# Food and feeding habits of Cyprinidae fish (Barbus macrops Boulenger, 1911) in Bia River, Côte-d'Ivoire

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*Abstract*— **The feeding habits of Barbus macrops from Bia River were studied using frequency of occurrence, numeric and gravimetric percentage and main food index (MFI). This study was conducted during two years of sampling (2012-2013) in rainy and dry seasons. Using gill nets of various mesh sizes and fish catch landings, fishes were sampled monthly, identified, weighed and measured for standard length. For 203 examined stomachs, data analysis of different prey ingested depicted that B. macrops is an omnivorous fish. Diet was composed of 14 items and this fish feed mainly on insects, while fruits and vegetable detritus represented the secondary prey items. Vacuity indexes were low and were 09% and 36.58%, respectively for rainy and dry seasons, suggesting a high trophic activity throughout the year. The results obtained from the analysis of gut contents showed significant difference in seasonal variation in the diet composition among fish size.**

***Index Terms*— *Côte d'Ivoire, Bia River, Barbus macrops, diet, feeding habit.***

## I. INTRODUCTION

Knowledge of the feeding habits is an important way to understand the mechanism and processes, which structure fish assemblages [1]. In addition, study on feeding activities of fish is of particular importance in maintenance of healthy populations of fish in the water systems and optimization of appropriate stock management strategies [2]. *Barbus macrops* is widely distributed in freshwater systems of West Africa. It inhabits in rivers Gibi Mountains and Farmington in Liberia in rivers Nipoué, Cavally, Bandaman, Comoe and Sassandra in Côte d'Ivoire [3], It is also harvested in many small coastal basins [3], [4].This specie *B. macrops* is one of the most important freshwater fish economically exploited in Bia River in Côte d'Ivoire. In addition, it is also important in aquariophily sector and is used as feed for carnivorous fish in fish farming [5]. Despite its importance, there has been no comprehensive investigation on the diet of *B. macrops* of commercial importance in Bia River. A few data are available on the feeding biology of this fish in Côte d'Ivoire [3]. Furthermore, given the significant changes observed in this ecosystem in recent years, an updated description of food habits and theirs changes over time is needed. The purpose of this study is to provide detailed information on the feeding habits of this specie as well as its variations according to season and fish size.

**Manuscript received April 29, 2015**

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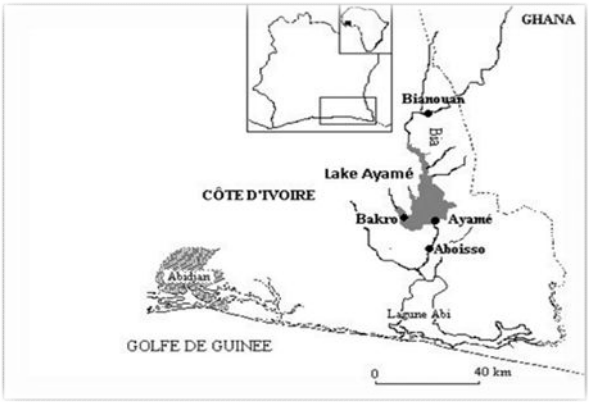
## II. MATERIALS AND METHODS

### A Sampling Area

The Bia River is a 300 km long, situated principally in Ghana and flows through Ghana and Ivory Coast (Figure 1). After entering Côte d'Ivoire, the Bia River flows in a southerly direction to the Aby Lagoon, an inlet of the Atlantic. A hydroelectric dam was built across the Bia River near Ayamé in 1959, causing the formation of Lake Ayame [6]. This book spawned three ecologically different environments: (1) upstream ( Bianouan ), (2) dam's reservoir ( Lake Ayame ) and (3 ) downstream ( Aboisso). This Figure shows the location of sampling stations selected (Bianouan, Ayame Lake and Aboisso).

**Fig. 1**: Location of sampling stations on the Bia River (based on [7]).




### B Sampling and data collection

A random sampling was carried out from January 2012 to December 2013 during the d dry season and the rainy season. Fish were randomly sampled using gill nets of various mesh sizes (8-25 mm) and fish catch landings (2-3 mm stretched mesh size) from 1500 mm depths at night and in the day. Seasons were defined as rainy (May-July and October-December) and dry (January-April and August-September). During the outings, all nets (batteries gill nets of various mesh sizes : (8-25 mm) were set in the late afternoon between 1600 and 1800 GMT and retrieved the next morning between 0600 and 0800 GMT for night's fisheries and re-visited before be raised at 13h for the days of fishing. Two nights of fishing were conducted each month. A total of 203 individuals of *B. macrops* were caught. In situ, the fish obtained were identified individually with the assistance of keys by [8], measured and weighed. Specimens were measured for standard

length (SL) to the nearest 0.1 mm, and the body weight (BW) taken to the nearest 0.1g. Then, in situ, after dissection, the stomachs were individually stored in 5% formaldehyde. In the laboratory, the weight of each individual and the stomach contents were determined using a scale of brand - Scout Pro of 1 g accuracy and maximum weight capacity of 2,000 g. The guts were opened and prey items were separated using a binocular microscope (magnification 10-60x). Preys were identified following the methods of [9], [10] and [11]. The food items of each specimen were determined and quantified using the following food indices.

The indices used to describe the diet were: the frequency of occurrence (%F), percent numbers (%N) and weight (%W) [12]. Main food Index (MFI) by [13] was also computed. The most important prey was determined based on the values of the main food index (MFI) [16]. The calculations were made according to the following formulas:

Frequency of occurrence (%F): % F = (Ni / Nte) x 100

With Ni = number of stomachs containing prey category i feed and Nte = total number of all stomachs;

Numerical percentage (N) [14] % N = ( Npi / N tp) x 100

Where Npi = total number of prey category i feed and Ntpi = total number of all prey;

This is to determine the percentage of stomachs containing a prey category (Ni) relative to the total number (Nte) of stomachs containing at least one prey [14].

Weight percentage (% P): % P = (Wti / Wtp) x 100

With Wti = total weight of prey category i feed and Wtp = total weight of all prey;

It involves determining the percentage of the mass of a food category i (Pi) relative to the total mass (Pt) of the stomach contents [15].

Main food Index (MFI) by [13] MFI = [%W (%N +%F) / 2]1/2

Vacuity index (VI): VI = (Ev / Nt) x 100;

This index was determined to assess the rate of feeding activity according:

Diet was analyzed in relation to seasonal variations in diet composition and fish size in order to establish if there were any changes in the prey category i feed in relation to fish size. Two groups were determined: 43≤Class I ≤54.9 mm and 54.9<Class II ≤68 mm, respectively for the juvenile and adults specimens.

The Spearman rank correlation test was used to compare the diets according to the variables considered

Seasonal vacuity of the fish was studied using Chi-square test ($\chi 2$) and values were tested at 95% confidence level.

## III. ANALYSIS RESULTS

### A Feeding intensity

The results of the analysis of 203 stomachs of the fishes have been presented in the Table 1. In this study, out of the 203 stomachs examined, 79.81% contained food and the rest 20.19% were without food. Seasonal variations of empty coefficient indicated that lowest values of empty stomachs were found in rainy season (9.09%) and increased to 36.58% in dry season. In dry season, a total of 82 specimens were collected and 30 stomachs were empty (36.58%), while in rainy season, 121 stomachs were analyzed, of these, 11 were empty (9.09%). Vacuity index was changed with seasonal variations. Chi-square test ($\chi 2$) was applied for testing the seasonal variation in vacuity index of *B. macrops*. It showed significant difference in vacuity index among seasons ($\chi 2 = 6.01$, $p < 0.05$).

### B Food patterns

A total of 14 prey items were identified in the diet of *B. macrops* and grouped in 5 prey categories (Table 1). Dietary contents in the stomachs of *B. macrops* included molluscs, crustacea, insect, macrophyte and annelid (Table I). Insects were the most important ingested prey category with 9 items, According

**Table I:** Diet composition and seasonal patterns of feeding of *B. macrops* in Bia River (Côte d'Ivoire). %F is frequency of occurrence; %N is Numeric percentage; %P is gravimetric or weight composition and MF is Main Food Index

| Food Items | Global patterns of feeding | | | | Seasonal patterns of feeding | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diet composition | | | | Dry season | | | | Rainy season | | | |
| | %F | %N | %P | MFI | %F | %N | %P | MFI | %F | %N | %P | MFI |
| Insects order | | | | | | | | | | | | |
| Coleoptera | 2.27 | 0.15 | 0.47 | 0.75 | | | | | 1.52 | 0.25 | 0.49 | 0.65 |
| Odonata | 2.73 | 0.26 | 1.73 | 1.61 | | | | | 5.17 | 0.38 | 2.54 | 2.65 |
| Ephemeroptera | 3.63 | 0.95 | 0.59 | 1.16 | | | | | 6.89 | 1.40 | 0.86 | 1.88 |
| Hymenoptera | 23.44 | 9.09 | 1.08 | 4.2 | 27.27 | 10.63 | 1.18 | 4.73 | 23.07 | 5.88 | 0.83 | 3.47 |
| Isoptera | 3.84 | 34.41 | 5.44 | 10.20 | 4.26 | 0.12 | 0.41 | 0.95 | 2.13 | 0.29 | 3.14 | 1.95 |
| Plecoptera | 4.49 | 0.30 | 1.22 | 1.71 | 4.26 | 0.12 | 0.14 | 0.55 | 4.58 | 0.49 | 1.53 | 1.97 |
| Hemiptera | 16.85 | 2.69 | 1.82 | 4.22 | 21.28 | 2.31 | 1.63 | 4.39 | 15.27 | 3.10 | 1.88 | 4.16 |
| Diptera | 20.32 | 21.12 | 5.2 | 10.37 | 9.45 | 13.34 | 4.2 | 6.91 | 30.1 | 32.1 | 7.4 | 15.17 |
| Insects appendages | 63.11 | 3.43 | 32.65 | 33.47 | 61.70 | 1.68 | 33.27 | 32.45 | 61.70 | 5.29 | 32.48 | 34.13 |
| Crustacea | 6.25 | 1.91 | 0.51 | 1.45 | 4.55 | 1.42 | 0.68 | 1.43 | 10.52 | 2.94 | 0.04 | 0.51 |
| Annelids | | | | | | | | | | | | |
| Nematods | 1.69 | 0.13 | 0.14 | 0.35 | 1.1 | 0.09 | 0.12 | 0.26 | 1.53 | 1.18 | 0.07 | 0.30 |
| Oligochaetes | 1.01 | 0.20 | 0.14 | 0.29 | 1.12 | 0.07 | 0.09 | 0.23 | 1.33 | 1.2 | 1.12 | 1.19 |
| Mollusques | | | | | | | | | | | | |
| Ancylidae | 5.66 | 0.77 | 3.42 | 3.30 | 6.87 | 1.28 | 3.50 | 3.78 | | | | |
| Macrophytes | | | | | | | | | | | | |
| Fruits and plants debris | 62.19 | 56 | 27.37 | 40.21 | 33.36 | 53.86 | 13.53 | 24.29 | 59.9 | 47 | 20.91 | 33.43 |
| TOTAL | | | | | | | | | | | | |
| INSECTS | | | | 66.87 | | | | 50.1 | | | | 66.03 |
| CRUSTCEA | | | | 1,45 | | | | 1,43 | | | | 0.51 |
| ANNELIDS | | | | 0.64 | | | | 0.49 | | | | 1.49 |
| MOLLUSQUES | | | | 3.30 | | | | 3.78 | | | | 0 |
| MACROPHYTES | | | | 40.21 | | | | 24.29 | | | | 33.43 |

frequency of occurrence, insect appendages were more presented in stomach, constituting (%F = 63.11) followed by macrophytes, (%F = 62.19), Hymenoptera (%F = 23.44) and Diptera (%F = 20.32) while the others items have a frequency of occurrence inferior to 10%. Numerically, macrophytes being the most abundant (%N = 56) followed by Isoptera (%N = 34.41) and Diptera (%N = 21.12) (Tab. I). According index values of the main food, *B. macrops* diet was composed mainly by insects (MFI = 66.87%), and secondarily by macrophytes (MFI = 40.21). Other items were accessories preys (MFI ≤ 25).

### C. Seasonal patterns of feeding based on percentage occurrence of food items

The taxonomic composition was analyzed according the seasons. A low seasonal variation in feeding habits of *B. macrops* has been observed (Table I). The outcomes of the study shown that the food items of *B. macrops* did not contain Coleoptera, Odonata and Ephemeroptera in dry season, while, in rainy season, food item Ancylidae was absent. The analysis of stomach contents revealed that the diet in dry season of the fish consists mainly of the insects appendages (%F = 61.70), macrophytes (%F = 33.36), Hymenoptera (%F = 27.27) and Hemiptera (%F = 21.28]. Numerically, macrophytes being the

most abundant (%N = 53.86) followed by Diptera (%N = 13.34) and Hymenoptera (%N = 10.63). Other insects are underrepresented (Table I). In the rainy season, the highest percentage (%F = 61.70), of Insects appendages, (%F = 59.9) of macrophytes, (%F = 30.1) of Diptera and (%F = 23.07) of Hymenoptera were observed as the most frequent prey in stomach. The most abundant prey being constituted of the macrophytes (% N = 47). As concerning index values of the main food, Insects were represented the main preys at rainy season (MFI = 60.03) and at dry season (MFI = 50.1). Despite slight seasonal variations between the dry season (MFI = 24.29) and the rainy season (MFI = 33.43), macrophytes remain a secondary prey. The comparison of the diet with the correlation test of Spearman rank among the dry season and the rainy season indicates significant differences (N = 10; R = -0.12; p = 0.72)

**D Feeding variations with fish size**

The results of the variation in abundance of prey categories with fish size is presented in the Figure 2. This variation in abundance of prey categories in diet for *B. macrops* with fish size indicated that the food of juvenile fishes (from 43 to 54.9 mm) mainly contained insects and macrophytes. The increase in fish length revealed an increase in the percentage of many prey categories in the diet of this species. Following the values of the main food index, juveniles specimens (class I) predation was preferentially insects (MFI = 82.34) and accessorily macrophytes (MFI = 0.86). For adults specimens (class II) insects were the most important ingested prey (MFI = 54.3), then followed macrophytes (MFI = 30.88), molluscs (MFI = 19.71), crustacea (MFI = 10.37) and annelids (MFI = 4.49) (Figure 3). Spearman rank correlation revealed significant differences between ingestion of juveniles (class I) and adults (class II) (N= 10, R=0.27, p=0.44).

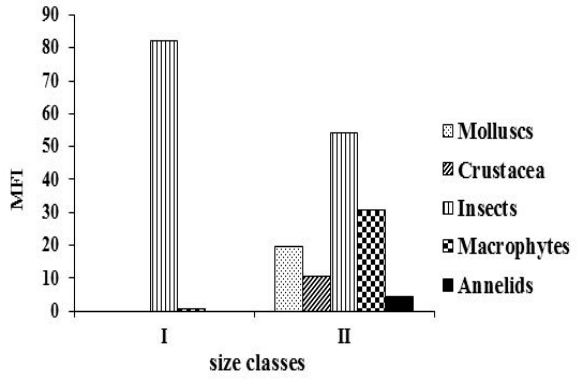



**Fig. 2:** Diet distribution in relation with size of *Barbus macrops* from Bia River (Côte d'Ivoire).

DISCUSSION

In Bia River, seasonal variations of vacuity index indicated that lowest value of empty stomachs was found in rainy season (9.09%) and the highest percentage of empty stomachs (36.58%) was observed in dry season. Overall, these values were low and indicated a higher trophic activity throughout the year. These results indicated that the feeding intensity of *B. macrops* is increased. This is in agreement with the findings of [5] and [16] in their study of food and feeding habits, of *B. callensis* and *B. setivimensis*, respectively. Indeed, similarly to our results, [16] reported values of vacuity index of 18% in summer, 24% in autumn and 26% in winter in l'Oued Boufekrane waters for *B. callensis*. Likewise, in Algeria, [16] observed emptiness coefficients of 23.33% and 9.09% for *B. setivimensis*, respectively in winter and in autumn. The seasonal variations of vacuity index observed may be attributed to the spawning activities, where the physical space in the body cavity available for the stomach at the spawning period was small or food availability [17]. Indeed, these seasonal variations of vacuity index could be explained by diet reduction during reproduction season because of migration of female to spawning habitat [5]. And, after reproduction period, fish might consecrate most of its time for alimentation in order to compensate the lost energy during reproduction [18]. The food and feeding habits of fishes vary from season to season. This variation may be due to the changes in the composition of food organisms occurring at different seasons of the year [19]. Besides, these changes may be correlated to the seasonal variation in food availability [20] and adaptation of the species [16], which is related to the water level, substratum, terrestrial and aquatic vegetation distribution [21; 22; 23]. The diversity in the diet of *B. macrops* which comprised low value in dry season and the maximum value in rainy season may also be attributed to the wide spectrum of food items in rainy season in the habitat [21; 22; 23]. In rainy period, there are much resources than dry period. These resources originate from terrestrial by water flowing [23]. This variation occurred due to the fact that as the density of particular prey type declines, a predator may switch to another prey which is more abundant [24]. The findings of the study shown that the food items of *B. macrops* consisted of, insects, macrophytes, molluscs, crustacea and annelids. In this case the nature of this fish is omnivorous because it feeds on many prey categories. However, among the food items, insects, was the most dominant, followed by the macrophytes through the whole year. Therefore, they can be considered as the most important prey items available for *B. macrops* in Bia River. Accoding to [25], fish diet composition is largely a reflection of the relative abundances of their prey. Macrophytes were secondary in importance, while the other prey groups had less importance and considered as accessory food. Our result coincided well with the findings of [26] for *B. bacagei* in Sorraia rivier, [21] for *B. luteus* and [5] for *B. callensis* in Oued Boufekrane. The analysis of stomach contents of *B. macrops* revealed variations in the diet spectrum of this species with its growth. Changes in diversity of prey categories with fish size for *B. macrops* indicated that the diet of small fishes (SL ≤ 54.9 mm) mainly contained insects, while insects were represented by minor importance in the diet of the adult fish. The food of adult fish consisted mainly of an increase in the percentage of macrophytes, molluscs, annelids, and Crustacea prey in the diet of this species. This diet shift has been observed in many, species [12], for example *Barbs bacagei* [26], *B. luteus* [21], *B. callensis* [5] and *B. setivimensis* [16]. Indeed, diet shift can be due to ontogenetic, anatomic and morphologic variations with fish growth [27]. The ontogenetic shift in feeding habits is a general phenomenon among fishes as result of increasing body size.The width and gape of mouth are linearly related to the fish size and increased body and mouth size permit fish to capture a broader range of prey size and prey types [21].

## CONCLUSION

This study showed that *B. macrops* is an omnivorous specie. Diet spectrum consisted of insects, macrophytes, molluscs, crustacea and annelids. *B. macrops* had an intense trophic activity throughout the year. The analysis of stomach contents showed feeding variations with fish length and seasonal variations of food patterns.

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