Research Article

Food and Feeding of Atlantic Mudskipper Periophthalmus Barbarus in Ogbo-Okolo Mangrove Forest of Santa Barbara River, Bayelsa State Niger Delta, Nigeria

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The food and feeding of Atlantic mudskipper *Periophthalmus barbarus* in Ogbo-Okolo mangrove Forest of Santa Barbara River, Bayelsa State Niger Delta, Nigeria was studied. The frequency of occurrence method was used for the gut content analysis. The results indicate that *P. barbarus* feeds on small prey such as small fish (20.3%), fish scales (56.0%), crabs (34.3%), and other arthropods like tiny crustaceans (40.0%). *P. barbarus* also feed on aquatic macrophytes (49.4%), bacillariophytes (17.1%), algal filament (45.1%), unidentified debris (38.0%) and polychaetes (20.0%). In Numerical Abundance size range 5.5-8.4cm were fish scales (12.8%), Algal filament (12.1%), unidentified debris (11.8%), fragment of higher plants (10.1%), other crustacean parts (8.8%) crustacean appendages (7.9%), crustacean eggs and gills (6.8.0%), polychaete (4.8%), Bacillariophytes (4.0%) while the rare once are cyanophytes (3.8%), carapace (3.0%), fish and bones (3.0%), copepods(2.5%), protozoans (2.0%) chlorophytes (1.5%), standard length range 8.5-9.9cm fish scales (13.6%), fragment of higher plants (12.4%), Algal filament and crustacean appendages (10.0%), other crustacean parts (8.5%), unidentified debris and crustacean eggs and gills (7.5%), polychaete (5.8%), fish and bones (5.5%), and standard length range 10.0-12.0cm fish scales (12.7%), fragment of higher plants (11.7%), other crustacean parts (10.4%), Algal filament (9.9%), unidentified debris (8.0%), crustacean appendages and crustacean eggs and gills (6.6%), fish and bones (5.2%), Bacillariophytes and cyanophytes (4.2%), while the rare once are chlorophytes and polychaete (3.5%). The findings suggest a versatile feeding behavior in P. barbarus, indicating adaptability to a range of prey items and environmental conditions. Understanding the dietary habits of this species is crucial for ecological assessments and conservation efforts in the studied mangrove ecosystem. Thus, the findings can shed light on the supply of the

fundamental knowledge about the baseline data for future ecological and biological studies of this species and other species within the Ogbo-Okolo mangrove Forest of Santa Barbara River, Bayelsa State Niger Delta, Nigeria.

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Introduction

The Atlantic mudskipper (Periophthalmus barbarus) is a mudskipper species indigenous to the tropical Atlantic coasts of Africa, spanning fresh, marine, and brackish waters (Okoyen *et al.,* 2020). Named by a Greek scientist for its distinctive eyes providing a wide field of vision, this member of the Periophthalmus genus, known for its dorsally positioned eyes and pectoral fins facilitating movement on land and in water, belongs to the Oxudercine gobies with a single row of canine teeth. Functioning as semi-aquatic creatures, they navigate tidal flats and mangrove forests, displaying unique locomotion capabilities with pelvic and pectoral fin usage. Carnivorous in nature, the Atlantic mudskipper employs an ambushing strategy for prey capture, utilizing a hydrodynamic tongue to suction prey into its mouth. While, the scientific name *Periophthalmus barbarus* is derived from the Greek words "Peri," meaning "around," and "*ophthalmos*", meaning 'eyes,' referring to its wide field of vision. In Greek, 'barbarus' means "foreign," possibly indicating distinct features compared to other gobies. The common name 'mudskipper' comes from their skipping movement on mud flats. Classified under oxudercene gobies, they live on both land and water, creating burrows for refuge and reproduction. The Oxudercine family was initially a one-species family, named *Oxuderces dentatus*. Oxudercine species have small to medium bodies, elongated with small scales, dorsally positioned eyes, and canine-like teeth. The dorsal, pectoral, and pelvic fins have varying spines. The Periophthalmus genus includes 12 species identified by a single row of teeth on the upper jaw and a maximum of 16 spines on the pectoral fins. Found in mangroves or mudflats, Periophthalmus species are distinguished by spots on their back or white spots and over 90 scales along their sides.

They grow up to 16cm in length, the body is covered with scales, coated with a mucus layer that helps to retain moisture and have more than 90 scales along the side of their body. and also retain moisture by storing water within gill chambers that allows them to breathe when out of water, they do not have a membrane that covers the gill chambers; instead, they are able to control the opening and closing of gill chambers. The gill may be controlled through muscles around the slits or through the differences in partial pressure (Michel *et al.,* 2016). In addition to retaining moisture by storing water from the surface which helps them to breathe through its skin, otherwise known as cutaneous respiration (Kutschera and Elliot, 2013). They have pair of caudal fins that aid in aquatic locomotion and pelvic fins in terrestrial locomotion (Pace and Gibb, 2009). Their pelvic fins are adapted to terrestrial-living by acting as a sucker to attach on land, their eyes are adapted closely together and can move independently of about 360 degrees, their eyes are also positioned further up on the head, enabling the eyes to remain above the water surface while their body is submerged underwater (Ansari *et al.,* 2014). Cup-like structures that hold water are located beneath the eye which aids in lubricating the eyes when it is on land. They have chemosensory receptors that are located within the nose and on the skin surface (Kuciel, 2013). Mudskippers have a mouth that can be reoriented. They have short digestives system that is comprises of an oesophagus, stomach, intestine and rectum (Wolczuk *et al.,* 2018). The surface of the intestine is folded which increases the surface area that enhance the absorption of nutrients, they have unique olfactory organ that include a canal 0.3 mm in diameter near it upper lips that increases in size into a chamber like sac. They have genital papillae that are located on the abdomen. Females can be distinguished from males who have less rounded papillae (Kuciel, 2013). They are semi-aquatic animals that live in an area with water that is slightly salty such as rivers, Estuaries and mud flats, they spend majority of the day on land in tide regions, they appear only during low tide to feed, they hide in their burrows at high tide. The burrows can extend to 1.5 meters deep in which mudskippers can seek refuge from predators (Ansari *et al.,* 2014). The burrows may contain a pocket of air which they can breathe from, despite their low oxygen availability (Ansari *et al.,* 2014). They generally able to tolerate high concentrations of toxic substances produced by industrial waste including cyanide and ammonia in the surrounding environments (Emuebie, 2011) in the present of high ammonia contamination, they can actively secrete ammonia through its gills within highly acidic environments (pH=9.0) (Ansari *et al.,* 2014).

They are also able to survive variety of environments including water with different temperatures and salinity levels. Hot and humid climate are optimal for Atlantic mudskipper as it enhances cutaneous respiration and help maintaining their body temperature of the surface ranging from 14-35 degrees Celsius. They build a wall of mud around it territory and its resources. The territory is approximately 1-meter-long and can aid in maintaining its population by storing food resources from predators. while hunting, they submerge itself under water whilst leaving its eyes out, using only sight to identify and locate prey, they launch on land using predominantly their pectoral fins and catch the prey using it

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mouth, when there is danger from predators on land, they proceed into flight behavior and either jump in the water or skip away on mud. (Ansari *et al.,* 2014).

On land, they feed by covering it prey with water, then sucking back the water into its mouth, through the hydrodynamic tongue (Michel *et al.,* 2015). They carry water in the mouth prior to emerging on land, which enable them to feed on land, they feed through suction feeding, similar to other aquatic species (Michel *et al.,* 2016, Olalekan *et al.,* 2019; Okoyen *et al.,* 2020; Raimi *et al.,* 2022a, b; Saliu *et al.,* 2023). Suction feeding includes building up pressure by expanding the head and mouth rapidly which pulls both food and water in (Kane *et al.,* 2019). They alter the force of suction such that the flow under water is stronger than on land (Michel *et al.,* 2016). The gape size of the mouth is larger in water, due to the pressure (Kane *et al.,* 2019).

They lunge simultaneous suctioning in order to catch prey (Kane *et al.,* 2019). The direction of the lung is the different between terrains. It catches prey horizontally underwater, whereas they reoriented its mouth such that it feeds on prey from above (Kane *et al.,* 2019). They are diurnal that is, they are actively feeding during the day and are flexible in regard to their diets choices, larger mudskipper ingests larger sized prey, potentially due to the correlation between their mouth gap and prey size. The feeding choices also vary by habitats and seasonally depending on what resources are most abundant. They feed more during dry season than rainy season; the optimal forage theory proposed that diet flexibility increases with lower food availability. They exhibit a diverse diet, consuming a range of foods in the wild, including worms, crickets, flies, mealworms, beetles, small fish, and small crustaceans like sesarmid crabs. Additionally, their diet comprises algae, invertebrates such as bloodworms or artemia, and even flakes. However, it's advised against feeding them dried food. Thus, this study investigates the food and feeding habits of *P. barbarus*, employing both occurrence and numerical abundance methods.

Materials and Methods

Study Area

The Ogbo-okolo mangrove Forest of Santa Barbara River is located in Nembe local government Area of Bayelsa State, Nigeria at 4.5328^{O}N, 6.4037^{O}E (see Figure 1 below). The area lies entirely below sea level with a maze of mendering creeks around the mangrove forest. Ogbo-okolo mangrove Forest of Santa Barbara River is significant in the provision of suitable breeding sites for diverse aquatic organism that abound in the area, good fishing ground for artisan fishers as well as petroleum exploration and production activities by Aiteo company.

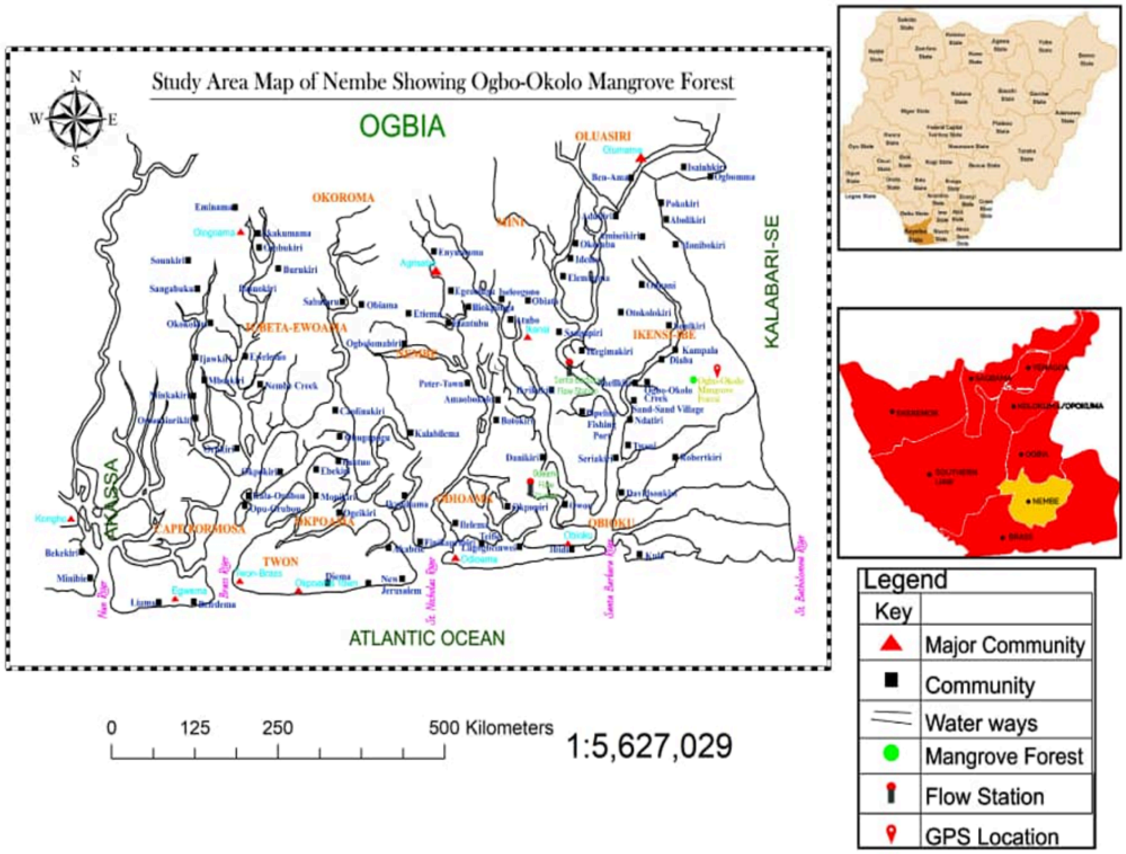

Figure 1. Map of Nembe showing Santa Barbara River and the Study Area Ogbo-okolo mangrove Forest.

Study site

The study site is in Ogbo-okolo mangrove forest along Santa Barbara River, Bayelsa State, Nigeria. The vegetation of the Ogbo-okolo mangrove consist of the red mangrove Rhizophora racemosa and white mangrove Avicenna Africana with the height ranging from 5 meters to 15 meters. The main sea flows into the smaller tributaries in high tide. The water is salty, and at low tide stilt like prop roots of the mangrove are visible; the intertidal mudflat is expose and serve as feeding ground for the mudskippers. Burrows small holes between 3.5-6cm in diameters around the prop-roots of the Rhizophora trees. The area serves as *Periophthalmus* species hide out. Traps shall be set around these areas to catch

Periophthalmus species. Bacteria and other microorganisms thrive in the mud produce a variety of sulfur containing gases that give mud flat a characteristics odour of rotten egg.

Sample Collection

Fish trapping method were used to collect 350 Specimen of Mudskippers *Periophthalmus barbarus* with standard length ranging from 5.5-11.9cm and total length ranging from 7.0-14.7cm respectively. The specimen was obtained during rainy season between May to June 2021. The fishing gears used is hands made rubber container and basket traps woven with cane materials with a single conical in curved opened. Each basket trap was 40cm long and 30cm wide. These traps are nonselective and can catch both adults and Juveniles. The traps were set during the low tide using scattered and broken crabs likes *Uca tangeri* (fiddler crab) *Callinetes sapidu* (marine swimming crab) and *Cardiosoma armatum* (terrestrial crab) was used as bait for the traps. As soon as catches were made, the specimens were removed and put in a bucket containing 5% formalin and a little water. These were later taken to the laboratory.

The frequency of occurrence method was used to examine the food and feeding of *Periophthalmus barbarus*: This method is one in which the relative importance (to the fish) of different food items in each stomach were identified and recorded. Here the number of fish in which each food items occurred in the stomach wall is recorded and express as a percentage of the total number of stomach examined. This method being qualitative portrays which organisms were best being used as food. In the laboratory the total length, standard length, total body weight and gut weight of the specimens were measured to the nearest 0.1 centimeters and to the nearest 0.1grams using a measuring board and a weighing balance, then each stomach cut open and the esophagus were pulled out in each of the specimen and preserved with 3% formalin in a universal specimen bottle, Each stomach were slit open and the content removed by scrapping the inner mucosa with spatula each were place in a plastic petri dishes containing fresh water to neutralize the effect of the formalin for a while. The weight of the content was taken as food items to be identified using stereo-microscope to identified. This was done by spreading out the food items over a plastic petri dishes with little water added to spread out food contents to be observed. Lastly the number of each taxonomic entity were recorded on a data sheet for each stomach. The gut contents were analyzed individually using frequency of occurrence method by (Hempel *et al.,* 2016. Nguyen and Tran, 2018).

$$\text{Frequency of occurrence method} = \frac{\text{Total number of stomachs with particular food items}}{\text{Total number of stomachs with food}} \times 100$$

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To evaluate the food of *P. barbarus* using the numerical abundance method. Numerical abundance method was used: In this method, the number of individual of each food type in each stomach is counted and expressed as a percentage of the total number of food items in the sample studied, or as a percentage of the gut contents of each specimen examined, using the numerical abundant method by Hempel *et al.,* (2016) and Nguyen and Tran, (2018).

$$\text{Numerical abundance method (NAM)} = \frac{\text{Total number of particular food items}}{\text{Total number of all food items}} \times 100$$

In the laboratory, the total length, standard length of the specimens was measured to the nearest 0.1 centimeter and total body weight and gut weight to the nearest 0.1gram, using a measuring board and a weighing balance. The stomach and the esophagus were pulled out in each of the specimen and stored in a specimen bottle containing 3% formalin. Each stomach was slit open and the content removed by scrapping the inner mucosa with spatula and place in plastic petri dishes containing fresh water to neutralize the effect of the formalin for a while before spread and observed. The weight of the content was taken as difference variation of food to be identified using stereo-microscope to identify to the lowest possible taxonomic level. Lastly, the number of each taxonomic entity was recorded on a data sheet for each stomach.

This method has been employed successfully by several studies of the gut (Dinh, 2018; Nguyen and Tran, 2018; Dinh *et al.,* 2918a, b; Dinh *et al.,* 2020a, b, c; Dinh *et al.,* 2021; Lam and Dinh, 2020). In this number method, no allowance is made for the differences in size of food items. The counting of comminuted plant matter in the stomach of fish is impracticable and will not yield correct evaluations. So also in the analysis of the gut contents of a carnivore which may consist of only one large sized fish and a couple of small larvae, the counting is of little value computations. These are summed to give totals for each kind of food item in the whole sample, and then a grand total of all items. The quotient of these gives the percentage representation, by number of each type of food item. Combination of these two methods was used so that one method shall nullify the disadvantage of the other.

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Result

Food Items	No of Species in which food items Occurred	Frequency of Occurrence %
Crustacean appendages	120	34.3
Crustacean gills and eggs	105	30.0
Other Crustacean parts	140	40.0
Fish scales	196	56.0
Fish, eggs and gills	71	20.3
Algal filaments	158	45.1
Fragment of higher plants	173	49.4
Molluska	15	4.3
Bacillariophyta	60	17.1
Cyanophyta	54	15.4
Protozoans	18	5.1
Copepods	28	8.0
Cladocera	12	3.4
Polychaetes	70	20.0
Poliferas	6	1.7
Chlorophyta	38	10.6
Euglenophyta	4	1.4
Unidentified debris	133	38.0
Carapace	55	15.7
Sand grain	11	3.1
Chrysophyta	6	1.7
Dinoflagellate	9	2.6

Food Items	No of Species in which food items Occurred	Frequency of Occurrence %
No Number of stomach Containing food	350	100
Total length range		7.0-14.9cm
Body weight range		3.4-30.9g

Table 1. Gut content analysis of Atlantic Mudskipper (*Periophthalmus barbarous)* in Ogbo-okolo Santa Barbara Bayelsa state using frequency of occurrence method

A total of 350 specimens were examined for stomach content analysis. In all, 22 food items ranging from fish scales (56%), fragment of higher plants (49.4%), algal filament (45.9%), other crustacean parts (40.0%), unidentified organic matters and debris (38.0%), crustacean appendages (34.3%), crustacean eggs and gills (30.0%), fish and bones (20.3%), polychaete (20.0%), bacillariophytes (17.1%), carapace (15.7%), cyanophytes (15.4%), chlorophytes (10.6%), copepods (8.0%), protozoans (5.1%), cladocera (3.4%), sand grain (3.1%), dinoflagellate (2.6%), polifera and chrysophytes (1.7%) and euglenophytes (1.4%) was recorded respectively.

	Size Range		
Food items	5.5-8.4cm	8.5 9.9cm	10.0-12.0cm
Crustacean appendages	7.9	10.0	6.6
Crustacean gills and eggs	6.8	7.5	6.6
Other Crustacean parts	8.8	8.5	10.4
Fish scales	12.8	13.6	12.7
Fish, eggs and gills	3.0	5.5	5.2
Algal filaments	12.1	10.0	9.9
Fragment of higher plants	10.1	12.4	11.7
Molluska	1.3	1.3	0.5
Bacillariophyta	4.0	3.8	4.2
Cyanophyta	3.8	2.8	4.2
Protozoans	2.0	0.8	1.0
Copepods	2.5	1.1	2.1
Cladocera	1.5	0.2	0.9
Polychaetes	4.8	5.8	3.5
Polifera	0.8	0.4	0.2
Chlorophyta	1.5	2.3	3.5
Euglenophyta	-	0.6	0.2
Unidentified detritus	11.8	7.5	8.0
Carapace	3.0	3.8	0.4
Sand grain	0.8	1.1	0.3
Chrysophyta	0.5	0.4	0.3
Dinoflagellates	0.3	0.8	0.3
Number of fish examined	105	132	113

Table 2. Shows the Stomach Content Analysis Using Numerical Abundance Method

Stomach Content Analysis using numerical abundance methods in. *P. barbarus shows that* Length ranging from 5.5 - 8.4cm have the dominant food items as fish scales (12.8%), Algal filament (12.1%), unidentified organic matters or debris (11.8%), fragment of higher plants (10.1%), other crustacean parts (8.8%) crustacean appendages (7.9%), crustacean eggs and gills (6.8.0%), polychaete (4.8%), bacillariophytes (4.0%) while the rare once are cyanophytes (3.8%), carapace (3.0%), fish and bones (3.0%), copepods (2.5%), protozoans (2.0%), chlorophytes (1.5%), cladocera (1.5%), mollusks (1.3%), polifera and sand grain (0.8%), chrysophytes (0.5%) dinoflagellate (0.3%), and no euglenophytes was observed. length ranging from 8.5 - 9.9 cm. The dominant food items were fish scales (13.6%), fragment of higher plants (12.4%), Algal filament and crustacean appendages (10.0%), other crustacean parts (8.5%), unidentified organic matters or debris and crustacean eggs and gills (7.5%), polychaete (5.8%), fish and bones (5.5%), bacillariophytes and carapace (3.8%), while the rare once are cyanophytes (2.8%), chlorophytes (2.3%), mollusks (1.3%), copepods and sand grain (1.1%), dinoflagellate and protozoans (0.8%) euglenophytes (0.6%) polifera and chrysophytes (0.4%) and cladocera (0.2%) and length ranging from 10.0-12.0cm. The dominant food items were fish scales (12.7%), fragment of higher plants (11.7%), other crustacean parts (10.4%), algal filament (9.9%), unidentified organic matters debris (8.0%), crustacean appendages and crustacean eggs and gills (6.6%), fish and bones (5.2%), bacillariophytes and cyanophytes (4.2%), while the rare once are chlorophytes and polychaete (3.5%), copepods (2.1%), protozoans (1.0%), cladocera (0.9%), mollusks (0.5%), carapace (0.4%), sand grain, chrysophytes and dinoflagellate (0.3%), polifera and euglenophytes (0.2%).

Discussion

The stomach content of 350 specimens of Atlantic mudskippers *Periophthalmus barbarus* generally showed twenty-two (22) items of food using the frequency of occurrence method. The food items discovered were fish scales (56%), fragment of higher plants (49.4%), algal filament (45.9%), other crustacean parts (40.0%), unidentified organic matters and debris (38.0%), crustacean appendages (34.3%), crustacean eggs and gills (30.0%), fish and bones (20.3%), polychaetes (20.0%), bacillariophytes (17.1%), carapace (15.7%), cyanophytes (15.4%), chlorophytes (10.6%), copepods (8.0%), protozoans (5.1%)

cladocera (3.4%), sand grain (3.1%), dinoflagellate (2.6%), polifera and chrysophytes (1.7%) and euglenophytes (1.4%). This is in line with the observation made by Mohammed *et al.,* (2016) who reported that shrimps and other crustaceans were among food items discovered from the gut of male and female mudskipper. It also agrees with the report of Bob-Manuel, (2011) who reported that fragment of higher plants (90.6%), algal filaments (80.60%), diatoms (85%), sand grains (61.9%) unidentified organic matter or detritus (43.0%), crustacean appendages (95.5%), polychaetes (86.4%), fish gills (50%) and sand grains (45.5%) were among food items extracted from the gut of mudskippers (*Periopthalmus koelreuteri)* and observation made by Tran *et al.,* (2021a, b, c) in *Glossogobius sparsipapillus* who reported with the following observations in Male; *Acetes* spp (50.00%), Small fish (26.27%), *Uca* spp (2.54%), Polychaeta (1.69%), others (27.12%), female (45.95%), (21.62%), (1.80%), (2.70%), (36.04%) and Immature (18.52%), (25.93%), (7.41%), (7.41%), (40.74%) respectively. The percentages of the food items recorded in his study are however, higher than those recorded in the present study. This difference in percentage of the food items could be due to seasonal and environmental changes and inadequacy of these food items in the present study area.

Numerical abundance methods in. *P. barbarus* length ranging from 5.5 - 8.4 cm revealed that the dominant food items were fish scales (12.8%), algal filament 12.1%), unidentified organic matters or debris (11.8%), fragment of higher plants (10.1%), other crustacean parts (8.8%) crustacean appendages (7.9%), crustacean eggs and gills (6.8.0%), polychaete (4.8%), bacillariophytes (4.0%) while the rare once are cyanophytes (3.8%), carapace (3.0%), fish and bones (3.0%), copepods (2.5%), protozoans (2.0%), chlorophytes (1.5%), cladocera(1.5%), mollusks (1.3%), polifera and sand grain (0.8%), chrysophytes (0.5%) dinoflagellate (0.3%), and no Euglenophytes observed. length ranging from 8.5 - 9.9 cm shows the dominant food items were fish scales (13.6%), fragment of higher plants (12.4%), algal filament and crustacean appendages (10.0%), other crustacean parts (8.5%), unidentified organic matters or debris and crustacean eggs and gills (7.5%), polychaete (5.8%), fish and bones (5.5%), bacillariophytes and carapace (3.8%), while the rare once are cyanophytes (2.8%), chlorophytes (2.3%), mollusks (1.3%), copepods and sand grain (1.1%), dinoflagellate and protozoans (0.8%) euglenophytes (0.6%), polifera and chrysophytes (0.4%), and cladocera (0.2%), and length ranging from 10.0-12.0cm also revealed that the dominant food items were fish scales (12.7%), fragment of higher plants (11.7%), other crustacean parts (10.4%), algal filament (9.9%), unidentified organic matters debris (8.0%), crustacean appendages and crustacean eggs and gills (6.6%), fish and bones (5.2%), bacillariophytes and cyanophytes (4.2%) while the rare once are chlorophytes and polychaete (3.5%), copepods (2.1%), protozoans (1.0%), cladocera (0.9%), mollusks

(0.5%), carapace (0.4%), sand grain, chrysophytes and dinoflagellate (0.3%), polifera and euglenophytes (0.2%). This varied from the observation made by other studies who work with difference specie of fishes *Epinephelus aeneus* and reported the following food items, unidentified plant part (36.4%), collinectus marginatus (4.5%), fish scale (13.6%), fish ribs (13.6%) fish head (4.5%), true crab (1.7%), partially digested crab (8.1%) and *Pamadasys jubilini:* and reported the following food items, unidentified plant part (10.9%), partially digested crab (10.1%), crab appendages (28.6%), partially digested fish (2.5%), fish scales (0.8%), unidentified animal part (1.7%). The variation in the percentages might be due to sizes of fish, species differences and seasons and available food items in the study environment.

Conclusion

The study on Atlantic Mudskippers, *P. barbarus* in Ogbo-okolo mangrove forest at Santa Barbara river Bayelsa state, Nigeria showed that, the specie is an omnivores and herbivorous, looking at the stomach content analysis as recorded, using frequency of occurrence and numerical abundance methods was used for the gut content analysis. The results indicate that they feed on aquatic macrophytes, algal filaments, crustaceans, small fishes, aquatic and terrestrial insects, bacillariophates and polychaetes. The amphibious lifestyle of the mudskipper shows its predatory behavior in its environment. In general, the primary components of their diet include small fish, fish scales, crabs, and other arthropods like tiny crustaceans. Additionally, P. barbarus consumes aquatic macrophytes, bacillariophytes, algal filament, unidentified debris, and polychaetes. The numerical abundance analysis further highlights the prevalence of certain food items in different size ranges.

Recommendations

Based on the findings from this study, the following recommendations were made.

1. Further research should be encouraged to be carried out in all environments inhabited with P. babarus in the entire Bayelsa state.
2. Government should promulgate laws prohibiting illegal fishing techniques like use of gammalin 20, electrification etc.
3. Fishermen and women should use the certified wire mess for fishing in the territorial waters.
4. Use of dynamites should be discouraged as well as selective exploration should be encouraged.

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