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Food and feeding habits of *Nemipterus japonicus* and *Nemipterus peronii* from coastal water of Bintulu, Sarawak, South China Sea

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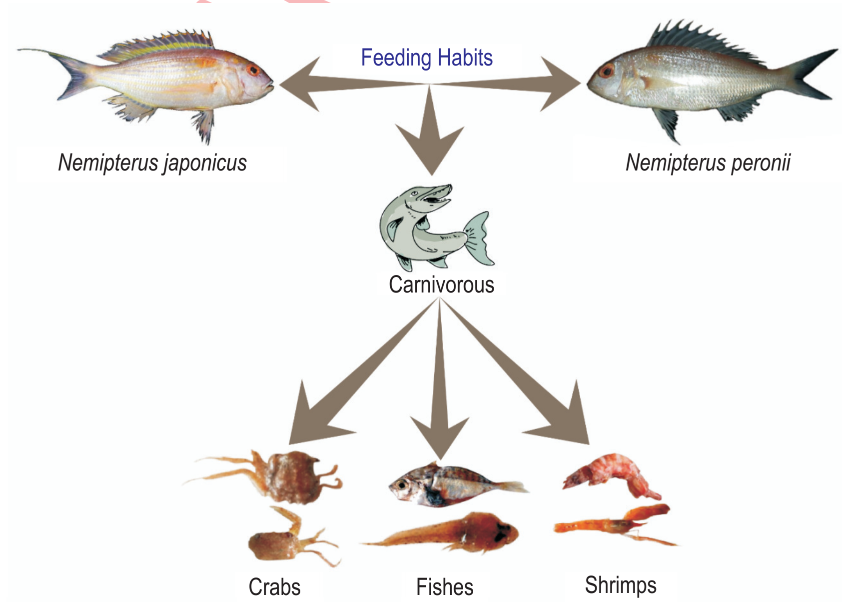
Abstract

Aim: Knowing that feeding habit of fishes is important for ecosystem management and conservation purposes. In this regard, a total of 240 fish stomachs of each species of *Nemipterus japonicas* (11.9-26.0 cm in length) and *Nemipterus peronii* (11.6 -25.3 cm in length) from the coastal area of Bintulu were examined monthly for one year from April 2013 to March 2014.

Methodology: Food items were analyzed using frequency of occurrence, numerical and fullness methods. Each species were grouped into three different length sized groups (large, medium and small). The degree of stomach fullness was classified into five categories (empty, one quarter full, half full, three quarter full and full).

Results: *N. japonicus* was an active feeder with a higher percentage (38.03%) of full stomachs, while *N. peronii* was poor feeder with higher percentage (27.05%) of one-quarter full stomachs. Diet composition contained seven major categories that included fish, crustaceans, molluscs, echinoderms, polychaetes, nematodes and unidentified food items. Crustaceans (mainly crabs) were preferred in both the *N. japonicus* and *N. peronei* at 13.54-35.71% of occurrence and 13.07-33.56%, respectively. Food items in both the species varied with season with maximum in intermediate and minimum in wet season.

Interpretation: Findings revealed that *N. japonicas* and *N. peronii* are carnivorous, and may change their feeding habits from shrimp to crabs, and then to fish as they grow.



Introduction

Analyzing the stomach contents of fish provides information about their ecological niche, and has become a standard practice in fish ecology and trophic linkage research (Hyslop, 1980; Ibrahim *et al*., 2003). Several studies on the reproductive and feeding biology of many fish species have been conducted such as those in the Northern of Persian Gulf (Kerdgari *et al*., 2009), off Veraval (Gopal and Vivekanandan, 1991), the Jizan Region of the Red Sea (Bakhsh, 1994), off Visakhapatnam (Rajkumar *et al*., 2003) and off the Andhra–Orissa coast (Krishnamoorthi, 1971). In Indian water, analyses of stomach content of *N. japonicus* was carried out by Gopal and Vivekanandan (1991) and found that *Acetes* spp. are the preferred food items.

The Japanese threadfin bream, *Nemipterus japonicas,* is an economically important and trawled throughout the South China Sea (Russel, 1990). It has a pinkish body color, silvery below and 11-12 pale golden-yellow stripes along the body from behind the head to base of caudal fin. It has a single continuous dorsal fin, a long pectoral fin which reaching beyond level of anal fin and a caudal fin with filamentous extension. This species is widespread in the Indo-West Pacific ranging from East Africa, including the Persian Gulf and Red Sea and the Indo-Malay Archipelago (Russel, 1993). It inhabits shallow sandy or muddy bottoms at depths of 5.0-80.0 m. Another species, *Nemipterus peronii* is also trawled in commercial quantities in the Straits of Malacca and off Terengganu Coast in the South China Sea (Russel, 1990; Said *et al.,* 1994). It has a pinkish upper body, with 7 to 8 indistinct darker pink saddles reaching to or just below the lateral line. The lower part of the body is silvery with faint golden lines following each scale row. The species is distributed in West Pacific from Taiwan to Northern Australia and in Indian Ocean including the Andaman Sea, Bay of Bengal, Sri Lanka, Arabian Sea, Persian Gulf and Red Sea.

The aim of this research was to investigate the food items and feeding habits of *N. japonicus* and *N. peronii* from the coastal area of Bintulu, Sarawak, South China Sea. Such studies could be important in terms of ecosystem management and conservation. This is because determining the preferred food items of fish can provide a basis for understanding their trophic interactions in aquatic food webs. Moreover, this represents an integration of many important ecological components that includes behavior, condition, habitat use and interaction. It is anticipated that the findings of this research could be helpful to evaluate the ecological role of these two commercially important species, as well as to provide an understanding of its position in the food web structure and tropic linkage in the coastal waters of South China Sea.

Materials and Methods

The samples were collected from commercial fish landing site at Bintulu (3°10' 13.9"N; 113°02'22.9" E) and Kuala Nyalau village (3°38' 26.9" N; 113°23'0.46" E) from April 2013 to March 2014 (Fig. 1). Samples were immediately transported to the

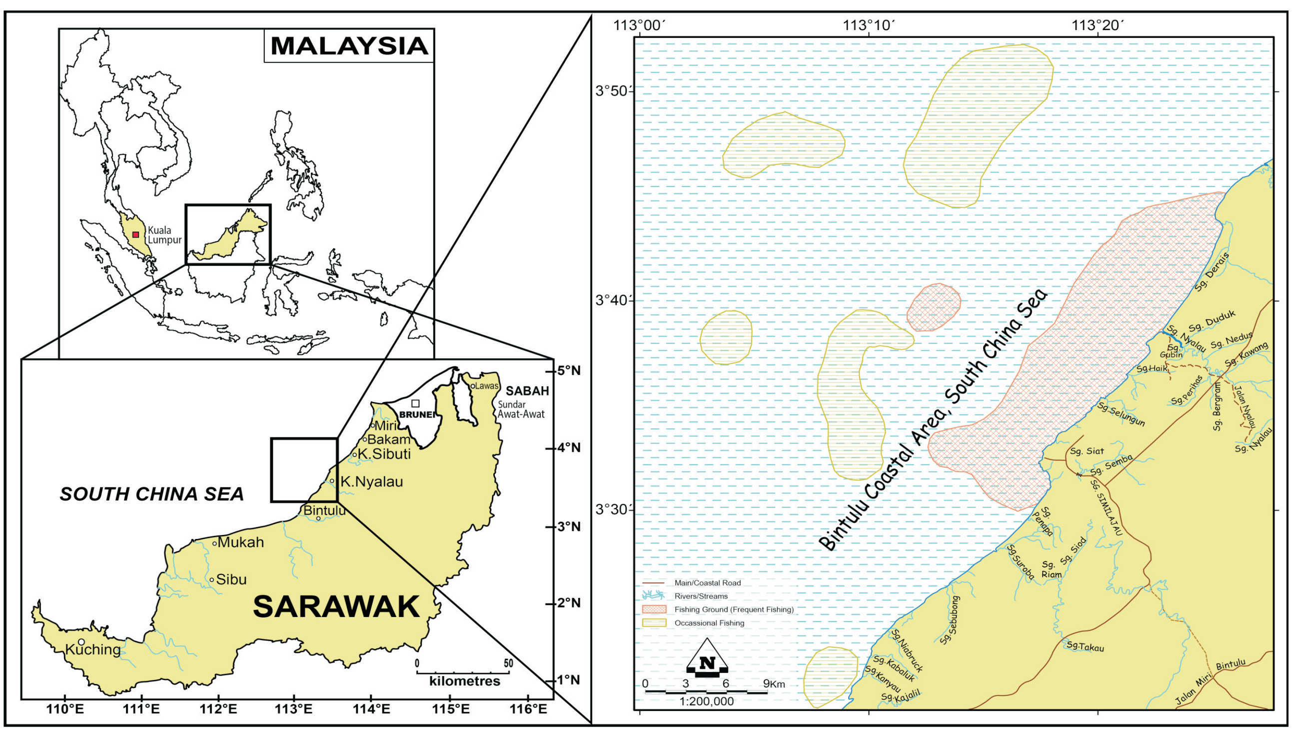


Fig. 1 : Location of the study area showing Bintulu coast in the South China Sea

laboratory for further analysis. Total length (TL) of individual was measured from the tip of snout to the tip of caudal fin according to Vivekanandan and James (1986) using measuring board to the nearest 0.1 cm. Body weight (BW) was measured using electronic balance to the nearest 1.0 g accuracy. The fishes were dissected, the stomachs were removed and were preserved in 10% formalin. The degree of stomach fullness was recorded by cutting the stomach open and all the contents were placed onto a petri dish for identification. Analysis was done using frequency of occurrence and numerical methods according to Hyslop (1980) and Hynes (1950). The occurrence of food items was expressed as the percentage of total number of stomachs containing food, while the number of each food items was expressed as the percentage of total number of food items found in the stomach. The stomach fullness was divided into five categories that included empty, one quarter full, half full, three quarter full or full.

Stomach content analysis : The percentage frequency of occurrence (F_{pi}) and percentage numerical abundance (C_i) for each type of prey was calculated by the formula given below (Chrisafi *et al*., 2007).

$$Fpi = (N1i/Np) \times 100$$

where, N_{1i} is the number of stomachs in which food item i was found while N_p is the number of non- empty stomachs.

$$Ci = \frac{ni}{\sum^{m} ni} \times 100$$

where, n_i is the number of ith food item and m is the number of food items.

Results and Discussion

Stomach fullness in different length classes of *N. japonicus* and *N. peronii* : The total length for *N. japonicus* and *N. peronii* ranged from 11.9-26.0 to 11.6-25.3 cm, respectively. The specimens were grouped into three-sized groups, namely small (11.0-15.9 cm), medium (16.0-20.9 cm) or a large size (> 21 cm) group. The feeding intensity for both fish species varied with different length classes (Table 1). The smaller sized group of *N. japonicus* showed a higher percentage of one quarter full (36.98%), while the medium and large sized groups showed a higher percentage of full stomachs at 26.35% and 38.03%, respectively. For *N. peronii*, the smaller sized group showed a higher percentage of one quarter full (51.04%), while medium sized group had a higher percentage of half full stomachs (24.95%). The larger sized group was found to have a higher percentage of full stomachs (46.81%).

Monthly variation in stomach fullness : The percentage of *N. japonicus* with empty stomachs varied with the season (Fig. 2). Stomach was not found to be empty in November, which was found higher in January (35%). Full stomachs were observed to be higher in April (40%), October (40%) and February (45%). This showed that the feeding activity was high during these three months. For *N. peronii*, empty stomachs increased from October to January (Fig. 3). The percentage of empty stomachs in *N. peronii* was found to be lower in September (0%), which became higher in January (35%). The amount of full stomachs was observed to be higher in April (40%) and October (40%) for *N. peronii*. The number of full stomachs decreased from April to June and then after gradually increased from July to October (intermediate season). Fish with full stomachs further decreased from November to February (wet season) up to the lower percentage (5%).

Diet composition in different length classes : The stomachs of smaller sized groups of *N. japonicus* consisted of 16 types of food items (Table 2). The results showed the most consumed food items were crabs and shrimp at the same percentage of occurrence at 13.54%. For the numerical method, foraminifera had the highest percentage (24.43%) by number. For the medium sized group of *N. japonicus* with a length class of 16-20.9 cm, 158 stomachs were examined and 20 stomachs were empty. There were 18 food items observed and the most frequent were crabs (22.91%). Based on the analyzed data, crabs were found to be the most important diet (24.48%) by number, which was followed by shrimp (10.00%). For the large sized group of *N. japonicus* with a length class >21cm, a total of 43 stomachs were examined with 4 stomachs that were empty and 16 food items were observed. Crabs were dominant food found in the stomachs of *N. japonicus* with a length class >21 cm at 20.83% percentage by occurrence.

Table 1 : Percentage of stomach fullness in *N. japonicus* and *N. peronii* from Bintulu coastal water, Sarawak

Stomach fullness	*N. japonicus* (%)				*N. peronii* (%)			
	11.0-15.9cm	16.0-20.9cm	>21cm	All length classes	11.0 -15.9cm	16.0 - 20.9cm	>21cm	All length classes
Full	9.13	26.35	38.03	24.50	4.17	13.57	46.81	21.52
Three quarter full	21.43	20.30	23	21.59	5.21	23.05	13.18	13.81
Half full	24.29	25.39	17.42	22.37	13.54	24.95	14.98	17.82
One quarter full	36.98	14.84	14.09	21.97	51.04	20.24	12.58	27.95
Empty	8.17	13.12	7.42	9.57	26.04	18.19	12.45	18.89

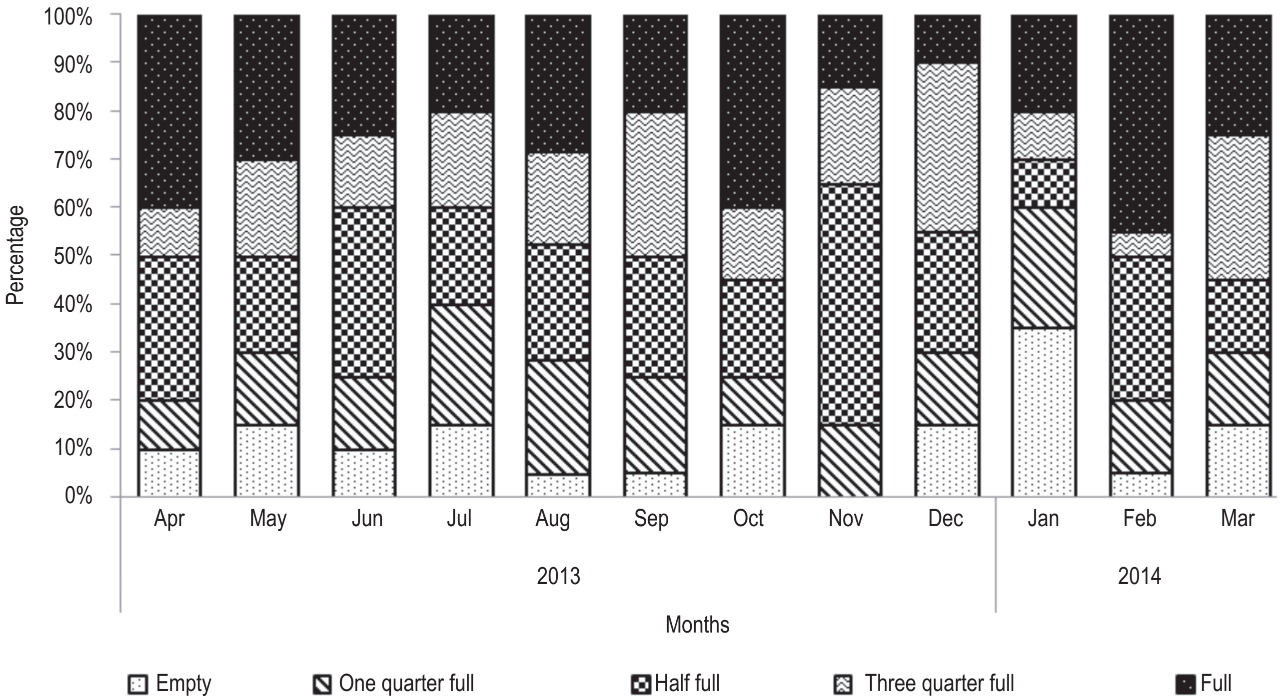


Fig. 2 : Seasonal variation frequency of *N. japonicus* stomach fullness categories in Bintulu coast, South China Sea

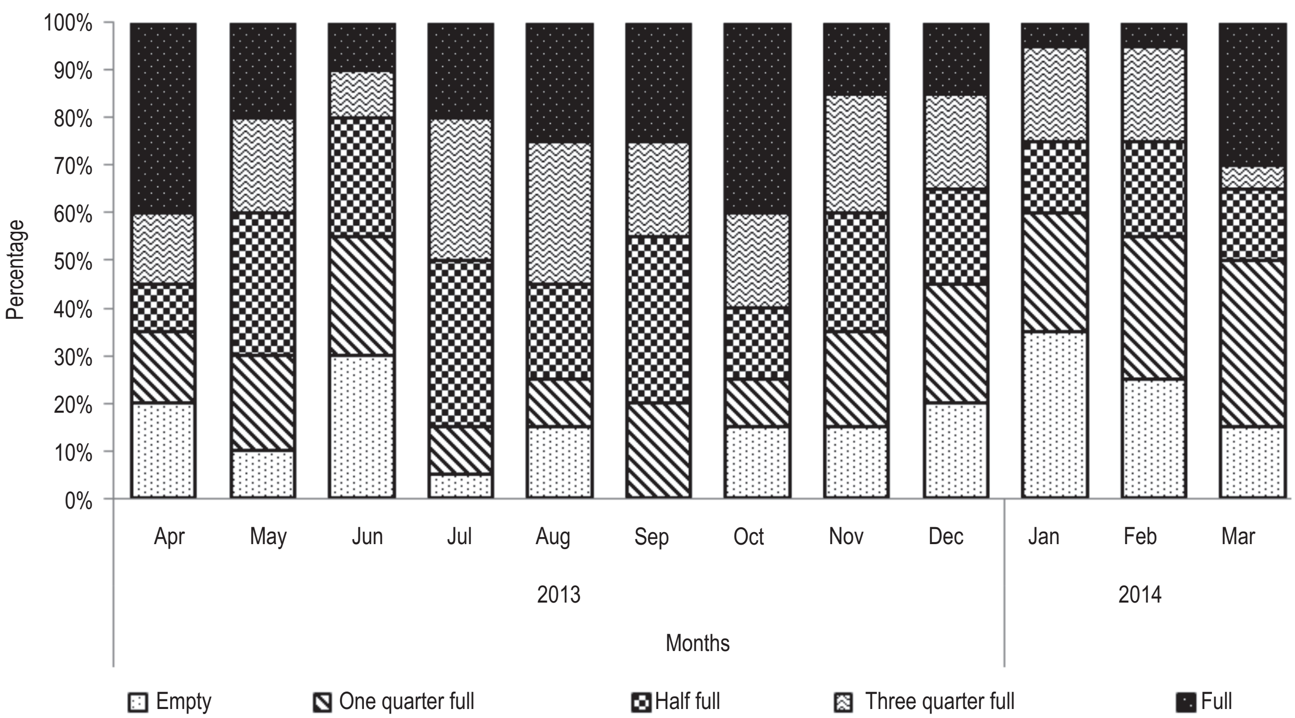


Fig. 3 : Seasonal variation frequency of *N. peronii* stomach fullness categories in Bintulu coast, South China Sea

Based on the numerical method, shrimp were present at a higher percentage (30.22%) compared to other food items.

Twelve food items were observed with shrimp (22.58%) that showed the highest percentage of occurrence (Table 3). For the numerical method, crab was the most consumed food item

Table 2 : Diet composition of *N. japonicus* with different length classes in the coastal area of Bintulu, Sarawak

Food categories	Length class					
	11.0 -15.9 cm		16.0 - 20.9 cm		> 21 cm	
	F_{pi}	C_i	F_{pi}	C_i	F_{pi}	C_i
Fishes	4.17	2.27	11.17	9.66	10.42	9.89
Crustaceans						
Crab	13.54	13.07	22.91	24.48	20.83	16.48
Shrimp	13.54	11.93	12.01	10.00	11.46	30.22
Mantis shrimp	6.25	3.41	6.42	5.86	8.33	8.79
Lobster	2.08	1.14	0.56	0.34	2.08	1.10
Isopod	1.04	0.57	1.68	1.03	1.10	1.65
Amphipod	8.33	4.55	8.94	9.48	3	1.65
Copepod	3.13	6.25	1.12	1.72	-	-
Ostracod	4.17	2.84	0.56	0.52	6.25	6.59
Molluscs						
Bivalve	7.29	4.55	4.19	2.59	5.21	3.30
Gastropod	6.25	3.98	3.07	2.59	5.21	3.30
Cephalopod	-	-	3.63	2.76	6.25	3.30
Echinoderms						
Ophiuroidea	10.42	10.23	8.38	6.21	4.17	3.30
Echinoidea	-	-	0.84	0.52	-	-
Foraminifera	6.25	24.43	2.51	8.28	3.13	4.40
Polychaetes	6.25	3.98	4.75	5.17	2.08	1.65
Nematodes	2.08	1.14	2.23	1.55	2.08	1.10
Unidentified food items	5.21	5.68	5.03	6.55	7.29	3.85

F_{pi}: Percentage frequency of occurrence, C_i: Percentage of number

with the percentage of 21.05%, followed by shrimp and mantis shrimp accounting for 15.79%. For the medium sized group of *N. peronii* with a length class of 16.0-20.9 cm, 144 stomachs were examined and 24 were found to be empty. There were 18 food items observed and the most preferred was crab with an occurrence of 35.71%. The most dominant food items among all were crabs (33.56%) followed by ostracods (26.82%), shrimp and foraminifera (5.71%), respectively, while fishes accounted for 5.54%.

Monthly variation in diet composition : The percent occurrence of food items in *N. japonicus* varied throughout the year. Fish, crabs, shrimp and ophiuroidea were present throughout the study period. The percentage of fish was higher during May (21.95% of occurrence) and lower in November (6.25%). Mantis shrimp was observed as food items to fish throughout the year, except for April and May. For the numerical method (Fig. 4), crabs were also found to be the most preferred food item among *N. japonicus* throughout the year as the percentage of crabs were higher from June to September as well as November and January. The highest percentage by number of crabs were consumed in November (47.77%). In April and February, shrimps were the dominant food item, followed by ostracod in May, mantis shrimp in October and foraminifera in December and March.

Studies showed that crab was the most important food item for *N. peronii* among all food items consumed. Fish, crabs and shrimps were present throughout the year. The percent of occurrence of crab remained higher throughout the year, except in April. The highest percent of occurrence (52.78%) of crab was found in July, while the percentage of fish was higher (20.00%) in October and lower (3.92%) in November. For the numerical method (Fig. 5), from May to August crab was the most dominant food item in stomach of *N. peronii,* with the highest percentage in July (73.91%). In September, the percentage of crabs sharply decreased as *N. peronii* consumed more on ophiuroidea (42.16%) whereas from October to March, *N. peronii* continued to consume more on crabs.

Feeding habits and strategies of *Nemipterus* spp. have been studied using stomach content analysis (Krishnamorthi, 1971; Afshari *et al*., 2013; Bakhsh, 1994; Raje, 2002; Said *et al*., 1994; Gopal and Vivekanandan, 1991; Gurlek *et al*., 2010; Ibrahim *et al.*, 2003; Joslin, 2009); these studies discovered an opportunistic feeding behavior and marked inclinations for small shellfish (Gopal and Vivekanandan, 1991; Joslin, 2009). Crabs, shrimp, mantis shrimp, lobsters, amphipods, copepods and ostracods were present in the stomachs of both the fish, which is in agreement with the findings of Krishnamoorthi (1971) and Afshari *et al*. (2013). Studies by Bakhsh (1994) and Raje (2002)

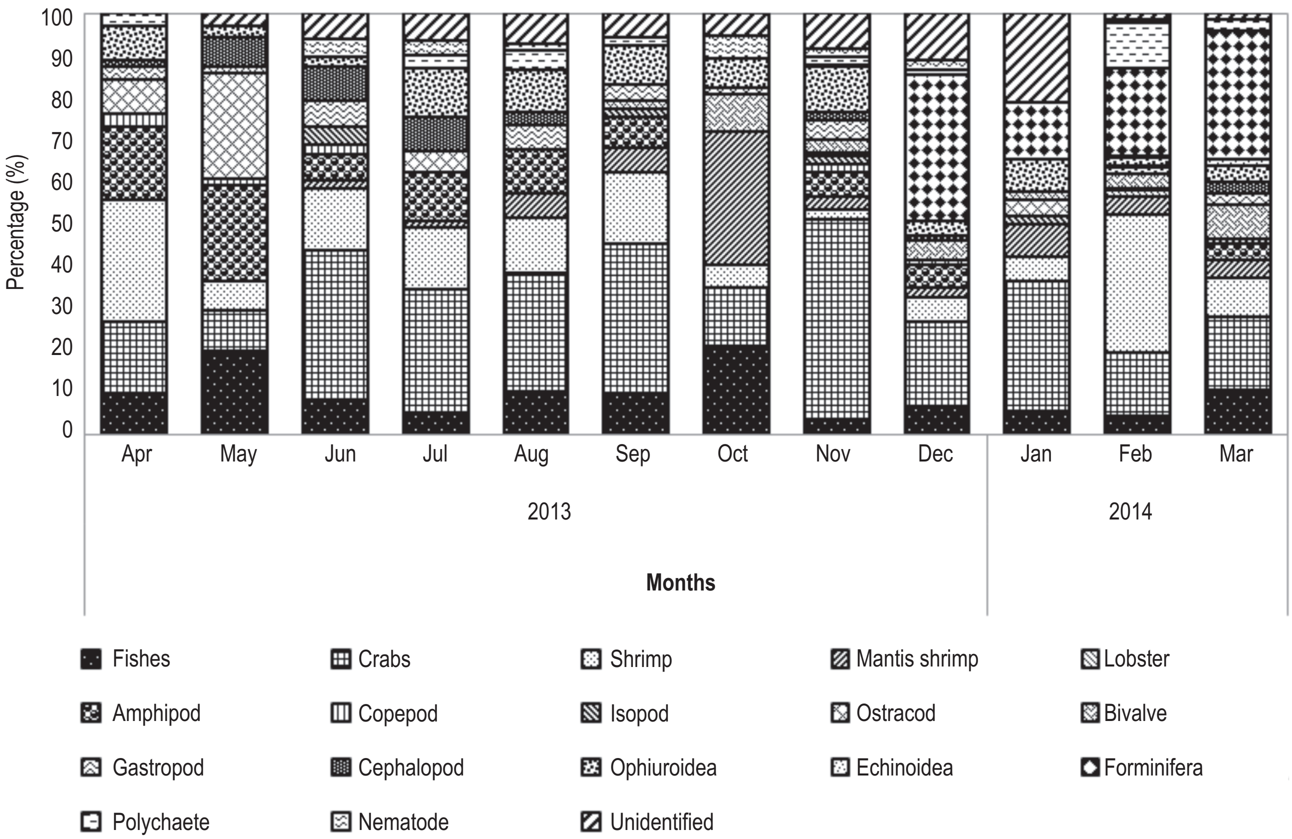


Fig. 4 : Seasonal variation percentage of *N. japonicus* stomach food items by number in Bintulu coast, South China Sea

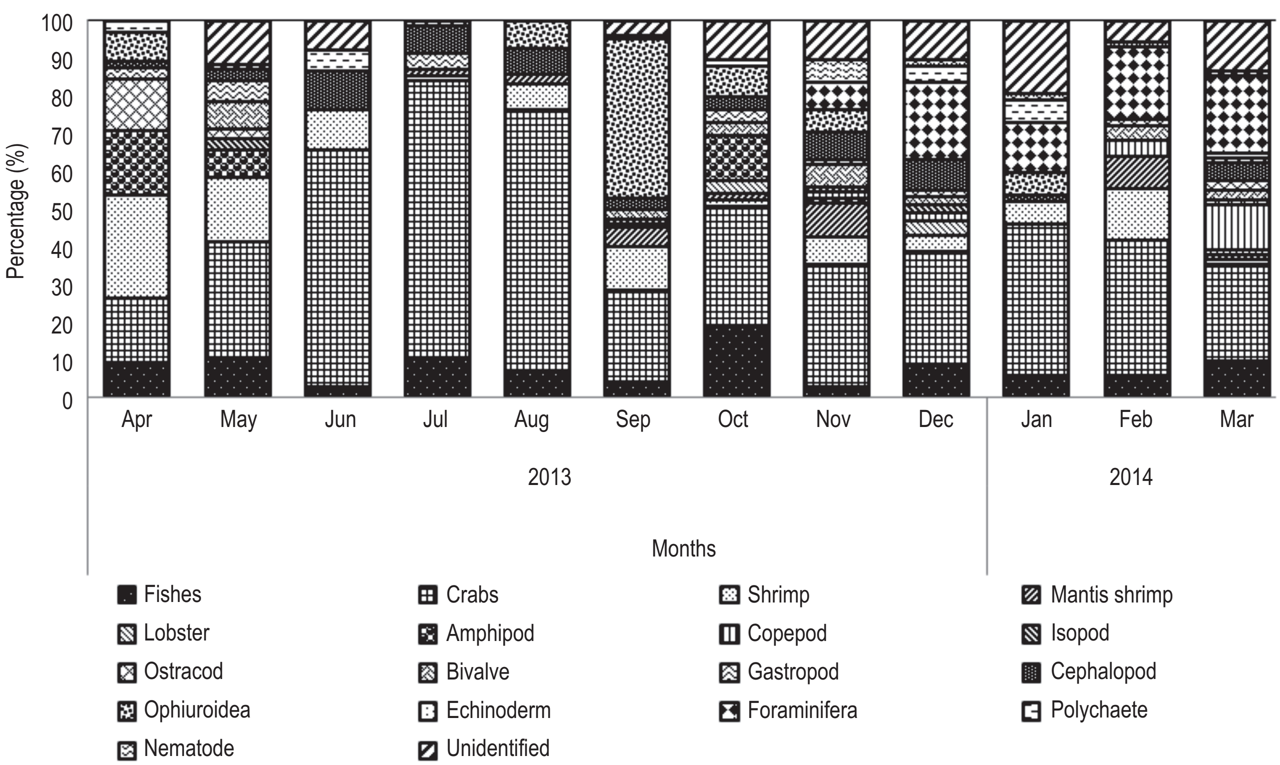


Fig. 5 : Seasonal variation percentage of *N. peronii* stomach food items by number in Bintulu coast, South China Sea

Table 3 : Diet composition of *N. peronii* with different length classes in the Coastal area of Bintulu, Sarawak

Food categories	Length class					
	11.0 -15.9 cm		16.0 - 20.9 cm		> 21 cm	
	F_{pi}	C_i	F_{pi}	C_i	F_{pi}	C_i
Fishes	-	-	11.11	5.54	15.03	10.27
Crustaceans						
Crab	19.35	21.05	35.71	33.56	26.59	27.38
Shrimp	22.58	15.79	6.35	5.71	9.83	7.60
Mantis shrimp	9.68	15.79	4.37	1.90	2.31	1.52
Lobster	3.23	3.51	0.40	0.17	1.16	0.76
Isopod	-	-	0.79	0.35	1.90	1.90
Amphipod	-	-	1.59	1.04	1.52	1.52
Copepod	3.23	8.77	1.19	1.56	3.42	3.42
Ostracod	3.23	12.28	1.98	26.82	1.90	1.90
Molluscs						
Bivalve	3.23	1.75	2.78	1.21	5.20	3.80
Gastropod	3.23	1.75	3.57	1.56	3.47	4.56
Cephalopod	9.68	5.26	8.33	3.81	6.36	4.18
Echinoderms						
Ophiuroidea	-	-	5.95	4.50	4.05	13.69
Echinoidea	-	-	0.40	0.17	0.58	0.38
Foraminifera	6.45	3.51	3.97	5.71	4.05	6.84
Polychaetes	3.23	1.75	1.98	1.04	1.16	0.76
Nematodes	-	-	1.59	0.69	1.73	1.52
Unidentified food items	12.90	8.77	7.94	4.15	7.51	7.22

F_{pi}: Percentage frequency of occurrence; C_i: Percentage of number

found that *N. japonicus* is mainly carnivorous and predominately feed on crustaceans, polychaetes, teleosts, molluscs, annelids and echinoderms. In Indian waters, *N. japonicus* preferred to feed on crustaceans, especially *Acetes* spp. (Gopal and Vivekanandan, 1991) while *N. peronii* mainly consumed crustaceans, especially crabs, which is in consistent with the findings of Said *et al*. (1994).

The percent occurrence of shrimp decreased as the length increased in *N. peronii,* but not in *N. japonicas*. Vivekanandan (1990) reported that in shallow waters, *N. japonicas* were observed to prey mostly on juvenile prawn, whereas those in deeper waters mostly consumed fish and crabs. This revealed that the smaller sized group of *N. peronii* mostly inhabits shallow coastal waters compared to the medium and larger sized groups. Concurring to the scavenging concept, the probability of prey capture is a function of prey density, size, total visibility and motion (Lazzaro, 1987), thus it could probably be the case for the present finding. Variations in the food composition from different length classes also provide information where fish changes their feeding habits from shrimp to crabs and then to fish as it grows. The medium and larger sized groups tended to consume fish compared to the smaller sized group. Preference for size selection by commercially important species has been advised in previous studies (Abu Hena and Hishamuddin, 2012; Bartulovic *et al*., 2004). However, in the present study, the size-selective preference may be related to season and prey availability, as well as length class distribution of the fish.

In general, according to the classification by Marichamy (1970), the medium and large sized groups of *N. japonicus* are active feeders with the higher percentage of full stomachs whereas the small sized *N. japonicus* were poor feeders. For *N. peronii*, the small sized group was also a poor feeder while the medium was moderate feeder and the large size was active feeder (Table 1). Krishnamorthi (1971) stated that the degree of stomach fullness did not increase with the size of the fish, however the type of food did. The seasonal composition of *Nemipterus* stomach contents was affected by monsoonal activities. Usually, prey items were higher in the intermediate season compared to wet season in this coastal water, indicating that *Nemipterus* were following an opportunistic feeding behavior, each time targeting the more available prey items whenever present. Both *N. japonicus* and *N. peronii* had a similar diet as they occupied the same ecological niches. Both species were found as predacious carnivores that exhibited a tendency of feeding at the bottom, as evidenced by the presence of benthic organisms such as brittle star, crabs, gastropods and polychaetes in their stomach. Bachok *et al.* (2004) also found teleosts, cephalopods, crustaceans, echinoderms and molluscs in the stomachs of carnivorous adult marine fish in Malaysian marine waters.

The present study found that crustaceans and other slow moving animals in the sea were the major food items for both *N. japonicus* and *N. peronii*. Similar results were obtained for *Nemipterus randalli* in the eastern Mediterranean sea (Gurlek *et al*., 2010), *Nemipterus marginatus* in South China Sea (Ibrahim *et al.*, 2003) and *Nemipterus delagoae* in Tamil Nadu, India (Joslin, 2009). Hajisamae *et al*. (2006) noted two carnivorous *Sillaginid* sp. in the southern part of the South China Sea that mainly feed on polychaetes and other benthic organisms. The species *Trichiurus margarites* consumed crustaceans, fish and molluscs in Beibu Gulf, South China Sea (Yan *et al*., 2012). This study has provided information about the effects of season on feeding, as well as fish size on food preference. Similar food preference by the larger fish may give rise to competition within the same trophic level or potentially cannibalism on smaller conspecifics (Qasim, 1972). In addition, any change in the prevalence of these carnivorous species could have a large impact on the crustacean diversity and abundance in any coastal ecosystems (Gurlek *et al*., 2010), which should be further investigated for fisheries management.

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