A comparative study of seasonal food and feeding habits of beardless barb, *Cyclocheilichthys apogon* (Valenciennes, 1842), in Temengor and Bersia Reservoirs, Malaysia

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Abstract

The food and feeding habit of beardless barb, *Cyclocheilichthys apogon* (Valenciennes, 1842), from family Cyprinidae was investigated by stomach content analyses of 374 collected fish in two consecutive reservoirs; Temengor and Bersia Reservoirs which are separated by Temengor Dam. The main aim of this study was to compare the stomach contents of *C. apogon* between these two reservoirs in wet and dry seasons. Results showed that *C. apogon* is omnivorous based on the moderate value of relative gut length. The main food items contained in their stomach were Oligochaeta, Chironomidae and detritus which made up over half of the stomach contents. Other food items, such as Cladocera, Crustacea and Gastropoda, supplemented the main food and were consumed in much smaller amounts. There were specific differences in the food preference between Temengor and Bersia populations i.e. Oligochaeta was the most preferred in the former while Chironomidae in the latter, but the general pattern was similar in both. There was no statistically significant difference ($p>0.05$) in frequency occurrences of food items in diet composition between the two reservoirs during both wet and dry seasons. Therefore, the seasonal feeding activities of *C. apogon* in Temengor Reservoir were relatively similar with those in Bersia Reservoir. In conclusion, for the present Temengor Dam does not affect the nutritional habit of *C. apogon* in Bersia Reservoir.

Keywords: *Cyclocheilichthys apogon*, Cyprinidae, Food preference, Seasons, Temengor and Bersia Reservoirs

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Introduction

Similar to other organisms, fish requires energy to grow, survive and reproduce (Lagler *et al.,* 1977). In a freshwater habitat, energy could be obtained from a variety of food such as detritus, plants and animals. Fishes in tropical streams have diverse feeding behaviour compared to temperate fishes.

Knowledge on the feeding habit and food preference of freshwater fish is important for maintenance and conservation of the species either in captivity or in its natural habitat. Apart from a few documentations by Yap and Furtado (1981) and Kulabtong and Kunlapapuk (2010), the food and feeding habits of *C. apogon* has not been adequately studied. Investigations on the food and feeding habits of other fishes in Perak River have been conducted for *Osteochilus hasseltii*, *Poropuntius deauratus*, *Neolissochilus soroides* and *Thynnichthys thynnoides* (Bat, 1992; Velerie, 1999; Nurulnajwa, 2004). The damming of Perak River that is the second longest river in Peninsular Malaysia (427 km), has created four consecutive reservoirs namely Temengor, Bersia, Kenering and Chenderoh Reservoirs. However, to date there is a lack of information on the Perak River populations. Therefore, to fill the knowledge gap on the stomach content of *C. apogon* in this important river system, this analysis was carried out to generate baseline information to facilitate sustainable freshwater fisheries of this species.

Materials and methods

Study area

This study was conducted in two consecutive reservoirs namely Temengor Reservoir and Bersia Reservoir which are located at the upper part of Perak River basin (Fig. 1). Temengor and Bersia Reservoirs serve as important hydroelectricity sources (Ambak *et al*., 2010).

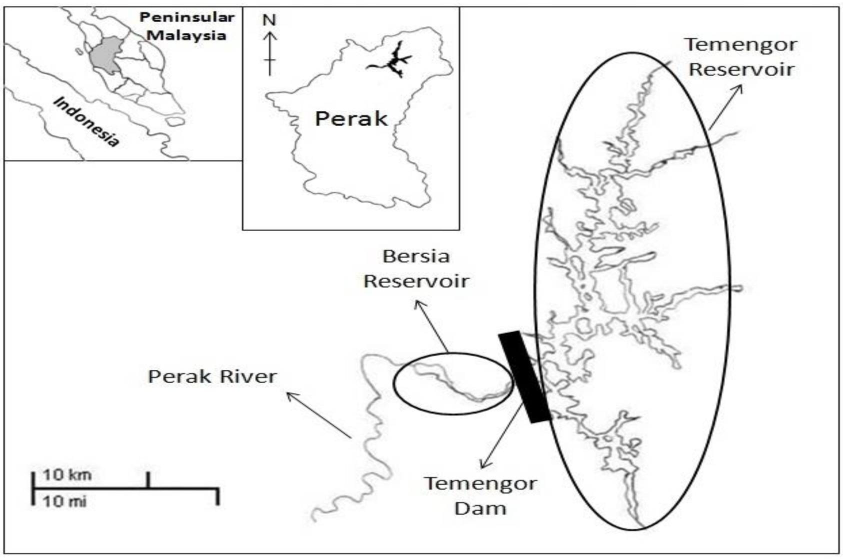


Figure 1: Location of Temengor Reservoir and Bersia Reservoir at the upper part of Perak River basin (Inset: Map of Peninsular Malaysia and Perak state).

Stomach contents analysis

A total of 374 fish measuring from 11.56 to 24.50 cm in total length, weighing from 38.52 to 179.35 g were collected and examined. The fish samples were bought from fishermen and were dissected to obtain the gut. The coiled gut was straightened and the gut length (GL) was measured from the oesophagus until the tip of the anus. The contents were taken out from the gut and preserved in formalin solution 5%. In this study, stomach content was analyzed using the frequency of occurrence (FOC) and numerical method (NM) as described by Hyslop (1980) and Costa *et al.* (1992). As for the food items, sand/mud was categorized differently with detritus.

Feeding behaviour related to fish size

For fish classes in both reservoirs, every class has a range of 2 cm of total gut length. Therefore, in Temengor Reservoir the total length of the gut that ranged from 14.70 to 28.35 cm was subdivided into eight classes, while in Bersia Reservoir the total length that ranged from 14.10 to 21.57 cm was subdivided into five classes. The composition of *C. apogon* diet was determined based on the numerical percentage for each class of food item.

Relative gut length (RGL)

Relative gut length was calculated based on the formula given by Montgomery (1977).

RGL=Gut length(cm) / Standard length (cm)

Diversity index

The extent of diet diversity was calculated using the diversity index of Shannon-Wiener (Ludwig and Rynolds, 1988). The non parametric Kruskal-Wallis H-test was used as frequency of food occurrence did not conform to normality assumption of Shapiro-Wilk test (Sahai and Ageel, 2000). This test was used to compare the occurrence of individual food items and the monthly variations in diet composition between Temengor and Bersia Reservoirs. All calculations were carried out using SPSS 11.5 and MVSP (Krebs, 1989).

Results

Frequencies of occurrence of different food items of C. apogon

Percentage of frequency of occurrence (% FOC) of food categories in the stomachs of *C. apogon* in Temengor and Bersia Reservoirs during wet and dry seasons is shown in Table 1. This study revealed that Chironomidae, Oligochaeta and detritus were highly represented among the food items in the stomach content in fishes of both Temengor and Bersia Reservoirs. These three food items made up of over half of the stomach content, making these food items as the main diet while other animal and plant materials supplemented the food supply of this fish. Based on Kruskal-Wallis H-test, there was no statistically significant difference ($p>0.05$) between the dietary analysis during either the wet or dry season, thus revealed the high similarity of feeding habit between these two reservoirs.

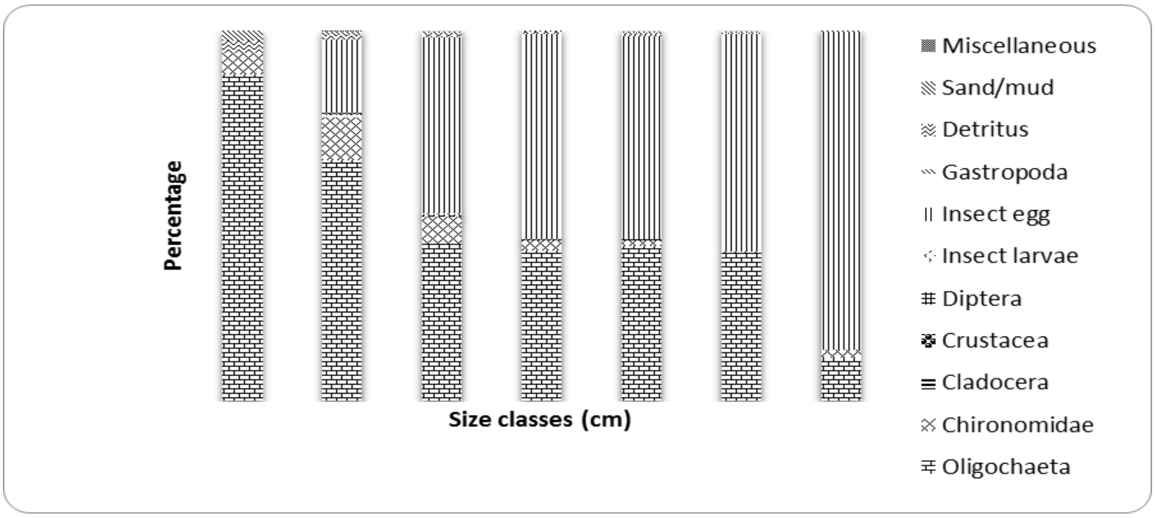
Table 1: Percentage of frequency of occurrence (%FOC) of food categories in the stomachs of *Cyclocheilichthys apogon* in Temengor and Bersia Reservoirs during wet and dry seasons.

		TW	**TD**	**BW**	**BD**
No. of fish examined		103	86	97	88
No. of empty stomachs		18	22	19	21
No. of stomachs containing food		85	64	78	67
Food Groups	Food categories	% FOC	% FOC	% FOC	% FOC
Annelida	Oligochaeta	88.24	31.25	10.26	4.48
Arthropoda	Chironomidae	27.06	34.38	61.54	56.72
	Cladocera	3.53	0.00	3.85	17.91
	Crustacea	3.53	4.69	2.56	10.45
	Diptera	1.18	12.5	3.85	25.37
	Insect larvae	0.00	1.56	0.00	4.48
	Insect egg	24.71	3.13	7.69	1.49
Mollusca	Gastropoda	0.00	7.81	3.85	1.49
Detritus	Detritus	97.65	85.94	73.08	52.24
Sand/mud	Sand/mud	38.82	29.69	34.62	20.9
Miscellaneous	Miscellaneous	21.18	14.06	16.67	11.94

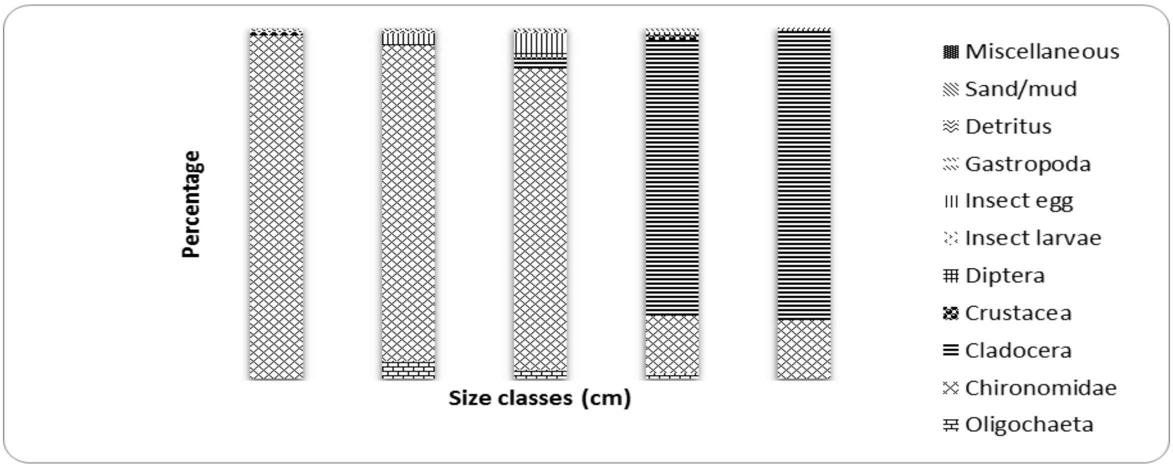
Notes:
TW: Temengor Reservoir during wet season
TD: Temengor Reservoir during dry season
BW: Bersia Reservoir during wet season
BD: Bersia Reservoir during dry season

Feeding behaviour related to fish size

The composition of *C. apogon* diet among size classes in Temengor and Bersia Reservoirs based on numerical percentage of prey are illustrated in Figs. 2(a) and 2(b), respectively. Frequencies and distributions of food items vary among size classes. In terms of diet variability, generally the diet of different size classes in both reservoirs showed similar trends with the lowest class (13-15cm) being the least variable. Similarly, the highest food item variation occurred in size class 17–19cm. However, the trend of diet of food preference at different life stages varied between the two reservoirs. In Temengor Reservoir fish in the lowest class (13-15 cm) fed mainly on Oligochaeta but the diet shifted to insect eggs as the fish grow bigger, whereas in Bersia Reservoir the lowest class fed mainly on Chironomidae but the diet shifted to Cladocera as the fish grows bigger.



(a) Temengor Reservoir



(b) Bersia Reservoir

Figure 2: Composition of *Cyclocheilichthys apogon* diet related to fish size group based on numerical percentage of prey in (a) Temengor Reservoir (b) Bersia Reservoir; (), Oligochaeta; (), Chironomidae; (), Cladocera; (), Crustacea; (), Daphnia; (), Diptera; (), Insect larvae; (), Insect egg; (), Gastropoda; (), Detritus; (), Sand/Mud; (), Miscellaneous.

RGL

The measurements of total length, standard length, weight, gut length, gut weight and relative gut length (RGL) of *C. apogon* based on the size classes in Temengor and Bersia Reservoirs are shown in Table 2. The values of relative gut length were low in smaller fish and tend to increase as the fish grow until it reaches the maximum size. Beyond this point, the values decrease as the fish grow larger. The RLG had moderate value suggesting that this fish is omnivore.

Diversity index

The variations in diversity indices of Shannon-Wiener of *C. apogon* in both Temengor and Bersia Reservoirs based on the size classes are shown in Table 3.

Generally, for both reservoirs the medium size classes showed the highest variations. The results also showed that the diversity and evenness indices in Temengor Reservoir were higher than those of Bersia Reservoir in all size classes. Based on Kruskal-Wallis H-test, there was no statistically significant difference (p>0.05) in diet composition between Temengor and Bersia Reservoirs during either of the wet or dry seasons. Thus, results revealed that the diet of *C. apogon* between Temengor and Bersia Reservoirs showed high similarity. It appeared that Temengor Dam has no influence on feeding habit in Bersia Reservoir. However, there may be other subtle differences that were not revealed by this approach.

Table 2: The mean (±SD) values of relative stomach length according to the size classes in Temengor and Bersia Reservoirs in 2011.

Reservoir	Size class (cm)	Total length (cm)	Standard Length (cm)	Weight (g)	Gut Length (cm)	Relative Gut Length (cm)
Temengor	**13 - 15**	14.700 ± 0.424	11.560 ± 0.321	38.526 ± 3.297	13.540 ± 2.123	1.169 ± 0.158
	15 - 17	16.169 ± 0.536	12.873 ± 0.827	51.803 ± 6.267	16.627 ± 2.365	1.292 ± 0.173
	17 - 19	18.079 ± 0.564	14.337 ± 0.802	75.101 ± 14.343	18.401 ± 2.637	1.285 ± 0.179
	19 - 21	19.963 ± 0.521	15.760 ± 0.753	93.734 ± 16.003	21.560 ± 3.463	1.366 ± 0.194
	21 - 23	21.689 ± 0.534	17.253 ± 0.648	116.702±16.994	22.200 ± 3.591	1.305 ± 0.209
	23 - 25	23.700 ± 0.566	18.850 ± 0.778	156.395±17.671	22.400 ± 1.273	1.183 ± 0.019
	27 - 29	28.350 ± 0.354	24.500 ± 0.424	179.350±12.092	24.100 ± 0.990	0.984 ± 0.057
Bersia	**13 - 15**	14.100 ± 0.802	11.871 ± 2.400	40.653±10.134	12.729 ± 5.348	1.157 ± 0.511
	15 - 17	16.269 ± 0.464	12.765 ± 0.491	59.094 ± 7.565	17.561 ± 1.973	1.376 ± 0.147
	17 - 19	18.030 ± 0.637	14.134 ± 0.553	82.369 ± 12.564	18.218 ± 2.584	1.289 ± 0.173
	19 - 21	19.931 ± 0.545	15.575 ± 0.525	114.586±14.431	18.866 ± 2.027	1.211 ± 0.120
	21 - 23	21.570 ± 0.291	17.070 ± 0.340	149.913±9.015	20.200 ± 2.864	1.182 ± 0.153

Table 3: Diversity and evenness Indices of food items in the stomach contents of *Cyclocheilichthys apogon* in different length groups from Temengor and Bersia Reservoirs in 2011. N=Number of food items.

Length group (cm)	Temengor			Bersia		
	Diversity	**Evenness**	**N**	**Diversity**	**Evenness**	**N**
13 - 15	0.711	0.355	4	0.108	0.054	4
15 - 17	1.478	0.493	8	0.674	0.195	11
17 - 19	1.508	0.436	11	0.963	0.269	12
19 - 21	1.273	0.383	10	1.062	0.307	11
21 - 23	1.245	0.415	8	0.771	0.298	6
23 - 25	1.082	0.419	6	-	-	-
25 - 27	-	-	-	-	-	-
27 - 29	0.694	0.299	5	-	-	-

Discussion

The *C. apogon* could be classified as a euryphagous omnivore, feeding on a wide range of food of benthic organisms. However, it shows preference for certain food items. In both Temengor and Bersia Reservoirs, detritus was found in gut of almost all specimens (52–97%). Furthermore, the abundance of leaf, wood, and related matter in the stomach showed that the basic diet was detritus (Pekcan-Hekim and Horppila, 2007). Thus, together with the relatively high occurrence of small wood debris and plant materials, they provided evidence that this species is a bottom feeder.

The occurrence of sand/mud in addition to detritus throughout the study period provided further evidence of the bottom feeding habit of *C. apogon.* Mud and grains could be taken in coincidentally while the fish was burrowing in the sand to prey upon benthic animals. In addition, it could also be accidentally ingested while feeding on other food items, particularly insects, Crustacea, and Mollusca (Prasad and Anvar-Ali, 2008). Golikatte and Bhat (2011) documented the occurrence of sand particles in the stomach of *Gerres filamentosus* from Sharavati estuary. They suggested that the presence of sand may be due to an accidental ingestion of the food items that have been picked up together with the main food materials.

Its elongated coiled gut provides further evidence for an efficient system for the digestion of algae and plant materials (Yap, 1988). In addition, the occurrence of Gastropoda, Crustacea and Cladocera in stomach, even though in small amounts but in significant fractions, indicated a bottom feeding tendency. This supports the higher abundance of fishes that contributes to the food web in the habitat. Another advantageous characteristic to support its feeding habit is its downwardly directed mouth which facilitates the intake of benthic organisms which are attached to the bottom level of water body.

The lack of difference in frequency occurrence of food items between Temengor and Bersia Reservoirs during both wet and dry seasons indicated that *C. apogon* in both reservoirs utilised almost similar diet and presumably the habitats provide similar resources. However, there were specific differences in diet preference between Temengor and Bersia populations i.e. Oligochaeta was the most preferred in the former while Chironomidae in the latter, but the general pattern was similar in both. Zakaria-Ismail (1993) highlighted that the type of food that fish has affinity to eat is also dependent on the opportunity to catch the food and frequentness of finding them. This probably correlates with the abundance factor of food availability for *C. apogon*. The variable diet components in both reservoirs were highly correlated to the biotic and abiotic environmental factors present such as the food availability and fish interactions (competition and predation) at the particular period of study time. Generally, fish tend to change their diet based on food abundance in their environment (Nowak *et al.*, 2004). The slight variations in quantity of food items in the stomach may be related to seasonal variation in food availability, the age of fish and variation in feeding diversity as suggested by Yankova *et al.* (2008) who conducted a diet investigation on *Trachurus mediterraneus ponticus* (horse mackerel) in Bulgaria.

Most of the analyzed fish measured more than 13 cm in length. Abdel Aziz *et al.* (1993) reported that food consumption appeared to be correlated with age (body size), water temperature, spawning activity and food availability. The highest variability of food items in both reservoirs occurred in size class 17-19 cm suggesting a greater adaptability of food preference at or around this size range. This phenomenon also presumably relates to high food consumption and the increase of metabolism rate in this size class. The lower food consumption of older fish is probably related to a decreased rate of metabolism, since it is more favourable for a larger fish to obtain more mass of energy expenditure at lower rate (Afraei *et al.*, 2009). Weerts *et al.* (1997) reported that along the coast of Africa, the dietary habits of *Sillago sihama* was very distinctive where fishes less than 6 cm standard length fed on planktonic prey, mainly Larvacean and Copepods, while larger fishes fed on benthic Crustacea, Polychaetes and Bivalves. In a similar study, Hajisamae *et al.* (2004) noted that *S. sihama* inhabiting the Johor Straits changed its diet from planktonic micro-crustaceans during the early life stages to polychaetes and gammarid amphipods as they grow bigger.

RGL is a useful index which provides an indication of the nature of food consumed (Biswas, 1993). In fishes, it can also be used as a reference point for interspecific comparisons (Al-Hussaini, 1947). The gut lengths are shorter in smaller fish and increases until the fish reaches its maximum size. Digestive tract becoming longer and more coiled in order to digest and absorb food efficiently, hence resulting in the increment of relative gut length (Sarpanah *et al*., 2010). So, the adult fishes would have longer intestine as compared to juvenile fishes. In the present study, the gut length and weight increased as the fish length increased. In parallel, the RGL is directly proportional to fish age. As reported by Sarpanah *et al.* (2010), RGL value was lowest in the fry stage and highest in the older fish of *Neogobius caspius* (Caspian goby). Therefore, older and hence larger fish will have higher ratio of gut length to body length in comparison with smaller fish.

Thus results revealed that there was no significant difference in terms of diet composition of *C. apogon* between Temengor and Bersia Reservoirs. It appeared that Temengor Dam has no influence on fisheries in Bersia Reservoir.

This study showed that *C. apogon* is omnivorous based on the medium value of relative gut length. This euryphagous fish feeds on a variety of prey items.

However, feeding habits were similar in both investigated reservoirs. The main food items in both reservoirs were Oligochaeta, Chironomidae and detritus while other food materials such as Cladocera, Crustacea and Gastropoda were less utilised indicating their low importance or low availability. However, the diet and feeding behaviour changed within reservoir, season, month, and fish size. The results showed that the fish community in the reservoir were directly dependent on several biotic and abiotic components that make up the food chain such as detritus, animals, planktons and other organisms. The study on the stomach content is fundamental to understand food web structure in an ecosystem.

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