FOOD COMPOSITION AND DIGESTIVE ENZYMES IN THE GUT OF THE AFRICAN ELECTRIC CATFISH, *Malapterurus electricus* (GMELIN 1789) (MALAPTERURIDAE)

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ABSTRACT

Analyses of stomach contents of 330 *Malapterurus electricus* (Standard length, 10.1-30.5cm) in Mahin Lagoon (Southwestern Nigeria) established it as a bottom feeder. There was a preponderance of insects accounting for >80% occurrence and > 25% of total volume in stomachs of specimens, suggesting a stenophagous predatory habit. Qualitative and quantitative assays of digestive enzymes in the different regions of the gut (oesophagus, stomach, doudenum, ileum, rectum) were investigated. Carbohydrases (amylase, maltase), chitinase, proteases (pepsin, chymotrypsin, trypsin) and lipases were detected in different gut regions with different activity. The pattern of distribution and relative activity of the enzymes correlated with his predatory diet.

Key Words: Carbohydrase, proteases, lipases, gut regions, electric catfish, *Malapterurus electricus.*

INTRODUCTION

The African electric catfishes, *Malapterurus lacepede* (Family Malapteruridae) are endemic to tropical Africa (Leveque *et al.,* 1991), and of the three species presently recognized (*M. electricus M. minjiriya, M. microstoma*) (Teugels, 1996), *M. electricus* (Gmelin 1789) is common in commercial catches in west Africa (Holden & Reed, 1972). It is more or less available throughout the year and the dietary habits have been previously studied by Sagua (1979, 1987), based on samples taken in freshwater floodplains and Lake Kainji (Nigeria). No study has hitherto been conducted on the natural diet of *M. electricus* in the brackishwater/mangrove swamp habitat where they are often caught. This paper reports the qualitative and quantitative composition of food items in the gut of *M. electricus* specimens obtained from catches of fishermen in Mahin Lagoon, (Southerwestern Nigeria).

The study of digestive enzymes of fish relates its food habits to the enzymes found in the gut and is widely used in nutritional physiology as important means of investigating digestive abilities in fish. According to Moreau (1988) the presence of appropriate enzymes determines the ability of an organism to digest a given food item. No information is available on the quantitative and qualitative assays of digestive enzymes in the gut of *M. electricus* compared with other commercially important African catfish species, whose digestive enzymes assays have been established (Olatunde & Ogunbiyi, 1977; Uys & Hecht, 1987; Olatunde *et al.*, 1988; Fagbenro, 1990; Fagbenro *et al.*, 1993). In this paper, the occurrence, distributionk"\xv and activity of certain digestive enzymes in the different gut regions (oesophagus, stomach, duodenum, ileum, rectum) of *M. electricus* are described, for the first time.

Material and Methods

Study Area

Mahin Lagoon is situated in the coastal wetlands (mangrove swamps) of southwestern Nigeria between Longitude 4°20'E and 5°08'E of the prime meridian and Latitudes 5°58'N and 6°29'N of the equator. It runs parallel to the coastline and is separated from the sea (Atlantic Ocean) by a strip of sandy land which varies in width from 2 to 16 km. The lagoon is 25 km long and supports a thriving artisanal fishery based on tilapias, catfishes and *Heterotis.*

Dietary Habits

A total of 330 *M. electricus* specimens were collected once weekly over 12 months having beeen caught by artisanal fishermen using gill nets of 3cm stretched mesh in deep waters, basket traps and baited longlines near the shores. Each specimen was measured for standard length (SL, cm) and body weight (g). After dissection, their stomachs were removed and separately preserved in 5% formaldehyde solution, immediately. The number of empty stomachs were recorded. Individual stomachs were examined under a stereo-dissecting microscope and the component food items were identified. Food items encountered were later analysed by a combination of frequency of occurrence (%O) and volumetric (%V) methods (Hyslop, 1980) in order to minimise bias typical of each method. The prominence of each food item was determined by computing the ranking index, I (Oda & Parrish, 1980) as follows:

$$I = (\%\ \text{Occurrence} \times \%\ \text{Volume}) \times 10^{-2}$$

Digestive Enzymes Assays

Twenty-five adult specimens (TL>25-30cm) were kept unfed for 72 hrs inside outdoor concrete cisterns in order to bring them to similar physiological state as well as ensure the emptiness of the entire gut. They were anaesthetized with benzocaine and dissected to remove the entire guts (oesophagus to rectum), later separated into the anatomically distinct regions. The different gut regions were pooled and homogenized using cold neutralized potassium hydroxide and the homogenates were centrifuged at 1200 g for 30 min at 4°C. The supernatants were used as enzyme extracts and assayed using various substrates and techniques based on photometric procedures.

Benedict"s qualitative reagents were used for the qualitative assay of carbodydrates following the methods of Olatunde *et al.* (1988), while quantitative assays were conducted using the dinitrocyclate (DNS) methods. Qualitative and quantitative assays of proteases followed the method of Balogun & Fisher (1970). The methods of Danulat & Kausch (1984) were used to determine chitinase activity qualitatively and quantitatively, while the methods described by Ogunbiyi & Okon (1976) were used to determine lipase activity both qualitatively and quantitatively. Controls were run simultaneously in triplicates.

Results and Discussion

Dietary Habits

Fish growth is determined through the combined effects of food quality and quantity; and the study of dietary habits of fishes is essential in determining its diet with respect to age, size, life history stages, season, time of day as well as locality in which they occur. Altogther, stomachs of 330 *M. electricus* specimens with SL ranging from 10.1-30.5 cm were examined and the food items identified included planktonic and benthic organisms as well as detritus. Analyses of food composition in the stomach of *M. electricus* from Mahin Lagoon showed a predatory habit with particular preference for insects. The ranking index (I) values presented in table 1 establish benthic insects as the main food item in the lagoon.

The incidence of empty stomachs observed was 13.6%, and the remaining stomachs with food were more than half-full. The low incidence of empty stomachs coupled with almost full stomachs suggest a fairly regular feeding intensity in all the habitats. Insects, small fish and detritus were the dominant food items in the diet of *M. electricus*, occuring in > 90% of stomachs with food, all having high I values. Other food items recorded include tadpoles, bivalves, annelids, penaeid prawns, macrophyte parts and sand grains. The inclusion of sand grains was possibly an accidental ingestion along with benthic invertebrates (insect larvae, annelids, prawns, bivalves) while the high occurrence and prominence of detritus (I values, Table 1) suggest a frequent bottom feeding. The occurrence of planktonic organisms was low and was insignificant as food items, and may have originated from the prey fish (young ciclids, characoids, clupeids, cyprinids) in the lagoon which are predominantly planktophagous.

Digestive enzymes assays

In *M. electricus*, the oesophagus is short and dilatable, facilitating the passage of large prey organisms, nd the intestine is simple, thin-walled and relatively short, implying a dependence on protein-rich foods. Table 2 shows the various enzymes detected in the different regions of *M. electricus* gut, their distribution and activity varying along the gut length. No enzyme activity occurred in both the oesophagus and rectum which, as Olatunde & Ogunbiyi (1977) suggested, serve merely as passage for ingested and undigested food, respectively. Only pepsin activity was detected in the sotmach, while other proteolytic enzymes occurred in the duodenum and ileum; thus suggesting that protein digestion commences in the stomach and continues in the duodenum and ileum. Fagbenro *et al.* (1993) observed a similar general pattern of enzyme distribution in *Heterobranchus bidorsalis* (Table 3), which like *M. electricus*, has a predatory dietary habit. A weak chitinase activity was detected in the stomach.

Of all the carbohydrases tested for, only amylase and maltase activity were recorded, an indication that there was little carbohydrate in its diet and their activity might be a device evolved for digesting starch manufactured by the algae consumed by its prey. Such low level of carbohydrase activity implies the inability of *M. electricus* to utilize carbohdrate food components as dietary energy source. Prey fish or insects are probably the most important source of dietary lipids which represents the utilization of poly-unsaturated fatty acids as the energy source. This is confirmed by a high lipase activity detected in the duodenum.

The protein-hydrolysing enzymes found in the stomach was pepsin while those in the duodenum and intestine were alkaline proteases, trypin and chymotrypsin. The relatively higher activity levels of proteases, particularly in the duodenum (Table 1), was not surprising taking cognisance of protein components (insects, small fish) being predominant in its diet (Sagua, 1979).

Chitinases are associated with chitin eating habit (i.e. feeding on crustaceans or insects) and have been detected in the stomachs of Atlantic cod, Japanese sea bass and trout (Okutan & Kimata, 1964; Micha *et al.*, 1973; Danulat & Kausch, 1984; Danulat, 1986). Chitin is the major structural component of the cuticle of insects and the exoskeleton of crustaceans, which like cellulose has no utilizable energy value of fish. According to Lindsay (1984), the primary function of gastric chitinase in fish may be to disrupt chemically the chitin envelope of the prey.

Lipase activity, probably of pancreatic origin, occurred only in thee duodenum and ileum (Table 1). Similar lipase distribution and activity was reported in *Clarias isheriensis* (Sydenham 1980) by Fagbenro (1990) (Table 3). From the foregoing, it is evident that *M. electricus* is well equipped to digest protein and lipid components in its carnivorous diet.

Acknowledgements

Thanks go to Mrs Felicia Samuel for the supply of *M. electricus* specimens used in these studies.

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Table 1: Percentage composition of food items in *Malapterurus electricus* from Mahin Lagoon.

{PRIVATE }Size range (cm) No. examined Empty stomachs (%)	10.1-30.5 330 45 (13.6%) 45 (13.6%0 %O	%V	I
Phytoplankton Algae Diatoms	27.4 25.3	0.2 0.3	0.05 0.08
Zooplankton Protozoans Rotifers Micro-crustaceans	15.8 13.7 17.2	0.3 0.7 0.5	0.05 0.10 0.09
Insects immature adult appendages	64.9 100.0 75.4	10.1 13.7 8.3	6.55 13.70 6.26
Bivalves Penaeid prawns & appendages Annelids Tadpoles	22.1 69.5 36.8 33.3	3.4 15.0 3.0 2.1	0.75 10.43 1.10 0.70
FishEggs small fish & fish remains	13.7 100.0	1.4 18.8	0.19 18.80
Plant parts & seeds Sand grains Detritus	19.6 12.6 92.6	1.0 1.1 20.1	0.20 0.14 18.61

%O = % Occurrence; % V = % Volume; I = ranking index.

Table 2: Summary of assays of digestive enzymes in the gut of *Malapterurus electricus*

{PRIVATE }	Stomach	Duodenum	Ileum
Carbohydrases			
α-amylase	-	++	+
maltase	-	+	++
cellulase	-	-	-
lactase	-	-	-
sucrase	-	-	-
Proteases Pepsin	+++	++	-
trypsin	-	+++	++
chymotrypsin	-	++	+++
Chitinases	++	-	_
Lipases	-	+	+

_ no enzyme activity
\+ low enzyme activity
++ high enzyme activity
+++ very high enzyme activity

Table 3: Digestive enzymes assayed in guts of tropical African catfishes.

{PRIVATE}	Schilbe mystus	Eutropius niloticus	Physalia pellucida	Clarias gariepinus (syn. Clarias Lazera)		Clarias isheriensis	Heterobranchus bidorsalis	Malapterurus electricus
Amylase	+	+	-	+	+	+	+	+
Cellulase	-	-	-	-	-	+		-
Lactase	-	-	-	-	+	-		-
Maltase	+	-	-	-	+	+	+	+
Sucrase	-	-	-	-	+	+		-
Salicinase	-	-	-	-	-	+		-
Trehalase	-	-	-	-	-	+		
Chymotrypsin	-	-	-	-	-	+	+	+
Pepsin	+	+	+	+	+	+	+	+
Trypsin	+	+	+	+	+	+	+	+
Chitinases	-	-	-	-	-	-	-	+
Lipases	-	-	-	+	+	+	+	+
References	Olatu-e & Ogunbiyi (1977)			Uys & Hecht (1987)	Olatu-*et al (1988)*	Fagbenro (1990)	Fagbenro *et al* (1993)	Fagbenro *et al* (this study)

\+ enzyme activity detected
\- enzyme activity absent