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Food and Feeding Habits of Wild *Pangasius nasutus* (Bleeker 1863) in Jerantut District of Pahang River Mainstream, Malaysia

Goh Ming Ying[1], Izharuddin Shah Kamaruddin[2]*, Rozihan Mohamed[2], Rumeaida Mat Piah[3], Muhammad Ikhmal Roslan[2], and Aziz Arshad[1,2]

[1]*International Institute of Aquaculture and Aquatic Sciences, Universiti Putra Malaysia (UPM), 70150 Port Dickson, Negeri Sembilan, Malaysia*

[2]*Department of Aquaculture, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia*

[3]*Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*

ABSTRACT

Despite the ecological and commercial importance of *Pangasius nasutus*, limited information is available related to the feeding habits of the species in the natural river systems. This study was conducted to provide preliminary information on the food and feeding habits of wild *P. nasutus* in Jerantut District of Pahang River mainstream, Malaysia. A combination of frequency of occurrence and numerical methods was used. The length (cm) and weight (g) of all samples were measured, and their stomach contents were recorded. The differences in diet composition were compared between different total length size groups. A total of 265 individuals were collected from January 2022 to March 2023. Food items of *P. nasutus* revealed omnivorous feeding habits, although they consumed more animal-based foods than plant-based foods. Based on frequency of occurrence (% F), avian carcasses were the major food items that occurred with 38.92%. This was followed by *Corbicula fluminea* (29.34%), plant debris (21.56%), unidentified animal remains (15.57%), decapods (11.38%), Osteichthyes (10.18%), *Ficus* sp. fruits (9.58%), *Elaeis* sp. fruits (7.19%), sand grains (2.40%) and unidentified plant materials (0.60%). However, based on percentage prey abundance (%N), *C. fluminea* was the most abundant (86.11%). This was followed by avian carcasses (3.49%), plant debris (2.63%), Osteichthyes (2.36%), *Elaeis* sp. fruits (1.45%), unidentified animal remains (1.40%), decapods (1.29%), *Ficus* sp. fruits (0.91%), sand grains (0.32%) and unidentified plant materials (0.05%).

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E-mail addresses:
gs58708@student.upm.edu.my (Goh Ming Ying)
izharuddin@upm.edu.my (Izharuddin Shah Kamaruddin)
rozihanm@upm.edu.my (Rozihan Mohamed)
rumeaida@umt.edu.my (Rumeaida Mat Piah)
gs65038@student.upm.edu.my (Muhammad Ikhmal Roslan)
azizarshad@upm.edu.my (Aziz Arshad)
* Corresponding author

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Findings indicated that ontogenetic resource partitioning also played an important role in the coexistence of *P. nasutus* populations in the Pahang River, Malaysia.

Keywords: Feeding habits, ontogenetic resource partitioning, Pahang River, *Pangasius nasutus*, stomach content analysis

INTRODUCTION

The food and feeding habits of fish have always been an important area of research, especially in the studies of fisheries science and aquaculture. Knowledge of fish diets provides insight into a species' biology, including its condition, energy intake, and reproduction. In a broader sense, knowing what a fish species consumes can help fisheries scientists and managers to understand the trophic relationships, population dynamics and community dynamics within the ecosystem of the species, which enables comparisons between other systems (Amundsen & Sánchez-Hernández, 2019).

Pangasius nasutus, a species from the Pangasiidae family, can be found in the Perak and Pahang River basins of Peninsular Malaysia, and other riverine systems in Sumatra and Borneo (IUCN, 2020). In Malaysia, it is an important fish source and one of the most sought-after and preferred edible freshwater fish species. The price can be up to RM160 (USD 40) per kilogram. At all times, this species was classified as an omnivore that feeds on benthic invertebrates, seeds and fish (Gustiano & Pouyaud, 2005). However, there is a lack of empirical data on their diet and feeding habits. Furthermore, there is no solid information about their ecology, population size, and the effects of anthropogenic threats to the status of *P. nasutus* in the wild (Vidthayanon & Ng, 2020).

According to the IUCN Red List of Threatened Species, *P. nasutus* was assessed in 2019 and listed as "least concern", stating its population trend to be stable (IUCN, 2020). However, a study by Jaafar et al. (2023) indicated that this species in the Pahang River is vulnerable to overfishing due to its slow growth rate. Therefore, investigating its food and feeding habits could help address existing research gaps, particularly regarding its ecological role within its habitat. Fish are both predators and prey embedded in complex trophic networks, and understanding the food web interactions through their dietary patterns is essential in developing harvesting strategies in maintaining fish stocks at a sustainable level (Traugott et al., 2020). This is becoming more important as world consumption of aquatic animal foods has increased significantly in recent years and will rise continually, with an average annual growth rate of 3.0 percent between 1961 and 2021, outpacing the annual population growth rate of 1.6 percent (Food and Agriculture Organization [FAO], 2024).

In Malaysia, several studies have been done related to food and feeding habits of fish species (Ara et al., 2016; Azfar et al., 2015; Azim et al., 2021; Hamid et al., 2015; Intan-

Faraha et al., 2020; Mustafa-Kamal et al., 2012). Malaysia is rich with different types of aquatic ecosystems, which provide high diversity of fishes that are commercially important, especially to the local communities. These high-value species are cultured for aquaculture production in the country. Despite this, scientific information on the food and feeding habits of *P. nasutus* is very limited and has only been shared verbally among the local fishermen.

Therefore, this study aimed to determine the food and feeding habits of wild *P. nasutus* in Jerantut District of Pahang River mainstream, Malaysia. To achieve the aim, two objectives were developed: first, to determine the stomach contents of *P. nasutus* and second, to compare differences in the diet composition of *P. nasutus* in the study area. This study will contribute to a better understanding of the feeding ecology and dietary composition of *P. nasutus* in the Pahang River, Malaysia. The findings will provide baseline information on the stomach contents and dietary variation of the species, which can improve knowledge about its ecological role, feeding preferences, and habitat utilisation in the wild. In addition, the study may support future fisheries management, conservation planning, and sustainable exploitation of the species, particularly in the riverine systems of the Pahang River, Malaysia.

METHODOLOGY

Site Description

Pahang River is the longest river in Peninsular Malaysia, with a length of 459 kilometres, and its upstream section of the river system is located in the Main Range of Titiwangsa (Lun et al., 2011). It is located in the State of Pahang, which is also the largest state in Peninsular Malaysia. The Pahang River Basin lies between latitude N 2° 48' 45" and N 3° 40' 24" and between longitude E 101° 16' 31" and E 103° 29' 34". It has two main tributaries named the Tembeling River and the Jelai River, which meet at the confluence of Kuala Tembeling.

The Pahang River plays an important role as a drainage system to drain excess water from the river basin to the South China Sea during the northeast monsoon season (Lun et al., 2011). In general, the annual rainfall of the basin was 2,170 mm. However, during the northeast monsoon season between October and January, the amount of rainfall reach to the peak and flooding in the lowland areas occurs frequently due to overflowing from the Pahang River (Lun et al., 2011).

Study Location and Duration

This study was conducted at a section of the Pahang River which is located in the Jerantut district of Pahang (Figure 1). The section was only a small part of the whole stretch of the Pahang River, with a length of about 40 kilometres. This section was selected as it was believed to be the district where *P. nasutus* are the most abundant. This was supported by the findings of Jaafar (2024), which reported that Jerantut recorded the highest number of *P. nasutus* during their study period between 2021 and 2022. Furthermore, due to limitations in sampling resources such as time and manpower, it is justifiable that only the Jerantut district was explored as the study location.

Figure 1. Map of Jerantut District, Pahang River, Pahang, Malaysia (Google, 2023)

This study was conducted every month from January 2022 to March 2023 for five days per week each month. In total, the one-year and three-month study period was conducted to observe the monthly and seasonal patterns of food and feeding habits of *P. nasutus*.

Data Collection and Sampling

The main data collected for this study were the number of fish, length of fish (cm), weight of fish (g), weight of stomach, and stomach content data such as the number and type of food items consumed by *P. nasutus*.

Collection of fish samples was conducted using traditional fishing methods employed by local fishermen. This approach enabled efficient and practical sampling within the natural riverine environment and is considered suitable for feeding habit studies, as it reflects the species naturally captured in local fisheries. Although some selectivity toward certain size classes may occur, the method remains widely acceptable for dietary analysis because it provides representative specimens from the existing population in the study area. Similar approaches have been widely applied in previous dietary studies of freshwater and marine fishes (Zacharia & Abdurahiman, 2004).

An average of 20 samples in total were separated, weighed, and collected from the fishermen for each month. Each individual was wrapped in plastic and immediately frozen before being taken to the Aquatic Biology and Ecology laboratory located in the Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Selangor.

Laboratory Analysis of Samples

In the laboratory, all fish were defrosted to air temperature, and their total weight (g) was measured using a digital balance for each individual (Figure 2). Later, the fish were placed on a measuring board for the total length (cm) measurement (Figure 3). The total length of the fish was recorded, measured from the tip of the snout to the tip of the tail of the fish.

Figure 2. P. nasutus weighed using a digital balance

Figure 3. P. nasutus placed on a measuring board

Subsequently, scissors were used to cut open the ventral side of the fish from the anus all the way up to the gills. All the internal organs were removed by cutting at the upper part of the oesophagus to the anal opening. The stomach was removed from the other internal organs, beginning from the upper end of the oesophagus to the pylorus before the upper end of the fish intestine. Each stomach was then preserved in bottles with 10% formalin solution for further analysis.

For analysis of stomach contents, each stomach was dried using filter paper before the total stomach weight (g) was measured using a digital balance. The stomachs were cut using fine dissecting scissors, and all the items in the stomach were emptied into petri dishes, counted and identified visually (Figure 4). The items were then placed under a Leica compound microscope with 10× to 40× magnification for identification. After emptying the contents, the empty stomachs were weighed (g) using a digital balance.

All the contents of the stomachs were counted and identified to the lowest taxonomic level possible. Identification of the molluscs was performed using the taxonomic key provided by McMahon & Bogan (2001). Prey items that lacked identifiable diagnostic structures due to being highly digested were classified as unidentified animal remains, plant debris, and unidentified plant materials. Finally, the food items were preserved in bottles of 70% denatured ethyl alcohol and were labelled accordingly.

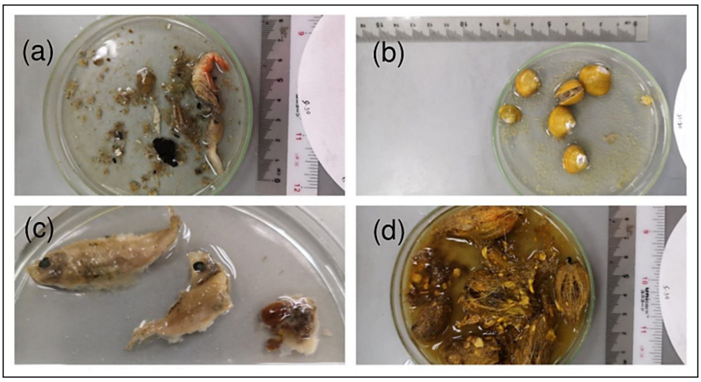

Figure 4. Examples of food items found in the stomach of *P. nasutus:* (a) unidentified decapoda or shrimps; (b) mollusc; (c) unidentified fish; (d) oil palm fruits (*Elaeis* sp.)

Frequency of Occurrence (%F)

The occurrence method was used to quantify the food items that occurred in the fish stomachs. The individual stomach contents were grouped into food categories, and the number of stomachs that contained one or more individuals of each category was recorded (Hyslop, 1980). Then, the numbers were expressed as a percentage of all stomachs with food. The equation for calculation of frequency of occurrence (f_i) is shown in Equation 1:

$$f_i = \frac{N_i}{N} \quad [1]$$

where N_i is the number of fish with prey category i in their stomach, and N is the total number of fish with stomach contents (Amundsen & Sánchez-Hernández, 2019). Differences in digestion rates between hard-bodied prey (e.g., molluscs) and soft-bodied prey may influence detectability in stomach contents and may bias frequency-based estimates of diet composition; hence, the relative importance of some prey categories should therefore be interpreted with caution.

Percentage Prey Abundance (%N)

Apart from the occurrence method, the numerical method is also used to provide information on the amount of food consumed by *P. nasutus* for each category. This is done by recording the total number of individuals in each prey category and then expressed as a percentage of the total individuals in all prey categories (Hyslop, 1980). This gives the percentage prey abundance. The equation for calculation of percentage prey abundance (p_i) is shown in Equation 2:

$$p_i = \frac{\Sigma S_i}{\Sigma S_T} \qquad [2]$$

where S_i is the amount of stomach contents for prey category i, and S_T is the total amount of prey present in each stomach for all categories. (Amundsen & Sánchez-Hernández, 2019).

Ontogenetic Diet Shifts

Differences in diet composition of *P. nasutus* were compared between body sizes to provide information on the ontogenetic diet shift among fishes. The fish samples were grouped into four total length size classes, which are 35.6 to 40.5 cm, 40.6 to 45.5 cm, 45.6 to 50.5 cm, and 50.6 to 55.5 cm. Later, differences in percentage prey occurrence and percentage prey abundance were compared. This interval width was selected to balance statistical robustness and ensure adequate sample sizes within each group. The selected range captured over 98% of the individuals sampled. Alternative size classes were explored during preliminary analysis but resulted in highly uneven sample distributions and were therefore not retained.

Statistical Analysis

The total number of fish caught during the study period was calculated, and all fish were categorised by size classes based on their individual total length (cm). For each category, the number of stomachs with or without food was also recorded, and their percentage were calculated. All statistical analyses were conducted using IBM SPSS software version 26. Pearson's Chi-square, Kruskal-Wallis, and Mann-Whitney tests were utilised to test for significant differences between different diet compositions and different total length size classes of *P. nasutus*.

RESULTS AND DISCUSSION

Overall Diet Composition of *P. nasutus*

This study gives the first overview of the food and feeding habits of *P. nasutus* in Jerantut District of the Pahang River mainstream, Malaysia. The occurrence method and numerical method were both used to provide preliminary data on diet composition of this species, as both methods were among the most rapid and cost-efficient methods used, where their percentages in one sample indicate homogeneity of feeding among the populations (Hyslop, 1980). A total of 265 fish individuals of *P. nasutus* were collected from the Pahang River during the study period from January 2022 to March 2023. Out of all the specimens examined, 98 individual fish (36.98%) had empty stomachs, while 167 individual fish (63.02%) had at least one food item that they consumed. There are several factors which may result in fish with empty stomachs, such as differences in gastric evacuation rates, environmental conditions, or sampling time relative to feeding cycles (Vinson & Angradi, 2011). Further studies can be done to evaluate these factors which cause variations in the percentage of empty stomachs in fish.

Moreover, Pangasiid catfishes are often reported to exhibit nocturnal feeding behaviour in riverine systems (Segaran et al., 2023). However, the present study relied on fish obtained from local fishermen, and the exact capture times of individual specimens were not recorded. Therefore, it was not possible to evaluate diel feeding patterns or determine whether the observed diet composition reflects nocturnal feeding activities. Future studies incorporating controlled sampling with recorded capture times would provide further insight into potential diel feeding cycles of *P. nasutus*.

Overall Percentage Prey Abundance (%N) of *P. nasutus*

A total of 1,864 prey items were found and counted from the stomachs of all fishes during the study period from January 2022 to March 2023. *Corbicula fluminea* (etak) (86.11%) were the most abundant, followed by avian carcasses (3.49%), plant debris (2.63%), Osteichthyes (2.36%), *Elaeis* sp. fruits (oil palm seed) (1.45%), unidentified animal remains (1.39%), decapods (1.29%), *Ficus* sp. fruits (0.91%), sand grains (0.32%) and unidentified plant materials (0.05%) (Figure 5). These results did not account for the sizes of the food categories, which had major differences; for example, *C. fluminea* usually occurred in large numbers in a single sample, while avian carcasses were counted as a single food item that already made up the whole contents of a single stomach. One of the fish alone consumed a number of 379 *C. fluminea*, which already made up 20.33% of all food items in terms of %N. The high %N of *C. fluminea* may reflect high abundance of this species in the Pahang River. However, further studies are required, as studies related to the species were also conducted in other states in Malaysia, such as in Kelantan, Sabah and Sarawak (Aweng et al., 2021, 2022). The high numerical abundance of *C. fluminea* may also be influenced by shell persistence in stomach contents, which could lead to overrepresentation in numerical counts compared to non-shelled prey items.

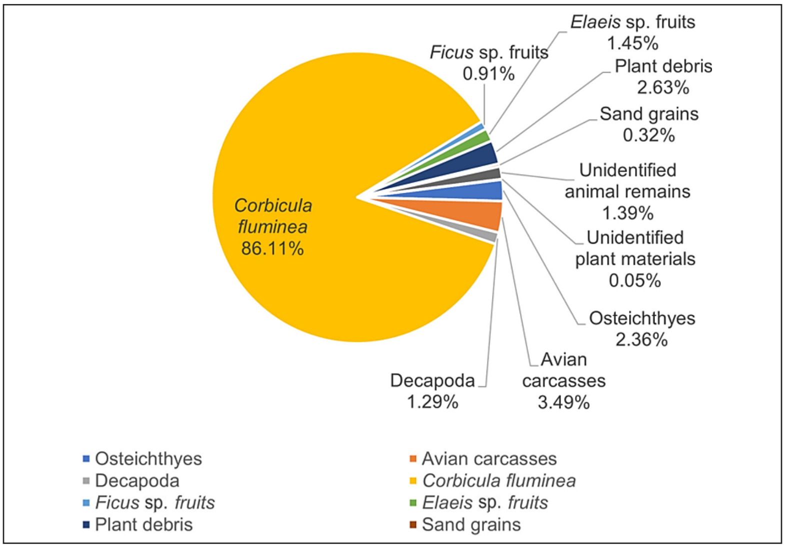

Figure 5. Percentage prey abundance (%N) of *P. nasutus* during the whole study period

Originally distributed in Asian waters, *C. fluminea* was reported as an invasive species in American and European freshwater habitats, as it can grow rapidly and has high fecundity, with tolerance to variable water conditions (Sousa et al., 2008). The dominance of this bivalve in the diet may reflect broader ecosystem-level changes associated with its proliferation, which can alter benthic community structure and nutrient cycling in freshwater systems (Sousa et al., 2008). In Malaysia, *C. fluminea* is a famous delicacy, especially in Kelantan state where it has always been harvested by the locals in Pergau Lake (Rak et al., 2022). Being a benthic feeder, *P. nasutus* would encounter the prey frequently, making it a readily available food source. In river systems where *C. fluminea* is absent or rare, the diet composition of *P. nasutus* may differ substantially depending on the availability of alternative benthic prey.

The reliance on *C. fluminea* could reflect resource partitioning, allowing coexistence with other fish species in the studied area. However, the dominance of *C. fluminea* in the diet of the fishes reflects the changes that occurred in the food web in the studied area, which remain to be fully explored as it may have contributed to the changes in fish abundance (Feyrer et al., 2003). Furthermore, the low representation of bony fish (2.36%) and decapods (1.29%) in the diet of *P. nasutus* indicated that the species may occupy a distinct trophic niche to avoid competition with sympatric piscivores or decapod specialists. The *P. nasutus* in the Kapuas River consumed prey items such as prawns, terrestrial insects and snails, while molluscs were more predominant in the stomach contents of *P. conchophilus* than any other Pangasius species in the river (Roberts & Vidthayanon, 1991). For unidentified animal remains (1.39%), plant debris (2.63%) and unidentified plant materials (0.05%), these were present in highly digested forms, and the structures are no longer identifiable. It remains uncertain whether plant debris was intentionally consumed or incidentally ingested during benthic feeding activities.

Overall Frequency of Occurrence (%F) of Prey Items of *P. nasutus*

The results revealed that 65 out of 167 fishes (38.92%) consumed avian carcasses, and this was the highest percentage of food item that occurred in the stomachs of *P. nasutus* in the study area. This was followed by *C. fluminea* (29.34%), plant debris (21.56%), unidentified animal remains (15.57%), decapods (11.38%), Osteichthyes (10.18%), *Ficus* sp. fruits (9.58%), *Elaeis* sp. fruits (7.19%), sand grains (2.40%) and unidentified plant materials (0.60%) (Table 1).

The occurrence of "avian carcasses" is an unexpected and ecologically significant finding, which contradicts typical dietary patterns observed in many benthic catfish species. They are often described as omnivores or detritivores which focus on invertebrates, molluscs, plant matter, and small fishes (Haque et al., 2022; Haubrock et al., 2018; Khan, 1988; Rao, 2017; Roberts & Vidthayanon, 1991). Avian carcasses may represent a seasonally or spatially abundant food source, particularly in river systems that intersect with bird migration routes or nesting sites, such as Tekam Forest Reserve situated in the Jerantut District of Pahang, which serves as a habitat for many bird species (Hassan, 2017). Moreover, this occurrence also reflects anthropogenic subsidies such as poultry waste disposal. This study does not quantify the source of the avian carcasses, either from the contribution of natural or anthropogenic inputs cannot be determined and requires further investigation. The presence of avian remains may reflect opportunistic scavenging behaviour rather than targeted predation.

Table 1
Percentage frequency of occurrence (%F) of prey items of P. nasutus *during the study period from January 2022 to March 2023*

Prey items	No. of Fish Found with Prey Items (n)	%F
Avian carcasses	65	38.92
Corbicula fluminea	49	29.34
Plant debris	36	21.56
Unidentified animal remains	26	15.57
Decapoda	19	11.38
Osteichthyes	17	10.18
Ficus sp. fruits	16	9.58
Elaeis sp. fruits	12	7.19
Sand grains	4	2.40
Unidentified plant materials	1	0.60

Although the frequency of occurrence of avian carcasses (38.92%) appeared slightly higher than that of *C. fluminea* (29.34%), statistical analysis using the Chi-square test revealed no significant difference between the two ($X^2 = 3.41$, $p > 0.05$). The result indicates that both prey categories were consumed by *P. nasutus* with relatively similar frequency. This may suggest that both preys play a comparable, though possibly minor, role in the diet, potentially reflecting opportunistic feeding behaviour. Avian remains (e.g., feathers and bones) and mollusc shells may persist longer in the stomach compared to softer prey such as decapods or plant matter, potentially expanding their perceived occurrence (Buckland et al., 2017; Hyslop, 1980).

Other than that, the occurrence of bony fishes in the stomachs of *P. nasutus* indicated that the species is opportunistic and flexible in its feeding habits. The low occurrence and abundance of bony fishes consumed by *P. nasutus* does not define the species as piscivorous. Other than the *Ficus* sp. fruits, *P. nasutus* was also known to consume *Elaeis* sp. fruits. Most of the other plant-based food sources found were in small pieces, and they were classified as plant debris. It was unclear whether plant debris was ingested accidentally or was selected by the fishes during the study period. The low occurrence and abundance of sand grains may indicate that *P. nasutus* has a benthic foraging behaviour, possibly while feeding within the riverbed area, possibly when consuming *C. fluminea* (Admassu et al., 2015; Hamid et al., 2015). Sandy substrates produce a yellow colour to the shells of *C. fluminea* (Aweng et al., 2022). The occurrence of animal-based and plant-based foods in the diet of *P. nasutus* determined that the species is an omnivore fish.

Ontogenetic Variation of Food Consumption of *P. nasutus*

All the fish caught were grouped into different size groups based on their total length (cm). There were four size groups established, including from 35.6 cm to 40.5 cm, 40.6 cm to 45.5 cm, 45.6 cm to 50.5 cm, and 50.6 cm to 55.5 cm (Figure 6). A total of 121 individual fish had a total length ranging from 45.6 cm to 50.5 cm, the highest among all size groups. The proportion of empty stomachs was the highest in the size group of 50.6 cm to 55.5 cm (58.82%), while the lowest proportion of empty stomachs was in the size group of 35.6 cm to 40.5 cm (11.43%).

The observed increase in the percentage of empty stomachs, as fish size increases, may be due to changes in feeding frequency of the fish. The smaller fish require more frequent feedings to meet their metabolic demands compared to the larger fish. As they grow in size, they are able to consume larger prey or more food during each feeding session, thus requiring fewer feeding sessions per day. Vinson and Angradi (2011) revealed that the percentage of fish with empty stomachs was positively correlated to the total length of fish at maturity.

Ontogenetic Variation of %N of Prey Items of *P. nasutus* by Total Length (cm)

Overall, *C. fluminea* was the most abundant prey observed (%N) in all length size groups, although it showed different results in different size groups (Figure 6). In the 35.6 cm to 40.5 cm group, %N was 96.41%, while in the 50.6 cm to 55.5 cm group, %N was only 31.25%. Sample sizes varied across size groups, ranging from 14 to 60 individuals. Due to this imbalance and non-normal distribution of prey numbers, a Kruskal-Wallis test was implemented to reduce sensitivity to unequal variances and non-normal distributions, and to test differences in numerical abundance. The results revealed a significant difference between the groups ($H = 24.66$, $p < 0.05$), while the post-hoc pairwise comparisons showed that fishes in the 35.6 cm to 40.5 cm group had more *C. fluminea*, significantly difference ($p < 0.05$) when compared to the other three size groups. In terms of abundance, dietary breadth increases as size increases, as *P. nasutus* shifted its diet from *C. fluminea* to a diverse range of food items. This shows that niche or resource partitioning occurs to reduce dietary overlap among small and large individuals and possibly reduce interspecific competition for food between and within species. High dietary diversity in larger individuals may reflect both genuine expansion of dietary breadth and greater cumulative prey intake, due to a larger stomach capacity.

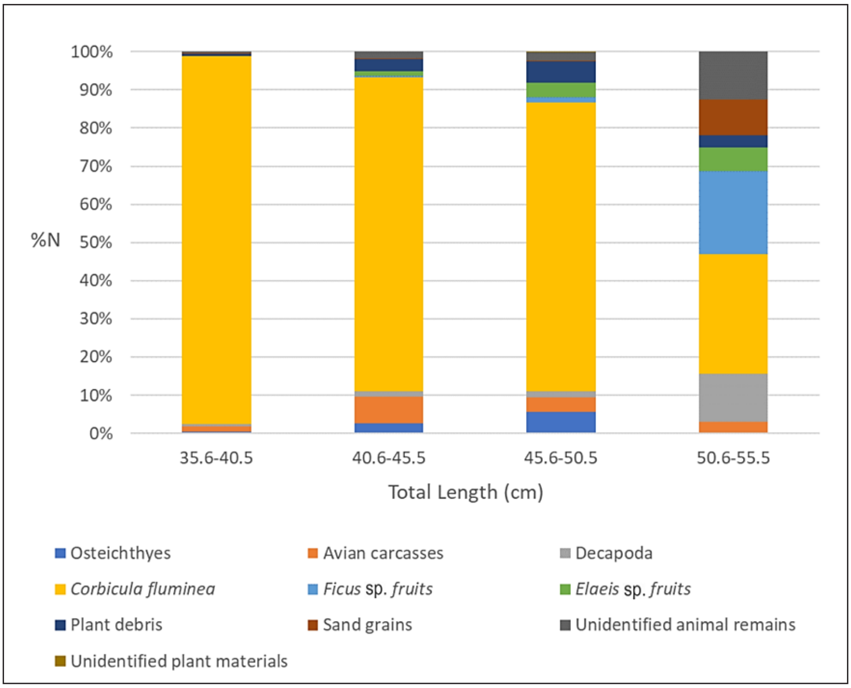

Figure 6. Percentage prey abundance (%N) of *P. nasutus* of different size groups (total length in cm)

It was observed that *C. fluminea* was an important food source of *P. nasutus*, although the percentage of prey abundance (%N) decreased as fish increased in length. In contrast with other fish species, it is not uncommon that smaller fish individuals were observed to consume small planktonic invertebrates, particularly among the juveniles (Intan-Faraha et al., 2020; Pereira et al., 2015). The current study revealed that smaller *P. nasutus* focused on molluscs as their main prey items, while the larger individuals consumed more decapods (mostly appendages). This may also be due to larger fish individuals foraging in different microhabitats within the river areas where they encounter different prey assemblages (Sánchez-Hernández et al., 2019). Generally, the results above show that *P. nasutus* can be classified under benthopelagic fish feeding types.

Ficus sp. And *Elaeis* sp. Fruits were not found in the stomachs of the smallest size group (35.5cm to 40.5cm) and were observed in abundance in the bigger size groups. Fish in the largest size group (50.6cm to 55.5cm) had significantly higher *Ficus* sp. Fruits when compared to the other size groups (H = 25.43, $p < 0.05$). However, the numerical abundance of *Elaeis* sp. Fruits did not differ significantly between different size groups (H = 5.81, $p > 0.05$). Plant debris also increased numerically, which may indicate that *P. nasutus* shift their diet from a carnivorous diet to an omnivorous diet, which includes plant food items. This shift in the diet was common among fishes in various studies and may be driven by both ecological and physiological factors. German et al. (2014) discovered that *Phytichthys chirus* consumed larger proportions of algae as they increased in size, which exhibited changes in gut length and an increase in digestive enzyme activities.

Ontogenetic Variation of %F of prey items of *P. nasutus* based on Total Length (cm)

The differences in the highest percentage of prey occurrence and prey abundance, based on the total length size groups, are presented in Figure 6 and Table 2. Other than percentage prey abundance, C. fluminea (61.29%) also had the highest percentage prey occurrence in the size group of 35.6 cm to 40.5 cm, with a chi-square test showing a significant difference ($X2 = 25.75$, $p < 0.05$). Avian carcasses occurred the most in the stomachs of fish of the size group of 40.6 cm to 45.5 cm (51.67%), and it was significant ($X2 = 10.70$, $p < 0.05$), while Ficus sp. Fruits (42.86%) occurred the most in the size group of 50.6 cm to 55.5 cm, and it was significance ($X2 = 25.16$, $p < 0.05$).

Table 2
Frequency of occurrence (% F) of prey items of P. nasutus *for each size group (total length)*

Prey Items	**%F**			
	Size Groups (Total Length)			
	35.6 – 40.5 cm (n = 31)	**40.6 – 45.5 cm (n = 60)**	**45.6 – 50.5 cm (n = 58)**	**50.6 – 55.5 cm (n = 14)**
Corbicula fluminea	61.29	31.67	13.79	7.14
Avian carcasses	35.48	51.67	34.48	7.14
Ficus sp. Fruits	0.00	3.33	12.07	42.86
Plant debris	12.90	20.00	31.04	7.14
Decapoda	12.90	10.00	12.07	14.29
Unidentified animal remains	9.68	13.33	18.97	28.57
Osteichthyes	9.68	11.67	12.07	0.00
Sand grains	3.23	1.67	1.72	7.14
Elaeis sp. Fruits	0.00	5.00	12.07	14.29
Unidentified plant materials	0.00	0.00	1.72	0.00

Although prey size was not measured in this study, visual observations showed that prey size increased with predator size, which was shown by the increase in occurrence of *Ficus* sp. As *P. nasutus* increased in size. Riparian fig trees are commonly found along a river system, making them accessible to surface or mid-water feeder fishes (Pothasin et al., 2014). This food item was not found in fishes of the smaller group (35.6 cm to 40.5 cm), which may be due to gape size, where larger individuals with greater gape size and swimming capacity may be more efficient in exploiting the *Ficus* sp. The ontogenetic variations may be related to the changes in types of prey consumed in different habitats. Further studies can be done in other areas of the Pahang River to compare the differences in prey items consumed, related to the mouth size, and habitat tilizedon of the *P. nasutus* in a river system.

Furthermore, the decrease in occurrence of *C. fluminea* in the stomachs of *P. nasutus* as they increase in length shows that some individuals exhibited selective feeding behaviour and had a strong preference for *C. fluminea*, while others, in general, exhibited generalist feeding behaviours. The introduction of avian carcasses due to human activities may influence changes in the diet composition of *P. nasutus*, as found in the size group of 40.6 to 45.5 cm, where they fed on larger prey as a preference. Long-term dietary studies with adequate sample size across all ontogenetic stages can reveal a true dietary pattern and interannual variations of fish species (Sánchez-Hernández et al., 2022).

The difference in diet composition between fish sizes provides a clearer view of both the biological and ecological aspects of *P. nasutus*. Resource partitioning is observed between fish of different sizes as they exhibit ontogenetic dietary shifts. Smaller fish primarily consumed *C. fluminea*, while larger fish consumed a more diverse diet, including decapods, plant debris, and fruits. This shift suggested potential ontogenetic resource partitioning, which may reduce dietary overlap among size classes. The dietary flexibility of *P. nasutus* illustrates that the species has potential as a bioindicator for monitoring trophic conditions in river systems, although additional ecological studies would be required to confirm this role. This trophic information should inform multi-scale management approaches that integrate habitat conservation and fisheries regulation to ensure the long-term sustainability of wild *P. nasutus* populations in the Pahang River. However, feeding ecology alone is insufficient to reassess the conservation status of *P. nasutus*. Additional analyses would be required to establish stronger links between trophic ecology and conservation assessments, including long-term population monitoring, evaluation of habitat quality, assessment of prey availability, and comparisons across multiple river systems.

One of the limitations faced when conducting this study was the unevenness of the sample size. Other than that, the fish samples collected were constrained to one location of the whole stretch of the Pahang River. Further studies should be conducted on other parts of the Pahang River to give a broader view on the diet of *P. nasutus*. As the sampling location increases, possible differences in food items occurring in the stomachs of the species may provide information about relationships of food, feeding habits and different habitats tilized by the fishes. Although prey size appeared to increase with predator size based on visual observations, quantitative morphometric measurements were not performed. Therefore, conclusions regarding gape limitation should be interpreted cautiously. Other than that, soft-bodied prey items may be affected because of faster digestion and reduced detectability during microscopic examination.

Future studies should also implement DNA-based techniques, which are useful to improve the accuracy of results obtained from traditional methods, such as improving identification of highly digested prey items and reducing the proportion of unidentified materials. Finally, environmental parameters that could influence fish behaviour and its diet, such as water temperature, pH, dissolved oxygen, flow rates, and habitat complexity, should also be accounted for in future studies. Sampling of prey in the river system would also provide a clearer view of food availability and distribution, which in turn impacts the feeding success of *P. nasutus*. Information gained in this study could help to improve aquaculture practices of the species and conserve riparian vegetation such as *Ficus* species along the Pahang River to ensure species sustainability in the natural habitat. As the study was conducted over a period of one year and three months, the results represent a snapshot of feeding patterns within this time-frame. Longer-term studies would be required to determine whether the observed dietary patterns remain consistent across years.

CONCLUSION

This study provides a critical understanding towards the feeding habits of *P. nasutus* in the Pahang River, Malaysia. Results obtained provide insight into the abundance of *C. fluminea* as the main food item present in the stomach of *P. nasutus*. The occurrence of animal-based and plant-based food items in the diet of *P. nasutus* confirmed the species as omnivorous fishes with opportunistic feeding behaviours, indicating a diverse and wide range of diet for the species. The high occurrence of avian carcasses was an interesting finding, not as a natural food source within the aquatic environment, but likely associated with human activities occurring in the surrounding areas. The dietary composition across ontogenetic stages indicated that *P. nasutus* shifts from predominantly animal-based food items to more plant-based resources as body size increases, suggesting that different size classes have distinct nutritional and energetic requirements throughout development. The findings should enhance all efforts made by the fisheries managers to ensure sustainable management planning and conservation programs for *P. nasutus* in the Pahang River, Malaysia.

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