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Comparative study of food and feeding habits of the Sompat grunt *Pomadasys jubelini* (Cuvier, 1830) Perciformes, Haemulidae in three lagoons complex of Côte d'Ivoire: Grand-Lahou, Ebrie and Aby

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Abstract

The feeding habits of *Pomadasys jubelini* was investigated in the three lagoons (Grand-Lahou, Ebrie and Aby) from January 2007 to December 2008. The diet was studied in relation to localities, fish size and seasons. A total of 2284 stomachs were examined. The index of relative importance (%IRI) showed that *P. jubelini* had an omnivorous diet with benthophagous tendency in all lagoons. Crustaceans, Gastropods, Bivalves, Insects, Annelids and Plants were the major feed. Juveniles (Fork Length (FL) < 13.20cm in Grand-Lahou, FL < 11.75cm in Ebrie and FL < 12.35cm in Aby lagoons) consumed Insects principally Chironomid larvae, while sub adults (13.20 - 15.20cm FL, 11.75 - 13.42cm FL, 12.35 - 14.52cm FL in Grand-Lahou, Ebrie and Aby lagoons respectively) and adults (>15.20cm FL, >13.42 cm FL, >14.52cm FL in Grand-Lahou, Ebrie and Aby lagoons respectively) fed mainly on Crustaceans, Annelids, Molluscs and Plants. In Grand-Lahou lagoon, Spearman correlation showed a significant difference between diet of juveniles (N = 12; Rs = 0.54; p = 0.068), sub adults (N = 12; Rs = 0.23; p = 0.47) and adults (N = 12; Rs = 0.48; p = 0.11) of *P. jubelini* in all seasons.

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Introduction

Studies of trophic ecology are useful and fundamental to an understanding of the functional role of the fish within their ecosystems (Cruz-Escalona *et al.*, 2000; Hajisamae *et al.*, 2003). *Pomadasys jubelini* (Cuvier, 1830) is a Haemulidae naturally occurring in coastal waters, estuaries and freshwaters along the West African coast and from Mauritania to Angola (Paugy *et al.*, 2003). It is a demersal fish species that inhabits sandy, muddy bottoms of coastal waters and can be found at depths below 100 m (Adebiyi, 2011). This species is caught by artisanal fisheries using gill nets, beach seines, long lines and industrial fisheries using trawls. *Pomadasys jubelini* is very appreciated by local population because of its high quality flesh and is one of the commercially important fish in Côte d'Ivoire. Despite its worldwide importance, little information has been available on the feeding ecology of this species. The only work on *P. jubelini* were, in one hand, on food habit in Ebrie lagoon (Koné *et al.*, 2007), in Lagos coast (Adebiyi, 2011) and in the New calabar-Bonny River (Agbugui *et al.*, 2014). On other hand, the researches focused on length-weight relationship on this species (Adebiyi, 2013) and on fishery, gut length and food preferences (Emmanuel *et al.*, 2013).

This study is part of a program whose objective is to Identify and promote local resources – especially *Pomadasys jubelini* – in order to determine their aquaculture potential. Therefore knowledge of fish diet is necessary. Thus, this study aims at providing further information on the nourishment and abundance of natural food needed by *P. jubelini* according to sizes and seasons in three lagoons complex of Côte d'Ivoire.

Material and methods

Study area

The present study is conducted in Grand-Lahou, Ebrie and Aby lagoons (Côte d'Ivoire). These lagoons are located between 2°50 and 5°25 west longitudes and 5°25 north latitude (Durand and Skubich, 1982) and have an equatorial climate, including two rainy seasons (April - July and October - November), and two dry seasons (December - March and August - September).

They are permanently connected to the sea from the Grau of Grand-Lahou for Grand-Lahou lagoon, Vridi Canal for Ebrie lagoon and the Pass of Assinie for Aby lagoon (Durand and Guiral, 1994). Their catchment areas are 190, 532 and 424 km² respectively for Grand-Lahou, Ebrie and Aby lagoons (Lae, 1982).

These lagoons are divided into sectors or strata in relation to the climate, the primary and secondary production and the bathymetric parameters (N'goran, 1995). In Grand-Lahou lagoon, the Eastern zone is under the influence of continental and oceanic input, while in the western zone, the marine and continental influences are less. In Ebrie lagoon, the permanent linkage with the Atlantic Ocean produces typical estuarine characteristics, especially in sectors near the Vridi canal. Conversely, the others sectors are oligohaline, stable, and homogeneous throughout the year (Durand and Guiral, 1994). In Aby lagoon, the strata 2 (south Aby) which receives the marine influence is estuarine. In contrast, the strata 1 (north Aby), strata 3 (Tendo), and strata 4 (Ehy) under the continental influence are very stable and oligohaline (Fig. 1).

Sampling

Fish samples were collected monthly from January 2007 to December 2008 in Grand-Lahou lagoon (Braffedon and Mackey), Ebrie lagoon (Layo and N'djem) and Aby lagoon (Adiaké, Eboué and Assinie) using gill nets with mesh sizes of 10, 12, 15, 20, 25, 30, 35, 40 and 50 mm. This combination of various gill nets mesh sizes was employed to have a wide range of fish size. Sampling was carried out at various day periods in various areas of the Lagoon. The night sampling was done between 5.00 p.m to 6.00 a.m while the day sampling was between 7:00 a.m. to 3:00 p.m. Fish captured were identified according Bauchot (1992) identification keys.

Laboratory examination

In the laboratory, each specimen of *P. jubelini* was measured to the nearest cm for the fork length (FL) and weighed to the nearest 0.01 g using a top loading Satorius balance (model BP 310S) and dissected to remove the stomach.

Stomachs were preserved in 5 % formalin solution. Subsequently, each stomach was slit opened and its contents were sorted, counted under a binocular microscope Olympus SZ51 (0.80 - 4x). All prey items were weighed to the nearest 0.001 g with Sartorius

A200 S-F₁ and identified to the lowest taxonomic according to Dejoux *et al.*, (1981), Diomandé *et al.* (2000), Durand and Lévêque (1981) and Tachet *et al.* (2003).

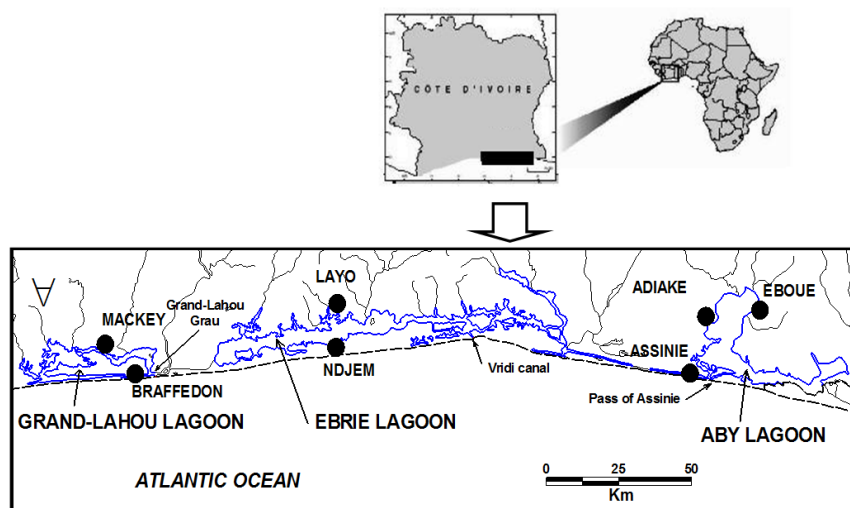


Fig. 1. Sampling areas and samples sites ● in Lagoons complex Grand-Lahou, Ebrie and Aby (Cote d'Ivoire) from January 2007 to December 2008.

Data analysis

Diet of *Pomadasys jubelini* was assessed using the following indices:

1. Correct occurrence percentage (Fc) (Rosecchi and Nouaze, 1987): $F_c = (F_i / \Sigma F_i) \times 100$ with $F_i = N_i / N_t$; where N_i = stomachs which contained prey i and N_t = total number of non-empty stomachs,
2. Numerical percentage (% N) (Hureau, 1970): $\% N = (N_i / N_t) \times 100$ where N_i = total number of prey i and N_t = total number of prey items,
3. Weight percentage (% W) (Hyslop, 1980): $\% W = (W_i / W_t) \times 100$, where W_i = total weight of prey i and W_t = total weight of prey items,
4. Relative importance index (IRI) (Pinkas *et al.*, 1971) combining occurrence (Fc), numerical (N), and weight percentages (W), was used to assess importance of single taxa in the diet of fish. %IRI was explained as follow: $\% IRI = (\% N + \% W) \times \% F_c$.

Relative importance index (IRI) varied from 0 to 100%. Values of IRI were expressed in percentage to facilitate the comparison with others studies (Cortès *et al.*, 1996). The classification scale of prey followed those of Simenstad (1979).

To study diet variation with size, the life stages of fish were divided into 3 categories (Juveniles, Sub-adults and Adults) according to species fork length size (FL), size at first sexual maturity (L_{50}), size of the smallest mature individual (SMI) and following Bodji *et al.* (2013). Thus, fish of $FL < SMI$ was considered as juveniles; $SMI < L_{50}$ was categorized as sub-adults and $FL > L_{50}$ was classified as adults. Vacuity coefficient (VC) was calculated to evaluate feeding intensity according to Hureau (1970): $VC = (\text{number of empty stomachs}) / (\text{number of stomachs examined}) \times 100$

Spearman's correlation coefficient (Fritz, 1974) was used to compare the diet composition of *Pomadasys jubelini* between lagoons, fish sizes and seasons (max probability retained: $p\text{-level} = 0.05$). All statistical analyses were performed with the software Statistica 7.1 version.

Results

General diet composition

A total of 2284 stomachs of *Pomadasys jubelini* were examined: 422 in Grand-Lahou, 712 in Ebrie and 1150 in Aby lagoon.

One thousand hundred forty eight (1148) stomachs were full and 1136 stomachs were empty, indicating vacuity coefficient of 49.74 %. Qualitative analysis of the diet of *P. jubelini* included 15 different preys belonging to six major categories: Crustaceans, Annelids, Fishes, Insects, Molluscs and Plants (Table 1). An important sedimentary fraction composed of sand and mud (Fc = 100 %) was noted in all stomach contents of *P. jubelini*. This fraction has no nutritional value.

Therefore, it was excluded from all the quantitative values. Molluscs (IRI = 34.67%) and crustaceans (IRI = 24.93%) were classified in the category of preferential preys, while insects (IRI = 21.70%) and fishes (IRI = 12.94%) were considered as secondary foods. Annelids (IRI = 1.95%) and plants (IRI = 3.81%) represented accidental preys. Among species, *Penaeus notialis* (IRI = 22.65%), *Turitella* sp. (IRI = 20.34%) and *Chironomid larvae* (IRI = 21.70%) were mostly ingested by *P. jubelini*.

Table 1. General diet composition of *Pomadasys jubelini* (n = 1148; 8.50 - 32.70 cm Fork length) from Grand-Lahou, Ebrie and Aby lagoons; % N = Numeric percentage; % Fc = Correct occurrence percentage; % W = Weight percentage; % IRI = index of relative importance percentage.

Prey taxa	% Fc	% N	% W	% IRI
Crustaceans				
<i>Penaeus notialis</i>	22.90	11.21	36.98	22.65
<i>Penaeus kerathurus</i>	0.26	0.06	0.26	0.00
<i>Sesarma alberti</i>	5.96	2.34	5.56	1.91
<i>Aroides</i> sp.	2.42	1.07	1.86	0.33
Isopoda	0.78	0.39	0.45	0.04
Annelids				
<i>Nereis</i> sp.	4.06	4.46	2.57	1.95
Fishes				
Clupeidae	14.00	12.52	15.30	12.94
Insects				
<i>Chironomidae larvae</i>	13.05	15.43	8.81	21.70
Molluscs				
Gasteropods	12.19			
<i>Turitella</i> sp.		14.83	12.80	20.34
<i>Littorina</i> sp.	0.52	3.47	0.25	0.18
Bivalves				
<i>Corbula trigona</i>	5.62	10.74	3.28	6.24
<i>Lutraria</i> sp.	3.03	6.75	2.24	2.12
<i>Mutela rostrata</i>	4.06	13.95	3.25	5.79
Plants				
Plant detritus	10.63	2.64	6.02	3.80
Fruits	0.52	0.13	0.37	0.01
Total				
Crustaceans	32.32	15.07	45.11	24.93
Annelids	4.06	4.46	2.57	1.95
Fishes	14.00	12.52	15.30	12.94
Insects	13.05	15.43	8.81	21.70
Molluscs	25.42	49.75	21.82	34.67
Plants	11.15	2.77	6.39	3.81

Spatial variations of diet

The total number of taxa found in the stomachs was 12 in Grand-Lahou, 13 in Ebrie and 15 in Aby lagoons (Table 2). In Grand-Lahou, Crustaceans (IRI = 36.61%) and Molluscs (IRI = 34.49%) were the main ingested preys.

They were mostly represented by *Penaeus notialis* (IRI = 34.24%) and *Turitella* sp. (IRI = 17.33%). Insects (IRI = 16.93%) and fishes (IRI = 5.79%) were secondary ingested, while Annelids (IRI = 3.20%) and Plants (IRI = 2.98%) were occasionally eaten. In Ebrie lagoon, Molluscs (IRI = 35.51%) and

Crustaceans (IRI = 28.57%) were most frequently observed, followed by fishes (IRI = 17.21%) and insects (IRI = 12.93%). Among the preferential preys taxa, *Corbula trigona* (IRI = 19.54%) and *Penaeus notialis* (IRI = 24.21%) were the most consumed. In Aby lagoon, Molluscs (IRI = 35.42%) and Insects (IRI = 26.65%) were the frequently eaten preys, followed by Crustaceans (IRI = 17.73%) and Fishes (IRI = 15%). The preferential preys were represented mainly by *Turitella* sp. (IRI = 24.94%) and

Chironomid larvae (IRI = 26.65%). Alternatively, Annelids (IRI = 1.22%) and Plants (IRI = 3.98%) were the most important rarely eaten.

The spearman tests confirmed that diets in the three lagoons were similar: Grand-Lahou and Ebrie lagoons (N = 15; Rs = 0.77; $p = 0.0008$), Grand-Lahou and Aby lagoons (N = 15; Rs = 0.92; $p = 0.00001$), Aby and Ebrie lagoons (N = 15; Rs = 0.89; $p = 0.00008$).

Table 2. Diet composition of *Pomadasys jubelini* from Grand-Lahou, Ebrie and Aby lagoons, with their index of relative importance percentage (% IRI).

Prey taxa	%IRI		
	Grand-Lahou lagoon (n = 252)	Ebrie lagoon (n = 303)	Aby lagoon (n = 593)
Crustaceans			
<i>Penaeus notialis</i>	34.24	24.21	16.29
<i>Penaeus kerathurus</i>	-	-	0.01
<i>Sesarma alberti</i>	1.71	3.72	1.27
<i>Aroides</i> sp.	0.64	0.61	0.11
Isopoda	0.02	0.03	0.05
Annelids <i>Nereis</i> sp.	3.20	1.94	1.22
Fishes Clupeidae	5.79	17.21	15.00
Insects <i>Chironomidae larvae</i>	16.93	12.93	26.65
Molluscs Gasteropods			
<i>Turitella</i> sp.	17.33	10.88	24.94
<i>Littorina</i> sp.	-	0.74	0.20
Bivalves <i>Corbula trigona</i>	2.93	19.54	4.23
<i>Lutraria</i> sp.	5.38	0.42	1.45
<i>Mutela rostrata</i>	8.85	3.93	4.59
Plants Plant detritus	2.98	3.84	3.94
Fruits	-	-	0.04
Total Crustaceans	36.61	28.57	17.73
Annelids	3.20	1.94	1.22
Fishes	5.79	17.21	15.00
Insects	16.93	12.93	26.65
Molluscs	34.49	35.51	35.42
Plants	2.98	3.84	3.98

Diet variations according to fish size and lagoons

In Grand Lahou lagoon juveniles (n = 40) have LF < 13.20 cm, sub-adults (n = 32), 13.20 cm < LF < 15.20 cm and adults (n = 180), LF ≥ 15.20 cm. In Ebrie lagoon, juveniles (n = 69) had LF < 11.75 cm; sub-adults (n = 94), 11.75 cm < LF < 13.42 cm and adults (n = 140), LF ≥ 13.42 cm. In Aby lagoon, juveniles (n = 117) had LF < 12.35 cm; sub-adults (n = 124), 12.35 < LF < 14.56 cm and adults (n = 352), LH ≥ 14.56 cm.

The diet of *Pomadasys jubelini* according to size was showed in Fig. 2. Juveniles mainly feed on insects (*Chironomid larvae*) in all lagoons with 88.29% in Grand-Lahou, 90.53% in Ebrie and 89.83% in Aby lagoons. Sub adults consumed preferentially annelids (33.98%) and plants (21.26%) with the major secondary food item being crustaceans (15.23%) and insects (14.73%) in Grand-Lahou lagoon.

In Ebrie lagoon, their mainly ingested preys were molluscs and crustaceans with respectively 42.55% and 38.47%. In Aby lagoon, their favorite preys were plants (50.51%) following by Molluscs (22.86%) and Crustaceans (12.98%).

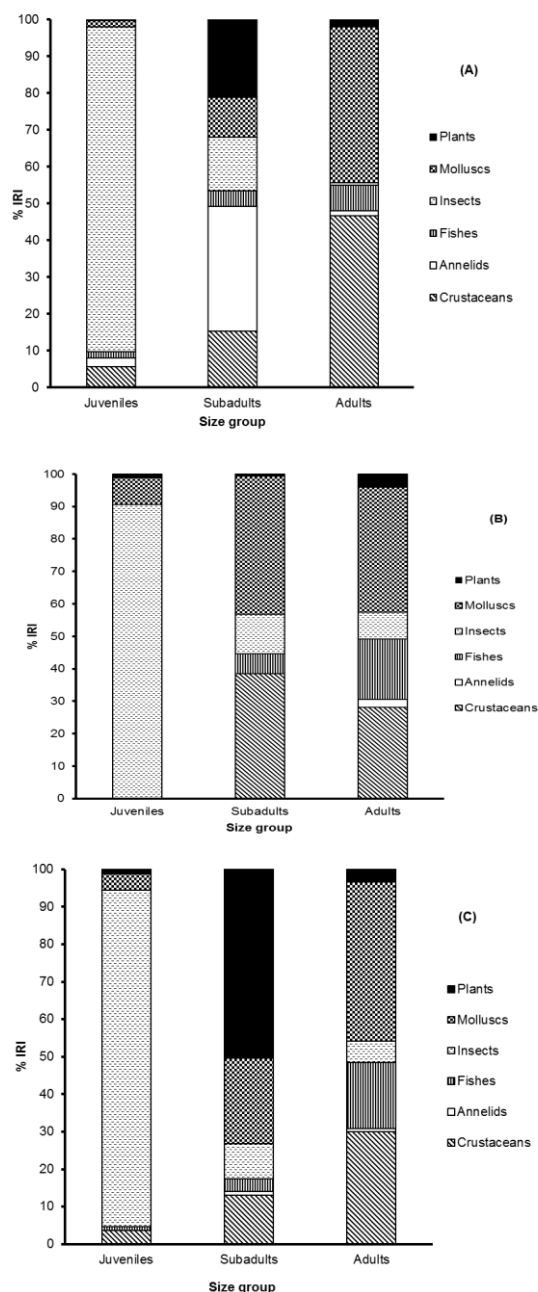


Fig. 2. Index of relative importance (%IRI) in juveniles (Fork length FL < 13.20 cm, FL < 11.75 cm, FL < 12.35 cm), sub adults (13.20 cm ≤ FL ≤ 15.20 cm, 11.75 cm ≤ FL ≤ 13.42 cm, 12.35 cm ≤ FL ≤ 14.52 cm), and adults (FL > 15.20 cm, FL > 13.42 cm, FL > 14.52 cm) of *Pomadasys jubelini* caught from January 2007 to December 2008 in Grand-Lahou (A), Ebrie (B) and Aby (C) lagoons.

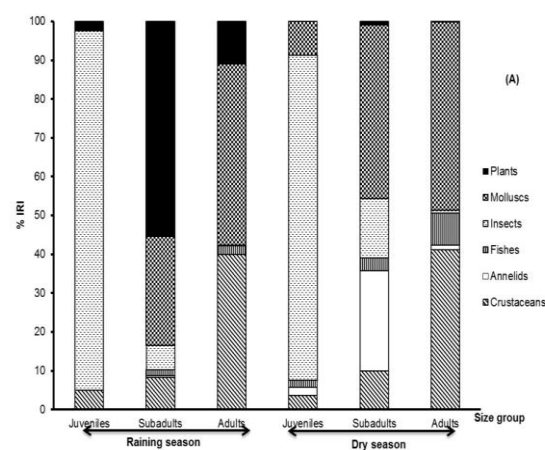
In adults, crustaceans (46.60%) and molluscs (42.37%) were mainly eaten in Grand-Lahou lagoon. However, crustaceans and molluscs were the primary ingested prey with respectively 28.16% and 38.51% in Ebrie lagoon and with 29.91% and 42.38% respectively in Aby lagoon.

The results of Spearman rank order analysis for testing differences in food composition between size groups of *P. jubelini* have revealed significant similarities between the diets of juveniles to subadults ($N = 15$; $R_s = 0.83$; $p = 0.0001$), juveniles to adults ($N = 15$; $R_s = 0.81$; $p = 0.0003$) and sub adults to adults ($N = 15$; $R_s = 0.67$; $p = 0.007$) in Aby lagoon. Diets of juveniles to sub adults ($N = 13$; $R_s = -0.095$; $p = 0.76$), juveniles to adults ($N = 13$; $R_s = 0.48$; $p = 0.094$) and sub adults to adults ($N = 13$; $R_s = 0.035$; $p = 0.91$) were not significantly.

Correlated in Ebrie lagoon. The spearman test revealed also significant feeding similarities between the diets of juveniles to sub adults ($N = 12$; $R_s = 0.75$; $p = 0.005$), while there were no significant correlation between the diets of juveniles to adults ($N = 12$; $R_s = 0.12$; $p = 0.72$) and sub adults to adults ($N = 12$; $R_s = 0.14$; $p = 0.66$) in Grand-Lahou lagoon.

Seasonal diet composition according to lagoons and fish size

Fig. 3 show seasonal variation in feeding habits of *Pomadasys jubelini*. Juveniles consumed mostly insects essentially dominated by *Chironomid larvae* during rainy and dry season with respectively 92.60% and 83.75% in Grand-Lahou lagoon, 75.93% and 91.73% in Ebrie lagoon and, 83.59% and 98.12% in Aby lagoon.



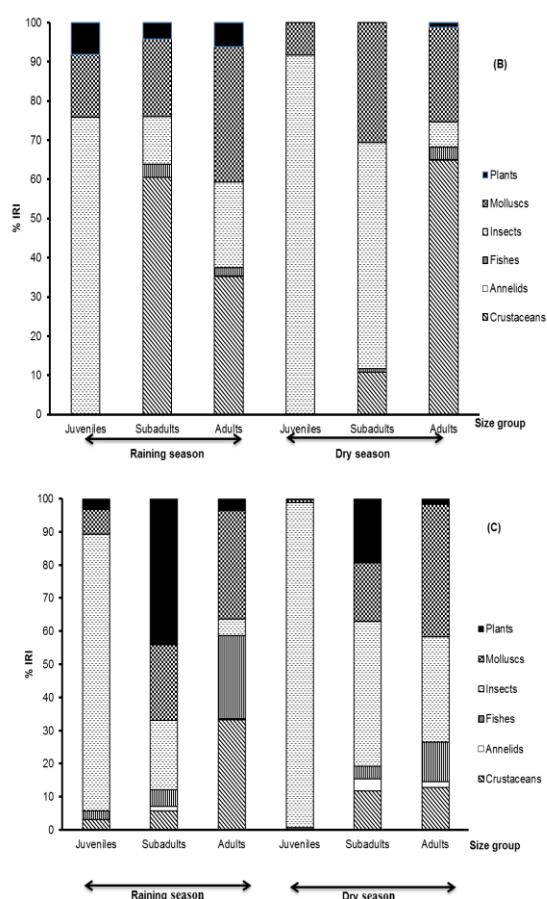


Fig. 3. Seasonal variation of diet of *Pomadasys jubelini* in Grand-Lahou (A), Ebrie (B) and Aby (C) lagoons between January 2007 and December 2008, based on the % IRI of the major prey groups.

In Grand-Lahou lagoon, sub adults fed on plants (55.41%) preferentially and molluscs (28.02%) secondary in rainy season, molluscs (44.65%) and annelids (25.73%) constituted the preferential preys during the dry season. In adults, during the rainy and dry seasons, the preferential preys were represented by molluscs (46.61% and 48.56% respectively) and crustaceans (39.97% and 41.14% respectively).

In Ebrie lagoon, sub adults, crustaceans (60.60%) were the most eaten preys in the rainy season and insects (57.67%) became preferential preys in dry season. In adults, during the rainy season, preferential preys were composed mainly by crustaceans (35.24%) and molluscs (34.46%) and insects (21.78%). However, adults ingested preferentially crustaceans (64.84%) following by molluscs (24.19%) during the dry season.

In Aby lagoon, sub adults consumed plants (44.13%) and molluscs (22.83%) as principal preys following by insects (20.95%) in rainy season. Insects (43.82%) and plants (19.35%) were a principal preys during a dry season. In adults, during the rainy season, crustaceans (33.17%) and molluscs (32.63%) were the most frequently preys eaten following by fishes (25.08%) considered as secondary prey. Molluscs (39.98%) and insects (31.88%) were the main ingested preys during the dry season, and Crustaceans (12.85%) and fishes (12.01%) represented the secondary preys.

The Spearman rank correlation coefficients attested that the seasonal variations in diet composition of juveniles ($N = 12$; $R_s = 0.54$; $p = 0.068$), subadults ($N = 12$; $R_s = 0.23$; $p = 0.47$) and adults ($N = 12$; $R_s = 0.48$; $p = 0.11$) were not significantly similar in Grand-Lahou lagoon during dry and rainy seasons. However, in Aby lagoon these correlation were significantly similar for juveniles ($N = 15$; $R_s = 0.86$; $p = 0.00005$), sub adults ($N = 15$; $R_s = 0.94$; $p = 0.00001$) and adults ($N = 15$; $R_s = 0.83$; $p = 0.0001$). In Ebrie lagoon, during dry and rainy seasons diets recorded were similar in juveniles ($N = 13$; $R_s = 0.84$; $p = 0.0004$), sub adults ($N = 13$; $R_s = 0.842$; $p = 0.0003$) and different in adults ($N = 13$; $R_s = 0.453$; $p = 0.119$).

Discussion

Pomadasys jubelini presented a large food spectrum and a great plasticity of feeding habits that included mainly crustaceans, annelids, fishes, insects, molluscs and plants. Similar diets were described previously for the same species from the Ebrie lagoon by Koné *et al.* (2007), in Nigeria lagoons by Adebisi (2011) and in the New Calabar - Bonny River by Agbugui *et al.* (2014). For these authors, *P. jubelini* fed on *Chironomid larvae*, Shrimp larvae, Crab, Molluscs and fishes.

An important sedimentary fraction composed of sand and mud was noted in all stomach contents of *P. jubelini*. This confirmed its benthic behavior. Many species such as *Synodontis shall* (Yao, 2006; Yatabary, 1983), *Tylochromis jentengi* (Konan *et al.*, 2008), *Synodontis bastiani*, *S. schall* (Yao, 2006) and *S. koensis* (Yao *et al.*, 2010) were also found to ingest mud and sand.

According to Villela (2002), ingestion of sand by species could be explained by the consumption of biofilm associated to the sand in one hand and their importance in mechanical digestion of plant items or hard parts of some food items such as insects, crustaceans and molluscs in other hand. Also, by ingesting a larger quantity of sand and mud, fish get microorganisms such as bacteria, interstitial organisms, etc. which are used in digestion.

Spearman test attested significant similarities in the diet of *P. jubelini* in the three lagoons studied. These similarities could be explained by the common food availability in the three lagoons, the feeding habits, the types of habitats and the niche breadth by this species (Albaret, 1994; Durand and Skubich, 1982).

Present survey showed that food habits changed with fish size considerably in all lagoons. Juveniles consumed insects (*Chironomid larvae*) as principal preys. Sub adults and adults eat crustaceans (*Penaeus notialis*), annelids (*Nereis* sp), plants and molluscs (*Turitella* sp.) as major prey. Our results differ to those observed by Koné *et al.* (2007) in Ebrie lagoon who found no significant difference in food between fish size. These dietary requirements with size could also be related to change in certain anatomical and morphological structures such as velocity, mouth and teeth (Lévêque, 1997).

Pomadasys jubelini increased the ingestion of larger preys rather than catch a greater number of prey for the growth. In proportion to a larger mouth size there was an increased ability to catch crustaceans, Fish and Molluscs. These ontogenetic changes are almost always accompanied by a change of large prey (Werner, 1986). Derbal *et al.* (2007) reported that this food trend oriented prey increasingly large at the expense of the number observed in the ontogenetic development. It would explain the orientation of the predation of adults to a wider range of large macro benthic preys (Crustaceans, Molluscs, and Fishes). Such changes in food habits with fish size could decrease the risk of competition between small and large individuals (Harmelin-Vivien *et al.*, 1989).

In this study, the food content of *P. jubelini* showed little seasonal variations in Ebrie and Aby lagoons. In both lagoons, these observations could probably be attributed to the availability of its preferred fish food within all study areas and throughout the year. In Grand-Lahou lagoon, seasonal changes in the diet of *P. jubelini* were related to the selectivity of prey, structure and availability of the community as noted Philippart and Ruwet (1982). Also, this variation in food could be explained by the proximity of estuarine area which received more oceanic influence and were under influence of upwelling throughout the year. Indeed, during the rainy season, there was a great variety and abundance of food available from the Boubo and Bandama Rivers, and Atlantic Ocean by upwelling, which favored the growth of phytoplankton and productivity of invertebrates. This was reflected in the increase in the intensity of food during this period (Albaret and Laë, 2003).

Conclusion

Pomadasys jubelini was an omnivorous diet with benthophagous tendency in the three lagoons. Crustaceans, Gastropods, Bivalves, Insects, Annelids and Plants were major feeds. Juveniles consumed insects principally *Chironomid larvae* while adults and sub adults feed mostly Crustaceans, Annelids, Molluscs and Plants.

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