Diets of Large-scaled Mullet, *Parachelon grandisquamis* (Valenciennes, 1836) from St. Nicholas River, Bayelsa State, Nigeria

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Abstract

The diets of fishes are used to study trophic interactions in aquatic communities and are important tools for fisheries management. The diet of Parachelon grandisquamis from St. Nicholas River, Bayelsa State, Nigeria was studied for one year (November 2020 to October 2021) using the stomach contents. Fish were caught from the full stretch of the river and identified to species level using keys and descriptions. A total of two hundred and sixteen (216) P. grandisquamis stomachs were studied. Stomachs were excised, preserved and the contents analyzed using the numerical, frequency of occurrence methods as well as the index of food significance. The results showed that the food of P. grandisquamis as indicated by the stomach contents were plant parts > diatoms algae > crustaceans > fish parts > annelids; other items included sand grains and detritus. For % number of food items, plant parts (55.91%) showed the highest numbers followed by diatoms (20.57%), especially Fragillaris sp (n=439), algae (16.92%), crustaceans (3.45%), fish parts (2.02) and the least were annelids (1.13%). For % frequency of occurrence detritus (27.00%) was recorded as the most frequently occurred followed by sand (25.00%), plant parts (19.63%), crustaceans (9.88%), diatom (7.63%), algae (7.13%), fish parts (2.13) and annelids (1.63%). The result of the % index of significance showed that the primary food items (i.e., IFS ≥ 3%) of P. grandisquamis are plant parts (77.55%), followed by diatoms (11.095) and algae (8.52%). Crustaceans (2.41%), fish parts (0.30%) and annelids (0.13%) are secondary food items (i.e., IFS ≥ 0.1 to < 3 %). Others such as sand grains and detritus are regarded as incidental food items (i.e., IFS ≤ 0.1%). There was no seasonal variation in the type of the food items consumed however, the total number of food items consumed was greater in the dry season (3483) compared to the wet season (2457) with plant parts > diatoms > algae > crustaceans > fish parts > annelids in both seasons. In conclusion, P. grandisquamis from St. Nicholas River is an omnivorous and opportunistic feeder with preference for plant-based materials.

Keywords: *Food, Feeding, stomach content, numerical methods, frequency of occurrence.*

1. INTRODUCTION

The importance of food in the life of any living organism cannot be overemphasized. Food is important for survival, growth and general well-being of living organisms (Akuna and Amachree, 2019). The study of fish diets is fundamental to understanding their ecological roles, trophic relationships and adaptive strategies within an aquatic ecosystem (Wootton, 1990) and are crucial for effective ecosystem management, conservation efforts, and fisheries management (Braga *et al*., 2012). Stomach content analysis is an established method used to study the diet of aquatic organism (Hyslop, 1980; Lindstrøm *et al*., 1997; Akuna and Amachree, 2019). Analysis of stomach content of fish using methods such as numerical, point, gravitational and frequency of occurrence (Hyslop, 1980; Ugwumba and Ugwumba, 2007; Akuna and Amachree, 2019) provides valuable information on feeding relationships between species (Arrington *et al.*, 2002), habitat use, feeding strategies, and the influence of environmental factors on resource utilization, efficient utilization of resources within an ecosystem (Chea *et al.*, 2017) as well as aid in the development of management and conservation strategies that consider multiple species (Abdel-Aziz and Gharib, 2007).

Parachelon grandisquamis (synonyms of *Liza grandisquamis*), is a species of mullet belonging to the family Mugilidae and are found in both freshwater rivers and coastal brackish water ecosystem of the world (Schneider, 1990; Thomson, 1990; Harrison, 2008; Albaret, 2003; Ara *et al.*, 2019). *Parachelon grandisquamis* represents a valuable food source, contributing to food security and nutrition (FAO, 2016), and is one of the commercially important food fish in Nigeria including Bayelsa State, yet its diet remained poorly studied. Studies on other mullet species have reported diet to consist of organic detritus, protozoa, plant materials, dinoflagellates, plankton, benthic organisms, epiphytic algae and detritus (De Silva and Wijayarantne, 1977; Blay, 1995; Blaber, 2000; Jamabo and Maduoka, 2015; Whitfield *et al*., 2022). Mullets exhibit considerable flexibility in their diet and the variations in dietary composition among different species exist due to various factors such as season, locations, age, habitat types, substrate type, habitat conditions, food availability, ecological niches and the availability of organic material in their environment (Whitfield, 2015; Cardona, 2016). Such dietary plasticity enables them to adapt to the fluctuating conditions of estuarine environments, where the availability of food resources can be highly variable. Like other mullet species, *P. grandisquamis* have a specialized feeding morphology that enables them to exploit a wide range of food resources material (Thomson, 1966; Blaber and Blaber, 1980). Given the feeding behaviour of closely related species, it can be implied that *P. grandisquamis* may also rely on a similar range of food resources, although local environmental factors could influence its specific dietary composition. While general information about the feeding behavior of mullet species is available, there remains a need for specific research on the diet of *P. grandisquamis*.

St. Nicholas River, Bayelsa State, is an important water resource that supports artisanal fisheries and providing livelihoods for local communities. Despite its importance, the river is subjected to various anthropogenic pressures, including pollution, overfishing, and habitat degradation, which could affect the availability and quality of food resources for fish species (Agboola and Denloye, 2011). Hence, studying the diet of *P. grandisquamis* in St. Nicholas River, Bayelsa State, Nigeria, becomes pertinent. The paucity of data on the feeding habits of

P. grandisquamis in Nigerian waters, specifically in St. Nicholas River, presents a critical gap in understanding of the species ecology and role in the local food web. Furthermore, given that in the assessment by the International Union for Conservation of Nature (IUCN) for The IUCN Red List of Threatened Species, *P. grandisquamis* was categorized as "Data Deficient"; research into its diet could provide much-needed information on its dietary preference among others (IUCN 2023). Additionally, such research would contribute to the conservation of this species and the sustainable management of the estuarine ecosystems where mullet species often serve as indicators of environmental quality due to their sensitivity to changes in water quality and habitat conditions (Blaber, 2000; Whitfield and Elliot, 2015).

2. MATERIAL AND METHODS

2.1 Study area

The St. Nicholas River is one of the major estuaries of the river Niger. It is situated between longitude 6°27' 02"E and latitude 4°18' 43"N (Fig 1). The Stretch of the river is 17 km. and an average width of 0.6 km (Akani *et al*., 2010). Anthropogenic activities such as sand mining, waste disposal, open defecation, pollution emanating from boat engine and so on are rampant there. The vegetation is predominantly mangrove, *Rhizophora racemosa*, *Rhizophora mangle*, sparsely *Avicenia africana* and normal forest vegetation at the coastline.

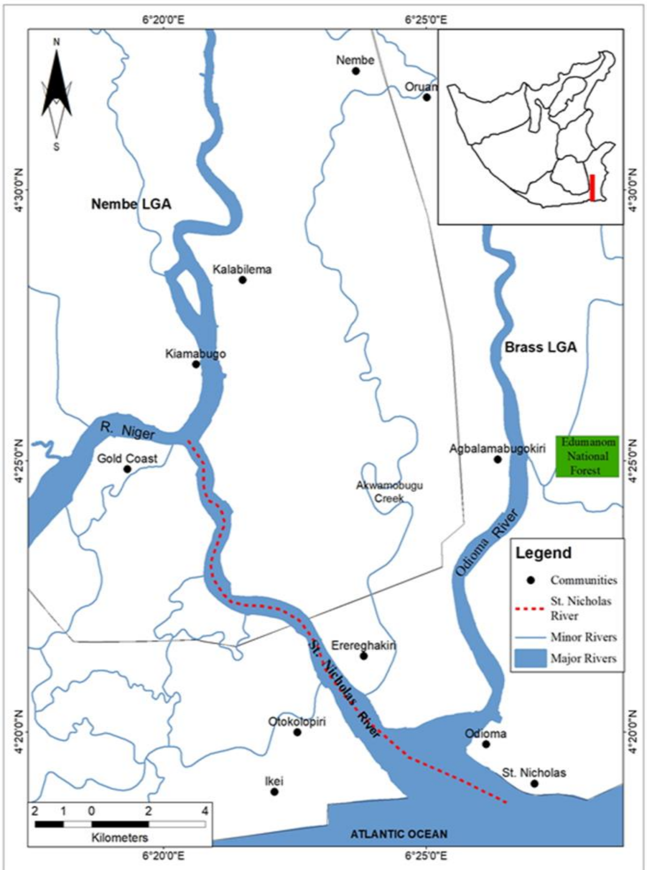

Figure 2.1. Map showing study area (St. Nicholas River, red dash line).

2.2 Sampling Technique and Identification

Two hundred and sixteen (216) *P. grandisquamis* were used for the study. The samples were collected monthly for twelve (12) months (November 2020 to October 2021). *P. grandisquamis* were either caught with cast net or procured as landed fish from artisanal fishers and middlemen at St. Nicholas landing site. Fish species were taken on ice in a cooler to the laboratory and preserved in 4% formaldehyde solution (Akunna and Amachree, 2019). Identification was performed using descriptions (Albaret, 1992) and online databases including FishBase and Eschmeyer's Catalogue of fishes.

2.3. Analysis of Stomach Content

Analysis of Stomach contents were performed according to Akuna and Amachree, (2019). Briefly, *P. grandisquamis* (*n*=216) stomachs were carefully removed and placed individually in already labelled containers. Thereafter, a longitudinal cut was made across each stomach and content was emptied into a petri dish, examined under a light microscope (Olympus CK30-F200, Japan) and identified. Stomachs were analyzed not later than 2 weeks from the date of collection. To avoid skewness in the data, stomachs were excised with the same technique throughout the sampling period. Stomach contents were identified to species level were possible and analyzed using the frequency of occurrence and number methods (Hyslop, 1980; Ugwumba and Ugwumba, 2007; Akuna and Amachree, 2019) while, the importance of the food items was determined with index of food significance (Allison and Sikoki, 2013) using the following equations:

2.3.1. Number method

The number of the individual food items in the stomach sorted out and counted. A total of all food items was recorded and expressed as % number of individual food items in the stomach with the following equation:

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

2.3.2. Frequency of Occurrence method

The Stomach contents were examined and the individual food items sorted out and identified. Thereafter, the number of stomachs containing the food items with the following equation:

$$\% \text{ occurrence of food item} = \frac{\text{Total number of stomachs with a particular food}}{\text{Total number of stomachs with food}} \times 100$$

2.3.3. Index of Food Significance

The value of the number and frequency of occurrence methods were employed to calculate the Index of Food Significance (IFS) with the following equation modified after Allison and Sikoki, (2013):

$$\% \, IFS = \frac{\% \text{ Frequency of occurrence x \% number of method}}{\Sigma \text{ (\% Frequency of occurrence x number method)}} \times 100$$

Where Food with IFS > 3% are regarded as primary, > 0.1 to < 3 % as secondary, whereas < 0.1% are considered as incidental.

3. RESULTS

3.1. Stomach content analysis of *P. grandisquamis*

The result of the stomach content analysis of *P. grandisquamis* is shown on Table 1. The results showed that all the stomachs of *P. grandisquamis* used for the experiment were with food. *P. grandisquamis,* as indicated by the stomach content, fed in descending order mainly on plant parts > diatoms algae > crustaceans > fish parts > annelids, others items included sand grains and detritus.

3.1.1. Number method

The result of the stomach content (Table 1) as calculated using the number method showed plant parts (55.91%) as the highest food item found followed by diatoms (20.57%) especially *Fragillaris sp* (*n*=439), algae (16.92%), crustaceans (3.45%), fish parts (2.02) and the least was annelids (1.13%). Sand grains and detritus were not calculated using this method.

3.1.2. Frequency of occurrence

Unlike the number method, the frequency of occurrence method recorded detritus (27.00%) as the most frequently occurred followed by sand (25.00%), plant parts (19.63%), crustaceans (9.88%), diatom (7.63%), algae (7.13%), fish parts (2.13) and annelids (1.63%).

3.1.3. Index of food significance (IFS)

The primary food items (i.e., IFS ≥ 3%) of *P. grandisquamis* as shown in Fig.1, are plant parts (77.55%), followed by diatoms (11.095) and algae (8.52%). Crustaceans (2.41%), fish parts (0.30%) and annelids (0.13%) are secondary food items (i.e., IFS ≥ 0.1 to < 3 %). Others such as sand grains and detritus are regarded to as incidental food items (i.e., IFS ≤ 0.1%).

Table 1: Composition and analysis of the stomach contents of *Parachelon grandisquamis* in St. Nicholas River, Bayelsa State, Nigeria

Food Item	No. of Food Item	No. of Stomach with a particular food item	% Number Method	% Frequency of Occurrence Meth
Algae	**1005**	**57**	**16.92**	**7.13**
Cladophora sp.	309	30		
Oscillatoria sp.	342	21		
Spirogyra sp.	354	6		
Diatoms	**1222**	**61**	**20.57**	**7.63**
Fragillaria sp.	439	12		
Melosira sp.	412	9		
Cyclotella sp.	371	21		
Micrasterias sp.	70	19		
Plant parts	**3321**	**157**	**55.91**	**19.63**
Fish parts	**120**	**17**	**2.02**	**2.13**
Sand		**200**	**0.00**	**25.00**
Detritus		**216**	**0.00**	**27.00**
Crustaceans	**205**	**79**	**3.45**	**9.88**
Shrimp parts	154	61		
Cyclops sp.	51	18		
Annelids	**67**	**13**	**1.13**	**1.63**
Total	**5940**	**800**	**100**	**100**

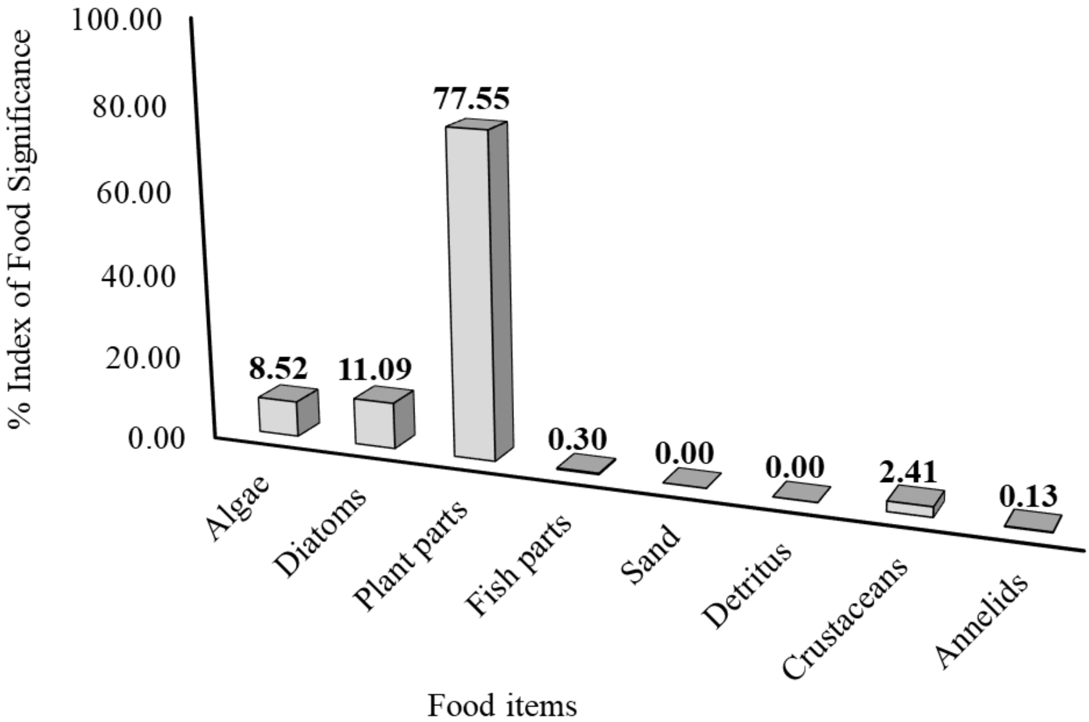

Figure 1. Index of food significance of the stomach content of *P. grandisquamis* from St. Nicholas River. Food with IFS ≥ 3% are regarded as primary; ≥ 0.1 to < 3 % as secondary; and ≤ 0.1% are considered as incidental.

3.1.4. Seasonal variation in the composition of stomach content of *P. grandisquamis*

The result of the seasonal variations of the stomach contents of the *P. grandisquamis* is presented in Table 2. The result indicated that *P. grandisquamis* consumed the same kind of food items in both seasons however, the total number of food items consumed was greater in the dry season (3483) compared to the wet season (2457) with plant parts > diatoms > algae > crustaceans > fish parts > annelids in both seasons (Table 2).

Table 2: Seasonal variation in the composition and analysis of stomach content of *P. grandisquamis* from St. Nicholas River, Bayelsa State Nigeria

	Dry season (Nov 2020 - March 2021)				Wet season (April 2021 –Oct 2021)			
	Numerical Method		Occurrence method		Numerical method		Occurrence method	
Food items	No. of food items	% number method	No. of stomach with a particular food	% Frequency of occurrence	No. of food items	% number method	No. of stomach with a particular food	% Frequency of occurrence
Algae	587	16.85	32	7.02	418	17.01	25	7.27
Diatoms	721	20.70	32	7.02	501	20.38	29	8.43
Plant parts	1953	56.07	87	19.08	1368	55.68	70	20.35
Fish parts	73	2.10	11	2.41	47	1.91	6	1.74
Sand grains	-	-	120	26.32	-	-	80	23.26
Detritus	-	-	128	28.07	-	-	88	25.58
Crustaceans	115	3.30	40	8.77	90	3.66	39	11.34
Annelids	34	0.98	6	1.32	33	1.34	7	2.03
Total	**3,483**	**100**	**456**	**100**	**2,457**	**100**	**344**	**100**

Discussion

4.1. Stomach contents analysis of *P. grandisquamis*

The diet of *Parachelon grandisquamis* provides crucial insights into its ecological role and trophic interactions within the marine ecosystems. Previous studies reveal that this species primarily consumes detritus, algae, and organic matter (Whitfield *et al*., 2012; Jamabo and Maduako, 2015), consistent with its classification as a benthic grazer (Harrison, 2008). Such dietary habits align with observations from other Mugilidae species, which demonstrate a strong dependency on primary productivity and organic-rich sediments in coastal and estuarine environments. The dietary habits of *P. grandisquamis* observed in this study highlight the species' omnivorous and opportunistic feeding behaviour, dominated by a preference for plant-based materials. The stomach content analysis revealed that plant parts were the most significant dietary component, representing the highest proportion across all methods of analysis.

4.1.1. Number method

The numerical method demonstrated that plant parts accounted for 55.91%, followed by diatoms (20.57%), algae (16.92%), and lower contributions from crustaceans, fish parts, and annelids. The significant presence of *Fragilaria* species among diatoms underscores the importance of primary producers in the diet of *P. grandisquamis*. The results of the present study slightly differ from other works with Mugilidae within West Africa (Payne, 1976; Albaret and Legendre; 1985; King, 1988). Their works reported that mullets primarily feed on diatoms, organic detritus, and sand grains. While the nutritional contents of detritus may be little, it is widely acknowledged as a significant source of vitamin B12 for mullets (Vallet *et al.*, 1970 as cited in Eggold and Motta (1992). Additionally, detritus is abundant in bacteria and protozoa, which may provide some nutritional benefits for the fish (Mohamed and Abood, 2019).

4.1.2. Frequency of occurrence method

The frequency of occurrence method revealed a notable shift in dietary interpretation. Detritus (27.00%) and sand grains (25.00%) were the most frequently encountered items, possibly reflecting incidental ingestion during foraging activities in sediment-rich habitats.

However, plant parts remained a crucial dietary component with a 19.63% frequency of occurrence, supporting their ecological importance in sustaining the species. The result is in line with Gisbert *et al.* (2024), who suggested that grey mullets consume sand particles within a certain range. Also, according to Rangely *et al.* (2023), the ingestion of sand particles is purportedly beneficial for the process of food particle grinding within the thick-walled pyloric stomach, which functions as a gizzard. In addition to the process of grinding, sand particles, together with the microorganisms they harbour, function as a nutritional resource (Górski *et al.*, 2015; Mohamed and Abood, 2019).

4.1.3. Index of Food Significance

The Index of Food Significance (IFS) further emphasied the role of plant material, with plant parts (77.55%) emerging as the primary food source. Diatoms (11.09%) and algae (8.52%) were also significant, indicating reliance on autotrophic resources. Secondary food items, such as crustaceans (2.41%) and fish parts (0.30%), reflect occasional predatory (carnivorous) behavior, while incidental materials like detritus and sand showed negligible contributions (IFS $\leq$ 0.1%). These findings suggest that *P. grandisquamis* primarily exploits the benthic and epiphytic flora within its habitat, supplemented by opportunistic consumption of animal matter. The preference for plant material is in line with previous studies on mullet feeding ecology, which reported herbivory or detritivores as predominant traits (Thomson, 1990).

The presence of incidental materials like sand further supports the hypothesis that benthic feeding strategies expose *P. grandisquamis* to sediment ingestion during routine foraging. Also, it highlights the species' adaptability to dynamic coastal lagoons and estuaries benthic environments and its role in nutrient cycling within its habitat. Its feeding behaviour enhances sediment turnover and supports ecosystem productivity, highlighting its importance in maintaining estuarine health and reinforces the importance of maintaining the integrity of its habitats to sustain its dietary needs and ecological roles.

4.1.4. Seasonal variation in the composition of the stomach content of *P. grandisquamis*

The seasonal results highlighted the feeding habits of *P. grandisquamis*, revealing variations in the quantity of food consumed while maintaining a consistent dietary composition. The species exhibited an opportunistic or generalist feeding behaviour, consuming a variety of food items, with plant parts being the dominant category. During the dry season, the total number of food items consumed was 29.46% higher than in the wet season. This variation suggested seasonal changes in food availability, accessibility, and environmental factors such as water quality and turbidity, which can influence the activity levels and feeding intensity of the fish (Omondi *et al*., 2013). Furthermore, the predominance of plant parts and diatoms in the diet indicates that *P. grandisquamis* relies significantly on plants (e.g., primary producers) and detrital materials, reflecting its adaptability to a predominanntly herbivorous or omnivorous diet, which is in line with previous studies indicating plants and detrital materials as predominant food (Thomson, 1990). These feeding patterns are evital for understanding the ecological role of the species in nutrient cycling and energy transfer within aquatic ecosystems.

CONCLUSION

In conclusion, *P. grandisquamis* from St. Nicholas River is an omnivorous and opportunistic feeder with preference for plant-based materials and is in agreement with previous studies on mullet feeding ecology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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