

ANALYSIS OF THE FEEDING HABITS OF LARGE-SCALED MULLET, *PARACHELON GRANDISQUAMIS*, IN 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 $\geq 3\%$) 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 $\leq 0.1\%$). 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). Mulletts 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 *Avicennia africana* and normal forest vegetation at the coastline.

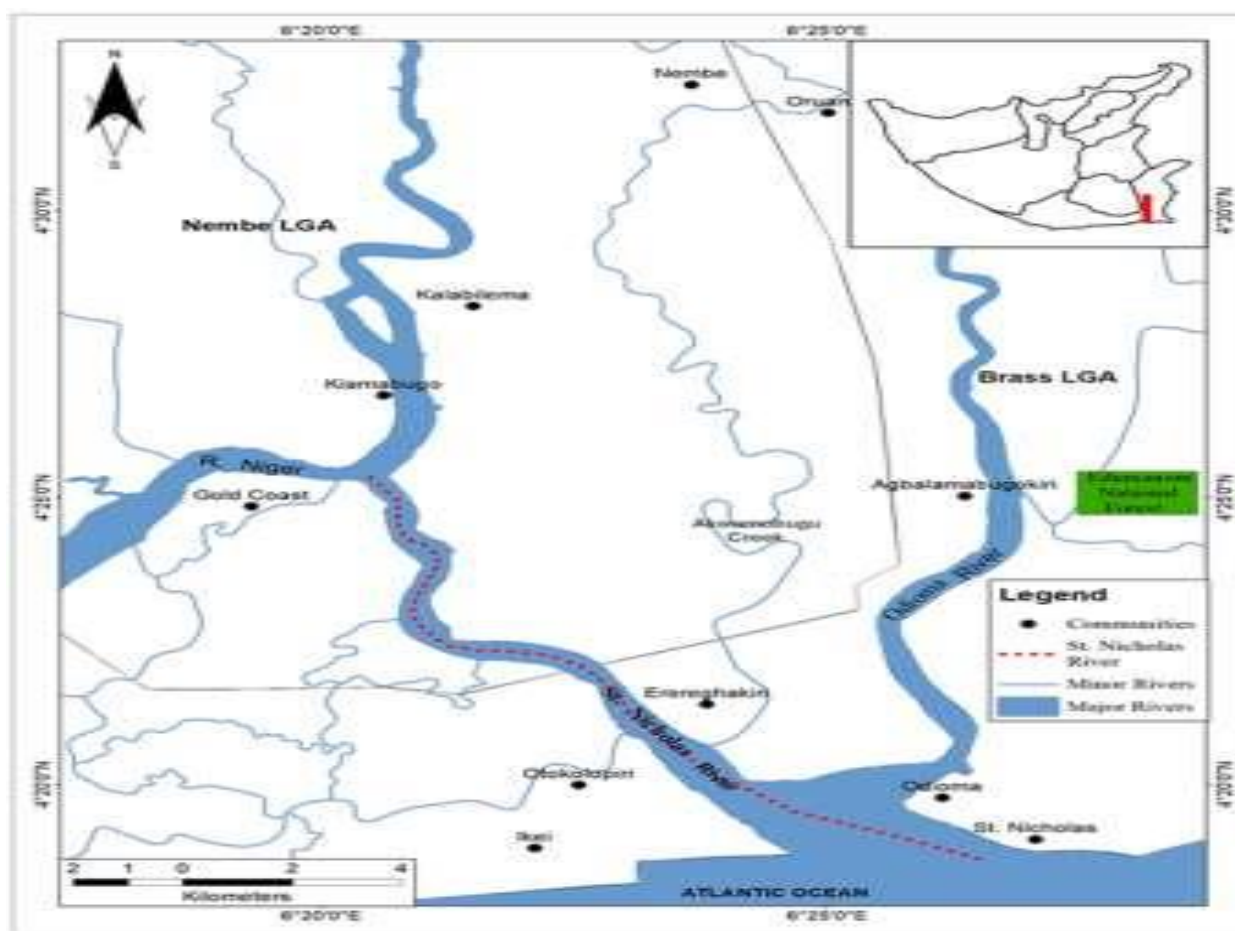


Figure 2.1. Map showing study area (St. Nicholas River, red dash line).

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% formalin 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 where 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):

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

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 *Parachelon 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., $IFS \geq 3\%$) 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., $IFS \geq 0.1$ to $< 3\%$). Others such as sand grains and detritus are regarded to as incidental food items (i.e., $IFS \leq 0.1\%$).

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 Metho
Algae	1005	57	16.92	7.13
<i>Cladophora sp.</i>	309	30		
<i>Oscillatoria sp.</i>	342	21		
<i>Spirogyra sp.</i>	354	6		
Diatoms	1222	61	20.57	7.63
<i>Fragillaria sp.</i>	439	12		
<i>Melosira sp.</i>	412	9		
<i>Cyclotella sp.</i>	371	21		
<i>Micrasterias sp.</i>	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		
<i>Cyclops sp.</i>	51	18		
Annelids	67	13	1.13	1.63
Total	5940	800	100	100

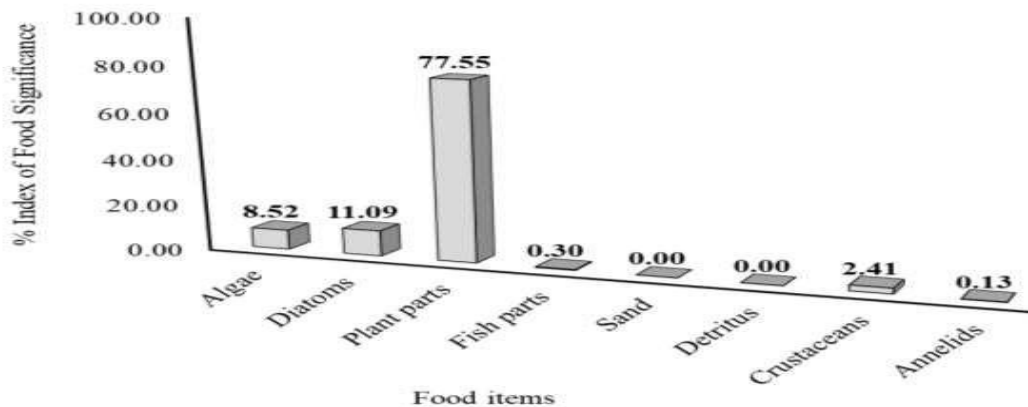


Figure 1. Index of food significance of the stomach content of *P. grandisquamis* from St. Nicholas River. Food with IFS $\geq 3\%$ are regarded as primary; ≥ 0.1 to $< 3\%$ as secondary; and $\leq 0.1\%$ are considered as incidental.

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 *Parachelon grandisquamis* from St. Nicholas River, Bayelsa State Nigeria

Dry season (Nov 2020 - March 2021)					Wet season (April 2021 –Oct 2021)			
Food items	Numerical Method		Occurrence method		Numerical method		Occurrence method	
	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 *Parachelon 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 emphasized 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 predominantly 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 vital for understanding the ecological role of the species in nutrient cycling and energy transfer within aquatic ecosystems.

CONCLUSION

In conclusion, *Parachelon 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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References

- Abdel-Aziz, N. and Gharib, S. (2007). Food and feeding habits of round sardinella (*Sardinella aurita*) in El Mex Bay Alexandria, Egypt. *Egyptian Journal of Aquatic Research*, 33: 202-221.
- Agboola, J. I. and Denloye, A. B. (2011). Preliminary Assessment of Anthropogenic impact on some ecological components of Abesan River, Lagos, Nigeria. *Journal of Water Resource and Protection*, 3: 98-104.
- Akani, G. C., Luiselli, L., Ogbeibu, A. E., Onwuteaka, J. N., Chuku, E., Osakwe, J. A., Bombi, P., Amuzie, C. C., Uwagbae, M. and Gijo, H. A. (2010). Aspects of species richness and seasonality of amphibians and reptiles in the coastal barrier Island of Brass (Nigeria). *Revue d'Écologie (La Terre et La Vie)*. 65: 151-161.
- Akuna, V. O and Amachree, D. (2019). Food of African butterfish, *Schilbe intermedius* (Rüppel, 1832) from Agbura landing site, Bayelsa State, Nigeria. *Global Scientific Journal*, 7 (3): 24-30.
- Albaret J-J. and Legendre, M. (1985). Biologie et écologie des Mugilidae en lagune Ébrié (Côte d'Ivoire) Intérêt potentiel pour l'aquaculture lagunaire. *Revue d'Hydrobiologie Tropical*, 18 (4): 281-304.
- Albaret, J-J. (1992). Mugilidae. In: Lévêque, C., Paugy, D. and Teugels, G. G. (Eds). The fresh and brackish water fishes of West Africa, Vol. 2. Paris: ORSTOM - MRAC. 432-449.
- Albaret, J-J. (2003). Mugilidae. In: Lévêque, C., Paugy D. and Teugels, G.G. (eds.) Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, Tome 2. Coll. Faune et Flore tropicales 40. Musée Royal de l'Afrique Centrale, Tervuren, Belgique, Museum National d'Histoire Naturelle, Paris, France and Institut

de Recherche pour le Développement, Paris, France. p. 601-611. Available online at: <https://www.fishbase.se/references/FBRefSummary.php?id=57400&speccode=1086> [Last accessed 25th November 2024].

- Allison, M. E. and Sikoki, F. D (2013). Food and Feeding Habits of *Parailia pellucida* (Boulenger, 1901) (Schilbeidae) in the Freshwater Reaches of the Nun River of the Niger Delta, Nigeria. *International Journal of Advanced Fisheries and Aquatic Science*, 1(1): 1-14.
- Ara, S. I., Azadi, M. A., Nasiruddin, M., Hossain, A. and Mustafa, M.G. (2019). Population dynamics of the mullet fish *Rhinomugil corsula* (Hamilton, 1822), in the Sitakunda Coast of the Bay of Bengal. *Bangladesh Journal of Zoology*, 47(2): 305-314.
- Arrington, D.A., Winemiller, K. O., Loftus, W. F. and Akin, S. (2002). How often do fishes “run on empty”? *Ecology*, 83: 2145-2151.
- Blaber, S., and Blaber, T. (1980). Factors affecting the distribution of juvenile estuarine and inshore fish. *Journal of Fish Biology*, 17: 143-162.
- Blaber, S. J. M. (2000). Tropical Estuarine Fishes: Ecology, Exploitation, and Conservation. Fish and Fisheries Series. Blackwell Science, Oxford. <https://doi.org/10.1002/9780470694985>.
- Braga, R. R., Bornatowski, H and Vitule, J. R. S. (2012). Feeding ecology of fishes: An overview of worldwide publications. *Reviews in Fish Biology and Fisheries*, 22 (4): 915-929.
- Blay, J. (1995). Food and feeding habits of four species of juvenile mullets (Mugilidae) in a tidal lagoon in Ghana. *Journal of fish Biology*, 46: 134-141.
- Cardona L. (2016). Food and feeding of Mugilidae. In: Crosetti, D and Blaber, S. J. M. (Eds.), *Biology, Ecology and Culture of Grey Mulletts (Mugilidae)*, CRC Press, Boca Raton, FL, 165-195 pp.
- Chea, R., Lek, S., Ngor, P. and Grenouillet, G. (2017). Large-scale patterns of fish diversity and assemblage structure in the longest tropical river in Asia. *Ecology of Freshwater Fish*, 26 (4): 575-585.

- De Silva, S. S. and Wijayarathne (1977). Studies on the biology of young mullet, *Mugil cephalus*, L. II. Food and feeding. *Aquaculture* 12: 157-167.
- Eggold B. T. and Motta P. J. (1992). Ontogenetic dietary shifts and morphological correlates in Striped Mullet, *Mugil cephalus*. *Environmental Biology of Fishes*. 34 (2): 139–158.
- FAO (2016). The State of World Fisheries and Aquaculture. Contributing to food security and nutrition for all, Rome, 200pp.
- Gisbert, E., Molas, S., Hernández, E., Carbó and Ruiz, A. (2024). Production of Flathead Grey Mullet (*Mugil cephalus*) and Lettuce (*Lactuca sativa*) in a Coupled Aquaponic System under Suboptimal Water Temperatures. *Fishes*, 9 (6): 189. doi.org/10.3390/fishes9060189.
- Górski, K., De Gruijter, C. and Tana, R. (2015). Variation in habitat use along the freshwater-marine continuum by grey mullet *Mugil cephalus* at the southern limits of its distribution. *Journal of Fish Biology*. 87(4):1059-1071.
- Harrison, I. J., (2008). Mugilidae. In: Stiassny, M. L. J., Teugels G. G. and Hopkins, C.D. (eds.). The fresh and brackish water fishes of Lower Guinea, West-Central Africa. Volume II. Collection Faune et Flore tropicales 42. Institut de Recherche pour le Développement, Paris, France, Muséum National d'Histoire Naturelle, Paris, France, and Musée Royal de l'Afrique Centrale, Tervuren, Belgium. 450-471pp. Ref No [81659] Key No. [1693]. Available online at <https://www.fishbase.se/references/FBRefSummary.php?ID=81659&speccode=9918>. [Last accessed 25/11/2024].
- Hyslop, E. J (1980). Stomach contents analysis-a review of methods and their application. *Journal of Fish Biology*, 17: 411-429.
- IUCN (2023). "The IUCN Red List of Threatened Species. Available online at. <https://www.iucnredlist.org/> [last accessed 25th November 2024).
- Jamabo, N. A and Maduako, N. C. (2015). Food and feeding habits of *Mugil cephalus* (Linnaeus 1758) in Elechi creek, Niger delta, Nigeria. *International Journal of Fisheries and Aquaculture*. 7 (3): 25-29.

- King R. P. (1988). New observations on the trophic ecology of *Liza grandisquamis* (Valenciennes, 1836) (Pisces: Mugilidae) in the Bonny River, Niger Delta, Nigeria, *Cybum* 12 (1): 23-36.
- Lindstrøm, U., Haug, T and Nilssen, K. T. (1997). Diet studies based on contents from two separate stomach compartments of northeast Atlantic minke whales *Balaenoptera acutorostrata*. *Sarsia*, 82: 63-68.
- Mohamed, A-R, M. and Abood, A. N. (2019). Food and trophic relationships of four mullet fish (Mugilidae) in the Shatt Al-Arab River Iraq. *Asian Journal of Applied Sciences*. 7(1):19-26.
- Omondi, R., Yasindi, A.W. and Magana, A.M. (2013). Food and feeding habits of three main fish in Lake Baringo, Kenya. *Journal of Ecology and Natural Environment*. 5 (9): 224-230.
- Payne A. L. (1976). The relative abundance and feeding habits of the grey mullet species occurring in an estuary in Sierra Leone, West Africa. *Marine Biology*. 35: 277-286.
- Rangely, J., de Barros, M. S. F., Albuquerque-Tenório, M. D., Madeiros, M., Ladle, R. J. and Fabré, N. N. (2023). Assessing interspecific variation in life-history traits of three sympatric tropical mullets using age, growth and otolith allometry. *Journal of Fisheries Research*. 260. doi.org/10.1016/j.fishres.2022.106577.
- Schneider, W. 1990. Field guide to the commercial marine resources of the Gulf of Guinea. FAO species identification sheets for fishery purposes. Rome, FAO. 268 p.
- Thomson, J. M. (1966). The grey mullets. *Oceanography and Marine Biology - An Annual Review*. 4: 301-355.
- Thomson, J. M., 1990. Mugilidae. In: Quero, J.C., Hureau, J. C., Karrer, C., Post, A and Saldanha, L (eds.). Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2. (Ref. 7399), 855-859pp. Available online at <https://www.fishbase.se/summary/Parachelon-grandisquamis.html>. [Last accessed 25th November 2024].
- Ugwumba, A.A.A. and Ugwumba, O.A. (2007). Food and Feeding Ecology of Fishes in Nigeria. Crystal Publishers, Lagos. 97pp.
- Vallet, F., Berhaut, C., Leray, B., Bonnetand, and Pic, P. (1970). Preliminary experiments on the artificial feeding of Mugilidae. *Helgolander wiss Meeresunters*. 20: 610-619.

- Whitfield, A. K. and Elliot, M (2015). Fish as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future. *Journal of Fish Biology*. 61 (sA): 229-250.
- Whitfield, A. K., Able, K. W., Blaber, S. J. M., Elliott, M., Franco, A., Harrison, T. D., Houde, E. D. (2022). Feeding ecology and trophic dynamics. In: Whitfield, A. K., Able, K. W., Blaber S. J. M., and Elliot, M. (Eds) *Fish and Fisheries in Estuaries: A Global Perspective*, pp. 255-331. doi.org/10.1002/9781119705345.ch5.
- Wootton, R. J. (1990). *Ecology of Teleost Fishes*. Fish and fisheries series. Chapman and Hall, London.