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Comparison of the diet of two species of Labeo (Cyprinidae): a rheophilic one, *Labeo sorex* and a limnophilic one, *Labeo lineatus* in the Malebo Pool (Congo River)

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Abstract

Comparison of the diet of two species of Labeo (Cyprinidae): a rheophilic one, Labeo sorex and a limnophilic one, Labeo lineatus in the Malebo Pool (Congo River)

We studied the diet of two Cyprinid fish of the genus Labeo: Labeo lineatus and L sorex from the food index: occurrence index of the preys, ponderal index, numerical index and the relative importance index. The relationship between the length of the intestine and the standard length of the studied specimens of Labeo is between 10.3 and 17.7 for L lineatus and 8.7 and 16.1 for L sorex. Which show that these two fishes species are nourished at the expense of the phytoplankton made up of Bacillariophyceae, Eugleunophyceae, Cyanophyceae and Cholorophyceae to which are added the vegetable remainders. The diet of these species do not change with the size of studied individuals.

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Keywords:
Cyprinid – Phytoplankton – primary consumer

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INTRODUCTION

Labeo lineatus (Boulenger, 1898) and Labeo sorex (Nichols & Griscom, 1917) are two Cyprinids fishes belonging to the genus Labeo frequently captured in Malebo Pool, Congo River. Labeo sorex belongs to the folded lips group of Labeo and it is a rheophilic species highly adapted to the rapid habitat of the Congo River (Pwema et al.2011; Tshibwabwa, 1997; Robert and Stewart, 1976) but L. lineatus is a limnophilic species with papillose lips who is largely distributed in the limnophilic habitats in the ichtyogeographic region of Congo (Pwema et al 2011; Tshibwabwa, 1997). These fishes can reach big sizes (640 mm SL with 9690 g body weight) and represents a significant share in the commercial captures of the Malebo Pool. They are largely used in a special cooking of fish parcels in plant leaves called ''Maboke '' in Lingala language.

Feed is the single source of acquisition of energy that animal use for the various ends (Lévêque, 1994). The knowledge of the diet of the fish species, in a defined environment is useful to determine their trophic positions and their ecological impacts. It is also necessary for the modelling of the ecosystems and to facilitate the definition of the food requirements of the species likely to be utilized in aquaculture (Froese & Pauly, 1999).

Thus, it constitutes a shutter essential for the knowledge of biology and ecology of fish (Rosecchi & Nouaze, 1987).

The studies of the diet make it possible to have data, not only on the presence, the abundance and the availability of the trophic potential of the environment, but more especially to understand the relations between fish and feed like their inter and intra specific relationships in the considered ecosystem (Kouamélan, 1999).

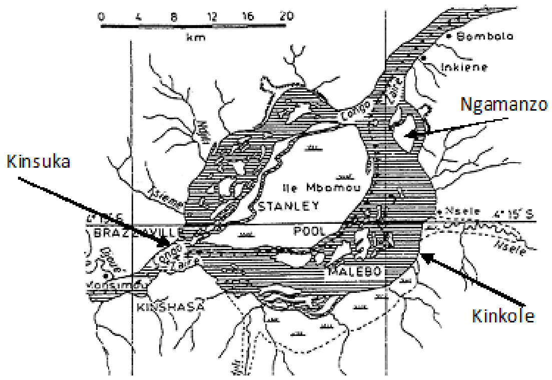
To know the real feed requirements of a fish species in its natural environment, the best approach rests on the analysis of the stomacal contents. This analysis makes it possible to identify the various consumed trophic components, while appreciating the relative importance of the preys in the diet.

In this study, we compared the diet of two species of the genus Labeo a limnophilic one, Labeo lineatus and a rheophilic one, Labeo sorex.

MATERIAL AND METHODS

Study sites

Our sampling campaign was performed in the Malebo Pool, Congo River. This study was conducted in 3 sites (Fig. 1): Ngamanzo (upstream part of Malebo Pool) (4° 10' 33.9" S; 15° 31' 20.9" E), Kinkole (4° 10' 29.6" S; 15° 27' 29.8" E) the middle of Malebo Pool and Kinsuka 1 (4° 19' S and 18° 15' E) the end of Malebo Pool.



Legend. Sampling sites

Figure I| **Map of Malebo Pool showing our three sampling sites (modified from Burgis & Symoens, 1987).**

Fish sampling

Fish were collected using gillnets (10 to 100 mm mesh with 1.8 m depth and 25 m long for each gillnet). Fishing was performed overnight (5PM to 7 AM). All Labeo species were identified and counted (Tshibwabwa and Teugels, 1995; Stiasny et al 2007; Ibala, 2010).

Specimens of L lineatus and L. sorex of various sizes was preserved in bottles containing a 10 % solution of formalin.

Analysis of the stomacal contents

The intestinal coefficient (Ci) was calculated for each individual fish by dividing the length of the intestine of the fish by its standard length (Paugy, 1994).

Each stomacal contents were diluted in 2 ml of water for small fish and in 10 ml of water for big size specimen. According to Hasle, (1978), the richness of specific diversity can vary according to dilutions. Thus, a too large dilution makes counting tiresome and slow, because of the too great dispersion of the elements, while a very weak dilution makes counting too difficult, because of the high density of prey elements (Nindara, 2002).

Examination of 0.5 ml of the contents was made under the inverted microscope - Leica-DMIL n° 451200. This microscope uses a cell of the type Bürker, no squared, having a cylindrical cavity. Planktonics elements form a deposit in a cellular layer; their morphological structures become quite visible then, which facilitates their identification.

Since it is difficult to examine all the cell of Bürker, Utermöhl (1958) quoted by Hasle (1978), recommends to examine a portion of the preparation or some transects, until the number of elements observed do not vary any more in a notorious way.

During this study, we still applied the method of under sampling (Plisnier, 1990; Mukankomeje et al., 1994). It consists in counting the number of microscopic fields which can give the maximum taxa. Thus, for five samples examined, we noticed that starting from the fifth transect, the number of taxa observed varied very little or not at all.

We thus chose the observation of five transects, by traversing them by the diagonal. This method thus allowed us to meet the maximum number of taxa. Their number was brought back to known volume. We multiply the result obtained by a correction factor which, according to Plisnier (1990), is obtained by dividing the volume of stomacal contents diluted (2 ml is 2000 mm 3) by the examined volume (0,5 ml are 500 mm 3).

The preys (microscopic) were identified, generally, until the kind, while resorting to the works of Bourelly (1966, 1968, 1970); Da, (1992); Zongo, (1994), John et al (2002), Wehr & Sheath (2003).

Results expressions

The classes of size of the specimens of Labeo captured were given starting from the rule of Sturge (Scherrer, 1984) according formula 1:

$$NC = 1 + (3.3 \log 10 \ N) \quad (1)$$

Where NC is the number of class and N is the total number of individuals for the sample considered.

Classes interval is determined by the ratio 2:

IC = (Max length – Minimal length)/Total number of the class (2)

We used two great groups of methods: the qualitative methods which consist in specifically inventory of the preys met in the stomachs and the quantitative methods which make it possible to specify the relative importance of the various preys (or groups of preys) in the total composition and the possible variations of the diet according to the environmental factors. They relate, either to the number, or to the weight, or to the volume of the various elements contained in the stomachs.

The various expressions of the diet defined and criticized by Hynes (1950), Lauzanne (1977), Hyslop (1980), Wallace (1981) are presented as followed.

The vacuity coefficient (CV). The vacuity coefficient of stomacal expresses the number of empty stomachs compared to the total number of analyzed stomachs.

The numerical index (N): is the percentage of the number of individuals of a category of preys for the unit of the sample compared to the total number of preys. It is expressed in formula 3:

NI = (Total number of the individual of the prey i/Total number of prey)*100 (3)

The occurrence (or frequency): determines the number of stomachs in which a prey (or a category of preys) is present. The Occurrence Index is expressed as a percentage compared to the total number of stomachs containing feed. Its expression is 4:

$$FC = \frac{\text{Total Number theof Individuals prey(i)}}{\text{Total Number of stomach pexamined}}\ x\ 100 \qquad (4)$$

The ponderal index (PI) : is a question of expressing the weight of the categories of preys, of the whole sample, compared to the total weight of the whole preys. The ponderal index gives a better idea of the relative importance of the various preys, but does not bring indications on the food preferences of the fish. It's shown in formula 5:

FC = (Total number of the prey i) / Total number of examined stomach)*100 (5)

Importance Relative Index (IRI)

The Importance Relative Index (IRI) takes into account the numerical percentage, the volumetric or ponderal percentage and the percentage of occurrence (Pinkas at al 1971). It is calculated by formula 6:

IRI = (N +V(P)) X FC (6)

Where:

N: numerical percentage
V: Volumetric percentage (%)
P: Weight Percentage (g)
FC: Occurrence Percentage

Intestine form

Fishes studied do not have a distinct stomach. The intestine is several times coiled. The degree of rolling up varies from one species to another.

Intestinal coefficient

The relationship between the intestine length of a fish and its standard length varies from one group to another and gives an indication on the type of food consumed by the fish. For the specimens studied, there is a significant linear relation ($R2 > 0.90$; $p < 0.05$) between the length of the intestine and the standard length of fish (Figure 2 and 3). The intestinal coefficient varies from 10.3 to 17.7 for the specimens of L. lineatus and from 8.7 to 16.1 for the specimen of L. sorex

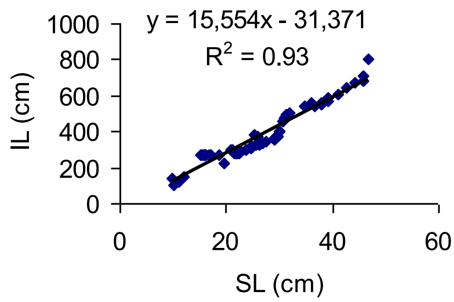


Figure II| **Relation between standard length (SL, cm) and the intestine length (IL, cm) of *Labeo lineatus.***

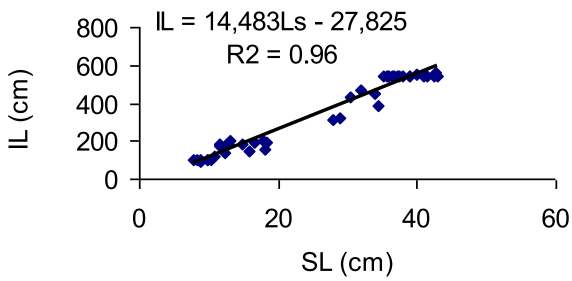


Figure III|**Relation between standard length (SL, cm) and the length of intestine (IL, cm) of *Labeo sorex.***

General diet

Table 1. Compared diet of the specimens of *Labeo sorex* and *L.lineatus* in the Malebo pool based on Importance Relative Index (IRI, %); n is the number of individuals.

N°	Espèces d'algues consommées	*L.sorex* n=108	*L.lineatus* n= 134

	Bacillariophyceae (Total)	**71,77**	**68**
1	*Achnanthes spp*	5,37	23,21
2	*Aulacoseira spp*	25,5	5,073
3	*Aulacoseira spp*	-	-
4	*Coconeis spp*	-	-
5	*Cymbella spp*	-	-
6	*Diatoma spp*	20,51	16,33
7	*Eunotia spp*	2,38	2,22
8	*Fragilaria spp*	5,17	6,69
9	*Gomphonema spp*	0,01	-
10	*Gyrosigma spp*	0,28	2,06
11	*Navicula spp*	6,87	6,89
12	*Nitzschia spp*	5,06	5,07
13	*Pinnularia spp*	0,62	1,47
14	*Stauroneis spp*	-	-
15	*Surirella spp*	-	-
16	*Tabellaria spp*	-	-
17	*Uronema spp*	-	-
Chlorophyceae (Total)		**13,26**	**17,5**
1	*Ankistrodesmus spp*	0,17	-
2	*Audouinella spp*	0,02	-
3	*Closterium spp*	-	0,15
4	*Cosmarium spp*	-	1,397
5	*Oedocladium spp*	1,07	14,9
6	*Oedogonium spp*		-
7	*Pediastrum spp*	4,57	-
8	*Scenedesmus spp*	0,77	1,03
9	*Spirogyra spp*	-	-
10	*Tetraedron spp*	-	-
11	*Zygnema spp*	6,66	-
Euglenophyceae (Total)		**1,11**	**1,74**
1	*Euglena spp*	1,11	1,735
2	*Phacus spp*	-	-
Cyanophyceae (Total)		**13,71**	**12,3**
1	*Anabaena spp*	0,17	0,074
2	*Aphanisomenon spp.*	0,02	0,707
3	*Aphanisomenon spp*		-
4	*Chrooccoccus spp*	-	-
5	*Goniochloris spp*	-	
6	*Merismopedia spp*	1,07	1,34
7	*Micrococcus spp*		-
8	*Microcystis spp*	4,57	
9	*Oscillatoria spp*	0,77	1,319
10	*Penium spp*	-	-
11	*Planctolyngbya.spp*	-	-
12	*Pseudanabaena spp*	7,11	4,553
13	*Sphaerocystisspp.*	-	-
14	*Spirulina spp*	-	-
15	*Stigeoclonium spp*	-	-
16	*Tetraspora spp*	-	-
Detritus (Total)		**0,15**	**0,53**

167 stomachs of L. sorex were examined, 108 were full stomachs, which gives a coefficient of vacuity of 54.6%. 87 stomachs of L. lineatus were examined in which, 34 stomachs were empty, and the vacuity coefficient were 65 %. On the whole, 45 different items food were found. These food items belong to four classes of phytoplankton (Bacillariophyceae, Cholorophyceae, Eugleunophyceae and Cyanophyceae) and of the remaining vegetables.

The Importance Relative Index (IRI) (Table 1), which combines at the same time the occurrence of the preys, the numerical percentage and weight percentage shows that Bacillariophyceae are the principal feed (> 68 %) for both type of Labeo fishes. In this group, Aulacoseira sp. (25.5%) like Diatoma sp. (20.5%) represents a significant share. Cholorophyceae (13.26 %), Cyanophyceae (13.71 %) and Eugleunophyceae (1.11%) constitute secondary food for *L sorex*.

No significant difference, between the diets was observed for each preys' category. The χ^2 calculated = 1,58, P (value) = 0,81; P> 0,05;ddl=4 for Bacillariophyceae); (χ^2 calculated = 2,33, P (P value) = 0, 67; P>0,05; ddl=4 for Cyanophyceae); (χ^2 calculated = 4,62, P value = 0, 32; P>0,05 for Chloroph yceae.) ; (χ^2 calculated = 1,62; P value) = 0, 80; P>0,05 for Eugleunophyceae).

Diet according to the size of the specimens

a. Labeo lineatus

Table 2. Class of size of *L lineatus* given starting from the Sturge rule (Scherrer, 1984) (N = a number of individuals in each class of size)

1	[6.4 ; 12.4 [	22
2	[12.4 ; 18.4 [	6
3	[18.4 ; 36.4 [	14
4	[36.4 ; 42.4 [	13
5	[42.4 ; 52.1[	27

The fishes examined feed on the periphyton which is composed of Bacillariophyceae, Cholorophyceae, Cyanophyceae and of Eugleunophyceae (figure 4). For all classes of size, Bacillariophyceae represents the main feed contents in the analyzed stomachs.

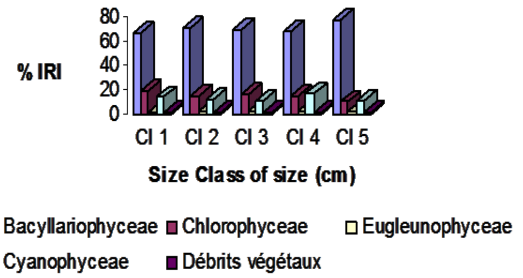


Figure IV| **Diet according to the classes of size for L lineatus**

Seven sizes of classes were determined using the Sturge rule (table 2). The L sorex diet according to the stages of development is shown on figure 5.

Table 3. Size classes defined for L sorex in Malebo Pool determined starting from the Sturge's rule (N = number of fish in each class)

Class	Limits of the class	N
1	[6.4 ; 13.4 [	18
2	[13.4 ; 20.4 [	20
3	[20.4 ; 27.4 [	15
4	[27.4 ; 34.4 [	17
5	[34.4 ; 41.4 [	21
6	[41.4 ; 48.4 [	9
7	[48.4 ; 55.4 [	8

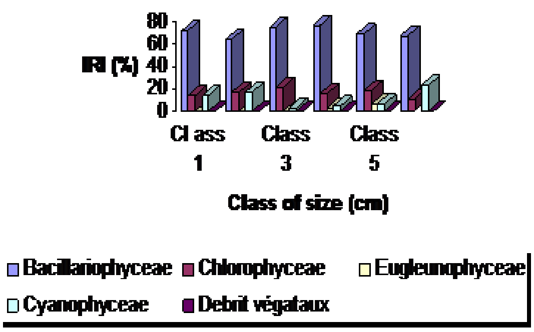


Figure V| **Diet of Labeo sorex according to the size of the individuals.**

According to figure 5, all the individuals feed mainly on Bacillariophyceae. Cyanophyceae, Eugleunophyceae. Cholorophyceae are not much found in the examined individuals no matter their size.

DISCUSSION

The intestinal coefficient of the specimens of Labeo lineatus and Labeo sorex studied in Malebo Pool lies between 9.7 to 17.6 and 7.4 to 16.7 respectively. Paugy, (1994) underlines the existence of a close relation between the type of feed consumed and the relative length of the intestine compared to the length of the fish's body . The ichtyophagous fish in general have a broad stomach and a short intestine, whereas the herbivorous and phytophagous fishes do not have defined stomachs. Their intestines are much longer than their body (Kramer & Bryant, 1995a et b ; Geidoefer, 1981).

By comparing the intestinal coefficient of fish of the Senegal basin, Paugy (1994) classified them in two categories. The first category corresponds to ichtyophagous fishes whose intestinal coefficient is between 0.8 and 3.01, and the phytophagous fish which has an intestinal coefficient ranging between 4.7 and 6.8. For fishes of the Red Sea, Al-Hussaini-Hussaini, (1947) classified them in the following way: Carnivorous species: $0.5 < Ci < 1.5$; species omnivorous: $2.5 < CI < 3.8$; and phytophagous species: $23.8 < Ci$. Labeo lineatus and Labeo sorex can be classified as periphytophagous species.

The macroscopic observation of the stomach contents of the studied specimens revealed a greenish pulp very hard to dissociate it into its components but the microscopic analysis identify four types of periphytoplankton. These are Bacillariophyceae, Chlorophyceae, Cyanophyceae and Eugleunophyceae. Similar results were obtained by Micha (1973) from observations carried out within the same group of fish . According to him, the stomach contents of Labeo lineatus is composed of a greenish paste composed of aquatic plants. These particular observations at the edge of the river enabled him to observe this fish feeding on film algae covering stones in low depth. For Lauzanne (1988) and Lévêque et al (1988), all the species of Labeo feed on the expense of the micro-organisms of the biofilm. Their diet is composed of various algae (diatoms) but also of the vegetable remains, molluscs and shellfish. These observations did not highlight the presence of molluscs and microscopic shellfish. On the other hand, our observations agree to those of Lévêque and Paugy (1999) which affirm that Cyprinids fishes in general and the genus Labeo in particular are primary consumers who consume external layer of the sediment generally made up of periphytic algae and which develops on various substrates : hard as stones and macrophytes or soft as mud. Unlike those who affirm the change of diet during the development of the fish (Lauzanne (1975), this study did not find the change of diet according to the sizes of the specimens. However, it's worth studying fish whose size is below 10 cm.

CONCLUSION

This study aimed at comparing the diet of two species of the genus Labeo which are frequently captured in Malebo's Pool by using the feed index. The outcome of this research showed that the two species feed on the periphyton made up of Bacillariophyceae, Eugleunophyceae, Cyanophyceae and Cholorophyceae; but Bacillariophyceae are more frequent in the analyzed fish stomachs.

We did not find a difference in the diet according to the individual size. Furthermore, we did not find also large difference between rheophilic and limnetic species but the taxonomic level of periphyton was limited at family and genus level. The determination at the species level shows probably a good separation of feed for these two Labeo species in order to avoid the competition between them.

RESUME

Nous avons étudié le régime alimentaire de deux espèces de Cyprinidae du genre Labeo : Labeo lineatus et de L sorex à partir des indices alimentaires : indice d'occurrence des proies, indice pondéral, indice numérique et indice d'importance relative. Le rapport entre la longueur de l'intestin et la longueur standard des spécimens de Labeo étudiés est situé entre 10,3 et 17,7 pour L. lineatus et entre 8,7 et 16,1pour L. sorex. Ce qui indique que ces deux espèces de poissons se nourrissent aux dépens du phytoplancton composée de Bacillariophyceae, Eugleunophyceae, Cyanophyceae et Cholorophyceae auquel sont ajoutés les restes végétaux. Le régime alimentaire de ces espèces ne change pas avec la taille des individus étudiés.

Mots clés : *Cyprinidae – Phytoplancton – Consommateur primaire*

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