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PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.

Dr. Oladeji S. O.

President Netlink Environmental Conservation Organization

Convener World Environmental Conservation Conference

TABLE OF CONTENT

FOOD AND FEEDING HABIT OF FLATHEAD GREY MULLET *MUGILCEPHALUS* (LINNAEUS, 1758) IN ILAJE COASTAL WATERS OF ONDO STATE, NIGERIA

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ABSTRACT

Unlike cultured fish species with fixed feeding regimen, gut content investigation is aimed at obtaining data on food, feeding habits, and condition factor of fish caught from the wild.The present study aimed to provide information on the type of food needed by Mugilcephalusin Ilaje coastal waters of Ondo state. Two hundred and forty samples of Mugil cephalus were procured monthly from fisher folks at the landing sites of the study areas from November 2021 to April, 2022. The natural food of M. cephalus was studied from the stomach contents of the fish. The stomach fullness was graded as empty, one-quarter full, half full, three-quarter full and full. The stomach contents were analyzed using two methods; frequency of occurrence method and numerical methods.Percentage of empty stomach ranged from 15% to 31.67%, while full stomach wasn't encountered throughout the study period. The stomach contents contained two groups of food items: algae (blue-green, diatoms and dinoflagellates) and detritus. The results showed that M. cephalusfeeds on topmost layer of sediment which is rich in detritus and micro algae. These results indicate that M. cephalusare benthic feeders.

Keywords: *Ecology, Coastal waters, M. cephalus, Nigeria.*

INTRODUCTION

To comprehend the functional significance of the fish within their habitat, it is crucial to fully understand the life cycle of species (Abdel-Aziz and Gharib, 2007). For the better management of fish stock, knowledge of food is essential as it forms the most important factor regulating or influencing the abundance, growth and migration of fishes. It is also fundamental to determining the population level of the aquatic biota, thereby providing information on the seasonal and life history changes of fish, since the types and magnitude of food available in consonance with the season it occurs plays a pivotal role in the history of fish (Akinwumi, 2003; Olawusi-Peters *et al*., 2015). According to Abdel-Aziz and Gharib (2007), studies on fish natural food consumption could offer details on the trophic interactions in aquatic ecosystems, which could be used to develop management strategy alternatives in a multi-species fishery.

In community ecology, it is crucial to investigate diet composition and stomach content as the utilization of resources by organisms has a substantial impact on population interaction. (Adewumi*et al*., 2014). Additionally, these studies can provide valuable insights into the positioning of fish within their food web and aid in the development of management strategies for multispecies fisheries (Adeyemi*et al*., 2009).

Mugilcephalus are commonly known as Flathead grey mullet. The familyMugilidae, which the species belongs, originates from order Perciformes (Perch-like fish). The family consists of 18 genera and 81 species (FAO, 2014). Nigeria's fisheriesresources are supported by the highly important commercial food fish known as mullets. Asuquo*et al*. (2015) noted that they contain high quality meat and their taste is very palatable. The mullets make up a sizeable portion of the catch made by local fishermen in estuaries and lagoons (Isangedighi *et al.*, 2009). They eat mostly benthic organisms, such as diatoms, aquatic macrophytes, benthic rotifers, larvae, fish eggs, cyclops, copepods, organic detritus, and minute algal cells, and they are able to survive. They swim at an angle to the bottom, raking their mouths through the sediments as they scoop up the food.

Previous studies have been carried out on food and feeding ecology of several fish species (Fagade and Olaniyan, 1972; Akinwumi 2003; Oso*et al*., 2006; Abowei 2009; George *et al*., 2013; Olawusi-Peters *et al*., 2015; Abdul *et al*., 2016; Abidemi-Iromini, 2019; among others). But there is little or no information on the food and feeding habit of *M. cephalus* in the areas selected for this study. Hence, this study will provide more information on the specie, to complement existing data in the management and culture of the species.

MATERIALS AND METHODS

Study Area

The study areas (Obi, Idi-Egbin, Okesiri and Araromi) are located in Ilaje Local Government Area (Fig. 1), the coastal region of Ondo State which lies within latitude 6°10′ to 6°50′N and longitude 2°45′ to 6°09′E (Jiboye *et al*., 2019). Ilaje is bounded in the west, east, north, and south by Ogun State, Ese-Odo LGA and Edo state, Irele LGA, Bight of Benin and the Atlantic Ocean, respectively. Nigeria's coastline stretches from Lagos to the Cross River (about 963 km), with over 20 million people living along the coastal area (Jiboye *et al*., 2019). The

southwestern coastal area of Nigeria extends from Nigeria/Benin Republic border and terminates at the Ondo-Edo border with Ilaje having the longest coastline in West Africa.

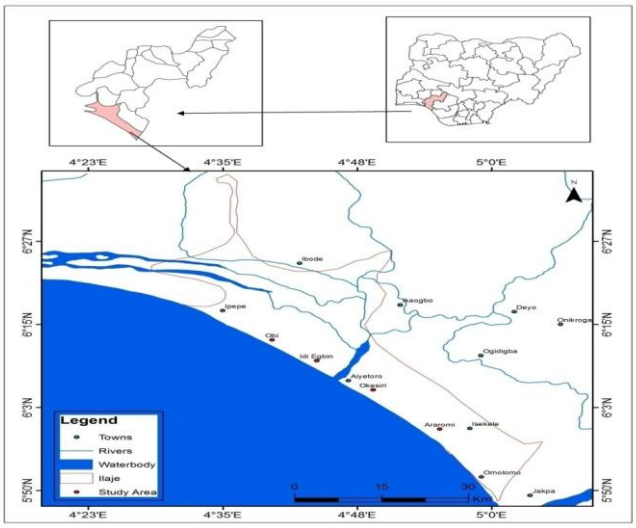

Figure 1: Map of Ilaje LGA showing the study areas

Collection and Identification of Samples

Two hundred and forty samplesof *Mugilcephalus*were procured monthly from fisher folks at the landing sites of the study areas from November 2021 to April, 2022. The fishes were identified using the keys provided by Olaosebikan and Raji (2013).The fish samples were stored in ice chest cooler and transported to the Limnology laboratory, Department of Fisheries and Aquaculture Technology, Federal University of Technology, Akure.

Analysis of Stomach Contents

The individual fish gut was carefully extracted by opening the abdominal segment of the fish. The gut (tip of the oesophagus to the end of the rectum (George *et al.*, 2013) were removed using forceps.Fish stomachs were dissected and the fullness were graded as {full (4/4), three quarter full (3/4), half full (2/4), one-quarter full (1/4), and empty (0/4)} according to Adewumi*et al.* (2014).

The stomach contents were mixed with 2.0 ml distilled water in a petri-dish for proper separationand easy identification of food items and were viewed under Olympus Research Microscope Model No: XSZ-107BN at a magnification of x40. The observed organisms were identified using plankton catalogue by Smith(1997). The various items in the fish stomach were analyzed using frequency of occurrence and numerical methods as described by Hyslop (1980).

Frequency of occurrence Method: In this method, the number of times a particular food item occurred in the stomach is counted and expressed as a percentage of the total number of stomachs with food (empty stomachs excluded). This is expressed as:

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

Numerical Method: In this method, the number of each food item in each stomach is counted and expressed as a percentage of the total number of all food items (grand total of all items).This is expressed as:

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

RESULTS

The analysis of the stomach fullness condition of *Mugilcephalus*isis presented in Table 1. Percentage of empty stomach ranged from 15% in Araromi to 31.67% in Okesiri. The remaining percentages of the fish sampled had one-quarter, half and three-quarter fullness of stomach. Samples with full stomach weren't encountered during this study.

The food items identified in the gut of *M. cephalus*with their respective percentage frequencies of occurrence and percentage numerical evaluation across the sampling stations over the collection period are shown in Table 2. The stomach contents contained two groups of food items: algae (blue-green, diatoms and dinoflagellates) and detritus. The abundant food items consumed in Obi were the diatoms, *Nitzschia sp*. (number: 37.33%; occurrence: 58.33%) and *Navicula sp*. (number: 33.33%; occurrence: 10.42%). The most frequently consumed food itemwere detritus accounting for 58.33% occurrence. Blue-green algae, *Nostoc sp*. (number: 22.67%; occurrence: 56%); diatoms, *Nitzschia sp*. (number: 22%; occurrence: 44%) were the most abundant food items in the stomach of the samples from Idiegbin. The most abundant

food item consumed in Okesiri was the diatoms. In Araromi, detritus was the most common food item ingested by *M. cephalus*, which accounted for 100% of occurrence.

Table 1: Degree of Stomach Fullness in *Mugilcephalus*from Obi, Idiegbin, Okesiri and Araromi.

Degree of Fullness (%)	OBI		IDIEGBIN		OKESIRI		ARAROMI	
	N	%	N	%	N	%	N	%
Empty (0)	12	20	10	16.67	9	15	19	31.67
One-quarter	20	33.33	38	63.33	32	53.33	25	41.67
Half	18	30	12	20	11	18.33	16	26.67
Three-quarter	10	16.67	0	0	8	13.33	0	0
Full (100)	0	0	0	0	0	0	0	0

Table 2: Diets composition observed in the gut of *Mugilcephalus*from Obi, Idiegbin, Okesiri and Araromi

Water	OBI		IDIEGBIN		OKESIRI		ARAROMI	
	O%	N%	O%	N%	O%	N%	O%	N%
Baccilariophyta (Diatoms)								
Naviculasp	10.42	33.33	18.0	14	-	-	15.67	15.53
Nitzschiasp	52.08	37.33	44.0	22	46.34	31.52	60.78	21.52
Melosirasp	-	-	40.0	19.33	-	-	33.33	13.04
Pyrrophyta (Dinoflagellate)								
Ceratiumsp	-	-	36.0	12.67	36.59	15.22	41.18	14.91
Cyanophyta (Blue-green algae)								
Nostocsp	43.75	32	56.0	22.67	56.10	40.22	62.75	24.22
Oscillatoriasp	4.17	10.67	16.0	9.33	17.07	13.04	17.65	11.18
Detritus	58.33	-	44.0	-	95.12	-	100.0	-

%O = % occurrence; % N= % numerical

DISCUSSION

The percentage of empty stomachs was as high as 31.67% (Okesiri) in the present study. This finding is in agreement with the work of Soyinka (2008) whorecorded 40.9% empty stomach and emphasized that the grey mullet typical food retention duration was 4-5 hours.Osibona and Eniola (2011) analysis showed that 23.73% of all the species (*Clariasgariepinus*, *Tilapiazilli*, *Pentamusquinquarius* and *Pseudolithustypus*) from Nigerian coastal waters had empty stomach. Majority of mullets probably digests their food while being caught in the nets. Additionally, some fishes may have regurgitated their food after being caught. Therefore, the level of fullness in mullet stomachs is unlikely to reflect feeding intensity (Soyinka, 2008).

In this present study, *M. cephalus* fed majorly on algae (blue-green, diatoms and dinoflagellates) and detritus.Diatoms were the most abundant algal food items in the diet of *M. cephalus* by number, while detritus was most abundant by occurrence which corroborate with the findings of Jamabo and Maduako, (2015) who reported plant materials, diatoms, algae and dinoflagellate constituted the main food of *Mugilcephalus* from Elechi Creek, Niger Delta, Nigeria. Fagade and Olaniyan (1973) studied food and feeding inter-relationship of the fishes in Lagos Lagoon; Soyinka and Okonkwo, (2012) studied food and biometric features of the grey mullet from Epe Lagoon and Lawson and Jimoh, (2010) studied aspects of the biology of grey mullet in Lagos lagoon.Diatoms and organic detritus (bottom deposits) were identified as the key food items in the stomach of mullets in these researches.Isangedighi*et al*., (2009) also observed mud particles, diatoms, green algae, blue green algae, dinoflagellates, microarthropods and macroarthropods from the stomach content of *Mugilcephalus* in the Cross River Estuary, Niger Delta, Nigeria. Soyinka (2008) however, reported that salinity play important role in differentiating food items aquatic organisms feed on. Thus, *M. cephalus* from high brackish water, consumed other food items such as crustaceans, mollucs, annelids, plant materials, fish parts, sand grain and desmids which is an indication of the omnivorous feeding habit of the species. Odum (1970) suggested that grey mullet demonstrated a clear preference for living plant material (algae) over plant detritus when both are in abundance. Whereas, Wells (1984) hypothesized that grey mullet in Waikato River and Lake Waahi, showed little or no preference for algae over macrophyte detritus, and that their diets were consistent with the availability of both food types in the two habitats.

Adult grey mullet are herbivores and primarily eat diatoms and algae that are grazed from soft bottom mud, with the exception of areas with submergent vegetation where they frequently consume attached algae (McDonough and Wenner, 2003). Juveniles are omnivores and feed on zooplankton and phytoplankton. To emphasize further, earlier research revealed that juveniles and adults consume various types of food. According to Blaber and Whitfield (1977), juveniles initially feed on zooplankton species exclusively before transitioning to a mixture food feeder and finally a plant feeder.

In relation to water body, the body size and gut contents of the fish species collected from this study stations- Obi, Idiegbin, Okesiri and Araromi follow similar trend. Although, the size range of the fish species in this study were within juveniles and adults size as reported by Soyinka (2008), Soyinka and Okonkwo (2012).The food items consumed by *M. cephalus* from Coastal waters of Ondo Staterevealed the kind of environment in which they were collected. According to Nwankwo and Akinsoji (1989), the diatoms *Navicula sp., Melosira sp.*, and*Nitzschia sp* are typically found clinging to submerged plants or substrates. This suggests that *M. cephalus* has the potential to graze food in water (Soyinka, 2008).

The results of this study show that the reported foods correlatewith the biology of *M. cephalus*, which is a benthic feeder that consumes dead and decaying organic debris deposited at the habitat bottom layers as well as algae made up of Bacillariophyceae, Chlorophyceae, and Mediophyceae as well as other benthic organisms, and this aligns with the findings of De Silva and Wijeyaratyne (1977) and Soyinka, (2008). In comparison with other aquatic ecosystems, food items reported in this present study were similar to those found in the gut of *Mugilcephalus* in freshwater habitats such as Lake Waahi and Waikato River in New Zealand (Wells, 1984). Similar gut contents were also reported in *M. cephalus*found in Mexican waters (Sanchez Rueda, 2002) and from Lake Pulicat in India (Rengaswamy, 1973).

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