Feeding habits of mudskipper fish (*Priopthalmus argentiliniatus*) in the mangrove ecosystem on The Northern Coast of Aceh

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Abstract. The mudskipper fish is one of the native fishes inhabit in mangrove ecosystem. Mangrove ecosystems are suitable habitats for marine life with high fauna diversity. Information about the feeding habits of mudskipper fish is essential to make domestication efforts for the conservation of mudskipper. Food determine the extent of distribution type and can control the size a population. This research was conducted in May until July 2024 in the mangrove ecosystem of Northern Aceh's coast. The study aims to analyze the feeding habits of mudskippers in the mangrove ecosystem of Northern Aceh. Fish samples were collected using the purposive sampling method at four different locations. A total of 80 individuals were obtained, and their stomachs and intestines were preserved using a 4% formalin solution. The type of food was observed under a microscope in the Marine Biology Laboratory, Faculty of Marine and Fisheries, USK. The research identified 6 major food types, namely Phytoplankton, Nematodes, Crustaceans, Polychaeta, Hexapod, and litter fragments. The highest index of preponderance (IP) value showed that nematodes were the main food of mudskipper fish which have an IP value was 47%, some research found that nematode is one of foods that obtained in the mudskipper stomachs. The mudskipper fishes inhabit in mangrove ecosystem of the north Mangrove coast of Aceh are categorized as carnivorous fish.

1 Introduction

Mangrove ecosystem is a type of tropical forest that typically grows along the coast or river estuary that is still influenced by sea water. Mangrove is one of productive ecosystems that inhabits tropical ecosystems with high nutrient content [1-3]. One of native fishes that can serve as a bioindicator of mangrove ecosystem fertility is the mudskipper from the Gobiidae family [4, 5], commonly known as the gelodok fish. The gelodok fish is a unique fish because it can inhabit in two different environments namely terrestrial and water [6, 7]. The gelodok fish has potential for utilization [4], it is consumed by coastal communities for its high protein content, such as in the Cilacap and Karawang regions, where it is eaten as dried or smoked fish [8]. It is also used as traditional medicine in India and as a prenatal health booster in China and Japan [9]. Some species are kept as ornamental fish and have been cultivated in countries like Bangladesh, Thailand, the Philippines, China, Taiwan, and Japan [4]. Additionally, this

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fish serves as a bioindicator in waters because it can survive in polluted conditions and accumulate heavy metals in its tissues [7]. [10] reported that *Periophthalmus waltoni*, as a bio accumulator, can absorb heavy metals and degrade them into environmentally friendly substances. However, in Indonesia, utilization and information about the gelodok fish remain limited.

Mudskipper fish is a fish that can only be found in the environment mangroves due to availability abundant food in mangroves and according to nutritional needs. Several studies have been explored the feeding habits of mudskipper fish. According to [11], the main food of mudskipper fish consists of three large groups, namely *Skeletonema* sp., *Nitzchia* sp., and *Pleurosigma* sp. Furthermore, [12] reported that mudskipper fishes are carnivorous, they consume group of crustacea, insect, polychaeta, and algae. [13] reported that the food that commonly find in stomach of mudskipper fish are included fish, molluscs, crustacea, polychaeta worms, and a few plants. Moreover, [14] noted that mudskipper fish *Periophthalmus keolreuteri* from the Nigerian coast consumed aquatic plants, diatoms, and filamentous algae in juvenile phase, however in adult phase they consumed more crustacea, terrestrial and marine insects, and marine worms. Other species, such as *Periophthalmus botdarti* consume nematodes, polychaeta, algae, and fish eggs [15].

Research on mudskipper fish in the coastal area of Aceh Besar has been conducted by [16] regarding the growth of mudskipper fish. This study also reported that the species of mudskipper found was the *P. gracilis* identified through morphological characteristics. However, there is no information about feeding habit mudskipper fish in the mangrove ecosystem, northern coast of Aceh. Therefore, study about feeding habits is needed in order to serve as reference data for the domestication of mudskipper fish. The purpose of study is to analyze the feeding habits of mudskipper fish in the mangrove ecosystem on the North coast of Aceh.

2 Methodology

2.1 Location and time of research

The research was started from May to June 2024 in the mangrove ecosystem on the North coast of Aceh. There were four stations established using purposive sampling method, namely Ruyung, Alue Naga, Gampong Jawa and Lambadeuk. Sample analysis and identification were carried out at the Marine Biology Laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala (USK). The research location showed in Fig 1.

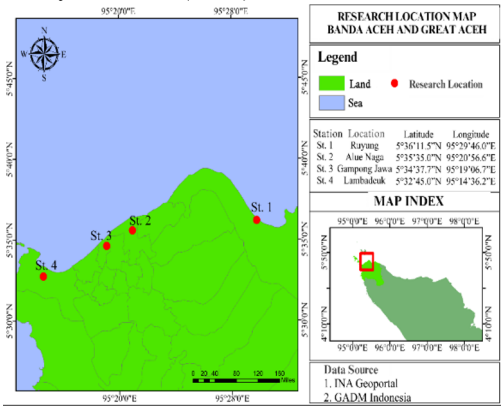

Fig. 1. Map of research locations.

2.2 Tools and materials

The main tool used during the study were scoops, nets, sample bottles, pH meters, refractometers, thermometers, Global Positioning System (GPS), digital scales, and digital camera. While the main materials used in the analysis were mudskipper fish, 70% alcohol, 4% formalin.

2.3 Sampling

The method used in determining the research location was the purposive sampling method. The fishes sample taken were 20 individuals each station, and totally 80 individuals collected from 4 different research stations. The process of taking fish samples was carried out when the sea water receded. Sampling of mudfish was carried out using a modified fishing gear consisting of wood and nets.

2.4 Observation of feeding habits

The fish samples obtained were weighed and their body length was measured. Then, the morphological of the fish was analyzed to identify the fish species. The observation of fish feeding habits was conducted by dissecting the fish and removing its stomach and intestines. The digestive organs were preserved with 4% formalin and put into a sample bottle. The stomach and intestines were split, and its contents were extracted, and was placed on a petri dish that had been given 2 ml of distilled water as a diluent. The stomach and intestine contents are separated by type, and each type of food is directly observed. The frequency of occurrence for each food type is recorded, and its volume is measured. Observation of the stomach and intestine contents was carried out using a digital microscope with a magnification of 40×10 to determine the type of food eaten by the fish.

2.5 Data analysis

The Index of Preponderance calculation is carried out to determine the type of food eaten by fish. The largest part index is a combination of two methods, namely the frequency of occurrence and the volumetric method using the equation formula [17], as follows:

$$IP = \frac{Vi\ x\ Oi}{\sum Vi\ x\ Oi} x\ 100\% \quad (1)$$

Description
IP = Index of preponderance (%)
Vi = Percentage of volume of a type of food (%)
Oi/FKM = Percentage of frequency of occurrence of a type of food (%)

Observation of eating habit parameters was carried out using the volumetric method using the equation formula [17]:

$$Vi = (vi/vt)\ x\ 100\% \quad (2)$$

Description:
Vi = percentage of one type of food (%)
vi = volume of one type of food (ml)
vt = total volume of all types of food (ml).

Organisms contained in the digestive tract (stomach) are counted one by one for both filled and empty stomachs. The amount of each type of food is expressed in percent (%) calculated using [18] as follows:

$$FKM = \frac{the\ number\ of\ occurrences\ of\ food\ type}{the\ amount\ stomach\ containing\ food} x\ 100\% \quad (3)$$

Description:
FO = Frequency of Occurrence

Measuring the relative length of the gut is one of the methods used to distinguish fish based on the type of food. [19] stated that the relative gut length (RGL) is calculated using the equation:

$$RGL(\%) = \frac{length\ of\ gut\ (cm)}{total\ body\ length\ (cm)} x\ 100\% \quad (4)$$

2.6 Measurement of substrate and water quality content

Measurement of substrate texture and substrate fraction in the mangrove ecosystem was taken in each sampling station, soil samples were taken at a depth of 25 cm. The samples were analysed in the Soil and Plant Research Laboratory, Faculty of Agriculture, Universitas Syiah Kuala. Furthermore, the water quality measured in this study area were temperature (°C), acidity (pH), dissolved oxygen (DO), and salinity (ppt).

3 Result and discussion

3.1 Index of Preponderance (IP), and frequency of food occurrence

The results showed that mudskipper fishes (Gobiidae) in the mangrove ecosystem on the North coast of Aceh was dominated by *Priophthalmus argentilineatus* and identified based on morphology form and genetic. Table 1 showed that there were 6 classes of food type were obtained, namely phytoplankton consisted 14 genera (*Synedra* sp., *Aulacoseira* sp., *Prochlorotrhix* sp., *Pinnularia* sp., *Navicula* sp., *Itshmia* sp., *Oscillatoria* sp., *Bacillarias* sp., Flagilaria sp., *Odentella* sp., *Pleurosigma* sp., *Pleuroraenium* sp., *Cylindrospermopsis* sp., *Planktothrix* sp., Nematoda (*Daptonema* sp.), Hexapoda (*Lasius* sp.), Crustacea (*Euphausiacea*), Polychaeta (*Lepidasthenia* sp. and *Phyllodocida*) and litter fragments (detritus). This is consistent with the findings of [20] and [13], who state that phytoplankton, crustaceans, and nematodes are common types of food found in the stomach and gut of mudskippers.

The volumetric value of the mudskipper fish as a whole was obtained as much as 3.64%, the IP (Index of Preponderance) value was 100%, and the FKM (Frequency of occurrence) value was 6.6% (Table 1). The types of food found at all stations with the calculation of the Index of Preponderance (IP), Volumetric (V) and Frequency of Food Occurrence values of mudskipper fish (Gobiidae) were 6 food classes/group and consisted of 20 genera. The index of preponderance of mudskipper fishes at research stations showed that nematode has highest IP value (47%) as the main food of mudskipper fish. [30] reported that the obtain various types of fish food Gelodok consists of Algae, Arachnida, Crustaceans, detritus, fish, molluscs, Chilopoda, Insects, macrophytes, Nematodes, sand grains, and fungi. The result explained mudskipper fish are very dependent on this food source in their daily lives. Based

on their feeding habits, fish can be classified as herbivores, carnivores and omnivores [21], thus *P. argentilineatus* categorized as carnivorous. According to [22] the food type found in the stomach of mudskippers consists mostly of animals, although small amounts of plant are also found. Nematodes is one of meiofaunas inhabit mangrove substrate and their presence are abundant, they an important user of marine environmental resources for microhabitats and food. Furthermore, nematodes play role to soft sediment and decaying leaves [31]. Fish feeding habits include the type, quantity, and quality of food consumed by the fish. The type of food consumed depends on the availability of food in the habitat and the fish's physiological adaptations, such as gut length, digestive characteristics, the shape of teeth and pharyngeal bones, body shape, environmental, and behavior [19]. Furthermore, [23] stated that fish feeding habits are influenced by several factors: habitat, preference for certain types of food, season, food size, food color, and the age of the fish.

Phytoplankton has an IP of 23%, litter fragment was 17%, hexapod was 7%, those were as complementary food. Furthermore, the IP of polychaeta and crustacean were 4% and 2% as additional food. Based on the IP, the composition of fish food types is categorized primary food if IP value is >40%, supplementary food (IP value is 4% - 40%), and additional food if IP value is <4% [31]. The detail data of IP and FKM showed in Table 1.

Table 1. Index of preponderance (IP), and Frequency of Food Occurrence (FKM).

Class	Species	V	IP (%)	FKM (%)
Phytoplankton	*Synedra* sp.	0.14	2.29	0.35
	Aulacoseira sp.	0.23	5.34	0.5
	Prochlorotrhix sp.	0.15	2.47	0.35
	Pinnularia sp.	0.13	1.44	0.25
	Planktothrix sp.	0.18	2.42	0.3
	Navicula sp.	0.14	1.88	0.3
	Ithsmia sp.	0.22	5.14	0.5
	Oscillatoria sp.	0.08	0.53	0.15
	Cylindrospermopsis sp.	0.05	0.23	0.1
	Pleurosigma sp.	0.06	0.28	0.1
	Pleurataenium sp.	0.03	0.18	0.15
	Odentela sp.	0.06	0.44	0.15
	Flagilaria sp.	0.06	0.40	0.15
Nematode	*Daptonema* sp.	0.86	47.31	1.2
Hexapod	*Lasius* sp.	0.27	6.74	0.55
Litter fragment	-	0.50	17.36	0.75
Polychaeta	*Lepidasthenia* sp.	0.18	1.61	0.2
	Phyllodocida sp.	0.16	1.89	0.25
Crustacea	*Euphausiacea* sp.	0.15	2.07	0.3
Total		3.64	100	6.6

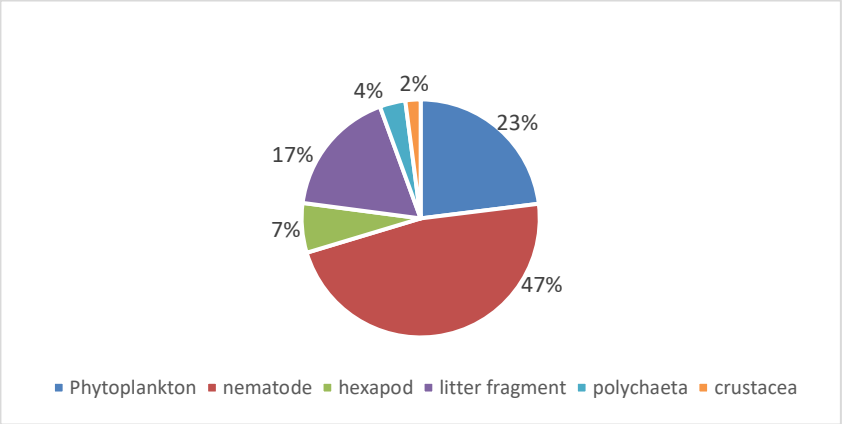

Fig. 2. Index of preponderance (IP) of mudskipper fish.

3.2 Niche area

The analysis of the food niche area was conducted to see the proportion of resources and the selectivity of a food utilized by a species. Table 2 showed the results of the calculation food niche area of mudskipper fish in the research station, the highest food niche area was at station 1 with the value was 5.83, and continue with station 3 (5.66). Meanwhile, at stations 2 and 4, the niche area value of mudskipper fish was lower than station 1 and station 3.

The group of fish with the large food niche area has more diverse type of food compared to the group with a small niche area [24]. A large niche area illustrates that the fish are not selective in utilizing food resources in nature and conversely a small niche area indicates that the fish are selective in choosing food [25]. The value of food niche breadth will be high when an organism utilizes food which vary in relatively equal amounts.

Table 2. Area of mudskipper fish niche.

Station	Niche area (Bi)	Standardization (BA)
1	5.83	0.44
2	4.72	0.47
3	5.66	0.33
4	4.12	0.22

3.3 Relative gut length

The analysis based on Relative Gut Length (RGL) showed that the feeding habit of mudskipper fish is a carnivorous. If the Relative Gut Length was <1 of the total length, the value classified that the feeding habits of mudskipper is carnivorous. [26] reported that RGL of red snapper was 0.7% (< 1). If the RGL has a value 3 then the fish is classified as herbivorous fish [27]. Moreover, [19] mentioned that the RGL of carnivorous fish if the RGL has a value of 1, value between 1-3 cm is classified as omnivorous fish, and the value >3 cm is classified as herbivorous fish. [33] reported that the feeding habit of mudskipper varied based on place, month and season, both males and females of mudskippers fall into carnivorous fish as RGL was <1.

Based on the results of the mudskipper fish sample measurements, the average body length at station 1 was 5.21 cm and the average Gut length was 1.805 cm, followed by station 2, 3 and 4 with an average body and gut length were 5.555 cm and 1.72 cm; 5.665 cm and 1.875 cm; 5.835 cm and 1.965 cm, respectively. The relative gut length (RGL) index is

helpful and have role for determination of feeding habit. Table 3 explained the detail data of average body length and RLG in the study area.

Table 3. Relative Gut Length (RGL) of mudskipper fish.

Station	Total body length (cm)	Length of gut (cm)	Average length of gut (cm)	Average body length (cm)	Relative gut length (RGL)
1	1 - 2.5	4 - 6	1.805	5.21	0.35
2	0.5 - 2.8	4.5 - 7	1.72	5.555	0.31
3	1 - 3.5	4.5 - 7.2	1.875	5.665	0.33
4	1 - 3	5 - 7.5	1.965	5.835	0.34

3.4 Water quality and substrate parameters

In the aquatic biota habitat, water quality plays an important role because the entire life cycle of the biota being maintained in the water [28]. The condition of environmental quality in the mangrove ecosystem is known by observing the physical and chemical environmental conditions including pH, temperature, salinity and DO [29]. The changing of water quality affects the presence of food, and will influence the type of feeding habits and growth. Reduced water quality will affect the fish's community for example impacting habitat, food availability, and dissolved oxygen, then it will influence their growth [34]. Moreover, salinity is water quality that an important factor in boundaries of species distributions in brackish ecosystem as mangrove ecosystem. [35] mentioned that salinity fluctuation can influence prey dynamic of predator in different ways, for example, foraging efficiency due to low salinity can be limited predator activity. The results showed the value ranged of temperature were 30°C-33°C, salinity 28-30 ppt, pH 6-7.7 and DO 1.01-1.08 mg/L (Table 4).

Table 4. Measurement of water quality in the mangrove ecosystem.

Parameter	Observation station			
	1	2	3	4
Temperature (°C)	33	31	30	32
pH	6.8	6	6	7.7
DO (mg/L)	1.08	1.22	1.01	1.05
Salinity (ppt)	28	30	30	29

Substrate texture is one of the indicators used to show the suitable habitat for supporting the growth and development of Mudskipper fish in the mangrove ecosystem. The result showed that station 1, 2, and 3 were sandy loam and substrate fraction was dominated by sand, whereas the substrate texture of station 4 was clay with the percentage of substrate fraction were sand (22.2%), dust (36.3 %), and clay (41.5 %).

Table 5. Soil substrate.

Station	Substrate Fraction (%)			Substrate Texture
	Sand	Dust	Clay	
1	78.8	5.3	15.9	Sandy loam
2	80.8	4.8	14.4	Sandy loam
3	75.3	4.9	19.7	Sandy loam
4	22.2	36.3	41.5	Clay

4. Conclusion

The species of mudskipper identified and dominated at research location was *Priopthalmus argentiliniatus*, and type of food found in the gut and stomach of fishes were phytoplankton, nematodes, crustaceans, polychaetas, hexapods, and leaf litter fragments (detritus). The highest index of preponderance (IP) indicated that nematodes (*Daptonema* sp.) is the dominant food found in the stomach and gut of mudskipper fishes, with an IP value of 47% and the feeding habit was categorized as carnivorous. The feeding habits of mudskippers adjust according to their body length and weight. Knowledge of fish feeding habits is one of the studies to monitor the carrying capacity of mangrove habitats for the presence of mudskipper fish, and is the first step in domestication in the field of cultivation and conservation efforts.

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