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Research Article

Food and feeding habits of critically endangered bagrid catfish *Hemibagrus punctatus* (Jerdon, 1862) (Teleostei: Bagridae) in the Cauvery River, South India

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Abstract: The aim of the study was to investigate the variation in diversity and abundance of food items in *Hemibagrus punctatus* in relation to season and also to assess its food preference and feeding behaviour which may reflect the availability of prey items in upstream and downstream areas of Hogenakkal area under the Cauvery river systems. Through its stomach content analysis, the fish has been found to be omnivorous and euryphagous, with only a few qualitative differences in the diet. Feeding rate was found to vary in relation to monsoon caused environmental changes during the course of a year. Among the wide variety of prey consumed, juvenile fishes (39.88%) formed an important dietary component. The next major food group was insects (19.50%) followed by diatoms (11.54%), green algae (8.40%), crustaceans (7.29%), blue green algae (3.98%), plant matter (2.79%), worms (2.71%), copepods (1.33%), cladocerans (1.33%), and mollusks (1.33%). All the food items of this fish (% of food- composition) was found vary in monthly. The present findings would facilitate the examination of complex food and feeding regimes of fishes and would help identify the groups of species that use similar resources within a specific community and could also serve as a reference database for feeding ecology of fishes in highly impacted tropical habitats.

Keywords: Siluriformes, Feeding ecology, Abundance, Preference, Tropical habitats.

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Introduction

Food habits and feeding ecology research are a fundamental tool to understand the role of fishes in aquatic ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux (Yanez-Arancibia & Nugent 1977; Hajisamaea et al. 2003), which allows inferring competition and predation effects on community structure (Krebs 1989). Other features like space and time have also been important for community ecology and the ecological theory predicts that resource partitioning at spatial, temporal and trophic level may increase the tolerance of niche overlap by reducing competition pressure between co-occurring species. Generally, the head water streams of the Western Ghats have been found to be poor in primary production, and the organisms living in this environment depend mainly on allochthonous resources as their major food (Johnson 1999). The fact that species share resources such as food, space and time with co-existing species results in problems in resource partition (Pianka 1969; Schoener 1985).

Ross (1986) identified that in aquatic environments, food is the main factor and that its partition defines functional groups within the community, which get together in guilds according to trophic similarity. The food availability and feeding behaviour of fishes vary from season to season. Seasonal change in temperature not only influence the food consumption and rate of digestion but also quality and quantity of available food organisms. Studies on the food and feeding habits of different fishes have been made by different workers (Hynes 1950; Bhuiyan et al. 1992, 1994, 1999).

The Nilgiri Mystus, *Hemibagrus punctatus*, a rare bagrid catfish, endemic to the Western Ghats, has been currently listed in the IUCN Red List, as 'Critically Endangered' with a possibility that it could be extinct (see Raghavan & Ali 2011). The last validated record of *H. punctatus* was known to be in 1998, and several surveys since then have not been able to collect the species from its native range (Ali et al. 2013). Jerdon (1849) described *Bagrus punctatus*, now included in the genus *Hemibagrus* Bleeker, 1862 from the River Cauvery in southern India, and suggested its occurrence in the river and its various tributaries. The exact type of location, however, was not mentioned. Subsequently, Day (1867, 1878) recorded the species from the Bhavani (a tributary of the Cauvery), at the foothills of the Nilgiri Hills. Since then, only a very few validated records and voucher specimens of this rare catfish are available. The Nilgiri Mystus, *H. punctatus* is endemic to the Western Ghats (Dahanukar et al. 2004) where it is restricted to the tributaries and reservoirs in the Cauvery drainage (Ng & Ferraris 2000; Raghavan & Ali 2011; Ng & Kottelat 2013; Ali et al. 2013). This fish inhabits rapid rivers and streams (Menon 1999). The species is also known to occur in midland areas with slow to moderate flow, poor vegetation cover, and with mud, sand and gravel as the major substrates. It prefers pristine, clear water streams and is affected by siltation (Biju 2005). The distribution of *H. punctatus* is currently restricted to type localities and stocks are declining in the wild (Ali et al. 2013). The information about the food and feeding habits of this species is still lacking. The present study focusses on the feeding biology of *H. punctatus* from Cauvery River.

Materials and Methods

The Cauvery is one of the perennial rivers of Tamil Nadu, flowing from west to east with a number of distributaries and tributaries before it confluence into the Bay of Bengal. The study was conducted in upstream and downstream areas of Hogenakkal water falls, (12°07'09.1"N, 77°46'26.4"E), Cauvery river system of Tamil Nadu, India. The Hogenakkal waterfalls is located on the borders of Krishnagiri and Dharmapuri district of Tamil Nadu state. The falls situated on the banks of the river Cauvery, the falls is often referred to as Kaveri. The Hogenakkal water falls cascades form an average altitude of around 750 feet above sea level from the Melagiri Hills. The falls are located at a place where river Cauvery enters into Tamil Nadu as a big stream. Because of the 'critically endangered' status of *H. punctatus*, fish collection was restricted to specimens caught by local fishermen and available at landing centers and markets located along the banks of the river. Samples were collected from January 2017 to December 2017. A total of 238 fish individuals were collected live and were fixed in buffered formalin (10%) for further analyses. Before gut analyses, the standard lengths (SL) of fishes were measured to the nearest 0.5mm with a Vernier caliber. Fish guts were dissected under a dissection microscope (5X magnification). And dissected the anterior third of the intestine (up to the first bend) (Herder & Freyhof 2006) and stored the contents in 70% ethanol. Later, gut content samples were examined under a dissection microscope (5X) for identification of different food categories.

Results

The monthly variations of gut content of *Hemibagrus punctatus:* There were 11 categories were made up of stomach contents of this fish. It comprises of fishes (39.88%), insects (19.50%), diatoms (11.54%), green

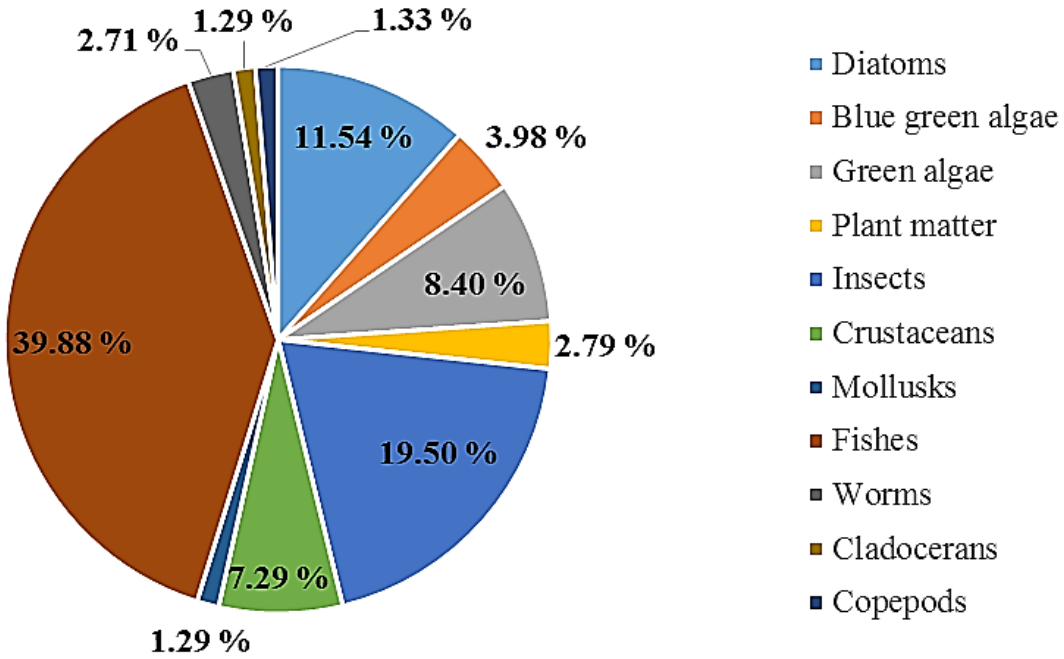

Fig.1. Proportion of food items in the gastro-intestine of *Hemibagrus punctatus*.

Table 1. Monthly percentage frequency of different prey types in the gastro-intestine of *Hemibagrus punctatus* during the study periods of 2016 Jan-Dec.

Food Item	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Diatoms	11	6	8	18	5	12.5	12	14	17	15	12	8
Blue green algae	3	2	1	3	12	5.5	2.25	3	4	2	4	6
Green algae	10	15	9	10	10	3.5	6.75	7.5	10	7	5	7
Plant matter	6	3	1	1	1	4.5	1.5	1.5	1	2	3	8
Insects	31	34	3	7	27	28	22	15	10	13	11	33
Crustaceans	8	10	18	27	2	6.5	5	7	1	2	1	0
Mollusks	0	0	0	0	4	2.5	3	2	2	0	1	1
Fishes	22	22	51	33	38	32.5	45	42	53	57	55	28
Worms	2	3	4	1	1	3.5	1	6	1	1	3	6
Cladocerans	1	3	3	0	0	0.5	1	1	1	1	2	2
Copepods	6	2	2	0	0	0.5	0.5	1	0	0	3	1

algae (8.40%), crustaceans (7.29%), blue green algae (3.98%), plant matter (2.79%), worms (2.71%), copepods (1.33%), cladoceans (1.33%), and mollusks (1.33%). The experiment on gut content analysis of fishes presented that the fish feed on variety of food items. Food organisms are found in the stomachs such as fishes (small size of fish and body parts), insects (body parts), diatoms, green algae (*Crucigenia apiculata, Closterium linula, Palmella* sp., *Tetraspora* sp., *Euglena granulata, Chlorella vulgaris, Scendesmus* sp., *Paediastrum* sp., *Cladophora glomerata*), diatoms (*Cyclotella meneghiniana, Fragillaria crotonensis, Diatoma vulgare, D. elongatum, Melosiera* sp., *Navicula gracilis,* and *Cymbella ruttneri*), crustaceans (prawn body parts, Nauplius and Cypris) (*Amphibalanus amphitrite*), blue green algae (*Anabaena circinalis, A. fertilissima, A. variabilis, A. oryzae, Nostoc carneum, N. commune, Microcystis protocystics*), plant matter, worms, Copepods (*Cyclops vicinus*), cladoceans and Molluscs (Table 1, Fig. 1).

Percentage composition of food items in relation to months: The highest percentage composition of fishes was reported in the month of October (57%) and the lowest during January and February (22%). Insect percentage compositions were highest in the month of February (34%) and lowest during March (3%). The percentage composition of diatoms was

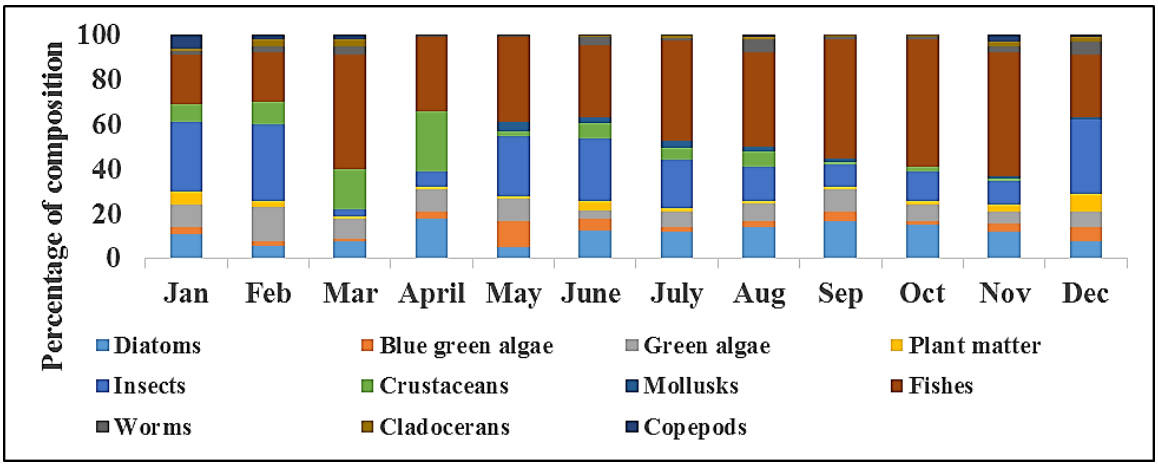

Fig.2. Monthly percentage compositions of food items of *Hemibagrus punctatus* from June 2016 to May 2017.

highest April (18%) and lowest in May (5%). The percentage of green algae was recorded high during February (15%) and low in March (3.5%). Crustaceans were found to be highest in during April (27%) and the lowest in December 2013 (0%). The blue green algae were observed in highest percentage during May (12%) and lowest in March (1%). Plant matter was reported in high contents during December (8%) and low in March, April, May and September (1%). The highest percentage of worms was examined high in August (6%) and low in April, May, July, September and October (1%). Copepods were recorded high in January (6%) and low in April, May, September and October (0%). Cladocerans were recorded high in February and March (3%) and low in April and May (0%). Mollusks were reported high in May (4%) and low in January, February, March, April and May (0%). From this analysis it indicates that the *H. punctatus* prefer the food item like fishes and insects in all months (Fig. 2).

Percentage composition of food items in relation to seasons: The dominated food items were insects (32.50%) and fishes (22%) whereas green algae (12.50%), crustaceans (9%), diatoms (8.50%), Copepods (6%), plant matter (4.50%), worms (2.50%), Blue green algae (2.50%), and Cladocerans (2%), included in low level at the time of winter (January-February 2016). Furthermore, summer and pre monsoon (March-May 2016) fishes (40.67%), crustaceans (15.67%), insects (12.33%), diatoms (10.33%) and green algae (9.67%) which are highly dominated but at the same time blue green algae (5.33%), worms (2%), mollusks (1.33%), plant matter (1%), Cladocerans (1%), and Copepods (0.67%) are low. Likewise, in monsoon fishes (43.13%), insects (18.75%) diatoms (13.88%), and green algae (6.94%) are the highest in percentage while crustaceans (4.88%), blue green algae (3.69%), worms (2.88%), plant matter (2.13%), Cladocerans (0.88) and copepods (0.50) in low level. Subsequently, In spite of having highest percentage of fishes (46.67%), insects (19%) diatoms (11.67%), during post monsoon (October-December 2016), green algae (6.33%), plant matter (4.33%) blue green algae (4%), worms (3.33%), Cladocerans (1.67%) Copepods (1.33%) Crustaceans (1%) and Mollusks (0.67%) were in low. Hence, the present findings are clearly indicates that food items are significantly varied among all the seasons (Fig. 3).

Discussion

Different types of food items are being eaten by *H. punctatus Viz.* fishes, insects, diatoms, green algae, blue green algae, crustaceans, copepods, plant matter, worms, mollusks and cladocerans. Presently the gut content analysis indicated that this species prefers animal food. The present report revealed that the gut of this fish was abundant with fish, diatoms, insects, green algae and other food items eaten by the fishes were regarded as not abundantly. The study on

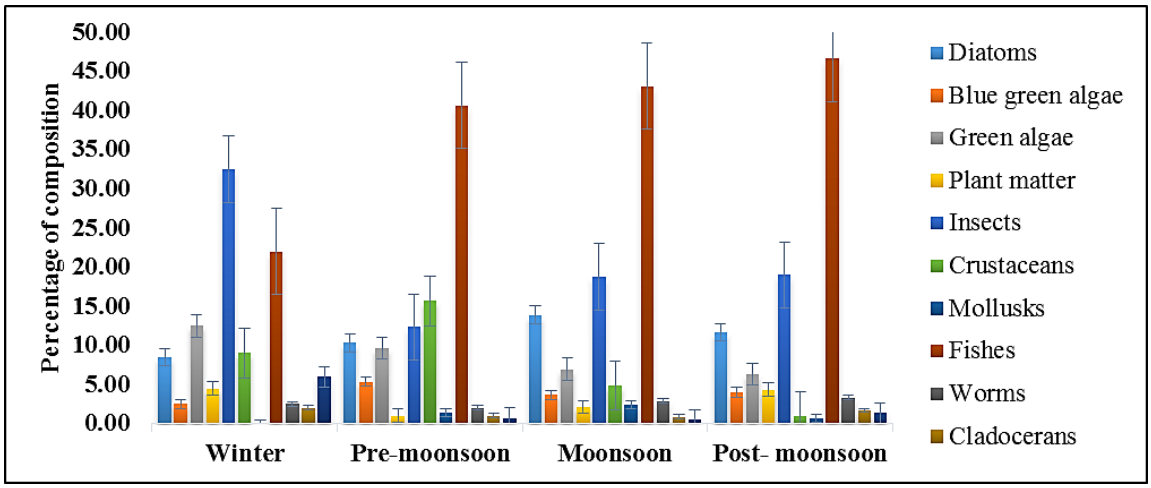

Fig.3. Seasonal variations of percentage compositions food items of *Hemibagrus punctatus*.

the food contents of *H. punctatus* strongly suggested that this fish is an omnivorous feeding. The existence of sand and mud in the guts of these fishes is providing the evidence about their feeding at the bottom. The results of the present study suggest that *H. punctatus* is an unspecialized in its feeding behaviour. Except from some minor disparity among different size groups, *H. punctatus* appears to be capable of widening the spectrum of feed items in its diet in response to food availability. A relatively unspecialized and feeding habit may an optimal strategy for habitats where food sources are subject to seasonal fluctuations (Welcomme 1979), as in the case of Cauvery river.

The presence of detritus and molluscan remains in the gut also indicated a possible benthic feeding activity of *H. punctatus*. In addition, fish scales constituted a major food item in all three size groups. Scale eating has been found to be common among other species of catfishes (Khan et al. 1988). Adult *H. punctatus* consumed a broad variety of food items including the small fishes and insects. Mud and sand particles were encountered sporadically in the gut contents. A euryphagous feeding habit has previously been recorded in several species of catfishes (Khan et al. 1988; Olojo et al. 2003). In general, the diet preferences of *H. punctatus* from Cauvery were similar to those of bagrid catfishes (Indodo-Umeh 2002).

The high incidence of crustaceans and small fishes in the stomach contents of *H. punctatus* may be related to the differential digestive property of specific food particles. Crustaceans and fish remains, particularly scales and otoliths resist digestions and tend to be over represented (in gut content analysis). Crustaceans with chitinous exoskeletons are reported to be identifiable in fish guts over a longer period when compared to many other food items (Wootton 1990). The abundance of crustaceans and fish parts the guts of *H. punctatus* in the present study may be a reflection of variations in digestion rates. Based on the feeding habits of related species within the genus *Hemibagrus* (Froese & Pauly 2012), *H. punctatus* is most likely to be a carni-omnivore. Rajan (1955) recorded adult specimen (103mm in length) and a severed head (25mm long) of *Garra stenorhynchus* inside the gut of *H. punctatus* (320mm in length) collected from the headwaters of the Bhavani River. In the present investigation, *H. punctatus* was found to be a carni-omnivore, subsisting both on animal and plant matter from its surroundings. Pandian (1971) studied *M. gulio* in the Cooum Backwater (Madras) and found the species as an omnivore. Food and feeding habits of other *Mystus* spp. have also been studied. Dietary components of *M. aor* from Ganga river system was analysed by Saigal (1967). Bhatt (1970, 197la, b) studied the feeding biology of *M. seenghala, M vittatus* and *M cavasius.* Mirza and

Ahmed (1981) noticed seasonal variation in feeding in *M. bleekeri.* Biological studies of the freshwater catfish *M. keletius* was carried out by Santhanakumar & Job (1984.) The food of *M. vittatus* from the highly polluted Hussain Sagar Lake was studied by Reddy & Rao (1987). Vinci (1986) studied the biology of *M. seenghala* from the reservoirs of Andhra Pradesh. Examination of gut contents of *M. bleekeri* revealed that it feeds mainly on insects and their larvae, crustaceans, molluscs and other planktonic organisms (Pandey 1983; Shrivastava, 1993). Both plant (algae and other hydrophytes) and animal matter form the food of *M. vittatus* (Bhatt 1971a; Reddy & Rao1993).

The most important food item of the carnivorous *Ompak pabda* in adults was the fishes, crustaceans, protozoans and insects (Bhuiyan & Islam 1991). Similar observations was found in *Notopterus notopterus* (Hossain et al. 1990), *Heteropneustes fossilis* (Karod & Radhakrishnan 2010), *Wallago attu* (Kumar & Roy 2009) and *Mystus gulio* (Begum et al. 2008; Kumar & Padmanabha 2016) also made similar observations. Khan et al. (1988) concluded that *Mystus nemurus* among the bottom feeders, mud and sand were found in large quantities in their stomachs. It was noted that the surface feeders in their stomachs. It was noted that the surface feeders were both omnivorous and carnivorous which feed on algae, rotifers, micro crustaceans and their larvae the mid or column feeders were herbivorous and carnivorous which feed on algae, aquatic plants, adults crustaceans, insects, fish, mud and sands and the bottom feeders are herbivorous, omnivorous and carnivorous, insects, which fed ort decomposed aquatic vegetation, bryozoans, insects, crustaceans, mollusks, fishes sand mud etc. (Chetri 2006; Branco et al. 2010; Manon & Hossain 2011).

In tropical regions, fish assemblages are found to be highly complex with many species co-existing in the same environment. The diversity is governed by localized environmental disturbances and fish's preference for different microhabitat and food items (Costa & Fernando 1967). In such variable ecosystems, the success of mudflat fishes is dependent on feeding strategies adopted. Diet change is also due to physical and chemical variations in the habitat, or biotic interaction, such as competition or predation (Gerking 1994). Food partitioning is defined as any use of food resources by the species that coexist in the same habitat (Ross 1986). Food overlap among different species or different sizes of the same species is one of the important directions to understand fish community organization (Krebs 1999). The somatic growth of the fish may differ according to biotic and abiotic factor, water temperature, food availability and habitat type, species, stage of fishes due to sex, maturity, season and environmental conditions (Khallaf 2003; Mohamad & Kannan 2009; Sandipan & Samir 2016). From the present findings, it can be inferred that variability in habitat, availability of food. Seasonal variations affect the food and feeding activity of *H. punctatus.* This is the first report pertaining to food and feeding habitat of this critically endangered fish species.

Conclusion

The present findings form important baseline information on the critically endangered bagrid catfish *H. punctatus* from the Cauvery river of South India. For initiating early management strategies and regulations for the sustainable conservation of the remaining stocks of this critically endangered species in the Cauvery river ecosystem, the output of the result would be an effective tool for fishery biologists, managers and conservationists. Furthermore, the obtained information on the feeding habits of *H. punctatus* would facilitate its culture purpose. Therefore, the results of this study not only provide valuable information for the online database but also provide an important baseline data for future on this critically endangered bagrid catfish.

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مقاله پژوهشی

غذا و رفتار تغذیه‌ای گربه ماهی *Hemibagrus punctatus* (Jerdon, 1862) (ماهیان استخوانی عالی: گربه ماهیان باگرید) در رودخانه کاووری، جنوب هندوستان

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چکیده: هدف این مطالعه بررسی تغییرات در تنوع و فراوانی مواد غذایی گربه ماهی *Hemibagrus punctatus* در فصول مختلف و همچنین ارزیابی ترجیح و رفتار غذایی بود که ممکن است در دسترس بدن اقلام غذایی را در نواحی بالادست و پایین‌دست منطقه هوگناکال در سیستم رودخانه‌ای کوواری منعکس کند. براساس تجزیه محتوای معده، ماهیان همه چیزخوار و یوری‌فاگوس با اندک تفاوت در کیفیت تغذیه‌ای بودند. نرخ تغذیه بسته به فصل مونسون که تغییرات محیطی را در طول دوره سالانه سبب می‌شد، متغییر بود. در بین طیف وسیعی از شکارهای مصرف شده، ماهیان جوان (۳۹/۸۸ درصد) به‌عنوان جزء مهم منبع تغذیه‌ای بود. عمده-ترین منبع غذایی بعدی حشرات (۱۹/۵۰ درصد)، دیاتومه‌ها (۱۱/۵۴ درصد)، جلبک‌های سبز (۸/۴۰ درصد)، سخت‌پوستان (۷/۲۹ درصد)، جلبک‌های سبز-آبی (۳/۹۸ درصد)، مواد گیاهی (۲/۷۹ درصد)، کرم‌ها (۲/۲۱ دصد)، کوپه‌پودا (۱/۳۳ درصد) کلادوسرا (۱/۳۳ درصد) و نرم‌تنان (۱/۳۳) درصد بودند. همه اقلام غذایی این ماهی (درصد غذا-ترکیب آن) به صورت ماهانه متغییر بود. یافته‌های حاضر می‌تواند آزمایش مجموعه غذایی و رژیم تغذیه‌ای را تسهیل و به شناخت گروههای گونه ای که منابع غذایی مشابه در یک جامعه ویژه مصرف می‌شوند، کمک نماید. همچنین به‌عنوان یک منبع اطلاعاتی برای اکولوژی تغذیه ماهیان در زیستگاه‌های بسیار تحت تاثیر کمک کند.

کلمات‌کلیدی: گربه ماهیان، اکولوژی تغذیه، فراونی، ترجیح، عادات تغذیه‌ای.