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Comparative Food and Feeding Adaptations of Two Teleosts in Ado-Ekiti Reservoir

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Abstract:
A comparative study of food and feeding adaptations of Clarias gariepinus (40.6-47.6cm) and Oreochromis niloticus (8.4–20.5cm) in Ado Ekiti reservoir was carried out using numerical, frequency of occurrence, volumetric assays and physical observation of the morphological features. The mouth gape and dentition, spacing and number of gill rakers as well as the length of O. niloticus and C. gariepinus wer significantly different from one another. The food items in the gut of O. niloticus include; detritus/mud, higher plant remains, Chlamydomonas, Closterium, Spirogyra, Volvox and insect parts. C. gariepinus were found to feed mainly on crustaceans, insects, molluscs, fish, detritus, algae and vegetable matters. The results reveal high level of similarities in the diet of O. niloticus and C. gariepinus. However, O. niloticus had more of higher plant (76.96% by numerical method) than C.gariepinus, indicating high herbivorous feeding in tilapia while C.gariepinus had higher occurrence of insect and fish parts (36.76%), thus highlighting omnivorous habit. The mouth gape, dentition, spacing and number of gill rakers and gut length of O. niloticus and C. gariepinus were significantly different (p<0.05) from one another. C. gariepinus and O. niloticus in Ado Ekiti reservoir are essentially omnivores and herbivores respectively, with some overlapping food preference. However, the different major food items fed upon by the species and the corresponding adaptations to feeding makes co-existence of the two species, amongst others, possible, and would ultimately reduce intense competition.

***Key words**: herbivore, omnivore, gape, dentition, detritus, zooplankton*

1. Background

Clarias gariepinus (Burchell 1822) and tilapia, *Oreochromis niloticus* (1758) are part of the ichtyofauna inhabiting Ado-Ekiti reservoir. These fish are of great importance in African fisheries and fish culture, mainly due to their excellent adaptation to climatic factors, ability to mature/produce throughout the year; in captivity and acceptance of relatively cheap feeds. The biological study of these two species is thus a continuous one, because of their high potential for culture.

Food is any structure or material that can be ingested, digested, assimilated, and utilized for energy production. Information on food and feeding habits of fish can provide baseline data, useful in artificial feed formulation for the species during culture and for proper management of the fish. The study of the food and feeding habits of freshwater fish species is a subject of continuous research, because it constitutes the basis for the development of a successful fisheries management program [1], [2].The study of the tropic ecology is useful and fundamental to the understanding of the functional role of the fish within their ecosystems [3]. The analysis of the diet composition is also important in community ecology, because the use of resources by organisms has a major influence on population dynamics [4].

The study of the food and feeding ecology of a fish species would not only investigate the dietary composition, their quantity and selectivity, but would also involve an examination of the functional, morphology and physiology of the alimentary system, as well as the fauna and flora of the environment, particularly, those that are food organisms forfish, to reveal their interrelationship with each other and the fish species. When compared to human, the digestive system in fish is relatively simple and there are also variations that are species-dependent. The stomachs of fish are also generally adapted to the kind of food they eat. Predatory fish generally have sac shaped stomachs that allow them to pack away enormous amount of food. The herbivores have an elongated intestine and their systems are more complicated than the carnivores.

This project was designed subsequent to the scarcity of data on the food and feeding habits of these fish species, amongst others, in Ado-Ekiti reservoir. There is need to study the comparative physiological/morphological adaptations of these widely accepted/eaten fish species, to their particular environment. This knowledge would further enhance their management in polyculture systems. This research is to set out to investigate and compare the food and feeding habits/adaptations of the two species make some recommendations for management of the stock and the reservoir.

2. Materials and Methods

Ado-Ekiti reservoir is situated at the water works in Ado-Ekiti, Nigeria. Geographically, Ado-Ekiti reservoir is at an altitude of 443 meters above the sea level and Ado-Ekiti lies within the tropical rainforest zone south-western Nigeria between altitude 7^0 35^1 N and longitude $5^0 12^1$ E. The reservoir was constructed by damming the Ureje river in 1958, for domestic water supply and rearing of fish. A stretch of grass covers the banks of the reservoir and among these are sparsely distributed trees. Notable herbs along the banks are *Talinum trangulare; Trides sp*, Guinea grass, elephant grass (*Pennisetum purpureum*), giant star grass (*Cynodomplecto stachyum*), rhodes grass (C*hloris guyanana*), siam weed (*Eupatorium odorantum*). Aquatic birds such as ducks, visit the reservoir. Several species of snails are present such as *Indoplnoris excustus*, *Biomphalaria* spp. Fish fauna found in the reservoir includes *Tilapia zillii, C. gariepinus, O. niloticus, Chysichthys nigrodigitatus, Hepsetus odoe, B*arbus sp.

One hundred and twenty (120) specimens used, per fish species, were collected from fishermen, twice in a month, between June and November, 2012. The fishermen used set nets, cast nets and traps for capturing the fishes. Samples collected were brought to the laboratory immediately after capture, killed and preserved in 40% formalin. At a later date, the fishes were sorted out and identified sexually. After identification, they were measured (cm) and weighed (gm).The fishes were then cut open for the gut length measurement, determination of fullness of stomach and analysis of stomach content. The fullness of the stomachs was determined thus:

- 0/4-Empty stomach
- 1/4-One quarter full stomach
- 2/4-Half full stomach
- 3/4-Three quarter full stomach
- 4/4-Full stomach

The content of the stomach of each fishsampled,was emptied into a petri dish and a few drops of water added to allow proper separation of the items so that they can be identified clearly. Frequency of occurrence and the numerical methods were used for the analysis.

3. Results and Discussion

Table 1 gives the morphometric parameters and the abundance, while Table 2 summarizes the diets of *O. niloticus* and *O. gariepinus* from Ado Ekiti Reservoir. Out of a total of 120 specimens of *O. niloticus* examined, 40% had empty stomachs (Fig. 1).

Species	Total examined	TL (cm)	SL (cm)	Wt (g)
O. niloticus	60	8.4– 20.5	6.3 – 15.2	9.4-132.0
C. gariepinus	60	40.6-47.6	35.0 -43.0	30.0-164

Table 1: The morphometric parameters of the species examined
TL - Total length; SL - Standard length; Wt- weight

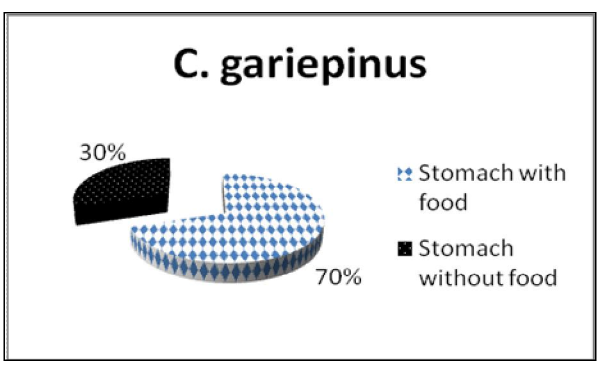

Figure 1a: The stomach fullness of C. gariepinus.

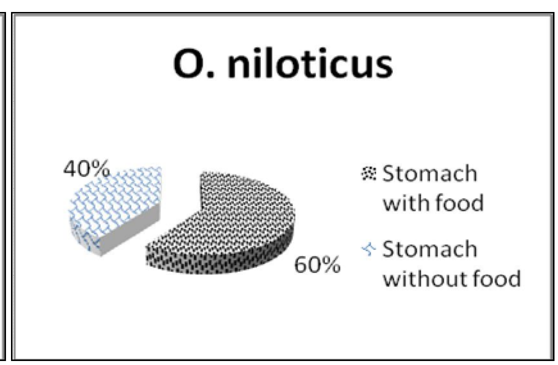

Figure 1b: The stomach fullness of O. niloticus.

A summary of the food items, as analyzed by the numerical method is shown in Table 2, while the items by the frequency of occurrence are shown in Fig. 2. Higher plant remains were the most important food items found (76.96% by numerical method and 65.25% by frequency of occurrence method), in *O. niloticus*. Green algae accounted for 37.44% and 39.20%, *C<u>hlamydomonas</u>* sp.

(33.19% and 39.20%), Closterium sp. (21.56% and 20.44%). Filamentous algae (*Spirogyra*sp) were 17.31% and 11.83% of the total food items.

	O. niloticus		***C.***	***gariepinus***
Food items	**Number**	**%**	**Number**	**%**
Detritus/Mud	41	33.87	64	43.56
Higher plant remains	72	76.96	72	37.78
Green algae: *Chlamydomonassp*	35	37.44	46	24.04
Closteriumsp	31	33.19	44	23.04
Diatoms	20	21.56	36	19.01
Filamentous algae: *Spirogyra sp*	16	17.31	67	34.91
Unidentified	23	24.56	23	12.07
Colonial algae: *Volvox* sp	13	13.87	29	14.75
Sand grain	12	11.96	73	38.22
Insect parts	7	7.54	65	34.21
Fish parts	11	11.74	53	27.98

Table 2: Summary of the diets of O. niloticus and C. gariepinus from Ado Ekiti Reservoir

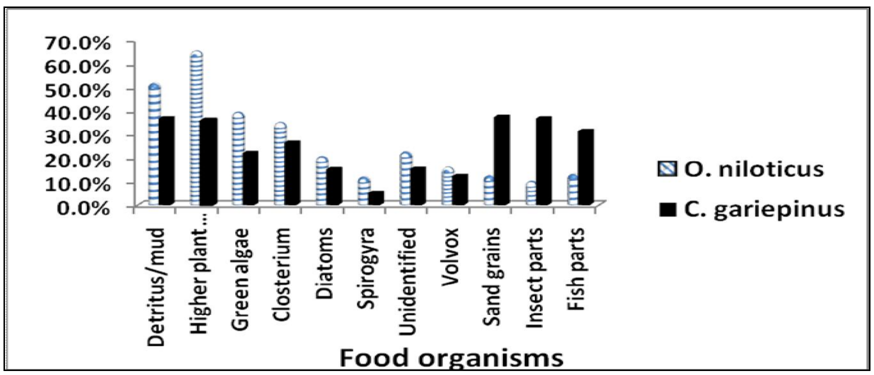

Figure 2: The food organisms of the fish species, by frequency of occurrence method

Other food items include detritus (43.87% and 51.73%), insect parts (7.54% and 9.93%), sand grains (11.96% and 12.47%), *Volvox* (13.87% and 15.83%), fish parts (11.74% and 13.13%) and unidentified spp. (24.56% and 22.50%), all by numerical and frequency of occurrence method respectively.

The specimens of *C. gariepinus* had total length of between 40.6cm – 47.6cm (standard lengths, 35.0cm to 43.0cm) and a corresponding body weight of between 30.9g to 164.0g. Of the specimens of *C. gariepinus* examined, 30.0% had empty stomach (Fig. 1). The summary of the stomach contents, as analyzed by numerical method is shown in Table 3, while the result by frequency of occurrence method is found in Fig. 2. Sand grains forms the important diet (38.22% and 37.42%), by numerical and frequency of occurrence methods respectively, while the *Volvox* sp was the least with 14.75% and 12.23%. Higher plant remains (37.78% and 35.75%) were lower than those of *O. niloticus* while fish parts (27.98) and insect parts(34.21%) were comparatively higher than those of *O. niloticus*. Detritus/mud (33.56% and 36.75%) was also high, by both numerical and frequency of occurrence methods. Unidentified species was 12.07% of the total diet found in it.

Variations were observed in the alimentary system, filtering apparatus and dental anatomy of the two species, which is related to their food preferences. The wideness of the mouth (gape) differs in the two species. It was found that mouth gape increased with increase in standard length for the two species and the mouth gape of *C. gariepinus* was significantly wider ($p<0.05$) than those of *O. niloticus*. *C. gariepinus* had small, numerous unicuspid teeth, lacking a particular arrangement (Plate 1) and with a pad-like or grinding mill appearance. The teeth at the anterior region of both the upper and lower jaws were found to be sharper to touch than posterior ones. The pharyngeal jaws can be seen to be numerous and conical (Plate 2).

Fish species	Range of gape length (cm)	Average gape length (cm)	Range of gut length (cm)	Average gut length (cm)
C. GARIEPINUS	2.2-4.0	3.23 ± 0.43	25.0-51.0	42.25 ± 4.50
O. NILOTICUS	2.2-2.5	2.35 ±0.10	166.5-187.7	177.10 ± 2.33

Table 3: Gape and gut lengths of the fish species

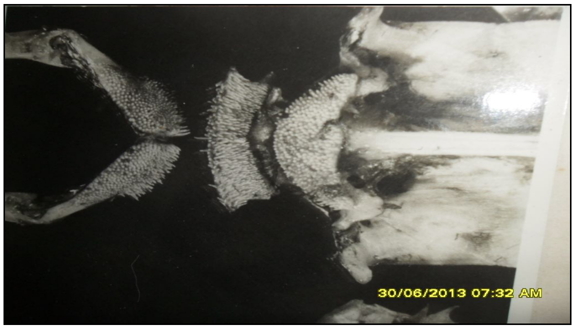

Plate 1: The upper and lower jaws showing the dentition of C. gariepinus
Plate 2: The pharyngeal teeth of C. gariepinus

In *O. niloticus*, the lower jaws were found to have two rows of teeth (Plate 3). The frontal rows have bicuspid teeth while the inner row has tricuspid teeth. On the upper jaw, three rows of bicuspid and tricuspid teeth were recorded. The pharyngeal bone was found to bear numerous compact rows of small, unicuspid and bicuspid teeth (Plate 4).

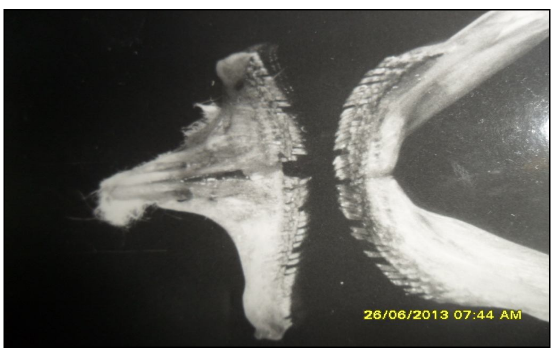

Plate 3: The upper and lower jaws showing the dentition of O. niloticus
Plate 4: The pharyngeal teeth of O. niloticus

Table 4 shows the ranges of the gut lengths of the two species. It was observed that specimens of *C. gariepinus* had relatively shorter ($p<0.05$) guts than specimens of *O. niloticus*. Fig. 3 shows the variation in the number and distance between adjacent gill rakers on a gill arch. The space between the adjacent gill rakers was found to be significantly wider ($p< 0.05$) in *C. gariepinus* than in *O. niloticus* (Table 4).

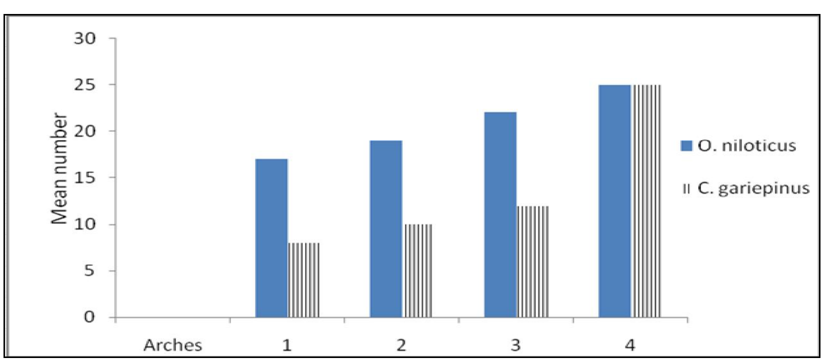

Figure 3: Relationship between the number of gill rakers and the position of the gill arches in the fish species

The gill rakers on the different gill arches in the same specimen differed numerically and also in spacing. In *O. niloticus*, the spacing was found to decrease inwardly, while there is an irregular spacing in *C. gariepinus*. The number of gill rakers recorded, on the gill arches, decreased inwardly, in the two species.

Species	Range in No of gill rakers	Av. No of gill rakers	Range in the distance between adjacent gill rakers	Av. distance between adjacent gill rakers
C. GARIEPINUS	8-13	10.50 ±1.77	0.32-0.62	0.43 ±0.03
O. NILOTICUS	18-23	12.00 ±0.72	0.21-0.32	0.28 ±0.03

Table 4: The number (No) and distance between adjacent gill rakers in the two species

The major food items of *O. niloticus* and *C. gariepinus* in Ado Ekiti water reservoir were similar. Several other workers also reported that the fish species have high degree of overlap in diet, as observed for fishes from the same community [5], [6], [2]. The high level of similarities in the diet of the two species could suggest some degree of food competition in the reservoir. Apart from the major food items, they also picked a variety of other food items. As stated by [7], that teleosts, including cichlids are able to exploit more than one source of nutrients. Examination of the diet of these two species showed that there was high percentage of mud and detritus in their stomachs. However, *C. gariepinus* recorded a higher level of sand grain (37.42% by frequency of occurrence) than the tilapia (12.47%), which reflects the benthic nature of *C. gariepinus*is. The presence of sand grains in the pelagic tilapia however, agrees with [8], who reported that high percentage of detritus and sand particles occurred in the stomach of *O. niloticus* in Abu-Zabal Lakes, Egypt. *O. niloticus* had more of higher plant (76.96% by numerical method) and zooplankton than *C. gariepinus* which indicates the tendency towards planktivorous feeding for tilapia. *Oreochromis* species has been severally reported to be an omnivorous opportunistic-generalist benthophagic browser or surface grazer that feeds on phytoplankton, periphyton, aquatic plants, small invertebrates, benthic fauna, detritus and bacterial films associated with detritusand even other fish and fish eggs[9],[10],[11].

C. gariepinus had higher occurrence of insect and fish parts (36.76% and 31.34%) than *O. niloticus*(9.93% 13.13%) which highlights the omnivorous habit in *C. gariepinus*. Larger individual of *C. gariepinus* had been reported to have fish parts and insects forming the bulk of its diet [12]. The food components of *O. niloticus* in Ado Ekiti reservoir, as reported in the present research, is in agreement with earlier reports for these fish species, found in some other water bodies. [13] reported that this fish species fed mainly on detritus, tiny insects, and plant materials in Ikpoba River. The result also shows that zooplankton form the bulk of the diets of the young tilapia while higher plant remains forms the bulk of the diet of adult *O. niloticus* thus confirming the omnivoryhabits of tilapia species, while *C. gariepinus* fish contain more of sand grain and high fish/insect parts in its diet, which confirms its name as ‘mudfish’ and its omnivorous habits. However, [14] reported that the inclusion of sand grains in the stomach of fish has been attributed to accidental ingestion along with other food items.*O. niloticus*have been observed to exhibit trophic plasticity according to the environment and the other species they coexist with [15].

Reference [16] conducted a comparative study of the gut length and food preference of three tilapia species, *T. mariae*, *T. zillii* and *O. niloticus*. This worker recorded that considerable quantities of zooplankton and phytoplankton were present in the food of the three species. Observation made in some lakes and rivers where *O. niloticus* occurs, shows the species prefer algae and plant materials in its diet but it ingests great variety of foods [17], [6]. The species tend to feed on bottom deposits derived from the plankton (phytophagous) and other sources and gains nutritive value from organic particles and other organism which cover water surface.

The feeding apparatus in these fishes shows various modifications which adapt the fishes to their respective diets. The rows of gill rakers serve as sieve to particles suspended in water that passes over the rakers, through the operculum. The numbers of gill rakers and spacing depend on the diet of the fish. The higher the number of gill rakers, the finer the mesh. The findings in this study agree with [18], who observed that gill rakers were closely packed in tilapia species. Depending on the food source, they will feed either via suspension filtering or surface grazing [19], trapping plankton in a plankton rich bolus using mucus excreted from their gills [20].

Bonds (1979) commented that fishes feeding on large preys, like *C. gariepinus*, have fewer number of gill rakers. As observed in this study, *C. gariepinus* had significantly wider ($p<0.05$) gape than *O. niloticus*. The gape of a fish determines the size of food that can be taken each time the mouth opens. As it has been noted, the catfish would need a wider gape to take in fairly large food organisms like molluscs and fish, fragments of which were seen in the stomach. With an increase in size of any fish, the gape increases, to allow in, enough food to meet its energy requirements. However, the rate of increase differs from species to species.

The jaw teeth of the tilapia are generally small, soft, bicuspid and tricuspid; lining the upper and lower jaws in rows. These are used for shredding. The shredded bits are then passed on, into the gut, over the pharynx (often referred to as ‘pharyngeal mill’). This acts as a surface for grinding of the food, mechanically breaking down plants, a major component of the food of tilapia, into smaller particles. Long plant filaments are broken into shorter particles during this process, thus increasing their surface area for digestion. Together with sand particles in detritus, mechanical breakdown of the cell wall of plants occur, thus facilitating digestion by increasing enzyme-substrate contact.

In *C. gariepinus*, the lower and upper jaws, as well as vomer (in the roof of the mouth) and pharynx, lined with flat rows of small soft pointed unicuspid teeth, obviously arranged to form a flat surface for crushing, grasping, holding and preventing the escape of hard parts of small preys, occurring in the diet and also to grind the wall of plants [21]. Teeth on jaws, similar to the papilliform teeth of *C. gariepinus*, were also described in several other catfishes such as *C. batrachus* [22], *Mystus gulio* [23], *Andersoni aleptura* and *Siluranodon auritus* [24]. The arrangement of the teeth in the vomer of cat fishes is used to identify them.

Specimens of *C. gariepinus* had relatively shorter ($p<0.05$) guts than specimens of *O. niloticus*. The long gut of *O. niloticus* (herbivores) makes the retention period of the food materials in the gut, long, thus enabling proper digestion and conversion to metabolizable forms, useful for fish growth. The fish is even reported to have low pH (pH 2) which enable it dissolve walls and membranes of cells [23]. Carnivores and omnivores (*C. gariepinus*) have faster rate of digestion than do the herbivores, hence the shortness of their gut.

The stomach of *O. niloticus* is small and sac-like in shape. Distension of the stomach is such that the distance between the oesophagus and the pylorus of the stomach is small. Therefore, food from the oesophagus can rapidly pass to the pylorus and then to the intestine, without being affected by gastric juice [24]. Their intestine is narrow and very long. It can be over 1000% of the body length of fish when filled with food. Due to the long intestine, retention time of food in the gut is also long, favoring continuous digestion and absorption of food, for longer periods. The stomach of *C. gariepinus* is sac-like, muscular and comparatively smaller than that of a typical predator. Their intestine is short, less than 100% of body length of fish. *C. gariepinus* is omnivorous, with predatory tendency, feeding mainly on fish, shrimps, zooplanktons, molluscs and higher plants. Youngs of this species feed primarily on detritus and larvae of insects, whereas larger individual contains fish parts and juveniles, with insects and fish making up the bulk of its diet [25].

The result obtained in this study shows that about 40% of *O. niloticus* stomachs examined were empty. In *C. gariepinus*, about 30% stomachs were empty. This may be due to the fact that the food items in their stomachs may have been regurgitated as the fish struggle for escape in the traps and gill nets. Specimen caught with cast net however, had lesser amount of empty stomachs. Thus, cast netting is recommended for study of food and feeding. The percentages of occurrence of empty stomach were relatively high for both species. This observation may also indicate that food is unavailable for these fish species and this could be because the reservoir was not rich in natural foods. This is to be expected, since the reservoir is constructed, primarily, for domestic water supply.

4. Conclusion

C. gariepinus and *O. niloticus* in Ado Ekiti Reservoir were essentially omnivores, with some overlapping food preference. However, the different major food items fed upon by the species and the corresponding adaptations to feeding makes co-existence of the two species, amongst others, possible, and would ultimately reduce intense competition.

5. Acknowledgement

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