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Diets and Trophic Niches of an Amphibious Fish from Jaja Creek South Eastern, Nigeria

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Abstract

The mudskipper, *P. barbarus* is a residential fish inhabiting the mudflats of the Niger Delta estuaries, and is economically viable as well as actively harvested by the local inhabitants of this area to whom it serves as a special delicacy. Its usage as bait to catch bigger fishes and application in traditional medicinal purposes due to its aphrodisiac values necessitated a research on aspects of its ecology for possible aquaculture exploitation. The study was carried out in Jaja creek Nigeria, West Africa. Monthly samples of the mudskipper were caught bi-monthly between June - November, 2019 with non-return valve basket traps set up for diurnal collection from mudflats of the mangrove swamp. They were preserved immediately in 10% formalin solution prior to laboratory procedure. A total of 600 mudskippers were analyzed. Each fish was dissected and the gut removed and preserved in 4% formalin solution. The gut of each fish was slit open with a scissor and the gut contents poured into a Petri dish, smeared with a few drops of water and the food items were identified macroscopically and microscopically to the nearest taxon. Analysis was carried out using numerical and frequency of occurrence methods respectively. The number of stomachs in which each food items occurred was sorted out and expressed as percentage of the total number of fish stomachs with food examined. The number of individual of each food item was counted and summed up to give the total of each food item, then the grand total of all items was calculated and expressed as percentage of the overall items found in each stomach. Feeding intensity was determined using Gut repletion index (GRI) and was calculated by dividing the number of non-empty guts by the total number of guts examined multiplied by 100. The gut contents revealed that the mudskipper fed on plants, animals and non-living matter as eight (8) major dietary compositions were identified. The dietaries were grouped into plant material (plants), crayfish, periwinkle, insect parts, snail and fish remains (animals), detritus and sand grains (non-living matter). Detritus was determined as the highest item ingested by the fish and plant materials were the lowest item ingested. 197 specimens recorded empty gut giving a gut repletion index (% GRI) of 67.17. Findings suggest that the wide variety of items occurring in the stomach of this fish species show that it is non-selective in feeding and is capable of utilizing many sources of food; and thus could be described as euryphagous.

Keywords

Food, Feeding, Stomach, Dietaries, Gut

1. Introduction

The amphibious fish mudskipper, *Periophthalmus barbarus* lives in the intertidal habitat of the mudflats and in mangrove ecosystem and are uniquely adapted to a [22], completely amphibious lifestyle [15]. They are quite active when out of water, feeding and interacting with one another and defending their territories. They have a range of peculiar behavioral and physiological adaptations to an amphibious lifestyle [15]. *P. barbarus* is a residential fish inhabiting the mudflats of the Niger Delta estuaries, it is economically important and actively fished by the local inhabitants of this area to whom it serves as a special delicacy, this fish is also used as bait to catch bigger

fishes, consumed as protein source, or in traditional medicinal purposes due to its aphrodisiac values [12]. Food and feeding ecology are necessary to understand fish biology and trophic interactions among species in a fish community [4]. Diet composition can vary according to fish size, season and habitat [1; 7 and 5]. This variation is driven by fish foraging behavior and food availability [9]. The study of the diet based upon the analysis of stomach contents is now a standard practice in fish biology.

The anthropogenic activities going on within Jaja Creek such as oil exploration and exploitation, fishing activities and other agricultural, domestic and industrial activities might pollute the aquatic ecosystem causing changes in the abundance, availability and distribution of aquatic flora and fauna which serve as food to fish including *Periophthalmus barbarous*.

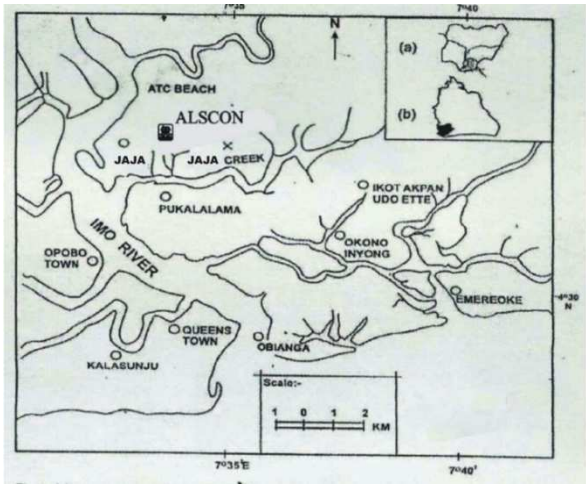
Few or no extensive research has been carried out on the food and feeding habits of *Periophthalmus barbarus*, hence knowledge on the trophic interaction and well-being of this species is not sufficient to build efficient conservation strategy. Therefore, this research would contribute or form baseline information towards understanding the food and feeding habits of this species. Hence this research on the trophic index of *Periophthalmus barbarus* becomes imperative.

2. Materials and Methods

2.1. Study Area

This study was carried out in Jaja creek in Ikot Abasi Local Government Area, Akwa Ibom State, Nigeria (Figure 1). Jaja creek is located at latitude 40°32' to 40°52'N and longitude 70°25' to 70°45'E with elevation generally less than 30 m above sea level. The Jaja creek extends to the western bank of Eyong creek about 12 km from Imo River where the water breaks the coastal area into an irregular shaped tidal mud flat. The area is typical of an estuarine tidal water zone with fresh water input from the Imo River and extensive mangrove swamps and inter-tidal mudflats. The Jaja creek is bounded by thick mangrove mostly by *Rhizophora* species and interspaced by Nypa palm. It has a climate that can be differentiated into two seasons; the wet which begins in April and ends in October, having an average annual rainfall varying between 2000 mm to 3500 mm, and dry which spans from November to March [24].

Jaja creek receives effluent from Aluminum Smelter Company (ALSCON) located a distance of about 4 miles from the creek. The main occupations of the people are fishing, farming, firewood cutting and water transportation [11]. The area is semi-rural community in which the inhabitants depend on rain and surface water as the only source of drinking and for domestic purposes. The major source of protein in the area is sea food (fish, crabs, crayfish, clams and periwinkle) [24 and 23], the effluent from Aluminum Smelter Plant and domestic waste water from Housing Estates (Ferrostal camp, Sweato camp, Worker's camp, Berger's camp and ALSCON camp) in Ikot Abasi are discharged into this creek.



Legend; × Study area, O Towns

Figure 1. *Map of Ikot Abasi Showing Jaja Creek and Aluminium Smelting Company (ALSCON).*

2.2. Samples Collection

Monthly samples of the mudskipper, *Periophthalmus barbarus* (Figure 2) were caught bi-monthly between June - November, 2019 with non-return valve basket traps from mudflats of the mangrove swamp of Jaja creek. Services of local fishers were employed in setting up traps and diurnal collections of the fish. They were preserved immediately after capture in 10% formalin solution in a plastic container prior to laboratory procedure. A total of 600 mudskippers were collected. The fish specimens were washed with salt water to remove any foreign debris such as leaf, mud, sand, that must have been attached to the body of the mudskipper. There after the samples were transported to Zoology Department laboratory, Akwa Ibom State University the same day and preserved till the period of analysis.

Figure 2. *Periophthalmus barbarus (Mudskipper).*

2.3. Stomach Content Analysis

In the laboratory, the total length of each fish was measured using a measuring board and recorded to the nearest centimeter and weighed to the nearest 0.1 g to obtain total weight (TW) using a top loading weighing balance. Each fish was dissected and the gut removed and preserved in 4% formalin solution. The gut of each fish was slit open using a scissor and the gut contents were poured into a Petri dish, smeared with a few drops of water and the food items

were identified macroscopically, then microscopically to the nearest taxonomic entity. Analysis was carried out using numerical and frequency of occurrence method respectively.

2.4. Frequency of Occurrence

The number of stomachs in which each food items occurred was sorted out and expressed as percentage of the total number of fish stomachs with food examined according [6].

It is calculated thus:

$$\%F = \frac{\text{Total number of stomach with particular feed}}{\text{Total number of stomach with food}} \times 100$$

2.5. Numerical Method

The number of individual of each food item was counted and summed up to give the total of each food item, then the grand total of all items was calculated and expressed as percentage of the overall items found in each stomach [8].

Percentage number of food items was calculated thus:

$$\%N = \frac{\text{Total number of particular food item}}{\text{Total number of all food items}} \times 100$$

2.6. Feeding Intensity

Feeding intensity was determined using Gut repletion index (GRI) and was calculated by dividing the number of non-empty guts by the total number of guts examined multiplied by 100 [18].

Gut repletion index (GRI) is expressed as:

$$GRI = \frac{\text{Number of non-empty stomach}}{\text{Total number of specimens examined}} \times 100$$

3. Results

A total of 600 specimens of *Periophthalmus barbarus* were collected from Jaja creek, with food composition of the fish species as shown in (Table 1). The mudskipper fed on food items that were made up of plants, animals and non-living matter. Eight (8) major dietary compositions were identified in the fish stomach. The dietaries were further grouped into plant material (plants), crayfish, periwinkle, insect parts, snail and fish remains (animals), detritus and sand grains (non-living matter). The food item with the highest number was detritus, while the lowest were plant materials.

Table 1. *Overall food composition of Periophthalalmus barbarus from Jaja creek.*

S/N	Food items	Numbers of food items
1	Detritus	266
2	Crayfish	101
3	Sand grains	21
4	Periwinkle	16
5	Insect parts	46
6	River snail	7
7	Fish remains	34
8	Plant materials	3
TOTAL		494

Monthly dietary composition of *P. barbarus* is shown in (Table 2). The number of food items ranged between 64 and 98 which were for July and August respectively. The analysis of the gut contents using frequency of occurrence and numerical abundance methods is shown in (Table 3). For both frequency of occurrence and numerical methods, detritus was determined as the highest item ingested by the fish and plant materials were the lowest item ingested. Out of 600 specimens sampled, 197 specimens recorded empty guts giving a gut repletion index (% GRI) of 67.17.

Condition factor ranged between 0.902 (July and November) and 1.22 (August) with a mean condition index of 1.06.

Table 2. *Monthly diet composition of Periophthalmus barbarus from Jaja creek*

Food Month	Detritus	Crayfish	Sand grain	Periwinkle	insect	River Snail	Fish Remain	Plant material	total
JUNE	58	26	3	2	2	1	3	0	95
JULY	30	20	3	3	8	0	0	0	64
AUGUST	47	11	7	4	13	5	11	0	98
SEPTEMBER	58	14	0	0	3	0	11	1	87
OCTOBER	38	15	3	5	15	0	9	0	85
NOVEMBER	35	15	5	2	5	1	0	2	65
TOTAL	266	101	21	16	46	7	34	3	494

Table 3. *Overall Numerical Abundance (%) and Frequency of Occurrence (%) of diet composition of Periophthalmus barbarus from Jaja creek*

Food Items	Number of Specimens in which food items occurred	Frequency Occurrence (%)	Numerical Abundance (%)
Detritus	266	66.00	53.85
Crayfish	101	25.06	20.45
Sand grains	21	5.21	4.25
Periwinkle	16	3.97	3.24
Insect	46	11.41	9.31
River snail	7	1.49	1.21
Fish remains	34	8.44	6.88
Plant materials	3	0.74	0.61
Number of specimens with food examined	403		
Total number of specimen examined	600		

4. Discussion

The morphology of *Periophthalmus barbarus* is adapted for bottom feeding although stomach contents may prove otherwise as the variety of food items contained in the stomach of fishes often reflect the ability of fishes to obtain food from different locations [2]. Morphological features, therefore cannot limit *Periophthalmus barbarus* as exclusive bottom feeders, [19] as stomach content indicates food items from different locations. The wide food spectrum of *Periophthalmus barbarus* is an indication of flexibility in trophic level, which gives the fish ecological advantage to feed effectively in different categories of diets based on the availability of the food items [30, 31, 32; 25].

The result of this study shows that *P. barbarus* from jaja creek fed on wide range of food items from plants (plant materials), animals (insect parts, fish parts, crayfish, periwinkle, and river snail) and non-living matter (sand grains and detritus). Feeding on food items comprising of both plant and animals possibly qualifies the species as an omnivore; while feeding on plants, animals and detritus reveals *P. barbarus* as an omnivorous detritivore [27; 25; 33; 2]. The wide variety of items occurring in the stomach of this fish species show that it is non-selective in feeding and it appears that the fish is capable of utilizing many sources of food. Feeding on a wide range of food organisms could make *P. barbarus* to be described as euryphagous. This is in agreement with the studies by [28; 14].

Based on monthly food composition, August recorded the highest food items and November recorded the lowest number of items. The high food abundance in August might be attributed to the peak of the rains in the Niger Delta region which leads to the bloom of both the aquatic flora and fauna as both become available to the fish to consume [24]. However, the lowest food availability in November might be attributed to the period of cessation of rains which might reduce the growth of both aquatic flora and fauna making less food items to be available to *P. barbarus* [24].

The analysis of the gut content of *P. barbarus* using frequency of occurrence and numerical methods showed that the food items consumed by the species followed nearly the same pattern with detritus being the dominant food item. The species in a decreasing sequence also consumed crayfish, insect part, fish remain, sand grain, periwinkle, river snail and plant materials. Detritus being the dominant food item as revealed in this study is in agreement with the work of [19] who stated that all the size groups of *P. barbarus* consumed mainly detritus. It is also in tandem with [21] who reported the species as a benthic detritivore, feeding principally on coarse particulate organic matter (CPOM), fine particulate organic matter (FPOM), diatoms and shrimps, while fish scales, insect remains, ants, filamentous and macro branched algae, sand grains, neritina, free living nematodes, macrophytes, fish bones and crabs were secondary dietaries. Ostracods, butterfly, unidentified insects, fish remains, bivalves and copepods were incidental food items.

However, this result is in contrast to the findings of [13, 10] who recorded crustaceans as the dominant food item; [13] who reported bivalves as the dominant prey item; and [17] who reported aquatic insects as the most abundant food item. [16] termed the species 'voracious' with principal food items comprising mud, crustaceans, gastropods, terrestrial insects and algal filaments with other food materials such as fish, nematodes and polycheates. Larger food items were consumed by the adult than juveniles, this being attributed to the well developed and larger mouth in adults. [29] described *P. barbarus* as an omnivore and a frequent feeder, feeding principally on crabs, detritus and vascular plant materials. Other food materials included insects, fish scales, nematodes and algae (blue green algae, desmids, euglenoids and diatoms).

Fish is common sight in the study area and as a beach and as a beach; it is also a landing site for boats which purchase "by-catch" from offshore vessels. Most sorting and washing activities are carried out here, where the unwanted components are thrown back into the water, hence; any fish could be as food to the mudskipper and may allow its description as piscivorous species [10]. The presence of fish part in the dietaries of *P. barbarus* in this study could be due to it fish eating habits and confirms the species as a predator as well. This is in agreement with studies by [19; 2] on some specialized predators in tropical communities and condition factor and diet of two species of *P. barbarus* from Aiba reservoir, Iwo, Nigeria respectively. The inclusion of sand grains in the stomach of *P. barbarus* could be attributed as an accidental ingestion along with other food items. This is in agreement with studies by [14; 19 and 2].

The presence of insect parts could be as a result of the consumption of aquatic insect by *P. barbarus*. This was probably due not only to its food preference, but also to the high availability of insects in the aquatic ecosystem. Indeed in Jaja creek, the presence of marginal wetland associated with aquatic vegetation could have boosted the proliferation of aquatic insects that were available for *P. barbarus.* This finding is in agreement with the report of [17]. The high gut repletion index (GRI) recorded by this species suggested that the species fed frequently and actively. This is in agreement with [3] and [10]. The wide food spectrum of *P. barbarus* is an indication of flexibility in trophic level which gives the fish ecological advantage to feed effectively on different categories of diet based on availability of the food item [19; 26]. This ability to exploit varying areas of food supply by this species no doubt reduce rate of competition with other species, hence confer survival value to *P. barbarus* and may cause it to be described as euryphagous species [13; 11] the fish species depended mainly on autochthonous food items.

Estuaries have been found to be very productive in terms of flora and fauna hence they have been described as spawning, nursery, and feeding grounds. [26] observed that the ecological advantage of this is that it enables a fish switch from one food category to another in response to fluctuation in their abundance. This leads to the ability of the species to utilize many different food objects effectively. The high percentage of detritus materials in the diets of *P. barbarus*

could make the fish species to be described as iliophagus (detritus feeder) [28]. The wide food spectrum of *P. barbarus* may be attributed to the high availability of these food resources in the water body regardless of seasons so that the species may have unlimited access and consumed them according to their needs and food requirement [25 and 20].

5. Conclusion

The stomach contents of the mudskipper, *Periophthalmus barbarus* fish species caught in the mangrove swamp of the Jaja creek Nigeria revealed that species possess a wide food spectrum which is an indication of flexibility in trophic level, thus giving the fish ecological advantage to feed effectively in different categories of diets based on the availability of the food items. The study further calls for close monitoring of this rare species stocks for sustainable management and aquaculture development.

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