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Full Length Research Paper

The feeding ecology of *Mugil cephalus* (Linnaeus) from a high brackish tropical lagoon in South-west, Nigeria

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The diet of the grey mullet (*Mugil cephalus* L.) was investigated in the Lagos Lagoon (high brackish) habitat in Nigeria from February 2004 – January 2006. The highest number of empty stomachs was recorded in October 2004, while the lowest was in December 2005. The highest number of empty stomachs was recorded in the small sized group (Standard length, 4.5 – 12.4 cm), while the least occurred in the large sized (Standard length, 20.5 – 28.4 cm). The fish fed throughout the year with no remarkable seasonal variation in the type of food consumed. Ten major food items were identified: algae, diatoms, desmids, plant materials, annelids, crustaceans, bivalves, fishes, detritus and sand grain. The small and large sized-fish groups did not feed on desmids and annelids throughout the investigation.

Key words: Lagos Lagoon, *Mugil cephalus*, stomach contents, food items, detritus.

INTRODUCTION

Mugil cephalus L. (Family: Mugilidae) occurs worldwide mainly between latitudes 42^0N and 42^0S. It inhabits coastal waters, estuaries and freshwater in tropical and temperate waters of all seas (Render et al., 1995). The adults and juveniles of the grey mullet are hardy, euryhaline, eurythermal and not competitor for food. School occurs in shallow coastal waters; they enter lagoons and estuaries to feed (Rheman et al., 2002). In estuarine waters, grey mullet feed on detritus, diatoms, algae and microscopic invertebrates which they filter from mud and sand through their mouth and gills (QFMA, 1991; McDonough and Wenner, 2003). A proportion of the sand is ingested to assist the grading of food in the muscular stomach (Michaelis, 1993).

In Nigeria, West Africa, mullets constitute important proportion of the catches by artisanal or subsistence fishermen in lagoons and rivers. *M. cephalus* has only been reported in both high brackish and low brackish water lagoons (Fagade and Olaniyan, 1974; Soyinka and Kassem, 2008) in the area unlike other genera caught in freshwater lagoons and rivers (K. Kusemiju and B.E. Emmanuel, Department of Marine Sciences, Faculty of Science, University of Lagos, Lagos, Nigeria, personal communication). Although several works have been done on the food and feeding habits of mullet species in some localities of Africa sub-region (Fagade and Olaniyan, 1973; Payne, 1976; Blay, 1995), similar investigations in this area are considered vital for a fuller understanding of the feeding ecology of various species of mullet.

In this report, the diet of the grey mullet, *M. cephalus* in Lagos Lagoon (high brackish) of a tropical country as Nigeria is described and considered in relation to the sources of food available in the habitat.

MATERIALS AND METHODS

Description of study area

The Lagos Lagoon (Figure 1) which lies between longitudes 3^0 20' and 3^0 40'E and latitudes 6^0 15' and 6^0 40' has an area of 208 km^2 and is the largest of the lagoon systems of the West African sub-region. It is the largest of the nine coastal lagoons of South-western Nigeria (others are Yewa, Badagry, Iyagbe, Ologe, Kuramo, Epe, Lekki and Mahin Lagoons, FAO, 1969). It has supported decades of small scale fisheries which have shown sign of continuous decline (Solarin, 1998). The lagoon characterized with seasonal fluctuation in salinity – high brackish water during the dry season (December – May), while freshwater condition exists in the rainy season (June – November) (Fagade and Olaniyan, 1974; Kusemiju, 1975; Ugwumba, 1984 and Solarin, 1998). It receives freshwater from Lekki Lagoon via Epe Lagoon in the North-east, and discharges from Majidun, Agboyi and Ogudu creeks as well as Ogun River in the North-west.

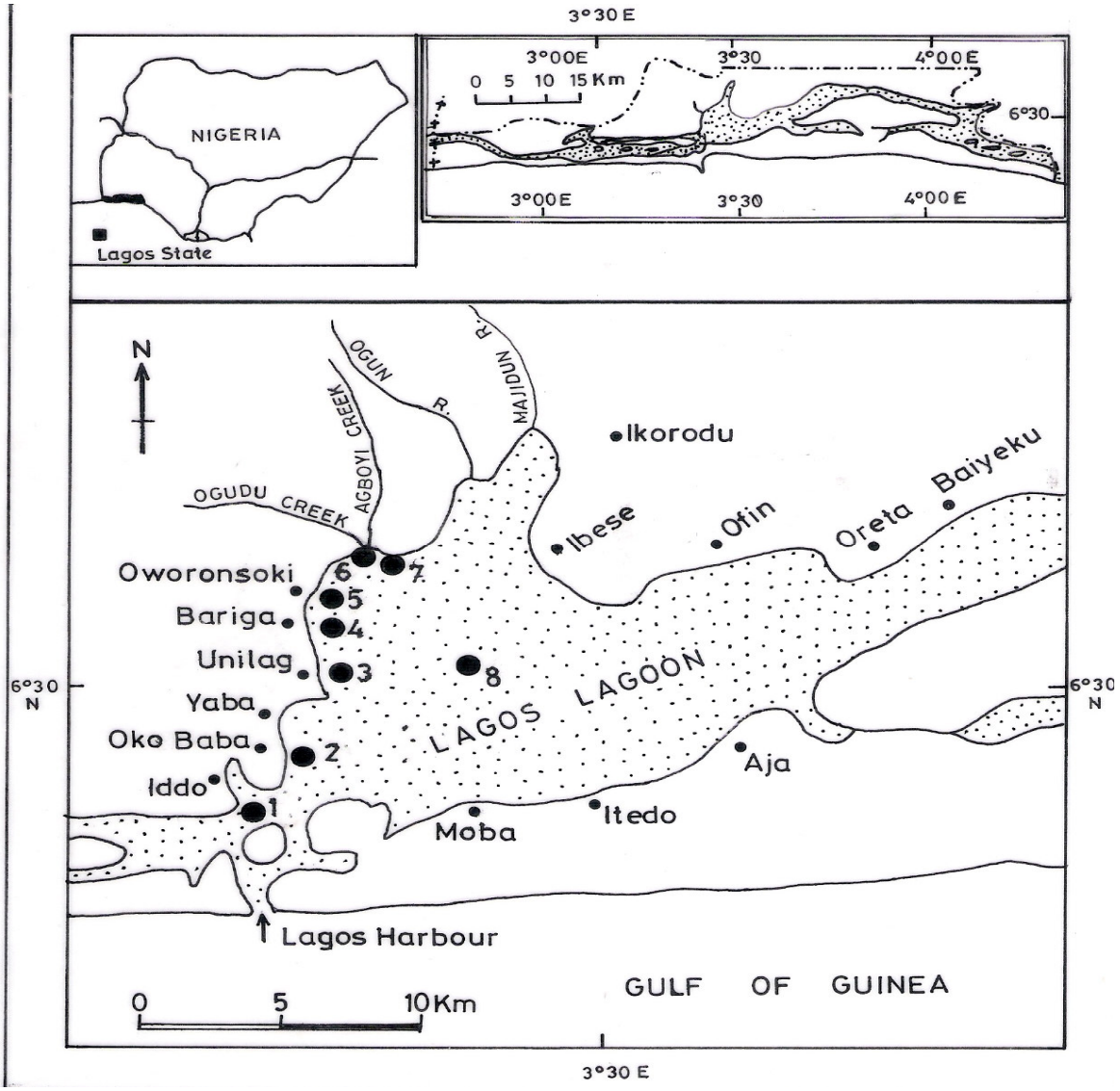

Figure 1. Map of Lagos Lagoon with the maps of Lagos state and Nigeria inserted.

Collection of specimens

The specimens of the grey mullet, *M. cephalus* were obtained from Ilaje and Makoko jetties of the Lagos Lagoon, Lagos state from fisher- folks (February 2004 – January 2006). The collections were made fortnightly and by random selection as the fish are being brought from the lagoon. The fish were transferred into a deep freezer at temperature of -20°C in the laboratory for further analysis.

Laboratory procedures

The preserved specimens were thawed and wiped dry before laboratory analysis. The standard and total lengths (in centimeters) were measured on a measuring board while the weights (in grammes) were determined using a sensitive Sartorious balance (Model 1106). The stomach contents were emptied into a Petri dish and examined under a binocular microscope. The state of fullness of each stomach was recorded and expressed as empty ($^0/_4$), one-quarter full ($^1/_4$), half-full ($^2/_4$), three-quarters ($^3/_4$) and full ($^4/_4$). The food habits were studied using the numerical and occurrence methods (Hyslop, 1980).

RESULTS

Empty stomach analysis

1867 specimens of *M. cephalus* were examined for food and feeding habits. 783 (41.9%) of the fish had empty stomach as shown in Table 1. Analysis of monthly variation in empty stomachs (Table 1) showed that the highest occurrence of empty stomachs was noted in October 2004 (63.4%), while the lowest was noted in December 2005 (11.3%). Variation in empty stomach by size group (Table 2) indicated that the small size group of *M. cephalus* had the highest number of empty stomachs

Table 1. Monthly variation in empty stomachs of *M. cephalus* from Lagos Lagoon (February 2004 – January 2006).

Year/month	Number examined	Number with empty stomachs	% Empty stomachs
FEB 2004	51	28	54.9
MAR	95	40	42.1
APR	80	17	21.3
MAY	65	21	32.3
JUN	76	25	32.9
JUL	97	31	32.0
AUG	72	28	38.9
SEPT	48	18	37.5
OCT	82	52	63.4
NOV	86	27	31.4
DEC	61	31	50.8
JAN 2005	104	32	30.8
FEB	40	16	40.0
MAR	62	27	43.5
APR	131	69	52.7
MAY	100	55	55.0
JUN	43	15	34.9
JUL	118	57	48.3
AUG	118	68	57.6
SEPT	91	44	48.4
OCT	97	32	33.0
NOV	-	-	-
DEC	71	8	11.3
JAN 2006	80	42	52.5
TOTAL	**1867**	**783**	**41.9%**

Table 2. Variation in empty stomachs by size of *M. cephalus* from Lagos Lagoon (February 2004 – January 2006).

Size/standard length (cm)	Number examined	Number with empty stomachs	% Empty stomachs
Small-sized fish (4.5 – 12.4)	670	341	50.9
Medium-sized fish (12.5 – 20.4)	1158	436	37.7
Large-sized fish (20.5 – 28.4)	39	6	15.4

(50.9%), while the large size group had the least number of empty stomachs (15.4%).

Food items in the stomach of *M. cephalus*

The stomach contents of *M. cephalus* are presented in Table 3 and the summary of the items is illustrated in Figure 2. The stomach contents were made up of ten major categories. These were algae, diatoms, desmids, plant materials, annelids, crustacean, bivalves, fishes, detritus and sand grains.

Plant materials are made up of the most important food item by numerical method (57.24%; 9.56% by occurrence), while detritus formed the most frequently consumed food item by the occurrence method (44.81%). Diatoms (*Cyclotella* sp., *Nitzschia* sp., *Synedra* sp., *Gyrosigma* sp., *Fragilaria* sp., *Navicula* sp. and *Epithemia* sp.) constituted 16.00 and 4.09% by numerical and occurrence methods, respectively. Algae (*Spirogyra* sp., *Oscillatoria* sp., *Spirulina* sp., *Protococcus* sp., *Chaetophora* sp. and *Cladophora* sp.) constituted 13.90 and 5.06% by numerical and occurrence methods, respectively. Crustacea (*Cyclops* sp. and shrimp parts) constituted 6.38 and 6.49% by numerical and occurrence methods, respectively, while Bivalvia (*Iphigenia sp*) constituted 4.46 and 1.79%, respectively. Pisces (fish eggs, scales and bones) constituted 1.46 and 1.58% by numerical and occurrence methods respectively, while Annelida (nematode worm) constituted 0.55 and 0.15%, respectively. The least consumed food item in the stomach of *M. cephalus* from the Lagos Lagoon were the

Table 3. The stomach contents of *M. cephalus* from the Lagos Lagoon (February 2004 – January 2006).

Food Items	Numerical method			Occurrence method	
	No	%		No	%
Algae	**1615**	**13.90**		**99**	**5.06**
Spirogyra sp.	630			45	
Oscillatoria sp.	745			36	
Spirulina sp.	40			6	
Cladophora sp.	5			1	
Chaetophora sp.	5			1	
Protococcus sp.	190			10	
Diatoms	**1859**	**16.00**		**80**	**4.09**
Cyclotella sp.	82			13	
Fragillaria sp.	32			4	
Nitzschia sp.	140			16	
Synedra sp.	300			19	
Navicula sp.	480			21	
Epithemia sp.	100			1	
Gyrosigma sp.	725			6	
Desmids	**3**	**0.03**		**2**	**0.10**
Closterium sp.	3			2	
Plant materials	**6652**	**57.24**		**187**	**9.56**
Annelids	**64**	**0.55**		**3**	**0.15**
Nematode	64			3	
Crustaceans	**741**	**6.38**		**127**	**6.49**
Cyclops sp.	701			109	
Shrimp parts	40			18	
Bivalves	**518**	**4.46**		**35**	**1.79**
Iphigenia sp.	518			35	
Pisces (fish bones, eyes, scales)	**170**	**1.46**		**31**	**1.58**
Detritus	**-**	**-**		**877**	**44.81**
Sand grains				516	26.37

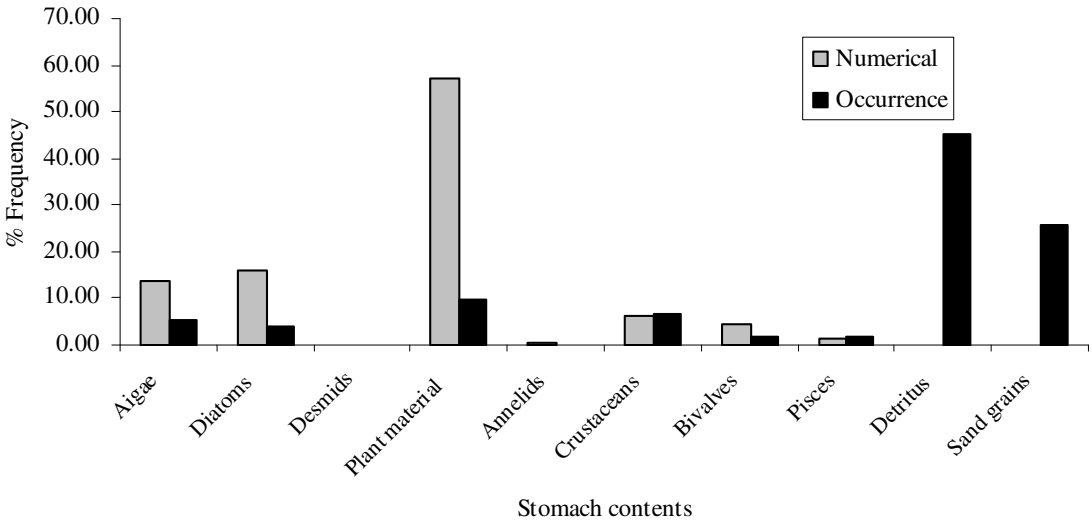

Figure 2. Summary of the stomach contents of *M. cephalus* from Lagos Lagoon (February 2004 – January 2006).

Table 4. The stomach content of *Mugil cephalus* (by size groups) from Lagos Lagoon (February 2004 – January 2006).

Stomach contents	Small-sized fish (4.5 – 12.4 cm) SL				Medium-sized fish (12.5 – 20.4 cm) SL				Large-sized fish (20.5 – 28.4 cm) SL			
	Numerical method		Occurrence method		Numerical method		Occurrence method		Numerical method		Occurrence method	
	No	%	No	%	No	%	No	%	No	%	No	%
Algae	156	8.13	17	3.02	1409	15.8	80	5.8	52	6.3	2	3.5
Diatoms	186	9.7	11	1.95	1658	18.6	64	4.6	35	4.2	5	8.8
Desmids	-	-	-	-	3	0.03	2	0.1	-	-	-	-
Plant materials	1232	64.2	61	10.8	4710	53.0	168	12.1	710	85.6	3	5.3
Annelids	-	-	-	-	64	0.7	3	0.2	-	-	-	-
Crustaceans	206	10.7	41	7.3	515	5.8	84	6.1	15	1.8	2	3.5
Bivalves	131	6.8	6	1.1	387	4.4	29	2.1	-	-	-	-
Fish parts	7	0.4	3	0.5	146	1.6	28	2.0	17	2.1	3	5.3
Detritus	-	-	257	45.7	-	-	590	42.6	-	-	31	54.4
Sand grains	-	-	167	29.7	-	-	338	24.4	-	-	11	19.3
	1918		**563**		**8892**		**1386**		**829**		**57**	

SL = Standard length.

desmids (*Closterium* sp.) and constituted 0.03 and 0.10% by numerical and occurrence methods, respectively.

Detritus were the most eaten food items. They were most prominent and abundant by occurrence method. They were present in highest percentage throughout the study period in the Lagos Lagoon. The percentage of sand grains ingested by this fish species is high using the occurrence method. Plant materials are the food items next in abundance after the detritus and sand grains by both the numerical and occurrence methods. They occurred during the study period except in February, April, May, September, October and December 2004, March, April, and June 2005. Desmids constituted the least consumed food item both by occurrence and numerical methods occurring only in March 2004. By numerical method, plant materials were the most abundant food item of *M. cephalus* in the Lagos Lagoon during the study period.

Other food items of importance consumed by this fish included the diatoms (with *Navicula* sp., *Gyrosigma* sp., *Synedra* sp. and *Nitzschia* sp. more abundant), which were more abundant than the algae by number but less important by occurrence. *Oscillatoria* sp. and *Spirogyra* sp. were the most abundant algae. The crustaceans (copepods and shrimp parts) were more abundant by occurrence than by numbers, with the copepod, *Cyclops* sp. being more prominent. The bivalves (shells of the false donax, *Iphigenia* sp.) were more in abundance by both numerical and occurrence methods than the pisces (fish eyes, shells and eggs). Both bivalves and fish parts were consumed at few times during the study period. Annelids (nematode worm) were very few in abundance with only a little above the desmids both by numbers and occurrence.

Generally, the contents of stomachs showed a clear pattern of distribution of food items with the detritus, plant materials and sand grains occurring in most months during the study period.

Feeding in relation to size

The food in relation to size in the Lagos Lagoon is shown in Table 4. Plant materials constituted the most consumed food item fed on in the three size groups both by numerical (64.2, 53.0, and 85.6%) and occurrence (10.8, 12.1, and 5.3%) methods. Detritus constituted the most occurring item in the stomachs of three size groups of *M. cephalus* from the Lagos Lagoon by occurrence (45.7, 42.6 and 54.4%). Sand grains were next in occurrence to the detritus in the number of stomachs where they are found in the three size groups (29.7, 24.4 and 19.3%). The medium size group fish consumed more food items than the other size groups.

Seasonal variation in stomach contents

The seasonal variation of the stomach contents of *M. cephalus* examined for Lagos Lagoon is presented in Table 5. The fish fed mainly on plant parts both in the rainy and dry seasons. Plant parts consumed were 39.0% by number and 11.0% by occurrence in the rainy season and 53.8% by number and 11.5% by occurrence in the dry season. The diatoms were next in abundance with 27.9% by number and 2.7% by occurrence in the rainy season and 15.1% by number and 5.6% by occurrence in the dry season. Among the diatoms, *Nitzschia* sp. and *Cyclotella* sp. were abundant in the dry months while *Navicula* sp. and *Fragilaria* sp. Predominated in the rainy season. *Synedra* sp. occurred between

Table 5. Summary of the seasonal variation in the stomach contents of *M. cephalus* from Lagos Lagoon (June 2004 – May 2005).

Stomach content	Rainy season (June 2004 – November 2004)				Dry season (December 2004 – May 2005)			
	Numerical method		Occurrence method		Numerical method		Occurrence method	
	No	%	No	%	No	%	No	%
Algae	237	19.0	19	3.9	18	1.4	3	0.6
Diatoms	347	27.9	13	2.7	193	15.1	27	5.6
Desmids	-	-	-	-	-	-	-	-
Plant materials	486	39.0	54	11.1	688	53.8	55	11.5
Annelids	-	-	-	-	-	-	-	-
Crustaceans	152	12.2	34	7.0	226	17.7	40	8.3
Bivalves	13	1.0	6	1.2	106	8.3	13	2.7
Fish parts	10	0.8	6	1.2	47	3.7	8	1.7
Detritus	-	-	213	43.7	-	-	219	45.6
Sand grains	-	-	142	29.2	-	-	115	24.0
Total	**1245**		**487**		**1278**		**480**	

April and June. *Gyrosigma* sp. occurred only in April 2004.

The algae, *Spirogyra* sp., was most abundant in the dry and rainy months. *Spirulina* sp. occurred in November 2004, while *Protococcus* sp., *Cladophora* sp. and *Chaetophora* sp. occurred in April 2004. The copepod crustacean was most commonly found in the stomach of *M. cephalus* than shrimp parts both in the dry and rainy seasons. Bivalve shells were more abundant in the dry season than in the rainy season. Nematode worm was the only annelid found in the stomach of *M. cephalus* in April 2004. Desmids occurred only in March 2004.

However, detritus was most abundant by occurrence both in the rainy season (43.7%) and in the dry season (45.6%).

DISCUSSION

The percentage of empty stomachs was as high as 41.9% (783 specimens) in the present investigation. Odum (1970) cited by Wells (1984) highlighted that the average retention time of food for grey mullet was 4 – 5 h. Many mullet are therefore likely to have digested their food while held in the nets. Also, some fish may have disgorged their food following capture. Consequently, the degree of fullness in stomachs of mullet is unlikely to represent the intensity of feeding.

In this present study, *M. cephalus* fed mainly on algae, diatoms, plant materials, desmids annelids, crustaceans, bivalves, fish parts, detritus and sand grains. Plant materials were the most abundant food item in the diet of *M. cephalus* from the Lagos Lagoon by number while detritus was most abundant by occurrence. Odum (1970) cited by Wells (1984) hypothesized that grey mullet show a distinct preference for live plant material (algae) over plant detritus when both are plentiful. Whereas, Wells (1984) suggested that grey mullet in the areas studied - Waikato River and Lake Waahi, showed little or no preference for algae over macrophyte detritus, and that their diets reflected the availability of these food types in the two environments. In relation to size, the trend among the three size groups of grey mullets from Lagos Lagoon remained unchanged. This followed the same trend in the seasonal variation of the stomach, contents of *M. cephalus* from the Lagos Lagoon. It is noteworthy that an appreciable amount of sand grains was also ingested by the fish during feeding as found in the stomach of the fish, and these were next in abundance by occurrence to the detritus both in relation to size and season. Thompson (1966) cited by Wells (1984) agreed that sand grains were found throughout the alimentary canal of mullets, and those helped in the trituration of food in the gizzard-like pyloric stomach. The proportion of sand and detritus in the gut of juveniles increased with length, indicating that they tend to take more food from the bottom as they grow older. Adult striped mullet have been described as herbivorous, detritivorous and “interface” feeders. The diet and feeding behaviour of mullet may vary by location, but their major foods are epiphytic and benthic microalgae, macrophyte detritus, or inorganic sediment particles (Collins, 1985). Wells (1984) noted that the grey mullet *M. cephalus* fed all year despite temperatures ranging from 7 – 26^{o}C on a wide range of algal species, some macrophyte detritus, inorganic particles and occasionally the snail, *Pota-mopyrgus antipodarum* in two freshwater habitats in New Zealand.

Blay (1995) noted that the diet of four juvenile mugilid fishes (*Liza falcipinnis, L. dumerili, Mugil bananensis* and *M. curema*) consisted mainly of bacteria, diatoms, blue/green algae, protozoan, detritus and particulate organic matter. No seasonal changes in the diet and feeding activities were observed. Quartz grains were the predominant material found in the stomach of *M. cephalus*

from Mauritanian coast, together with small portions of benthic diatoms and 'flakes' aggregates of fine-grained inorganic and organic particles (Michaelis, 1993). Mullet commonly feed by sucking up the top layer of sediment, which is rich in detritus and micro-algae, primarily diatoms and by grazing on epiphytes and epifauna from sea grasses and other substrates. This is similar to the findings in this present investigation. They also ingest surface scum when large concentrations of micro-algae are present at the air-water interface and swarming polychaetes (*Nereis succinea*) in the water column.

Quartz-like grains, dark-coloured grains and scum were noted in the stomach of *M. cephalus* from Lagos Lagoon during this investigation. Ching (1977) pointed out that the protruding and suctorial mouth of the fish is adapted for bottom sediments. The efficient filtering device formed by the modified gill rakers and pharyngeal teeth select the minute components. Consumption of food by the grey mullet, *Liza malinoptera*, may not only be influenced by the mechanics of the filtering device but also by the numerous taste buds which led to the rejection of faunal organisms.

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