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# Feeding Ecology, Length-Weight relationship and Condition Factor of *Mugil cephalus* (Pisces: Mugilidae; Linnaeus, 1758) From Cross River Estuary, Nigeria

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**Abstract:**

*This study was conducted to investigate the diet composition, length-weight relationship and condition factor of Mugil cephalus from the Cross River estuary, Nigeria, between May 2009 and July 2009. A total of 210 freshly caught specimens of Mugil cephalus were collected from the catches of the artisanal fisheries from the Cross River Estuary, Nigeria. Results obtained showed an allometric growth pattern for this fish species with a significant linear relationship given by the equation: $TW = 0.0586SL^{2.5631}$ and Log TW = 2.5631LogSL - 1.2318 ($r^2 = 0.5136$, $t = 3.768$, $n = 210$, $P < 0.05$, d.f 208). Variability was observed in the condition factor between months. Mean condition factor highest in May (1.96 ± 0.04) followed by 1.88 ± 0.04 (June) and 1.75 ± 0.05 (July). Mean condition factor (CF) in relation to size class was highest in 10.0 – 12.9 cm size class (2.8 ± 0.02) and lowest in 13.0*

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*– 15.9 cm size class (1.9 ± 0.04). Length frequency distribution of M. cephalus showed that standard length class of 16 – 18.9 cm had the highest frequency of 96 samples, followed by 13.0 – 15.9 cm length class (56), followed by 19.0 – 21.9 length class (39) and 10.0 – 12.9 cm length class (19). A total of 35 different diet components were obtained with numerical abundance of 1709. As a result of the high abundance of Synedra acus (185, 9.65%), copepods (175, 10.24%), Celothrix sp (102, 5.97 %), Mud/sand (102, 5.32%) and Skelotonema costatum (98, 5.97%) in the gut of Mugil cephalus this species was classified as heterotrophy detrivore/invertivore and filter feeder. The occurrence of shrimps (6,031%), fish bones (19,0.99%), copepod legs (37, 1.93%) and fish scales (!6,0.3%) implies that Mugil cephalus is an opportunistic feeder. This study has not only identified Muguil cephalus as a herbivorous feeder but has also provided information for future trophic modeling of the Cross River estuary*

**Key words:** *Mugil cephalus,* Diet composition, Length-weight relationship, Condition factor, Cross River Estuary, Length frequency distribution.

## Introduction

The grey mullet, *Mugil cephalus*, belonging to the family Mugilidae is one of the important food fishes that support the fishery resources of the Cross River Estuary in Nigeria. Its meat quality and taste is highly appreciated by the inhabitants of the estuary. The Mugilids are common faunal components of the West African Coastal waters, supporting subsistent and artisanal fisheries (Isangedighi *et al.,* 2009). In Nigeria, mullets form important proportion of the catches of artisanal or subsistence fishermen in lagoons and rivers and is highly appreciated by the inhabitants of the Cross River Estuary because of its taste and meat quality. The juveniles and adults of the grey mullet are hardy, eurythermal, eurhaline and do not compete for food (Rhema *et al.,* 2002). It feeds on detritus, diatoms, algae and microscopic algae in estuarine waters (McDonough and Wenner, 2003).

The study of the diet and feeding ecology forms a fundamental tool in understanding fish roles within their ecosystems, since they indicate relationships based on feeding resources and indirectly determines the direction of energy flow within an ecosystem (Haji *et al.,* 2003). According to Caddy and Sharp (1986), the most reliable method of determining the nature of biological interactions such as competition and predation among fish species can be obtained by this study. The success of both capture and culture fisheries depend largely on the knowledge of the food and feeding habits of fish which enables the scientist to develop a rational method of exploiting specific population of fishes (Adebisi, 1981). Studies on food and feeding habit is also important for fish nutritionist in the formulation of the dietary needs of fish species both in intensive and extensive culture systems.

The importance of condition factor in fisheries science is related to the growth, health status and feeding intensity in different fish species. Condition factor which compares the wellbeing of a fish is based on the hypothesis that heavier fish of a given length are in better condition (Bagenal and Tesch, 1978). According to Fagade (1979), condition factor decrease with increase in length and also influences the reproductive cycle in fish (Welcome, 1979).

Length –weight relationship (LWR) is another important tool in fisheries science. Among biometric relation in fishes, the length-weight relationship (LWR) are widely presented by authors as useful tools with several applications in the domains of fisheries sciences, population dynamics, ecology and stock assessment (Pauly, 1983). Its importance is pronounced in estimating the average weight at a given length group (Beyer, 1987) and in assessing the relative well being of a fish population (Bolger and Connoly, 1989). In Nigeria, findings on length-weight relationship of fishes have been published by several researchers including King (1996) for Nigeria fresh water fishes, Hart (1997) for *Mugil cephalus* in Bonny Estuary; Diri (2002) *Tilapia guineensis* in Elechi creek, Alfred-Ockiya and Njoku (1995) for mullet in New Calabar River etc.

This study is focused on evaluating the diet composition, length-weight relationship and condition factor of *Mugil cephalus*, which is a fundamental tool in establishing ecological status or trophic status of this species in the ecosystem. However information obtained from this study will provide knowledge for sustainable management of this species in the Cross River Estuary.

## Materials and Methods

### The Study Area Description

This research was carried out in the Cross River estuary, Nigeria, which lies approximately between latitude 4º and 8ºN and longitude 7º30 and 10ºE in the southern part of Nigeria (Eyo *et al.,* 2013a) . It takes its rise from the Cameroon Mountain and meanders westwards into Nigeria and then southward through high rainforest formation before discharging into the Atlantic Ocean at the Gulf of Guinea. The study area has mangrove forest vegetation (Ama-abasi *et al.,* 2004) with climate characterized by long wet season from April to October and a dry season from November to March. Mean annual rainfall is about 2000 mm (Akpan and Offem, 1993). A short dry period known as August break occurs in August. There is usually a cold, dry and dusty period between December and January, referred to as the harmattan season. According to Ama-abasi *et al.,* (2004) and Akpan and Offem, (1993), temperatures generally range from 22ºC in the wet to 35ºC in the dry seasons. Relative humidity is generally above 60% at all seasons, with close to 90% during the wet season (Ama-abasi *et al.,* 2004; Akpan and Offem, 1993).

## Collection and identification of *M. cephalus* species

Two and ten freshly caught specimens of *M. cephalus* were collected between May and July, 2009 from the catches of the artisanal fisheries at Nsidung beach, Calabar, a major landing point of the artisanal fisheries of the Cross River estuary. Samples were transported in ice-packed containers to the Fisheries and Aquaculture laboratory, Institute of Oceanography, University of Calabar, for further analysis (Eyo *et al.,* 2013b). Identification of *M. cephalus* was based on the identification key given by Fischer *et al.,* (1981).

## Measurements of *M. cephalus* biometric indices

Biometric parameters measured for each specimen include: Standard length (SL) and Total weight (TW). Standard length was measured from snout to the end of caudal peduncle. Measurements were taken to the nearest 0.1 cm and 0.1 g using measuring board for standard length and Metlar-2000D electronic weighing balance for total weight (Eyo *et al.,* 2013b).

## Gut content analysis

The fish specimens were dissected and degutted with the aid of a dissecting set. The guts (from Oesophagus to rectum) were tied with thread at both ends to prevent loss of food items. The guts were labeled serially with the fish and preserved in 10% formalin for 3 days according to Bowen and Windell (1978). After three days of preservation, each stomach was cut open and its content washed with clean water and emptied into a petri-dish. Macroscopic food items were identified with the unaided eyes and thereafter, a hand lens, stereo and compound microscope (mg x 10) were used to identify tiny and microscopic food items respectively.

## Data analysis

The stomach contents were analyzed using the following standard methods:

1) Numerical abundance method: The total number of an individual food item in each stomach were counted and summed together for all the stomachs. This was then expressed as the percentage of the total number of all the food items of all the stomachs examined.

   This is: $n_1 + n_2 + n_2$ ..................$n_n$ (Olojo *et al.,* 2003).

2) Percentage relative occurrence method: This was determined according to Onyia (1972) and Job (2006) using the formula

   $\% R_o = n/N \times 100$

   where n=number of individual food item
   N= total number of all food items (diet components)

## Length – Weight Relationship

The relationship between the total length (TL, cm) and weight (g) of fish was established for *M. cephalus* by least square regression using the logarithmic transformed values of the variables for individual specimen. The regression equation is shown below as follows:

Log W = Log a - bLog L (or $w = aL^b$) (Pauly, 1983).

Where w = Ungutted weight of fish (g)
L = Total length of fish (cm)
a = Intercept on log Y-axis
b = Slope of the curve

The exponent (b) of the length-weight relationship was tested for departure from isometry (i.e. b=3) using a t- statistic function given by Pauly (1984) as follows:

$$\hat{t} = \frac{S.d(x)}{S.d.(y)} \quad \frac{|b-3|}{\sqrt{1-r^2}} \quad \sqrt{n - 2}$$

Where S. d. (x) is the standard deviation of log TL values

S.d. (y) is the standard deviation of log W values

n= the number of fish used in the computation

b= the estimated exponent of the length–weight relationship.

$r^2$ = "coefficient of determination" of the relationship.

If $\hat{t}$ calculated is greater than the tabled value of t for degree of freedom; n-2, then the value of b is different from 3, (Pauly, 1984).

## Condition factor

Fulton's condition factor (CF) was calculated using the formula:

$$K = \frac{W \times 100}{TL^3}$$

Where CF = condition factor

W=ungutted weight (g)

TL= total length (cm) of fish specimen (Pauly, 1984)

## Result

## Condition factor of *M. cephalus* from the Cross River Estuary

Condition factor determined for 210 specimens of *M. cephalus* from the Cross River Estuary ranged from 1.12 for fish with standard length (SL-cm) of 17.0 cm and total weight (TW-g) of 55.0g to 2.46 for fish with standard length (SL-cm) of 12.0 cm and total weight (TW-g) of 42.5g with a mean and standard error of 1.87 ± 0.023. Mean monthly condition factor (Table 1 and Figure 1) showed that in May, mean condition factor was 1.96 ± 0.04, mean total length (15.87 ± 0.31 cm) and mean total weight (81.45 ± 3.99 g). In June, mean condition factor was 1.88 ± 0.04, mean total length (15.72 ± 0.28 cm) and mean total weight (76.59 ± 3.96 g). In July, mean condition factor was 1.75 ± 0.05, mean total length (16.64 ± 0.28 cm) and mean total weight (83.58 ± 4.26 g).

**Table 1: Mean Monthly Condition Factor of *M. cephalus* from the Cross River Estuary**

| Month | No. of fish | Mean SL± SE (cm) | Mean TW ± SE (g) | Mean CF ± SE |
|---|---|---|---|---|
| **May** | 70 | 15.87 ± 0.31 | 81.45 ± 3.99 | 1.96 ± 0.04 |
| **June** | 70 | 15.72 ± 0.28 | 76.59 ± 3.96 | 1.88 ± 0.04 |
| **July** | 70 | 16.64 ± 0.28 | 83.58 ± 4.26 | 1.75 ± 0.05 |

*SL = Standard Length in cm, Tw = Total Weight in g, CF = Condition Factor and SE = Standard Error

## Length-Frequency Distribution of *M. cephalus* from the Cross River Estuary

The standard length (SL-cm) of *M. cephalus* from the Cross River Estuary ranged from 12.0 cm to 20.0 cm. Length frequency distribution of *M. cephalus* during (Table 2 and Figure 2) showed that standard length class of 16 – 18.9 cm had the highest frequency of 96 samples, followed by 13.0 – 15.9 cm length class (56 samples), followed by 19.0 – 21.9 length class (39 samples) while 10.0 – 12.9 cm length class had the lowest frequency of 19 samples. Mean condition factor (CF) in relation to length class showed that in 10.0 – 12.9 cm length class, mean condition factor of 2.8 ± 0.02, in 13.0 – 15.9 cm length class, mean condition factor of 1.9 ± 0.04, in 16.0 – 18.9 cm length class, mean condition factor of 2.1 ± 0.03 and in 19.0 – 21.9 cm length class, mean condition factor of 2.0 ± 0.02

**Table 2: Length-Frequency Distribution of *M. cephalus* from the Cross River Estuary**

| Standard length Class Size (cm) | Class mark | Frequency | Mean Condition factor ± Standard Error |
|---|---|---|---|
| **10.0 – 12.9** | 11.45 | 19 | 2.8 ± 0.02 |
| **13.0 – 15.9** | 14.45 | 56 | 1.9 ± 0.04 |
| **16.0 – 18.9** | 17.45 | 96 | 2.1 ± 0.03 |
| **19.0 – 21.9** | 20.45 | 39 | 2.0 ± 0.02 |

## Length – Weight Relationship

The power regression of the Length-Weight relationship of *M. cephalus* (Figure 3) is defined by the equation:

$TW = 0.0586SL^{2.5631}$ ($r^2 = 0.5136$, $t = 3.768$, $n = 210$ and $P < 0.05$)

The linear regression of the logarithm transformed values of length and weight (Figure 4) is defined by the equation:

$\text{Log } TW = 2.5631 \text{Log} SL - 1.2318$ ($r^2 = 0.5136$, $t = 3.768$, $n = 210$ and $P < 0.05$)

The length-weight relationship indicated a positive significant relationship ($P<0.05$) between the length and weight of *M. cephalus* from the Cross River Estuary.

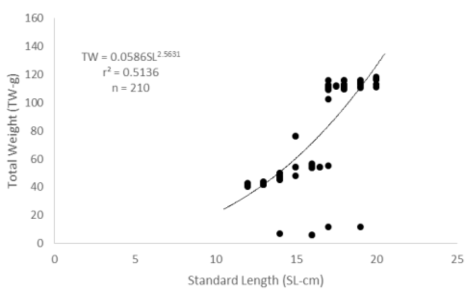


**Figure 3: Length –Weight relationship of *M. cephalus* from the Cross River Estuary, Nigeria.**

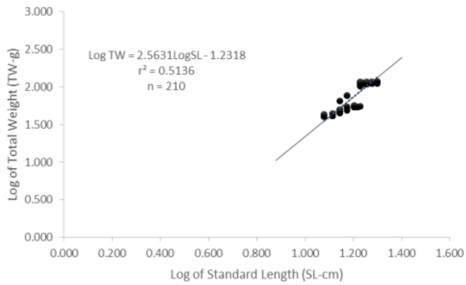


**Figure 4: Log-Log Transformation of Length and Weight of *M. cephalus* from the Cross River Estuary, Nigeria.**

## Food Abundance in the Gut of *M. cephalus* from the Cross River Estuary

A total of 35 different diet components were obtained with a total numerical abundance of 1709 (732-May, 520-June and 457-July). A percentage relative occurrence (RO %) of 100.00 % was obtained, with *Synedra acus* (185, 9.65%) being the most abundant food item, followed by copepods (175, 10.24 %), *Celothrix sp* (102, 5.97 %) and Mud/sand (102, 5.32%). *Skelotonema costatum* (98, 5.97%) was also of high abundant. The least abundant food items were Euglena, *Cyclotella comta* and plant materials (6, 0.35 %). *Nitzchia sp* (7, 0.41 %), *Cossinodiscus sp* (9, 0.53 %) and *Gyrosigma sp* (10, 0.59 %) were also low in abundance. Based on monthly evaluation, *Synedra acus* (67) was the highest abundant food item in May while the least abundant was *Conscinodiscus sp* (2). In June, copepods (114) was most abundant while *Navicula sp* (3) was of least abundant. In July, Copepods (139) had the highest abundance while *Pinnularia borealis* (2) was of least abundant. Table 3 shows the diet components and their numerical abundance in the gut of *M. cephalus* while table 4 shows the numerical abundance and percentage relative occurrence of the diet components of *M. cephalus* from the Cross River Estuary, Nigeria.

**Table 3: Diet components, their numerical abundance in the gut of *Mugil cephalus* (Grey Mullet) form the cross river estuary, (May-July, 2009)**

| S/N | Diet components | Numerical abundance (May, 2009) | Numerical Abundance (June 2009) | Numerical abundance (July 2009) |
|---|---|---|---|---|
| 1 | *Actinocyclus sp* | 9 | - | 17 |
| 2 | *Synedra, acus* | 67 | 49 | 69 |
| 3 | Fish scales | 11 | 5 | - |
| 4 | *Oscilatoria rubiscens* | 44 | 8 | - |
| 5 | *Lynbya sp* | 44 | - | - |
| 6 | *Melosira granulate* | 50 | 18 | 18 |
| 7 | *Gymnodinium sp* | 5 | - | 13 |
| 8 | *Navicula sp* | 16 | 3 | - |
| 9. | *Celothrix sp* | 56 | 32 | 41 |
| 10 | Copepods | 48 | 114 | 13 |
| 11 | *Spirogyra sp* | 30 | 7 | 16 |
| 12 | *Pleurosigma sp* | 56 | 12 | - |
| 13 | *Cocconeis sp* | 10 | - | 7 |
| 14 | *Surrivella Ovalis* | 17 | 13 | 19 |
| 15 | *Spirulina sp* | 10 | - | 7 |
| 16 | Mud/sand particles | 44 | 35 | 23 |
| 17 | *Cymbella sp* | 7 | - | 6 |
| 18 | *Nitzchia sp* | 7 | - | - |
| 19 | *Cyclotella comta* | 6 | - | - |
| 20 | *Scenedesmus sp* | 18 | 11 | 12 |
| 21 | *Bidulphia sinensis* | 6 | 11 | 9 |
| 22 | *Pnnularia borealis* | 19 | 19 | 2 |
| 23 | *Triceratium sp* | 14 | 6 | 7 |
| 24 | Coscinodiscus sp | 2 | - | 7 |
| 25 | *Skeletonema Costatum* | 18 | 15 | 65 |
| 26 | *Gyrosigma sp* | 10 | - | - |
| 27 | *Euglypha sp* | 18 | 64 | 9 |
| 28 | Crab finger | 9 | 32 | 31 |
| 29 | Cladoceran | 27 | 8 | - |
| 30 | Fish bones | 11 | 34 | 16 |
| 31 | *Trachelomonas sp* | 17 | 8 | 3 |
| 32 | Copepod legs | 26 | 10 | 27 |
| 33 | Euglena | - | - | 6 |
| 34 | plant materials | - | - | 6 |
| 35 | Shrimps | - | 6 | 8 |
| | **TOTAL** | **732** | **520** | **457** |

**Table 5: Numerical Aabundance and Percentage Relative Occurrence of the diet components of *M. cephalus* (Grey Mullet) from the Cross River Estuary, Nigeria**

| S/N | Diet components | Numerical abundance | Percentage Relative occurrence (%) |
|---|---|---|---|
| 1 | *Actinocyclus sp* | 26 | 1.52 |
| 2 | *Synedra, acus* | 185 | 10.83 |
| 3 | Fish scales | 16 | 0.94 |
| 4 | *Oscilatoria rubiscens* | 52 | 3.04 |

| | | | |
|---|---|---|---|
| 5 | *Lynbya sp* | 44 | 2.57 |
| 6 | *Melosira granulate* | 86 | 5.03 |
| 7 | *Gymnodinium sp* | 18 | 1.05 |
| 8 | *Navicula sp* | 19 | 1.11 |
| 9. | *Celothrix sp* | 129 | 7.55 |
| 10 | Copepods | 175 | 10.24 |
| 11 | *Spirogyra sp* | 53 | 3.10 |
| 12 | *Pleurosigma sp* | 68 | 3.98 |
| 13 | *Cocconeis sp* | 17 | 0.99 |
| 14 | *Surrivella Ovalis* | 49 | 2.87 |
| 15 | *Spirulina sp* | 17 | 0.99 |
| 16 | Mud/sand particles | 102 | 5.97 |
| 17 | *Cymbella sp* | 13 | 0.76 |
| 18 | *Nitzchia sp* | 7 | 0.41 |
| 19 | *Cyclotella comta* | 6 | 0.35 |
| 20 | *Scenedesmus sp* | 41 | 2.40 |
| 21 | *Bidulphia sinensis* | 26 | 1.52 |
| 22 | *Pnnularia borealis* | 40 | 2.34 |
| 23 | *Triceratium sp* | 27 | 1.58 |
| 24 | Coscinodiscus sp | 9 | 0.53 |
| 25 | *Skeletonema Costatum* | 98 | 5.73 |
| 26 | *Gyrosigma sp* | 10 | 0.59 |
| 27 | *Euglypha sp* | 91 | 5.32 |
| 28 | Crab finger | 72 | 4.21 |
| 29 | Cladoceran | 35 | 2.05 |
| 30 | Fish bones | 61 | 3.57 |
| 31 | *Trachelomonas sp* | 28 | 1.64 |
| 32 | Copepod legs | 63 | 3.69 |
| 33 | Euglena | 6 | 0.35 |
| 34 | Plant materials | 6 | 0.35 |
| 35 | Shrimps | 14 | 0.82 |
| | **Total** | **1709** | **100.00** |

## Discussion

In fisheries science, length- weight relationship provides a reliable data on the relative well-being and growth patterns of fish. The regression coefficient obtained from length-weight relationship (LWR) indicates the pattern of growth (isometric or allometric growth pattern) in fish which varies between stocks of same species. In this study, the values obtained for the length –weight relationship parameters (b=2.61, a=-1.28, t=3.768, $p<0.05$), showed that *M. cephalus* from the Cross River Estuary exhibit negative allometry in respect to growth pattern implying that they tend to become thinner with increasing length. The implication of this findings is that some conventional fish population dynamic models which assumes isometry in fish growth (b = 3) cannot be used in analyzing the population of this species. The negative allometric growth pattern reported in this study is similar to findings of other authors such as King (1996) who reported a negative allometric function (b=2.99) for Nigerian freshwater fishes and Torres (1991) who reported a negative allometry (b<3) in multi-species study. Findings obtained for growth parameters of different fish species in tropical water bodies indicates that growth pattern in fish varies with species. King (1991) reported allometric grwoth patterns in Tilapia species for Umuoseriche Lake, King (1996) reported isometric grwoth for *Pseudotolithus elongatus* from Qua Iboe estuary and Abowei and Hart (2009) reported positive allometric growth (b=3.6 and 3.5) for S. *maderensis* and C. *senealensis* respectively. More studies showed allometric growth in three Cichlids (*C. guntheri, T. mariae and Hemischromis fasciatus*) in Owa stream, South-West Nigeria (Olurin and Soluba, 1989). Variations in the growth parameters observed in different fish species may be attributed to developmental stage, sex, maturity, season and harsh environmental conditions (Lagler et al., 1997). Condition factor in fish could be used to evaluate the physiological state of the fish in relation to its welfare. In this study, mean condition factor was observed to vary with month and length class. Based on monthly comparison, mean condition factor was highest in May (1.96 ± 0.04) and lowest in July (1.75 ± 0.05) and based on length class comparison, mean condition factor was highest in 10.0 – 12.9 cm size class (2.8 ± 0.02) and lowest in 19.0 – 21. 9 cm size class (2.0 ± 0.05). The variations in condition factor obtained for monthly and size class evaluation for *M. cephalus* in this study may be attributed to accumulation of fat as a result of availability of food items (Abowei and Hart, 2009) and poor environmental conditions (Haruna and Bichi, 2005). According to Atobatele and Ugwumba (2011), low condition factor in fish may be attributed to reduced availability of food and prey items. According to Asuquo et al., (2012), studying fish diet is a major topic in the area of fish biology because it is the basis of establishing the ecological status of a given fish. Gut content analysis showed that a total of 35 different diet components were obtained with a total numerical abundance of 1709 (732-May, 520-June and 457-July). *Synedra acus* (185, 9.65%) was the most abundant food item, followed by copepods (175, 10.24 %), *Celothrix sp* (102, 5.97 %), Mud/sand (102, 5.32%) and *Skelotonema costatum* (98, 5.97%). The least abundant food items obtained in this study were Euglena, *Cyclotella comta* and plant materials (6, 0.35 %), *Nitzchia sp* (7, 0.41 %), *Cossinodiscus sp* (9, 0.53 %) and *Gyrosigma sp* (10, 0.59 %). This findings implies that *M. cephalus* can be classified as a heterotrophic species feeding on different types of food. However, this findings is similar to Soyinka (2008); Goldstein and Simon (1999) who classified *M. cephalus* as detritivoe/invetivore and filter feeder. Also, Etnier and Starners (1993) classified juvenile *M. cephalus* (<30mm) primarily as carnivores feeding on small invertebrates such as copepods and insect larvae. Odum (1970) and Ross (2001) termed this species as "Interface feeders" feeding at surface boundaries such as air-water, plant-water, or mud-water interfaces by sucking up the surface layer of mud, grazing on diatoms or algae attached to plant surface. The occurrence of shrimps, fish bones, copped legs, and fish scales (16,0.83%) in this study reveals the oppotunistic feeding habit of *M. cephalus* and this observation is similar to findings of Bishop and Miglarese (1978) who reported that this species was an opportunist. The preference shown by a species to a diet component is a biological strategy which discourages competition for available food resource within a species (Olojo et al, 2003, Job and Udo, 2002). Hence the absence of a particular food item in the gut of *M. cephalus* at one stage and the re-appearance at another stage is a common biological phenomenon in food and feeding ecology of both shell and fin fishes in their natural habitats.

## Conclusion

In conclusion, the study of diet composition of fish species is an important tool employed in the evaluation of the food and feeding ecology of fish species, thus findings obtained from this study will provide information for future trophic modelling of the Cross River Estuary.

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