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Food and feeding habits of *Hemichromis fasciatus* Peters, 1857 and *Heterotis niloticus (Cuvier, 1829)* in lake Ehuikro (Côte d'Ivoire)

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ABSTRACT

The main of this study was to compare the diet of *Hemichromis fasciatus* (Perciformes, Cichlidae) and *Heterotis niloticus* (Osteoglossiformes, Arapaimidae) in Lake Ehuikro (Bongouanou, Ivory Coast). Ffish were caught using gillnets between July 2017 and June 2018. A total of 206 stomachs of *H. fasciatus* and 71 stomachs of *H. niloticus* were examined and the relative importance index (RI) was used to analyze the importance of different items. Results indicate that both species are omnivorous tending towards insectivorous with a predominance of Chaoboridae. Despite the overlap obtained in diet of both species ($C\lambda = 0.89$), the ecological niche was small and wide in *H. fasciatus* and *H. niloticus*, respectively. Dietary variations indicated ontogenic changes in the first specie and seasonal changes in the second specie. Proportion of mineral fraction observed in stomach contents suggests pelagic feeding behavior in *H. fasciatus* and benthic behavior in *H. niloticus*.

Keywords: Diet, fish, omnivorous, insectivorous, ecological niche.

INTRODUCTION

The species *Hemichromis fasciatus* Peters, 1857 and *Heterotis niloticus* (Cuvier, 1829), colonize many natural aquatic systems ranging from rivers, streams to natural and marshy lakes (Coulibaly, 2008; Sirima et al., 2009; Kouakou et al., 2016). These two species are also the most represented in Lake Ehuikro (Kouadio et al., 2019). The study of the trophic ecology is key to determining the factors that control their distribution and abundance. Indeed, very few studies have been carried out on the food ecology of these species except the work of Aboua et al. (2010) in Bandama River and Blahoua et al. (2017) in Lake Ayamé 2 and Gooré Bi et al. (2019) in several aquatic systems, which indicated that *H. fasciatus* feeds mainly on fish and aquatic insects. Onyeche et al. (2013) observed a more diversified diet of blue-green algae, diatoms, protozoa and crustaceans in the Niger Delta. Concerning *H. niloticus*, Kouakou et al. (2016) showed that this fish consumes more microcrustaceans in the Agnéby River. Both species have an omnivorous diet (Kouakou et al., 2016;

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Blahoua et al., 2017). They coexist in the same environment, and their frequency of occurrence in our catches is greater than 50%. In addition, *H. fasciatus* and *H. niloticus* are intensively exploited by fishermen in the department of Bongouanou. Therefore, it would be important to have knowledge on plasticity, the strategy of their diet and to verify the hypothesis of overlapping species living in the same environment when taking food. The purpose of this study was to analyze the diet of both species in Lake Ehuikro.

MATERIALS AND METHODS

Study area

Lake Ehuikro was built as a result of the construction of a dam in 1973 as part of the national hydraulic programme on the Yakpo River in Bongouanou sub-district (Figure 1). It is located between latitude 6° 23’ 2" North and longitude 4° 57’ 25" West. It is under the influence of four seasons (two rainy seasons: March-July and September-October and two dry seasons: November-February and August). The sub-critical flow of this lake depends on the flows of the sacred river Yakpo and Kaby Lake. Lake Ehuikro is bordered to the south by rubber tree nurseries, poultry and pig farms and to the northwest by cassava, cocoa and food crops.

Fish sampling and stomach contents analysis

Fish were caught monthly between July 2017 and June 2018 using monofilament nets with mesh sizes of 15, 20, 25, 30, 40, 40, and 60 mm. Fish were identified according to Paugy et al. (2003a, b) and measured (standard length) and weighed. Then, each stomach was removed and stored in a pill box containing formaldehyde solution (5%) and the length of the intestine was measured. At the laboratory, stomach contents are filtered through a series of sieves with 500, 250 and 100 µm mesh sizes. A binocular was used to observe preys in the filtrate and they have been identified at the lower taxonomic level possible according to Elouard (1981); Dejoux et al. (1981); Tachet et al. (2003) and Moison (2010). Different size classes have been determined according to Sturges’ rule-(Scherrer, 1984).

Estimation of relative importance of food items

Frequency of occurrence (%F), numerical (%N) and weight (%W) percentage (Ricker 1968, George and Hadley 1979; Young et al., 1997) were employed in the analysis of the gut contents. To reduce bias, dietary importance of food items was determined using the relative importance index (RI) (George and Hadley 1979, Hyslop 1980). RI was determined by the following formula: $RI = (\%N + \%W + \%F)/\Sigma(\%N + \%W + \%F) \times 100$).

Food items were classified according to Georges and Hadley (1979): accessory preys, RI < 10%; secondary preys, 10% < RI < 50%; main preys RI > 50%.

Data analysis

Food overlap C_λ between species has been calculated, using the overlap measure of Horn (1966). Food overlap values superior than 0.60 are considered to be biologically significant (Zaret and Rand, 1971). To assess the feeding strategy along the studied period, the modified Costello (1990) graphical method (Amundsen et al., 1996) was used. Intraspecific seasonal and ontogenic changes in diet were evaluated using pearman’s Rank Correlation. All analysis were developed by using Past and Statistica 7.1 software.

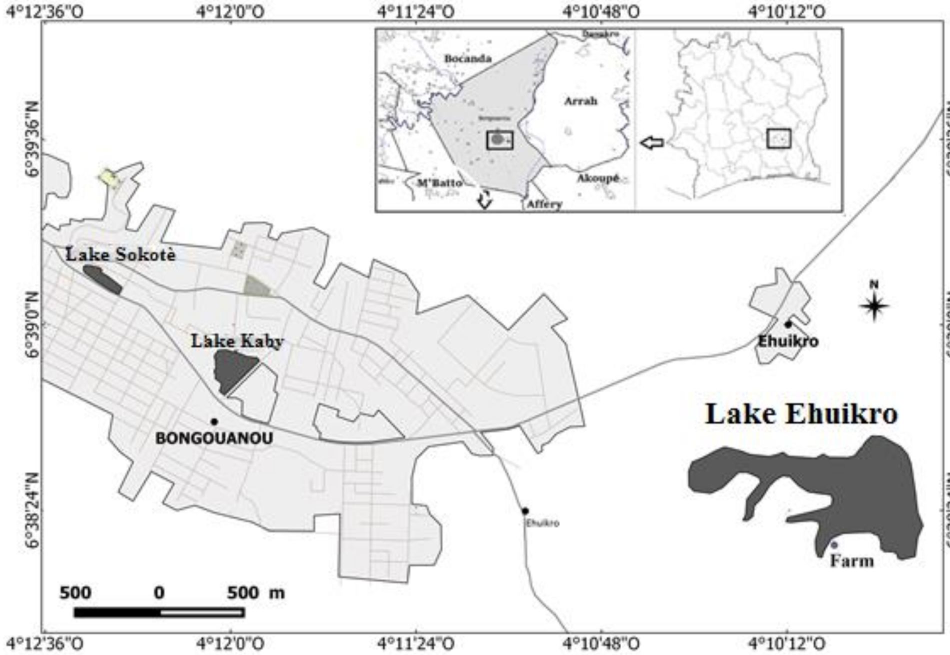

Figure 1: Map showing geographical location of Lake Ehuikro, Bongouanou, Côte d'Ivoire.

RESULTS

Size structure

Among *Hemichromis fasciatus*, 206 fish were captured. The standard lengths of these fish range from 64 to 158 mm LS (Figure 2). The distribution of the total population is unimodal. The size class, with the largest number of individuals, is [110-120] which constitutes 31.07% of individuals. Among *Heterotis niloticus*, there are 71 individuals with a standard length between 132 and 425 mm LS. The population of *H. niloticus* has a bimodal structure (Figure 2) and the largest modal class is [250-290] with 22.53% individuals.

Diet composition

Qualitative analysis (Table 1) of stomach contents shows that the food spectrum of *H. fasciatus* is more diversified than that of *H. niloticus*. Eighteen items were observed in six food categories in *H. fasciatus* compared to nine items in four food categories in *H. niloticus*. The most diversified category is insects. We also note the presence of a mineral fraction in the stomach contents of these two species. Quantitatively, digital abundance (%N) of the items (Table 1) reveals that insects are the most numerous in the diet of *H. fasciatus* (%N = 97.3%) and *H. niloticus* (75.06%). In terms of biomass, insects are still the most represented with a weight percentage of 77.88% and 64.74% respectively in *H. fasciatus* and *H. niloticus*. Insects are the preys that regularly appear in the diet of *H. fasciatus* with a frequency occurrence of 61.06%, followed by macrophyta (23.01%). On the other hand, macrophyta are frequently consumed by *H. niloticus* with a frequency occurrence of 39.92% followed by insects (%F = 31.85%).

Based on RI, insects are the main prey (RI = 78.98% and RI = 62.7%) respectively in both species. For *H. fasciatus*, macrophyta, fish, detritus, shrimps and annelids are accidental prey (RI < 10%) while for *H. niloticus*, macrophyta are secondary prey (RI = 36.01%). Fish and detritus are accidental prey. The result of the overlapping index (Cλ = 0.89) indicates that the diet of these two species is significantly overlapping.

Food in relation to fish size

Three size classes (SC1: LS < 80 mm; SC2: 80 mm ≤ LS < 130 mm and SC3: LS ≥ 130 mm) for *H. fasciatus* and two size classes (SC4: LS < 250 mm; SC5: LS ≥ 250 mm) for *H. niloticus* were determined using an upward classification analysis (Figure 3).

Stomach contents analysis by size class indicates that among small fish (LS < 80 mm for *H. fasciatus* and LS < 250 mm for *H. niloticus*), five food items in *H. fasciatus* and eight food items in *H. niloticus* were recorded (Table 2). The Relative Importance index indicates that in *H. fasciatus* and *H. niloticus*, insects (RI = 79.12% and RI = 55.06% respectively) represent the main prey. Macrophyta are described as secondary prey (RI = 20.88% in *H. fasciatus*, RI = 43.4% in *H. niloticus*). The other prey are categorized (fish and detritus) as accidental prey (RI < 10%) in *H. niloticus*. In the large fish (LS ≥ 130 mm for *H. fasciatus* and LS ≥ 250 mm for *H. niloticus*), 16 items in *H. fasciatus* and seven items in *H. niloticus* were recorded. The Relative Importance of Food index indicates that in *H. fasciatus*, insects (RI = 64.04%) are the main prey, fish (RI = 23.36%) are the secondary prey, macrophyta, annelids, shrimps and detritus are the accidental prey (RI < 10%) while in *H. niloticus*, it appears that insects are the primary prey (RI = 65.79%) and macrophyta (RI = 32.95%) are the secondary prey. Other prey are accidental or incidental (RI < 10%).

In medium-sized individuals (LS < 130 mm) observed in *H. fasciatus*, 14 food items divided into five categories were identified. Based on Relative Importance index, it was found that insects (RI = 83.13%) are the major prey. Other preys are described as accidental (RI < 10%). Spearman ranks-order correlation test performed on the basis of RI data in *H. fasciatus* showed a significant difference between the diets of individuals of height [80; 130] and those of size [130; 160] (N = 6; R = 0.77 and p = 0.07) on the one hand and between individuals of size [60; 80[and those of size [130; 160] (N = 6; R = 0.68 and p = 0.14) on the other hand. However, there is no significant difference between the food patterns of individuals of size [60; 80] and those of size [80]; 130[(N = 6; R = 0.84 and p = 0.03). In addition, the Spearman rank correlation test shows that the diet in *H. niloticus* does not differ according to the size of the individuals (N = 4; R = 1 and p = 0.000).

Seasonal changes in diet composition

The results of the qualitative analysis indicate that in *H. fasciatus*, the food spectrum is more diversified in the rainy season than in dry season with six prey categories compared to four categories, whereas in *H. niloticus*, the food spectrum is more diversified in dry season than in rainy season (Figure 4).

Among *H. fasciatus* species, insects remain the primary prey both in the rainy season and in the dry season with 80.72% and 73.69% of the Relative Importance index (RI) respectively. All other preys are classified as accidental (RI < 10%) in the rainy season while macrophytes are secondary prey in dry season with RI = 12.84%. Among *H. niloticus*, insects are also the main prey and macrophytes are the secondary prey in both dry season and rainy season. The other categories of prey are accidental (RI < 10%).

The comparison of the different RI values showed that the diet of *H. fasciatus* does not differ according to seasons (Spearman: N = 6; R = 0.98 and p = 0.0003) while the diet of *H. niloticus* differs significantly from one season to the other (Spearman: N = 4; R = 0.8 and p = 0.2).

Feeding strategy

The analysis of the food strategy based on the Costello diagram (Figure 5) makes it possible to separate two groups and three groups within the items ingested by *H. fasciatus* and *H. niloticus* respectively. The first group in these two species consists only of insects. The latter are characterized by their specific abundance (Si) and frequency of occurrence (%F) greater than 50% (Si > 50%

and %F > 50%) and are the dominant items in their diet. The second group presents prey items of low specific abundance (Si) and occurrence frequency (%F) (Si and %F < 50). This second group consists of macrophyta, fish, detritus, crustacea and annelids in individuals of *H. fasciatus* while in *H. niloticus* it is detritus and fish. These items are accidentally found in the stomach contents and represent rare foods in their diet. The third group in individuals of *H. niloticus* consists of macrophyta. They are distinguished by their specific abundance (Si) of less than 50% and their frequency of occurrence (%F) of more than 50% in the bolus of food.

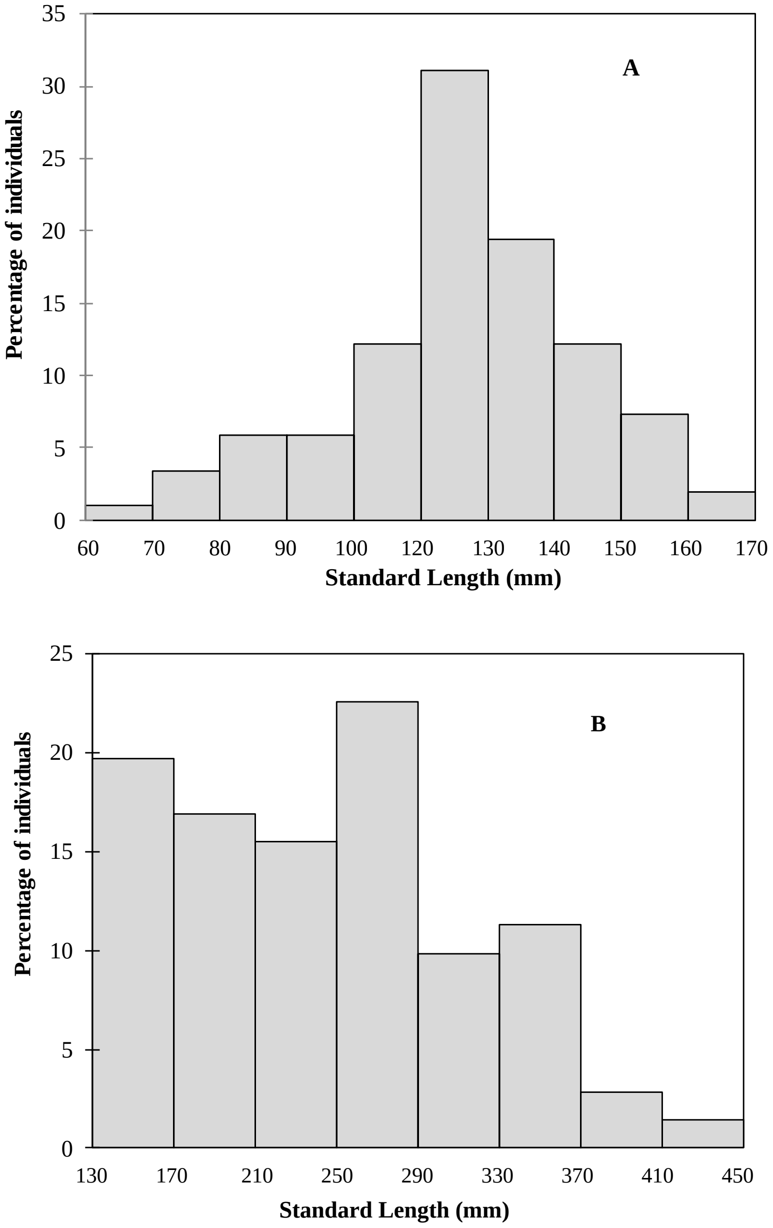

Figure 2: Distribution of size frequencies among individuals of *Hemichromis fasciatus* (n = 206) (A) and *Heterotis niloticus* (n = 71) (B) collected in Lake Ehuikro between July 2017 and June 2018.

Table 1: Summary of prey taxa in the diet of *H. fasciatus* and *H. niloticus* from lake Ehuikro as percent by frequency of occurrence (%F) numerical percentage (%N), weight percentage (%W). Relative importance index (RI) expressed as percent contribution to the diet are also shown.

	Hemichromis fasciatus				***Heterotis niloticus***			
ITEMS	**%F**	**%N**	**%W**	**RI**	**%F**	**%N**	**%W**	**RI**
INSECTS								
Diptera								
Chaoboridae	24,48	94,03	34,04	51,00	20,97	74,83	56,40	55,59
Chironomidae	1,77	0,11	0,04	0,64	0,81	0,02	0,01	0,30
Ceratopogonidae	0,59	0,02	0,01	0,21	-	-	-	-
Coleoptera								
Noteridae	1,18	0,10	0,14	0,48	-	-	-	-
Gyrinidae	0,88	0,03	0,07	0,33	0,40	0,01	0,47	0,32
Odonata								
Gomphidae	0,29	0,01	0,34	0,22	-	-	-	-
Heteroptera								
Corixidae	0,29	0,15	0,22	0,22	-	-	-	-
Gerridae	0,59	0,02	0,04	0,22	-	-	-	-
Notonectidae	0,29	0,01	0,04	0,12	-	-	-	-
Hymenoptera								
Formicidae	7,96	1,94	32,03	14,02	0,40	0,02	0,01	0,16
Insect remains	22,71	0,87	10,90	11,53	9,27	0,18	7,85	6,32
PISCES								
Fish	6,78	1,35	14,25	7,48	0,81	0,02	0,16	0,36
Fish eggs	0,29	0,12	0,05	0,16	-	-	-	-
ANNELIDS	0,59	0,02	0,02	0,21	-	-	-	-
SHRIMPS	0,59	0,02	0,20	0,27	-	-	-	-
MACROPHYTA								
Seed-fruits	1,77	0,11	0,13	0,67	25,00	24,60	32,40	29,95
Plant debris	21,24	0,81	3,50	8,54	14,92	0,30	1,37	6,06
DETRITUS	6,78	0,26	3,98	3,69	1,21	0,02	1,32	0,93
Mineral fraction								
Sand grains	0,88	ND	ND	ND	25,81	ND	ND	ND
Mud	-	-	-	-	0,40	ND	ND	ND
INSECTS	61,06	97,30	77,88	78,98	31,85	75,06	64,74	62,7
FISH	7,08	1,47	14,30	7,64	0,81	0,02	0,16	0,36
ANNELIDS	0,59	0,02	0,02	0,21	-	-	-	-
CRUSTACEA	0,59	0,02	0,20	0,27	-	-	-	-
MACROPHYTA	23,01	0,92	3,62	9,21	39,92	24,9	33,77	36,01
DETRITUS	6,78	0,26	3,98	3,69	1,21	0,02	1,32	0,93
MINERAL FRACTION	0,88	ND	ND	ND	26,21	ND	ND	ND

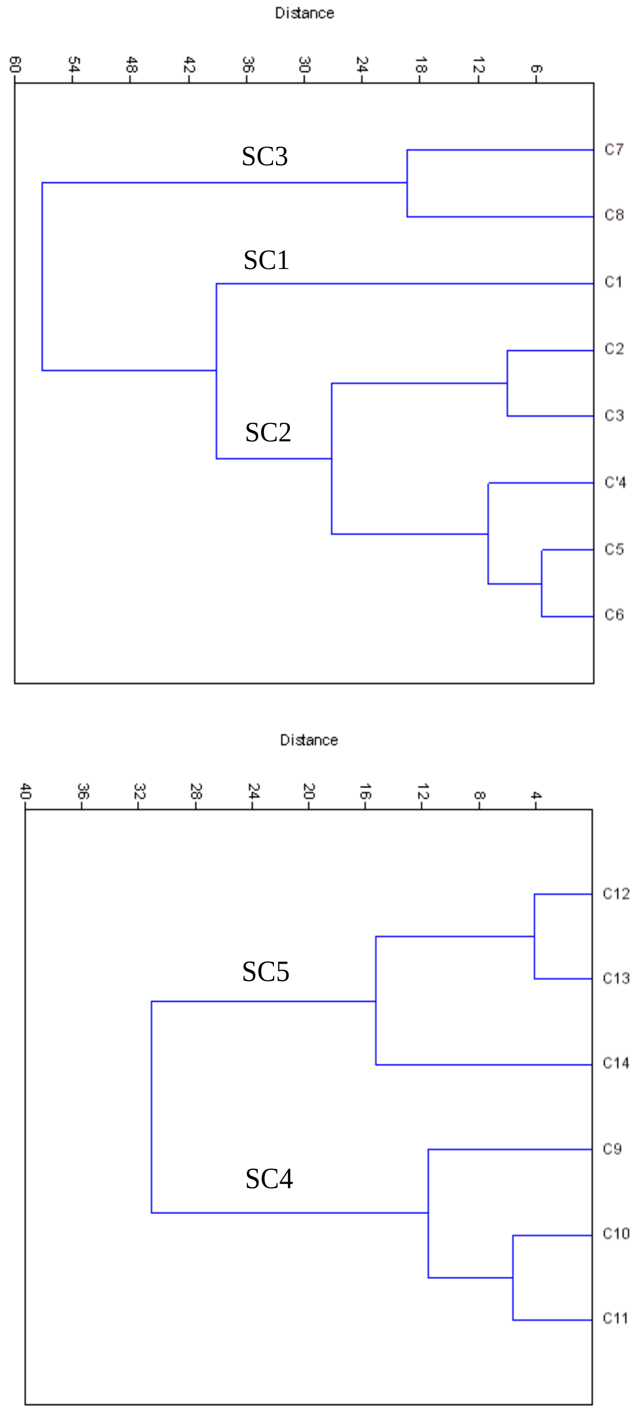

Figure 3: Diet similarity cluster of eight size classes of *H. fasciatus* (A) and six size classes *H. niloticus* (B) from lake Ehuikro, Bongouanou (Côte d'Ivoire).

Analysis based on Euclidean distance and Ward's method: SC1 = C1, LS<80 mm; SC2 = C2, C3, C4, C5, C6, 80≤LS<130 mm; SC3 = C7,C8, LS ≥ 130 mm (*H. fasciatus*); SC4 = C9, C10, C11, LS<250 mm ; SC5 = C12, C13, C14, LS ≥ 250 mm (*H. niloticus*).

Table 2: Diet of *Hemichromis fasciatus* and *Heterotis niloticus* according to size classes in Lake Ehuikro (Bongouanou, Côte d'Ivoire).
SC1= [60-80[; SC2= [80-130[; SC3= [130-160]; SC4= [130-250[; SC5 = [250-450]

	Hemichromis fasciatus			***Heterotis niloticus***	
	SC1	**SC2**	**SC3**	**SC4**	**SC5**
ITEMS	**RI**	**RI**	**RI**	**RI**	**RI**
INSECTS					
Diptera					
Chaoboridae	39,67	55,20	36,13	43,79	60,42
Chironomidae	7,63	0,43	0,53	-	0,59
Ceratopogonidae	-	0,14	0,50	-	-
Coleoptera					
Noteridae	3,82	0,35	0,51		
Gyrinidae	-	0,44	-	0,89	-
Odonata					
Gomphidae	-	-	0,92	-	-
Heteroptera					
Corixidae	-	0,29	-	-	-
Gerridae	-	0,14	0,52	-	-
Notonectidae	-	-	0,54	-	-
Hymenoptera					
Formicidae	-	14,95	12,22	0,33	-
Insect remains	28,00	11,19	12,17	10,04	4,78
PISCES					
Fish	-	3,18	22,46	0,50	0,30
Fish eggs	-	-	0,91	-	-
ANNELIDS	-	0,14	0,49	-	-
SHRIMPS	-	-	1,23	-	-
MACROPHYTA					
Seed-fruits		0,75	0,51	37,30	26,73
Plant debris	20,88	8,87	6,86	6,10	6,22
DETRITUS	-	3,92	3,51	1,05	0,96
INSECTS	79,12	83,13	64,04	55,06	65,79
FISH	-	3,18	23,36	0,50	0,30
ANNELIDS	-	0,14	0,49	-	-
CRUSTACEA	-	-	1,23	-	-
MACROPHYTA	20,88	9,63	7,36	43,4	32,95
DETRITUS	-	3,92	3,51	1,05	0,96

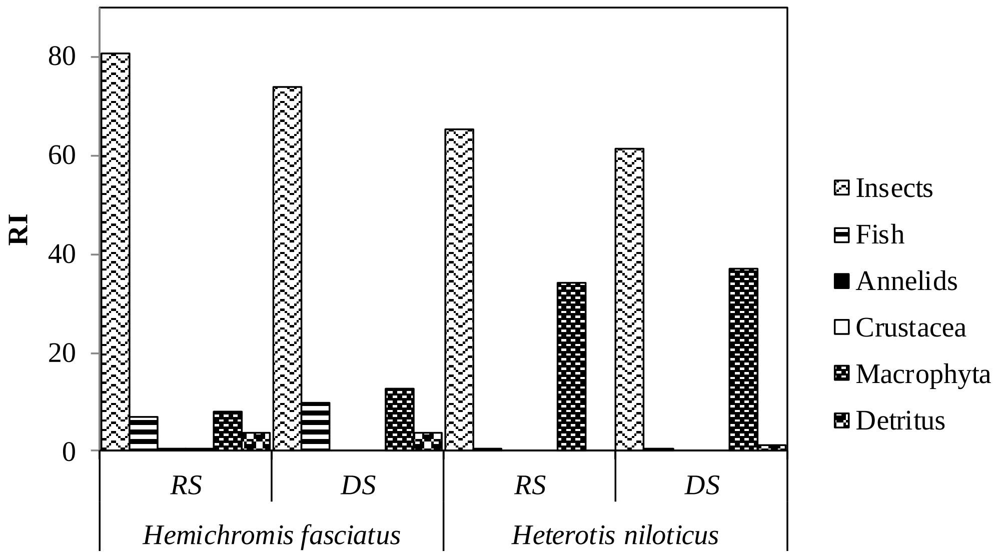

Figure 4: Diet based on the Relative Importance index (RI) of *Hemichromis fasciatus* and *Heterotis niloticus* from Lake Ehuikro (Bongouanou, Côte d'Ivoire) according to seasons.
RI = Relative Importance index; RS = rainy season; DS = dry season

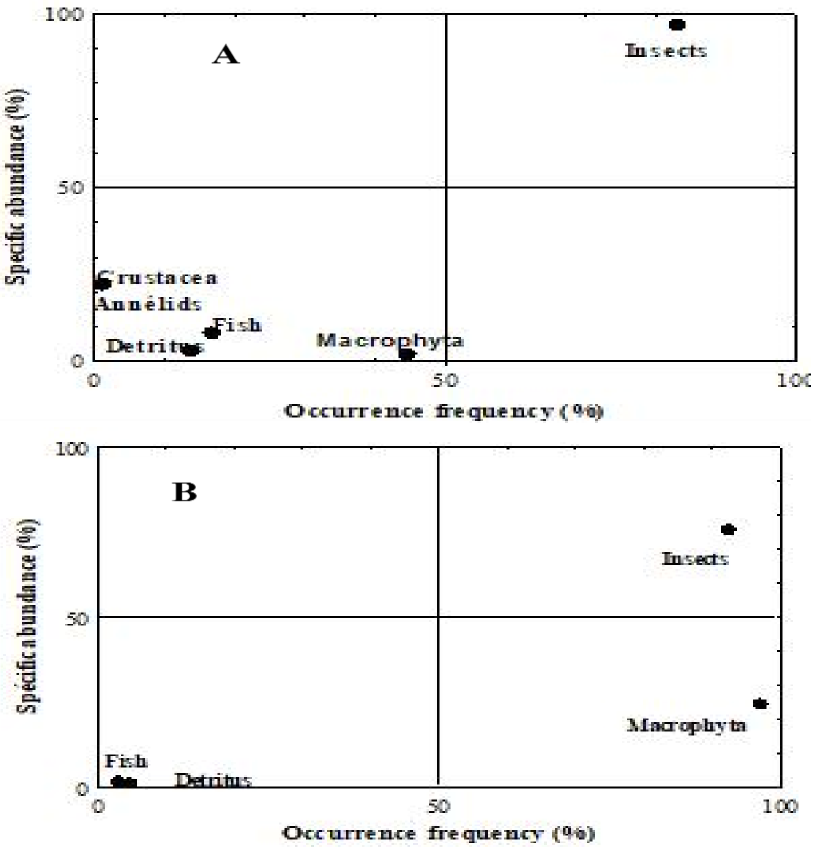

Figure 5: Diagram of the feeding strategy of *Hemichromis fasciatus* (A) and *Heterotis niloticus* (B) caught in Lake Ehuikro (Bongouanou, Côte d'Ivoire) between July 2017 and June 2018.

DISCUSSION

The majority of size classes are well distributed in *Hemichromis fasciatus* and *Heterotis niloticus* with unimodal and bimodal populations respectively. This is an index of healthy fish populations (Erbio, 2001). In addition, the maximum size obtained with *H. fasciatus* is 158 mm LS. This maximum size is greater than the maximum size of *H. fasciatus* (LS = 152 mm) by Koffi (2015) from Aby-Tendo-Ehy lagoon. This is due to the fact that *H. fasciatus* grows well in this environment. In addition, medium-sized individuals of *H. fasciatus* (LS < 130 mm) and small individuals of *H. niloticus* (LS < 250 mm) are more prevalent in the catch with respectively N = 153 and N = 37. Indeed, the more numerous they are, the more they colonize a huge area in search of food and therefore able to be captured. This result could also be due to their feeding activity which is high in order to maintain their positive growth.

The general aspect of the diet in *H. fasciatus* and *H. niloticus* showed an omnivorous diet with an insect-eating tendency in both species. This omnivorous diet indicates that there is a diversity of prey in their food bowl. This means that these two species are opportunistic and feed on the food available in the surrounding environment. (Kouamé et al., 2006). Thus, their ability of these two species to use various food sources in the environment reflects their dietary plasticity (Ikomi and Sikoki, 2001). In addition, preys in stomach contents are surrounded by mud with a frequency occurrence (0.88% in *H. fasciatus* and 26.21% in *H. niloticus*) and their diet is dominated by Chaoboridae. Therefore, the presence of these Chaoboridae and mud in the stomach contents is evidence of the benthophagous behavior of the fish (Belaud et al. 1990). The results regarding the diet of *H. fasciatus* differ from those obtained by Gooré Bi (2009) and by Meye and Ikomi (2011) in the aquatic systems of the Ivorian area, in Orogodo River in Nigeria, respectively. According to these authors, this species has a strictly piscivorous diet. Nonetheless, Blahoua et al. (2017) indicated that *H. fasciatus* is on an omnivorous tending towards piscivorous in lake Ayamé 2, and similar results have been reported in Mankessim reservoir by Atindana et al. (2016), in the aquatic systems of the Ivorian zone by Gooré Bi (2009), in lake Hlan (Benin) by Adite et al. (2005 ; 2013), in Anambra river (Nigeria) by Odo et al. (2009) and in Agnéby River (Côte d'Ivoire) by Kouakou et al. (2016). Indeed, Lauzanne (1976) indicated that *H. niloticus* have a benthophagous diet but can also become a major consumer of seeds and terrestrial insects, as is the case in this study.

The overlapping diet between *H. fasciatus* and *H. niloticus* could be explained by the abundance and accessibility of the same resources consumed by these two species, namely Chaoboridae (Jemaa et al., 2015). Indeed, Chaoboridae are main preys in both species. This result would also be related to period of trophic activity, coinciding with the period of occurrence of this prey, or the sharing of the same environmental niche in search of resources.

A significant difference in diet according to size classes was observed in *H. fasciatus*. Indeed, some fish that are considered as prey, are absent in small individuals, and they are accidental prey among medium-sized individuals. They move from accidental prey to secondary prey in large individuals. These changes in individuals' diets are due to the increase in nutritional needs during their development. In addition, ontogenic changes that are coupled with an increase in size, lead to the emergence of new physiological and ecological requirements in individuals (Paugy and Lévêque, 2006; Diaha et al., 2010) due to morphological and anatomical changes, particularly in the digestive system. Thus, the increase in size of fish preys is explained by the fact that a reduced number of preys provide much more energy (Paugy and Lévêque, 2006). In *H. niloticus*, the diet does not differ according to the size of the individuals observed. This similarity in diet between individuals can be explained by belonging to the same size range. Indeed, the standard length of the individual organisms examined during this work varies from 132 mm to 425 mm. In literature review, the sizes in this species range from 101.5 mm to 980 mm (Odo et al., 2009) in Lake Chad and between 120 and 780 mm (Kouakou, 2017) in Agnéby River (Côte d'Ivoire). Thus, with reference to these sizes, the results of this study indicate that the individuals caught belong more or less to the same size range, hence their ability to have the same prey.

Although there is no statistically significant difference in the diet of individuals of *H. fasciatus* according to seasons, the results of the qualitative analysis reveal that the food spectrum is more diversified in rainy season than in dry season. These results could be explained by the environment of the study area dominated by the crop production, which would host a large population of insect species. These insects, caused through the agency of wind and runoff water, could be found in the water environment, thus explaining the high number of preys recorded during rainy season. Indeed, Paugy and Lévêque (2006) and Castillo-Rivera (2013) indicated that during rainy season, aquatic environments are home to a high level of food items, thus increasing the food activity pace. In addition, water level fluctuations are the main factor influencing diet and food intake intensity (Kouamélan et al., 2000). With regard to seasonal variations of *H. niloticus*, this species consumes the same categories of prey in dry season and rainy season. The consumption of the same categories of prey regardless of the season is explained by the fact that this species is benthophagous or by the non-variability of the prey in this environment. Indeed, the various resources used by this fish are hardly influenced by seasons, particularly the difference in water level.

Analysis of the feeding strategy of *H. fasciatus* and *H. niloticus* based on the Costello method indicated that all or substantially all individuals capture insects, hence their abundance and high prevalence in diet of both species. Other prey with their low values of specific abundance and occurrence frequency show that the ecological niche of *H. fasciatus* is restricted (Amundsen et al., 1996). On the other hand, a widespread consumption of an item by all individuals of *H. niloticus* was noted. Thus, the results of this analysis show that this species has a homogeneous population with a large ecological niche (Garcia et al., 2005; Khelifi et al., 2017).

Conclusion

The present study showed that both species have an omnivorous diet dominated by insects and indicated significant seasonal and ontogenic variation in *H. fasciatus* and *H. niloticus*, respectively. Diet of both species are overlapping with a restricted ecological niche in the first specie and wide in the second.

COMPETING INTERESTS

The authors declare that there are no competing interests regarding the publication of this paper.

AUTHOR'S CONTRIBUTIONS

All authors contributed in the field data collection. The analysis of data and the preparation of manuscript were done by ANK and YAK, the manuscript correction by SSY and ZMG, and the supervision of the work by GGB.

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REFERENCES

Aboua BRD, Konan GN, Kouamélan PE, Berté S, Bamba M. 2010. Organisation spatiale du peuplement de poissons dans le Bandama. *Int. J. Biol. Chem. Sci.*, **4**(5): 1480-1493. DOI: http://dx.doi.org/10.4314/ijbcs.v4i5.65547.

Adite A, Gbankoto A, Toko II, Fiogbé ED. 2013. Diet breadth variation and trophic plasticity behavior of the African bonytongue *Heterotis niloticus* (Cuvier, 1829) in the Sô River-Lake Hlan aquatic system (Benin, West Africa): Implications for species conservation and aquaculture development. *Nat. Sci*., **5**(12): 1219-1229. DOI : http://dx.doi.org/10.4236/ns.2013.512149.

Adite A, Winemiller KO, Fiogbé ED. 2005. Ontogenetic, seasonal and spatial variation in the diet of *Heterotis niloticus* (Osteoglossiformes : Osteoglossidae) in the Sô River and Lake Hlan, Benin, West Africa. *Environ. Biol. Fishes*, **73**: 367-378. DOI: http://dx.doi.org/10. 1007/s10641-004-5563-9.

Amundsen PA, Gabler HM, Staldvik FJ. 1996. A new approach to graphical analysis of feeding strategy from stomach contents data – modification of the Costello (1990) method. *J. Fish Biol*., **48**(4): 607-614. DOI: https://doi.org/10.1111/j.1095-8649.1996.tb01455.x.

Atindana SA, Blay J, Yankson K. 2016. Investigation on food ecology of three Cichlid species in the Mankessim Reservoir, Central Region of Ghana. *Int. J. Fish. Aquac.*, **8**(5): 55-61.

Belaud A, Bengen D, Lim P. 1990. Approche de la structure du peuplement ichtyologique de six bras morts de la Garonne. *Annls Limnol.*, **26** (1): 81-90.

Blahoua KG, Adou YE, Gogbé ZM, N'Douba V. 2017. Régime Alimentaire de *Hemichromis fasciatus* (Perciformes, Cichlidae) dans le lac de Barrage Hydroélectrique d'Ayamé 2 (Côte d'Ivoire). *Eur. Sci. J.*, **13**: 1857- 7431. DOI : htt://dx.doi.org/10.19044/esj. 2017. v13n30p126.

Castillo-Rivera M. 2013. Influence of rainfall pattern in the seasonal variation of the fish abundance in a tropical estuary with restricted marine communication. *J. Water Resource Protec.*, **5**(3): 311-319. DOI: http://dx.doi.org/10.4236/jwarp.2013.53A032.

Costello MJ. 1990. Predator feeding strategy and importance: a new graphical analysis. *J. Fish Biol*., **33**: 261-263. DOI: https://doi.org/10.1111/j.1095-8649.1990.tb05601.x.

Coulibaly ND. 2008. Relation longueur-poids chez quatre espèces de poissons de la rivière Sourou au Burkina Faso. *Int. J. Biol. Chem. Sci.*, **2**(3): 331-338. DOI: http://dx.doi.org/10.4314/ijbcs.v2i3.39744

Dejoux C, Elouard JM, Forge P, Maslin JL. 1981. Catalogue iconographique des insectes aquatiques de Côte d'Ivoire. Rapport ORSTOM, 42, 178 p.

Diaha CN, N'da K, Soro Y. 2010. Régime alimentaire de *Scomberomorus tritor* (Cuvier, 1831) dans le Golfe de Guinée. *Int. J. Biol. Chem. Sci.*, **4**(3): 669-680.

Elouard JM. 1981. Diptères: caractères généraux, clés systématiques et familles peu importantes. In *Flore et Faune Aquatiques de l'Afrique Sahelo – Soudanienne*, Durand JR, Lévêque C (eds). ORSTOM : Paris ; 553-567.

Erbio. 2001. *Etude sur l'ichtyofaune d'eau douce pour le projet kaniambo*. Rapport d'inventaire. Etude environnementale de base. Rapport final, 201 p.

Garcia MA, Geraldi MR, Vieira PJ. 2005. Diet composition and feeding strategy of southern pipefish *Syngnathus folletti* in a Widgeon grass bed of the Patos Lagoon Estuary, RS, Brazil. *Neotrop. Ichthyol.*, **3**(3): 427-432. DOI: 10. 1590/s1679-62252005250003000011.

George EL, Hadley WL. 1979. Food and habitat partitioning between roch (*Ambloplites rupestris*) and small mouth bass (*Micropterus dolomievi*) young of the year. *Trans. Am. Fish. Soc.*, **108**: 253-261. DOI: https://doi.org/10.1577/1548-8659(1979)108<253:FAHPBR>2.0.CO;2.

Gooré Bi G. 2009. Impact des activités humaines sur les communautés de poissons dans les systèmes aquatiques de la zone côtière ivoirienne (Côte d'Ivoire) : Établissement d'un indice d'intégrité biotique (IIB). *Thèse de Doctorat d'État*. Université de Cocody, Abidjan (Côte d'Ivoire), 177 p.

Gooré Bi G, N'Zi KG, Kouamé T. 2019. Impact of human activities on fish communities in the aquatic systems of the ivorian coastal zone and establishment of a biotic integrity index (iib). *Int. J. Inf. Res. Rev.*, **10**: 6055-6060.

Horn HS. 1966. Measurement of «overlap» in comparative ecological studies. *Am. Nat.*, 100: 419-424. DOI: https://doi.org/10.1086/282436.

Ikomi RB, Sikoki FD. 2001. Studies on the distribution, abundance, growth pattern and dietary habits of *Brycinus nurse* (Ruppel, 1832) (Osteichthyes: characidae) in the river Jamieson, Nigeria. *Acta Ichtyol. Pisc.*, **31**(1): 27-44. DOI: 103750/AIP2001.31.1.02.

Jemaa S, Dussene M, Cuvilier P, Bacha M, Khalaf G, Amara R. 2015. Comparaison du régime alimentaire de l'anchois (*Engraulis encrasicolus*) et de la sardine (*Sardina pilchardus*) en atlantique et en méditerranée. *Leban. Sci. J.*, **16**: 7-22.

Khélifi N, Boualleg C, Sahtout F, Kaouachi N, Mouaissia W, Bensouillah M. 2017. Feeding habits of *Carassius carassius* (Cyprinidae) in Beni Haroun Dam (north- east of Algeria). *AACL Bioflux*, **10**(6): 1596-1606.

Koffi KB. 2015. Diversité de l'ichtyofaune et écologie trophique de quelques espèces dans le complexe lagunaire Aby-Tendo-Ehy (Côte d'Ivoire). Thèse de Doctorat. Université Félix Houphouët Boigny, Abidjan (Côte d'Ivoire), 187 p.

Kouadio AN, Koffi KB, Yao SS, Gooré Bi G, N'Doua ER, Konan YA. 2019. Inventory of ichtyological population and on some physicochemical parameters characteristics of a drinking water supply dam : the lake Ehuikro (Bongouanou, Côte d'Ivoire). *Int. J. Biosci.*, **15**(4): 339-349.

Kouakou IKF. 2017. Biologie et pêche de *Heterotis niloticus* (Cuvier, 1829) (poissons Cameroun) de la rivière Agnéby (Côte d'Ivoire). Thèse de Doctorat. Université Nangui Abrogoua, Côte d'Ivoire, 148 p.

Kouakou IKF, Koné T, Agnissan J-PA, Soro Y, N'Da K. 2016. Régime et éthologie alimentaires de *Heterotis niloticus* (Cuvier, 1829) dans la rivière Agnéby (Côte d'Ivoire). *Int. J. Innov. App. Stud.*, **14**(3): 721-732.

Kouamé MK, Ouattara A, Dietoa MY, Gourène G. 2006. Alimentation du Clupeidae *Pellonula leonensis* dans le lac de barrage de Buyo (Côte d'Ivoire). *Cybium,* **30**(2): 145-150.

Kouamelan EP, Teugels GG, Gourène G, Thys Van Den Audernaerde DFE, Ollevier F. 2000. Habitudes alimentaires de *Mormyrops anguilloïdes* (Mormyridae) en milieu lacustre et fluvial d'un bassin ouest-africain. *Cybium,* **24** : 67-79.

Lauzanne L. 1976. Régimes alimentaires et relations trophiques des poissons du lac Tchad. *Cahiers d'ORSTOM*, *Séries d'Hydrobiologie*, **10**(4) : 267-310.

Meye JA, Ikomi RB. 2011. Some aspects of the biology of banded jewel fish, *Hemichromis fasciatus* (Peters, 1857) in River Orogodo, Delta State, Nigeria. *The Zoologist*, **9** : 17-24.

Moisan J. 2010. Guide d'identification des principaux macroinvertébrés benthiques d'eau douce du Québec, 2010. Surveillance volontaire des cours d'eau peu profonds. Direction du suivi de l'état de l'environnement, Ministère du Développement Durable, de l'Environnement et des Parcs, Québec, Canada, 82 p.

Odo GE, Nwamba HO, Eyo JE. 2009. Aspects of the biology of *Heterotis niloticus* Cuvier 1829 (Osteoglossiformes: Osteoglossidae) in the Anambra flood river system, Nigeria. *Anim. Res. Int.*, **6**(2): 994-1002. DOI: 10.4314/ari.v6i2.48131.

Onyeche VEO, Onyeche LE, Akankali JA, Enodiana IO, Ebenuwa P. 2013. Food and fish feeding habits in Anwai Streal ichthyofauna, Niger Delta. *Int. J. Fish. Aquac.*, **5**(11): 286-294. DOI : 10.5897/IJFA2013.0387.

Paugy D, Lévêque C. 2006. Régimes alimentaires et réseaux trophiques. In *Les Poissons des Eaux Continentales Africaines : Diversité, Ecologie Utilisation par l'Homme*, Lévêque C, Paugy D (eds). IRD Editions : Paris ; 191-215.

Paugy D, Lévêque C, Teugels GG. 2003a. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Tome 1. Collection faune tropicale 40. Institut de Recherche pour le Développement (IRD) (Paris, France) MRAC et MHN (Tervuren), 457 p.

Paugy D, Lévêque C, Teugels GG. 2003b. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Tome 2. Collection faune tropicale 40. Institut de Recherche pour le Développement (IRD) (Paris, France) MRAC et MHN (Tervuren), 815 p.

Ricker WE. 1968. Methods for assessment of fish production in fresh waters. IBP Handbook, Philadelphia, Pennsylvania, Blackwell Scientific Publications, Oxford 3, 328 p.

Scherrer B. 1984. Présentation des données. In *Biostatistique*, Morin G (ed.). Boucherville, Canada ; 103-126.

Sirima O, Toguyeni A, Kaboré-Zoungrana CY. 2009. Faune piscicole du bassin de la Comoé et paramètres de croissance de quelques espèces d'intérêt économique. *Int. J. Biol. Chem. Sci.*, **3**(1): 95-106. DOI: http://dx.doi.org/10.4314/ijbcs.v3i1.42740

Tachet H, Richoux P, Bournaud M, Polatera PU. 2003. *Invertébrés d'Eau Douce : Systématique, Biologie, Ecologie*. CNRS: Paris; 587 p.

Young JW, Duyet TD, Bradford RW, Whitelaw AW. 1997. Feeding ecology and interannual variations in diet of southern bluefin tuna, *Thynnus maccoyii* in relation to coastal and oceanic waters of eastern Tasmania, Australia. *Environ. Biol. Fish*, **50**: 275-291. DOI: https://doi.org/10.1023/A:1007326120380.

Zaret TM, Rand AS. 1971. Competition in tropical stream fishes: support for the competitive exclusive principle. *Ecology*, **52**: 336-342. DOI: https://doi.org/10.2307/1934593.