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Overall diet of four species of *Marcusenius* (*M. monteiri*, *M. stanleyanus*, *M.* sp.'malebo' and *M. schilthuisiae*) from Pool Malebo, Congo River, Kinshasa

Ntumba Mabedi Jean Métis[1, 2*], Mbadu Zebe Victorine[2], Micha Jean-Claude[1, 4], Michaux Johan R. [3]

[1] École régionale post-universitaire d'Aménagement et de gestion Intégrée des Forêts et Territoires tropicaux (ERAIFT), Kinshasa (R.D. Congo), mabedi.ntumba@gmail.com

[2] Laboratoire d'hydrobiologie, Faculté des sciences de l'Université de Kinshasa « UNIKIN». ISTM/ Kinshasa, zebembadu@gmail.com

[3] Laboratoire de génétique de la conservation, Université de Liège. ASTRE, CIRAD, INRAE, F-34398 Montpellier, France, johan.michaux@uliege.be

[4] Unité de Recherche en Biologie Environnementale (URBE), Université de Namur, jean-claude.micha@fundp.ac.be

Corresponding Author: Ntumba Mabedi Jean Métis, E-mail: mabedi.ntumba@gmail.com, Tel. 00243827300897

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Abstract

The objective of this study was to analyze and compare the diet of four *Marcusenius* species living in the Malebo Pool. The Intestinal Coefficient of these fish ranges from 0.55 to 0.67. These average values make it possible to classify these species in the trophic group of invertivores (larvae of aquatic insects). The analysis of variance at the 5% threshold reveals that there is not a statistically significant difference between the average intestinal coefficients of 4 species of Marcusenius (Fischer = 2.46963; p = 0.06). stomach contents of *M. monteiri*, *M. stanleyanus*, *M. schilthuisiae* and *M.* sp.'malebo' confirm an invertivorous diet, with a predominance of benthic insect larvae, followed by crustaceans, periphyton and macrocosm organisms benthic that they find in their habitats.

Keyswords: diet, intestinal coefficient, invertebrate, index, prey

INTRODUCTION

Illegal fishing and the use of instruments that destroy the habitats in which the food resources of Mormyridae fish develop in Malebo Pool constitute a permanent threat to species of the *Marcusenius* genus. The diet constituting one of the pillars of the vital strategy of these fish is less known (Ntumba *et al*., 2022 b). The abundance and availability of the trophic potential of this ecosystem, the understanding of the relationships between these fish and the foods ingested as well as the inter and intra specific relationships are not known (Kouamélan, 1999).

A general consideration and not in-depth studies of the diet of West African *Marcusenius* (*M. frucidens* and *M. ussheri*) was made by Kouamélan (1999). General information on the diet of *M. monteiri, M. moorii* and *M. greshoffii* was provided by Bowmarker (1968) and Mattes (1964). In addition to the preliminary study of the diet of *M*. sp.'malebo' made by Pigneur (2005), precise information on the diet of *Marcusenius* species living in the Malebo Pool is lacking (Ntumba *et al*. 2022 a).

However, the rational use of this resource can be planned, if we understand the population dynamics and their diet (Soumaïla *et al*., 2009, Hanssens et al., 2008; Mbadu *et al*., 2010; Ntumba *et al*. 2022 b).

This study aimed to contribute to the in-depth knowledge of the diet of the *Marcusenius* of Pool Malebo. This parameter contributes to the development of a rational fishing management plan.

MATERIAL AND METHODS

Collection of samples

Fishing was organized once a month (July 2020 - June 2021) in the stations described in Figure 1.

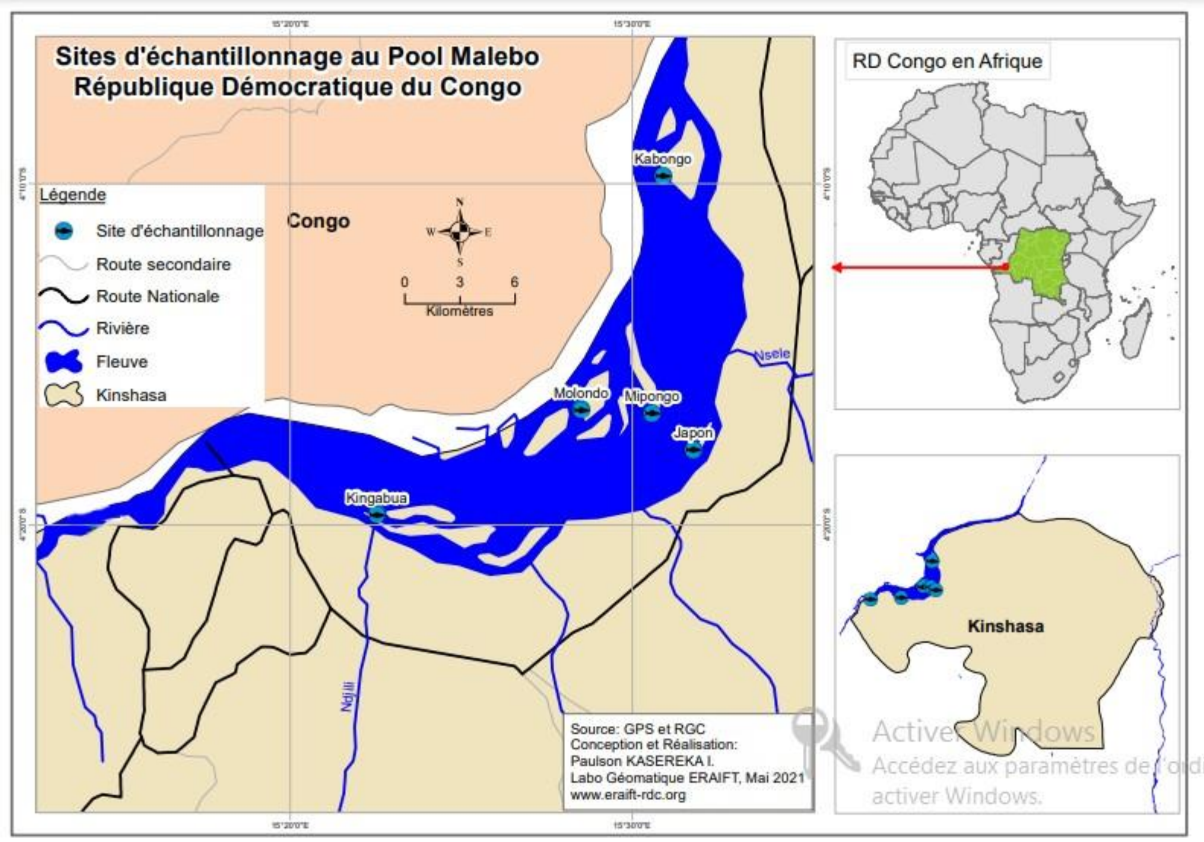


Figure 1: Map of the Malebo Pool, Congo River, indicating the sampling sites (Kabongo, Mipongo, Molondo, Japon and Kingabua) of the 4 *Marcusenius* species captured from July 2020 to June 2021.

These fisheries were carried out by ourselves with a team of artisanal fishermen using the techniques below.

• gillnet fishing: a battery of single-filament gillnets of 50 to 100 m in length and 1 to 2 m in height was made up of nets with increasing mesh sizes of (15; 25; 35; 50; 80 and 100 mm) between - knots, fitted with floats on the upper rope and lead on the lower rope. The use of different meshes makes it possible to reduce the biases due to the selectivity of the gillnets (Goffaux et al., 2005; Tejerina-Garro and Mérona, 2000). The net was laid in the evening around 6:00 p.m. to be removed in the morning at 6:00 a.m. After every one hour, the net was removed from the water to check the catch and remove fish before vomiting (Isumbisho and al., 2006).

• landing net fishing: a mosquito net or circular, fitted landing net, whose diameter varies from 2 to 3 m and with 1 mm mesh between knots, was used to capture young specimens near grassy banks.

Biological Material

The biological material used in this research consists of specimens of *Marcusenius* (Mormyridae) captured in the different stations of the Malebo Pool by experimental fishing (figures 2).

Figure 2 a : *M. monteiri* Günther, 1873

Figure 2 b *: M. stanleyanus* Boulenger, 1897

Figure 2 c : *M.* sp. 'malebo'

Figure 2 d : *M. schilthuisiae* Boulenger, 1899

Figure 2: a: *M. monteiri* Günther 1873, b: *M. stanleyanus* Boulenger 1897, c: *M.* sp.'malebo' d: *M. schilthuisiae* Boulenger 1899

Diet Analysis Methods

Studies of the diet provide data, not only on the presence, abundance and availability of the trophic potential of the environment, but also above all to understand the relationships between fish and the foods ingested (Kouamélan, 1999).

It makes it possible to identify the different trophic components ingested and identify the real dietary requirements of a fish species in its natural environment (Manko, 2016).

Samples of four species (*M. monteiri, M. stanleyanus, M.* sp.'malebo' and *M. schilthuisiae*) intended for the study of diet were collected, by experimental fishing carried out with the still net and the landing net.

The measurements and weights were taken from each specimen, namely: total length (Lt), standard length (Ls), total weight of the individual and its eviscerated weight.

Calculation of intestinal coefficient

After dissection, the digestive tract was removed, the intestine unrolled and then measured from the pyloric valve to the anus. Intestine length (LI) and standard length (LS) of fish were measured in mm using a tape measure. The intestinal coefficient (CI) of each specimen according to the following formula (Léveque and Paugy, 2006): $CI = \frac{LI}{LS}$

A correlation exists between the type of food, the relative length of the intestine and the length of the body. Thus, ichthyophagous fish generally have a wide stomach and a short intestine. While fish that feed on silt and mud (limnivores) and phytophages have intestines much longer than the body. Generally speaking, omnivorous, zooplanktonivorous or invertivorous fish have intestines measuring less than three times the length of the body. For these fish, the relationship between diet and intestine length is not significant (Léveque and Paugy, 2006).

Analysis of stomach contents

Each stomach was opened and its contents were poured into a petri dish for coarse sorting for removal of invertebrate macros. Then, the food bolus was diluted in 10 ml of distilled water. Using a micropipette, 0.5 ml of the slurry from the food bolus was taken and placed on a slide and covered with a coverslip. The contents are diluted and examined individually under the MOTIC (swift line) binocular microscope at 10X40 magnification (Mahamba *et al*., 2017).

The analysis of stomach contents is linked to the difficulty of knowing the state of the prey, some of which is partially digested or shredded, making identification difficult.

Expression of results

Diet analysis was carried out using the following qualitative and quantitative methods:

a) Qualitative method:

It consists of the taxonomic identification of prey down to the lower category level. The macroinvertebrates contained in the stomachs were identified down to the family level using the determination keys of Tachet *et al*. (2000), Durand & Lévêque (1981), Moisa (2010).

Regarding phytoplankton, the determination was made down to the genus level using the Bourelly key (1966 et 1968).

b) Quantitative method

- **Numerical index (% IN**). It is the percentage of the number of individuals of a prey category for the entire sample compared to the total number of prey found in all the stomachs examined. It is calculated by the formula, according to Kouamélan (1999):

$$\%\mathrm{IN} = (\frac{\mathrm{ni}}{\mathrm{NT}})\ \mathrm{x}100$$

With ni= total number of individuals of the same prey i

NT = total number of prey inventoried.

- **Percentage of emptiness (vacuity coefficient**: CV) (Lévêque & Paugy, 2006) :

$$\mathrm{CV} = (\frac{\mathrm{nv}}{\mathrm{nt}})\ \mathrm{x}100$$

With nv = number of empty stomachs and nt = total number of stomachs examined.

- **Occurrence index (% IO):** it is determined as a percentage by the following formula:

$$\mathrm{Io} = \frac{\mathrm{NA}}{\mathrm{NT}}\mathrm{x}100(\%)$$

With NA: the number of stomachs where food category A is present and NT the total number of non-empty stomachs analyzed.

- **Volumetric index (% IV):** this index, which takes into account the biovolume of prey, makes it possible to evaluate the relative biomass of different prey. It allows us to know the respective volume of each type of prey and gives the most representative image of the food bolus (Lévêque and Paugy, 1999).

$$\%IV = \frac{\text{Volume of 1 prey category}}{Total\ volume\ of\ \text{prey from all pray categories}}\ \mathrm{x}\ 100$$

Given the smallness of the food boluses and the prey found in the stomach contents, it was necessary to use the point method proposed by Hylsop (1980). Thus, a certain number of points was assigned to each prey based on its abundance and size. The number of points thus obtained for each food category for all stomachs examined are added and expressed as its percentage relative to the total number of points recorded for all prey (Munini *et al*., 2014; Manko, 2016; Nzanga *et al* ., 2022).

$$\%IV = \frac{Nomber\ of\ points\ allocated\ to\ component\ x}{Total\ points\ allocated\ to\ the\ subsample} X\ 100$$

- **Dietary or dominance index** (% AI): this index was calculated to compare the diets of different species of captured fish (Lauzanne, 1976). It takes into account both the occurrence index of each prey (Fi) and its volumetric index (Iv). The AI was calculated according to the Lauzanne formula (1976): IA $= Fi\ X\ \%V$.

Having a value which varies from 0 to 100, this index has the advantage of taking into account both countable and non-countable prey, which is a major advantage when we have to compare the diets of fish from different trophic positions (Munini *et al*., 2014). When calculated AI is greater than 50, the prey is said to be dominant; if it is between 50 and 25, it is said to be essential. When AI is between 25 and 10, the prey is characterized as important. Finally, the prey is said to be secondary if IA is less than 10.

- **Relative importance index** (%IRI): it is calculated from the formula (Diaha et al., 2018)

$$\%\text{IRI} = \%IO\ X\ (\%Ni + \%Vi);\ \text{et}\ \ \%IRIi = \left(\frac{IRIi}{\Sigma \text{IRIi}}\right) \text{x}100$$

With %Ni percentage by number of the specific food category, %Vi is the percentage by volume, %IO is the frequency of occurrence of the food category in question, %Vi is the percentage by volume, %IRIi is the percentage of the relative importance index, IRIi is the relative importance index for each category of prey, ΣIRIi is the sum of the relative importance indices for each category of prey. This index was calculated to quantify the contribution of each category of prey to the diet (Zanga *et al*., 2022).

Statistical tests

1-way Analysis of Variance, with a threshold value of 5%, was used to test the equality of the means of the intestinal coefficients of Marcusenius species.

To test the dietary similarity of prey consumed by individuals of each *Marcusenius* species (Kouamélan, 1999), the ascending classification analysis "cluster analysis" was carried out using the Relative Importance Index (RII). This made it possible to test the contribution of different categories of prey to the diets of fish species. To do this, the data were analyzed with Past software version 2.17c.

RESULTS

Overall diet analysis of *M. monteiri*

The results of the overall diet analysis of *M. monteiri* are presented in Table 1.

Table 1: Percentage of numerical indices (% IN), occurrence indices (% IO), volumetric indices (% IV), dietary indices (% AI) and relative importance indices (% IRI) of prey identified in the stomachs by *M. monteiri.*

	% IN	% IO	% IV	% IA	%IRI
INSECTS	**25,53**	**36,36**	**37,26**	**52,15**	**53,45**
Diptera					
Chironomidae	14,89	21,21	13,21	33,73	39,80
Coleoptera	3,19	9,09	13,21	14,46	9,95
Noteridae	4,26	3,03	0,47	0,17	0,96
Gyrinidae	3,19	3,03	10,38	3,79	2,75
CRUSTACEANS	**27,66**	**24,24**	**33,02**	**23,06**	**20,97**
Palaemonidae	7,45	6,06	28,30	20,65	14,47
Cladocera					
Chydoridae	2,13	3,03	0,47	0,17	0,53
Bosmidae	2,13	3,03	0,47	0,17	0,53
Copepoda					
Calanidae	6,38	3,03	0,47	0,17	1,39
Diaptomidae	4,26	3,03	1,42	0,52	1,15
Cyclopoida					
Cyclopidae	5,32	6,06	1,89	1,38	2,92
ARACHNIDA					
Hydrachanidae	**3,19**	**9,09**	**18,87**	**20,65**	**13,39**
PERIPHYTON	**30,85**	**15,15**	**8,02**	**2,93**	**7,86**
Chlorophyceae					
Cosmarium sp	3,19	3,03	3,30	1,20	1,31
Pediastrum sp	7,45	3,03	0,94	0,34	1,70
Scenedesmus sp	4,26	3,03	0,94	0,34	1,05
Tetraedron sp	7,45	3,03	0,94	0,34	1,70
Volvocales sp	8,51	3,03	1,89	0,69	2,10
ANNELIDA					
Oligochaetes	**2,13**	**3,03**	**0,94**	**0,34**	**0,62**
MISCELLANEOUS	**10,64**	**12,12**	**1,89**	**0,86**	**3,71**
Unknown	2,13	3,03	0,94	0,34	0,62
Plant debris	5,32	6,06	0,47	0,34	2,34
Sand	3,19	3,03	0,47	0,17	0,74
Total %	**100**	**100**	**100**	**100**	**100**

The analysis of 36 stomachs of *M. monteiri* revealed 4 stomachs without food bolus. Thus, the calculated vacuity coefficient (% CV) is 11.11. The analysis of 32 stomachs found with food bolus made it possible to identify 94 types of prey classified in the 6 major groups such as annelids, crustaceans, arachnids, periphyton, insects and miscellaneous (plant debris, sand and unknown, etc.).

It appears from Table 1 that the numerical index (number of individuals of prey category) (% IN) which determines the main source of food is made up of 30.85% of periphyton followed by 27.66% of crustaceans and 25.53% insects. Arachnids and annelids are less represented with 2.13% and 3.19% respectively. The various fractions difficult to count and separate from other contents represent 10.6% of the total number of organisms identified.

Regarding the percentage of occurrence index (%IO), the main food source consists of 36.36% insects, 24.24% crustaceans, 15.15% periphyton and 9.09% % of arachnids. The miscellaneous mainly made up of plant debris, sand and unidentified or unknown bodies represent 12.12%.

The respective volume analysis of each type of prey which gives the most representative image of the food bolus (volumetric index: % IV) indicates 37.26% insects, mainly chironomids and beetles; 33.019% of crustaceans; 18.87% arachnids, 8% periphyton, 0.9% annelids and 1.8% miscellaneous.

The comparison of the types of prey included in the diet of *M. monteiri* made by calculating the dietary index (% AI) shows that the dominant prey are made up of insects (% AI = 52.15%), followed by prey important consisting of crustaceans (% AI = 23.06%) and arachnids (% AI = 20.65%). The remains of identified prey are secondary, because the %AI is less than 10%.

The contribution of each category of prey in the diet of *M. monteiri* quantified by calculating the relative importance of these prey (% IRI) indicates that the insect category contributes more to the diet with 53.45%, followed by crustaceans with 20.967% and arachnids with 13.39%. Periphyton contributes with 6.50%. Annelids and miscellaneous contribute weakly with 0.62% and 3.7% respectively.

Overall diet analysis of *M. stanleyanus*

The results of the overall diet analysis of *M. stanleyanus* are presented in Table 2.

Table 2: Percentage of numerical indices (% IN), occurrence indices (% IO), volumetric indices (% IV), dietary indices (% AI) and relative importance indices (% IRI) of prey identified in the stomachs of *M. stanleyanus.*

	% IN	**% IO**	**% IV**	**% IA**	**%IRI**
INSECTS	**37,98**	**41,03**	**71,71**	**80,33**	**68,35**
Diptera					
Chironomidae	10,08	5,13	15,94	13,11	11,89
Tabanidae	8,53	10,26	11,95	19,67	18,72
Simuliidae	6,20	7,69	15,94	19,67	15,18
Coleoptera					
Curculionidae	4,65	7,69	11,95	14,75	11,38
Gyrinidae	3,88	5,13	3,98	3,28	3,59
Odonata					
Anisoptera	4,65	5,13	11,95	9,84	7,59
PERIPHYTON	**44,19**	**23,08**	**4,78**	**1,97**	**11,19**
Bacillariopbyceae					
Amphora sp	5,43	2,56	0,40	0,16	1,33
Aulacoseira sp	10,08	2,56	0,80	0,33	2,48
Diatoma sp.	6,20	2,56	0,40	0,16	1,51
Cymbella sp	0,78	2,56	0,40	0,16	0,27
Navicula sp.	4,65	2,56	0,40	0,16	1,15
Gyrosigma sp.	2,33	2,56	0,40	0,16	0,62
Pinnularia sp.	4,65	2,56	0,80	0,33	1,24
Surirella sp.	3,88	2,56	0,40	0,16	0,98
Cyanophycea					
Surirella sp.	6,20	2,56	0,80	0,33	1,60
CRUSTACEANS	**10,08**	**15,38**	**1,20**	**1,80**	**8,26**
Decapods					
Atyidae	5,43	12,82	0,80	1,64	7,11
Cladocera					
Bosmidae.	4,65	2,56	0,40	0,16	1,15
ARACHNIDA					
Hydrachanidae	**3,10**	**7,69**	**7,97**	**9,84**	**7,59**
ANNELIDA	**3,10**	**7,69**	**8,37**	**3,61**	**2,89**
Nematodes	0,78	5,13	0,40	0,33	0,54
Nemathelminthes	2,33	2,56	7,97	3,28	2,35
MISCELLANEOUS	**1,55**	**5,13**	**5,98**	**2,46**	**1,72**
Plant debris	0,78	2,56	3,98	1,64	1,09
Sand	0,78	2,56	1,99	0,82	0,63
Total %	100,00	100,00	100,00	100,00	100,00

Of 44 *M. stanleyanus* stomachs analyzed, 5 were found without a bolus. Thus, the vacuity coefficient (% CV) calculated is 12.8%. The analysis of 39 stomachs found with the food bolus

made it possible to identify 129 types of prey classified in 6 major groups, namely, annelids, crustaceans, arachnids, periphyton, insects and miscellaneous (table 2). The main food source for *M. stanleyanus* is made up in numerical terms (% IN) of 44.19% of periphyton followed by insects with 37.98%, 10.08% of crustaceans, 3.10% of arachnids and 3. 10% of annelids. Miscellaneous represents 1.55%.

Regarding the quantity, the percentage of occurrence index (%IO) indicates that the main food source is 41.03% insects; 23.08% periphyton and 15.38% crustaceans. Arachnids and annelids have 7.69% each. The miscellaneous mainly consists of plant debris and sand (5.13%).

The analysis of the respective volume of each type of prey in the food bolus (volumetric index: % IV) indicates that 71.71% are insects, followed by annelids and arachnids with 8.37% and 7.96% respectively. Periphyton and crustaceans occupy a small volume of 0.78% and 1.19% respectively. Miscellaneous occupies 5.972%.

Comparison of the types of prey included in the diet of *M. stanleyanus* (% AI) shows that the dominant prey is made up of insects (% AI = 80.32%). Other prey have a dietary index (%AI) of less than 10%. These prey are secondary in the diet of *M. stanleyanus*.

Analysis of the relative importance (% IRI) of prey identified in the diet of *M. stanleyanus* indicates that insects contribute more to the diet with 68.35%, followed by periphyton with 11.19% and crustaceans with 8.26%. Arachnids represent 7.59%. Annelids and those made up of animal debris and sand have a low IRI of 2.89% and 1.71% respectively.

Analysis of the overall diet of *M. schilthuisiae*

The results of the overall diet analysis of *M. schilthuisiae* are presented in Table 3.

Table 3: Percentage of numerical indices (% IN), occurrence indices (% IO), volumetric indices (% IV), dietary indices (% AI) and relative importance indices (% IRI) of prey identified in the stomachs of *M. schilthuisiae*.

	% IN	% IO	% IV	% IA	% IRI
INSECTS	**45,86**	**28,57**	**39,68**	**61,02**	**61,71**
Diptera					
Chironomidae	23,31	11,43	19,84	39,37	39,78
Muscidae	13,53	7,14	11,90	14,76	14,66
Coleoptera					
Noteridae	5,26	8,57	3,97	5,91	6,38
Odonanta					
Anisoptera	3,76	1,43	3,97	0,98	0,89
PERIPHYTON	**32,33**	**41,43**	**16,67**	**10,43**	**16,98**
Bacillariophyceae					
Aulacoseira sp.	6,77	4,29	0,79	0,59	2,61
Pinnularia sp.	4,51	4,29	0,79	0,59	1,83
Surirella sp.	3,76	4,29	0,79	0,59	1,57
Navicula sp.	3,01	7,14	0,79	0,98	2,19
Chlorophyceae					
Cosmarium sp	2,26	4,29	0,79	0,59	1,05
Scenedesmus sp	3,01	8,57	0,79	1,18	2,63
Volvocales sp	2,26	1,43	3,97	0,98	0,72
Cyanophyceae					
Spirogyra sp	3,76	5,71	3,97	3,94	3,56
Spirulina sp	3,01	1,43	3,97	0,98	0,80
CRUSTACEANS	**13,53**	**8,57**	**11,90**	**8,86**	**8,79**
Cladocera					
Chydoridae	8,27	4,29	7,94	5,91	5,60
Copépods					
Calanoidae	5,26	4,29	3,97	2,95	3,19
ANNELIDA					
Nématelminthes	**2,26**	**12,86**	**3,97**	**8,86**	**6,45**
ARACHNIDA					
Hydrachanidae	**1,50**	**4,29**	**7,94**	**5,91**	**3,26**
MISCELLANEOUS	**4,51**	**4,29**	**19,84**	**4,92**	**2,81**
Aninal debris	1,50	1,43	3,97	0,98	0,63
Sand	1,50	1,43	7,94	1,97	1,09
Plan debris	1,50	1,43	7,94	1,97	1,09
Total %	100	100	100	100	100

A total of 39 *M. schilthuisiae* stomachs were collected. 9 of them were found without a food bolus. Thus, the vacuity coefficient (% CV) calculated is 23.08%.

The analysis of 30 stomachs found with food bolus made it possible to identify 133 types of prey classified in the following 6 major groups: annelids; the crustaceans; arachnids; periphyton; insects and miscellaneous.

The main food source for *M. schilthuisiae* is made up in numerical terms (% IN) of 45.86% of insects followed by periphyton with 32.33%, and crustaceans with 13.53%. Arachnids and annelids are less represented with 1.50% and 2.26% respectively.

The occurrence index (% IO) indicates that the main food source consists of 41.42% periphyton, 28.57% insects, 12.86% annelids. Arachnids and crustaceans are 4.28% and 8.57% respectively. Miscellaneous represents 4.2 8%.

The analysis of the respective volume of each type of prey in the food bowl (volumetric index: % IV) indicates 39.68% insects, followed by 19.8% miscellaneous consisting of animal debris, plant debris and sand; followed by periphyton with 16.67%. Crustaceans and arachnids represent a volume of 11.90% and 7.94% respectively. Annelids occupy a small volume of 3.96%.

The comparison of the types of prey included in the diet of *M. schilthuisiae* (% AI) shows a dominance of insects (% AI = 61.02%), followed by periphyton (% AI = 10.43%). Annelids, crustaceans, arachnids and others constitute secondary prey (% AI less than 10%).

The relative importance index (% IRI of preys that enter the diet of *M. schilthuisiae* indicates 61.71% insects followed by 16.98% periphyton, 8.8% crustaceans and 6.45% of annelids. Arachnids and miscellaneous have a low relative importance index of 3.26% and 2.81% respectively.

Analysis of the overall diet of *M*. sp.‘malebo’

The results of the overall diet analysis of *M*. sp.‘malebo’ are presented in Table 4.

Table 4: Percentage of numerical index (% IN), occurrence indices (% IO), volumetric indices (% IV), dietary indices (% AI) and relative importance indices (% IRI) of the prey identified in the stomachs of M. sp.'malebo'

	% IN	% IO	% IV	% IA	%IRI
INSECTS	**41,94**	**38,10**	**61,59**	**83,91**	**76,60**
Diptera					
Chironomidae	18,47	9,52	40,18	74,11	63,06
Simulidae	3,06	4,76	5,60	1,71	1,54
Tabanidae	4,08	7,14	5,04	2,05	2,17
Coleoptera					
Noteridae	6,12	4,76	3,82	2,34	3,54
Gyrinidae	8,16	4,76	3,73	3,04	5,66
Odonata					
Anisoptera	2,04	7,14	3,22	0,66	0,62
PERIPHYTON	**40,82**	**33,33**	**18,78**	**7,29**	**13,61**
Bacillariopbyceae					
Amphora sp.	2,04	2,38	2,38	0,48	0,52
Aulacoseira sp.	2,04	4,76	1,23	0,25	0,39
Cymbella sp.	2,04	2,38	0,72	0,15	0,33
Pinnularia sp.	4,08	2,38	1,51	0,62	1,33
Surirella sp.	6,12	2,38	2,15	1,31	2,49
Navicula sp.	5,10	2,38	1,79	0,91	2,05
Chlorophyceae					
Cosmarium sp.	2,04	2,38	0,36	0,07	0,29
Pediastrom sp.	4,08	2,38	1,79	0,73	1,40
Scenedesmus sp.	2,04	2,38	0,72	0,15	0,33
Volvocales sp.	3,06	2,38	2,64	0,81	1,02
Cyanophyceae					
Spirogyra sp.	2,04	4,76	0,82	0,17	0,34
Spirulina sp.	6,12	2,38	2,68	1,64	3,14
CRUSTACES					
Palaemonidae	**6,58**	**11,90**	**11,27**	**7,41**	**6,84**
ARACHNIDA					
Hydrachanidae	**4,08**	**7,14**	**1,83**	**0,75**	**1,41**
ANNELIDA					
Nematodes	**3,27**	**2,38**	**0,72**	**0,23**	**0,76**
MISCELLANEOUS	**3,06**	**7,14**	**5,37**	**0,82**	**0,78**
Sand	1,02	2,38	2,68	0,27	0,22
Animal debris	2,04	4,76	2,68	0,55	0,56
Total %	100	100	100	100	100

Analysis of the 45 stomachs of *M*. sp. 'malebo' collected revealed 42 stomachs with food bolus and 3 empty stomachs. The calculated vacuity coefficient (% CV) is 6.67%. The analysis of the stomachs found with the prey made it possible to identify 98 types of prey classified in 6 major groups, namely insects, arachnids, annelids, crustaceans, periphyton, and miscellaneous (animal debris, sand).

The percentage of the number of individuals of each category of food source prey of *M*. sp.'malebo' is made up of 41.94% of insect larvae followed by 40.81% of periphyton, 6.583% of crustaceans and 4, 08% arachnids. Annelids and miscellaneous represent 3.27 and 3.06% of prey, respectively.

The percentage of occurrence index (% IO) indicates that the most frequent food source consists of 38.09% insects followed by 33.33% periphyton and 11.9% crustaceans. Arachnids and miscellaneous represent 7.14% of prey each. Annelids represent 2.38% of prey.

Analysis of the respective volumes of each type of prey (volumetric index: % IV) indicates that 61.59% are insects, mainly chironomidae, 18.37% periphyton, 11.3% crustaceans and 5.4% miscellaneous. . Arachnids and annelids occupy a small volume of the food bolus, respectively 1.8 and 0.72%.

Comparison of the types of prey included in the diet of *M*. sp.'malebo' (% AI) shows that the dominant prey is made up of insects (% AI = 83.9%). Given that the % AI of other identified prey is less than 10%, these prey are qualified as secondary prey.

The quantification of each category of prey in the diet of *M*. sp.'malebo' (index of relative importance of prey in the food bolus: % IRI) indicates that the insect category contributes more to the diet with 76.60%. , followed by periphyton with 13.6% and crustaceans with 6.84%. Arachnids, annelids and others represent a small proportion of the prey which constitute the diet of *M*. sp.'malebo' with respectively 1.41%, 0.76% and 0.78%.

Intestinal coefficient analysis

Table 5: Average intestinal coefficients of four species of *Marcusenius* from Pool Malebo

N°	**Species name**	**N**	**Everage CI CI= LI/LS**	**Regression equation**	**r^2**	**R**	**P-value**
1	*M. monteiri*	36	0,67 ± 0,02	Y= 1,0585x – 0,3898	0,6695	0,82	0,06
2	*M. stanleyanus*	44	0,55 ± 0,01	Y= 1,0948x – 0,387	0,9319	0,97	0,06
3	*M.* sp.'malebo'	45	0,64 ± 0,3	Y= 1,0418x – 0,3088	0,6566	0,81	0,06
4	*M. schilthuisiae*	39	0,56 ± 0,01	Y=1,3005x – 0,8502	0,5838	0,76	0,06

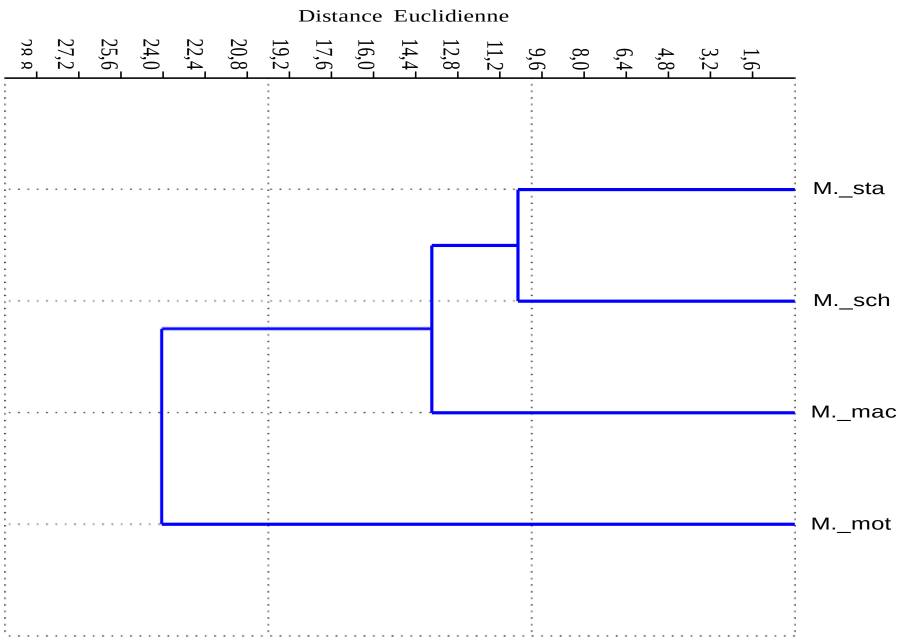
It appears from Table 5 that the four *Marcusenius* species analyzed have similar intestinal coefficients which vary from 0.55 to 0.67. The analysis of variance reveals at the 5% threshold that there is no statistically significant difference between the average intestinal coefficients of the 4 species of *Marcusenius* (Fischer = 2.46963; p = 0.06).

These average values make it possible to classify these species in the trophic group of "invertivores" which mainly consume the benthic invertebrates of their environments. Analysis of the lengths of their "LI" intestines reveals that they are shorter than the standard "LS" lengths. Which therefore confirms their mainly insectivorous diet (larvae of aquatic insects).

As in the other dissected species of *Marcusenius* from Pool Malebo (*M. schilthuisiae* and *M. stanleyanus*, *M. monteiri*), the digestive tract of M. sp.'malebo' is made up of a non-muscular stomach with a curved shape, followed 2 pyloric caecums and a relatively short intestine, not very much rolled up on itself (figure 3).

Figure 3: digestive tract of *M*. sp.'malebo' with an unrolled intestine

Analysis of dietary similarity of the 4 *Marcucenius* species studied



R = 0,852

Figure 4: Dietary similarity between different species of the genus *Marcucenius* based on the relative importance index "IRI" at Pool Malebo.

Legend: M. sta: *M. stanleyanus*; M. sch: *M. schilthuisiae*; M. mac: *M*. sp.'malebo'; M. mot: *M. monteiri*.

The dendrogram (figure 4) indicates the grouping of species of the genus *Marcucenius* based on the prey consumed. The food similarity dendrogram (correlation coefficient 0.85) obtained from the food items consumed by individuals of each species and established from the Relative Importance Index (RII) generated two main food groups. The isolation of these two groups from a Euclidean distance of 24 from the origin is justified by the relative importance of the specific prey ingested by each group.

The first, consisting of the species *M. monteiri*. This species feeds on insects (IRI = 53.45%), crustaceans (21.0%) and arachnids (13.4%), therefore a diet composed respectively of Simulidae, Chironomidae, Tabanidae; Crustaceans and hydracarians. Other prey such as peripyton and annelids are poorly consumed (%IRI = 7.9 and 0.62) (figure 4).

The second group consisting of *M.* sp.'malebo' located at a Euclidean distance of 14 from the origin, consumes insects (% IRI = 76.5), periphytons (% IRI = 13.6), crustaceans (%IRI = 6.8), arachnids (%IRI = 1.4). The rest of the prey are very weakly represented.

This second group subdivided into two subgroups from a Euclidean distance of 10 from the origin; the first subgroup includes *M. schilthuisiae* which consume more insects (% IRI = 61.7), periphytons (% IRI = 16.97), crustaceans (% IRI = 8.8), annelids (% IRI = 6.5) and arachnids (% IRI = 3.3). The second subgroup includes M. stanleyanus which feeds on insects (% IRI = 68.3), periphytons (% IRI = 11.2), crustaceans (% IRI = 8.3), arachnids (% IRI = 8.3 = 7.6) and annelids (% IRI = 2.9).

DISCUSSION

Analysis of the overall diet of the four species of *Marcusenius* (*M. monteiri, M. stanleyanus, M*. sp.'malebo' and *M. schilthuisiae*) living in the Malebo Pool revealed a moderately low intestinal coefficient (0.55 - 0.69). Our results are within the limits (0.32 - 2.18) defined by Paugy (1994) and Lévêque and Paugy (2006). According to these aforementioned authors, most Mormyridae have low average values of intestinal coefficients. These results are in agreement with those found by Mahamba *et al.* (2017), which places these species in the invertivore trophic group, primarily consuming benthic invertebrates found in their habitat.

The indices calculated for the different categories of prey found in the four species of Marcusenius analyzed show that, on a qualitative level, they feed on 6 groups of prey, namely: annelids, arachnids, crustaceans, insects, periphyton and the various ones made up of animal debris, plant debris and sand.

Our results are in agreement with those of Munini *et al*. (2014) and Lévêque and Paugy, (2006) who noted that the consumption of prey thus categorized would be justified by their abundance in habitats, where the development of zooplankton organisms and insect larvae depends on periphyton and floating macrophytes and submerged.

All of these results agree with those of Pigneur (2005) on the diet of *M*. sp.'malebo', those of Kouamélan (1999) on the diets of *M. frucidens and M. ussheri* and Bowmarker (1968) and Mattes (1964) who worked on *M. monteiri*, *M. moorii* and *M. greshoffii*.

Analysis of prey found in the stomachs of four species confirms that *Marcusenius* have an invertivorous diet, with a dominance of insects. Other prey (annelids, crustaceans, arachnids and periphyton) are either important or secondary depending on the species.

Due to the presence of a diversity of benthic taxa (insects, crustaceans, annelids, periphyton and others) in their diets, these fish are considered second-order consumers (Pigneur, 2005; Mahamba *et al.*, 2017). The primary producers (periphyton) are more diversified with a numerical index of 30.85% in *M. monteiri*, 44.19% in *M. stanleyanus*, 32.33% in *M. schilthuisiae* and 40.81% in M. sp.'malebo'). They represent a low volume index of 8.02% in *M. monteiri*, 4.78% in *M. stanleyanus*, 16.67% in *M. schilthuisiae* and 18.78% in *M*. sp.'malebo' and one occurrence respectively 15.15%; 23.07%; 41% and 33.3%.

The presence of sand among the categories of prey found in the stomachs of the many Marcusenius specimens examined results from the fact that these fish feed on benthic prey which mainly comes from the bottom of the watercourse. Sand grains were also noted by Mambo *et al*. (2016) among the prey identified in Mormyridae. They have no energy value, but can be used for grinding food.

Animal debris consisting of the legs and antennae of certain unidentified crushed insects has an occurrence of 4.76% for *M.* sp.'malebo', 1.42% for *M. schilthuisiae*, 2.56% for *M. stanleyanu*s and 3.03% for *M. Monteiri*. The advanced state of grinding and digestion of the prey made identification difficult. This difficulty was also highlighted by Mambo *et al*. (2016).

Analyzes of the diets of the four species of *Marcusenius* from Pool Malebo show that they all have an invertivorous diet dominated by insects (mainly Chironomidae, Coleoptera and Diptera), crustaceans and periphyton. The absence of preferred prey leads these 6 Marcusenius species to consume what they find in the environment.

These results corroborate those of Pigneur (2005), Mahamba *et al.* (2017) and Mambo *et al.* (2016) who found that Mormyridae have an invertivorous diet, dominated by the presence of insects and feeding opportunism depending on the prey found in the environment. Thus, the Marcusenius studied are part of the non-terminal small-mouthed Mormyridae which feed mainly on the bottom and depend on the benthic invertebrate fauna.

The dendrogram generated from the relative importance indices of prey ingested by the four species of *Marcusenius* indicates two insect larvae-dominated diet groups separated by a Euclidean distance of 24 from the origin for the species *M. monteiri* and *M.* sp.'malebo'. The latter group was subdivided into two closely related subgroups of *M. stanleyanus* and *M. schilthuisiae*. Which reflects a similarity of the prey ingested in their eating habits.

According to Kouamelan (1999), congeneric species with comparable constitution and biological structure have similar ecological requirements and they exploit the same abundant trophic resource in the environment, which allows their coexistence. As in all waters in tropical environments, the Malebo Pool is characterized by the presence of significant benthic trophic resources exploited by the Marcusenius studied (Matthes, 1964).

CONCLUSION

This work aimed to determine the overall diet of the *Marcusenius* species living at Pool Malebo. The four species of Marcusenius (*M. monteiri, M. stanleyanus, M.* sp.'malebo' and *M. schiltuisiae*) examined have a moderately low intestinal coefficient which places them among the trophic group of invertivores essentially consuming benthic invertebrates (Chironomidae, Coleoptera and Diptera). This diet is supplemented by either crustaceans, periphyton or arachnids found in their habitat.

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