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Feeding Habits of Fishes in the Pengkalan Gawi–Pulau Dula Section of Kenyir Lake Terengganu, Malaysia

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Abstract

A study was conducted to determine the feeding habits of the fish in the Pengkalan Gawi–Pulau Dula section of Kenyir Lake, Terengganu, Malaysia. Fish were collected on a monthly basis from February 2008 to January 2009 and their stomach contents were identified and quantified. A total of 261 individual fish from 6 different species were captured and the sample size of each species ranged from between 10 to 98 individuals. Aquatic insects were the most abundant among food items consumed. Four species namely, *Barbodes schwanenfeldii* (Bleeker, 1853), *Notopterus* sp., *Hampala macrolepidota*, Kuhl and van Hasselt, 1823, and *Pristolepis fasciatus* (Bleeker, 1851) were classified as omnivorous species, whereas *Hemibagrus nemurus* (Valenciennes, 1840) was classified as insectivorous and *Channa micropeltes* (Cuvier, 1831) was classified as piscivorous. The feeding habits of the three most dominant species were found to differ spatially and temporally. A more complex feeding habit was observed in the Pulau Pupi station and changes in feeding guilds were observed at each season throughout the study period.

Introduction

Freshwater fish catches including those from reservoirs in Malaysia have declined over the past few years. According to Ambak and Jalal (2006), the fish stocks in reservoirs, in general, are in a state of decline and a concerted effort is required to maintain exploitable resources at a sustainable level. Khoo et al. (1987) observed that Malaysian inland capture fisheries was principally dominated by cyprinids and silurid fish species especially in large rivers and lake systems, and sharp declines in catches were recorded during recent decades. These declines can be attributed to a number of factors, which include pollution, siltation, dam construction, illegal mass fishing methods as well as overfishing (Khoo et al. 1987).

Recently, freshwater reservoir fishery was recognised by the Malaysian government as an important sector which deserves special attention for development. In order to manage and conserve freshwater fish resources, it is important to gather basic information on the fish community in the area. The key factor is to understand both the biological and fundamental processes of individual fish species, which includes the knowledge of their feeding habits.

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Kenyir Lake in Malaysia requires serious management attention for the conservation of its fishery resources. This lake, which lies at latitude 4° 41’ N and longitude 102° 40’ E., is currently the biggest man-made lake in Malaysia with a surface area of about 36,900 ha. The average depth of the lake is 37 m; however, the maximum depth is 145 m. There are 340 islands in the lake, more than 14 waterfalls and numerous rapids and rivers.

In 1995, Jackson and Marmulla (2001) reported that the annual fish catch in Kenyir Lake was 720 $tonnes \cdot year^{-1}$. Recent data in 2010 updated by the DOF (2010), however, showed a reduced catch of 58.58 $tonnes \cdot year^{-1}$. The fish production of Kenyir Lake is declining and monitoring is needed to manage the lake ecosystem. Detailed studies on the feeding habits of fish in Kenyir Lake are lacking too. Therefore, this study was undertaken to determine the feeding habits of *Barbodes schwanenfeldii* (Bleeker, 1853), *Notopterus* sp., *Hampala macrolepidota,* Kuhl and van Hasselt, 1823, *Hemibagrus nemurus* (Valenciennes, 1840), *Channa micropeltes* (Cuvier, 1831) and *Pristolepis fasciatus* (Bleeker, 1851) in the Pengkalan Gawi–Pulau Dula section of Kenyir Lake. The findings are expected to provide some useful inputs for fishery management and conservation programmes in the Kenyir Lake.

Materials and Methods

The study was conducted at the Pengkalan Gawi–Pulau Dula section of Kenyir Lake which extends from Pengkalan Gawi (Gawi Jetty) in the north to Pulau Dula (Dula Island) in the south and lies between 5°03’ N to 5°08’ N, and 102°44’ Eto 102°52’ E (Fig. 1). The section is only a small part of the lake which covers an area of about 30 km^2. The section is located at the main entrance – visitor’s access to the Lake where a boat jetty is located. Fish were sampled monthly from February 2008 to January 2009 at three stations in the lake. These stations were designated as Station A (Pulau Dula), Station B (Sungai Ikan) and Station C (Pulau Pupi). Station A (Pulau Dula) is located at Dula Island where the littoral zone is covered with submerged dead tree trunks that emerge from the lake’s water surface. Station B (Sungai Ikan) is situated at the river mouth of Sungai Ikan where water from that river flows into the lake, while Station C (Pulau Pupi) is located near the Pupi Island and has a very steep and deep littoral zone.

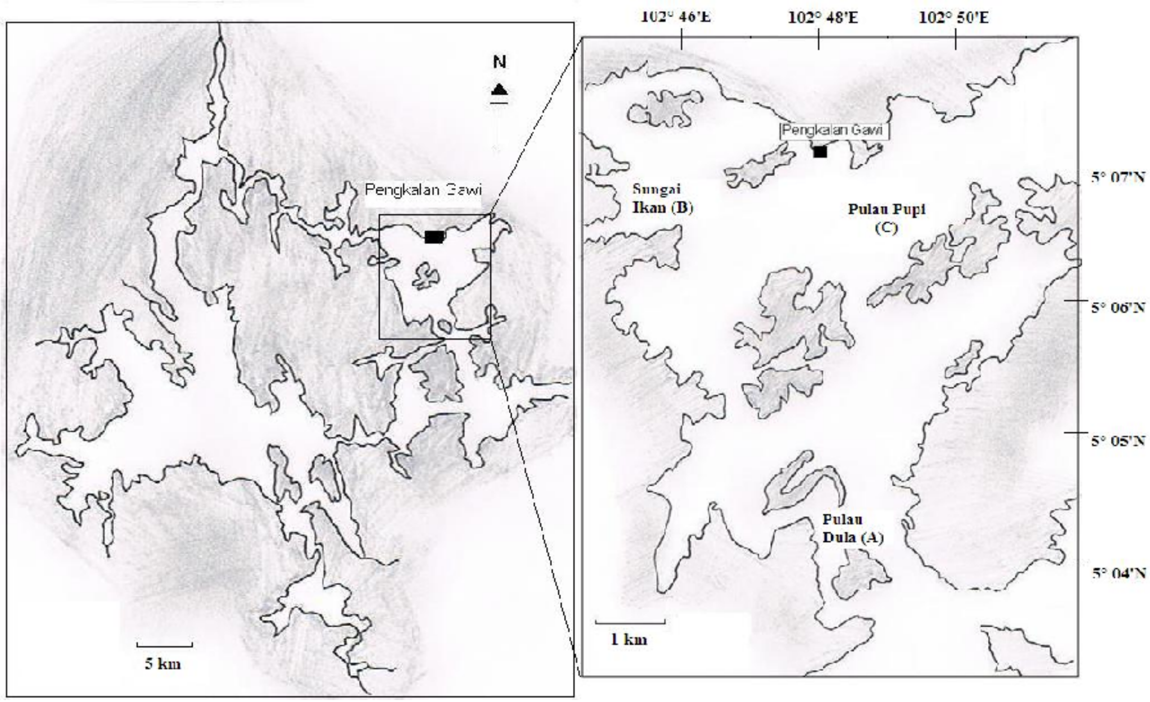

Fig 1. Maps showing sampling stations at the Pengkalan Gawi–Pulau Dula section of Kenyir Lake Terengganu.

Fish samples were collected by using gill nets of various mesh sizes (5.08, 6.35 and 7.62 cm). All fish caught were identified using keys from Mohsin and Ambak (1983). The stomach of each fish was removed and preserved in sample bottles containing a 5% formalin solution. In the laboratory, these stomach contents were weighed and were taxonomically identified and counted. The fish feeding habit indices used in this study are as follows: 1) percentage composition of food items (CFI), 2) frequency of occurrence of food items (FOFI) and 3) trophic level.

Percentage composition of food items (CFI)

The CFI method was used to measure the food composition that was present in every stomach and the total was expressed as a percentage of the total number of food items found.

[1] CFI (%) = (Number of food A item occurring / Total number of food items sampled) x 100

Frequency of occurrence of food items (FOFI)

The FOFI method was used for recording the number of stomachs containing one type of food item and the total was expressed as a percentage of the total number of stomachs examined.

[2] FOFI (%) = (Total number of stomachs containing food item A / Total number stomachs examined) x 100

Trophic level

The trophic level of individual fish was performed using the Troph-Lab computer programme which was introduced and developed by ICLARM-FAO (Pauly et al. 2000). The equation is as below:

[3] TROPHIC LEVEL $=1+\sum DC_{ij} \times TROPH_j$

Results

A total of 261 individuals belonging to 6 fish species were analysed for feeding data. The number of individual fish ranged from 10 individuals for *P. fasciatus* to 98 individuals for *B. schwanenfeldii*. Altogether, four species of fish namely *B. schwanenfeldii, Notopterus* sp., *H. nemurus* and *P. fasciatus* consumed aquatic insects as the main food item. Food consisting of fish items dominated the diets of *H. macrolepidota* and *C. micropeltes*. Plant material although not the most abundant food item found in the stomachs of any of the fish species sampled, was present in the stomachs of all six species (Table 1).

In terms of the trophic level, the values for all species ranged from 2.74±0.36 for *P. fasciatus* to 3.56±0.63 for *C. micropeltes* (Table 1). Four species were categorised as omnivorous species due to values less than 3. These were *B. schwanenfeldii*, *Notopterus* sp., *H. macrolepidota* and *P. fasciatus*. Meanwhile *H. nemurus* and *C. micropeltes* were categorised as predators.

For *B. schwanenfeldii*, although the percentage composition of aquatic insects in the stomach was high (62.7%), the percentage of occurrence of aquatic insects amongst these samples was relatively low (22.5%). The other food item that was abundant in the diet of *B. schwanenfeldii* was plant material comprising 16.9% of the total food items consumed and an estimated 22.1% of the total guts examined. This species was classified as omnivorous where both animal and plant origins of food items were consumed in equal amounts.

The percentage composition of aquatic insects consumed by *Notopterus* sp. was 64.6% from the total guts examined. Subsequently, about 14.8% of stomachs were found to contain plant material and 14.5% of stomachs were found to contain detritus as the other component of the diet of this species. *Notopterus* sp. was also the only species in this study which was found to consume all of the food items classified. Overall, this species was classified as an omnivorous species with trophic level of 2.86±0.34.

Table 1. Percentage composition of food items (%CFI), Frequency of occurrence of food items (%FOFI) and trophic level for the six most dominant species in Pengkalan Gawi–Pulau Dula Section of Kenyir Lake from February 2008 to January 2009.

Species	**Food item**	**%CFI**	**%FOFI**
B. schwanenfeldii	Fish	0.1	0.7
(Trophic level: 2.85±0.33)	Aquatic insect	62.8	22.5
(n= 98)	Molluscs	3.0	3.6
	Crustaceans	-	-
	Plant Materials	16.9	22.1
	Detritus	2.1	6.1
	Copepods	2.2	6.4
	Cladocerans	1.3	5.0
	Rotifer	1.5	5.0
	Bacillariophyta	3.2	8.2
	Chlorophyta	3.2	9.3
	Euglenophyta	0.8	3.6
	Cyanophyta	2.3	5.7
	Unidentified	0.6	1.8
Notopterus sp.	Fish	0.9	2.2
(Trophic level: 2.86±0.34)	Aquatic insect	64.6	21.6
(n= 75)	Molluscs	0.1	0.9
	Crustaceans	2.3	7.7
	Plant Materials	13.3	14.8
	Detritus	7.2	14.5
	Copepods	0.7	3.4
	Cladocerans	1.6	3.4
	Rotifer	1.1	3.7
	Bacillariophyta	1.9	4.9
	Chlorophyta	1.5	5.2
	Euglenophyta	0.5	3.1
	Cyanophyta	1.5	4.0
	Unidentified	2.8	10.5
H. macrolepidota	Fish	24.3	31.3
(Trophic level: 2.96±0.47)	Aquatic insect	13.5	14.1
(n= 44)	Molluscs	1.0	1.6
	Crustaceans	7.8	7.8
	Plant Materials	7.8	9.4
	Detritus	8.7	14.1
	Copepods	4.9	6.3
	Cladocerans	-	-
	Rotifer	-	-
	Bacillariophyta	8.7	4.7
	Chlorophyta	14.6	4.7
	Euglenophyta	1.0	1.6

	Cyanophyta	5.8	1.6
	Unidentified	1.9	3.1
H. nemurus	Fish	3.4	11.4
(Trophic level: 3.11±0.41)	Aquatic insect	77.0	38.6
(n= 22)	Molluscs	-	-
	Crustaceans	7.5	20.5
	Plant Materials	2.9	11.4
	Detritus	7.5	13.6
	Copepods	-	-
	Cladocerans	-	-
	Rotifer	-	-
	Bacillariophyta	-	-
	Chlorophyta	-	-
	Euglenophyta	-	-
	Cyanophyta	-	-
	Unidentified	1.7	4.5
C. micropeltes	Fish	62.5	71.4
(Trophic level: 3.56±0.63)	Aquatic insect	-	-
(n= 12)	Molluscs	-	-
	Crustaceans	-	-
	Plant Materials	37.5	28.6
	Detritus	-	-
	Copepods	-	-
	Cladocerans	-	-
	Rotifer	-	-
	Bacillariophyta	-	-
	Chlorophyta	-	-
	Euglenophyta	-	-
	Cyanophyta	-	-
	Unidentified	-	-
P. fasciatus	Fish	0.9	3.2
(Trophic level: 2.74±0.36)	Aquatic insect	37.9	22.6
(n= 10)	Molluscs	9.5	6.5
	Crustaceans	-	-
	Plant Materials	0.9	3.2
	Detritus	0.9	3.2
	Copepods	6.0	6.5
	Cladocerans	1.7	3.2
	Rotifer	1.7	6.5
	Bacillariophyta	15.5	16.1
	Chlorophyta	12.1	12.9
	Euglenophyta	2.6	6.5
	Cyanophyta	10.3	9.7
	Unidentified	-	-

Pristolepis fasciatus was also classified as an omnivorous species that consumed mostly aquatic insects (37.9%) and phytoplankton (40.5%). It was the only species that fed on a high volume of molluscs (snails) which comprised 9.5% of the stomach contents. On the other hand, although *H. macrolepidota* was frequently found to consume fish, it was still classified as an omnivorous species. This is due to the equal proportion of animal and plant material food items consumed, with a total of 51.5% and 49.5% of the total composition respectively.

The trophic value for *H. nemurus* was 3.11±0.41. It was therefore categorised as an insect feeder with a diet consisting of 77.0% aquatic insects in the stomach. Meanwhile, *C. micropeltes* was numerically the most representative with fish prey food items at 62.5%. Therefore, this species was grouped under the category of fish predator or piscivorous species.

Spatial feeding habits of fish

The feeding habits of the three most dominant species of fish namely *B. schwanenfeldii, Notopterus* sp. and *H. macrolepidota* were determined through the analysis of spatial data. These species were chosen due to their abundance at each station throughout the sampling period from February 2008 to January 2009.

The trophic value for *Notopterus* sp. showed that it was omnivorous at all stations, whereas *B. schwanenfeldii* was omnivorous in Pulau Dula and Sungai Ikan but was herbivorous in Pulau Pupi. The highest value for *B. schwanenfeldii* (2.91±0.35) was recorded in Sungai Ikan and for *Notopterus* sp. (2.88±0.36) in Pulau Pupi. This differed when compared to *H. macrolepidota* which was determined to be omnivorous in Sungai Ikan but was found to be carnivorous in Pulau Dula and Pulau Pupi (Table 2). Different kinds of feeding habits in different stations were also observed.

In Pulau Dula, fish were omnivorous and carnivorous. *Barbodes schwanenfeldii* and *Notopterus* sp. at this station were classified as omnivorous whereas *H. macrolepidota* fed solely on crustaceans (shrimp) and was thus categorised as a shrimp predator species. On the other hand, the only feeding type identified in Sungai Ikan station was omnivorous.

Three feeding types were observed in Pulau Pupi (omnivorous, herbivorous and carnivorous). The feeding habit of *Notopterus* sp. in this station was omnivorous, similar to *Notopterus* sp. at the Pulau Dula and Sungai Ikan stations. *Barbodes schwanenfeldii* at this station meanwhile differed in comparison to the other stations as they consumed mainly plant material (64.8%) and thus was categorised as a herbivore. The only species categorised as carnivorous was *H. macrolepidota* which consumed mainly aquatic insects and fish prey food items (25.5% each) (Table 2).

Table 2. The percentage composition of food items (%CFI) and frequency of occurrence of food items (%FOFI) of the three most dominant species at each station during the study period.

Station	**Food item**	***B. schwanenfeldii***		***Notopterus* sp.**		***H. macrolepidota***	
		%CFI	%FOFI	%CFI	%FOFI	%CFI	%FOFI
Pulau	Fish	0.1	0.7	-	-	-	-
Dula	Aquatic insect	62.6	24.8	57.1	20.0	-	-
(A)	Molluscs	5.7	3.3	1.3	6.7	-	-
	Crustaceans	-	-	-	-	100.0	100.0
	Plant Materials	11.9	19.3	11.7	19.9	-	-
	Detritus	1.0	3.3	16.9	20.0	-	-
	Copepods	2.2	6.7	-	-	-	-
	Cladocerans	1.0	3.3	-	-	-	-
	Rotifer	2.5	7.3	1.3	6.7	-	-
	Bacillariophyta	4.5	9.3	-	-	-	-
	Chlorophyta	3.8	11.3	1.3	6.7	-	-
	Euglenophyta	0.8	3.3	-	-	-	-
	Cyanophyta	3.8	6.7	3.9	6.7	-	-
	Unidentified	0.1	0.7	6.5	13.3	-	-
	Trophic Level		2.91±0.37		2.78±0.32		3.37±0.58
Sungai	Fish	0.1	1.1	1.1	2.5	23.5	40.0
Ikan	Aquatic insect	71.7	19.2	64.8	21.7	2.0	4.0
(B)	Molluscs	0.3	2.1	0.1	0.8	-	-
	Crustaceans	-	-	2.7	9.4	5.9	8.0
	Plant Materials	13.5	23.4	15.7	16.0	3.9	8.0
	Detritus	2.3	6.4	6.2	13.9	7.8	16.0
	Copepods	1.4	5.3	0.6	2.5	-	-
	Cladocerans	1.5	7.4	1.5	3.3	-	-
	Rotifer	0.8	3.2	0.8	3.7	-	-
	Bacillariophyta	2.6	9.6	1.5	4.9	17.6	12.0
	Chlorophyta	2.7	8.5	1.3	4.5	25.5	4.0
	Euglenophyta	1.0	5.3	0.6	3.3	2.0	4.0
	Cyanophyta	1.4	6.4	0.9	3.3	11.8	4.0
	Unidentified	0.8	2.1	2.2	10.2	-	-
	Trophic Level		2.91±0.35		2.87±0.35		2.68±0.40
Pulau	Fish	-	-	0.2	1.6	25.5	26.3
Pupi	Aquatic insect	11.9	22.1	65.0	20.3	25.5	21.0
(C)	Molluscs	3.1	8.3	-	-	2.0	2.6
	Crustaceans	-	-	1.0	3.1	7.8	5.3
	Plant Materials	64.8	30.6	4.5	9.4	11.8	10.5
	Detritus	7.0	16.7	9.2	15.6	9.8	13.2

Copepods	7.0	8.3	1.5	7.8	9.8	10.5
Cladocerans	2.3	5.6	2.5	4.7	-	-
Rotifer	-	-	2.2	3.1	-	-
Bacillariophyta	-	-	3.7	6.3	-	-
Chlorophyta	2.3	2.8	2.0	7.8	3.9	5.3
Euglenophyta	-	-	0.5	3.1	-	-
Cyanophyta	-	-	3.2	6.3	-	-
Unidentified	1.6	5.6	4.5	10.9	3.9	5.3
Trophic Level		2.31±0.25		2.88±0.36		3.21±0.52

Temporal feeding habits of fish

Variations in feeding habits between seasons were also observed in this study. The feeding habits of the three most dominant species were determined over time. The feeding habits of these species were computed quarterly and were grouped into the following intervals: February/April; May/July; August/October; and November/January.

Fish captured during February/April, May/July and August/October had aquatic insects as the most dominant food item, while those captured during November/January had plant material as the dominant food item (Table 3). During the study period of February to April, three groups of feeding habits were identified. These included insect feeders, omnivores and fish predators. *Barbodes schwanenfeldii* was categorised as an insect feeder whereas *Notopterus* sp. was categorised as omnivorous due to the presence of both aquatic insects and plant materials as the main feed contributor. The only fish predator during this season was *H. macrolepidota* with a high trophic level value of 3.73±0.65.

During May to July, three feeding habits were also observed. These habits were categorised as insect feeders, omnivores and carnivores. *Barbodes schwanenfeldii* which fed on a high proportion of aquatic insects (80.5%) was classified as an insect feeder. *Notopterus* sp. was categorised as an omnivore with a trophic level value of 2.96±0.38, while *H. macrolepidota* during this season was categorised as a carnivorous fish species.

During August to October all of the species were categorised as omnivorous species, feeding primarily on both aquatic insects and plant materials. Two types of feeding habits (herbivorous and omnivorous) were categorised during the months of November to January. During this period, *B. schwanenfeldii* switched their feeding strategy to be a herbivore while *H. macrolepidota* fed primarily on detritus (46.2%) and thus was classified as a detritivore. In the case of *Notopterus*sp, it continued to remain omnivorous with a trophic level of 2.90±0.35 (Table 3).

Table 3. Temporal data (quarterly) for the percentage composition of food items (%CFI), and frequency of occurrence of food items (%FOFI) of three most dominant species.

Station	**Food item**	***B. schwanenfeldii***		***Notopterus* sp.**		***H. macrolepidota***	
		%CFI	%FOFI	%CFI	%FOFI	%CFI	%FOFI
February	Fish	0.1	1.0	0.6	2.5	58.3	33.3
To	Aquatic insect	80.1	31.3	60.4	17.5	8.3	13.3
April	Molluscs	0.1	1.0	0.3	1.7	-	-
	Crustaceans	-	-	1.8	7.5	8.3	13.3
	Plant Materials	7.0	15.5	20.1	17.5	4.2	6.7
	Detritus	1.5	1.9	7.1	15.0	4.2	6.7
	Copepods	1.2	5.8	0.1	0.8	4.2	6.7
	Cladocerans	1.2	5.8	1.5	5.0	-	-
	Rotifer	1.2	5.8	1.0	5.0	-	-
	Bacillariophyta	2.4	8.7	1.1	3.3	8.3	13.3
	Chlorophyta	2.0	8.7	0.4	2.5	-	--
	Euglenophyta	1.1	5.8	0.6	4.2	-	-
	Cyanophyta	1.4	6.8	1.8	5.8	-	-
	Unidentified	0.7	1.9	3.2	11.7	4.2	6.7
	Trophic Level		3.01±0.37		2.80±0.34		3.73±0.65
May	Fish	-	-	-	-	33.3	42.1
To	Aquatic insect	80.5	27.0	69.8	22.0	41.6	26.2
July	Molluscs	0.7	4.2	-	-	4.2	5.3
	Crustaceans	-	-	4.9	14.3	4.2	5.3
	Plant Materials	8.4	24.9	7.4	12.0	-	-
	Detritus	0.4	2.1	3.4	11.0	8.3	10.5
	Copepods	0.4	2.1	1.1	5.5	4.2	5.3
	Cladocerans	1.8	6.3	1.8	3.3	-	-
	Rotifer	1.4	6.3	1.4	3.3	-	-
	Bacillariophyta	3.2	10.4	4.2	7.7	-	-
	Chlorophyta	1.4	8.3	1.8	6.6	-	-
	Euglenophyta	0.4	2.1	0.2	1.1	-	-
	Cyanophyta	1.4	6.3	2.4	4.4	-	-
	Unidentified	-	-	1.6	8.8	4.2	5.3
	Trophic Level		3.02±0.38		2.96±0.38		3.48±0.55
August	Fish	0.6	1.8	5.0	7.7	4.9	15.4
to	Aquatic insect	28.7	9.1	51.8	11.9	2.5	7.6
October	Molluscs	2.9	5.5	0.6	3.8	-	-
	Crustaceans	-	-	1.3	3.8	12.2	15.4
	Plant Materials	18.7	18.2	6.9	7.7	4.9	7.7
	Detritus	0.6	1.8	15.0	15.4	-	-
	Copepods	5.8	9.1	1.9	7.7	7.3	15.4

	Cladocerans	2.9	7.3	0.6	3.8	-	-
	Rotifer	4.7	7.3	2.5	3.8	-	-
	Bacillariophyta	11.7	12.7	1.9	3.8	17.1	7.7
	Chlorophyta	10.5	14.5	5.0	11.5	34.1	15.4
	Euglenophyta	1.2	3.6	0.6	3.8	2.4	7.7
	Cyanophyta	11.7	9.1	0.6	3.8	14.6	7.7
	Unidentified	-	-	6.3	11.5	-	-
	Trophic Level		2.53±0.23		2.83±0.35		2.42±0.28
November To January	Fish	-	-	0.9	2.8	7.1	7.7
	Aquatic insect	13.3	15.2	69.3	24.7	7.2	7.6
	Molluscs	13.8	6.1	-	-	-	-
	Crustaceans	-	-	0.6	2.8	-	-
	Plant Materials	53.9	28.8	11.2	18.1	35.7	30.8
	Detritus	6.4	19.7	8.8	16.7	42.9	46.2
	Copepods	5.0	9.1	0.9	4.2	-	-
	Cladocerans	0.4	1.5	1.9	1.4	-	-
	Rotifer	0.7	1.5	0.4	2.8	-	-
	Bacillariophyta	0.7	3.0	0.6	2.8	-	-
	Chlorophyta	3.9	7.6	1.7	5.6	7.1	7.7
	Euglenophyta	0.4	1.5	0.7	4.2	-	-
	Cyanophyta	0.4	1.5	0.4	1.4	-	-
	Unidentified	1.1	4.5	2.6	12.5	-	-
	Trophic Level		2.39±0.21		2.90±0.35		2.26±0.24

Discussion

The variations in trophic level values among the six species of fish examined in this study suggested that these fish have different feeding requirements and strategies. In general, two of them were found to be specialist feeders and four of them were found to be generalist feeders. The four species which were generalists were categorised as primary consumers and were classified as omnivorous species, while the other two species which were categorised as secondary consumers were classified as predators. Although the lake is considered oligotrophic with low productivity (Yusoff et al. 1995), most fish in the studied lake section showed a high food intake.

Hemibagrus nemurus exhibited a feeding trend dominated by the main diet item of aquatic insects. Aquatic insects as a food item were also important in the diets of three other species although they were categorised as omnivorous species. Aquatic insects which were found in fish stomachs may have been due to the location of the lake which is situated within the primary rain forest on the hilltops of the state of Terengganu. Insects are very common in Kenyir

Lake (Hasan and Ambak, 2005). According to Rouf et al. (2008), the Kenyir Lake catchment area was originally part of the dense, hilly forest which provided for the abundance of insects.

The abundance of insects in fish stomachs were also reported by Sakri et al. (2010) in their study in Kenyir Lake. Their study listed the groups of insect species and this included mayflies, fireflies, water beetles, water striders and dragonflies. According to Mason and MacDonald (1982), the abundance of this fish group is related to the easy capture of insects in aquatic ecosystems. Furthermore, insects are rich in proteins and nutrients (Nico and Morales, 1994).

The use of 'food items of animal origin' such as aquatic insects and fish prey food items in the diet of omnivorous species was almost consistent with the intake of 'food items of plant origin' such as plant material and phytoplankton. It is possible that this kind of group is more of a generalist, using other types of food when they are available in larger amounts (Melo et al. 2004). According to Lowe-McConnell (1987) generalist species have a better chance to become widely distributed in an aquatic ecosystem. This could be the reason for the dominance of omnivorous species such as *B. schwanenfeldii, Notopterus* sp. and *H. macrolepidota* in this lake section.

On the other hand, only one piscivorous (*C. micropeltes*) species was observed during the duration of this study. The stomach contents of *C. micropeltes* were found to contain the highest percentage of fish food items. This was almost similar to the results of the study by Sakri et al. (2010) who studied the stomach contents of fish species in Kenyir Lake and classified this species as a piscivore. The morpohometric characteristics of *C. micropeltes* clearly showed that this species was a real predator. *Channa micropeltes* was piscivorous with a strong jaw and wide mouth aperture (Wootton, 1998). Although the intake of fish food prey item provides high quality nutrients, the feeding strategy of predators required complex adaptations to overcome the defence strategies of their prey (Keenleyside, 1979).

Different trends of feeding habits were observed seasonally and spatially. Sungai Ikan is actually a good site where the simplest feeding habit is exhibited because all of the three dominant species (*B. schwanenfeldii*, *Notopterus* sp. and *H. macrolepidota*) were categorised as omnivores. None of them was classified as aquatic insect feeders although *B. schwanenfeldii* and *Notopterus* sp. fed on this prey. The most complex feeding habits were observed at Pulau Pupi. Some fish species earlier known as omnivores changed their diet to include plant materials and became herbivorous, or include fish food items and became a carnivorous species. This could be a consequence of a wider variety of food items available in this habitat for fish species to select (Hajisamae et al. 2003). Temporally, some fish species underwent changes in their feeding habits during different seasons. These were *B. schwanenfeldii* and *H. macrolepidota*. They shifted from aquatic insect feeders to herbivores for *B. schwanenfeldii*, and from piscivorous species to detritivore for *H. macrolepidota*. On the other hand, carnivorous species were present during February/April and May/July. However, this carnivorous guild was absent during August/October and November/January. According to Hajisamae et al. (2003), the dietary shifts are probably a major feature in structuring the trophic guild in the habitat.

Although *H. macrolepidota* had fish food prey items in its diet during November/January, this was accompanied by other food items such as detritus. Thus this species was considered as detritivorous species. The types of detritus found were fish scale, rock, sand and mud. From this finding, it is evident that the detritivory habit may be one of the important feeding strategies available during this season. Caragitsou and Papaconstantinou (1994) described that the organic content of mud may play an important role in the nutrition of fishes. This is because detritus contains large amounts of microorganisms (Keenleyside, 1979).

The feeding patterns during February/April and May/July could be categorised into three different feeding guilds observed in each season. This indicated that the three species fed on specific types of food items due to abundance and availability of each food item during each season. However, the specific types of feeding guilds need not necessarily mean that the species feeds completely on a different suite of food. There was some overlap in food choices where aquatic insects, plant materials and zooplankton were found in all the stomachs of these fishes. The fish species in each particular habitat, however, has many strategies for avoiding trophic competition and for optimising available resources (Hajisamae et al. 2003).

Conclusion

Stomach contents of the six fish species can be used as indicator of their diet. The differing stomach contents consisted of a variety of food items. The food items varied from the smallest organisms such as phytoplankton and zooplankton to the biggest prey such as fish, molluscs and crustaceans. This indicated that these different fishes depend on one another and also depend on the stability of the ecosystem which provided the suitable food sources for the fish. The findings of this study are expected to be valuable inputs for the planning and management strategies towards the sustainability and conservation of the fisheries resources. Future studies can be conducted to better understand the fish population in Kenyir Lake. The Pengkalan Gawi–Pulau Dula section of Kenyir Lake can be properly managed and developed for eco-tourism and fish production on a sustainable basis.

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