

Food Habits of *Bryconaethiops boulengeri* Pellegrin, 1900 (Characiformes: Alestidae) of Djiri River Tributary of the Right Bank of Congo River

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Abstract

Diet of 300 specimens of *Bryconaethiops boulengeri* from Djiri River (Congo Brazzaville) caught with cash nets was studied according to the size of fish, sampling stations and hydrological season. Sampling focused on twelve annual withdrawals made during three years. The relative importance index combining numerical and weight percentages of occurrence was calculated and also the sex ratio was evaluated. *Bryconaethiops boulengeri* consumes terrestrial and aquatic insects and everything that falls into the water (birds feathers, plant debris, fruits, etc.). The percentage of emptiness is 9.66% of the three sampling stations selected; no significant difference in diet was observed whatever the season.

Keywords

Djiri River, *Bryconaethiops boulengeri*, Food Habits, Occurrence, Eclectic Insectivore

1. Introduction

Bryconaethiops boulengeri is an Alestidae widespread throughout the Congo Basin [1], mostly found in Alima River [2] and in Léfini River [3]. Moreover, *Bryconaethiops boulengeri*, *Bryconaethiops microstoma*, *Micralestes stormsi* and *Synodontis nigriventris* are the most abundant species found in the Djiri River [4]. However, very little information is available on the biology, ecology, mainly their food habits. It should be noted that a major study of fishes ecology

and ethology conducted in Lake Tumba and Ikela region provided qualitative data on food habits of *B. Boulengeri* [5]. This present study gives information on nutrition, diet change according to the environment, season and the size of *Bryconathrops Boulengeri*.

2. Materials and Methods

2.1. Study Area

Djiri River is located in the 9th district of Brazzaville rises in the southern hiller Mbé and the high hills that extend to the Batékés plates. Length is about 50 km covering an area of 853 km², of 850 mm flow by year, the deficit flow is 960 mm, a flow rate of 27 l/s/km² and a flow coefficient of 47%. Djiri River flowing in the direction NW-SE main tributaries Kouala-Kouala, Bamba and Souo on its left bank and Bilolo and Bitatolo on its right bank [6]. The sampling area is located between 04.18117 to 04.13095 South latitude 15.31177 to 015.32192 east longitude (Figure 1).

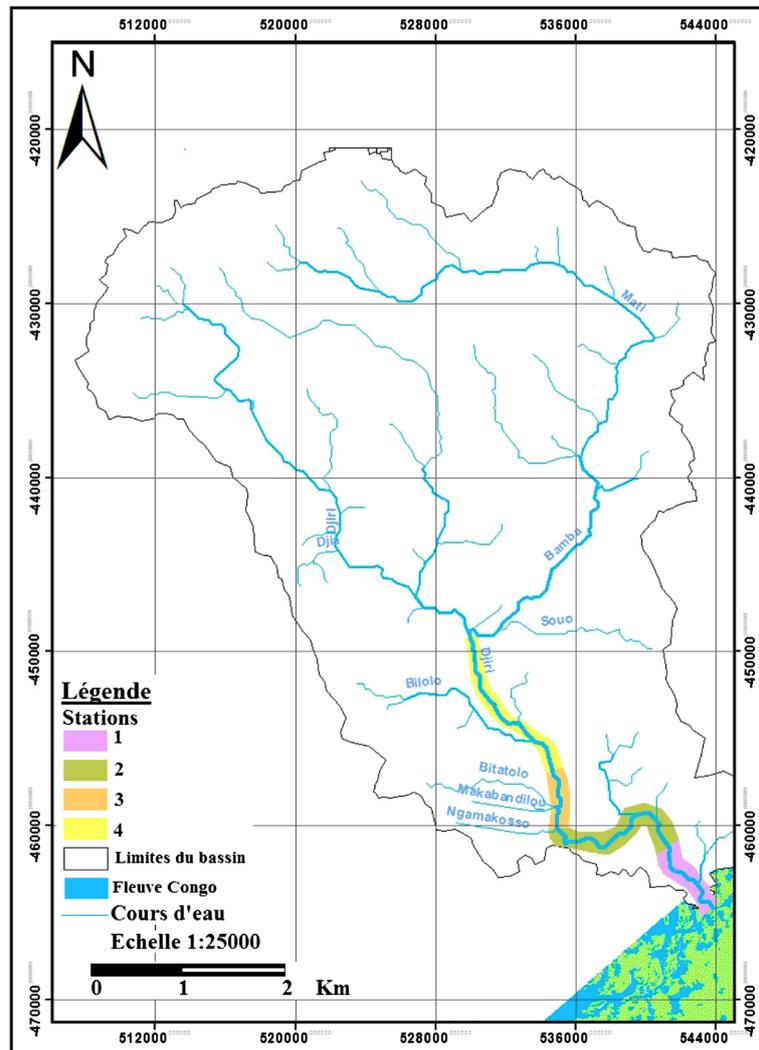


Figure 1. Study area (SRTM picture “Shut Radar Mission 2000”).

2.2. Sampling and Analyzes

Fishes were caught in the lower reach of Djiri River during monthly fishing trips from February 2008 to January 2011. They were immediately fixed in formalin 10% and then transferred the next day in 5% formalin for preservation. Each specimen was weighted to the nearest milligram and measured (standard length). The stomach contents were then diluted in water and examined under a binocular microscope. Different food taxa were sorted and identified, when their state of degradation permitted, according to Lausanne protocol [7].

2.3. Percentage of Emptiness

The percentage of emptiness was estimated as the following formula.

$$V = \frac{N_v}{N_t} \times 100$$

N_v : number of empty stomachs.

N_t : total number stomachs examined.

2.4. Intestinal Coefficient

The digestive tract has been described from 300 individuals whose are between. Intestinal coefficient (C) is calculated following the formula [8].

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

Li : intestinal length.

Ls : standard length.

2.5. Percentage of Occurrence

The percentage of occurrence was calculated according to the following formula [9].

$$\%Oc = \frac{n_i}{N_T} \times 100$$

n_i = number of stomachs containing a category of preys.

N_T = total number of full stomachs examined.

2.6. Preponderance Index

To quantify the relative importance of prey, the following indices were calculated: percentage of occurrence and weight percentage [10]. To avoid biases related to the use of these indices, the preponderance index [11] that incorporates these two indices was estimated with the following formula.

$$Ip = \frac{\%Oc \times \%P}{\sum (\%Oc \times \%P)} \times 100$$

Ip : preponderance index.

$\%P$: weight percentage.

Different preys categories are classified According to the values of preponderance index.

- $I_p < 10$: accessory prey.
- $10 < I_p < 25$: secondary prey.
- $25 < I_p < 50$: important prey.
- $I_p > 50$: main prey.

A hierarchical cluster analysis (single linkage cluster analysis) was used to highlight the similarities between trophic stations and classes size. Classes size were determined according to the rule of Sturge [12].

$$NC = 1 + \frac{10 \log_{10} N}{3}$$

$$I = \frac{LS \max - LS \min}{NC}$$

NC : Number of classes size.

I : interval of classes.

N : total number of classes.

$LS \max$: maximum length standard.

$LS \min$: minimum length standard.

The index of Schoener was used to assess the degree of similarity between the different seasons, stations and classes size [13].

$$\alpha = 1 - 0.5 \left(\sum_{i=1}^n |Px_i - Py_i| \right)$$

Px_i : proportion of prey i consumed by a mature stage (individuals in a season).

Py_i : proportion of prey i consumed by a mature stage (individuals of the season).

The diets are considered substantially similar if the Schoener index α is greater than or equal to 0.6 [13].

3. Results

The digestive tract is formed of a thick-walled esophagus, followed by a U shaped stomach surrounded by pyloric caeca. There are an average of 8 pyloric caeca and intestine is curled (Figure 2).

There was a significant linear relationship between the length of the intestine and the standard length of the fish ($r = 0.84$, $p < 0.05$). Intestinal coefficient of 300 individuals analyzed varies between 0.71 and 1.29 with an average of 0.95 ± 0.48 (Figure 3). The intestine of *Bryconaethiops boulengeri* is so short.

3.1. General Profile of the Diet

Of the three hundred *Bryconaethiops boulengeri* stomachs examined, 29 were empty, a percentage of 9.66% of emptiness. Seventeen categories of food divided into five groups were identified (Table 1): insects, arachnids, crustaceans, nematelmiths, macrophytes and others (fish scales, birds feathers, plastic bags). The weight index shows that preferential foods *B. boulengeri* are coleoptera (32.7%)



Figure 2. Digestive tube of *Bryconaethiops boulengeri*.

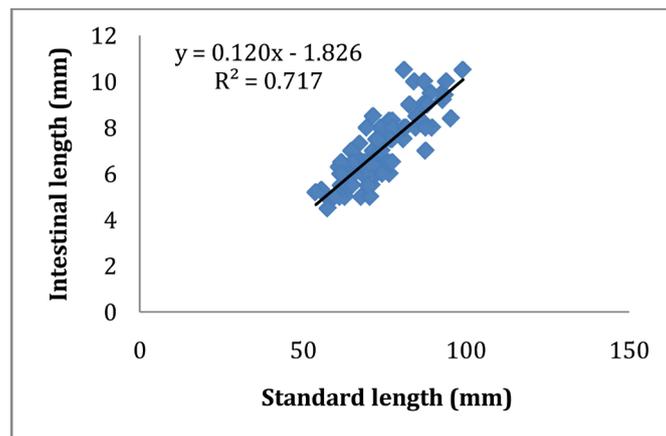


Figure 3. Relationship between intestinal length and standard length of *B. boulengeri*.

followed by odonata larvae (26.97%) and ephemeroptera (25.9%). The analysis of stomach contents showed that *Bryconaethiops boulengeri* consumes mainly insects (coleoptera, ephemeroptera and odonata larvae) with a preponderance index of 90.19 followed by macrophytes (dicot leaves and plant debris) with a preponderance index of 8.17.

3.2. Qualitative and Quantitative Aspects of Diet

Food items found in the stomachs of fish one spread over animal and plant fractions (**Table 1**). Animal fraction contains 17 items divided into six classes: insects, arachnids, shellfish, nematodes, fish, birds feathers. The fraction consists in plant leaf, fruit and stems of dicotyledonous. The classification of preys by calculating the preponderance index (I_p) has classified insects (90.19%) in the category of main prey and macrophytes (8.17%) as accidental prey.

3.3. Study of the Diet According to Season

Insects are the main preys eaten by *Bryconaethiops boulengeri* whatever the season, with a preponderance index 83.60% in the rainy season against 86.61% in the dry season. Macrophytes are secondary preys during two seasons with a preponderance index of 10.80% in the rainy season and 12.70% in the dry sea-

son. Beetles are important preys in the rainy season followed by Ephemeroptera and Odonata larvae that are secondary preys (Table 2). In the dry season, Ephemeroptera and Odonata larvae are important preys followed by beetles that are secondary preys. Schoener index between the two seasons is 0.89. The study of diet depending on the hydrological season shows no significant difference between the dry season and the rainy season (Schoener index = 0.89). This diet

Table 1. Composition of diet *Bryconaeithiops boulengeri* in Djiri River Oc = % occurrence; % P = weight percentage; Ip = preponderance index.

	Preys	% Oc	%P	Ip
	Coleoptera	22.33	22.32	32.704
	Odonata larvae	20.67	19.89	26.977
	Ephemeroptera	22.33	17.68	25.905
	Hymenoptera	8.33	5.19	2.837
	Plecoptera	5	3.21	1.053
Insects	Lepidoptera	4	1.97	0.517
	Diptera	2	1.25	0.164
	Orthoptera	0,67	0.29	0.013
	Trichoptera	0.67	0.2	0.009
	Hemiptera	0,33	0,43	0.009
	Total	86.33	72.43	90.19
Arachnids	Spiders	0.33	0.1	0.002
Crustaceans	Shrimps	2.67	6.08	1.065
Nematodes	Ni	0.67	0.75	0.033
	Fruits	3.67	2.08	0.501
Macrophytes	Sheet Dicotes	7.67	8.94	4.499
	Plant debris	9.33	5.18	3.171
	Total	20.67	16.2	8.171
	Scales	2.67	0.89	0.468
	meat and fish bones	1	1.29	0.085
Other foods	Birds feathers	1	0.34	0.022
	Grease	2.67	1.64	0.287
	Bag	0.67	0.31	0.014

Table 2. Composition of the dominant items in the diet of *B. boulengeri* in Djiri River according to season (Ip).

Preys	Saison de Pluies (n=135)	Saison Sèche (n=136)
Coleoptera	40.70	24.44
Odonata	21.30	28.54
Ephemeroptera	19.20	28.66

similarity between the two seasons could be related to the fact that Djiri River did not have a strong period of floods and low flows.

The affinity of prey consumed between the two seasons dendrogram shows no discrimination regime between the two seasons (Figure 4). Two groups of preys are discriminated, prey to high consumption (Coleoptera, Odonata larvae and that of Ephemeroptera) forming group 1 and those of low consumption (dicot leaves, plant debris and other Hymenoptera).

3.4. Study Diet According to Stations

Insects are the main prey of *Bryconaethiops boulengeri*, whatever the station with a preponderance index of 84.44% at station 1, 94.34% to 83.35% and station 2 to station 3. Macrophytes are secondary prey in station 3 with 16.6% of weight and accessory prey at station 1 and 2 respectively with a preponderance index of 9.03% and 2.58% (Table 3).

Among insects, Coleoptera, the Ephemeroptera and Odonata larvae are most consumed in the three stations (Table 4).

An isolated sequence provided by the station 1, it has relatively low affinities of diet with the stations 2 and 3. The hierarchical cluster analysis performed on the basis of index calculated in each different station isolates the feed station 1 to the other two stations (Figure 5).

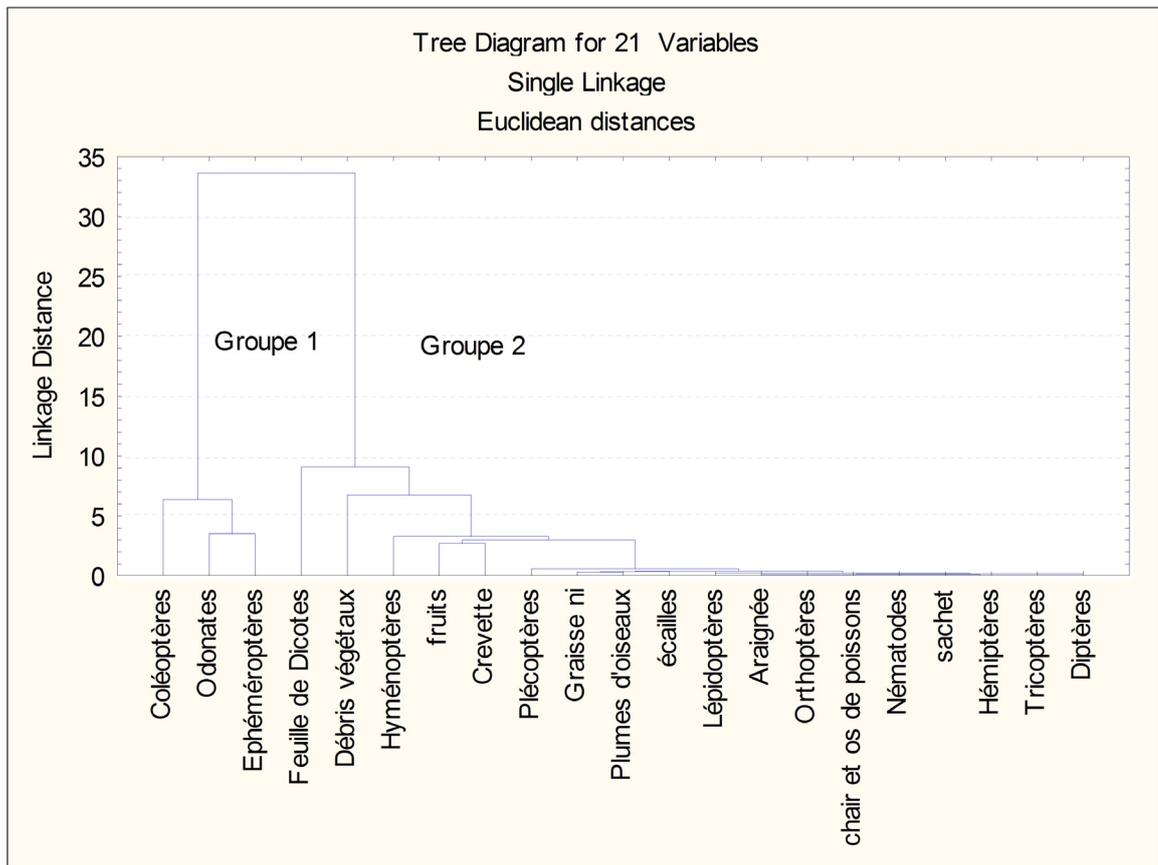


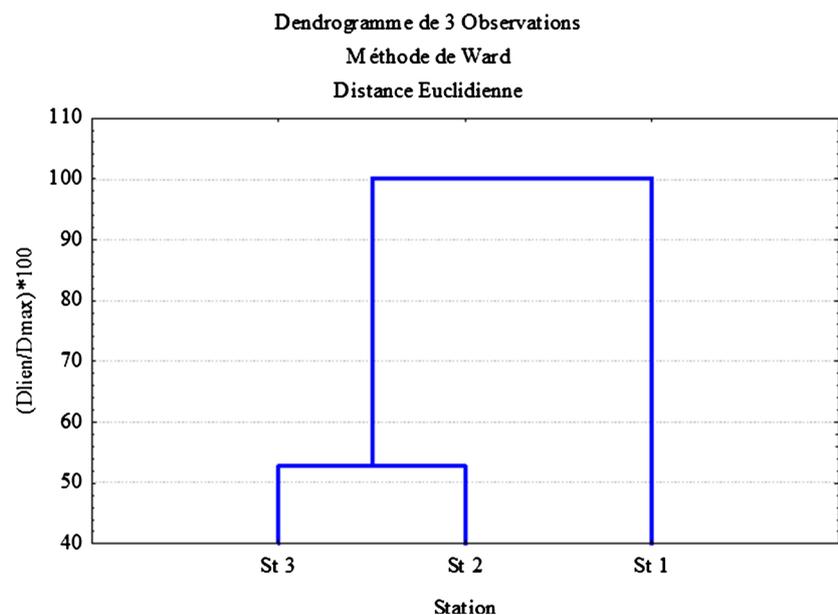
Figure 4. Affinity dendrogram of different food items according to season.

Table 3. Composition of food items *B. bouleengeri* in Djiri River according to station (Ip).

Preys	Station 1 (n = 91)	Station 2 (n = 91)	Station 3 (n = 90)
Insects	84.44	94.34	83.35
Macrophytes	9.03	2.58	16.6
Crustaceans	2.62	2.45	0.01
Fish scales	1.15	0	0
Nematodes	0.01	0.15	0
Bird's feathers	0.01	0.05	0.01
Arachnids	0	0	0.01

Table 4. Composition of the dominant food items *B. bouleengeri* in Djiri River according to station (Ip).

Preys	Station 1 (n = 91)	Station 2 (n = 91)	Station 3 (n = 90)
Ephemeroptera	24.21	29.87	20.61
Coleoptera	14.73	36.22	39
Odonata	37.13	26.22	18.8

**Figure 5.** Affinity dendrogram of different food items according to station.

There is no significant variation in diet among the three sampling stations. Schoener index is equal to 0.87 between the first and second biotope of 0.88 between second and third biotope and 0.86 between the first and third biotope. This observation confirms that the diet of a species is substantially the same throughout its range [10].

3.5. Study of the Diet According to Size

Specimens examined were between 39.6 and 114.6 mm standard length. Nine

classes size were determined according to the Sturge rule (Table 5). Due to the very low numbers, class 1 was fused to Class 2 and Class 9 is fused to Class 8.

Class 1 (n = 1): $39 \leq LS < 47.5$ mm; Class 2 (n = 13): $47.5 \leq LS < 56$ mm; Class 3 (n = 49): $56 \leq LS < 64.5$ mm; Class 4 (n = 69): $64.5 \leq LS < 73$ mm; Class 5 (n = 62): $73 \leq LS < 81.5$ mm; Class 6 (n = 46): $81.5 \leq LS < 90$ mm; Class 7 (n = 24): $90 \leq LS < 98.5$ mm; Class 8 (n = 5): $98.5 \leq LS < 107$ mm; Class 9 (n = 1): $107 \leq LS < 115.5$ mm.

The hierarchical cluster analysis performed on the basis of different weight calculated in each class size food index, allows us to consider four groups of classes size (Figure 6). Group 1 consists of specimens of the 7th class; group 2 consists of specimens of the sixth class, group 3 specimens consisting of the 4th, 5th and 8th classes, and finally the group consisting of 4 specimens of the second and third classes.

Table 5. Composition of food items *B. bouleengeri* in Djiri River according to size (Ip).

	Class 2 (n=14)	Class 3 (n=49)	Class 4 (n=69)	Class 5 (n=62)	Class 6 (n=46)	Class 7 (n=24)	Class 8 (n=6)
Insects	99.40	98.08	85.08	87.68	92.55	88.1	87.4
Arachnids	0.00	0	0	0	0.04	0	0
Crustaceans	0.00	0	0.04	0.25	1.19	5.4	2.52
Nematodes	0.00	0	0.08	0	0	0	0
Macrophytes	0	1.93	14.55	10.74	5.6	3.7	9.7
Fish scales	2.3	0	0.21	0.58	0.25	1.8	0
Birds feathers	0	0	0.01	0	0.18	0.8	0

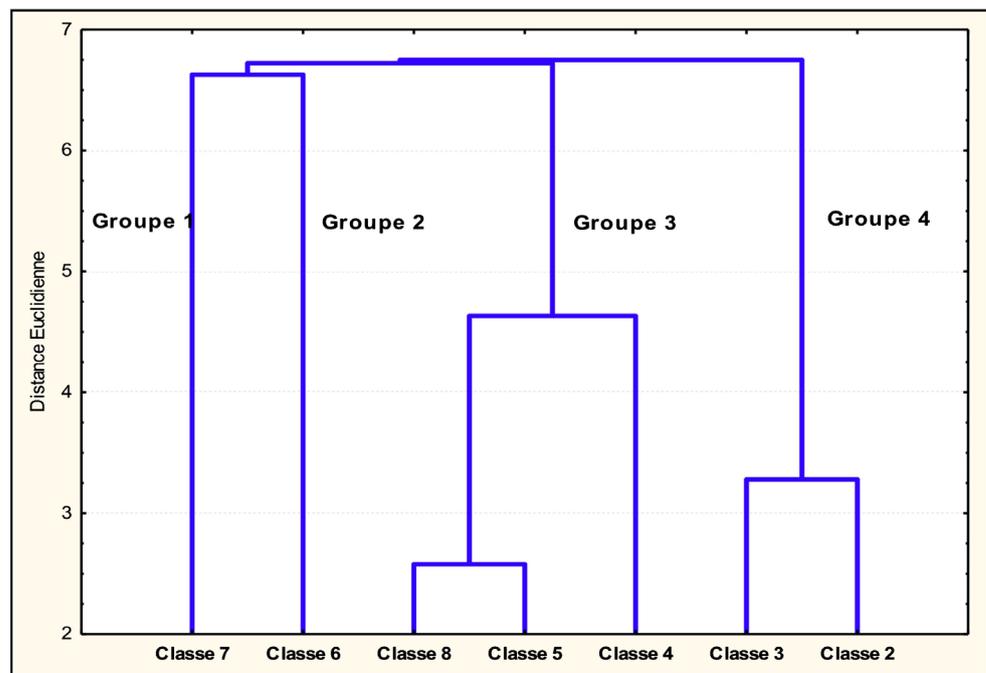


Figure 6. Dendrogram affinity of various food items according to classes size.

Insects are the main prey of *Bryconaethiops boulengeri* in all groups of classes size. The Macrophytes are secondary preys in class 4 and class 5. All other items are the some accessories preys either group. Furthermore, no significant difference was observed between individuals of different size, the Schoener index is greater than 0.60 between the four groups. However, the similarity dendrogram regime reveals that individuals in the group 3 (class 4, class 5 and class 8) consume more macrophytes than other groups, this result shows that the young fishes of group 4 (class 2 and class 3) feed almost exclusively insects and they incorporate other foods into their diet with age (size superior to 64.5 mm).

4. Discussion

The intestinal coefficient of the 300 individuals of *Bryconaethiops boulengeri* varies between 0.71 and 1.29, with an average of 0.95 ± 0.01 . The intestine is usually short in carnivores, less than two standard and long length herbivores two to eight times the standard length [14] [15]. From a qualitative point of view, the stomach contents analyse are consistent with those of Lac Tumba and Ikela region [5], who reports that *Bryconaethiops boulengeri* is polyphagous. Stomach contents include plant debris, sometimes some sand, and insect debris (nymphs of Ephemeroptera and odonates), ants, small Hymenoptera and Coleoptera. Quantitative analysis of the stomach contents of *Bryconaethiops boulengeri* shows that it consumes mainly insects (Coleoptera, Ephemeroptera and odonate larvae) with a preponderance index of 90,188 followed by macrophytes (dicotyledonous leaves and plant debris) with a preponderance index of 8.17. However, considering the two aspects of the diet (the qualitative and quantitative contributions), it seems clear that this fish is entomophagous. The study of the diet according to the hydrological season shows no significant difference between the dry season and the rainy season (Schoener index is 0.89). This similarity could be linked to the fact that the Djiri River does not experience a strong period of floods and low flows. These results are consistent with the authors who report that the diet of fish in rivers that do not overflow does not change significantly. There is no significant variation in diet between the three sampling stations [7] [16]. The Schoener index is 0.87 between the first and second biotopes, 0.88 between the second and third biotope, and 0.86 between the first and third biotope. This observation confirms that the diet of a species is substantially the same throughout its range [7]. There is not significant change in the diet of *Bryconaethiops boulengeri* as a function of height, the Schoener index being greater than 0.6. From this study, only one trophic guild is identified according to size, season or station at *Bryconaethiops boulengeri*, the nature of the prey items consumed by the young remains strictly identical to those ingested by adults. Intraspecific competition would be great because it offers a reduced exploitable food spectrum by individuals of the same species. In this species, the exploitation of the same food resource would lead to an intraspecific competition for the exploited common resource [8] [17]. However, this kind of competition can be

avoided because if the diet remains insectivorous, three main biological groups (Coleoptera, Odonata larvae, Hymenoptera) considered as prey organisms constitute the preponderant food of *Bryconaethiops boulengeri* at all sizes, at all levels in all seasons and in all stations.

5. Conclusion

The analysis of 271 digestive tubes of *Bryconaethiops boulengeri* of Djiri River allows us to conclude that this species is insectivorous, it operates relatively well available food resources (because the coefficient of emptiness is low), it means that, the sustainability of resource, could explain the subjugation of this species in streams tributary of the Congo River. The food always available limits the width of the trophic recess. The speed variation depending on season, size class or station is not significant. It is desirable to extend this study to the reproduction in order to complete data on the bioecology of this species.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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