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Diet comparison in three species of *Distichodus* Müller & Troschel, 1845 (Distichodontidae, Pisces) of Pool Malebo, Congo River (Democratic Republic of Congo)

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ABSTRACT

The diet of *Distichodus antonii*, *D. affinis* and *D. lusosso* was studied in Malebo Pool (Congo River, Kinshasa, D.R. Congo) through the analysis of 396 stomach contents in relation to the size of fish and the hydrological seasons. The Index of preponderance (% Ip) was calculated. The analysis of the preponderance index (Ip) showed that *D. antonii* and *D. affinis* are herbivorous. *D. antonii* feeds mainly on leaves and stems of *Echinochloa pyramidalis*, while *D. affinis* consumes in addition roots and detritus. Periphyton was regularly found in the stomach contents of the three species. During the two hydrological seasons, a significant overlap of diet was observed between all the sizes of *D. affinis* and *D. antonii.* In *D. lusosso*, overlap of diet was not observed. *Distichdus lusosso* is generalist; its food is composed of detritus, animal preys such as fishes, shrimps, crabs, nymphs and larvae of insects, molluscs. This study shows that *D. lusosso* takes advantage of diversified food items compared with *D. antonii* and *D. affinis*. These dietary strategies developed by theses three species contribute probably to their coexistence in Pool Malebo.

Keywords: Food and feeding, *Distichodus species*, fish size, competition, D. R. Congo.

INTRODUCTION

Distichodus antonii Schilthuis, 1891, *D. affinis* Günther, 1873 and *D. lusosso* Schilthuis, 1891 are Characiformes fishes endemic to African freshwater. They belong to the Distichondotidae family. Several species of Distichodontidae are known from the Congo River basin (Boulenger, 1909; Daget and Gosse, 1984).

In this family, *Distichodus* genus represents the single one that shows a major economic interest.

These fishes are found in shallow as well as deep water (Lowe-McConnell, 1987) inhabited by water plant communities where they extract their food.

They are considered by some authors as fishes adapted to a phytophagous diet (Durand and Lévêque, 1981). However, Lauzanne (1988) declared that they can, depending of environmental conditions, become omnivorous or detritivorous.

The present knowledge on *Distichodus* genus diet is very fragmented and scarce. Indeed, the available dietary data on *Distichodus* are only about *Distichodus* species of Nile basin: *D. niloticus* Linnaeus, 1762 (Hickley and Bailey, 1986), and about

species of lake Tchad: *D. rostratus* Günther, 1864 and *D. engycephalus* Günther, 1864 (Lauzanne, 1972). However, diet is very important in the growth and the reproduction of species.

In addition, diet study provides baseline scientific data for any investigation for ichthyologic biodiversity conservation and for better and sustainable exploitation.

The present study is dedicated to the analysis of diet through the examination of stomach contents of *Distichodus antonii, D. affinis* and *D. lusosso* from Malebo Pool (Congo River, Kinshasa, D.R. Congo). The aim is to identify, quantify and compare their diet and to investigate dietary changes. This will allow to precise their trophic level in relation to fish size and the hydrological seasons.

Study area

The Malebo Pool (Figure 1) is an enlargement of the Congo River abreast of Kinshasa and Brazzaville towns. It is located between the coordinates 4°05' to 4°18'S and 15°19' to 15°32' E.O. at a mean altitude of 272 m.; its area is about 500 km^2. This zone belongs to the Aw_4 climate type (Bultot and Griffits, 1971) characterized by: temperature > 18 °C, high rainfall, four months of dry season. . The substratum is muddy or muddy sandy. Malebo Pool is characterized by slow-running and turbid water. For the thirty last years, the current speed was 0.8 $m.s^{-1}$ and the depth varies between 3 m in july - august to 10 m in november- december (Burgis and Symoens, 1987). The mean flow of Congo River in Kinshasa is estimated at 40000 $m^3.s^{-1}$. (Technical data from the Congolese office of waterway "Régie des Voies fluviales « RVF »").

At Malebo Pool, Congo River water is slightly mineralised, the conductivity varied between 20 and 31 $\mu S.cm^{-1}$, the pH between 5.2 and 6.7; the dissolved oxygen between 7.7 $mg.l^{-1}$ and 9.1 $mg.l^{-1}$ and the water temperature is between 17.1°C and 31.5 °C (Burgis and Symoens, 1987).

The rainfall is unequally distributed over the year. For the period from 1990 to 2006, july is the driest month with a average rainfall of 0.85 mm while november is the wettest with a average rainfall of 258.7 mm (Mettelsat station: Ndjili / Kinshasa).

Many plant associations are found at Malebo Pool as *Pistia stratiotes* L., *Salvinia molesta* L., *Eichhornia crassipes* M. & S., *Echinochloa pyramidalis* (L.) H. & C., *Ludwigia abyssinica* A. R., *Ipomoea aquatica* F., *Oryza barthii* A. C.

The periphyton, identified by an undergoing study, is constituted by Bacillariophyceae, Chlorophyta, Euglenophyta, Cyanophyta, Dinophyceae and Rhodophyta.

MATERIALS AND METHODS

Fish sampling

The study was carried out from january 2005 to october 2007 at Kinkole station: 4°16'32,4" S-15°30'39,2"E.

Distichodus fishing was undertaken mainly with two batteries of gill nets of 10 mm, 15 mm, 25 mm, 35 mm and 50 mm stretched mesh sizes; each gill net was 2 m high and 30 m wide.

The gill nets were immersed between 5:00 pm to 5:00 pm on the next day, near the grassy banks. Thus, we had a cycle of 24 hours. But especially for the diet study, samples of fish were collected after each three hours of nets' immersion.

After capture, fishes were identified according to (Boulenger, 1909; Daget and Gosse, 1984) and according to a new key (Mbadu and Vreven, unpublished data); the following parameters were recorded: weight to nearest 1 g, total length and standard length with a calliper to the nearest 0.1 mm for the small individuals and a rule graduated to nearest 1 mm for the biggest specimens. The small fishes were kept in a 4% formalin solution before dissection while for the biggest ones, after dissection at the site, only the stomach contents were kept in the formalin solution.

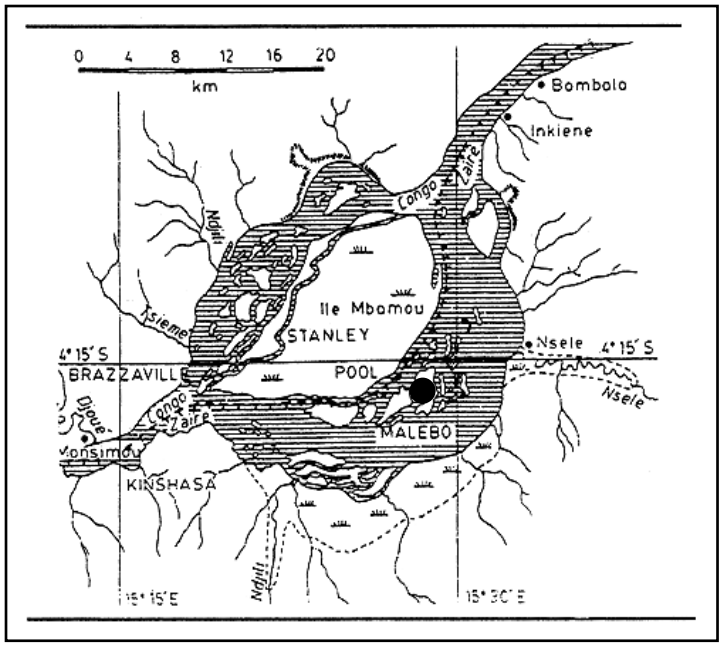

Figure 1: Map of Pool Malebo (Modified, according to Burgis and Symoens, 1987).
● = Study station.

The intestinal length was also recorded to calculate the intestinal coefficient which is the ratio between the intestinal length (mm) and the standard length (mm).

Stomach contents

Stomachs were drained on an absorbent paper, weighed and dissected. The stomach envelope was then weighed to nearest 0.0001 g in order to have the weight of stomach contents. The stomach content volume was estimated by measuring the increasing of the displacement of a water column in a graduated tube.

For each stomach content, we separated two fractions: the macroscopic and the microscopic fractions.

The macroscopic fraction of the stomach contents had been classified, identified and counted under a NIKON hand lens with a magnification of 10 to 50X.

The preys in small quantities were entirely counted while for the most abundant preys, we used the under sampling method. The preys, diluted in water, were spread in a Petri dish squared each 1 cm. We counted preys in five square centimetres and the result has been extended to the whole surface of the box.

Plant preys were identified by using the data records of the laboratory of plant biology at the faculty of sciences of the University of Kinshasa.

The invertebrates were identified according to Durand and Lévêque (1981).

A small quantity of stomach content has been diluted in 2 ml (small contents) or 10 ml (large contents) of a formalin solution at 4 % for the microscopic fraction analysis. The dilution depends on the sample size and the wealth of the specific diversity can change with the dilutions (Hasle, 1978).

For the analysis, 0.5 ml of the dilution was examined under an inversion LEICA-DMIL microscope (12.5 X 40). This microscope is provided with a Bürker cell; the morphological structures of preys become well visible and make easier their identification.

Since it is hard to examine the entire Bürker cell, we used the methods recommended by Utermöhl (1958) cited by Hasle (1978) and we applied the method of under sampling (Plisnier, 1990, Mukankomeje et al., 1994). The observed result is then multiplied by a correcting factor which, according to Plisnier (1990), is found by dividing the diluted stomach content volume (2 ml) by the examined volume (0.5 ml).

The identification of different microscopic elements was conducted according to Bourelly (1966, 1968), Canter-Lund and Lund (1995). The biovolume of algae was estimated according to Sournia (1978) and Pohlmann (2001).

Expression of the results

The intestinal coefficient (*CI*) for each individual was set following the relation:

$$CI = \frac{Li}{Ls}$$

Li : intestinal length ; *Ls* : standard length.

The dietary indexes used to express the results of the study (Kouamélan, 1999) are the occurrence Index (*Fc*) of Rosecchi and Nouaze (1987) normalised at 100 and the weight Index (P (%)) of Hynes (1950).

The values of "% Foc" and "% P" were combined through the index of preponderance (%Ip) using the equation (Marshall & Elliott, 1997):

$$Ip(\%) = \frac{\%Foc * \%P}{\sum_{i=1}^{n} \%Foc * \%P} * 100$$

%Foc: frequency of occurrence normalised, %P: weight index.

Food items were classified according King et al. (1991) cited by Kouamélan (1999):

Ip<10: accessories food items;

10< Ip<25: secondary food items;

25 <Ip<50: important food items;

50 >Ip: principal food items.

-Diet Niches Overlap Index

Diet overlap of fish species or different fish sizes of the same species allows to explain the structure of the communities or to assess the competitive relations. (Wallace, 1981 cited by Doumbia, 2003).

Many indexes are used to determine the rate of diets overlap; we used the Schoëner Index such as it is recommended by Wallace (1981), Linton et al. (1981) and Hurlbert (1978) cited by Doumbia (2003).

Schoëner Index (α) is given by the following relation:

$$\alpha = 1 - 0{,}5\left(\sum_{i=1}^{n} \left| p_{xi} - p_{yi} \right| \right)$$

n: number of preys categories; p_{xi}: proportion (in biovolume) of the prey *i* in the diet of species *x* or of the size class x; p_{yi}: proportion (in biovolume) of the prey *i* in the diet of the species *y* or of the size class *y* (Hynes, 1950).

Schoëner Index is situated between 0 (lack of overlap) and 1 (total overlap). A significant diet overlap exists when the index value is between 0.60 and 1 (Werner and Hall, 1977).

The number of size classes is given by the Sturge rule (Kouamélan, 1999):

Number of size classes $(N) = 1 + 3.3 \log_{10} n$

n: number of specimens

The interval of class is obtained by the expression (Lmax-Lmin)/*N*; where Lmax (mm) is the greatest observed length and Lmin (mm) the smallest observed length; *N* is the number of size classes.

Data analysis

Multivariate ANOVA were performed on data using SPAD software (version 5.0).

RESULTS

Intestinal coefficient

The mean intestinal coefficient was calculated for the three species: *D. affinis* (2.23±0.4; n = 122), *D. antonii* (3.08±1.2; n = 144) and *D. lusosso* (1.06±0.3; n = 130).

We noted a good correlation between the intestinal length and the standard length of fish for the three species ($r \geq 0.90$) (Table 1).

General food composition of *D. affinis, D. Antonii* and *D. lususso*

396 stomach contents of *D. Antonii* (n = 144), *D. affinis* (n = 122), and *D. lususso* (n = 130), were analysed.

87 categories of food items (Table 2) were identified and classified according to their taxonomy into 11 groups.

The percentages of indexes of preponderance resulting from the analysis of stomach contents revealed intra and inter specific variations of the three species diet.

The leaves and stems of *E. Pyramidalis* constitute the principal food of *D. antonii*. Plant detritus were abundant in *D. affinis*, while in *D. lususso*, plant detritus and Odonata larvae represent the principal preys.

Fish size

The phytophage diet is confirmed for all the fish sizes of *D. antonii* and *D. affinis*; the juveniles feed also on plant detritus and on small pieces of *Echinochloa pyramidalis* leave. In addition, periphyton is regularly found in the stomach contents.

In *D. lususso*, an omnivorous tendency is observed for all the fish sizes; juveniles feed too on diversified preys: crustaceans, insects' larvae (Striatomidae and Chironomidae).

In the three species, there was no intraspecific significant difference of the diet for all the fish sizes during a season or between the two seasons ($p < 0.05$).

Seasonal change

The consumption of plant detritus for the three species is more important during the dry season (*D. affinis:* Ip = 99.38%, *D. antonii*: Ip = 99.9%, and *D. lususso:* Ip = 84.33%) than during the wet season (*D. affinis*: Ip = 3.42%, *D. antonii*: Ip = 24.40% and *D. lususso*: Ip = 38.76%). On the other hand, during the wet season, the consumption of leaves and stems of *Echinochloa pyramidalis* are more important in *D. antonii* (Ip = 75.60) and *D. affinis* (Ip = 63.55).

The analysis of variance on the general diet of the three species did not show a statistical significant difference in the average trophic composition for the two seasons (wet season: F calculated = 0.089 < F tabulated = 3; dry season: F calculated = 0.00001 < F tabulated = 3; $p = 0.05$).

During the wet season, the frequencies of occurrence for periphyton were highest in *D. antonii* (Foc = 87.11%) and in *D. affinis* (Foc = 82.47%). For macrophytes with detritus included, the frequency of occurrence was 23.84% in *D. antonii*. It was smaller in *D. lususso* (Foc = 13.51%) and in *D. affinis* (Foc =10%). Insects were found in *D. lususso* with Foc = 14.72% (Figure 2a).

In the dry season, frequencies of occurrence were higher for periphyton in *D. antonii* (Foc = 82.73%) and in *D. affinis* (Foc = 77.55%).

The frequencies of occurrence for macrophytes with detritus included were: *D. lususso* (Foc = 23.47%), *D. antonii* (Foc = 19.05%) and *D. affinis* (Foc = 18.12%). Insects were well represented in *D. lususso* (Foc = 18.38 %) (Figure 2b).

Diet overlap

During the wet season (Table 3a, b, c), in *D. antonii*, 66.66% of sizes pairs showed high degree of overlap (> 0.60), while in *D. affinis* only 28.57% of sizes pairs overlapped. We observed the lack of significant overlap between all the sizes of *D. lususso*.

During the dry season (Table 4a, b, c), high values of overlap (> 0.60) were observed for 71.42% (*D. antonii*) and 100% (*D. affinis*) of sizes pairs. Only 10% of sizes pairs overlapped in *D. lususso.*

For the sizes pairs of each species, no significant difference of feeding overlap values between the two hydrological seasons was found. (*D. affinis:* χ^2 calculated = 0.99< χ^2 tabulated = 6.571; *D. antonii*: χ^2 calculated = 0.99< χ^2 tabulated = 1.635; *D. lususso:* χ^2 calculated = 0.99< χ^2 tabulated = 1.145; $p = 0.05$).

Table 1: Mean intestinal coefficient (CI mean) of *D. affinis, D. antonii and D. lusosso*.

	n	CI mean	Standart deviation	Equations	r
D. affinis	122	2.23	0.44	LI (mm) = 2.7244 LS (mm) – 31.027	0.91
D. antonii	144	3.08	1.21	LI (mm) = 4.8871 LS (mm) – 126.13	0.99
D. lusosso	130	1.06	0.34	LI (mm) = 2.3424 LS (mm) – 84.108	0.97

n: number of specimens, r: coefficient of correlation, LI (mm): intestinal length, LS(mm): standard length.

Table 2: Diet composition and index of preponderance (Ip) of *D. affinis, D. antonii and D. lusosso* during the wet and the dry seasons.

	Wet season			Dry season		
Food items	*D. affinis* Ip%	*D. antonii* Ip%	*D. lusosso* Ip%	*D. affinis* Ip%	*D. antonii* Ip%	*D. lusosso* Ip%
Macrophytes						
Plants detritus	3.42	24.40	38.76	99.38	100.00	84.33
E.pyramidalis (stems and leaves)	63.55	75.60	<0.001	<0.001	<0.001	<0.001
Roots	32.99	<0.001	<0.001	<0.001	<0.001	<0.001
Seeds	0.03	<0.001	<0.001	<0.001	<0.001	<0.001
Fungus	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Periphyton						
Bacillariophyceae						
Asterionella sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aulacoseira spp.	0.0002	<0.001	<0.001	0.142	<0.001	<0.001
Aulacoseira granulata	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Unidentified centriques	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Coconeis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyclotella sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cymbella sp.	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
Diatoma sp;	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Eunotia spp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fragilaria sp.	<0.001	<0.001	<0.001	0.602	<0.001	<0.001
Frustula sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gomphonema sp.	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Gyrosigma sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Meridion sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Navicula spp.	0.0007	<0.001	<0.001	0.129	<0.001	<0.001
Nitzchia sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pinnularia sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Stauroneis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Surirella sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Synedra sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tabelaria sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Unidentified Bacillariophyceae	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chlorophyta						
Actinastrum sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ankistrodesmus sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ankyra sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Closterium sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Coelastrum sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cosmarium sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Crucigena sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chaetophora sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Euastopsis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oedogonium sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oedocladium sp	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oocystis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Piediastrum sp	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Scenedesmus sp.	<0.001	<0.001	<0.001	0.0001	<0.001	<0.001
Selenastrum sp;	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Spyrogyra sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Unidentified Chlorophyta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Unidentified filamentous algae	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Euglenophyta						
Euglena sp.	<0.001	<0.001	<0.001	0.022	<0.001	<0.001
Trachelomonas sp.	<0.001	<0.001	<0.001	0.0005	<0.001	<0.001
Phacus sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dinophyta						
Peridinium sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ceratium sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyanophyta						
Anabaena sp.	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Anabaenopsis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aphanothece sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloococcales	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lyngbya sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Merismopedia sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Microcystis sp.	<0.001	<0.001	<0.001	0.004	<0.001	<0.001
Nostoc sp.	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Oscillatoria sp.	<0.001	<0.001	<0.001	0.006	<0.001	<0.001
Pseudanabaena sp.	<0.001	<0.001	<0.001	0.007	<0.001	<0.001
Planktolyngbya sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sphaerocystis sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Spirulina sp.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Unidentified Cyanophyta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nematoda	<0.001	<0.001	<0.001	0.020	<0.001	<0.001
Rotifers	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oligocheta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Silks of Naididae	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Insects						
Nymphs of Libellulidae	<0.001	<0.001	18.28	<0.001	<0,001	<0.001
Larvae of Chironomidae	<0.001	<0.001	8.80	<0.001	<0.001	<0.001
Insects larvae	<0.001	<0.001	18.00	<0.001	<0.001	<0.001
Insects wings	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Larvae of Stratiomyiidae	<0.001	<0.001	0.02	<0.001	<0.001	<0.001
Eggs of unidentified insects	<0.001	<0.001	0.06	0.22	<0.001	8.11
Crustaceans						
Atyidae (shrimps)	<0.001	<0.001	6.59	<0.001	<0.001	<0.001
Crabs	<0.001	<0.001	0.010	<0.001	<0.001	<0.001
Copepods	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cladocerans (Daphnia)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Unidentified arthropods	<0.001	<0.001	6.12	<0.001	<0.001	<0.001
Fish	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fish eyes	<0.001	<0.001	1.16	<0.001	<0.001	<0.001
Cycloid scales of fish	<0.001	<0.001	1.43	<0.001	<0.001	<0.001
Ctenoid scales of fish	<0.001	<0.001	0.32	<0.001	<0.001	<0.001
Gasteropoda						
Physidae	<0.001	<0.001	<0.001	<0.001	<0.001	0.25
Pila leopoldvillensis	<0.001	<0.001	0.44	<0.001	<0.001	0.72
Total						
Macrophytes	99.99	100	38.76	99.38	100	84.33
Périphyton	<0.001	<0.001	<0.001	0.38	<0.001	<0.001
Nematoda	<0.001	<0.001	<0.001	0.020	<0.001	<0.001
Plathelminthe	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Rotifers	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Insects	<0.001	<0.001	45.16	0.220	<0.001	8.11
Crustaceans	<0.001	<0.001	6.60	<0.001	<0.001	<0.001
Gasteropoda	<0.001	<0.001	0.45	<0.001	<0.001	0.97
Oligocheta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fish	<0.001	<0.001	2.91	<0.001	<0.001	6.19
Unidentified arthropods	<0.001	<0.001	6.12	<0.001	<0.001	<0.001

In regard to the general feeding overlap calculated for the three species pairs, a high value (0.85) was observed between *D. antonii* and *D. affinis* and a moderate value between *D. antonii* and *D. lusosso* (0.62) in dry season. We noted a moderate value (0.69) in the wet season for the species pair *D. antonii* - *D. affinis*, the two other species pairs did not show feeding overlap.

There are significant differences of feeding overlap values between the two hydrological seasons for the three species (χ^2 calculated = 0.99 > χ^2 tabulated = 0.103; p = 0.05).

DISCUSSION

Intestinal coefficient

In fishes, intestinal coefficient gives informations on the diet. This coefficient is small in carnivorous and large in detritivorous, reflecting generally the resistance of different foods to digestion (Winemiller, 1991; Bowen, 1983).

Table 3a, b, c: Schoener index comparison between the different sizes of classes of *D. antonii* during the wet season (WS).

(a)

D. antonii **WS**	**Size Classes**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	1							
	2	0.29						
	3							
	4							
	5	0.21	**0.85**					
	6	0.21	**0.84**			**0.93**		
	7	0.21	**0.86**			**0.94**	**0.92**	
	8	0.21	**0.84**			**0.98**	**0.93**	**0.95**

(b)

D. affinis **WS**	**Size Classes**	**1**	**2**	**3**	**4**	**5**	**6**
	1						
	2	**0.75**					
	3	0.07	0.20				
	4	**0.89**	**0.77**	0.10			
	5	0.19	0.08	0.04	0.19		
	6	0.13	0.28	**0.75**	0.15	0.08	
	7	0.12	0.28	**0.68**	0.17	0.08	**0.73**

(c)

D. lusosso **WS**	**Size Classes**	**1**	**2**	**3**	**4**
	1				
	2	0.45			
	3	0.28	0.26		
	4	0.33	0.33	0.13	
	5				
	6				
	7	0.31	0.37	0.072	0.51

The small intestinal coefficient in *D. lusosso* (1.06± 0.3) can suggest a diet orientated to animal preys, which can justify the important part of insects in its diet.

The intestinal coefficient calculated for *D. antonii* and *D. affinis* are near to those for *D. rostratus* of Bandama River in Côte d'Ivoire (Berté et al., 2008) and *D. brevipinnis* (Daget, 1959). These two species are micro-macrophytophages.

This index suggests therefore that *D. antonii* and *D. affinis* are herbivorous as reported by and Matthes (1964) and Lauzanne (1988).

The cut-off values of the intestinal coefficient for each diet category are not the same for all the authors (Kouamelan, 1999),

Table 4a, b, c: Schoener index comparison between the different sizes of classes of *D. antonii* during the dry season (DS).

(a)

D. antonii **DS**	**Size Classes**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	1								
	2	**0.77**							
	3	**0.68**	**0.85**						
	4	**0.67**	0.59	0.46					
	5								
	6	0.59	**0.79**	**0.77**	0.41				
	7								
	8	**0.68**	**0.77**	**0.72**	0.50		**0.72**		
	9	**0.64**	**0.81**	**0.77**	0.48		**0.84**		**0.77**

(b)

D. affinis **DS**	**Size Classes**	**1**	**2**	**3**	**4**	**5**
	1					
	2	**0.88**				
	3	**0.96**	**0.91**			
	4	**0.96**	**0.89**	**0.97**		
	5	**0.96**	**0.90**	**0.97**	**0.96**	
	6	**0.65**	**0.69**	**0.66**	**0.65**	**0.67**

(c)

D. lusosso **DS**	**Size Classes**	**1**	**2**	**3**	**4**
	1				
	2	0.13			
	3	0.49	0.31		
	4	0.32	0.25	0.52	
	5	0.45	0.13	**0.67**	0.42

that's why stomach contents must be analysed to assess clearly the diet habits of fish.

Stomach contents analysis

In Pool Malebo, stomach contents analysis confirms clearly the herbivorous diet of two species (*D. antonii* and *D. affinis*). Similar diets were reported by Matthes (1964) for *D. antonii* inhabiting the rivers of Ikela area and the Lake Tumba (Congo basin).

The important contribution of additional preys constituted by invertebrates and fish remains in stomach contents of *D. lusosso* describes it as a generalist or opportunistic feeder

But, it appears that the most energy supporting the three species was derived from macrophytes and vegetal detritus.

According to Lauzanne (1988), detritivorous food habits can be observed in

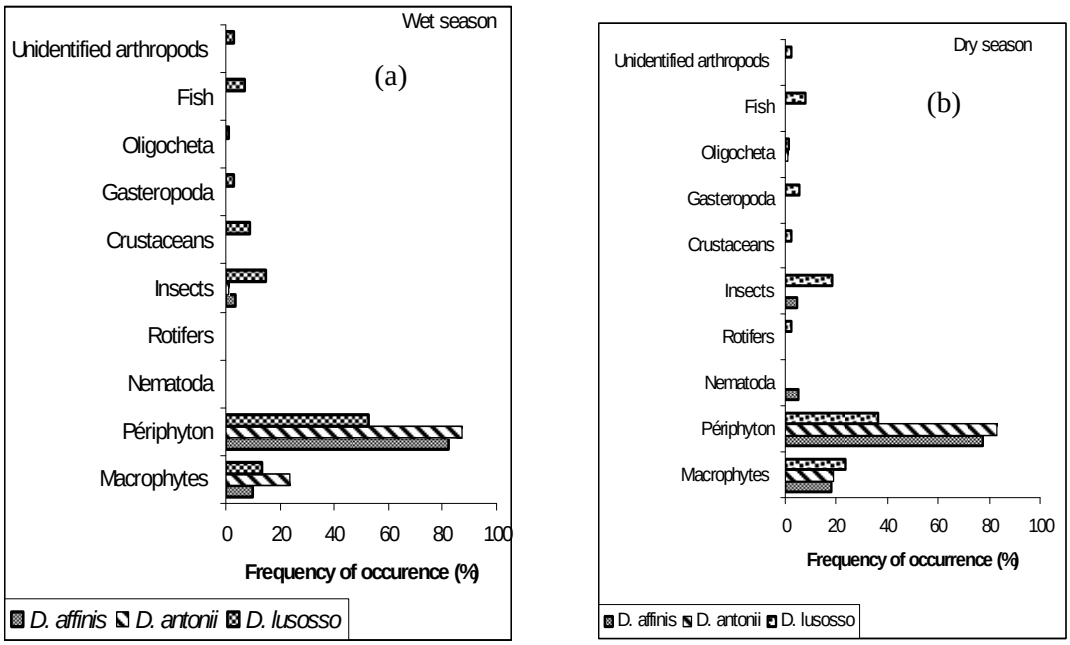

Figure 2 a & b: Frequencies of occurrence (%) of the main food categories in stomach contents of *D. affinis, D. antonii and D. lusosso* during the wet and the dry seasons.

Distichodus spp; we noted it principally in *D. affinis* and to a certain extent in *D. antonii* and *D. lusosso*.

Periphyton found in *D. antonii* and *D. affinis* is probably constituted by epiphytic algae ingested at the same time with the macrophytes.

In the other hand, zooplankton, constituted by cladocerans and copepods, was observed particularly in *D. lusosso*. The cladocerans settle the sub aquatic plant community and live too on submerged organic fragments (Durand and Lévêque, 1981).

The roots observed in the diet of *D. affinis* suggest that this fish feeds in benthos while the predominance of *Echinochloa pyramidalis* leaves in the stomach contents of *D. antonii* shows that it climbs again to the surface for feeding.

Fish size

According to fish sizes, the variation of the diet is not very perceptible for juveniles and adults of the three species. That is in opposition to *D. rostratus* whose juveniles, according to Daget (1959), feed only on phytoplankton. On the other hand, our findings are in harmony with the observations made by Berté et al. (2008) on *D. rostratus* from Bandama River in Côte d'Ivoire.

Hydrological seasons

In response of alternating wet and dry seasons, the ecosystem Pool Malebo undergoes cyclic changes.

It was possible to perceive different tendencies in accordance with this seasonality. In dry season, the shortage of macrophytes due to the water level falling makes the three species to feed more on vegetal detritus and on periphyton.

For *D. lusosso* particularly, the consumption of insects increases in the wet season corresponding to the reproductive period for many insects (Durand et Lévêque, 1981).

As reported by Fernandez and Oyarzún, (2001) and Haakana et al. (2007), we observed that the three species may

successively exploit different food resources available in the season.

But *D. antonii* and *D. affinis* remain in the same trophic guild regardless of the season, showing some degree of specialization while *D. lusosso* shows during the two seasons a propensity for omnivorous food habits.

D. antonii feeds principally on leaves while *D. affinis* feeds in addition on plant fragments and roots. It clearly appears that they specialize in different plant tissues and find their food at different habitats. These two species, potentially competitive facing the macrophytes consumption, can coexist because they exploit different plant resources.

According to Amundsen et al. (1996), we can conclude that *D. lusosso* is a generalist while *D. affinis* and *D. antonii* are specialists.

We suggest an ecomorphological study to more understand the possible trophic adaptations in these three species.

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