International Journal of Agricultural Policy and Research Vol.2 (4), pp. 125-131, April 2014
Available online at http://www.journalissues.org/ijapr/

ISSN 2350-1561

Original Research Paper

Seasonal feeding variation of the yellow mule (*Mugil cephalus*, Linnaeus 1758, Mugilidae) in Senegal River estuary fishery

Accepted 28 March, 2014

[1]Sarr Serigne Modou, [1]Camara Mouhameth and [2]*Kabré Jean-André Tinkoudgou

[1] Université de Thiès, Institut Supérieur de Formation Agricole et Rurale, B.P 54, Bambey, Sénégal.
[2]Université Polytechnique de Bobo-Dioulasso, Institut du Développement Rural, Laboratoire de Recherche et de Formation en Pêche et Faune, 01BP 1091BOBO DIOULASSO 01, Burkina Faso.

*Corresponding Author's
E-mail :kabretink@gmail.com
Tél :+22670231734

This study aims to determine the seasonal feeding variation for *Mugil cephalus* caught from the estuary of the Senegal River. Random sampling using the creel survey on site was carried out in three fish catch landings (Goxumbathie, Gueth Ndar Diagne and Sor) of the Senegal River estuary. The results obtained from the analysis of stomach contents showed no significant difference in seasonal variation in the diet of yellow mule among age classes (0 +, I + II + III + IV + and V +). For 1478 examined stomachs, coefficients of emptiness were 7.62, 6.69 and 5.87%, respectively for the cold dry, hot dry and rainy seasons. Factorial Analysis of Correspondences (FCA) performed on the data of different prey ingested depicted that yellow mullet feed primarily on pinnate diatoms, cyanobacteria, detritus and centric diatoms with respective occurrence indices of 26.48, 24.27, 8.00 and 7.71%. Other occasional feeds such as sand and zooplankton are considered as secondary foods.

Key words: *Mugil cephalus*, diet, diatoms, cyanobacteria, Senegal River.

INTRODUCTION

Estuarine environments of West Africa have very diverse populations of fish and constitute a habitat for a great number of Mugilidae temporarily or permanently (Albaret and Diouf, 1994). According to the same authors, the estuary of the Senegal River is a traffic area for migrating larvae and juveniles of *M. cephalus* between the ages of recruitment and sexual maturity. Sarr et al. (2013) discussed the recruitment and exploitation of this species in the estuary of the Senegal River; large size yellow mules have a great commercial value in the Grande Côte in Senegal.Several authors in Africa (Isangedighi et al., 2009; Lawson et al., 2010) and in Europe (Bekova et al., 2013) have determined the feeding habits of *M. cephalus*. However in Francophone Africa and Senegal in particular, no author has worked on the seasonal feeding variation of the trophic ecology of *M. cephalus* by using the method of stomach contents analysis (Albaret and Legendre, 1985; Soyinka, 2008). The objective of this study is to describe the seasonal feeding variation of the trophic ecology of yellow mules in the Senegal River. The yellow is of high commercial interest in Senegal therefore a good knowledge of its biology might improve its production in a farming system.

MATERIALS AND METHODS

Study area and data collection

The Senegal River is 1,700 km in length passing through Senegal before emptying into the sea at the southern side of the city of Saint Louis by a single mouth (Sarr et al., 2013). The study area is located between latitudes 15° 45'and 16° 30' North and longitudes 15° 40' and 16° 35' West.

A random sampling was carried out between March 2011 and June 2013 during the hot dry season (SSC), the cold dry season (SSF) and the rainy season (SDP). A multiparameter probe of mark MLM was used to measure abiotic factors of temperature (T), hydrogen potential (pH), electrical conductivity (EC), salinity and total dissolved solids (TDS).

Table 1. Number of stomach sampled according to age groups and seasons (Hot Dry Season (SSC), Cold Seasons dryer (SSF) and Rainy Season (SdP)).

Season	0^+	I^+	II^+	III^+	VI^+	V+	Total
SSC	23	72	134	108	57	54	448
SSF	33	63	178	170	134	112	690
SdP	68	70	122	45	21	14	340
Total	124	205	434	323	198	172	1478

The age groups (fom 0^+ to V^+) were determined according to Sarr et al. (2012)

The study of seasonal variation in the trophic ecology of *M. cephalus* was conducted by examining the stomach contents of 763 juveniles and 715 adults making a total of 1478 stomachs collected (Table 1) and analyzed for their food contents. The total lengths (Lt) of the fish were measured using a graduated ichthyometer. The weight of each individual and the stomach contents were determined using a scale of brand - Scout Pro of 1 g accuracy and maximum weight capacity of 2,000 g.

After dissection in the laboratory, the stomach contents were extracted, rinsed with water and put in a Petri dish filled with alcohol at 90°C and then examined under a binocular microscope. Prey identification was made possible using aquatic insects keys (Grasse et al., 1961; Hyslop, 1980). The food items of each specimen were determined and quantified using the following food indices.

The coefficient of emptiness (Cv)

The coefficient is the percentage of emptiness or voids relative to the total number of stomachs examined:

$$Cv = \frac{Nv}{Nt} \times 1($$

where Nv = Number of empty stomachs; Nt = Total number of stomachs examined.

The percentage of occurrence corrected (Fc)

This is to determine the percentage of stomachs containing a prey category (N_e) relative to the total number (Nt) of stomachs containing at least one prey (Bahou et al., 2007).

$$\%Fc = (F_i / \sum F_i) \times 100$$

$$F_i = \frac{N_e}{N_t}$$

Numerical percentage (N)

The total number of individuals in the food category i (prey) in all stomachs (Ni) is noted and expressed as a percentage of the total number of individuals (Nt) of all prey categories (Bahou et al., 2007).

$$N = \frac{N_i}{N_t} \times 100$$

where N = numerical percentage; Ni = total number of prey category i feed; Nt = total number of all prey.

The weight percentage (P)

It involves determining the percentage of the mass of a food category i (Pi) relative to the total mass (Pt) of the stomach contents (Hyslop, 1980; Paugy and Levêque, 1999).

$$P = \frac{P_i}{P_t} \times 100$$

For the classification of prey, the index of relative importance (IRI) according to Pinkas *et al*. (1971) but modified by Hacunda (1981) is determined thus:

$$IRI = (\%N + \%P) \times \%F$$
$$\%IRI = (IRI / \sum IRI) \times 100$$

The main food or Main Food Item (MFI) is determined by the formula according to Zander (1982) thus:

$$MFI = \sqrt{\left(\frac{F\% + N\%}{2}\right) P}$$

Category of prey is determined by: Q = P x N%

Data processing

To determine the distribution of the diet statistical analysis using multivariate analysis in XLSTAT program was performed. The Factorial Analysis of Correspondences (FAC) used the matrix "relative abundance of different prey categories multiplied by length classes of fish analyzed". The correlation matrix (Pearson (n)) was used to determine the most significant variables correlations between abiotic and biotic variables.

RESULTS

Distribution of phytoplankton and zooplankton based on water physico-chemical characteristics

The two axes of the Principal Component Analysis (PCA)

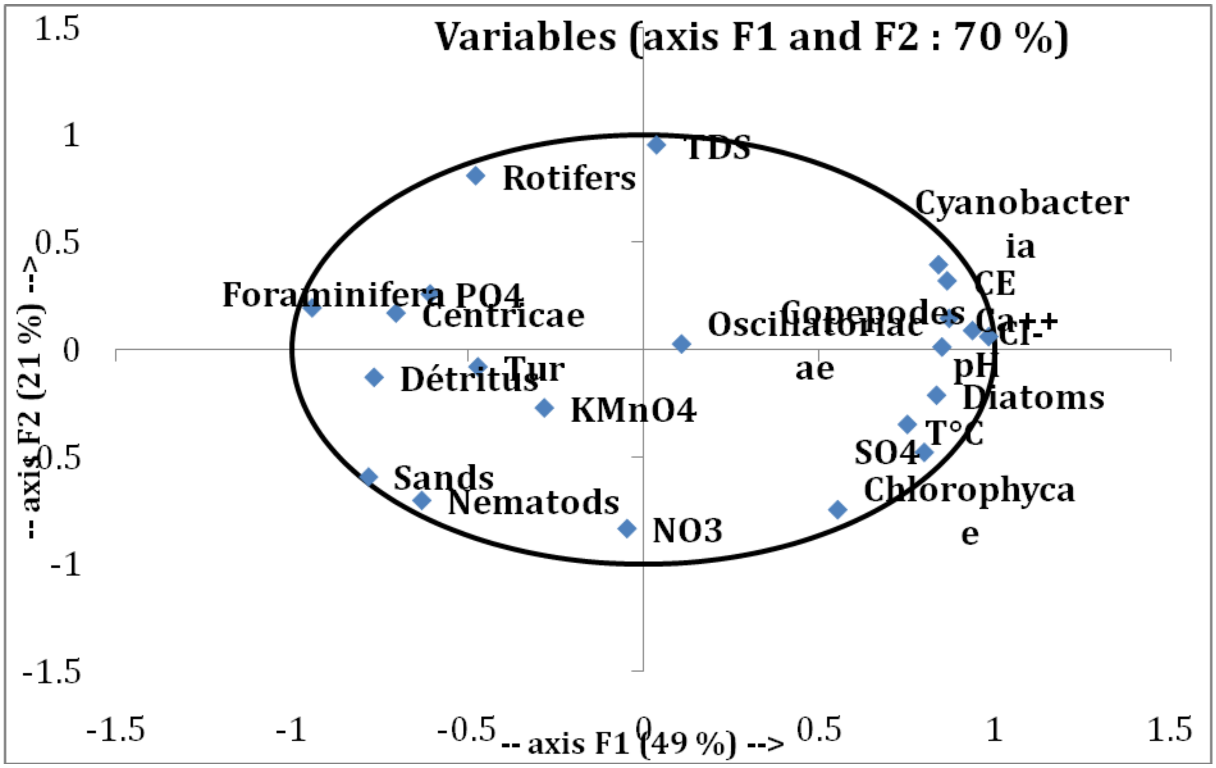

Figure 1 : Factorial F1xF2 variables.
T = temperature, pH = Potential Hydrogen, EC = Electrical Conductivity, Turbidity = Tur, Ca + + = Calcium Chloride = Cl-, SO4 = Sulfate, PO4 = orthophosphates, NO3 = Nitrate.

explained 70% of variation that is, 49 by 21% for axes 1 by 2 (Figure 1).

The Pearson correlation matrix shows that cyanobacteria, diatoms and copepods exhibit a positive correlation significant (r = 0.994, 0.886 and 0.931, respectively) with all elements of mineralization (chlorides, sulfates and calcium) and other abiotic factors (pH, temperature, EC, TDS). Rotifers (r = 0.818), Sand (r = 0.882), the litter (r = 0.834), the Oscillatoriacae (r = 0.868), Foraminifera (r = 0.840) and Centricae (r = 0.972) show a positive correlation with organic matter, nutrients and nitrates .

Diet of *M. cephalus* in Senegal River estuary fishery

In terms of food supply occurrence, the study of the stomach content indicates that yellow mule's diet is dominated by pinnate and centric diatoms (34.19 %); especially pinnate diatoms with an occurrence of 26.48% (Table 2). Cyanobacteria belonging to 3 families (Chroococcacae, Oscillatoriacae and Chlorophyta) were the most isolated in juveniles (34.49 %) than in subadult (27.97 %) and adults (24.27 %) (Table 2). In contrast, for zooplankton, the occurrence is higher among adults (18.17%) than in subadults and juveniles. Detritus and sand exhibited thesame occurrence (7.78, 8.23 and 8.54%, respectively) for juveniles, subadults and adults. Zoobenthos exhibited the lowest occurrence ranging between 2.35 and 4.29%.

In terms of abundance, the diet of *M. cephalus* is dominated by diatoms (53.20%) while cyanobacteria (10.39%) ranked second in the level of abundance. The pinnate represent 71.33 % of diatoms. Zooplanktons were the less abundant (4.12%) in the diet of *M. cephalus*.

From a qualitative point of view, the stomach contents of yellow mules age classes were dominated by the presence of diatoms, cyanobacteria, plant debris, sand, zooplankton and zoobenthos with values of 92.72, 6.22, 3.67, 2.3, 1.0 and 0.96%, respectively (Table 2). According to occurrence, the proportions were 37.65, 34.49, 7.78, 7.68 and 11.07% respectively, for diatoms, cyanobacteria, debris, sand and zooplankton.

Feeding strategy of yellow mules

The food spectrum of *M. cephalus* decreases with age. Classes 0^+, I^+, II^+ and III^+ have a larger food spectra than for adults (IV^+ and V^+). Classes IV^+ and V^+ are more selective in taking prey.

When the Factorial Analysis of Correspondences was performed, the results depicted that different prey were ingested by different age groups of fish: I^+, 0^+ age classes eat mostly Chroococcacae , Copepodes and Cladocera while the

Table 2 . Food spectrum for *Mugil cephalus* in the Senegal River Estuary based on age

Prey item	Code	Juveniles		Subadults		Adults	
		N(%)	Fc(%)	N(%)	Fc(%)	N(%)	Fc(%)
Phytoplankton	PHYT	98.94	87.7	89.5	78.84	94.68	79.08
Cyanobacteria	Cyan	6 .22	34.49	13.91	24.27	11.12	27.97
Chroococcacae	*Chrooc*	4.24	18.25	7.73	15.4	8.85	17.62
Oscillatoriacae	*Osc*	1.04	14.73	5.7	7.57	3.42	10.2
Chlorophyta	Chlo	0	0	0.45	0.73	0	0
Diatoms	Diat	92.72	37.65	75.59	38.11	83.56	34.11
Centricae	*Cen*	0.22	4.59	8.46	7.88	7.45	6.93
Pennatae	*Pen*	86.42	30.33	66.54	25.99	69.26	23.12
Detritus	DET	3.67	7.78	3.3	8.23	0.2	8.57
Sand	SAB	2 .6	7.68	2 .3	8.23	0.1	8.57
Zooplankton	ZOO	1.03	11.07	11.07	17.11	5.28	18.17

N: numeric percentage; Fc: percentage of occurrence corrected

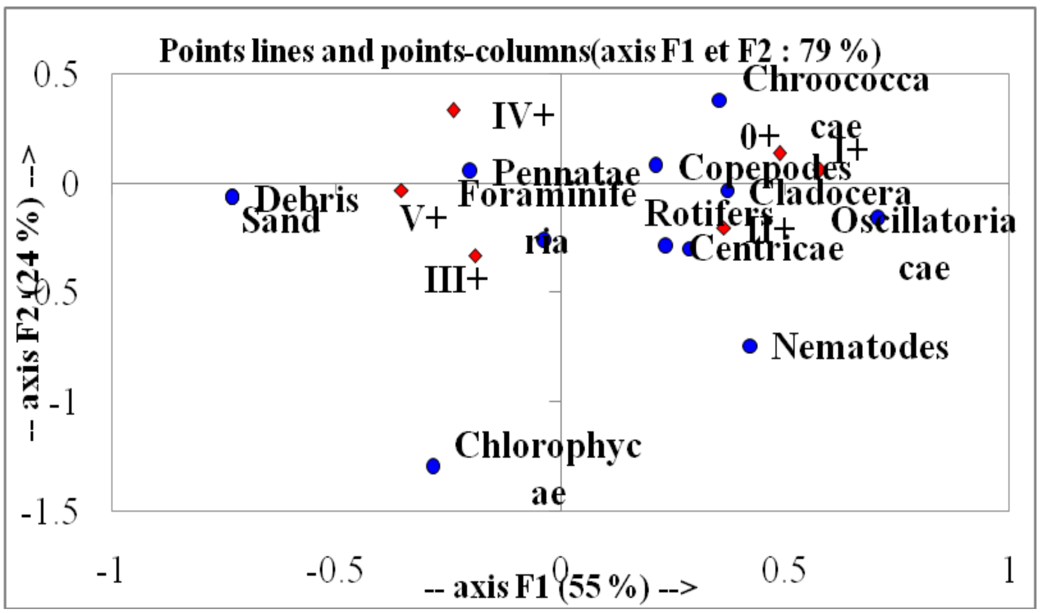

Figure 2 : Factorial analysis of correspondence between age and ingested prey of yellow mules

classes II⁺, III⁺ have a more diverse food spectrum (Figure 2). Indeed, their prey (the last two classes) consists mostly of pinnate diatoms, rotifers, centricae and oscillatoriacae with respective occurrences of 26.48, 24.27, 8.00 and 7.71%. Other preys are considered to be secondary feed for *M. cephalus.* However, for the older age groups the distribution of prey for large fish shows a dominance of diatoms pinnate on all prey with an occurrence of 23.12%; Forominiferia and Chroococcacae, ranked second with an occurrence of 17.62%. Debris are in third place with an occurrence of 6.00%. Other preys, considered secondary, are ranked last with very low proportions.

The chi-square test (χ^2) of independence yielded the values; χ^2 observed (816) greater than the critical value χ^2 (536.287 with df = 484). The relative dependence of growth (age classes) of yellow mules and prey is significant. Each individual variable had a significant (95%) effect on the growth of individuals.

Ethology of feeding of mules in Senegal River estuary

In terms of feeding patterns, this study indicated that the food spectrum of *M. cephalus* decreased with age. The diet of large sized yellow mules consisted of pinnate diatoms (mainly *Amphora ovalis* with a rate of occurrence of 93.74%) in contrast to younger age groups (0+ and I+) which had various diet consisting mainly of diatoms (lower occurrence of 54.74 %), zooplankton, benthos and zoobenthos. A rich and variable diet would effectively impact positively on the growth of yellow mules. Sexual maturity in yellow mules requires more energy for migration and spawning. For age classes (0+ and I+) (Figure

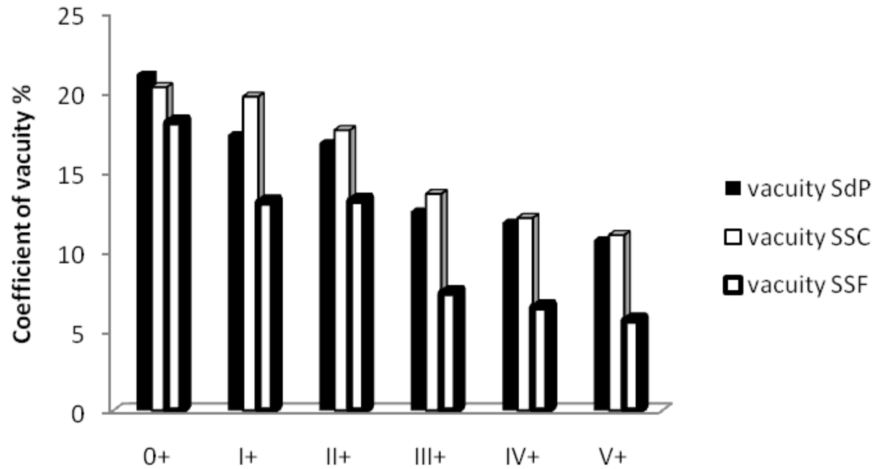

Figure 3. Variation of the coefficient of vacuity according to the seasons
SdP = Rainy Season; SSF = Cold Season dryer; SSC = Hot Dry Season

Table 3 . Feeding indices of *M.cephalus*

Food or prey	Indices					
	F	N	Q	P	MFI	IRI
Chroococcacae	4.24	18.25	77.38	18.85	14 .56	213.27
Oscillatoriacae	1.04	14.73	15.31	3.42	5.19	5.7408
Chlorophytes	2.4	11.2	26.88	8.4	7.56	51.84
Centricae	0.22	4.59	1.01	7.45	4.23	1.87
Pennatae	86.42	30.33	2621.1	69.26	63.58	13745.1
Detritus	1.05	7.78	64.57	7.76	7 .89	96.78
Sand	2. 34	7.78	49.48	9.13	8.04	77 .72
Zooplankton	1.03	11.07	11.40	5.28	5.65	7.59

Fc, percentage of occurrence corrected; Q, ingested prey categories; P, weight percentage; MFI, Main Food Item; IRI: Indice of Relative Importance

3), the coefficient of emptiness is higher throughout the year compared to sub adults (III +) and adults (IV + and V +). It shows a slight increase and thus a decrease in energy during the hot dry season, which coincides with the spawning period of yellow mules. With the chi-square test, independence of seasonal variation of prey and the value of χ^2 observed (0.019) is much lower than the critical value χ^2 (9.488 with df = 4). The presence of prey for *M. cephalus* in the estuary is not season related so there's a good availability of food (95%) during any season.

Table 3 gives different indices for feeding evaluation. For *M. cephalus*, irrespective of the food index considered, phytoplankton including diatoms and cyanobacteria pinnate are the main prey while zooplankton, debris and sand are complementary or secondary food.

DISCUSSIONS

The analysis of variable factorial F1xF2 in the PCA revealed that the axis defined by the factorial F1 is determined by the physicochemical elements of the main variables which include the conductivity (EC), salinity, total dissolved solids (TDS), chlorides (Cl^-), calcium (Ca^{++}), sulfates ($SO4^-$). In the F1 axis, the main contributions of the elements are 0.885 for chloride, 0.780 for calcium and 0.854 for sulfates. F1 principal component thus defines a gradient of mineralization, or in other statement, an increasing level of dissolved salts; finally it thus defines a mineral pole on the right. The factorial axis F2 is characterized by organic matter (KMnO4) , nutrients such as orthophosphate (PO4) and nitrate ($NO_3{}^-$) which are negatively correlated with respective coefficients (r) of -0.490, -0.523 and -0.730. These variables describe a state of orthogonality as compared to axis 1: gradient enrichment in organic material and nutritive salts is opposed to mineralization as represented by axis 1.

The results of seasonal variation in the trophic ecology of *M. cephalus* in the Senegal River estuary fishery were determined by the method of stomach contents analyses which showed that the yellow mullet feed primarily on phytoplankton including diatoms and cyanobacteria.

Debris, sand and zooplankton are secondary foods. Our results in Senegal are in line with those obtained by Sánchez (2002) in Mexico Lagoon Tamiahua (Bekova *et al*., 2013), those reported by Isangedighi (2009) in the Niger River.

According to Sarr *et al*. (2012), the population of yellow mules in the estuary of the Senegal River is distributed in six age groups (0 + I + II + III + IV + and V +). For the 1478 stomachs examined, coefficients of emptiness were 7.62, 6.69 and 5.87% respectively, for the cold dry, hot dry and rainy seasons. The analysis of stomach contents of different age groups depicted that the phytoplankton (Table 2) is the main diet of yellow mules. Zooplankton, benthos including elements of the zoobenthos, debris and sand are occasional foods (Table 2). The detailed study of the food spectrum corresponding to the different age groups showed that the diet of individuals regardless of their stage of development (juvenile, sub adult and adult) is dominated by diatoms pinnate with numeric values and respective occurrences of 86.42 and 30.33% for juveniles, 66.54 and 25.99% for subadult and 69.26 and 23.12% for adults. Such results are explained by the abundance of pinnate diatoms in the lagoons and estuaries or by the food preference (or selectivity) of *M. cephalus* for this type of algae (Sánchez, 2002; Bekova et al., 2013 and Soyinka, 2008). Detritus and sand show values and relatively low occurrence length classes of the species of *M. cephalus* in the estuary of the Senegal River. Their numerical occurrence values are between 2.60 and 3.67% and 7.78 and 8.57%, respectively. Zooplankton (consisting of cladocerans, copepods, foraminifera, rotifers) and nematodes exhibit occurrences and very low numerical percentages for all length classes.

Factor Analysis of Correspondences (FAC) of prey ingested by yellow mules and length class confirmed that the pinnate diatoms are the preferred food of yellow mules in the estuary fishery of the Senegal River. The FAC (Figure 3) explains 95% of the total inertia (axis 1 = 85% and axis 2 = 10%). Axis 1 includes pinnate diatoms, cyanobacteria, zooplankton and detritus while axis 2 includes pinnate diatoms, cyanobacteria and sand. Axis 1 is characteristic of the diet of sub adults and adults and it is the opposite of axis 2. The latter determines the food spectrum of *M. cephalus* juveniles that consume more sand compared to yellow mules of medium and large size.

Seasonal variation in the trophic ecology of *M. cephalus* showed no significant difference in the estuary of the Senegal River. There was no significant variation (df = 18, p = 0.029; $p < 0.05$) in the numerical proportions of the preferential prey *M. cephalus* from one season to another. This may reflect a relative stability in prey availability in the sampled habitat (Akin and Winemiller, 2006). Authors like Kurma and Ramesh (2013) have shown in their work the continuous availability of food resources for estuarine fish such as Mugilidae.

In terms of classification of items ingested by yellow mules using the index of relative importance (IRI), it is concluded that pinnate diatoms (63.58 %) were the preferred prey of *M. cephalus* in the estuary of Senegal River. According to Sánchez (2002), *M. cephalus* has a large diet spectrum; with a high number of individuals specializing in the consumption of a class of prey (diatoms pinnate). According to Rosechi and Nouazé (1987) IRI indices favor dramatically and permanently abundant prey but with low weight value; the food index MFI and Q prefer items with percentages F, N and P that have average or high values, at least for F and P.

Conclusion

The analysis of stomach contents showed that *M. cephalus* feeds mainly on pinnate diatoms, cyanobacteria, zooplankton, mud (sand and plant debris) and undetermined prey. A comparison of the nutritive value of the diverse ingested items between different age groups indicated that the food of younger fish groups 0+, I+ II+ and III+ is richer and more diverse than the one of the elder groups IV + and V+ . However for the same age groups, no difference was observed comparing the diet between fish caught during the three seasons. It is concluded that the growth of yellow mules in the estuary of the River Senegal depends heavily on the food spectrum and its availability. It is suggested that a comparison of food cues using the method of analysis of stable isotopes of carbon and nitrogen could provide additional relevant results with respect to the feeding ethology of the yellow mule in the estuary fishery of the Senegal River.

REFERENCES

Akin S, Winemiller KO (2006). Seasonal Variation in Food Web Composition and Structure in a Temperate Tidal Estuary. Estuarine Research Federation, 29(4): 552–567.

Albaret J-J, Legendre M (1985). Biologie et écologie des Mugilidae en lagune Ebrié (Côte d'Ivoire) l'intérêt potentiel pour l'aquaculture lagunaire. Rev. Hydrobiol. Trop., 18 (4) : 281-303.

Albaret J-J, Diouf PS (1994). Diversité des poissons des lagunes et des estuaires ouest -africains. In: Biological diversity in African fresh- and brackish water fishes: geographical overviews PARADI symposium - Diversité biologique des poissons des eaux douces et saumâtres d'Afrique (Ed. G.G. TEUGELS). Annales du Musée Royal d'Afrique Centrale, Sciences Zoologiques (BEL).

Bahou L, Kone T, N'Douba V, N'Guessan KJ, Kouamelan EP, Gouli GB (2007). Food composition and feeding habits of little tunny (*Euthynnus alletteratus*). In: Ccontinental shelf waters of Côte d'Ivoire (West Africa). International Council for the Exploration of the Sea. Oxford J.

Bekova R, Raikova-Petrova G, Gerdzhikov D, Petrova E, Vachkova V, Klisarova D (2013). Food spectrum of grey mullet (*Mugil cephalus* L.) along the Bulgarian Black Sea coast. Agric. Sci. Technol, 5(2) : 173-178.

Grassé P-P, POISSON R, TUZET O (1961). Précis de Zoologique-Tome 1 Invertébrés, Précis de Sciences Biologiques. Masson et Cie, Paris.

Hacunda JS (1981). Trophic relationships among demersal fishes in coastal area of the Gulf of Main. Fishery Bulletin, 79: 775-788.

Hyslop EJ (1980). Stomach contents analysis, a review of methods and their application. J. Fish Biol., 17: 411-429.

Isangedighi IA, Udo PJ, Ekpo IE (2009). Diet Composition of *Mugil cephalus* (Pisces: Mugilidae) In The Cross River Estuary, Niger Delta, Nigeria. Niger. J. Agric., Food Environ, 5(2-4): 10-15.

Kurma RR, Ramesh KB (2013). Studies on Grey Mullets Collected from Interu Swamp, at Krishna Estuarian region, Andhra Pradesh, India. Res. J. Marine Sci., 1(2): 12-16.

Lawson EO, Abayomi A, Jimoh A (2010). Aspects of the biology of grey mullet, *Mugil cephalus*, in Lagoslagoon, Nigeria. *AACL* Bioflux, 3(3) : 181-194.

Paugy D, Levêque C (1999). Régimes alimentaires et réseaux trophiques. In : Les poissons des eaux continentales africaines : Diversité, écologie et utilisation par l'homme (Ed. C. LEVÊQUE). Editions IRD, Paris.

Pinkas L, Oliphant MS, Iverson ILK (1971). Food habits of albacore, blue fin tuna and bonito in California waters. California Fish and Game, 152 : 100-105.

Rosecchi E, Nouaze Y (1987). Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux. Rev. Trav. Inst. Pêches. Mart., 49 (3 & 4):111-123.

Sánchez PR (2002). Stomach content analysis of *Mugil cephalus* and *Mugil curema* (Mugiliformes: Mugilidae) with emphasis on diatoms in the Tamiahua lagoon, México. Rev. Biol. Trop., 50(1): 245-252.

Sarr SM, Kabré J-AT, Diadhiou H (2012). Age et croissance de *Mugil Cephalus* (Linneaus, 1758, Mugilidae) dans l'estuaire du fleuve Sénégal. Int. J. Biol. Chem. Sci., 6(5):2149-2157.

Sarr SM, Kabré J-AT, Cecchi P (2013). Recruitment, mortality and exploitation rates estimate and stock assessment of *Mugil cephalus* (Linnaeus, 1758 Mugilidae) in the estuary of the Senegal River. Int. J. Agric. Pol. Res., 1 (1): 001-010.

Soyinka OO (2008). The feeding ecology of *Mugil cephalus* from a high brackish tropical lagoon in South-west, Nigeria. Afr. J. of Biotechnol.,7 (22): 4192 – 4198.

Zander CD (1982). Feeding ecology of littoral gobiid and blennioid fish of the Banyuls area (Mediterranean Sea). I Main Food and trophic dimension of niche écotope. *Vie et Milieu*, 32:1-10.

Cite this article as :Sarr SM, Camara M, Kabré J-AT(2014).Seasonal feeding variation of the yellow mule (*Mugil cephalus*, Linnaeus 1758, Mugilidae) in Senegal River estuary fishery. Int. J. Agric. Pol. Res.2(4):125-131