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Aspects of the biology of grey mullet, *Mugil cephalus,* in Lagos lagoon, Nigeria

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Abstract. Investigations were conducted in Lagos lagoon, Nigeria between February 2009 and January 2010 on the biological aspects of grey mullet, *Mugil cephalus* with aim that information obtained from the study will contribute to the baseline data for carrying future studies on its ecology and conservation and development of its fisheries in this water body in particular and the Gulf of Guinea in general. *M. cephalus* is a commercially valued fish in Nigeria and a member of the Family Mugilidae. It is a catadromous fish species and widely reported in fresh, estuarine and brackish waters. In this study, the occurrence of this fish was both seasonal and salinity dependence with highest occurrence of 29.04% of the total catch when salinity was 20%o. 1^+, 2^+ and 3^+ years' old age classes were encountered. Fish ranged between 9.0 and 32.0 cmTL and weighed 12 and 345gBW respectively. The length-weight relationships were estimated as LogW= -11.551+ 2.968 Log L (r=0.001) for males and LogW= -11.249 + 2.929 Log L(r=0.993) for females. The estimated growth parameters of the von Bertanlaffy equation $L\infty$ =37.0 (±0.22) cm, K = 0.22.year^{-1}, and t_o = -1.8 year. The pattern of growth was near isometric with b=2.98 and 2.926 for males and females respectively. The diet composition of this species included nine (9) groups of food items. Occurrences of the diets varied monthly. The most foods were organic detritus and sand grains occurring in 40.60 and 85.66% of the stomachs respectively. The presence of algae in the stomachs was an indication of herbivorous habit of this fish, while occurrence of protozoans, crustaceans, nematodes, chaetognaths, and juveniles of other fish was indication of its carnivorous tendency, however, presence of detritus presumed the fish as an omnivore. The overall sex ratio was 1 male to 1.09 female. A chi-square revealed a significant departure from the theoretical 1:1 sex ratio (X^2 =17.662 > $X^2_{1,\ 0.05}$=3.84). Fecundity varied from 620,320 to 1, 082, 200 eggs (801,300 ±2,000 eggs) for fish measuring 20.1 cm TL(60.3gBW) and 32.0cmTL (345gBW) respectively. In this study the biological aspects of grey mullet, *M. cephalus* in Lagos lagoon were discussed.
Keywords: abundance, von Bertalanffy, asymptotic, detritus, estuarine.

Résumé. Des enquêtes ont été menées dans la lagune de Lagos, au Nigeria, entre Février 2009 et Janvier 2010 sur les aspects biologiques de mulet, Mugil cephalus avec l'objectif que les informations obtenues de l'étude contribueront à les données de base pour la réalisation de futures études sur l'écologie et la conservation et le développement de ses activités de pêche dans cette masse d'eau en particulier et le golfe de Guinée en général. M. cephalus est un poisson d'une valeur commerciale au Nigeria et membre de la famille Mugilidae. C'est une espèce de poissons catadromes et largement rapportés dans l'eau douce, les eaux estuariennes et les eaux saumâtres. Dans cette étude, la présence de ce poisson est à la fois saisonnières et de la dépendance de la salinité avec la plus grande présence de 29,04% du total des captures, lorsque la salinité était de 20% o. classes 1 +, 2 + et 3 + ans de vieillesse ont été rencontrées. Les poissons variaient entre 9,0 et 32,0 cmTL et pesait 12 et 345gBW respectivement. Les relations longueur-poids ont été estimées comme LogW = -11.551 + 2,968 log L (r = 0,001) pour les hommes et LogW = -11.249 + 2,929 log L (r = 0,993) pour les femelles. Les paramètres de croissance estimés de l'équation de von Bertanlaffy L ∞ = 37,0 (± 0,22) cm, K = 0.22.year^{-1}, et = -1,8 années. Le modèle de croissance a été proche isométrique avec b = 2,98 et 2,926 pour les hommes et les femmes respectivement. La composition du régime alimentaire de cette espèce comprend neuf (9) groupes de produits alimentaires. Occurrences de l'alimentation variée mois. La plupart des aliments ont été détritus organiques et des grains de sable se produisent dans 40,60 et 85,66% des estomacs, respectivement. La présence d'algues dans l'estomac est une indication de l'habitude herbivores de ce poisson, tout en présence de protozoaires, crustacés, nématodes, chaetognathes, et les juvéniles de poissons autre indication de sa tendance carnivores, cependant, la présence de détritus présumée du poisson en tant que omnivore. Le sex-ratio global était à 1,09 1male femmes. Un chi-carré a révélé un écart important par le sex-ratio 1:01 théorique (X^2 = 17,662> $X^2_{1,\ 0,05}$ = 3,84). La fécondité varie de 620.320 à 1.082.200 d'œufs (801.300 ± 2.000 œufs) pour les poissons de mesure 20.1cmTL (60.3gBW) et 32.0cmTL (345gBW) respectivement.
Dans cette étude, les aspects biologiques de mulet, M. cephalus dans la lagune de Lagos sont donc examinees.
Mots-clés: abondance, von Bertalanffy, asymptotique, de détritus, d'estuaire.

Introduction. Grey mullet, *Mugil cephalus* (Linnaeus, 1758), is a member of the Family Mugilidae occurring in the fresh, brackish, hypo saline lagoons and coastal marine waters of shallow depth of less than 20 meters (FAO 1990). It forms one of the important fisheries of tropical and subtropical regions. Of recent there are dearths of information on *M. cephalus*, most of the reviews though may be old are still relevant when investigating or discussing this fish. Its abundance in waters according to Kurian (1975) is related to their food and feeding habits. Aspects of its biology was documented by De Silva & Pereira (1976), Payne (1976), De Silva & Wijeyaratne (1977), De Silva & Silva (1979), De Silva (1980), Lee & Menu (1981), Arruda et al (1991), and Njoku & Ezeibekwe (1996). Effects of salinity on life history, growth, physiology, and habitat selection of this fish were variously discussed by Walsh et al (1989, 1991), Lee & Menu (1981), Murashige et al (1991), Lee et al (1992), and Cardona (2000). Some related species are *M. curema, Liza falcipinnis* and *L. grandisquamis.* Various techniques have been used to validate age in fishes in tropical water including Lagos lagoon (Bayagbona 1969; Tobor 1969; Kusemiju 1973; Fagade 1973; Warbuton 1978; Ezenwa & Kusemiju 1981; Kendall et al 2010. Ageing fish through otolith was investigated by Geffen (1986) and Pawson (1990), and by observations of other hard parts such as spine, dentary bone section, and vertebrae bone (Pantulu 1961; Penella 1971; Campana & Nielson 1985; Hoffnagle & Timmons 1989). Statistical analyses for ageing fish and length frequency data as distribution mixture was reported by Fagade & Olaniyan (1972), Rengaswamy (1973), Macdonald & Pitcher (1979), Schnute & Fournier (1980), Rosenberg & Beddington (1987), Sheperd (1987), Sparre (1987), and Morales-Nin & Ralston (1990), Schnute & Fournier (1980). Rosenberg & Beddington (1987) introduced the von Bertalanffy growth function to estimate growth parameters. Several methods were used by Hyne (1950), Luther (1962), Widell (1968), and Hyslop (1980) to provide quantitative descriptions of the diet of fish. The foods such as microalgae (Thomson 1966), algae and diatom (Das 1977s), detritus and algae (Payne 1976), foraminifera, benthic diatom, polychaetes, molluscs, ostracods and debris (Rengaswamy 1973; Farrugio 1976) were reported in the stomachs of grey mullet. The food and feeding habits of this species differ in time and space (De Silva & Wijeyaratne 1977).

Recent information relating to grey mullet, *M. cephalus* is scanty in Gulf Guinea with special emphasis on Lagos lagoon in Nigeria, therefore we decided to carry out an investigation of aspects of its biology with particular references to its occurrence, age determination, growth patterns and food and feeding habits and reproduction in the lagoon. This study will be part of baseline data for carrying out future investigations into ecology, conservation and fisheries of this and other fishes in this water body.

Study Area. Lagos lagoon (Figure 1) in Nigeria is located at longitudes 3°20′ and 3°50′W and latitudes between 6°24′ and 6°36′N. It is the largest lagoon system occurring in West African coast, covering 208 km^2. It is fed in the north by Ogun River, the southern margin is bounded by five cowries and Badagry creeks, and in the east by Lekki and Epe lagoons. Most reviews on the lagoon were based on biological aspects of non-related genera such as *Tilapia* (Fagade 1969); *Chrysichthys* (Kusemiju 1973; Ezenwa & Kusemiju 1981); *Elop* (Ugwumba 1984) and *Mugil* (Lawson 1998). Collection sites for this study were Oko Baba located in the west, Ibese in the north and Ilubinrin in the south of lagoon.

Materials and Methods. 737 Specimens of grey mullet, *Mugil cephalus* were caught from Lagos lagoon between February 2009 and January 2010. Gears used for their collected included cast nets (12-22 mm mesh sizes) for collecting specimens from shallow waters (0-6mm), gill nets (18-45mm mesh sizes) for collection of specimens at depths not exceeding 25mm and two motorized canoes as crafts. Services of local fishermen were also employed. Samples of water were collected in sampling bottles at every trip.

In the laboratory, specimens were fixed in 4% formaldehyde solution prior to further analysis. Biometric data such total length (TL) to the nearest 1 mm and body weight (W) to nearest 0.01g on individual specimen were collected. Salinity of water was determined by salinometer.

Occurrence of the fish in the lagoon was determined monthly by from the pool of the weekly collections.

Age was determined from the analysis of the length frequency data (Petersen method) and the modal length progression method (Pauly 1980).

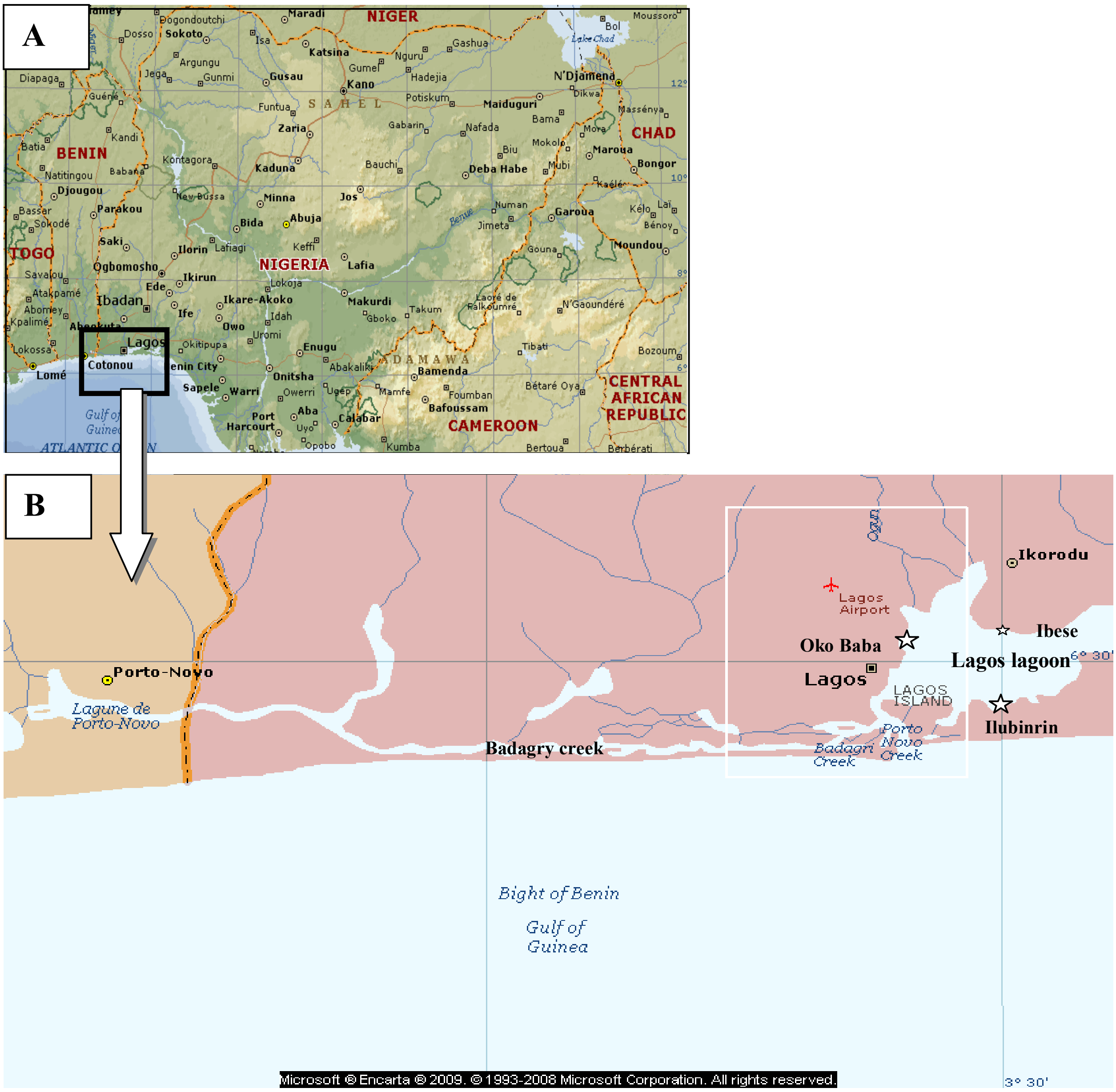

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Figure 1. (A) The Administrative map of Nigeria; (B) Inset Lagos lagoon complex (collection sites marked ☆).

The von Bertalanffy function $L_t = L\infty\ (1-e^{-k(t-to)})$ was used to describe growth in size (for TL), where L_t is the total lenght of fish (cm) at age t; K is the rate at which the growth curve approches the asymptote; $L\infty$ is the asymptotic lenght in cm; and t_o is the theoretical time at which the fish lenght is zero (Erkoyuncu 1995). Length - weight relationship of the fish was represented by equation, W=a+bL (Le Cren 1951). Parameters 'a' and 'b' were estimated from non-linear least squares regression and transformed into a linear form by logarithm transformation: LogW= a + bLog L where, W=body weight of fish (g), L=total length measurement of fish (cm). Confidence intervals of 95% were calculated for b to see if these were statistically different from 3.

The analysis of the food items of the fish was undertaken by both numerical and frequency of occurrence methods according to Hyne (1950), Hyslop (1980), Wootton (1990) and Lawson (2004).

Sex of mature specimens was determined by naked eye, while macroscopic examination was done for immature specimens. Sex ratios were tested with Chi-square analyses (X^2). Stages of gonadal maturation were determined. Female gonads at ripe stage were preserved in Bouins fluid for 7 days for fecundity study. Eggs were washed after their separation from the ovarian wall. Estimation of fecundity was carried out by volumetric method according to Bagenal (1978).

Results. Summary of monthly percentage of occurrence of *M. cephalus* is presented in Table 1. In Lagos lagoon, salinity varied between 2 and 20%o, representing low and high brackish waters respectively. The occurrence of this species was salinity dependent. 29.04% of the 737 specimens were caught in April 2009 when water salinity was 20%o. However, in August 2009 at 2%o, the percentage of occurrence of fish was 1.36%. High percentages of fish were caught between February and May 2009 when the salinities were high. At salinities 2 and 3%o in September, October and November, 2009 there was no specimen.

Table 1

Monthly percentage of occurrence of *M. cephalus* in Lagos lagoon, Nigeria

Month	*Year*	*Salinity (%o)*	*% total catch per month*	*Small (9.0-14.9 cmTL)*	*Medium (15.0-23.9cmTL)*	*Large (24.0-32.0 cmTL)*
February	2009	10	18.45	20.59	64.71	14.71
March		15	15.6	10.44	64.34	25.22
April		20	29.04	29.44	50.47	20.09
May		16	12.62	24.73	53.76	21.51
June		4	9.50	22.86	57.14	20.00
July		2	3.12	34.78	43.48	21.74
August		2	1.36	20.00	30.00	50.00
September		2	-	-	-	-
October		2	-	-	-	-
November		3	-	-	-	-
December		7	5.7	42.86	35.71	21.43
January	2010	9	4.61	14.71	64.70	20.59
			n=737	23.75%	32.72%	20.63%

* n =sample size

Specimens were classified into three size groups in Lagos lagoon. Small fish measured between 9.0 and 14.9cmTL, medium ranged from 15.0 and 23.9cm TL and large, 24 to 32.0cm. They constituted 23.75, 32.72 and 20.63% of the catch respectively. The medium fish dominated except in the months of August and December when large (50.0%) and small (42.86%) specimens dominated.

In this study males ranged between 10.0 and 30.0cmTL, and females from 10.0 to 32.0 cmTL. The length frequency histograms (Figure 2) presented 1^+, 2^+ and 3^+ years old age classes with modal TL values of 14.0, 24.0 and 32.0 cm respectively. The most dominant group was 1^+ year old fish while 2^+ and 3^+ year old classes were fewer in number.

The von Bertalanffy growth parameters from the polygons of the frequency distribution (Figure 3) showed modal classes of 12.0, 17.0 and 21.0cm mean TL. The theoretical maximum length, L∞; rate at which this size was attained, K; and the hypothetical time at which the size of the fish will be zero, t_o were thus 37.0 (SE=0.26) cm, 0.22.year^{-1}and–1.8 year respectively.

The length-weight relationships for the species were Log W = -11.551 + 2.968 Log TL (r = 0.991) (Figure 4) for males and Log W = -11.249 + 2.926 Log TL (r = 0.993) (Figure 5) for females. The 'b' values males and females were nearly isometric (b=3.0). The correlation coefficient 'r' values of the length-weight relationships were very high for both sexes.

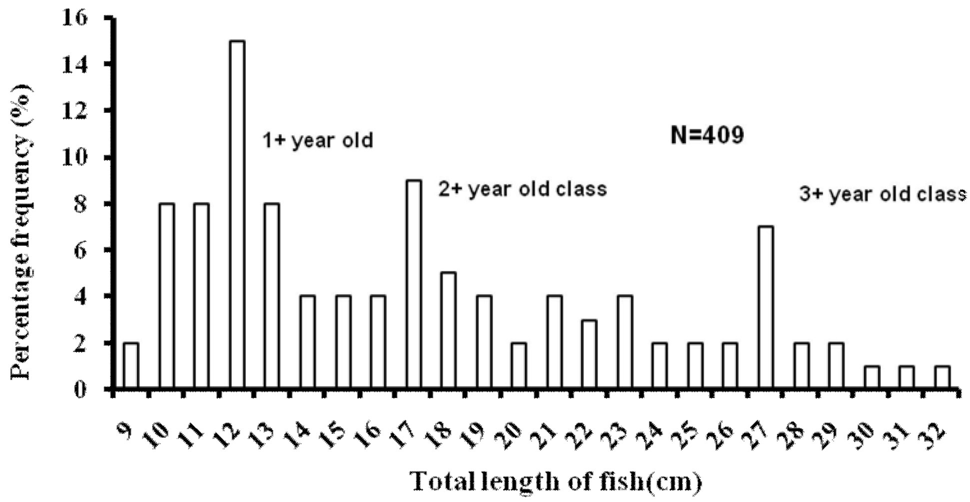

Figure 2. Histograms showing Length-Frequency distribution of *M. cephalus* in Lagos lagoon, Nigeria.

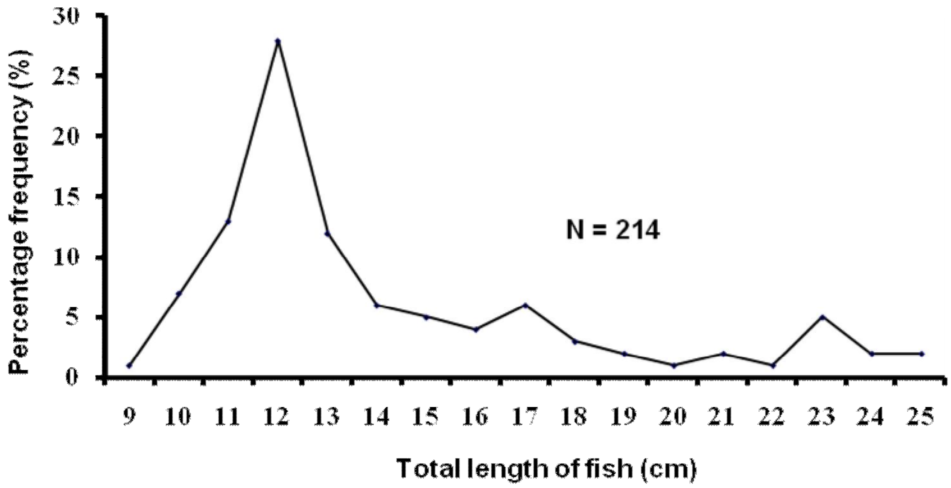

Figure 3. Growth curves of *M. cephalus* obtained from Pauly's method (data adapted from April 2009 catch)

A summary of the composition of food items of *M. cephalus* is presented in Table 2. Of the total catch 579 specimens were found with various food items. The foods were classified into nine (9) groups. The major foods included algae, protozoans, crustaceans, detritus (both organic and inorganic) and nematodes, however, the minor foods were fish scales, and chaetognaths. Some unidentified food masses were also encountered.

The organic detritus accounted for 24.30% and 40.60% by number and occurrence respectively. The inorganic detritus (sand grains) constituted 60.23% by number and occurred in 85.66% of the stomachs. The diatoms constituted 6.62 and 30.17% by number and occurrence methods, the filamentous algae accounted for 0.09% by number and occurred in 13.78% of the stomachs. *Radiolaria, Calanus, Sagitta sagitta* and fish scales accounted for 0.02, 0.10, 0.02 and 0.04% by number and 1.06, 18.62, 0.56 and 9.50% by occurrence methods respectively. The unidentified food masses contributed 0.60% by number and occurring in 18.62% of the stomachs with foods respectively.

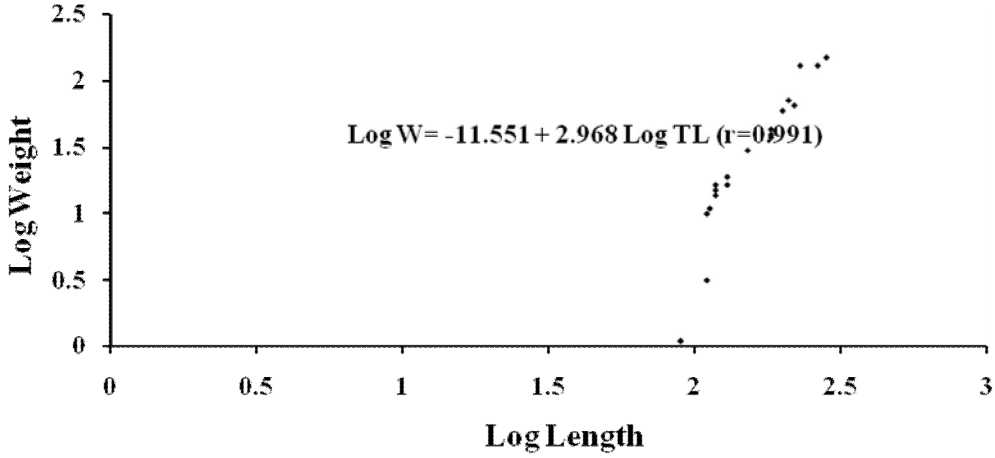

Figure 4: Log Lenght -Log Weight Relationship for male *M. cephalus* in Lagos lagoon, Nigeria.

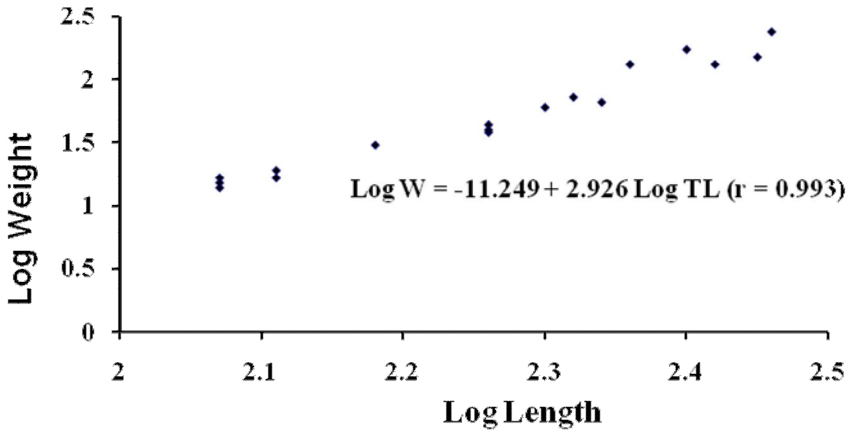

Figure 5: Log Length-Log Weight relationship for Female *M. cephalus* in Lagos lagoon, Nigeria.

Table 2

Summary of composition of food items of 579 stomachs of *M. cephalus* in Lagos lagoon, Nigeria

Food item	*Numerical method*		*Occurrence method*	
	Number	*%*	*Number*	*%*
ALGAE				
Diatom	8321	6.62	162	30.17
Filamentous algae	113	0.09	74	13. 78
PROTOZOA				
Tintinopsis sp	9706	7.72	178	33.15
Radiolaria	22	0.02	6	1.06
CRUSTACEA				
Calanus species	128	0.10	100	18.62
Crustacean broken parts	33	0.03	9	1.68
NEMATODA	150	0.12	148	27.56
CHAETOGNATHA				
Sagitta sagitta	29	0.02	3	0.56
PISCES				
Fish scale	47	0.04	51	9.50
ORGANIC DETRITUS				
Decayed plant materials	30, 560	24.30	218	40.60
INORGANIC DETRITUS				
Sand particles	75, 912	60.36	460	85.66
UNIDENTIFIED FOOD MASS	751	0.60	100	18.62

A summary of the monthly percentage variation (by number) in the relative abundance of the food items of the species is given in Table 3. The plant materials and sand grains were the most eaten items. The former constituted between 8.36 and 44.25% while the latter between 31.23 and 77.42%. However, the unidentified food masses constituted between 0.15 and 10.99%. These items were present except between September and October 2009. Nematode worms (0.01 - 0.47%) were absent in June, September, October, and November 2009. *Diatom* (0.36 – 20.13%), filamentous algae (0.01 – 0.21%), *Tintinopsis* (0.05 – 20.50%), *Sagitta sagitta* (0.01-0.09%) and broken parts of crustaceans (0.01 – 0.1%) were absent in June and November 2009. *Radiolaria* (0.01-0.04%) and *Calanus* species (0.009 – 0.20%) were absent in February, March, April and May 2009. The fish scales were encountered from February (0.02%) to August (1.42%) 2009.

Table 4 presents summary of monthly sex ratio of *M. cephalus* in Lagos lagoon. In this study the females dominated males and immature. There were 156 immature fish, 208 males and 303 females representing 21.17, 37.72 and 41.11% of the total catch respectively. The overall sex ratio of males to females was 1: 1.09. A chi-square revealed a significant departure from the theoretical 1:1 sex ratio (X^2 =17.662 > $X^2_{1, 0.05}$=3.84). In April sex ratio was ratio 1:0.96 in favour of male and 1:1 in August 2009. Fecundity was estimated in 105 ripe gonads. Fecundity varied from 620,320 to 1,082,200 eggs (801,300 ±2,000 eggs) for fish measuring 20.1 cmTL (60.3 gBW) and 32.0 cmTL (345 gBW) respectively.

Table 3

Monthly percentage variation (by number) in relative abundance of the food items in 599 stomachs of *M. cephalus* in Lagos lagoon, Nigeria.

Month	Year	Organic detritus	Inorganic detritus	Unidentified food mass	Nematode worm	Diatom	Filamentous algae	*Tintinopsis*	*Sagitta sagitta*	Crustacean broken parts	*Radiolaria*	*Calanus* species	Fish scale
February	2009	27.64	71.23	0.25	0.02	0.73	0.01	0.05	0.01	0.01	0.03	0.009	0.02
March		8.36	64.74	0.14	0.01	13.94	0.06	12.12	0.03	0.01	0.01	0.06	0.02
April		14.93	57.36	0.27	0.29	6.17	0.21	20.50	0.01	0.02	0.01	0.2	0.04
May		44.25	31.23	1.31	0.07	20.13	0.07	2.58	0.03	0.04	0.04	0.19	0.05
June		34.78	63.59	1.58	-	-	-	-	-	-	-	-	0.05
July		23.18	65.53	10.99	0.06	-	-	-	-	-	-	-	0.24
August		24.17	71.56	2.37	0.47	-	-	-	-	-	-	-	1.42
September		-	-	-	-	-	-	-	-	-	-	-	-
October		-	-	-	-	-	-	-	-	-	-	-	-
November		-	-	-	-	-	-	-	-	-	-	-	-
December		23.65	75.33	0.40	0.03	0.36	0.09	0.07	0.06	0.03	-	-	-
January	2010	21.11	77.42	0.15	0.07	0.92	0.05	0.1	0.09	0.1	-	-	-

Table 4

Summary of sex ratios of *M. cephalus* in Lagos lagoon, Nigeria

Month	Year	Sample size	No of immature	No of males	No of Females	Sex ratio male:female
February	2009	136	20	55	61	1:1.11
March		115	23	42	50	1:1.19
April		214	65	76	73	1:0.96
May		93	8	42	43	1:1.02
June		70	14	26	30	1:1.15
July		23	05	08	10	1:1.25
August		10	02	04	04	1:1
September		-	-	-	-	-
October		-	-	-	-	-
November		-	-	-	-	-
December		42	11	13	18	1:1.38
January	2010	34	08	12	14	1:1.17
		n=737	156(21.17%)	278(37.72%)	303(41.11%)	1:1.09

n=sample size

Discussion. In this study occurrence of grey mullet, *Mugil cephalus* in Lagos lagoon was salinity and seasonally dependent. The species was most abundance, constituting 29.04% of the total catch in April 2009 when salinity was 20‰. This month coincided to the peak of dry period in Lagos area (Lawson 1998), while July was the peak of wet season. Secondly, high salinity value of 20‰ was recorded in the lagoon during the same period. Its availability when salinities were between 2 and 20‰ was an indication of its euryhalinity and confirmation of its ability to survive in a wide salinity regime. Euryhalinity of this species was reported for the fish by Kurian (1975) though its salinity tolerance and preference were not part of this study but were supported by Walsh et al (1989, 1991), Lee & Menu (1981), Murashige et al (1991), Lee et al (1992), and Cardona (2000).

In this study fish size ranged between 9 and 32.0 cm TL. The small, medium and large fish were available in the lagoon. The medium size was between 15.0 and 23.0 cm TL and the largest was 32.0 TL cm. Information on the age of the fish indicated that 1^+, 2^+ and 3^+ years old age groups were present in the lagoon, thus attaining a mean total length of 12.0, 17.0 and 23.0 cm respectively. This was in agreement with that of Silva (1977) on the same species in a coastal lagoon of Sri Lanka. The theoretical maximum length, $L\infty$ attainable by the species was 37.0cm while the rate at which this size was attained (K) was 0.22.year^{-1} and the hypothetical time at which this size of fish will be zero, t_o was −1.8 years. Marquez (1975) obtained values of $L\infty$ = 51cm and K = 0.3425.year^{-1} for the same species in Tamiahua lagoon in Mexico. Differences in the values of the parameter may be ecological or probably be due to differences in the locations or regions of the two lagoons. The growth exponential ‘b’ value was strongly allometric (b=2.926 for females and 2.968 for males) or near isometric (b=3.0). This reason may account for its robustness in Lagos lagoon. The allometric growth was also reported by Grant & Spain (1977) for the Australian mullet.

The diet composition of this species in Lagos lagoon includes 9 groups. The major foods were detritus, algae, crustaceans, and nematode worms, chaetognaths while fish scale was the minor item. A similar report was provided by Payne (1976) among the mullet in estuarine of Goa in India. Thompson (1966) reported carnivorous and herbivorous habits of this fish. Sand grain in the stomachs did not presume it to be the most important food item in the diet of the fish (Bagenal 1978). The grains might have been picked up along with other food items during feeding or may assist in the digestive process of the fish. This was strongly supported by Zismann et al (1975) who reported that sand grain may be deliberately selected by mullet or probably found its way to the gut of the fish during benthic feeding.

The composition and quantitative description of the diet of this species in respect of the microalgae (Thomson 1966); algae and diatom (Rengaswamy 1973, Das 1977); detritus and algae (Payne 1976); Foraminifera, benthic diatoms, polychaetes, mollusks ostracods and debris (Farrugio 1976); sand grains, decayed organic matters, dinoflagellates and fragment of copepod (Rengaswamy 1973) were reported at various times in the stomachs of the grey mullet. The variation in dietary items probably made for a fair sharing of the available food in the environment (Zismann et al 1975) and to avoid inter-specific competition among the fish (Blaber 1977). Variations in the composition or occurrence of the food items in the fish may be attributed to diel (Mittelbach 1984) and seasonal variation (Goulding 1980) in the standing crop of the food.

In this study females were dominant, the sex ratio was 1 male : 1.09 female. A similar situation has been reported by De Silva & Pereira (1976), De Silva & Silva (1979), De Silva (1980). Fagade (1969) and Lawson (1998) reported 1 male: 1 female in their studies on some non-related fish species in Lagos lagoon. The estimated fecundity of 820,000 and 1,082,200 eggs was an indication that this species was highly fecund in Lagos lagoon.

This study provides some important information on biological aspects of *M. cephalus* that would be useful for fisheries biologists to propose adequate regulation for sustainable fisheries management, ecology and conservation of this commercially and economically valued fish species in Lagos lagoon.

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References

Arruda L. M., Azevedo J. N., Neto A. I., 1991 Age and growth of grey mullet (Pisces: Mugilidae) in Ria de Aveiro (Portugal). Sci Mar **55**(3):497-504.

Bagenal T. B., 1978. Aspects of the fish fecundity. In: Ecology of Freshwater Fish Production]. Shelby D. G., (Ed.), Blackwell Scientific Publication, Oxford 75-101.

Bayagbona E. O., 1969 Age determination and Bertalanffy Growth parameters of *P. typus* and *P. senegalensis* using burnt otolith technique. Proceedings of the Symposium on the Oceanography and Fisheries Resources of Tropical Atlantic, UNESCO, 249-359.

Blaber S. J. M., 1977 The feeding ecology and relative abundance of mullet (Mugillidae) in Natal and Pondoland estuaries. Biological Journal of Limnology Society **9**(3): 259-275. doi: 10.1111/j.1095-8312.1977.tb00269.x

Campana S. E., Nielson J. D., 1985 Microstructures of fish otoliths. Canadian Journal of Fisheries and Aquatic Science **42**:1014-1032.

Cardona L., 2000 Effects of salinity on the habitat selection and growth performance of Mediterranean flathead grey mullet *Mugil cephalus* (Osteichthyes, Mugilidae). Estuarine Coastal and Shelf Science **50**(5):727-737. DOI: 10.1006/ecss.1999.0594

Das H. P., 1977, Food of *M. cephalus*, L from GOA region. Mahasagar **10**(1-2):35-43.

De Silva S. S., 1980 Biology of juvenile grey mullet: A short review Aquaculture **19**(1):21-36. doi:10.1016/0044-8486(80)90004-6

De Silva S. S., Pereira P. A. B., 1976 Studies on the biology of young grey mullet, *M. cephalus*, L. I. Effect of salinity on food intakes, growth and food conversion. Aquaculture **7**:327-338. doi:10.1016/0044-8486(76)90129-0

De Silva S. S., Silva E. I. L., 1979 Biology of young mullet (*M. cephalus*, L) population in a coastal lagoon in Sri Lanka. Journal of Fish Biology **15**:9-20. doi: 10.1111/j.1095-8649.1979.tb03568.x

De Silva S. S., Wijeyaratne M. J. S 1977 Studies on the biology of young grey mullet, *Mugil cephalus* L. II. Food and Feeding. Aquaculture **12**(2):157-167. doi:10.1016/0044-8486(77)90183-1

Erkoyuncu I., 1995 Balikcilik biyolojisi ve populasyon dinamigi [Fisheries biology and population dynamics]. Ondokuz Mayis University Publications, Sinop. [In Turkish]

Ezenwa B. I. O., Kusemiju K., 1981 Age and growth determinations in the Catfish, *Chrysichthys nigrodigitatus* by use of dorsal spine. Journal of Fish Biology **19**: 345-351. doi: 10.1111/j.1095-8649.1981.tb05837.x

Fagade S. O., 1969 Studies on the biology of some fishes and fisheries of the Lagos lagoon. Ph.D thesis, University of Lagos, Nigeria.

Fagade S. O., 1973 Age Determination in *Tilapia melanotheron*. In: Ageing of Fishes, Bagenal T. B. (ed.), Gresham Press, Old Woking, England, pp. 1234.

Fagade S. O., Olaniyan C. I. O., 1972 The Biology of the West Africans shad, *Ethmalosa fimbriata* (Bowdich) in the Lagos lagoon, Nigeria. Journal of Fish Biology. 14:519-533. doi:10.1111/j.1095-8649.1972.tb05699.x

Farrugio H., 1976 First observations on the diet of mullet in the Tunisich Lake. Comm Int Explor Sci Mer Mediterr Monaco **23**(8):45-46.

Food and Agricultural Organisation, FAO, 1990 Field Guide to the Commercial Marine Resources of the Gulf of Guinea. FAO/UN, Rome (Italy). 265pp

Geffen A. J., 1986 The growth of herring larvae, *Clupea harengus*, L in the Clyde: An assessment of the suitability of otolith ageing methods. Journal of Fish Biology **28** (6):723-738. doi:10.1111/j.1095-8649.1986.tb05165.x

Goulding M., 1980 The Fishes and The forest: exploitation in Amazonian natural history. University of California press, Berkeley. 280 pp

Grant C. J., Spain A. U., 1977 Variation in body shape of 3 species of Australian mullets during the course of development. Australian Journal of Marine and Freshwater Resources **28**(6):723-738.

Hoffnagle T. L., Timmons T. J., 1989 Age, growth and catch analysis of the commercially exploited Paddlefish population in Kentucky Lake, Kentucky Tennessee. North American Journal of Fishery Management **9**:316-326. doi: 10.1577/1548-8675(1989)009<0316:AGACAO>2.3.CO;2

Hyne H. B. N., 1950 The food of freshwater sticklebacks *(Gasteosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. Journal of Animal Ecology **19**:36-58. Available at: http://www.jstor.org/pss/1570. Accessed on 29 July 2010.

Hyslop E. J., 1980 Stomach contents analysis - A review of methods and their applications. Journal of Fish Biology **17**:411-29. doi:10.1111/j.1095 8649.1980.tb02775.x

Kendall B. W., Gray C. A., Bucher D., 2010 Age validation and variation in growth, mortality and population structure of *Liza argentea* and *Myxus elongatus* (Mugilidae) in two temperate Australian estuaries. Journal of Fish Biology **75**(10):2788–2804. 10.1111/j.1095-8649.2009.02485.x

Kurian C. V., 1975 Mullets and mullets Fisheries of India. Aquaculture **5**(1):114

Kusemiju K., 1973 A study of the catfishes of Lekki lagoon with particular reference to *Chrysichthys walkeri* (Bagridae). Ph.D Thesis, University of Lagos, Nigeria.

Lawson E. O., 1998 Bioecolgy of the Mudskipper, *Periophthalmus papilio* (Pallas) in the mangrove swamps of Lagos lagoon, Nigeria. Ph.D thesis. , University of Lagos, Nigeria. 180pp.

Lawson E. O., 2004 Food and feeding habits of mudskipper, *Periophthalmus papilio* in mangrove swamps of Lagos lagoon, Lagos, Nigeria. Journal of Research and Review in Science **3**:355-358.

Le Cren E. D., 1951 The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology **20**:201-219.

Lee C. S., Menu A., 1981 Effects of salinity on egg development and hatching in Grey mullet, *M. cephalus*, L. Journal of Fish Biology **19**(2):179-188. doi:10.1111/j.1095-8649.1981.tb05822.x

Lee C. S., Tamaru C. S., Kelley C. D., Moriwake A., Miyamoto G. T., 1992 The effect of salinity on the induction of spawning and fertilization in the striped mullet, *Mugil cephalus.* Aquaculture **102**:289-296. doi:10.1016/0044-8486(92)90155-E

Luther G., 1962 The food habit of *Liza macrolepsis* and *Mugil cephalus*, L. Indian Journal of Fisheries **9**(2):604-624.
Macdonald P. D. M., Pitcher J. T., 1979 Age groups from size-frequency data: a versatile and efficient method of analyzing distribution mixtures. Journal of Fisheries Resources Board of Canada **36**:987-1001.
Marquez A., 1975 Observations on the mortality and growth of the mullet *(M. cephalus)* in the Tamiahua lagoon, Mexico. Aquaculture **5**(1):109.
Mittlebalch G. G., 1984 Predation and resources partitioning in two sunfishes (Centrarchidae). Ecology **65**:499-513.
Morales-Nin B., Ralston S., 1990 Age and growth of *Lutjanus kasmira* (Forskal) in Hawaii waters. Journal of Fish Biology **36**:191-203. doi:10.1111/j.1095-8649.1990.tb05595.x
Murashige R., Bass P., Wallace L., Molnar A., Eastham B., Sato V., Tamaru C., Lee C. S., 1991 The effect of salinity on the survival and growth of striped mullet (*Mugil cephalus*) larvae in the hatchery. Aquaculture **96**(3-4):249-254. doi:10.1016/0044-8486(91)90155-Z
Njoku D. C., Ezeibekwe I. O., 1996 Age composition and growth of the large-scaled mullet, *Liza grandisquamis* (pisces: Mugilidae), Valenciennes, 1836 on the New Calabar Estuary, off the Nigerian coast Fisheries Research **26**(1-2):67-73. doi:10.1016/0165-7836(95)00420-3
Pannella G., 1971 Fish otoliths: Daily growth layers and periodical patterns. Science N.Y., **173**:1124-1127.
Pantulu V. R., 1961 On the use of the pectoral spines for the determination of age and growth of *Mystus gulio* (H). Proceeding of Natural Institute of Science, India, **27** B(4):1-30.
Pauly D., 1980 A selection of simple method of assessment of tropical stock. Fish Circ **729**:15-44.
Pawson M. G., 1990 Using otolith weight to age fish. Journal of Fish Biology **36**: 521-531. doi:10.1111/j.1095-8649.1990.tb03554.x
Payne A. I., 1976 The relative abundance and feeding habit of grey mullet species occurring in an estuary in Sierra Leone, West Africa. Marine Biology **35**(3)277-286. doi: 10.1007/BF00396875. ISSN: 0025-3162 (Print) 1432-1793 (Online)
Rengaswamy C. P., 1973 Studies on the age and growth anf food habit of the grey mullet (*M. cephalus*, L) of the Lake Publicat. Journal of Inland Fisheries Society, India, Barrackpore **5**:9-22.
Resenberg A. A., Beddington J. R., 1987 Monte-Carlon testing of two methods for estimating growth from length frequency data with general conditions for their applicability. In: Length –Based methods in Fisheries Research. Pauly D., and Morgan G. R. (eds), pp. 283-289. ICLARM Conference proceedings 13, Manila.
Schnute J., Fournier D., 1980 A new approach to length frequency analysis: growth structure. Canadian Journal of Fisheries and Aquatic Science **37**:1337-1351. doi:10.1139/f80-172
Shepherd J. G., 1987 A weekly parametric method for estimating growth parameters from length composition data. In: Length based Methods in Fisheries Research. Pauly D., and Morgan G. R. (eds), pp. 113-119. ICLARM Conference proceedings 13 Manila.
Sparre P., 1987 A method for estimating of growth, mortality and gear selection/recruitment parameters from Length frequency sample weighed by catch per effort. In: Length Based Methods in Fisheries Research. Pauly D., and Morgan G. R. (eds), pp. 75-102. ICLARM Conference proceedings 13, Manila.
Thomson J. M., 1966 Synopsis of biological data on the grey mullet, *M. cephalus,* L. SCIRO Fish Oceanography Fish Synopsis **1**:14.
Tobor J. G., 1969 Species of Nigeria Ariid Catfishes, their taxonomy, distribution and preliminary observation of the biology of one of them. Bull Inst for Afr noire, Ser A **2**:643-658.

Ugwumba O. A., 1984 The biology of the ten pounder, *Elop lacerta* (Val.) in the freshwater, estuarine and marine environment. Ph.D thesis, University of Lagos, Nigeria.

Walsh W. A., Swanson C., Lee C. S., Banno J. E., Eda H., 1989 Oxygen consumption by eggs and larvae of striped mullet, *Mugil cephalus*, in relation to development, salinity and temperature. Journal of Fish Biology **35**(3):347–358. doi:10.1111/j.1095-8649.1989.tb02987.x

Walsh W. A., Swanson C., Lee C. S., 1991 Combined effects of temperature and salinity on embryonic development and hatching of striped mullet, *Mugil cephalus*. Aquaculture **97**(2-3):281-289 doi:10.1016/0044-8486(91)90270-H

Warbuton K., 1978 Age and growth determination in a marine catfish using otolith Check technique. Journal of Fish Biology **13**:429-434. doi:10.1111/j.1095-8649.1978.tb03451.x

Widell J. T., 1968 Food analysis and rate of digestion. In: Methods of Assessment of Fish Production in Freshwater. Ricker W. E. (ed.), IBP Handbook no 3.

Woottoon R. J., 1990. Ecology of Teleost Fishes. Chapman and Hill Press. USA Second edition. 404 pp.

Zismann L., Berdugo V., Kimor B., 1975 The food and feeding habits of early stages of Grey mullet in the Haifa Bay region. Aquaculture **6**(1):59-57. doi:10.1016/0044-8486(75)90089-7

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