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Food and feeding of three *Citharinus* species in Lake Kainji, Nigeria

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This paper provides information on the food and feeding habits of three *Citharinus* species in Lake Kainji. A total number of 2357 specimens made up of 1628 *Citharinus citharus*, 705 *C. distichodoides* and 24 *C. latus* were examined. The majority of the fish caught by gill-netting had empty stomachs unlike those caught by cast-netting and electrofishing. The main food items were planktonic and epipelic blue-green and green algae. All the three species had similar feeding habits and also fed on the same items; their food varied with the seasons. *Citharinus* spp. have high gut length/standard length ratios which are adaptations to the microphagous and planktivorous feeding habits.

I. INTRODUCTION

Citharinus species are known to have an important role in the fisheries of African inland waters. Worthington (1929) reported that *Citharinus citharus* formed the main catch of Lake Albert. In Senegal, Daget (1962) showed that *Citharinus* sp. represented 32% (1288 tons) of the fish caught. In Nigeria, Welman (1948) reported an abundance of *Citharinus* sp. in the lower reaches of the Benue River. Hulot (1956) also found that *Citharinus* sp. played an important role in the fisheries of the equatorial region of Central Africa.

Daget's (1961) investigations on the Niger River prior to the formation of Lake Kainji led him to conclude that *Citharinus* would be commercially important in the Lake. Another study by Banks *et al.* (1966) showed that *Citharinus citharus* formed over 60% of the cast net catches in the area now covered by the lake.

Motwani (1970) remarked that the role of *Citharinus* in the fishery of the Niger River seemed to be favoured by their effective feeding behaviour and the availability of suitable breeding grounds. Other investigations by Bakare (1968) and Imevbore & Bakare (1970) on their food and feeding habits showed that *Citharinus* species fed on fine bottom sediment rich in carbon and nitrogen content.

Imevbore & Okpo (in press) reported that *Citharinus citharus* was most abundant in the lake shortly after its formation. It then formed 20% of the entire lake fishery and 70% of the catch in the middle basin. In another study, Turner (1970) noted that *Citharinus citharus* was dominant, forming 35·6% by weight of the entire fish yield in the lake. Bazigos (1972) also reported that *Citharinus* spp. dominated the fish catches during the first 2 years of Lake Kainji and that the decline in the yield of fish was due to a fall in the number of this important fish species.

Imevbore (1971) reported that *Citharinus citharus* thrived in the early years of the lake because of the luxuriant algal growth which provided food for them. Imevbore & Okpo (in press) reported that those *Citharinus* spp. which were detritus feeders in the river changed their diet and became phytoplankton feeders in the lake. In view of this finding, this study was undertaken to provide detailed information on the food and feeding habits of three *Citharinus* species in Lake Kainji, namely: *Citharinus citharus*, *C. distichodoides* and *C. latus*.

II. MATERIALS AND METHODS

A total of 2357 specimens representing 1628 *Citharinus citharus*, 705 *C. distichodoides* and 24 *C. latus* were examined. The fish were caught by gill-netting, cast netting or electrofishing between October 1970 and May 1972 over the central basin area of the lake and its tributaries (stations A–M on Fig. 1).

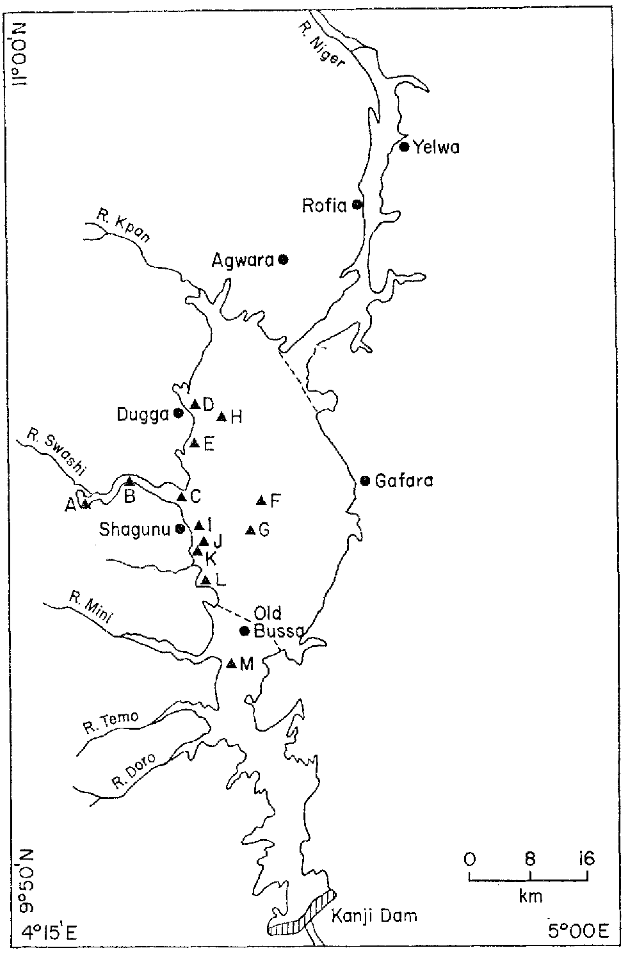

FIG. 1. Map of Lake Kainji showing the sampling stations (A–M) and the tributaries.

The fish were opened and the contents of stomach and intestines examined. The volume of the stomach contents was determined by displacing water in a measuring cylinder according to Lagler (1964). The sand, mud and detritus were estimated volumetrically after sedimentation. Samples of the food organisms were examined, identified and counted under a microscope. Each colony of filamentous algae comprising a minimum number of five cells was counted as a unit. The number of fish in which each food item occurred was recorded as a percentage of the total number of fish examined. The incidence of all items was expressed as a percentage, to show composition of the diet according to Hynes (1950). Stomach contents which could not be examined immediately were preserved in 4% neutral formalin. The size of the soil particles in the stomach contents was determined by sieving. For the study of feeding habits, live fish were kept in tanks.

III. RESULTS

FOOD

Food was present in the stomachs of 810 of 1628 *Citharinus citharus*, 135 of 705 *C. distichodoides* and 6 of 24 *C. latus*. From Table I, it is evident that fish caught by cast netting and electrofishing had food in their stomachs while the majority of the specimens caught by gill-netting had empty stomachs: 67% for *C. citharus*, 80% *C. distichodoides*, and 86% *C. latus* respectively.

Arawomo (1972) noted that *Citharinus* species were no longer bottom dwellers in Lake Kainji and for this reason the majority of the specimens were caught in cast-nets and surface gill-nets. He also added that these species were mainly caught in the sampling stations situated in the rivers and shallow creeks of the lake (see Fig. 1). This indicates that *Citharinus* species could take phytoplankton from the blooms covering the lake and when the phytoplankton density decreased, they could change to feeding on the accessible epipelic algae on the bottom.

TABLE I. Specimens examined for stomach contents by different fishing methods

Species	Specimens caught in gill-nets		Specimens caught in cast-nets		Specimens caught by electrofishing	
	Total number caught	No. with empty stomachs	Total number caught	No. with empty stomachs	Total number caught	No. with empty stomachs
Citharinus citharus	1087	729	409	8	51	—
Citharinus distichodoides	436	348	36	6	17	—
Citharinus latus	21	18	3	—	—	—

Table II shows the average percentage composition and the percentage occurrence of the types of food ingested by the three *Citharinus* species. The main food items were planktonic and epipelic blue-green and green algae; diatoms, and rotifers were ingested on occasions with sand and mud. The three *Citharinus* species fed mainly on similar types of food with only slight differences. Sand was ingested seasonally by the three species with *C. citharus* having the largest sand grains; *C. latus* ate fine particles while *C. distichodoides* had particles which were intermediate in size (see Table III). It was also observed that the greenish coatings of organic material on the sand particles were digested during the passage of the sand particles through the intestine.

This result contrasts with the findings of Bakare (1968, 1970) and Imevbore & Bakare (1970) that *Citharinus* species were bottom feeders in the River Niger. It however agrees with the findings of Imevbore & Okpo (in press) that *Citharinus* species were primarily feeders on phytoplankton in Lake Kainji, and confirms that the transition from river to lake was associated with a change in the diet and the feeding habits of the *Citharinus* species.

TABLE II. Stomach content analyses of *Citharinus* spp. in Lake Kainji from October 1970 to May 1972

Species	*C. citharus*		*C. distichodoides*		*C. latus*	
No. stomachs examined	810		136		6	
Food items	Average % composition	% occurrence	Average % composition	% occurrence	Average % composition	% occurrence
Sand	19·2	83·0	10·7	57·7	12·5	66·7
Mud+detritus	22·9	96·0	18·3	86·6	18·7	100·0
BLUE-GREEN ALGAE						
Anabaena sp.	1·9	8·5	2·0	8·7	3·1	16·7
Microcystis sp.	5·8	25·0	4·3	51·0	6·2	33·3
Oscillatoria sp.	0·2	0·74	1·1	2·3	3·1	16·7
GREEN ALGAE—UNICELLULAR						
Closteriopsis sp.	0·7	3·2	2·1	11·7	3·1	16·7
Closterium sp.	3·6	16·0	3·1	17·4	3·1	16·7
Cosmarium sp.	2·1	10·0	4·4	24·8	3·1	33·3
Crucigenia sp.	0·1	0·6	0·7	3·9		
Eudorina sp.	8·6	36·0	6·9	42·2	6·2	33·3
Eurastrum sp.	0·7	2·8	1·1	1·56		
Pediastrum sp.	2·8	13·2	4·1	23·2	3·1	33·3
Pleodorina sp.	1·7	0·74	1·4	12·2		
Scenedesmus sp.	2·3	11·4	3·4	19·0	3·1	16·7
Selenastrum sp.	0·2	1·5	0·6	1·56		
Staurastrum sp.	2·6	2·8	2·3	6·1	3·1	16·7
Volvox sp.	1·8	12·1	2·3	6·1	3·1	16·7
GREEN ALGAE—FILAMENTOUS						
Oedogonium sp.			0·9	0·78	3·1	16·7
Spirogyra sp.	0·2	0·74				
Ulothrix sp.	12·0	53·0	10·7	57·7	12·5	66·7
Zygnema sp.	8·2	36·5	7·4	42·2	8·5	50·0
DIATOMS						
Melosira sp.	1·1	3·1	3·7	12·2	3·1	16·7
Navicula sp.	0·4	1·6	1·6	8·7		
Pinnularia sp.	0·3	1·5	0·6	3·0		
Nitzchia sp.	0·2	1·5	0·6	3·9		
ROTIFERS						
Keratella sp.	0·6	4·5	1·1	6·1		

IV. FEEDING HABITS

All the three species were found to feed in the manner described by Bakare (1970) They were observed to draw in water after which their mouths were closed, and the water was forced through the gill apparatus where microbranchiospines functioned as sieves and filtered any particles which were then retained in mucus. In this manner, the fish fed on planktonic algae until the level of the Lake receded between April and September and the algal growth decreased, when they commenced to take epipelic algae from the bottom. To do this the young *Citharinus* specimens (below 12 cm) were found to lie almost parallel to the bottom, and stir the superficial layers of the bottom ooze with their pectoral fins. The epipelic algal suspension was then drawn in with sand, mud, and detritus and filtered. Adult *Citharinus* specimens (above 12 cm) fed in a slanting position with their mouths dipping into the bottom ooze, the topmost layer of which was scooped with some sand and mud and swallowed. Sometimes the adult fish also sucked in water currents containing small suspended particles in the same way as the juveniles.

TABLE III. Size relationship of filtering mechanism with filtered organisms by *Citharinus* spp

Species	Standard length (cm)	Mean distance between adjacent branchiospines (μm)	*Maximum size of filtered organisms (μm)
C. citharus	6·2	430	180
	10·8	560	250
	17·9	620	540
	29·4	735	680
	35·2	760	710
	37·8	785	750
	41·0	820	810
C. distichodoides	8·2	435	230
	11·7	480	250
	20·8	520	425
	27·2	675	650
	52·5	785	710
C. latus	15·2	460	250
	34·0	650	425

* Particle size of organisms measured with the Endecotts Test Sieves.

Table III shows that the size of the particles retained by the branchiospines were proportional to the mean distance between the respective adjacent branchiospines which confirmed the findings by Goose (1956) for *Citharinus* spp. in the Congo. There were therefore differences in the size of particles ingested by the young and the adult *Citharinus* spp. and also in the proportion of sand in the stomach contents. Both the young and the adult ingested similar food items. However the difference in the method of feeding between the young and adult raises the question at which size does the fish change its feeding habit?

V. FOOD HABITS IN RELATION TO SIZE AND SEASON

From July to September when the Lake waters were turbid and containing the least quantities of green algae, diatoms dominated the diet. *Melosira* sp. was the most abundant species during this time confirming findings that diatoms thrive best when rivers are in flood (Prowse & Talling, 1958; Imevbore, 1965). During this study, *Melosira* sp. dominated the phytoplankton throughout the period of the 'White' floods (i.e. July–September).

From October, the blue-green algae replaced the diatoms (Adeniji, 1971). At this time stomach contents of *Citharinus* species contained large quantities of *Microcystis* sp. and *Anabaena* sp. as well as *Eudorina* sp., *Pleodorina* sp. and *Volvox* sp.

Later, as the 'Black' floods set in (January–March) green algae (*Staurastrum* sp.) dominated the stomach contents of the *Citharinus* spp. However, as the Lake level receded during May and June, mixed quantities of green and blue-green algae were ingested.

These variations in the stomach contents confirm the accepted fact that the food of a fish varies with the seasons, depending on what is available and on the habitat of the fish. Such seasonal variation in the algal diet of *Tilapia* species was reported for the Lagos lagoon (Fagade, 1971).

VI. ADAPTIVE FEATURES OF THE GUT

Lagler *et al.* (1962) have shown that the digestive tract of fishes are adapted to their food types. It was therefore interesting to study the adaptations of the alimentary tract of *Citharinus* species. It was found that the digestive tract of *Citharinus* spp. consisted of a short oesophagus, a V-shaped cylindrically folded stomach, an intestinal ampulla with a large number of pyloric caecae, small proper intestine, a large intestine and a rectum. The cardiac part of the stomach had a thin membraneous wall while the pyloric wall was thick and muscular. The simple pyloric caeca were grouped at the beginning of the intestine proper, the intestinal ampulla. The small intestine had numerous convolutions. A characteristic feature in the large intestine was the development of a spiral valve.

Citharinus spp. have high gut length/standard length ratios The relatively long intestines, the possession of pyloric caecae and a spiral valve in the large intestine are adapted to the microphagous and planktivorous feeding habits. The development of pyloric caecae from the intestinal ampulla is a device to increase the surface of intestinal digestion and absorption. Hence the development of a greater number of pyloric caecae in *C. distichodoides* may compensate for its relatively shorter intestine. Similarly the development of a spiral valve in the large intestine is said to provide a high absorptive capacity (Lagler *et al.*, 1962).

VII. DISCUSSION

The high percentage of empty stomachs in *Citharinus* specimens caught by gill-netting could be attributed to the period of time which these fish remained in the gill-net before they were removed for examination. It has been observed that East African freshwater fish differed in their reactions to capture in gill-nets. Some species died soon after capture while others captured early in the evening digested a considerable part of their food before being removed from the gill-net the following morning. In other species digestion seemed to be delayed between the time of capture and the time of removal from the gill-net (Munro, 1967). *Citharinus* in Lake Kainji appeared to fall in that category of fish which either do not feed at night or do not die readily after capture with the result that most or a good proportion of their food is digested before removal from the gill-net the following morning. However fish caught in cast nets had food in their stomachs. It may be concluded therefore that *Citharinus* species fed intensively during the day, but it is doubtful that they feed to the same extent during the night. Such feeding behaviour has been reported for *Tilapia* species and *Hydrocynus vittatus* in some East African freshwaters (Munro, 1967).

Observations made on the hind gut contents of *Citharinus* specimens showed that all types of algae were digested by the fish; the sand and mud particles found at the hind gut lacked the greenish coatings of organic matter, and the algae had every appearance of having been digested.

Many fish are considered to be incapable of digesting blue-green algae except with the assistance of bacteria which are capable of digesting cellulose (West *et al.*, 1967). Schuster (1952; cited by Hickling, 1962) has also suggested that blue-green algae may be digested by fish once the algae have begun to decay. Both these factors could explain the ability of *Citharinus* spp. to digest blue-green algae; certainly their long intestinal tracts could provide suitable conditions for bacteria to act on the algae, and decomposing algae would be present in the bottom ooze.

Fryer & Iles (1972) have reported that *Tilapia nilotica* in Lake Rudolf digest large quantities of the blue-green algae, *Spirulina* and *Anabaenopsis*, which are typical of highly alkaline waters. This may also apply to Lake Kainji which is slightly alkaline.

These findings put the *Citharinus* spp. in Lake Kainji in the same ecological niche as *Tilapia melanopleura*, *Tilapia mossambica* and *Labeo attivelis* in the East African freshwaters (Munro, 1967); *Tilapia mariae* and *T. guineensis* in Lagos Lagoon, Nigeria (Fagade, 1971); and *Tilapia nilotica* in Lake Rudolf (Fryer & Iles, 1972). It will be interesting therefore to follow the establishment of the lacustrine fish population in Lake Kainji and study the relationship between the *Tilapia* and *Citharinus* species with respect to their food habits and growth rates.

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