

RESEARCHS / INVESTIGACIÓN

Diet Composition and Feeding Strategy of *Nemipterus japonicus* Bloch, 1791 from Tha-baw-seik, Myanmar.

Thet Htwe Aung.

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Abstract: Food composition of *Nemipterus japonicus* was studied by analyzing about 600 specimens from Tha-baw-seik (Lat. 14° 05' and long. 98° 05' E), Myanmar during October 2016 to September 2017. Based on the stomach content analysis, the relative importance index (IRI value) was calculated, and the predator feeding strategies were conducted during the study period. This study showed that *N. japonicus* is a generally demersal carnivore, and its trophic spectrum was composed of 23 food items. Among them, algae had not been described as a food item for *N. japonicus* in the other previous studies. Crustaceans were the most dominant diet in the guts in term of the IRI value. Also, fish items were commonly the most dominant food followed by prawn, crab, and *Acetes spp* in all length groups but sex variation had no significant food changes with their IRI value.

Key words: Relative importance index, feeding strategies, Tha-baw-seik and *Nemipterus japonicus*.

Introduction

Nemipterid fishes are a demersal fish resource, found on mud or sand bottoms, usually in schools, feeds mainly on small fishes, crustaceans, mollusks (mainly cephalopods), polychaetes and echinoderms. Nemipterid fishes have a small mouth opening, villiform teeth only on the jaws, soft gill raker with bristles, small stomach and long intestine adapted for small preys. The adaptation is also significant in preventing the escape of the prey¹.

The nemipterid fishes are one of the most important economic groups of marine fishes in Myanmar. From the commercial point of view, all species are treated as one group under the name 'Threadfin', locally known as 'ShweNgar or Ngar Ni.' It yields 3040.45 tonnes, and by percentage, it had 5.89% of the Myanmar marine fish landings in Yangon, the business city of Myanmar².

The study of the feeding habits of fish and other animals based upon the analysis of stomach content has become a standard practice¹¹. Stomach content analysis provides important insight into fish feeding patterns, and quantitative assessment of food habits is an important aspect of fisheries management. Moreover, food and feeding habit of fish are important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in association and to utilize all the available food¹².

It is virtually impossible to gather sufficient information about food and feeding habit of fish in their natural habitat without studying its gut contents. All knowledge on the food and feeding habit of fishes provide keys for the selection of species in culture and the importance of such information is necessary for successful fish farming. The food habit of different fish varies from month to month. This variation is due to changes in the composition of food organisms occurring at different seasons of the year.

The threadfin breams constitute an important group of commercial fishes in Tha-baw-seik, Myanmar. Tha-baw-seik is one of the large fishing landing areas in the southern part of Myanmar and it is located in Lat. 14° 05' and long. 98° 05' E. Some observations on the feeding habits of Nemipterids were made from different parts of the world; nevertheless the available information is rather meager and scanty.

In Myanmar, there was only one literature available about food and feeding habits of *N. japonicus*. Sabai Soe 2014⁸ observed on gut contents of threadfin breams (*genus- nemipterus*) in myeik waters, Myanmar. In this study, seven species of *Nemipterus* were observed during the study period.

The objectives of the present study were to provide information on the diet composition and feeding strategy of *N. japonicus* in Tha-baw-seik landings mainly based on their general stomach content analysis.

Materials and methods

Sample collecting and laboratory procedures

Around 600 specimens of *N. japonicus* were collected during October 2016 to September 2017 from the fish landings at Tha-baw-seik (Lat. 14° 05' and long. 98° 05' E) (figure 1). The standard length of the samples was recorded and ranged 100-140 mm in length and 141-190 mm in length and 191-220 mm in length. The stomach of the fishes was dissected with the help of simple scissors. The stomach contents were taken into a Petri dish, and the food items were identified under the binocular microscope, and they were counted and weighted in an electronic balance.

The relative importance index (IRI)

Several methods employed for analyzing the food habits of fishes reviewed by Bowen³ to quantify the feeding preference of fishes were applied in the present study.

For the nemipterid fishes, the relative importance index was found most suitable and hence is adopted in the present study.

The methods used in the present study are:

$$\text{Frequency of Occurrence, } O_i = \frac{J_i}{P}$$

Where J_i is the number of fish containing prey i and P is the number of fish with food in their stomach.

$$\text{Percent by number, } N_i = \frac{N_i}{\sum_{il} N_i}$$

¹ Demonstrator, Marine Science, Mawlamyine university, Myanmar.

Where N_i is the number of food category i

$$\text{Percent by weight, } W_i = \frac{W_i}{\sum_{il} W_i}$$

Where W_i is the weight of food category i

From these three indices, the relative importance of prey items was calculated using the Index of Relative Importance (IRI)⁴. The IRI was calculated for each prey as:

Index of relative importance, $IRI = (\% N_i + \% W_i) \% O_i$; Where, N_i , W_i , and O_i represent percentages of number, weight or volume and frequency of occurrence prey respectively.

Cluster analysis

A cluster analysis was done to find out the similarities between groups. The most commonly used clustering technique is the hierarchical agglomerative method. The results of this are represented by a tree diagram or dendrogram with the X-axis representing all predators and Y-axis defining the similarity level at which the predators are fused. Bray-Curtis coefficient¹⁴ was used to produce the dendrogram. The following formula calculated the coefficient:

$$S_{jk} = 100 \left\{ 1 - \frac{\sum_{i=1}^n \min(Y_{ij}, Y_{ik})}{\sum_{i=1}^n (Y_{ij} + Y_{ik})} \right\}$$

Where Y_{ij} represents the entry with i^{th} row and j^{th} column of the data matrix, i.e. the %IRI for the i^{th} prey in the j^{th} predator. Y_{ik} is the %IRI for the i^{th} prey in the k^{th} predator; 'min' stands for, the minimum of two values and \sum represents the overall rows in the matrix.

Besides, the significance of the difference between the IRI value of male and female was tested by One Way ANOVA¹³.

Predator feeding strategies

Prey- specific abundance is represented by the following equation:

$$P_i = (\sum S_i / \sum S_{ij}) \times 100$$

Where P_i is prey- a specific abundance of prey type i , S_i total stomach contents (number) comprised of prey i , and S_{ti} is the total stomach content of only the fish with prey item i in their stomach⁵. According to Amundsen et al⁵, the interpretation of the feeding strategy diagram can be obtained by examining the distribution of points along the diagonals and axes of the graph. The diagonal from the lower left to the upper right corner provides a measure of prey importance, with dominant prey at the top, and rare or unimportant prey at the lower end. The vertical axis represents the feeding strategy of the predator in terms of specialization or generalization. Predators have specialized on prey positioned in the upper part of the graph, whereas preys positioned in the lower part have been eaten only occasionally (generalization). Prey points located at the upper left of the diagram would be indicative of specialization by individual predators, and those in the upper right would represent specialization of the predator population. Prey with high specific abundance and low occurrence (upper left) were consumed by a few individuals displaying specialization, whereas prey with a low abundance and a high occurrence (lower right) were eaten occasionally by most individuals.

Results

Prey of *N. japonicus* in terms of frequency of occurrence (%FO), gravimetric (%W), numerical (%N), and index of relative importance (IRI).

The total 23 food items which are classified into eight general categories were included in the trophic spectrum of *N. japonicus*. Among them, crustacean with % IRI 70.98 dominated over all other food categories and was comprised of *Acetes spp* with % IRI 25.06, crab with % IRI 13.69, prawn with % IRI 29.46, lobster with % IRI 0.038 and *scylla* with % IRI 2.74. The subsequently abundant food category was fish constituted chiefly by immature ones of *Nemipterus spp* with % IRI 0.148, *Bregmaceros spp* with % IRI 7.77, *Secutor spp* with % IRI 0.14, *Sauridas spp* with % IRI 0.115, *Platycephalus spp* with % IRI

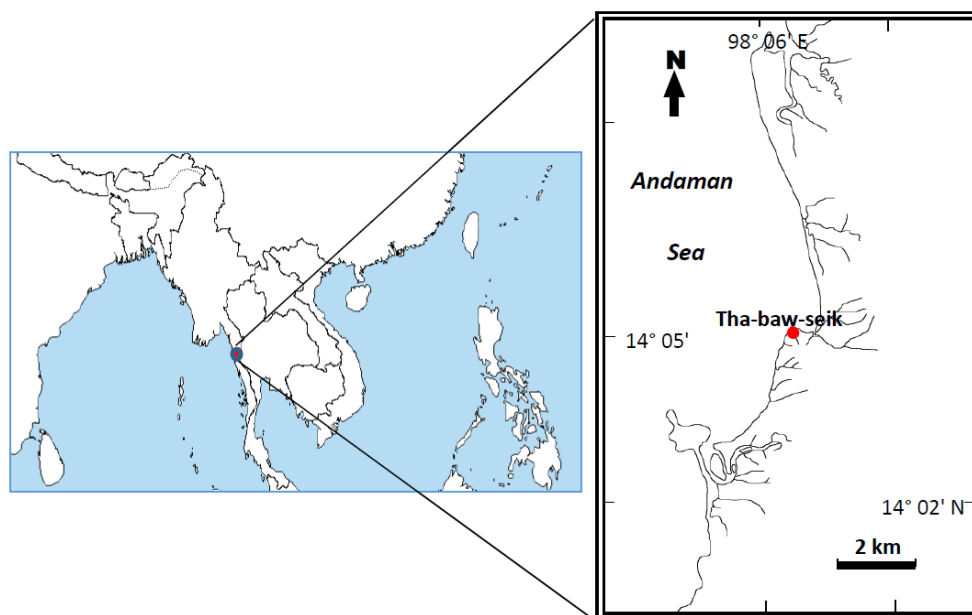


Figure 1. The map of Tha-baw-seik, myanmar.

0.332, *Cynoglossus spp* with % IRI 0.08, *Stolephorus spp* with % IRI 2.04, fish larvae with % IRI 0.38 and unidentified fishes with % IRI 3.53. The additional food items were cephalopod comprised of *Loligo* with % IRI 1.722 and *Sepia* with % IRI 0.855 and unidentified squids with % IRI 0.013, polychaetes with % IRI 0.54, nematodes with % IRI 0.892, the brittle star with % IRI 0.521, algae with % IRI 0.348 and miscellaneous items with % IRI 9.409.

In terms of frequency of occurrence, the prawn was observed 15.8% of the total stomach followed by *Acetes spp* with 14% and crab with 13%. Moreover, they were the most frequently. As for the weight, prawn with 17.17% and *Acetes spp* with 15.28% were mostly consumed by *Nemipterus japonicus* followed by *Bregmaceros spp* with 8.43% which is one item of the fish category. When considering the abundance, *Acetes spp* with 33.11% produced the largest part of the diet, followed by crab with 13.22% and prawn with 11.35% (table. 1 and fig.2

In different length groups of *N. Japonicus*, the contribution of crabs ranged from 19.08% in the smallest group and 18.73% in the medium group to 9.81% in the largest group. Therefore, there was a sharp decrease in IRI value in the largest group. Prawn was one of the major diets for every length sizes of fishes which ranged from 16.14% in the smallest groups and 15.85% in the median length groups to 19.81% in the largest groups (table 2).

Of the three different length groups, *Acetes spp* was consumed by the smallest length group of fishes the most with 14.04% of IRI value and subsequently, IRI value of this item was 15.19% in the medium length group and 10.407% in the largest length group. Fish was the most dominant food, with 30.33% in the largest length groups of *N. Japonicus* followed by 18.29% in the median length groups and 17.39% in the small length groups. The lobster was absent in the smallest length group and largest length group, but they were found only in the median length group with the lowest IRI value, 3.703%. Presence of *squilla* was the highest 11.11% in the largest length groups and lowest 4.37% in the smallest length groups. Contribution of squids ranged 10.14% in the smallest length groups, 3.65% in the median length groups and 3.703% in the largest length groups. Polychaetes ranged from 2.89% in the smallest length group to 5.097% in the median length groups, but they were absent in the largest length groups. Nematodes were only present in the smallest length groups with 4.34%. The fragments of brittle star constituted 1.449% in the smallest length groups, 3.65% in the median length groups and 3.703% in the largest length groups. Algae were only present in the median length groups with 2.43%. Miscellaneous item was found in all the length groups, which ranged from 8.69% in the smallest groups and 7.407% in the largest groups to 9.75% in the medium groups (table 2).

Comparison of IRI value in different sexes indicated that prawn was the most favorite food item in both sexes with 18.33% in male and 18.64% in female. Fishes were the second abundant food in both sexes with 16.66% in male and 14.705% in female. The next abundant food item was a miscellaneous item with 17.5% in male and 17.64% in female. The lobster was present in males with 0.833%. The lowest IRI values of males were lobster, and brittle star with 0.833% and the lowest IRI values of males was algae, with 0.989% (table 3).

Similarity analysis between different length groups can be found in the figure. 4. The similarity between the smallest group and the largest group had 67.93%. These groups shared diets such as *Acetes spp.*, benthic crabs, and prawns. Moreover, the similarity between medium and largest groups was observed at 72.31%.

The significance of the difference between the IRI values of males and females was tested by analysis of variance. Since the null hypothesis $H_0: \mu_A = \mu_B$ and H_0 is not rejected ($p \geq 0.05$), there is no significant difference in the relationship between males and females (table 4).

Predator feeding strategies

The feeding strategy of *N. japonicus* was found by plotting prey-specific abundance against the frequency of occurrence in figure 3. There were 23 different prey types represented by points. Based on the interpretation of Amundsen *et al.* 1996⁵ were important food of *N. japonicus*, whereas some species of fishes, lobster and squilla were unimportant. Also, *N. japonicus* were specialized on fish larvae, polychaetes, unidentified fishes and algae, etc. but some species of fish, crab, prawn, *Acetes spp.*, *squilla*, and lobster were eaten only occasionally. Although fish larvae, polychaetes, unidentified fishes and algae were consumed by a few individual predators, crab, prawn, *Acetes sp.*, *Bregmaceros spp.*, etc. were eaten by most individual predators. Therefore, though the abundance of certain prey items like fish larvae and polychaetes was very high in the ecosystem, their occurrence was meager in the diet. The analysis showed that *N.* has a specialized feeding strategy focusing on crustaceans, especially Crab, *Acetes spp.*, and Prawn, which they consumed in very large quantities. *Bregmaceros spp* and Misc. item was the next most often found prey items on which *N. japonicus* specialized. Therefore, they were consumed occasionally by most individuals. Though the abundance of certain prey items like fish larvae and polychaetes was very high in the ecosystem, their occurrence was meager in the diet.

Discussion

The present study revealed that *N. japonicus* is a benthic carnivore that relies mainly on benthic crustaceans and fishes. Rao and Rao⁶ described food items as *squilla*, crabs, prawns, teleosts, cephalopods, amphipods, polychaetes and other miscellaneous items in that order of importance from the gut of *N. japonicus*. Krishnamurthy⁷ described *N. japonicus* is actively predacious and possibly a sight feeder, feeding on crustaceans, mollusks, annelids and echinoderms. Moreover, about the results by SabaiSoe⁸, the food composition of *N. japonicus* consist of *Solenocera spp.*, *Stolephorus spp.*, *Squilla*, Crabs and Miscellaneous. According to the results conducted in the present study, the following food items were observed in the guts of fishes: fish comprised with *Nemipterus spp.*, *Bregmaceros spp.*, *Secutor spp.*, *Sauridas spp.*, *Platycephalus spp.*, *Cynoglossus spp.*, *Leiognathus spp.*, *Stolephorus spp.*, fish larvae and unidentified fishes, crustacean comprised with *Acetes spp.*, crab, prawn, lobster and *Squilla*, cephalopod comprised with *Loligo*, *Sepia* and unidentified squids, polychaetes, nematodes, brittle stars, algae and miscellaneous items. Therefore, the food items of the present study were almost the same as the previous studies of *N. japonicus*. Russel 1990¹ observed that cephalopods mainly squid and cuttlefish formed dominant food followed by finishes and other benthic crustaceans. In contrast, the present study was observed that benthic crustaceans were the most dominant food.

Of the crustacean items, *Acetes pp*, prawn and crab were the favorite food of *N. japonicus* with the highest IRI value, but *Squilla* and lobster were also found occasionally with the lowest IRI value. Fish ranked in the second dominant food category of *N. japonicus*. Among them, *Bregmaceros spp* was observed with the important quantities, and other species

Food items	N%	O%	W%	IRI	IRI%
Fish					
<i>Nemipterus</i> spp.	0.68	1.05	0.75	1.474	0.148
<i>Bregmaceros</i> spp.	6.105	8.41	8.43	77.07	7.77
<i>Secutor</i> spp.	0.63	0.708	1.064	1.38	0.14
<i>Sauridas</i> spp.	1.028	0.517	0.227	1.145	0.115
<i>Platycephalus</i> spp.	0.479	0.94	3.007	3.306	0.332
<i>Cynoglossus</i> spp.	0.483	0.799	1.17	1.418	0.14
<i>Leiognathus</i> spp.	0.34	1.01	0.45	0.801	0.08
<i>Stolephorus</i> spp.	2.51	3.553	4.989	20.23	2.04
Fish larvae	2.01	1.989	0.89	3.7992	0.383
Unidentified fishes	4.676	5.85	5.18	35.06	3.534
Crustacean					
<i>Acetes</i> spp.	33.11	14.09	15.28	248.60	25.06
Crab	13.22	13.95	8.78	135.82	13.69
Prawn	11.35	15.8	17.71	292.306	29.46
Lobster	0.221	0.41	0.38	0.379	0.038
<i>Squilla</i>	1.642	3.115	8.2	27.21	2.74
Cephalopod					
<i>Loligo</i>	1.735	2.73	5.62	17.08	1.722
<i>Sepia</i>	1.55	2.08	3.317	8.48	0.855
Unidentified squids	0.104	0.175	0.16	0.336	0.013
Polychaetes	1.433	2.21	1.77	5.359	0.54
Nematodes	5.633	3.59	0.89	8.854	0.892
Brittle stars	1.18	2.17	1.83	5.17	0.521
Algae	1.08	5.81	0.407	3.455	0.348
Misc. items	8.73	8.96	9.43	93.34	9.409

Table 1. Prey of *N. japonicus* collected from the Tha-baw-seik coastal areas in terms of frequency of occurrence (%FO), gravimetric (% W), numerical (%N), and index of relative importance (IRI).

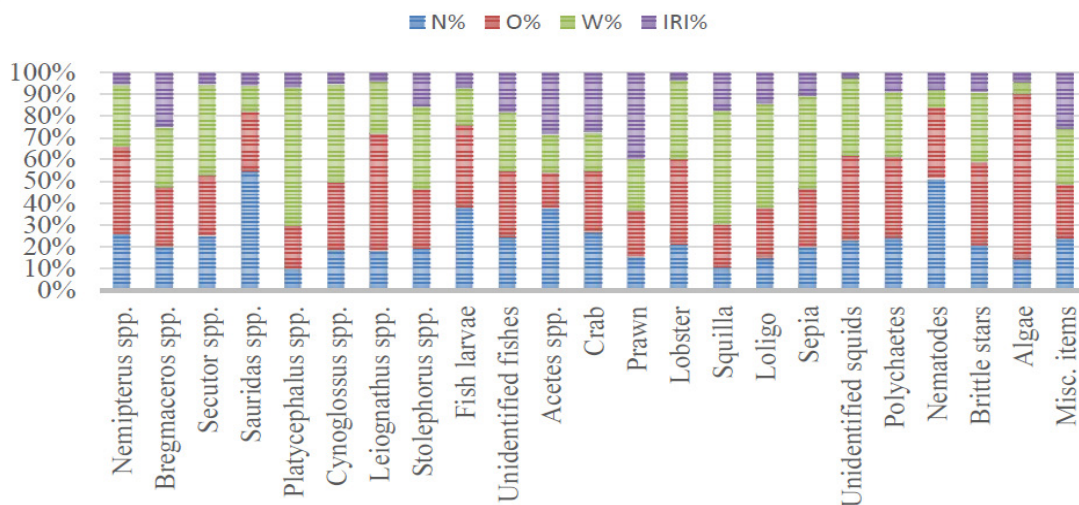


Figure 2. Prey of *N. japonicus* collected from the Tha-baw-seik coastal areas in terms of relative importance index (IRI).

had the negligible quantities. The studies of Manojkumar⁹ and Abdu Rahiman¹⁰ made the fish prey items identify up to the species level but the present study could not be done because of their digestion.

Loligo and *Sepia* were considerably found but *Loligo* was more abundant than *Sepia*. The miscellaneous items comprised of debris, rubbish, unidentified bones, unidentified shells, unidentified hairs, and silts were found very often. However, polychaetes, nematodes, brittle stars, and algae were negligible food or minor food in some months.

As for predator feeding strategies, Abdu Rahiman¹⁰ showed that *N. japonicus* most often specialized on crustacean mainly *S. choprai*, benthic crabs, unidentified fishes, *A. indicus* and *L. durance* in his study whereas the present study found that crab, *Acetes* spp, prawn, *Bregmaceros* spp and Misc. items

represented the specialization of the predator population.

In all length groups, fishes were commonly the most dominant food followed by prawn, crab and *Acetes* spp. According to the IRI values, *N. japonicus* were generally increased with the increasing length of them in fishes, prawn, and *squilla* while the values were decreased with the decreasing length in *Acetes* spp, crab, squid and miscellaneous item. A large percentage of fishes, prawn, and *squilla* in the largest length groups indicate they alter in feeding towards fish, prawn and *squilla* items as length increases. On the pieces of evidence from the report of Rao and Rao 1991, *squilla* dominated for all length groups followed by crabs and prawns. A large proportion of prawns mainly *S. choprai* and *A. indicus*, *L. duvauceli* and fish, which are active mobile benthic organisms recorded in large length groups indicated predatory behavior of *N. japo-*

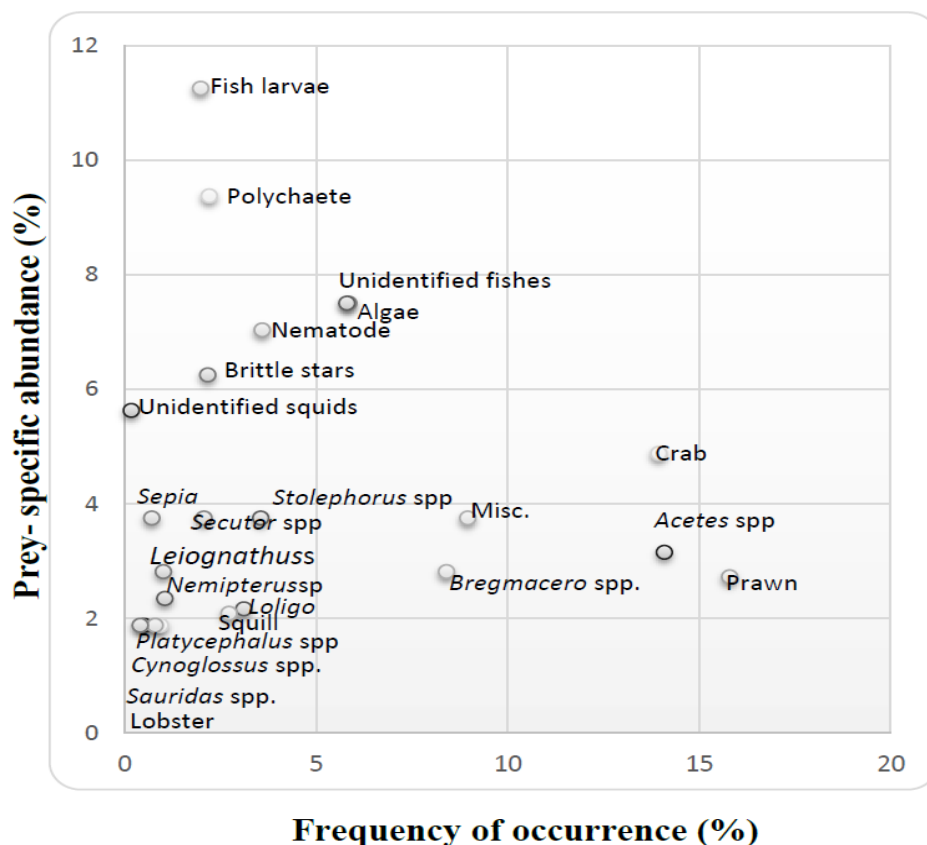


Figure 3. Feeding strategy diagram for *N. japonicus*. Prey-specific abundance (%) plotted against frequency of occurrence of food items in its diet.

Food items	<i>N. japonicus</i>		
	smallest group (100-140 mm)	median group (141-190 mm)	largest group (191-220 mm)
Fish	17.39	18.29	30.33
<i>Nemipterus</i> spp.	0.96	3.26	6.72
<i>Bregmaceros</i> spp.	8.77	5.36	16.38
<i>Secutor</i> spp.	0	0.42	0
<i>Sauridas</i> spp.	5.38	1.13	0
<i>Platycephalus</i> spp.	0	1.53	0
<i>Cynoglossus</i> spp.	0	0.26	0
<i>Leio gnathus</i> spp.	0	0	0.93
<i>Stolephorus</i> spp.	0	2.15	1.36
Fish larvae	0	0.55	0.69
Unidentified fishes	2.28	3.62	4.25
<i>Acetes</i> spp.	14.04	15.19	10.407
Crab	19.08	18.73	9.81
Prawn	16.14	15.85	19.81
Lobster	0	3.703	0
Squilla	4.37	7.37	11.11
Squid	10.14	3.65	3.703
Polychaetes	2.89	5.097	0
Nematodes	4.34	0	0
Brittle stars	1.449	3.65	3.703
Algae	0	2.43	0
Misc. items	8.69	9.75	7.407

Table 2. Ontogenetic variation in %IRI of different prey of *N. japonicus*.

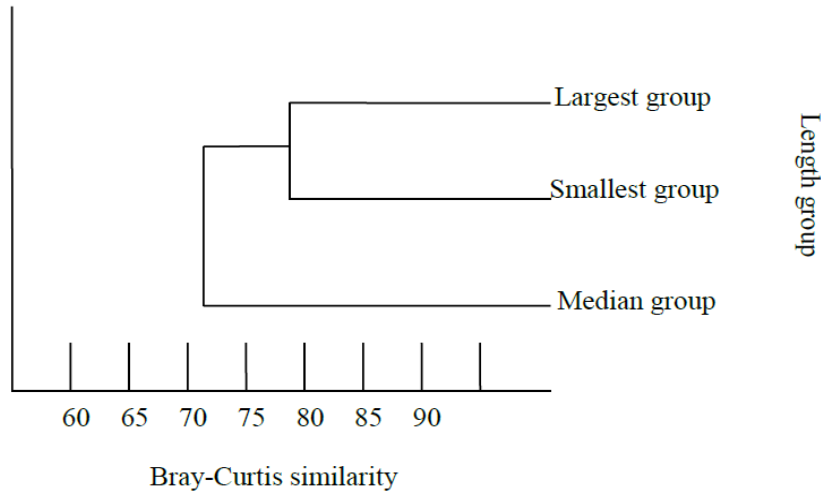


Figure 4. Dendrogram based on %IR: values of different length groups of *N. japonicus* using Bray-Curtis similarity.

Food items	Male	Female
Fish	16.66	14.7
<i>Nemipterus</i> spp.	2.56	0
<i>Bregmaceros</i> spp.	4.98	9.38
<i>Secutor</i> spp.	0.39	0
<i>Sauridas</i> spp.	1.22	1.26
<i>Platycephalus</i> spp.	1.34	1.55
<i>Cynoglossus</i> spp.	0.26	0
<i>Leiognathus</i> spp.	0.13	0
<i>Stolephorus</i> spp.	1.56	0
Fish larvae	0.76	0
Unidentified fishes	3.46	2.51
Acetes spp.	10	8.823
Crab	17.5	20.588
Prawn	18.33	17.64
Lobster	0.833	0
Squilla	5	4.893
Squid	3.33	2.941
Polychaetes	3.33	5.882
Nematodes	1.66	2.941
Brittle stars	0.833	2.941
Algae	2.5	0.989
Misc. items	17.5	17.64

Table 3. Sex variation in %IRI of different prey of *N. japonicus*.

ANOVA					
Sources	SS	df	MS	F _{cal}	P value
Between Groups	0.149	1	0.149	0.0	0.95
Within Groups	1534.9	40	38.37		
Total	1535.09	41			

Not significant at 5% level

Table 4. Comparison of IRI value between male and female of *N. japonicus* from Tha-baw-seik, Myanmar.

nicus on benthic animals. Compared with the present study, it is proved that almost all food items observed in the guts were only the benthic organisms. Moreover, it was also found that the sex variation in IRI value of *N. japonicus* had no significance with their different food items.

Conclusions

Acetes spp., Crab, Prawn and *Squilla* were the favorite food of *N. japonicus*. Regarding preyed fishes, it seems to eat *Bregmaceros spp* as its major food. It cannot be denied that *N. japonicus* is the kind of benthic fish because almost all food items were only the benthic organisms. Moreover, it can be concluded that their food items can be their associated animals. Therefore, the species found in their guts may be distributed along the Tha-baw-seik and its adjacent coastal waters.

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