



A Seasonal study on food and feeding pattern of *Cynoglossus macrostomus* in Vembanad Lake, Kerala

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Abstract:

Gut content analysis of *Cynoglossus macrostomus* offered important insights into its dietary preferences and seasonal feeding behaviour. Using Point's method, the study identified crustaceans, detritus, algae, and miscellaneous items as consistently "very common" or "common" food components across all seasons. Algae from the family *Oedogoniaceae* were particularly dominant in the diet, reflecting their abundance in the study area. The findings highlight that food associations in fishes are primarily ecological, with seasonal variations in gut contents closely reflecting the availability of resources in the habitat.

Key words: Vembanad lake, seasonal feeding behaviour, dietary preferences, *Cynoglossus macrostomus*,

Introduction

Cynoglossus is a genus of fish belonging to the order Carangiformes and the family Cynoglossidae, comprising 67 recognized species. Among them, the Malabar tongue sole (*Cynoglossus macrostomus* Norman, 1928) is a small flatfish restricted to the shallow, muddy coastal waters of Kerala, where it inhabits soft sediment habitats. This species occurs at depths between 9 and 120 metres (Manilo & Bogorodsky, 2003). It was most recently evaluated for the IUCN Red List in 2019 and is currently classified as Vulnerable under criteria A2bd (Nair et al., 2020).

Vembanad Lake, the largest in Kerala, covers an area of about 2,033 square kilometers and extends 96.5 kilometers in length, touching the districts of Alappuzha, Kottayam, and Ernakulam. It is a rare blend of freshwater and brackish water: the northern stretch near Kochi is saline due to its link with the Arabian Sea, while the inland regions are replenished by six major rivers Achenkovil, Manimala, Meenachil, Muvattupuzha, Pamba, and Periyar. As part of the Vembanad-Kol wetland system, a Ramsar site of global ecological significance, the lake sustains rich biodiversity, including diverse fish species, migratory birds, and thriving mangrove forests.

Since fish are the higher trophic level consumers of almost all aquatic ecosystems, it is important to know their food and feeding nature to understand the energy relationship in an ecosystem. The feeding biology is an important aspect in understanding and learning the evolution of animal diversity and life history. The mode of diet also indicates the integration of various important ecological components like behaviour, habitat use, energy intake, inter or intra-specific interactions, etc.

Knowledge on the natural diet in any animal species is very important for studying animal nutritional needs and conscription dynamics within species and also to understand trophic relationships, material and energy dynamics across various habitats in all ecosystems (Manko, 2016; Cutwa and Turingana, 2000; Navia, et al., 2010; Abdel-Aziz and Gharib, 2007; Omondi, et al., 2013). Knowledge and data on feeding ecology can help to construct food webs and expect potential changes in food chains and the transfer of energy between and within ecosystems (Baxter, et al., 2004; Nakano and Murakami, 2001; Manko, 2016).

The most noticeable activity in the entire life of a fish is its feeding behaviour. Natural feeding behaviour of fish can provide good information on the trophic relationships in aquatic ecosystem (Omondi, et al., 2013). The feeding habit of a fish can be analysed by its stomach contents (Fagade, 1978; Oronsay and Nakpodia, 2005; Saha and Dewan, 1979). The stomach content analysis provides various information on food and feeding habits of fish (Arthi, et al., 2011; Khaing and Khaing, 2020). The length of the alimentary canal is also important for studying and understanding the feeding biology of fish and other animals.

By analysing the gut contents, the feeding patterns and trophic interactions in aquatic food webs can be understood. The particular trophic relations of fish commence with food and feeding routine of individual fish or species. Identification of the food in gut content can be used to evaluate effects of establishment of exotic species (Manko, 2016; Chipps and

Garvey, 2007). Based on the type of food, fish are classified into the following groups:

Herbivorous type: The food of this type of fish consists of 75% or more of the total gut contents are plant materials and 1-10% gut contents consist of animal parts. They mainly feed on unicellular and filamentous algae, small water plants, portion of higher aquatic plants, detritus with some mud and sand.

Carnivorous type: Carnivorous fish take large quantity of animals as food and their food includes copepods, cladocerans (water fleas), insects like beetles, water bugs, larvae of various insects, molluscs, small fishes, tadpole larvae, etc.

Omnivorous type: They eat all type of food. Though insects are their favourite food, they take vegetarian-based food like unicellular and filamentous algae, different aquatic plants, zooplankton like crustaceans, rotifers, insects and its larvae, mud and sand.

Plankton feeders: Zooplankton and phytoplankton are the food of fish in this group. Plankton feeders trap their food by filtering water through their gill rakers. Some plankton feeders in their young stages feed on zooplankton. When they reach one-inch length they will lose their teeth and become filter feeder and consume phytoplankton and some tiny invertebrates (Abo-Taleb, 2019).

Materials and Methods

Collection and preparation of specimen

The fish, *Cynoglossus macrostomus* were caught through February 2021–January 2022 during day light hours (0600–1800h) from the study locations - Cheerpunkal (76o25'48.108" E, 9.63934oN), Vaikom (76o24'14.328" E, 9.73988oN), Konchumada (76o25'8.004" E, 9.56501oN), Muhamma (76o21'53.604" E, 9.60511oN), Punnamada (76o21'22.824" E, 9.52221oN) and Thanneermukkom (76o23'53.232" E, 9.6749oN) region of the Vembanad Lake in Kerala (Figure 1&2).

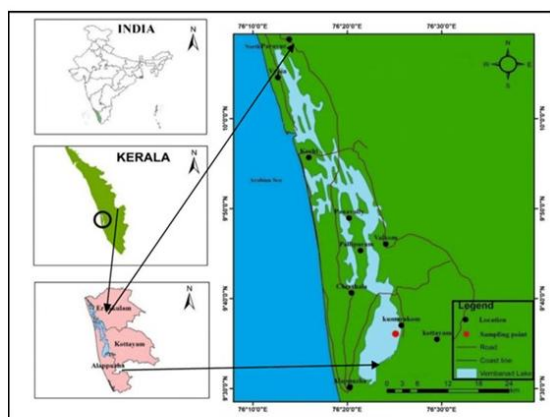


Figure 1: Map showing Vembanad Lake

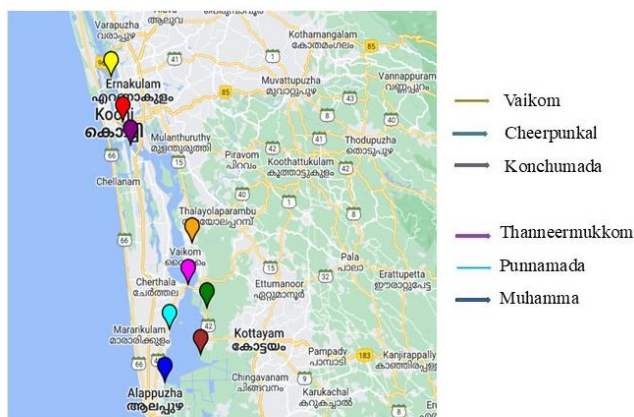


Figure 2: Location sketch of study sites in Vembanad Lake

A total of 165 fish were studied with 56 in pre monsoon, 51 in monsoon and 58 in post monsoon season. The total length of each fish was measured from the tip of the snout to the end of the caudal fin. All were between 8 to 15 cm in length. The fish were immediately dissected ventro-laterally by using dissection tools to collect the gut content and preserved in 6% buffered formalin.

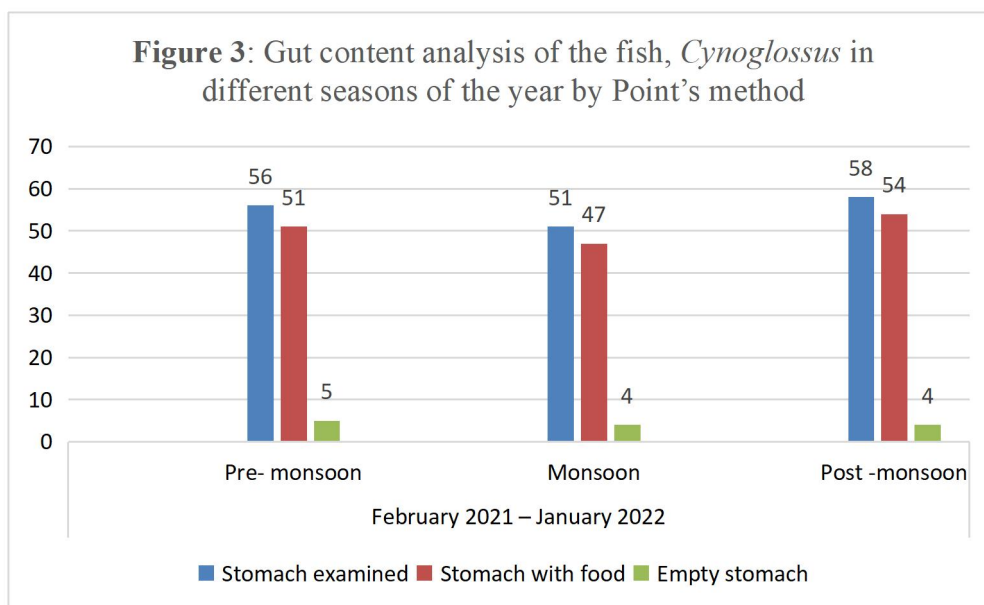
Analysis of stomach contents

For the study of diet composition in each specimen, the stomach contents were analysed using the point's method. Swynnerton and Worthington (1940) early proposed the point's method by means of a subjective scale like very common, common, frequent, rare, etc., based on rough counts and evaluation by eye. Various experimental works have proven that the point's method was the most satisfactory approach with rapid and easy way to analyse stomach contents (Mahesh, et al., 2018; Amundsen and Sánchez-Hernández, 2019).

The length of alimentary canal was measured and stomach was removed from the gut. The stomach was examined for the presence and absence of food contents (Khaing and Khaing, 2020). The food contents observed in the stomach were transferred into a clean Petri dish. General identification of undigested food was done and digested food were identified with the help of compound microscope (Salem and Mageed, 2021; Jordan and Verma, 1996; Hyslop, 1980). Food contents were grouped into seven categories such as Algae, Crustaceans (amphipods, brachyura, copepods, decapods & isopods), Molluscs (bivalves & gastropods) Polychaetes, Small fishes, Detritus and Miscellaneous food materials (semi digested body parts of invertebrates). The % frequency of occurrence of gut contents was calculated for each season. Frequency of occurrence is calculated as: $\% F_{fi} = N_{fi} / N_f \times 100$, where $\% F_{fi}$ is the frequency of occurrence of given item i , N_{fi} is the number of stomachs in which given item i occurs and N_f is the total number of stomachs with some food (Hynes 1950). This approach at worst provides only a minor loss of information relative to more intensive and superficially detailed methods, and at best provides the only robust and interpretable models (Ahlbeck et al. 2012; Baker et al. 2014).

Table1: Seasonal observation of Gut content by Point's method

Year	Season	Stomach examined	Stomach with food	Empty stomach	Very common	Common	Frequent	Rare	Very rare
February 2021 – January 2022	Pre-monsoon	56	51	5	Algae, Decapods, Sand mud, Miscellaneous items	Amphipods, Copepods	Bivalves, Brachyura, Isopods	Gastropods, Small fishes	Polychaetes
	Monsoon	51	47	4	Copepods, Decapods, Sand mud, Miscellaneous items	Algae, Polychaetes	Amphipods, Gastropods,	Bivalves Isopods,	Brachyura, Small fishes,
	Post-monsoon	58	54	4	Amphipods, Sand mud, Miscellaneous items	Algae Copepods, Decapods,	Bivalves, Gastropods	Isopods, Polychaetes	Small fishes

Figure 3: Gut content analysis of the fish, *Cynoglossus* in different seasons of the year by Point's method

Table 2: Gut content analysed from the *Cynoglossus* stomach.

PRE-MONSOON			MONSOON		POST MONSOON	
Specimen Examined	51		47		54	
Stomach examined with	Nos	% F	Nos	% F	Nos	% F
Algae	19	37.25	20	42.55	16	29.63
Amphipods cr	15	29.41	7	14.89	19	35.19
Bivalves	10	19.61	1	2.13	8	14.81
Brachyura cr	7	13.73	1	2.13	4	7.41
Copepods cr	11	21.58	25	53.19	9	16.67
Decapods cr	25	49.02	22	46.81	13	24.07
Gastropods	5	9.80	5	10.64	5	9.26
Isopods cr	8	15.69	2	4.26	3	5.56
Polychaetes	0	0	20	42.55	3	5.56

Small fishes	4	7.84	0	0	1	1.85
Detritus	26	50.98	26	55.32	21	38.89
Miscellaneous items	22	43.14	29	61.70	17	31.48

Figure 4: % Frequency of occurrence of Gut content analysed from the *Cynoglossus* stomach in the Pre-Monsoon Season

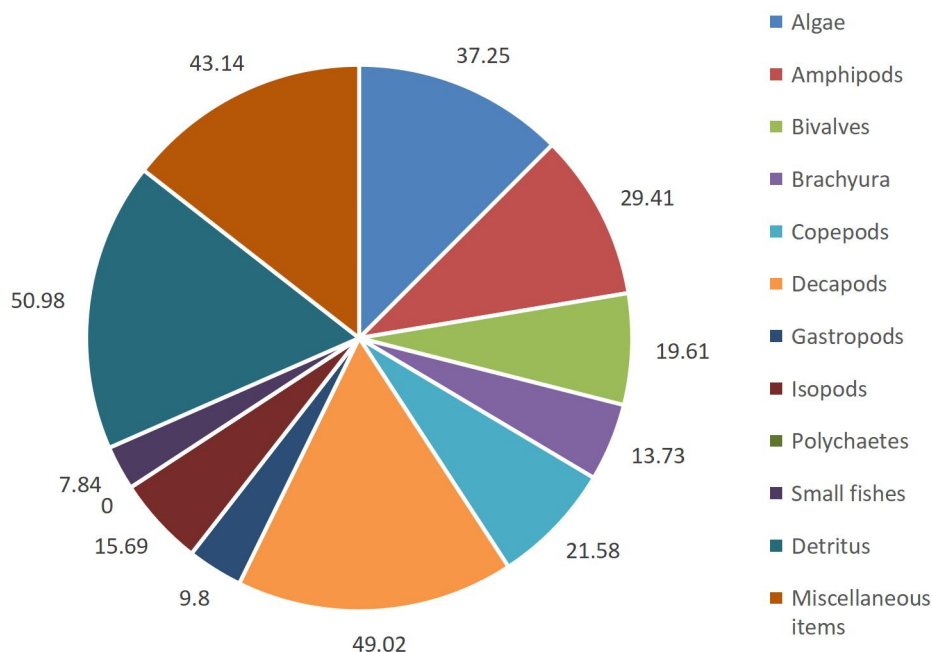
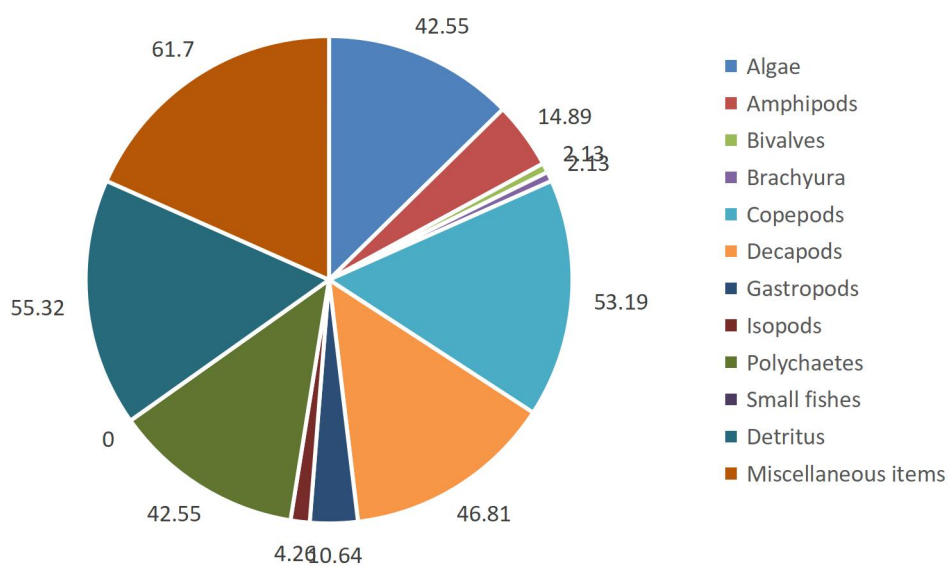
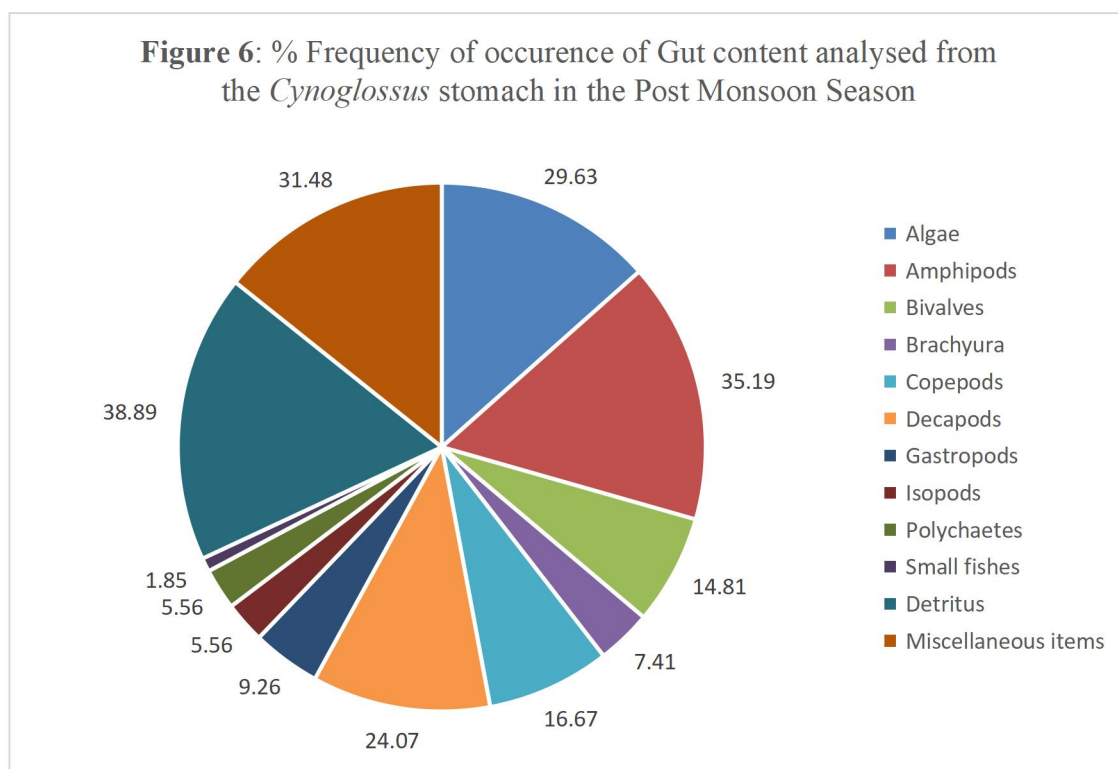


Figure 5: % Frequency of occurrence of Gut content analysed from the *Cynoglossus* stomach in the Monsoon Season





Observation And Result

Of the 165 specimens of *Cynoglossus macrostomus* collected in the pre monsoon, monsoon and post monsoon seasons, 152 (92.12%) were with food and 13 (7.87%) without food (Table 1, Figure 3). The % frequency of occurrence of gut contents observed in the pre monsoon, monsoon and post monsoon season appears to be slightly varied based on the availability of food resources (Table 2, Figure 4, 5 & 6).

The gut content study revealed that in fish, *Cynoglossus macrostomus*, crustacean form the major part of the diet comprising decapods, amphipods, copepods, isopods and brachyura followed by detritus, miscellaneous food items, molluscs and small fishes in all seasons. Polychaetes were absent in the pre monsoon season diet but seen dominant in the monsoon season along with crustaceans. Remarkable presence of algae in the gut content was observed in all seasons (Table 2, Figure 4, 5 & 6).

Discussion

Seasonal changes in the frequency of gut contents simply mirror the availability of food resources in the habitat. The upwelling process can disrupt detritus-feeding flatfishes, prompting them to shift toward off-bottom feeding on alternative prey such as amphipods and copepods. The presence of bivalves, copepods, and polychaetes in their diet highlights the richness of the faunal assemblage in the area.

The present study shows that crustaceans constitute the primary component of gut contents across all seasons examined. Similarly, De Groot (1971), in his study of 12 *Cynoglossus* species, found crustaceans to be the dominant dietary element and concluded that members of this genus are primarily crustacean feeders.

Fish diets often include large amounts of detritus, which contains diverse benthic organisms along with decaying phyto- and zooplankton. This detritus, found at the lake bottom in coarse particulate form, is one of the most abundant, accessible, and nutritive food sources in shallow areas. In many ecosystems, settled detritus plays a more significant role in fish nutrition than all other food groups combined. The productivity of bottom-dwelling macrobenthos depends on the continuous fall of dead phyto-zooplankton from the upper layers. However, the volume of this organic "rain" varies from year to year, increasing during periods of higher primary and secondary productivity. Species such as the Malabar sole make efficient use of the energy stored in detritus. Their population abundance follows a distinct cyclic pattern that mirrors fluctuations in sea productivity and the intensity of detritus deposition (Jayaprakash, 2000).

The algal parts collected from the gut contents were examined using microscope, which revealed that most of the algae are coming under the family *Oedogoniaceae*. They were identified with the help of standard reference (John and Francis, 2013). The other groups of algae were *Scenedesmus* sps. (Green algae), *Oscillatoria* sps., *Bulbochaete macrandra* (Family: *Oedogoniaceae*), *Pithophora oedogonia* (Chlorophyceae), *Cosmarium* sps. (green algae), *Anabaena* (nitrogen-fixing blue-green algae) and several diatoms like *Tabellaria flocculosa*, *Eunotia lunaris*, *Navicula pupula*, *Pinularia* sps., *Cymbella* and *Nitzschia*. An investigation was also done to collect algal samples at regular intervals from the sampling sites from where *Cynoglossus* fish were collected to confirm their presence in the water.

In all seasons, algae are a common food item of *Cynoglossus macrostomus* together with other changing food habits. This may be due to the high nutritional support of algae for the fish's health. Since algae are rich in protein, Omega -3- fatty acids (especially EPA and DHA), vitamins and minerals, they have the ability to support healthy fish growth. Algae have antioxidant properties that help to protect fish from cell damage and oxidative stress. Another important health benefit of algae in fish feed is that algae can help to maintain the health of the fish gut microbiome. Algae can enter the fish gut through ingestion while feeding on aquatic plant parts, detritus or small invertebrates that have algae attached to them. Algae can be ingested with zooplankton or phytoplankton as they are attached to the planktons. Algae present in the water column can enter the fish while the fish swim or feed (Norambuena, et al., 2015).

Species that feed on phytoplankton and floating or attached algae occupy trophic level I, while those consuming zooplankton and other filter-feeding animals (both pelagic and benthic) fall under trophic level II. Flatfishes such as the Malabar sole, whose diet includes detritus, has a heterogeneous mix of suspended and settled organic matter can be positioned as secondary consumers - omnivores at trophic level III.

Conclusion

Gut content analysis of *Cynoglossus macrostomus* provided valuable insights into its dietary preferences and seasonal feeding patterns. Feeding activity peaked during the pre-monsoon season and was lowest during the monsoon. The analysis, conducted using Point's method, revealed crustaceans, detritus, algae, and miscellaneous items as consistently "very common" or "common" food components across all seasons. Among these, crustaceans, detritus, and algae were the dominant food groups. In most specimens studied, algae belonging to the family *Oedogoniaceae* were present, reflecting their abundance in the study sites. Overall, the findings suggest that food associations in fishes are largely ecological, with seasonal variations in gut contents closely mirroring the availability of resources in the habitat.

References

1. Abdel-Aziz, N. E., & Gharib, S. M., 2007, Food and feeding habits of round sardinella (*Sardinella aurita*) in El-Mex bay, Alexandria, Egypt. *Egypt. J. Aquat. Res.*, 33, 202-221.
2. Abo-Taleb, H., 2019, Importance of Plankton to Fish Community. In *Biological Research in Aquatic Science*. IntechOpen. <https://doi.org/10.5772/intechopen.85769>.
3. Ahlbeck, I., Hansson, S., & Hjerne, O., 2012, Evaluating fish diet analysis methods by individual-based modelling. *Canadian Journal of Fisheries and Aquatic Sciences*, 69(7), 1184-1201.
4. Amundsen, P. A., & Sánchez-Hernández, J., 2019, Feeding studies take guts—critical review and recommendations of methods for stomach contents analysis in fish. *Journal of Fish Biology*, 95(6), 1364-1373.
5. Arthi, T., Nagarajan, S., & Sivakumar, A. A., 2011, Food and feeding habits of two freshwater fishes, *Ompak bimaculatus* and *O. malabaricus* of river Amaravathy, Tamil Nadu. *The Bioscan*, 6(3), 417-420.
6. Baker, R., Buckland, A., & Sheaves, M., 2014, Fish gut content analysis: robust measures of diet composition. *Fish and Fisheries*, 15(1), 170-177.
7. Baxter, C. V., Fausch, K. D., Murakami, M., & Chapman, P. L., 2004, Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. *Ecology*, 85(10), 2656-2663.
8. Chipps, S. R., & Garvey, J. E., 2007, Assessment of food habits and feeding patterns. Analysis and interpretation of freshwater fisheries data. *American Fisheries Society*, Bethesda, Maryland, 473-514.
9. Cutwa, M. M., & Turingan, R. G., 2000, Intra locality variation in feeding biomechanics and prey use in *Archosargus probatocephalus* (Teleostei, Sparidae), with implications for the ecomorphology of fishes. *Environmental biology of fishes*, 59, 191-198.
10. De Groot, 1969, Digestive system and sensorial factors in relation to the feeding behavior of flatfish (Pleuronectiformes). *J. cons. perm. int. Explor. Mer*; 32 : 384-394.
11. Hynes, H. B. N., 1950, The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. *The Journal of Animal Ecology*, 36-58.
12. Hyslop, E. J., 1980, Stomach contents analysis—a review of methods and their application. *Journal of fish biology*, 17(4), 411-429.
13. Jayaprakash, A.A., 2000, Food and feeding habits of Malabar Sole *Cynoglossus macrostomus* Norman. *Journal of Marine Biological Association of India* 42((1&2)): 124-134.
14. John, J., & Francis, M. S., 2013, *An Illustrated Algal Flora of Kerala, Vol. 1, Idukki District*. GCS Books, Cochin, ISBN-13: 978-9385657054.
15. Jordan, E. L., & Verma, P. S., 1996, *Invertebrate Zoology sixth revised and Enlarged edition*. S. Chand and Company, Ltd. 857pp.
16. Khaing, M. M., & Khaing, K. Y. M., 2020, Food and feeding habits of some freshwater fishes from ayeyarwady river, mandalay district, Myanmar. In *IOP Conference Series: Earth and Environmental Science* (Vol. 416, No. 1, p. 012005). IOP Publishing.
17. Mahesh, V., Ambarish, G., & Rekha, N. J., 2018, Stomach content analysis techniques in fishes. *Recent advances in fishery biology techniques for biodiversity evaluation and conservation*, 104-115.
18. Manilo, L.G. and Bogorodsky, S.V., 2003, Taxonomic composition, diversity and distribution of coastal fishes of the Arabian Sea. *Journal of Ichthyology* 43: S75-S149.
19. Manko, P., 2016, *Stomach content analysis in freshwater fish feeding ecology*. University of Prešov, 1- 116. ISBN 978-80-555-1613-4.

20. Nair, R., Munroe, T.A. & Weerts, S.P., 2020, *Cynoglossus macrostomus*. The IUCN Red List of Threatened Species 2020:e.T202038A2732189. <https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T202038A2732189.en>.
21. Nakano, S., & Murakami, M., 2001, Reciprocal subsidies: dynamic interdependence between terrestrial and aquatic food webs. *Proceedings of the National Academy of Sciences*, 98(1), 166-170.
22. Navia, A. F., Cortés, E., & Mejía-Falla, P. A., 2010, Topological analysis of the ecological importance of elasmobranch fishes: A food web study on the Gulf of Tortugas, Colombia. *Ecological modelling*, 221(24), 2918-2926.
23. Norambuena, F., Hermon, K., Skrzypczyk, V., Emery, J. A., Sharon, Y., Beard, A., & Turchini, G. M., 2015, Algae in fish feed: performances and fatty acid metabolism in juvenile Atlantic salmon. *PloS one*, 10(4), e0124042.
24. Omondi, R., Yasindi, A. W., & Magana, A. M., 2013, Food and feeding habits of three main fish species in Lake Baringo, Kenya. *Journal of Ecology and the Natural Environment*, 5(9), 224-230.
25. Oronsay, C. G., & Nakpodia, F. A., 2005, A comparative study of the food and feeding habits of *Chrysichthys nigrodigitatus* and *Brycinus nurse* in a tropical river. *Biological Sciences-PJSIR*, 48(2), 118-121.
26. Saha, S. N., & Dewan, S., 1979, Food and feeding habits of *Oreochromis niloticus*. I. Types and amount of food taken by the fish and its size and patterns of feeding. *Bangladesh Journal of Zoology*, 7, 53-60.
27. Salem, T. A., & Mageed, A. A. A., 2021, Assessment of the impact of the Nile flood on food chain in Lake Nasser—Egypt, with Special Reference to Turbidity. *Open Journal of Ecology*, 11(1), 41-51.
28. Swynnerton, G. H., & Worthington, E. B., 1940, Note on the food of fish in Haweswater (Westmorland). *The Journal of Animal Ecology*, 183-187.