), were selected during pre-monsoon period, which is also the peak breeding period of the fish.

Key words: Nematalosa nasus, dietary preference, feeding ecology, Chilika lagoon

INTRODUCTION

Fishes exhibit varieties of feeding behavior, from highly specialized (e.g. lepidophagy) to very generalized(available abundant resources) food types(Nelson 2006; Winemiller, *et al*. 2008).Knowledge on food types and feeding ecology of any fish species is important to understand its functions in relation to its habitat (Wetherbee and Corte´s, 2004),prey selection (Motta and Wilga, 2001),predation (Martin, *et al.* 2005), competition and trophic interactions (Stergiou and Karpouzi, 2002), that form basis for their resource management and conservation. Feeding ecology of a species includes the food habits, foraging behavior and its foraging habitat (Gerking, 1994). As food selectivity or prey specificity of a fish species has strong influence on the behavior of a fish (Jobling, 1995), including its reproductive behavior (Safina and Burger, 1988; Brooker, *et al*. 2012),studies on feeding ecology of fishes of various feeding habits (Juanes, *et al.*, 2008) and growth stages (Pepin and Penney, 2000; Gaughan and Potter, 1997) are important in developing trophic models for conservation/ management strategies for both, the species and its environment (Hoggarth, *et al.* 2005; Simpfendorfer, *et al.* 2011).

Clupeidae, among the families of world's important fish species for food, oil and fish meal; include shads, herrings, sardines, anchovies, *etc.* (Windsor, 2001; Pike and Jackson, 2010).They are mostly marine foraging fishes (Froese and Daniel, 2015), although some are brackish water, freshwater and anadromous (Whitehead, 1985). Dietary information on Clupeids in general are vast; mostly classified as generalized filter feeders, adapted to forage on pelagic and benthic plankton (Lévêque, 1997). The feeding habits of these fishes show wide spatial and temporal variations (Marshall, 1991; Shoji and Tanaka, 2005). The Bloch's gizzard shad, *Nematalosa nasus*, belonging to the family Clupeidae, is ananadromous fish that inhabits a wide range of marine, brackish water and freshwater, pelagic to neritic environments (Riede, 2004). The species is distributed from the eastern (Conlu, 1986; Mohsin, 1996) and western (Hussain, 1998;

Al- Dubakel, 1986; Majeed, 1989; Taher, 2010) Indian Ocean to northwest and western central Pacific Ocean (Whitehead, 1985). The species forms commercial fisheries in China (Ni, 1999; Chen, 2004), Japan (Pauly, 1982), Sri Lanka (Atapattu and Nissanka, 2005) and India (Talwar and Kacker, 1984; Sen, 1987). In spite of the wide distribution and commercial importance, little is known of the biology of the fish, especially the dietary preference and feeding ecology. From southern Iraq Al- Dubakel (1986) reported that the diet of the species consists of algal matter and copepods, while Majeed (1989) and Taher (2010) reported detritus and fish eggs as food of the fish and classified the fish as omnivore. Though Jeyaseelan and Krishnamurthy (1980), Al-Dubakel (1986), Majeed (1989) and Taheer (2010) have qualitatively described the gut contents of the species, its feeding ecology and specific food preference remain largely unknown. Although the fish has been reported from all along the coasts of India (Parimala, 1983 and Daniels 2002), along the northern Bay of Bengal, it forms a major commercial fishery, especially in the coastal lagoon, Chilika, which is Asia's largest brackish water lagoon and a Ramsar site (Ramsar Advisory Mission, 2001). The species forms year round fishery in the lagoon, contributing to 21% of the total fish landing (Jones and Sujansingani, 1954; CDA, 2013). The lagoon, with its estuarine environment, due to freshwater influx through rivers and seawater through seamounts, provide breeding and foraging ground for the fish (Jhingran and Natrajan, 1963; Kowtal, 1970; Kowtal 1976) and are caught indiscriminately. As prerequisites for ecosystem based management of fisheries of the lagoon, generation of information on their feeding ecology is important. The available information on the food of the fish from Chilika lagoon suggests the fish subsists on detritus (Rajan *et al.*, 1968).The objective of this study was to examine the diet preference and feeding ecology of *N. nasus* in Chiilka lagoon. Seasonal variation in food type and its relation to the habitat of the fish were also included to provide comprehensive information on its feeding ecology.

MATERIALS AND METHODS

STUDY AREA

Chilika lagoon, situated in Odisha, along the north east coast of India, lying between 19^o 28' and 19^o 54' North latitude and 85^o 06' and 85^o 35' East Longitude, is Asia's largest brackish water lagoon, with a water spread of 1165 km^2 and depth varying between 0.38 and 4.2 m (Annandale and Kemp, 1915). It has been a designated Ramsar site since 1981 (Ramsar Advisory Mission, 2001). The lagoon supports a large number of flora and fauna including highly commercial fish species. The lagoon has characteristics of an estuarine ecosystem, as a result of precipitation and influx of freshwater from 52 rivers; of which distributaries of Mahanadi river system are the most important, and seawater influx from Bay of Bengal through two sea mouths; one directly opening the Bay of Bengal (Sea mouth 1) and the other through a narrow canal at the southernmost tip of the lagoon (Sea mouth 2) (Figure. 1). Based on the salinity gradient and depth, the lagoon has been classified into four broad ecological zones, the southern zone (saline), central zone (brackish), northern zone (fresh water) and the outer channel (saline) (Balachandran *et al.*, 2005) as shown in Figure. 1. The salinity of the sectors ranged between 6. 10-33.20 ppt in southern zone, 6.30-23.90 ppt in central zone, 0-0.8 ppt in northern zone and 1.20-34pp) in outer channel. Thus the lagoon support diverse fish (Jhingran and Natrajan, 1963; Rajan *et al.*, 1968; Rama Rao, 1995) as well as plankton communities (Jhingran and Natrajan, 1963; Patnaik, 1971; Srichandan *et al.*, 2012).

SAMPLE COLLECTION

A total of 142 specimens of *N. nasus*were sampled monthly from the four sectors of the lagoon from fishers' catch when they were being fished. Immediately after capture the fishes were dissected and their viscera were preserved in 4% formalin to prevent further digestion. The digestive tract was separated from the viscera from esophagus to anus and measured for length and weight. These were then slit open and the gut contents were collected. The empty guts were measured to find the volume of the gut contents and the contents analyzed using numerical (by both number method and frequency of occurrence) (Hynes, 1950; Hyslop, 1980) and volumetric (point method) (Lima-Junior and Goitein, 2001) methods. To see the seasonal variation in diet preference, the study period was classified into three major seasons of the locality, as pre-monsoon (March-June) thesummer, monsoon (July-October) having rainfall and post-monsoon (November-February) the winter.

Plankton sampling took place at 12 stations located in the four sectors of the lagoon (Figure. 1) from July 2012 to June 2013. Within each of these stations plankton net of 20 micron mesh were used for plankton collection. Immediately after collection, the samples were fixed and preserved in 4% formalin and brought to laboratory for further analysis.

DATA ANALYSIS

Plankton samples were identified using Newell and Newell (1986); Prescott (1961); Tomas (1997) and Ward and Whipple (1959) up to genus/ species level wherever possible. Quantitative analysis was carried out by Sedgewick Rafter counting cell (APHA, 2005). The quantitative and qualitative analysis of the gut contents were carried out by using 'Index of Relative Importance' (IRI) (Pinkas *et al.*, 1971). The index takes into account the unit volume of the food item, its frequency of occurrence and number expressed in percentage. Thus IRI is expressed as $\mathbf{IRI_i = (\%N_i + \%V_i)\ \%Oi}$, where, N_i, V_i and O_i represent the percentage of number, volume and frequency of occurrence of prey 'i' respectively. The size of the food items were measured by capturing images under 10 to 60x magnification, using a Nicon Eclipse 50i microscope having image processing features. To estimate the feeding strategy and prey importance of the fish, the prey-specific abundance method, a modified Costello's (Costello, 1990) method by Amundsen (1996) was followed (Figure. 2). The prey- specific abundance i.e. percentage of prey taxa using only those predators in which the prey taxa actually occurred is calculated as $\mathbf{P_i = (\sum S_i / \sum St_i) * 100}$. Where S_i is the stomach content comprised of prey i and St_i is the total stomach content in only those fishes with prey i in their stomach. According to Amundsen (1996), a graph plotted with the above calculated prey specific abundance against frequency of occurrence provides information on prey importance and feeding strategy of a predator. Points on the vertical axes represent feeding strategy, the upper part denotes specialization and lower part denotes generalization on prey type. Points on upper right and lower left indicate dominance or rarity of a prey type in the feeding habit. The prey points in upper left or lower right indicate high specific abundance (different individuals specialize on different prey types) and low specific abundance (most individuals utilize many prey types simultaneously) respectively, i.e. between and within phenotype contribution to the niche width.

Seasonality in feeding behavior was assessed by the analysis of similarity (ANOSIM) using the Plymouth Routines in Multivariate Ecological Research (PRIMER V6.1.6) software package (Clarke and Gorley 2006). The Manly-Chesson selectivity index (Manly, 1974; Chesson, 1978) for relative abundance of different taxa was used to determine food species preference of fish species, considering the plankton in environment and fish gut. When selectivity index (α_i) values are greater than 1/m, where m is the total number of prey types, the prey is considered as preferred, whereas values less than 1/m indicate avoidance. Because α_i is a function of the number of plankton groups or prey types present and as the number of groups varied between sampling periods, selectivity values were converted to electivity values (e_i) according to Chesson (1983). The e_i values vary between +1 to -1, where, +1 indicates complete preference, -1 indicates complete avoidance and 0 indicates neutral selectivity.

RESULTS

DIET COMPOSITION

The diet of 73 *N. nasus* specimens were examined from the 142 sampled that contained gut contents, ranging in L_T from 100 to 250 mm. A cumulative prey curve of the gut data (Ferry and Caillet, 1996) approached an asymptote at 40 guts demonstrating the sample size was satisfactory to adequately describe the diet composition (Figure. 3).The gut contents consisted of 35 prey taxa from among the 230 taxa identified from the environment from where the species were sampled; the main prey groups being foraminiferans (%IRI= 35.79) and Chlorophyaceae (%IRI= 20.52)(Figure. 4). The most common prey item identified from the guts was *Ammonia beccarii* (% Oi= 24.11) a foraminifera species. Of the second dominant group Chlorophyaceae, the most common prey taxa were *Spirogyra* sp.(% Oi= 26.03)and *Microspora* sp. (% Oi= 21.92%). Bacillariophyaceae (%IRI = 12.30%) were also relatively important group with *Tabellaria* sp. (% Oi= 23.29), *Navicula* sp. (% Oi= 20.55), *Gyrosigma* sp (% Oi= 16.44) and *Synedra* sp. (% Oi= 12.33) as most commonly occurring (Table I). Cyanophyaceae (6.53%) though was the least dominant group with *Oscillatoria* sp. (%Ni= 0.57) and *Lyngbya* sp. (%Ni= 1.10) relatively less in number, the occurrence of these species (% Oi= 24.66 and 10.96 respectively) were considerably high. Though the sand particles were ingested less (% Oi=17.81, %Ni= 3.04), their volume (% Vi= 11.79) magnified the importance (% IRI= 10.22)in the gut contents. These food types ranged between 14.42 µm - 590.78 µm, which when categorized were found to be microplankton and mesoplankton (Table II). For all the three seasons (pre-monsoon,

monsoon and post-monsoon) of a year, there was difference in occurrence across prey type percentage. Foraminiferans dominated both numerically and volumetrically during monsoon (Figure. 4a) and post-monsoon (Figure. 4b) period, but the relative importance (%IRI=28.35) was highest during pre-monsoon period (Figure. 4c). Unlike Chlorophyaceae, that dominated the diet as second most occurring taxa during monsoon and post-monsoon, Bacillariophyacea was dominant during pre-monsoon. The proportion of Cyanophyaceae, Euglenophyaceae and Copepods varied with seasons; increasing from pre-monsoon to post-monsoon. Other numerically and relatively important groups like Nematodes and Crustaceans were mostly restricted to post-monsoon. When comparing the frequency of sand particles in gut contents, which appeared throughout the seasons, the percentage (%Oi, %Ni) was higher during pre-monsoon. The fish being a benthic filter feeder (Jeyaseelan and Krishnamurthy, 1980) the sand particles appeared to be incidentally ingested while foraging.

FEEDING STRATEGY

In order to assess the feeding strategy of the species, the prey specific abundance (*% pi*) was plotted against the frequency of occurrence (*% F*) (Figure. 2). The diagonal in the upper right corner of the graph indicated prey importance as foraminiferans being the most dominant prey type, whereas nauplii, cladocerans, nemata and other crustaceans, located in the lower left corner of the diagram, were rare prey groups and of lower importance for *N. nasus*(Figure. 5). Specialization on Chlorophytes and generalization on Bacillariophytes, Cyanophytes and Euglenophytes are also evident from the graph. The species had high between-phenotype component (BPC) to the niche width only in other unidentified plant matter, which meant only few individuals of the fish population showed specialization to other unidentified plant matter.

No within-phenotype component to any food type was observed, which meant no specialization to any food type within the population of *N. nasus*.

PREY PREFERENCE

Of the 35 prey taxa identified from the gut of *N. nasus*, only ten were consumed in greater proportion than they constituted in the plankton community they were sampled from (Table III). The prey preference varied with seasons, wherein *Gyrosigma* sp. (α_i-0.98,e_{i-}0.85), *Synedra* sp. (α_i-0.47,e_{i-}0.71), *Tabellaria* sp. (α_i-0.58, e_{i-}0.47) in Bacillariophytes and *Ulothrix* sp. (α_i-0.06, e_{i-} 0.34) in Chlorophytes were preferred during monsoon and post-monsoon period, while *Campylodiscus* sp. (α_i-0.04e_{i-}0.17), *Microspora* sp. (α_i-0.18e_{i-}0.76), *Ammoniabeccarii*. α_i-(0.77 e_{i-}0.98) were selected during pre-monsoon. The other groups like copepods, nauplii and nematodes were relatively less selected despite their continuous presence in the gut.

DISCUSSION

This study examined the diet and feeding ecology of *N. nasus,* a very common and commercially important clupeid fish in Chilika lagoon, India. It linked gut contents of the species to prey abundance in its habitat across different seasons. As pyloric stomach in the foregut and pyloric caecae in mid-gut of partially folded digestive tract increases the surface area for absorption (Buddington, 1986) and a relative gut length of around 0.85 indicated omnivorous feeding habit (Ostrander, 2000), *N. nasus*can be classified to be an omnivore. But these observations do not concur with Taher (2010), who classified the species under carnivore, indicating fish eggs as most dominant food content followed by organic detritus and crustaceans. Al-Dubakel(1986) and Majeed (1989)reported diatoms, plant and organic matter as major content of the gut and thus classified the fish as omnivore. Jeyaseelan and Krishnamurthy (1980), though classified the fish species under omnivore with plant, animal and detritus matter as food, however examined only juveniles of size range 61-90mm. The present study observed year round occurrence of planktonic diatoms, copepods and foraminiferans along with filamentous algae and nematodes in the gut of *N. nasus* from Chilika lagoon. As evident from frequency of occurrence (% Oi) and IRI (Figure. 4), foraminiferans (35.79%) were the dominant gut content, followed by *Spirogyra* sp. and *Microspora* sp. under Chlorophyacae (20.52%) and a number of diatoms under Bacillariophyaceae (12.30%). The food types when categorized on the basis of size were found to fall under two categories; microplankton and mesoplankton (Table II) and index of relative importance showed microplankton to comprise 80% of the food type (Table I).

Plots of feeding strategy (Figure. 2) suggested *N. nasus* to follow a mixed feeding strategy, but basicallya generalized feeder, feeding on large number of food types (mostly Bacillariophycae, Cyanophyceae, Euglenophycea) as also indicated by diet composition. The prey points (Figure. 5) indicated specialized feeding only on Chlorophyacae, which possibly is based on their availability in the habitat (Pinnegar *et al.*, 2003). Theindividuals of the population showed specialization in their food type by high between-phenotype components (BPC) to the niche width. Thus, the specialization in prey selection was individualistic and not by entire population. Foraminiferans occurred as the most dominant food type (Figure. 4), but varied with seasons (Figure. 4a, b and c).The significant difference in diet within individuals and seasons (ANOSIM p= 0.001, R=0.583) could be attributed to the preference on plankton based on their availability in the habitat.

Seasonal variation in diet may possibly be related to the availability of prey items in the habitat, whose distribution and abundance vary with characteristics of the habitat (Muto *et al.*, 2001). Manly-Chesson selectivity index (Manly 1974; Chesson 1978) for relative abundance of different prey species was used to determine prey preference of fish species, considering the prey items in habitat and fish gut. The gut content of *N. nasus* showed most frequent occurrence of 20 species of Bacillariophyaceae, three species of Cyanophyaceae, three species of Chlorophyceae and one species of foraminifera. The food types were mostly microplankton (Table II), a group representing lower but important strata of the food chain (Calbet and Landry, 2004; Calbet, 2008). Abundance of the same in the habitat was estimated in average as 428434 unit m^{-3}. In the present study, the Manly's index calculated (α_i) should be greater than 1/m *i.e.* 1/34= 0.03 and Chesson's (ei) index to be +1 for a prey species to be preferred item (Manly 1974; Chesson 1978). During monsoon and post-monsoon period the fish species preferred Bacillariophyte and Chlorophyte microplankton like *Gyrosigma* sp., *Tabellaria* sp., *Synedra* sp., *Fragilaria* sp. and *Ulothrix* sp. Only during the pre-monsoon period, the fish specifically preferred the foraminiferan species, *Ammonia beccarii*, over other food types along with *Microspora* sp. This preference of *N. nasus* on foraminiferans coincided with its peak breeding season during June-July (Jhingran and Natrajan, 1963; Kowtal, 1970). Kowtal (1976) also reported the lagoon as breeding ground of the fish. The southern sector of the lagoon being connected to the sea has higher salinity during pre-monsoon period, thus supports a number of marine plankton. While the northern and central sectors remain low in salinity due to freshwater incursions from a number of rivers, which is not favorable for *Ammonia beccarii,* a marine microplankton (Gross, 2014) foraminiferan. *A. beccarii* is abundant in plankton samples of the lagoon, especially the outer channel (Jayalakshmy and Rao, 2001) and southern sector during pre-monsoon. It is also reported to be the most dominant and widely distributed foraminiferan species in the lagoon (Rao *et al.*, 2000). Thus the fish can feed on the foraminiferans, when it enters the southern sector of the lagoon for breeding. Whereas, during the monsoon and post-monsoon period, the fish species prefers other microplankton species of Chlorophyaceae (11479 and 386 unit m^{-3}), Bacillariophyaceae (54738 and 1157 unit m^{-3}), and Cyanophyaceae (47507 and 3997 unit m^{-3}) along with copepods (41499 and 4543 number m^{-3}) and nematods (39 and 75 number m^{-3}), which are abundant throughout the lagoon. The specific prey selectivity influencing reproductive behavior of a number of fishes have been reported (Safina and Burger, 1988; Brooker, *et al*. 2012), but the affinity of *N. nasus* towards the foraminiferans in the present study, during breeding period, though evident, needs further detailed investigations to understand the reason for such selectivity and its relation to the breeding of the fish.

In Conclusion, the results suggested that *N. nasus* is a microplankton feeder in Chilika lagoon with dominant and seasonally specialized feeding habit on benthic foraminiferans (*Ammonia beccarii*) during breeding season and generalized feeding habit on other microplankton groups of bacillariophyaceae, chlorophyaceae, cyanophyaceae and copepods, nematodes in other seasons. The species being commercially important, with generalized feeding habit may well adapt to changes in the prey items in the habitat with changes in hydrological regime in respect of salinity, but its specialized feeding on *Ammonia beccarii* in breeding season needs consideration while managing the environment. Information on their feeding habit and role of microplankton in their feeding ecology will help better understanding for applying ecosystem principles to fisheries management of the species.

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TABLES

Table 1. Percentage of number (% Ni) and the percent of frequency of occurrence (% Oi) of each important taxon identified from the guts of *N. nasus*.

Gut contents	% Ni	% Oi	Gut contents	% Ni	% Oi
Cyanophyaceae	**2.02**	**43.84**	*Cycotella* sp.	2.17	5.48
Oscillatoria sp.	0.57	24.66	*Diploneis* sp.	1.28	2.74
Lyngbya sp	1.10	10.96	*Grammatophora* sp.	1.28	6.85
Phormidium sp.	0.34	8.22	*Cymbella* sp.	0.16	2.74
Chlorophyceae	**0.30**	**7.00**	*Aulocosira* sp.	1.45	1.37
Spirogyra sp.	24.62	26.03	*Diatoma* sp.	2.24	1.37
Microspora sp.	3.24	21.92	**Euglenophyaceae**	0.10	15.07
Ulothrix sp.	0.30	6.85	**Rhodophyacae**	**0.28**	**4.11**
Bacillariophyaceae	**17.00**	**164.38**	*Polysiphnia subtilissima*	0.28	4.11
Navicula sp.	1.75	20.55	**Plant matter**	12.59	27.40
Nitzschia sp.	0.24	6.85	**Tintinnida**	**0.94**	**5.48**
Asterionella sp.	0.14	6.85	*Favella* sp.	0.26	2.74
Synedra sp.	1.26	12.33	other tintinnids	0.68	2.74
Gyrosigma sp.	0.33	16.44	**Foraminifera**	**8.73**	**69.86**
Rhizosolenia sp.	0.20	8.22	*Ammonia* sp.	8.73	69.86
Fragilaria sp	0.12	4.11	Copepoda	4.61	38.36
Tabellaria sp.	1.19	23.29	Cladocera	1.87	4.11
Thalassionema sp.	0.30	2.74	Rotifera	5.58	1.37
Rhopalodia sp.	0.11	1.37	Nauplii	0.54	5.48
Frustalia sp.	1.22	4.11	Isopoda	0.34	1.37
Pinnularia sp.	0.29	13.70	Crustacea	4.22	12.33
Coscinodiscus sp.	0.56	9.59	Nemata	8.75	5.48
Campylodiscus sp.	0.70	13.70	Sand particles	3.04	17.81

Table 2. Average size (micron) with standard deviation of prey items of *N. nasus.*

Prey item	Average size (micron)	Std. dev	Classification based on size
Bacillariophyaceae	33.46	31.5	Microplankton

Chlorophyceae	33.8	36.8	
Cyanophyaceae	14.42	6.84	
Euglenophyaceae	54.87	9.36	
Rotifera	104.49	53.98	
Foraminifera	169.05	62.56	
Plant matter	151.67	147.06	
Copepoda	590.78	217.11	Mesoplankton
Nemata	277.66	75.92	
Rhodophyacae	507.14	788.3	
Molluscan shells	397.61	34.17	

Table 3. Manly-Chesson selectivity index of *N. nasus* to determine prey species preference.

	Pre-monsoon		Monsoon		Post-monsoon	
Food items	**alpha**	**ei**	**alpha**	**ei**	**alpha**	**ei**
Asterionella sp.	0.00	0.00	0.00	-1.00	0.00	-1.00
Aulocosira sp.	0.01	-0.54	0.00	-1.00	0.00	-1.00
Campylodiscus sp.	0.04	0.17	0.00	-1.00	0.00	-1.00
Coscinodiscus sp.	0.00	-0.98	0.00	-1.00	0.00	-0.78
Cyclotella sp.	0.00	-0.90	0.00	-1.00	0.00	-1.00
Cymbella sp.	0.00	-1.00	0.00	-1.00	0.00	-1.00
Diatoma sp.	0.00	-1.00	0.00	-1.00	0.00	-1.00
Diploneis sp.	0.00	-1.00	0.00	-1.00	0.00	-0.86
Fragilaria sp.	0.00	-1.00	0.07	0.40	0.00	-0.72
Frustalia sp.	-	-	0.00	-1.00	0.30	0.87
Grammatophora sp.	0.00	-0.99	0.00	-1.00	0.01	-0.39
Gyrosigma sp.	0.00	-0.99	0.75	0.98	0.27	0.85
Navicula sp.	0.00	-1.00	0.00	-0.97	0.00	-0.74
Nitzschia sp.	0.00	-1.00	0.00	-1.00	0.00	-0.94
Pinnularia sp.	0.00	-1.00	0.00	-1.00	0.05	0.26
Rhizosolenia sp.	-	-	0.00	-1.00	0.00	-1.00
Rhopalodia sp.	-	-	0.00	-1.00	0.01	-0.58
Synedra sp.	0.00	-0.99	0.08	0.47	0.15	0.71
Tabellaria sp.	0.00	-0.97	0.10	0.58	0.08	0.47
Thalassionema sp.	0.00	-1.00	0.00	-0.87	0.00	-0.85
Lyngbya sp.	0.00	-0.87	0.00	-0.88	0.00	-0.99
Oscillatoria sp.	0.00	-1.00	0.00	-0.84	0.01	-0.48
Phormidium sp.	0.00	-1.00	0.00	-1.00	0.00	-0.82
Microspora sp.	0.18	0.76	0.00	-1.00	0.01	-0.68
Spirogyra sp.	0.00	-1.00	0.00	-1.00	0.00	-0.97
Ulothrix sp.			0.00	-1.00	0.06	0.34
Euglena sp.	0.00	-1.00	0.00	-0.96	0.00	-0.79

Polysiphnia subtilissima	0.00	-1.00	0.00	-1.00	0.02	-0.19
Tintinnida	0.00	-1.00	0.00	-1.00	0.00	-1.00
Ammonia sp.	0.77	0.98	0.00	-1.00	0.00	-1.00
Copepoda	0.00	-1.00	0.00	-0.98	0.00	-0.99
Cladocera	0.00	-1.00	0.00	-1.00	0.00	-1.00
Rotifera	0.00	-1.00	0.00	-1.00	0.00	-1.00
Nauplii	0.00	-1.00	0.00	-1.00	0.00	-0.98

FIGURES

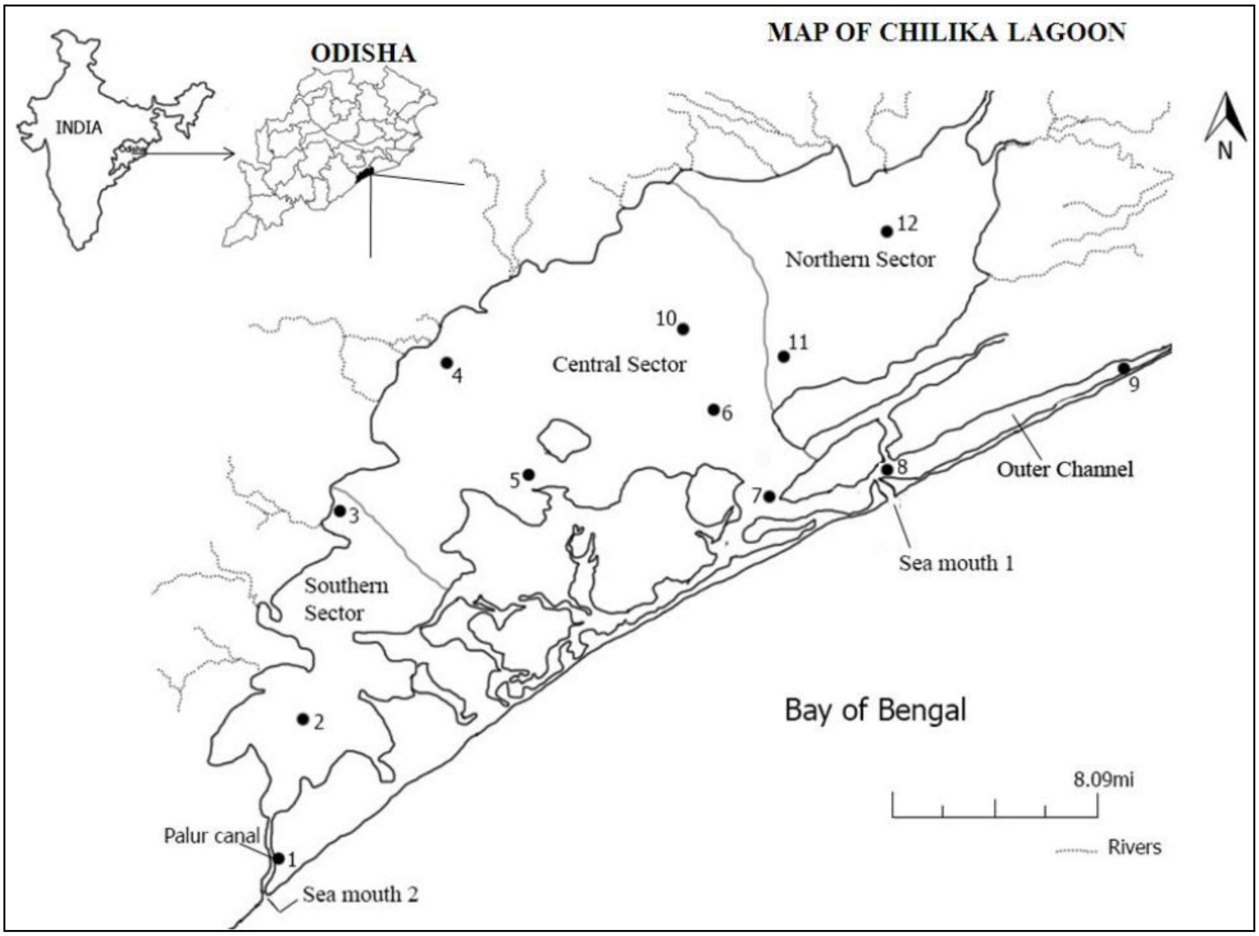

Figure. 1 Map of Chilika lagoon with sectors covered for the study.

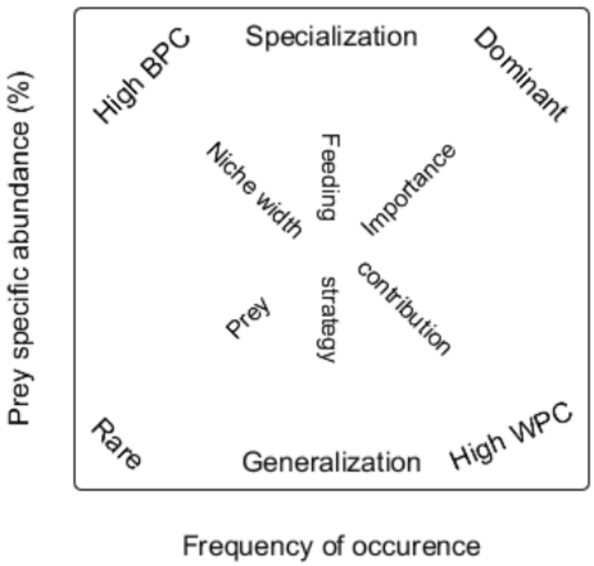

Figure. 2. Amundsen (1996) explanatory diagram for feeding strategy and prey importance

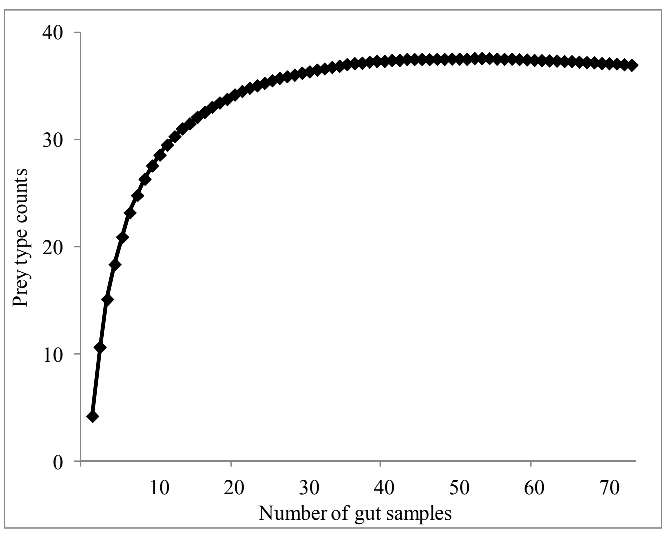

Figure. 3. Cumulative prey curve for the number of prey types encountered in the gut of *N. nasus*.

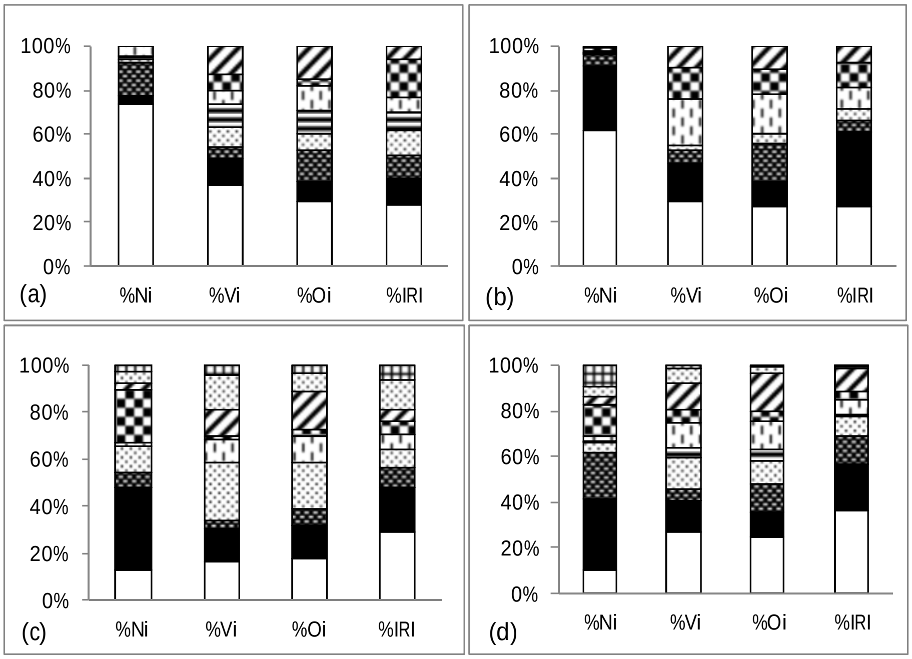

Figure. 4. Percent by number (%Ni), volume (%Vi), occurrence (%Oi) and Index of relative importance (%IRI) of major prey taxa [Nemata (▦); Crustacens (▨); Sand particles (◪),Plant matter (◘); Cyanophyaceae (◫); Eugleophyaceae (▬);Copepods (▨); Bacillariophyaceae (▩); Chlorophyaceae (■); Foraminiferans (□)] present in the gut contents of *N. nasus*; during pre-monsoon (a), monsoon (b), Post-monsoon (c) total year (d).

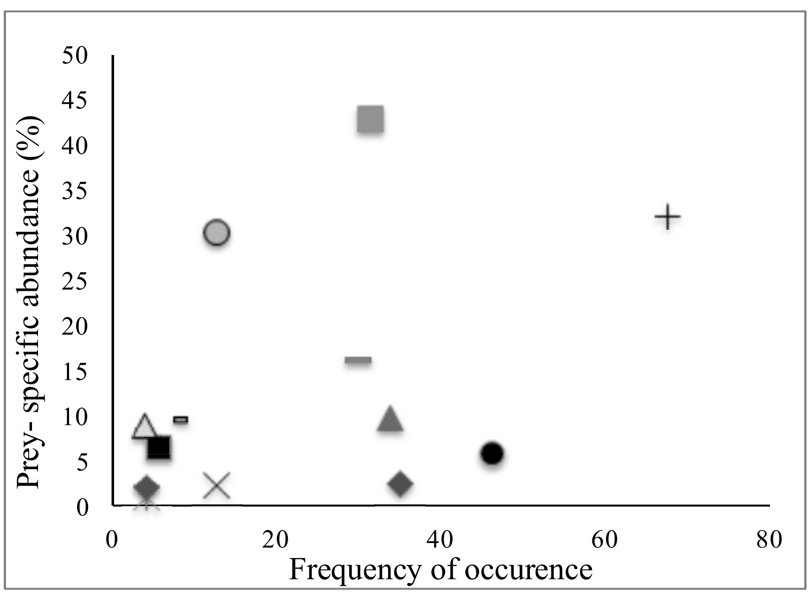

Figure. 5. Feeding strategy and prey importance of *N. nasus* based on Amundsen, 1996. [Cyanophyaceae (◆), Chlorophyaceae(■), Bacillariophyaceae (▲), Euglenopyaceae (×), Rhodophyaceae (✳), Plant matter (●), Foraminifrea (+), Copepods (▬), Cladocera (◆), Nauplius (■), Nemata (△), Crustaceans (-) and sand particles (●)].

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