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Trophic Structure of Jaguar Cichilid *Parachromis Managuensis* (Günther, 1867) Caught In Penjalin Reservoir, Central Java

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Abstract

The jaguar cichlid *Parachromis managuensis* (Günther, 1867) or with the local name marsella fish is a native fish originating from Central American waters but has been introduced to several countries such as North America, South America and Southeast Asia. This research aims to provide the information about the food preference and trophic structure of jaguar fish from Penjalin Reservoir. The method in this research uses the calculation of the Index of Preponderance (IP) and determining the trophic level. The study revealed that the average food composition of jaguar fish consists of 82.29% fish pieces, 4.70% insect pieces, 0.18% zooplankton pieces, 2.25% gastropods pieces and 10.62% detritus. The overall average trophic level value for fish is 4.22 (TL5) or carnivorous fish.

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Introduction

Penjalin Reservoir is a reservoir located in Winduaji Village, Paguyangan District, Brebes Regency, Central Java. Located at an altitude of 365 meters above sea level with a surface area of 125 hectares and a volume of 9.5 million m^3. Water from Penjalin Reservoir comes from several rivers such as Penjalin River, Soka River, and Garung River (Sentosa *et al.,* 2022). Penjalin Reservoir functions as irrigation, tourist site and capture and cultivation fisheries (Hedianto *et al.*, 2013). Fisheries activities in the reservoir are dominated by capture fisheries using both fishing rods and gill nets (Hendrawan *et al.*, 2013). Hedianto *et al.*, (2013) in their research stated that one of the main abundant catches in Penjalin Reservoir is jaguar cichlid (*Parachromis managuensis*) or marsela fish.

The jaguar cichlid or fish with the local name marsela fish or manila fish is native to Costa Rica, Nicaragua and Honduras but has been introduced in several countries such as North America, South America, and Southeast Asia (Hasan & Widodo, 2021). This fish shows its predatory habits and tolerance to new habitats, so it can threaten the existence of native or endemic fish in various waters because it has the potential to become an invasive species. Invasive species or invasive alien fishes are described as alien fishes that disturb the population of endemic and native fishes in an aquatic ecosystem (Syafei & Sudinno, 2018). Elias *et al.*, (2022) stated that the impact of the presence of invasive fish in a body of water can reduce the number of native or endemic fish and provide little benefit to the local population around the waters. Invasive alien fish show characteristics in the ecosystem such as having a high level of fecundity, having a relatively short regeneration period, the ability to master various habitats (very wide food range) and genetic diversity is very high (Syafei & Sudinno, 2018).

The phenomenon of the decline of native fish by the presence of jaguar fish occurred in the semiarid region of Brazil, which reduced the population of Hoplias malabaricus (Resende *et al.*, 2020). Indonesia itself experiences a similar phenomenon related to the presence of invasive fish. In the research of Kartamihardja *et al.*, (2015) showed that the presence of glass fish reduced the pora-pora fish population in Lake Toba. Research Nasution *et al.*, (2019) revealed that louhan fish (*Amphilopus trimaculatus*) had a decreasing impact on endemic fish populations such as Telmatherina antoniae and Glossogobius matanensis in Lake Matano, South Sulawesi. Similar conditions occurred in the Ciliwung River where the presence of broom fish (*Pterygoplichthys* spp.) reduced the population of benthic organisms and the silver barb (*Barbonymus gonionotus*) (Hadiaty, 2011).

The jaguar cichlid has the potential as an invasive fish in various fresh waters. This is supported by research by Hasan & Widodo (2021) which states that this fish is tolerant of environmental changes such as temperature fluctuations and low oxygen content. This fish is a high-level predatory fish whose presence can threaten the existence of native fish in a body of water (Puspasari *et al.*, 2020). This is evidenced by the presence of jaguar fish in several locations such as the Klawing River, Purbalingga (Saprudin *et al.*, 2023), Cirata Reservoir, West Java (Sentosa *et al.*, 2022), then Ir. H. Djuanda Reservoir, West Java (Hendrawan *et al.*, 2021) and this fish has been found in the Lingsar River, West Nusa Tenggara (Hasan & Widodo, 2021).

Many studies related to jaguar fish in Indonesia and abroad have been conducted, such as the presence of fish (Del Moral-Flores *et al.*, 2020; Elías *et al.*, 2022; Sharpe *et al.*, 2017; Hasan & Widodo, 2021;

Hendrawan *et al.,* 2021), biological research such as fish eating habits, growth and behavior (Barros *et al.,* 2012; Kresnasari & Darajati, 2020; Putri *et al.,* 2023). Trophic level is a description of the stages of material or energy transfer from each level or group to the next starting from primary producers, primary consumers (herbivores), then secondary, tertiary, and ending with apex predators (Almohdar *et al.,* 2013). Studies on trophic levels of fish have not been conducted, especially for jaguar cichlid fish in the waters of Penjalin Reservoir. Previous research by Dzakiyyah *et al.,* (2019) only classified fish based on functional groups of fish food, but trophic level studies have not been conducted.

Information on trophic levels is important to illustrate how jaguar fish interact in the community in the waters of Penjalin Reservoir and show indicators if there is an invasion of foreign species (Bubun *et al.,* 2014). Based on this information, research on the trophic structure of jaguar fish needs to be conducted with the aim of providing a current picture of the trophic structure of jaguar fish in Penjalin Reservoir.

Materials and Methods

Sample Collection

Figure 1 depicted the Jaguar Cichlid from Penjalin Reservoir. This samples were obtained from the catch of fishermen in Penjalin Reservoir. Samples were taken twice, namely in December 2022 and August 2023. This research was conducted in Penjalin Reservoir, Brebes Regency with sampling conducted twice, namely in December 2022 and August 2023. Fish dissection and observation of stomach contents were carried out at the Pescica Marina Laboratory, Faculty of Fisheries and Marine Science, Jenderal Soedirman University.

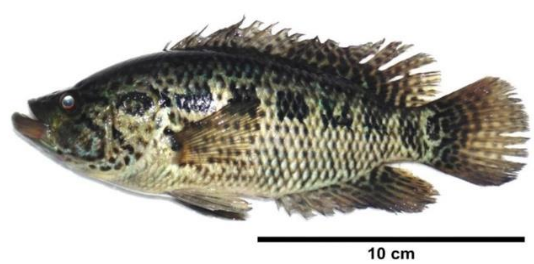

Figure 1. Jaguar Chiclid (*Parachromis managuensis)*

The materials used in this study were jaguar fish, formalin 1000 ml (10%) for fish preservation, ethanol (70%) for preserved fish storage media and formalin (4%) for preservation of fish digestive tract organs (Avila *et al*., 2023). The tools used in this study were surgical scissors, millimeter block laminating, dropper pipette, tray, documentation tools, OLYMPUS LC30 stereo microscope and CX 23 binocular microscope.

Food Content Analysis

The collected fish were then measured for length (total length and standard length) using a digital caliper with an accuracy of 0.01 mm. Fish weighed using digital scales with 0.01 g accuracy. The digestive organs from the stomach to the end of the intestine were removed from the body cavity, then preserved in 4% formalin solution. The intestines and stomach were dissected using an assembly made of needles and chopsticks, and the contents of the food removed were put into a sample bottle, then the intestines and stomach were observed to analyze the contents of the food inside. All digestive contents were observed using a CX 23 binocular microscope with 10x10 magnification. Fish food types were then identified to the lowest taxonomic level if possible.

Data Analysis

Food compositions

The composition of the fish diet was determined using the Index of Preponderance which refers to Natarajan & Jhingran (1967) as follows:

$$\mathrm{IP} = \frac{\mathrm{V_i} \times \mathrm{O_i}}{\sum \mathrm{V_i} \times \mathrm{O_i}} \times 100$$

IP is Index of Preponderance, V_i is Volume percentage of one type of food and O_i is the percentage frequency of occurrence of one type of food.

The volume of food species was determined by assigning points based on their size starting from 0.5, 1, 2, 4, 8, 16, 32 and 64 (Mahesh, et al., 2018). The results of the food composition analysis were assessed based on the percentage index from (Effendie, 1997) with IP > 40% as the main food, IP 4-40% as additional food and IP < 4% as complementary food.

Trophic Level

Trophic level or trophic level of fish is determined based on the type or food item using the results of stomach analysis and calculated with Trophlab2K software (Pauly, *et al*., 2000). Determination of fish trophic level is based on the following formula (Pauly, *et al*., 2000):

$$\mathrm{Troph}_{\mathbf{i}} = 1 + \sum_{J=1}^{G} \mathrm{DC_{ij}} \times \mathrm{Troph_j}$$

$\mathrm{Troph}_{\mathbf{i}}$ is Prey trophic level fraction, $\mathrm{DC_{ij}}$ **is** fraction of prey j in the diet of the i-th predator and G is total number of prey organisms.

The trophic position of the fish studied will be grouped according to the results of research from Stergiou & Karpouzi (2002) with the following categories:

a.	TROPH 2,0-2,1 :	True herbivores domi nantly feed on algae (TL1)
b.	2,1<TROPH< 2,9:	Omnivora tend to eat plants (TL2)
c.	2,9<TROPH<3,7 :	Omnivores tend to eat animals (zooplankton) (TL3)
d.	3,7<TROPH ≤4,0 :	Carnivores whose main diet is decapods and fish (TL4)
e.	4,0<TROPH≤4,5 :	Carnivores whose main diet is fish and cephalopods (TL5)

Results and Discussion

Structure of Fish

The information in **Figure 2** shows that the size distribution of fish based on length is divided into 6 length classes.

The size of jaguar fish in this study has a size that is not much different from the fish found in other waters such as previous research conducted by Saprudin *et al.*, (2023) in the Klawing watershed, the size of jaguar fish obtained ranged from 5-17.2 cm then research conducted by Hamiyati *et al.*, (2019) in Penjalin Reservoir previously obtained jaguar fish size results ranging from 7.5-20.3 cm, from two studies that have been conducted at different times show results that are not so different from the size range obtained in this study.

The composition of the length class distribution shows that fish samples at 12.33 -14.49 cm have a dominant number compared to other size classes. This size is categorized as yuwana/juvenile towards adults or still in the category of juvenile fish or young fish. Based on research by Putri *et al.*, (2023) the adult size of jaguar fish has a length of ≥14.14 cm while jaguar fish that have a length of ≤ 14.14 cm are categorized as yuwana. The results of research by Lente *et al.*, (2024) showed that the dominant sample

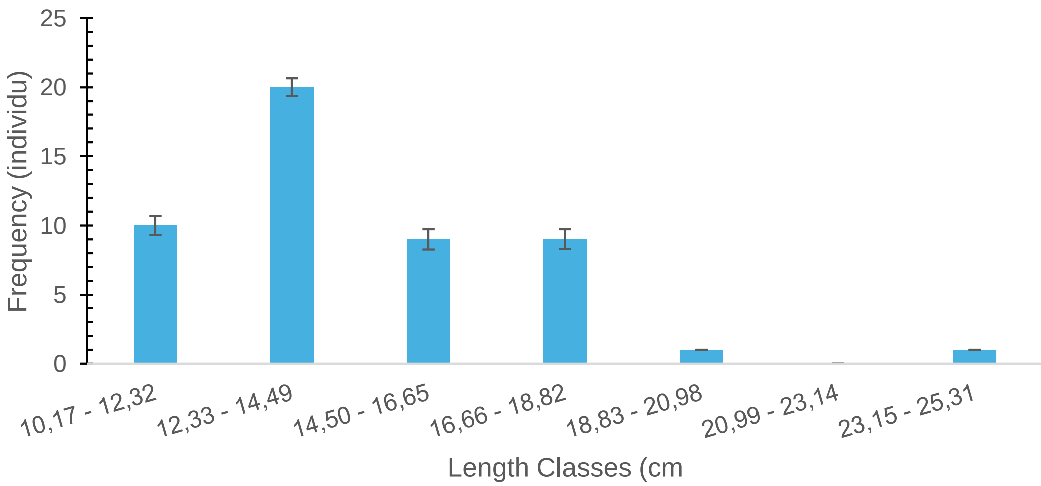

Figure 2. Number of Jaguar Fish Based on Length Classes

size was in the range of 3 - 10 cm, then in the research of Kresnasari and Darajati (2020) the dominant sample was in the size of 11.1 - 12.9 cm, from these two studies it can be compared if the dominant sample size in this study is larger than other studies.

If it is referring to the research of Holmes *et al.,* (2020) which shows that the size of jaguar fish in its natural habitat can reach 55 cm, there is a difference in body size of jaguar fish from its natural habitat because the water conditions of Penjalin Reservoir are unlike its native waters in Central America which are rich in freshwater organisms and diverse ecosystems (Contreras-MacBeath *et al.,* 2022). Penjalin Reservoir is a reservoir that has a mesotrophic water fertility level (Kresnasari & Darajati, 2020). The fertility level in Penjalin Reservoir itself indicates that the water conditions are more suitable for herbivorous or plankton-feeding fish (planktivores) than the jaguar fish itself, whose main diet is crustaceans, invertebrates and fish (Sentosa *et al.,* 2022).

Food Composition

Analysis of the contents of the digestive tract of jaguar fish shows that there are 5 types of food, namely fish pieces, insect pieces, zooplankton pieces, gastropod pieces and unidentified types of food or food pieces (detritus) shown in **Figure 3**. Data on the percentage of food composition in each length class were calculated using the Index of Preponderance (IP) value so that differences in the composition of food utilized by jaguar fish based on length class are presented in Table 1.

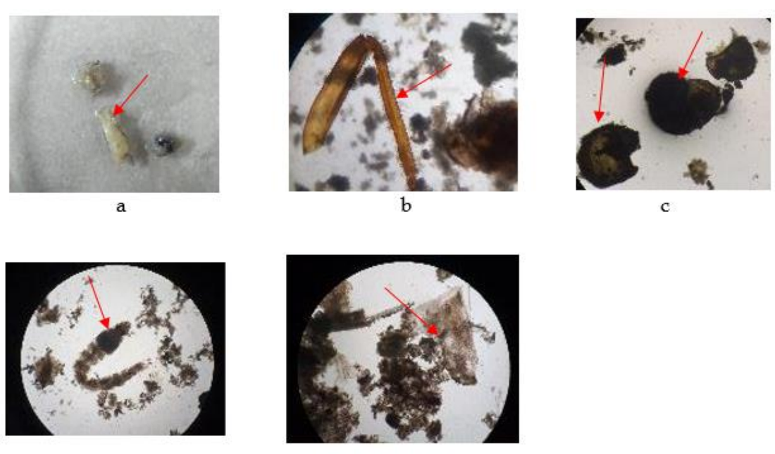

Figure 3. several types of food from stomach of jaguar fish. a) fish fraction b) insects fraction c) gastropod fractions d) zooplankton e) detritus

Tabel 1. Composition of food from jaguar fish (%)

Type of Foods	Lenght Classes (cm)						Mean ± SD
	10,17–12,32	12.33–14,49	14,55–16,65	16,66–18,82	18,83–20,98	23,15–25,31	
Fish fraction	82,44	78,55	94,89	87,87	66,67	100	85,05±11,96
Insect fraction	8,38	17,64	2,16	0,02	-	-	4,7±7,12
Zooplankton	0,2	0,24	0,46	0,03	-	-	0,16±0,18
Gastropods fraction	-	1,34	-	12,07	-	-	2,24±4,85
Detritus	8,98	2,23	2,49	-	33,33	-	7,84±12,92
Total	100	100	100	100	100	100	

Information in Table 1 shows that size group 1 has a food percentage of fish pieces 82.44%, insect pieces 8.38%, zooplankton pieces 0.2%, detritus 8.98%. Group size 2 has a food percentage of fish pieces 78.55%, insect pieces 17.64%, zooplankton pieces 0.24%, gastropod pieces 1.34%, and detritus 2.23%. Group size 3 had a food percentage of fish pieces of 94.89%, insect pieces of 2.16%, zooplankton pieces of 0.46%, and detritus of 2.49%. Group size 4 had a food percentage of fish pieces 87.87%, insect pieces 0.02%, zooplankton pieces 0.03%, gastropod pieces 12.07%. Size group 5 had a percentage of 66.67% fish pieces, 33.33% detritus and size group 6 had a percentage of 100% fish pieces.

The average food composition of the entire size class is 85.05% fish pieces, 4.70% insect pieces, 0.16% zooplankton pieces, 2.24% gastropod pieces and 7.84% detritus. Based on research by Hedianto *et al.* (2013) showed the food composition of jaguar fish in Penjalin Reservoir has a percentage of the main food in the form of fish which is 95.34% while additional food in the form of crustaceans 3.28%, insects 1.34%, plants 0.03%. Analysis of the contents of the digestive tract in jaguar fish in Penjalin Reservoir shows that jaguar fish utilize quite diverse natural food resources such as fish, insects, zooplankton, gastropods and detritus. This statement is supported by research by Saprudin *et al.* (2023) which states that jaguar fish include fish with predatory properties and belong to the bentopelagic group that feeds on smaller organisms such as fish juveniles, molluscs and crustaceans. In another study, it was mentioned that jaguar fish eat insects, earthworms, mysis and crickets (Hasan & Widodo, 2021).

Food types can be divided into 3 categories, namely main, additional and complementary foods. The main food is the type of food that has an Index of preponderance (IP) value greater than 40%, additional food 4 - 40% and complementary food less than 4% (Fatah & Adjie, 2015). All size groups of jaguar fish in this study utilized fish as the main food. The difference lies in the utilization of additional and complementary foods.

Size group 1 utilized insect pieces (8.38%) and detritus (8.98%) as supplementary food, size group 2 utilized insect pieces (17.64%) as supplementary food, then size group 4 utilized gastropod pieces as supplementary food (12.07%), and size group 5 utilized detritus as supplementary food (33.33%). Supplementary food of size group 1 utilized zooplankton pieces (0.02%), size group 2 utilized zooplankton pieces (0.24%), gastropod pieces (1.34%) and detritus (2.23%), size group 3 utilized insect pieces (2.16%), zooplankton pieces (0.46%) and detritus (2.49%) and size group 4 utilized insect pieces (0.02%) and zooplankton pieces (0.03%).

Size group 2 (12.33 – 14.49 cm) with an average length of 13.14 cm has the most diverse diet among the other size groups. This is because the size in that group is preparing to enter the adult and spawning phases, so the food needed for nutritional fulfillment is more diverse compared to the size group above it that has already entered the adult stage. This is supported by the research of Resende *et al.* (2020), which states that jaguar fish reach their first adult size at around 13.6 cm.

Trophic Level

The trophic level of the jaguar fish based on its length size class is shown in Figure 5. The trophic level value of the entire length size class shows a trophic level of TL 5 or carnivores whose main food is fish, with an average overall trophic level value of 4.22±0.29. The information in **Figure 4** shows the trophic level values for size group 1, which is 4.17, for size group 2, which is 4.21, then for size group 3 with a trophic level value of 4.31, size group 4 has a trophic level value of 4.35, then size group 5 has a trophic level value of 3.68, and finally, size group 6 has a trophic level value of 4.5.

The difference in trophic value in the size class 5 is caused by the food identified in the sample, which consists of only 66.67% fish pieces and 33.33% detritus (the body or fragments of dead organisms). Detritus itself is a food item often found in fish with a trophic level of 2.00 (Umar & Hatta, 2021), so the trophic level in size class 5 falls into the TL 3 category (omnivores tend to eat animals). Unlike size class 6, which has the same trophic level value as size classes 1 to 4 because the identified food composition consists only of fish pieces.

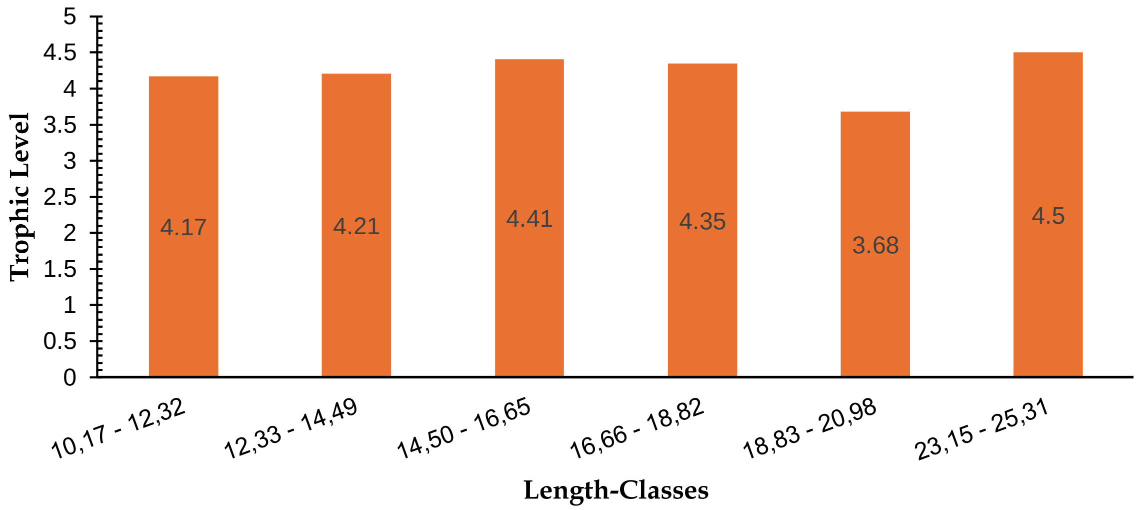

Figure 4. Trophic level of Jaguar fish based on length

The research results of Purnamaningtyas & Tjahjo (2013) show that carnivorous fish such as betutu fish and hampal fish in Djuanda Reservoir have trophic values of 3.92 and 4.00, which are not much different from the trophic value of jaguar fish in this study. The louhan fish, which belongs to the same family as the jaguar fish, found in Lake Matano, has a trophic value of 3.42 (TL 3). The difference in value is due to the louhan fish adapting to the environment in Lake Matano by utilizing the available food resources as the size of the fish increases. However, the food composition shows that the louhan fish utilizes gastropods, insects, and fish as its main food, similar to the jaguar fish (Hedianto & Sentosa, 2019).

The difference in trophic level values in the size group 5 compared to other size groups does not change the conclusion and still indicates that the jaguar fish is a carnivorous fish, in addition to this fish having the ability to adapt and utilize the food resources available in its habitat (França *et al.*, 2017; Elinah *et al.*, 2016). If we look back at the average trophic level value of the jaguar fish from all size groups, which shows a value of 4.22 or falls into the TL 5 category (carnivorous fish tend to eat fish), referring to the trophic position classification by Stergiou and Karpozi (2002), this fish is at the top trophic level and dominant in the fish community in Waduk Penjalin (Puspasari *et al.*, 2020). The jaguar fish in Penjalin Reservoir itself shows a dominance in number, as the research conducted by Hedianto *et al.*, (2013) indicates that out of a total of 200 samples from 6 fish species, the jaguar fish has the highest number, which is 129 individuals, compared to herbivorous fish such as nile tilapia dan silver barb.

This condition needs to be taken into consideration if the proportion of carnivorous fish is greater than the fish at the trophic levels below it, as it will cause an imbalance in the predator-prey ratio within the food web of the fish community in Waduk Penjalin (Fugi *et al.,* 2008). The balance of the food web in a fish community can be observed from the transfer of energy flow through the trophic levels, moving from producers, primary consumers (herbivores), secondary, tertiary, and apex predators (Almohdar & Souisa, 2017). The dominance of carnivorous fish over herbivorous or omnivorous fish leads to insufficient energy transfer to support the life of carnivorous fish (Setyaningrum *et al.,* 2020). This case of fish has the potential to become an invasive species that can disrupt the habitat of native fish living in the waters, which has already occurred when the jaguar fish was introduced into the waters of Mexico due to its aggressive nature and preference for eating small fish as a predator (Kresnasari & Darajati, 2020).

The jaguar fish is an alien fish that has no economic value and can be classified as a pest or nuisance, so the decline of economically valuable fish species in the Penjalin Reservoir can be prevented by implementing management strategies to control its population, thus preventing it from becoming invasive through continuous capture or eradication if necessary (Sentosa *et al.,* 2022).

Conclusion

Jaguar fish (*Parachromis managuensis*) from Penjalin Reservoir, Brebes, show an average food composition consisting of fish pieces 85.05%, insect pieces 4.70%, zooplankton pieces 0.16%, gastropod pieces 2.24%, and detritus 7.84%. Therefore, the main food composition of the jaguar fish consists of fish pieces, with additional food being insect pieces, zooplankton pieces, and detritus, and supplementary food being gastropods. The trophic value range of the jaguar cichlid based on the food composition from all size groups is 3.68-4.5. The average trophic level value overall is 4.22, which falls into the category of carnivorous fish with fish as their main food.

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