International Journal of Zoology Studies
www.zoologyjournals.com
ISSN: 2455-7269
Received: 16-04-2022, Accepted: 01-05-2022, Published: 17-05-2022
Volume 7, Issue 1, 2022, Page No. 96-108

Diets of Alestidae (Teleostei: Characiformes) in Two Rivers (Boumba and Kadei) in Eastern Cameroon

Sandrine Jueya[1], Gifty A-T Attu[2], Leandro Castello[3], Emmanuel Frimpong[3], David Nguenga[4], Arnold R Bitja Nyom[1], [5*]
[1] Department of Biological Sciences, Faculty of Sciences, University of Ngaoundere, Ngaoundere, Cameroon
[2] Department of Fisheries and Watershed Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[3] Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University Blacksburg, Virginia, United States
[4] Institute of Agricultural Research for Development, Fisheries Research Unit, Foumban, Cameroon
[5] Department of Fisheries and Aquatic Ecosystem Managements, Institute of Fisheries Sciences, University of Douala, Douala, Cameroon

Abstract

The dietary ecology of the Alestidae fishes was studied from two rivers, Boumba and Kadei, in eastern Cameroon. A total of 106 (individual) fish specimens including five species in the Boumba (*Alestes macrophthalmus*, *Brycinus macrolepidotus*, *Brycinus longipinnis*, *Bryconaethiops* sp. and *Hydrocynus vittatus*) and four species in the Kadei (*A. macrophthalmus*, *B. macrolepidotus*, *Brycinus imberi* and *H. vittatus*) was collected monthly from December 2018 to May 2019. The stomach contents of these fish were analyzed using Corrected frequency of Occurrence (Fc), Percentage by Weight (P) and Index of preponderance (Ip). Qualitative analysis of all of these stomach contents reveals that the diet of fish hovers around four food categories: prey fish, macroinvertebrates, macrophytes, and other unidentifiable particles. Depending on their food preferences, the Alestidae of the Boumba and the Kadei rivers were placed into two groups: carnivores and omnivores. Although their eating habits may vary significantly and / or not with the size of individuals, diet overlap exists among omnivorous diet species. In addition, some Alestidae (*Alestes macrophthalmus*, *Brycinus macrolepidotus*) adapt their diets according to the quality and quantity of resources available in their living environment.

Keywords: Alestidae; diet; Congo Basin; Eastern Cameroon

Introduction

Fishes, which alone constitute more than half of the vertebrates on Earth [1], are the world's main source of protein of animal origin [2]. Most fish species have a diverse range of dietary habits that allow them to adapt best to environmental conditions, although their morphology is sometimes adapted to a specific diet [3]. Thus, research in the food ecology of fishes provides information on the trophic potential of the environment and is essential for understanding the relationships between the different species of an aquatic ecosystem [4]. Data on the dietary preferences and behavior of fish are important for the implementation of conservation strategies and sustainable management of stocks [5]. Indeed, the quality and quantity of food are among the most important exogenous factors that directly affect the growth and indirectly the maturation and mortality of fishes [6].

The feeding of the fish takes into account the time when it feeds, the place and the duration of the feeding period, the preys that are most adequate (size and nutritional value), the way in which it will seek these preys and capture them [7]. This diet is correlated either to the morphology of the head and the mouth [7], or to the position of the mouth [8], or even to the morphology of locomotion (linear or serpentine) [8]. This is the case with the example of *Alestes baremoze* (Joannis 1835), a zooplanktonivore and an excellent swimmer capable of migrating over long distances in lakes [9].

In their natural environment, fishes encounter very diverse food elements. Some species feed on dead animals, others on live animals, some feed only on microorganisms, others on larger plants and animals, and finally some species of fish are opportunistic, feeding on everything they can find in their environment [10]. Depending on the type of diet, fish in general are divided into four broad categories, herbivores which feed on plants; scavengers that eat decaying organisms; omnivores who have a mixed diet, plant and animal; carnivores that feed on other fishes and invertebrates [11]. However, while the diets of many fishes around the world is relatively well understood, the diet of fishes across the tropics, where most species are found, is relatively poorly understood.

The Congo Basin is full of tropical forest waterpaths that present a very great ichthyological diversity as well as a diversity of food source for the fishes that live there [12]. Unfortunately, apart from the work of Akenze *et al.* [13] on the feeding behavior of *Schilbe grenfelli* (Boulenger 1900) in the Congo River (near Brazzaville), to our knowledge, there is no other study on the diet of fishes in the Congo Basin in general and the Boumba and Kadei in particular. The aim of this work is to make a contribution to the knowledge of the diets of Alestidae, a family of fish well represented in the Boumba and Kadei rivers, through the study of their stomach contents with an evaluation of their variability according to the environment and the size of individuals.

Materials and Methods

Description of the Study Sites

This study was carried out between December 2018 and May 2019 in two rivers (Boumba and Kadei, Congo Basin) in the region of East Cameroon, located respectively in the Department of Boumba and Ngoko for the Boumba and in the Department of Kadei (Division of Ndélélé) for the portion of Kadei that was the subject of this study (Figure 1).

The Boumba River, which is nearly 530 km long, takes its source around Lomié to the north-west of that of the Dja, and has an average annual flow of 106 m3 / s [14]. With a catchment area of 27,400 km2, the Boumba is a tributary of the Dja River, near Mouloundou and it is adjacent to the Boumba -Bek National Park, bounded on the east by the Boumba and on the west by the Bek River. It receives on the right bank the Bek River at Moulondou level and on the left bank the Landjoué and Bangé Rivers and Lokomo around Yokadouma [14]. The Kadei River, for its part, originates at an altitude of about 100 m at Garoua - Boulaï and corresponds to the border between Cameroon and Central African Republic for about 80 km [14]. It is 570 km long and has an average annual flow of 247 m3 / s [15]. It receives on the right of the banks of river Oudou the downstream of Ngoura and on the left bank, the Doumé in Mindourou and the Boumbé II downstream of Mindourou [14]. Throughout the Congo Basin, the prevailing climate is sub-equatorial same as the Congo-Guinean type with two dry seasons which alternate with two rainy seasons. The average rainfall varies between 1,500 and 2,000 mm over 10 months. The annual average temperature is in the range of 23 to 27 ° C. The relative and average humidity is above 80% [16].

Sampling for this study on the Boumba river took place at two places: Biwala 1, geographical coordinates 03o 13. 306 ’N and 014o 54. 158’ E and altitude 477 m; and Biwala 2, geographical coordinates 03o 13. 205 ’N and 014o 55. 281’ E and altitude 481m. On the Kadei river, this sampling took place in both places: Soné, geographical coordinates 04o 05. 940 ’N and 014o 55. 001’ E and altitude 572 m; and Mindourou, geographical coordinates 04o 08. 074 ’N and 014o 34. 208’ E and altitude 574m.

To draw statistical interpretation, descriptive statistics, i.e., mean and standard error of mean along with the one way ANOVA were performed to test the presence of any significant differences between all the data at 0.05 level.

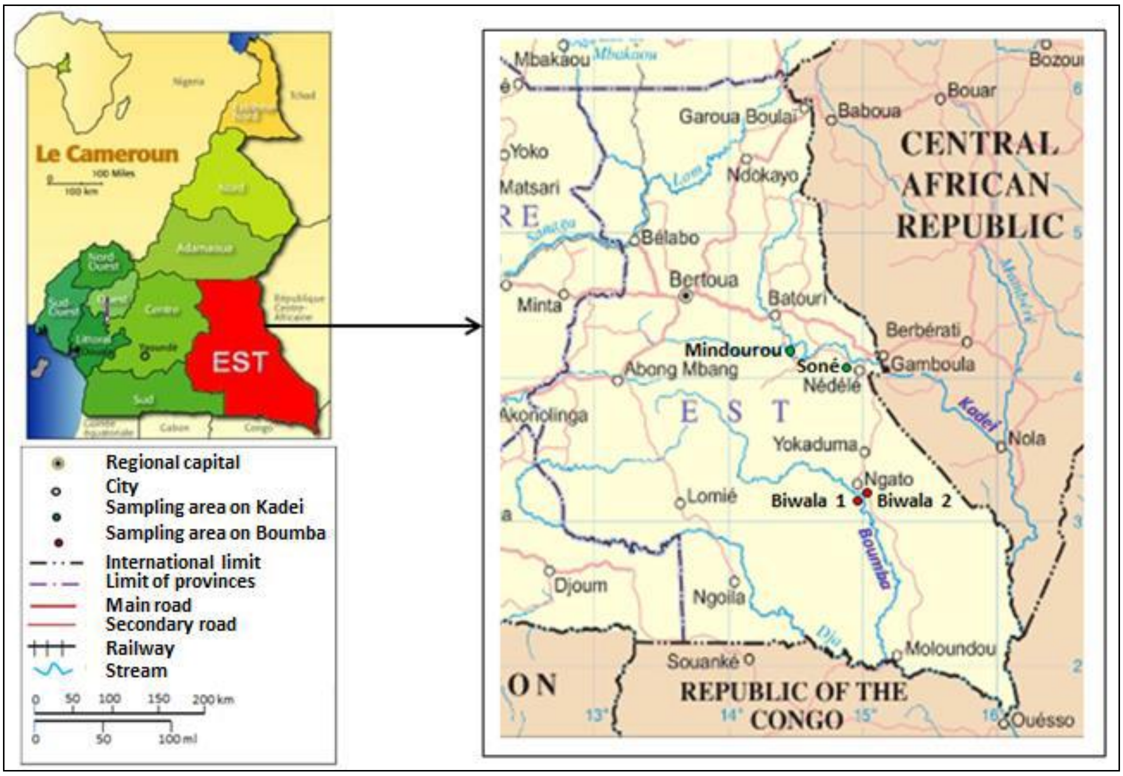

Fig 1: Map of the study area locating Boumba and Kadei and the Sampled Localities.

Data Collection

Sampling and Dissection of Fish

The fish were collected successively twice a day (morning from 5:30 a.m. to 11 a.m. and evening from 3 p.m. to 6 p.m.), six days a week, during the six months of sampling, using different fishing gears that are usually used by local fishermen (gillnets, cast net, hook, trap). The captured fish were sorted and classified on a morphological basis, then transported fresh in cold isothermal coolers to the packing station where they were tagged and photographed on the left side on a dissection rack graduated to the nearest millimeter. The sample fish were weighed using a portable balance with a sensitivity of 0.5g and their standard (SL) and total (TL) lengths were measured using an ichthyometer to the nearest millimeter. The fish were then dissected to remove the stomach tubes, which were stored in 60ml (for small specimens) and 125ml (for large specimens) tubes, each containing 70% alcohol. The carcasses of the fish stripped of their stomach tubes were kept in a container containing 10% formaldehyde for later identification at the Zoology laboratory of the University of Yaoundé I.

Fish identification was done on the basis of morphometric and meristic characteristics using a combination of fish identification keys [17, 18, 19]. Species details were carefully observed under a 10X magnification "WILD HEERBRUGG M5-63644" brand binocular loupe.

Identification of Stomach Contents

In the laboratory, the stomachs of the sample fish were opened by incision; the contents obtained were rinsed in petri dishes, then filtered through a sieve with a 25 µm diameter mesh, to remove the very fine materials and the digestive juices present. The fractions retained on the sieves and the filtrate was sorted either with the naked eye or under the LEICA EZ4D brand camera microscope with magnification (8X to 13.5X) according to the size of the constituents. The different elements were separated, determined and most often counted (except in the case of phytoplankton or uncountable prey).

Preys were identified using a combination of stomach contents identification keys [20, 21, 22, 23, 24]. They were counted and weighed using a precision electronic balance to the nearest thousandth of a gram (0.001g). In the case of animal prey already fractionated in the digestive tract, counting of fragments was carried out (e.g. whole heads with the rest of the body digested) and these were counted as whole individuals, then a total weight of each item was calculated.

Data Analysis

To accurately assess the different diets and their variations, various diet indexes were calculated, for all sampled fish, including the digestive emptiness coefficient (Cv), the corrected percentage of occurrence (Fc), the weight percentage (P), as well as the preponderance index (Ip) of Natarajan and Jhingran [25] modified by Amundsen *et al.* [26] and the Horn's dietary overlap index [27], expressed respectively as follow:

- **Vacuity Coefficient (CV)**

This coefficient allowsto identify the weak and intense periods of feeding activity of the fish studied over time and the availability of food in an environment [28]: $Cv = (Ev / Nt) \times 100$

Where, Ev = number of empty stomachs and Nt = total number of stomachs examined.

- **Corrected Frequency of Occurrence (Fc)** [29]:

$$Fc = Fi/\Sigma Fi \times 100 \text{ with } Fi = ni / nt$$

Where, Fi = frequency of prey i, ni = number of stomachs containing prey i, nt = total number of full stomachs examined. The calculation of the corrected frequency of occurrence (Fc) makes it possible to assess the degree of fidelity of the fish to its prey. It varies as follows

- When Fc is greater than or equal to 80% ($Fc \geq 80\%$), the prey is considered to be very frequent;
- When (Fc) is between 60 - 79% ($60 \leq Fc \leq 79\%$.), the prey is said to be frequent;
- When (Fc) is between 40 - 59%. ($40 \leq Fc \leq 59\%$.), the prey is said to be quite frequent;
- When (Fc) is between 20 and 39% ($20 \leq Fc \leq 39\%$.), the prey is said to be accessory;
- When (Fc) is less than 20% ($Fc <20\%$), the prey is said to be accidental.

- **Weight percentage (P)** [30]

$$P=Pi/Pt \times 100$$

Where, Pi = total weight of individuals of the same prey category i, Pt = total weight of inventoried prey.

- **Index of preponderance (Ip) of Natarajan and Jhingran [25] modified by Amundsen *et al*. [26] and combining the percentages of occurrence (Fc) and weight (P): $Ip = Fc \times P/\Sigma (Fc \times P) \times 100$;**

The preponderance index (Ip) was chosen in order to eliminate the bias caused by the different percentages (Fc and P) that compose it [29, 30]. This index varies from 0 to 100 and the prey categories have been classified according to the following classification scale:

$Ip < 10$: accessory prey;
$10 < Ip < 25$: secondary prey;
$25 < Ip < 50$: important preys;
$Ip > 50$: main prey.

This index has the advantage of not including a numerical percentage because among the prey taxa there is a large amount of leaves, plant debris and insect debris that cannot be counted.

- **Horn's dietary overlap index** [27]

$$C_{\lambda} = \frac{2 \sum_{i=1}^{S} x_i y_i}{\sum_{i=1}^{S} x_i^2 + \sum_{i=1}^{S} y_i^2}$$

Where S is the total number of food items; xi and yi represent the proportion (Ip) of a prey i consumed respectively by species x and y. This index is used to assess the degree of similarity between the diets of individuals of different species. If the value of Cλ is between 0 and 0.6 ($0 < C\lambda < 0.6$) it means that the two species do not have the same diet; on the other hand, if the value is greater than 0.6 ($C\lambda > 0.6$) this means that there is an overlap of the diet [31]. The different size classes of the sampled specimens were defined on the basis of Sturge's rule [32], as follow:

- Number of classes (NC) = 1 + 3.3 log10 N, where N = total number of specimens examined.
- The interval of each class was determined according to the formula: I = (SL max-SL min) / NC, with SL max = maximum standard length and SL min = minimum standard length.

Spearman's rank correlation tests were performed to compare diets across the sampled data based on location and size of fish. Statistical analyzes were performed using Excel 2010 software and the differences were considered significant at $p < 0.05$.

Results

Specific Richness and Abundance of Alestidae

A total of 106 fish specimens belonging to the Alestidae family, divided into four genera (*Alestes* Müller & Troschel, 1846, *Brycinus* Valenciennes, 1850, *Bryconaethiops* Günther, 1873 and *Hydrocynus* Cuvier, 1816) and six species (*Alestes macrophthalmus* Günther 1867, *Brycinus imberi* (Peters 1852), *Brycinus macrolepidotus* Valenciennes 1850, *Brycinus longipinnis* (Günther 1864), *Bryconaethiops* sp. and *Hydrocynus vittatus* (Castelnau 1861)) were collected in the two rivers. Five of these species are present in the sampled stations in Boumba and four in those of the Kadei. The Boumba's collection has 63 specimens including 39 *A. macrophthalmus*, 12 *B. macrolepidotus*, one *B. longipinnis*, 10 *Bryconaethiops* sp. and one *H. vittatus* while the Kadei's sample has 43 specimens including two *A. macrophthalmus*, 23 *B. macrolepidotus*, 13 *B. imberi* and five *H. vittatus.*

Depending on the sampling sites, the average size and weight of specimens varies, from individual to individual (within the same species) and from species to species (Figure 2).

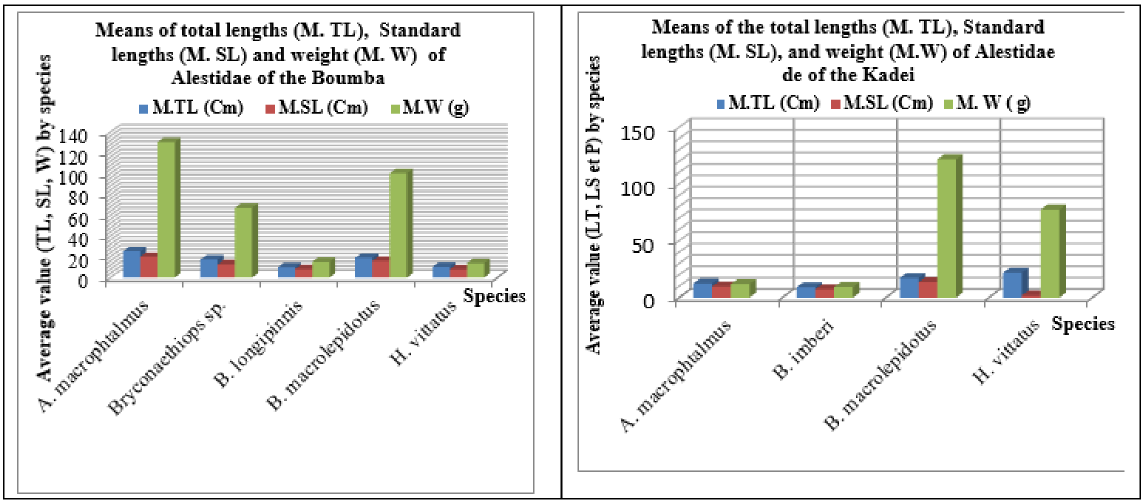

Fig 2: Comparative variations in average length and weight of different species of Alestidae collected. MTL = average of total lengths, MSL = average of standard lengths, M.W = average of weights.

General Diet Profile

Of the 106 individuals sampled, the stomachs collected were either full or empty. Thus 89.7% of the fish collected in the Boumba had full stomach tubes against 7.7% empty, while in the Kadei, 76.1% of the stomachs were full against 14.9% empty. The stomachs of some individuals were decomposed before their laboratory analysis and were therefore considered to be absent (Figure 3).

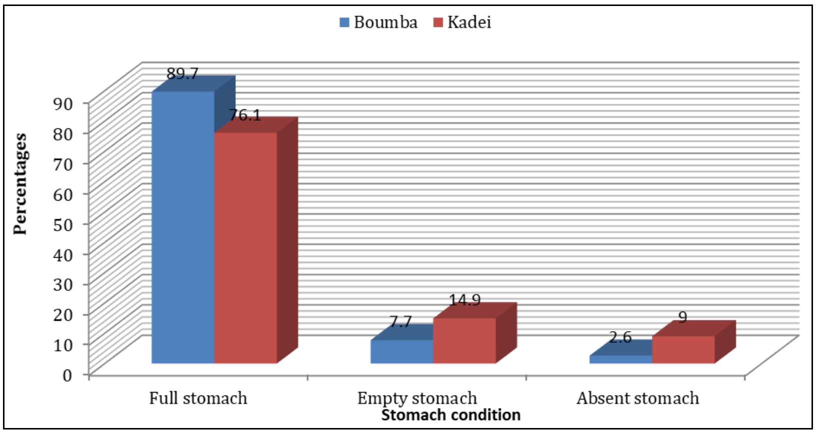

Fig 3: State of the stomachs of fish according to the sampling sites.

Observation of these stomachs made it possible to assess the emptiness coefficient of each species listed in the different sites. Thus in *A. macrophthalmus* it is 8.33 at Boumba and 50 at Kadei, the high value of the vacuity coefficient observed in this species at Kadei is mainly due to the low number of individuals collected (two individuals including one had an empty stomach and the other was loaded); in B*ryconaethiops* sp and *B. imberi* the coefficient of emptiness is 33.3 and 25 respectively, which means that only a few individuals of each of these species had empty stomachs and the vast majority had full stomachs; in *B. macrolepidotus* it is zero (0) in the Boumba and 9.09 in the Kadei, this means that all the individuals captured in the Boumba had their stomachs stuffed with food, as in the Kadei, the observation is almost similar, as the vast majority of individuals captured had a loaded stomach (Table 1).

Table 1: Calculation of the coefficient of vacuity in the different species of the two rivers

Species	**Boumba**	**Kadei**
	Coefficient of vacuity	**Coefficient of vacuity**
A. macrophthalmus	8.33	50
Bryconaethiops sp	33.3	/
B. longipinnis	0	/
B. macrolepidotus	0	8.69
B. imberi	/	25
H. vittatus	100	60

Qualitative analysis

The qualitative analysis of all the stomach contents of the different species of fish collected in the Boumba and in the Kadei reveals that the fish diet oscillates around four food categories: prey fish, macroinvertebrates, macrophytes, and others miscellaneous unidentifiable particles. Prey fish are made up of small fish, fish scales and fish debris (bones, skulls, fins). Macroinvertebrates are represented by aquatic insects (Diptera, Coleoptera, Ephemeroptera, Trichoptera and Odonata); terrestrial insects and invertebrates (Isoptera, Hymenoptera, Lepidoptera and Myriapoda) and Crustaceans (which are represented here by Shrimps only). In the category of macrophytes, one fraction consists of terrestrial plants (fragments of leaves, flowers, seeds, fruits) and another consists of aquatic plants (mosses, ferns, green algae and other unidentified leaves). The already decomposed or unidentified food fraction and other miscellaneous debris have been grouped together under the term "other". From this analysis it clearly emerges that macroinvertebrates are also well represented both in the diet of fish from the Boumba and those from the Kadei; these are followed by macrophytes (Table 2).

Table 2: Presence-absence of prey identified in the stomach contents of dissected individuals.

Sites	**Prey**	**Fish**			**Macroinvertebrates**									**Macrophytes**					**Other**			
	Species	**Wh/Pat**			**AI**			**InsT/InvT**					**Cr**	**TP**				**AP**			**Mis**	
		Sf	**Fs**	**Fd**	**Co**	**Tr**	**Od**	**Or**	**Le**	**Hy**	**Is**	**My**	**De**	**Lf**	**Fl**	**Fr**	**Se**	**AP**	**Ib**	**Ie**	**Ff**	**Un**
Boumba	*A. macrophthalmus*			+	+			+	+								+	+	+	+		+
	Bryconaethiops sp.		+				+		+									+				
	B. longipinnis								+													

	B. macrolepidotus								+	+				+		+		+				
	H. vittatus																					
Kadei	*A. macrophthalmus*							+														
	B. imberi			+	+	+	+	+	+	+	+							+	+			
	B. macrolepidotus				+	+				+		+	+		+	+		+	+		+	
	H. vittatus	+																				

Quantitative analysis

Analysis of stomach contents of fish species sampled in Boumba and Kadei was done using the frequency of occurrence (Fc) and the preponderance index (Ip). According to the frequency of occurrence (Fc), Lepidoptera are the most frequent (Fc = 100%) and main (Ip = 100%) preys in the diet of *B. longipinnis* in the Boumba, while at the Kadei, the Orthoptera (Fc = 100%; Ip = 100%) and prey fish (Fc = 100%; Ip = 100%) are the most frequent in *A. macrophthalmus* and *H. vittatus* respectively. However, the vast majority of the prey consumed by the different species of fish in the Boumba and in the Kadei seems to be accidental (Fc <20%) and / or accessory (Ip <10) prey, with the exception of Hymenoptera which are fairly frequent (40 ≤ Fc ≤ 59%) and main (Ip> 50) preys in the diet of *B. macrolepidotus* in Kadei. In the Boumba in this same species, the Hymenoptera appear as accidental (Fc <20%) and / or accessories (Ip <10) preys (Table 3).

Table 3: Corrected frequencies (Fc), weight percentages (P) and preponderance indices (Ip) of the prey consumed by the different species of fish sampled in Boumba and Kadei.

Preys	**Metric analyzed**	**Sites**								
		Boumba					**Kadei**			
		A. macrophthalmus	***Bryconaethiops* sp.**	***B. longipinnis***	***B. macrolepidotus***	***H. vittatus***	***A. macrophthalmus***	***B. imberi***	***B. macrolepidotus***	***H. vittatus***
Fishes	Fc	2.9	14	0	0	0	0	7.1	0	100
	P	0.1	2.6	0	0	0	0	4.5	0	100
	IP	0	0.7	0	0	0	0	3	0	100
Coleoptera	Fc	2.9	0	0	0	0	0	7.2	5.9	0
	P	1.1	0	0	0	0	0	6.7	0.1	0
	IP	0.1	0	0	0	0	0	4.5	0	0
Trichoptera	Fc	0	0	0	0	0	0	7 .1	2.9	0
	P	0	0	0	0	0	0	1.1	0.1	0
	IP	0	0	0	0	0	0	0.8	0	0
Odonates	Fc	0	14	0	0	0	0	7.1	0	0
	P	0	4.1	0	0	0	0	13.1	0	0
	IP	0	1.1	0	0	0	0	9	0	0
Orthoptera	Fc	15	0	0	0	0	100	7.1	0	0
	P	12	0	0	0	0	100	6 .2	0	0
	IP	3.6	0	0	0	0	100	4.2	0	0
Lepidoptera	Fc	5.9	14	100	8.3	0	0	7.1	0	0
	P	5.9	2.6	100	1.2	0	0	0.2	0	0
	IP	0 .7	0.7	100	0.4	0	0	0.2	00	0
Hymenoptera	Fc	0	0	0	8.3	0	0	14	53	0
	P	0	0	0	18	0	0	15	60	0
	IP	0	0	0	5.7	0	0	20	90	0
Isoptera	Fc	0	0	0	0	0	0	7.1	0	0
	P	0	0	0	0	0	0	31	0	0
	IP	0	0	0	0	0	0	21	0	0
Myriapoda	Fc	0	0	0	0	0	0	0	2.9	0
	P	0	0	0	0	0	0	0	6.6	0
	IP	0	0	0	0	0	0	0	0.6	0
Decapods	Fc	0	0	0	0	0	0	0	2.9	0
	P	0	0	0	0	0	0	0	0.2	0
	IP	0	0	0	0	0	0	0	0	0
Fruit	Fc	0	0	0	25	0	0	0	2.9	0
	P	0	0	0	28	0	0	0	2.8	0
	IP	0	0	0	27.2	0	0	0	0.2	0
Flowers	Fc	0	0	0	0	0	0	0	5.9	0
	P	0	0	0	0	0	0	0	2.7	0
	IP	0	0	0	0	0	0	0	0.5	0

Leaf fragments	Fc	0	0	0	17	0	0	0	0	0
	P	0	0	0	13	0	0	0	0	0
	IP	0	0	0	8.8	0	0	0	0	0
Aquatic plants	Fc	62	57	0	42	0	0	7.1	12	0
	P	79.1	90.7	0	35.4	0	0	11.1	24.2	0
	IP	96	98	0	58	0	0	7.5	8.1	0
Other	Fc	12	0	0	0	0	0	29	12	0
	P	1.3	0	0	0	0	0	11	3.1	0
	IP	0.1	0	0	0	0	0	30	0.6	0

To better appreciate the quantitative values of the food items, a grouping by categories of prey was carried out and recorded in (table 4). It emerges that, the majority of fish, regardless of the study site, has a strong food preference for macroinvertebrates followed by aquatic plants.

Table 4: Corrected frequencies (Fc), weight percentages (P) and preponderance indices (Ip) of the prey groups consumed by the different fish species sampled in the Boumba and the Kadei.

Preys	**Metric analyzed**	**Sites**								
		Boumba					**Kadei**			
		A. macrophthalmus	***Bryconaethiops* sp.**	***B. longipinnis***	***B. macrolepidotus***	***H. vittatus***	***A. macrophthalmus***	***B. imberi***	***B. macrolepidotus***	***H. vittatus***
Fish	Fc	2.9	14.3	0	0	0	0	7.1	0	100
	P	0.1	2.6	0	0	0	0	4 .5	0	100
	IP	0.01	0.7	0	0	0	0	3	0	100
Macroinvertebrates	Fc	26.5	28.6	100	16.7	0	100	57.1	67.6	0
	P	20.5	6.7	100	18.7	0	100	73.3	67.2	0
	IP	4 .4	1.8	100	6.1	0	100	59	0.1	0
terrestrial plants	Fc	0	0	0	41.7	0	0	0	8.8	0
	P	0	0	0	41.1	0	0	0	5.6	0
	IP	0	0	0	36	0	0	0	0.7	0
aquatic plants	Fc	61.8	57.1	0	41.7	0	0	7.1	11.8	0
	P	79.1	90.7	0	35.4	0	0	11.1	24.2	0
	IP	95.6	97.5	0	57.9	0	0	7.5	8.07	0
miscellaneous	Fc	8.8	0	0	0	0	0	28.6	11.8	0
	P	0.2	0	0	0	0	0	11.2	3.1	0
	IP	0.02	0	0	0	0	0	30.2	0.6	0

In Boumba there is an overlap in diet between *A. macrophthalmus* and *Bryconaethiops* sp.; *A. macrophthalmus* and *B. macrolepidotus* and between *Bryconaethiops* sp. and *B. macrolepidotus*. On the other hand, at Kadei there is an overlap in diet only between *A. macrophthalmus* and *B. imberi* (Table 5).

Table 5: Index of dietary overlap between different species.

Sites	**Comparison Species /species**	**Overlap index (Cλ)**	**Observations**	**overlap in diet**
Boumba	*A. macrophthalmus/ Bryconaethiops* sp.	0.999	$C\lambda > 0.6$	Yes
	A. macrophthalmus/ B. longipinnis	0.046	$0 < C\lambda < 0.6$	No
	A. macrophthalmus/ B. macrolepidotus	0.804	$C\lambda > 0.6$	Yes
	A. macrophthalmus/ H. vittatus	0	$0 < C\lambda < 0.6$	No
	Bryconaethiops sp. / *B. longipinnis*	0.018	$0 < C\lambda < 0.6$	No
	Bryconaethiops sp. / *B. macrolepidotus*	0.797	$C\lambda > 0.6$	Yes
	Bryconaethiops sp. /*H. vittatus*	0	$0 < C\lambda < 0.6$	No
	B. longipinnis/B. macrolepidotus	0.083	$0 < C\lambda < 0\ .6$	No
	B. longipinnis/H. vittatus	0	$0 < C\lambda < 0.6$	No
	B. macrolepidotus/H. vittatus	0	$0 < C\lambda < 0.6$	No
Kadei	*A. macrophthalmus/B. imberi*	0.818	$C\lambda > 0.6$	Yes
	A. macrophthalmus/ B. macrolepidotus	0.002	$0 < C\lambda < 0.6$	No
	A. macrophthalmus/H. vittatus	0	$0 < C\lambda < 0.6$	No

	B. imberi /H. vittatus	0.041	0 < Cλ <0.6	No
	B. imberi/ B. macrolepidotus	0.037	0 < Cλ <0.6	No
	B. macrolepidotus/H. vittatus	0	0 < Cλ <0.6	No

In order to assess the variation in the diet of fish according to size, it is necessary to first assess the different size classes by species. Thus, at the Boumba, in *A. macrophthalmus* the smallest size interval is [11.5 to 13.8], as a difference of 2.3 from one interval to another and in the Kadei it is [9.8 to 20.25], with a difference of 10.45 from one interval to another (Table 6).

Table 6: size range class of different fish species depending on the biotope.

River	**Parameter**	***A. macrophthalmus***	***Bryconaethiops* sp.**	***B imberi***	***B. longipinnis***	***B. macrolepidotus***	***H.vittatus***
Boumba	Number of classes	6	4	0	1	4	1
	interval	[11.5 - 13.8]	[10.5 - 13.5]	0	[1 - 8.3]	[5.8- 9.8]	[1- 8.2]
Kadei	Number of classes	2	0	4	0	5	3
	Interval	[9.8 - 20.25]	0	[4.9 - 6.5]	0	[7.7 - 9.8]	[14.7 - 15.5]

In a given environment, individuals of the same species can modify their food preferences according to their size. Thus, the study of the preponderance index (Ip) as a function of increasing size intervals in Boumba and Kadei reveals a change in food preference during growth. This is the case in *B. macrolepidotus* in the Boumba (Table 7) and Kadei (Table 8) where food preferences change from one size interval to another. In particular, he switches from a diet exclusively made from Lepidoptera in individuals of size between 7.7 and 9.8 cm to a diet based on plant resources (plants and fruits) in individuals of sizes between 17.8 and 21.8 centimeter, passing through a very varied diet in individuals of intermediate sizes at these two previous intervals (Table 7).

Table 7: preponderance index (Ip) in *B. macrolepidotus* in the Boumba.

Classes	**[5.8- 9.8]**	**[9.9-13.8]**	**[13.9-17.8]**	**[17.8 -21.8]**
Aquatic plants	0	0	45.96	50.50
Terresrtral plants	0	0	28.09	0
Hymenoptera	0	0	18.30	0
Lepidoptera	100	0	0	0
Fruit	0	0	7.66	49.50

At the level of Kadei, the change in food preference in *B. macrolepidotus* according to size intervals is also visible, but this is contrary to the that observed in Boumba. Here, small individuals ([7.7 - 9.8]) have a food preference based on aquatic plants (Ip = 80) and large individuals ([16.2-18.2]) have rather a diet made only from Hymenoptera. Individuals at intervals between these other two have a diet that tends to be more varied (Table 8).

Table 8: preponderance index (Ip) in *B. macrolepidotus* in the Kadei.

Classes	**[7. - 9.8]**	**[9.9-11.9]**	**[12-14]**	**[14.1-16.1]**	**[16.2-18.2]**
Aquatic plants	80	0	4.70	25.04	0
Miscellaneous	0	0	0	1.67	0
Hymenoptera	0	97.14	94.98	63.61	100
Lepidoptera	0	0	0	0	0
Trichoptera	0	2.86	0	0	0
Insects broyard	20	0	0	0	0
Crustacea	0	0	0.31	0	0
Myriapoda	0	0	0	9.68	0

However, in *A. macrophthalmus* in Boumba, the finding is totally opposite to that made in *B. macrolepidotus* in the two rivers. In fact, the diet does not change (or almost does not) during the growth of *A. macrophthalmus*, since individuals of small sizes ([11.5 - 13.8]), individuals of large sizes ([24. 3- 26.8]) passing through those of intermediate sizes, there is a strong preference for foods of plant origin (Ip> 50), interspersed with a small fraction of other food items (Table 9).

Table 9: preponderance index (Ip) in *A. macrophthalmus* in the Boumba.

Classes	[11.5 - 13.8]	[13.9- 16.4]	[16.5-19]	[19.1-21.6]	[21.7- 24.2]	[24.3- 26.8]
Aquatic plants	52.11	0	100	88.39	88.8	100
Miscellaneous	0	0	0	0.43	0	0
Coleoptera	0	0	0	0.32	0	0
Orthoptera	0	0	0	10.83	4.47	0
Prey fish	0	0	0	0.03	0	0
Lepidoptera	47.89	0	0	0	6.45	0
Insects broyard	0	0	0	0	0.09	0

Confirmation of whether or not the diets of different-sized fish overlap requires a correlation test. Thus, the result of the Pearson correlation test ($p < 0.05$), carried out between the diets of class fish of different sizes in *B. macrolepidotus* at Boumba reveals a negative correlation between fish of size intervals between [5.8-9.8] and [13.9-17.8] on one part and those between [5.8-9.8] and [17.8-21.8] for another side (Table 10).

Table 10: Correlation test between the diets of the different size intervals in *B. macrolepidotus* in the Kadei.

Classes compared	Pearson correlation coefficient (r); (p < 0.05)	Sense of correlation
[5.8- 9.8] and [13.9-17.8]	-0.159	Negative
[5.8- 9.] and [17.8 -21.8]	-0.123	Negative
[13.9-17.8] and [17.8 -21.8]	0.591	positive

Similarly, to Kadei in this same species, this test reveals a negative correlation between individuals with size intervals between [7.7-9.8] and [9.9-11.9]; [7.7 - 9.8] and [12-14] and between those of [7.7 - 9.8] and [16.2-18.2]. However, there is a positive correlation between individuals with size intervals between [7.7 - 9.8] and [14.1-16.1]; [9.9-11.9] and [12-14]; [9.9-11.9] and [14.1-16.1]; [9.9-11.9] and [16.2-18.2]; [12-14] and [14.1-16.1]; [12-14] and [16.2-18.2]; [14.1-16.1] and [16.2-18.2] (Table 11).

Table 11: Correlation test between the diets of the different size intervals in *B. macrolepidotus* in the Kadei.

Classes compared	Pearson correlation coefficient (r); (p < 0.05)	Sense of correlation
[7.7 - 9.8] and [9.9-11.9]	-0.128	Negative
[7.7 - 9.8] and [12-14]	-0.077	Negative
[7.7 - 9.8] and [14.1-16.1]	0.229	positive
[7.7 - 9.8] and [16.2-18.2]	-0.124	Negative
[9.9-11.9] and [12-14]	0.998	positive
[9.9-11.9] and [14.1-16.1]	0.918	positive
[9.9-11.9] and [16.2-18.2]	0.999	positive
[12-14] and [14.1-16.1]	0.937	positive
[12-14] and [16.2-18.2]	0.999	positive
[14.1-16.1] and [16.2-18.2]	0.920	positive

On the other hand, in *A. macrophthalmus* in the Boumba, the various Pearson correlation tests ($p < 0.05$) carried out between the different size intervals all revealed a positive correlation (Table 12).

Table 12: Correlation test between the diet of the different size intervals in *A. macrophthalmus* in the Boumba.

Classes compared	Pearson correlation coefficient (r); (p < 0.05)	Sense of correlation
[11.5 - 13.8] and [16.5-19]	0.683	positive
[11.5 - 13.8] and [19.1-21.6]	0.659	positive
[11.5 - 13.8] and [21.7- 24.2]	0.726	positive
[11.5 - 13.8] and [24.2- 26.8]	0.683	positive
[16.5-19] and [19.1-21.6]	0.993	positive
[16.5-19] and [21.7- 24.2]	0.997	positive
[16.5-19] and [24.2- 26.8]	1	positive
[19.1-21.6] and [21.7- 24.2]	0.94	positive
[19.1-21.6] and [24.2- 26.8]	0.993	positive
[21.7- 24.2] and [24.3- 26.8]	0.997	positive

Discussion

Specific richness and abundance of Alestidae in the localities sampled

The results showed that the sampled sites in the Boumba River have a greater number of individuals and species of Alestidae (63 specimens captured belonging to five species) than those of the Kadei River (43 distributed only in four species). In the Boumba, the most abundant species is *A. macrophthalmus*, while in the Kadei it is *B. macrolepidotus*, with numbers of 39 and 23 individuals respectively, *A. macrophthalmus* was represented by only two individuals in the Kadei. The absence of *A. macrophthalmus* in the Kadei (at Soné and Mindourou sites) can be explained by the fact that the vegetation (preferred food of *A. macrophthalmus*) is severely damaged at the level of the Kadei, following very marked human activities at the banks of the river Kadei. This is not the case at Boumba where the vegetation is less degraded. Indeed, according to Kouamelan *et al.* [33], the presence of significant vegetation along the river would promote the availability of macrophytes (fruits and plant debris), food sources for several fish. Likewise, *B. macrolepidotus* is thought to be more present in Kadei because it is a surface swimmer with a diet based on terrestrial insects and, to a lesser extent, macrophytes [34]. The physiological parameters (length and weight) taken from identical species belonging to the two rivers show a big difference. This may be due to the quantity and quality of food resources present in each environment.

General diet profile

Depending on the species and the river, the emptiness coefficients varied. In *A. macrophthalmus*, the low value of the emptiness coefficient observed could be explained by the fact that this species has a diurnal food activity, having a strong food preference for plants, which are immobile prey and therefore accessible at any time. Our observations are similar to those of Lauzanne [35] who, following a study on the diets of the main fish species of the eastern archipelago of Lake Chad, qualified *A. macrolepidotus* as grazers of submerged plants.

In *Bryconaethiops* sp and *B. imberi* the values of the emptiness coefficient obtained in these two sites, would be explained by the fact that the search for food in these two species is essentially linked to their opportunistic character, which allows them to eat what they find in their habitat [36].

In *B. macrolepidotus*, the permanent presence of food in the stomach is certainly due to the abundance of resources that it exploits in its living environment, and the fact that it does not have a particular time slot for its feeding. In fact, the natural daily and seasonal variations in the availability of food in the natural environment influence the rate of feeding activity in certain fish, including *B. macrolepidotus* [37]. In *B. longipinnis*, its poor representation in the samples (a single individual) unfortunately does not allow us to conclude on the state of emptiness of its stomach.

In *H. vittatus*, the high proportion of empty stomachs could be caused by certain fishing techniques of the purse seiners. Indeed, catches with gillnets would cause stress, which could lead to regurgitation of the prey contained in the stomachs of the fish caught [38]. This observation corroborates that made by Menard *et al*. [39], who in their work on the feeding of tunas linked to the fish concentration device and those in free schools, showed that fish with empty stomachs were more numerous under the fish concentration device than those in free schools. However, the advanced state of digestion observed in some stomachs, would reflect the diurnal predatory nature of this species. Because according to Koné *et al.* [5], the high percentage of empty stomachs, usually reported in predatory fish, is linked to the faster digestion of animal prey. In addition, it should be pointed out that the small proportion of individuals of this species in our sampling does not allow us to draw definitive conclusions about this species.

Food preference depending on the river system

In *Brycinus longipinnis*, Lepidoptera appeared to be the very frequent (Fc = 100%) and main (Ip = 100%) prey, in the diet. This would mean that this species is carnivorous with specialist tendencies of insects, which are their preferential prey. This result is similar to that of Planquette and Lemasson [40] which revealed that *B. longipinnis* mainly consumed aquatic insects in Bandama in Côte d'Ivoire. Similarly, Dietoa *et al.* [41], showed that this species had a predominantly entomophagous diet in Bia in Côte d'Ivoire. In addition, in the Tovè river in South Benin, *B. longipinnis*, showed a feeding tendency dominated by insects associated with plant debris [42]. However, the low numbers of individuals of *B. longipinnis* do not allow a conclusion.

The presence of fish as the only prey found in the stomachs of *H. vittatus* indicates that this species is a predatory carnivore and specialist especially in prey fish. This result agrees with that of Lewis [43] who reported that *Hydrocynus forskhalii* and *Hydrocynus brevis* were both predators, one feeding largely on small clupeids, and the other preying on a wide variety of species of which it swallows entirely (small fish) and / or consumes in pieces (large fish).

In both rivers, *A. macrophthalmus* not only exploits prey fish, but also certain other animal resources (insects) as well as plant resources. The finding here suggests that this species has a general omnivorous diet. This result corroborates those of Poll [44], as well as those of Ricardo-Bertram [45] and Bowmaker [46] who had all shown that *A. macrophthalmus* has an omnivorous diet based on fish, aquatic insects and plants in both Lake Tanganika and Lake Bangwéolo.

B. macrolepidotus in both rivers exploits both animal (invertebrate) and plant resources, which shows that this species is omnivorous. This observation made here in *B. macrolepidotus* corroborates that of Dietoa *et al.* [35] which had revealed that *B. macrolepidotus* is an omnivorous fish, mainly feeding on exogenous food in the Bia basin in Côte d'Ivoire. In addition, in this species, Hymenoptera are prey whose frequency value varies from one stream to another (fairly frequent and main prey like Kadei, but accidental and / or accessory prey like Boumba). This would mean that *B. macrolepidotus* has a high capacity for adaptation depending on the quality and quantity of the resource encountered in its living environment.

Bryconaethiops sp. in the Boumba and *B. imberi* in the Kadei each exploit in its biotope almost the same food resources (of animal and plant origin). By these feeding behaviors they would both be taxed as omnivorous.

Overlapping diets between different species of fish in their biotopes

Interspecific competition is defined as a reduction in individual fertility, survival, or growth resulting from the joint exploitation of resources or from interference with individuals of another species [47]. Our results show that several species of fish exploit the same food resources in their living environment, suggesting an overlap in diet. For example, in Boumba, there is an overlap in diet between *A. macrophthalmus* and *Bryconaethiops* sp; *A. macrophthalmus* and *B. macrolepidotus* and between *Bryconaethiops* sp. and *B. macrolepidotus*. On the other hand at Kadei there is an overlap in diet only between *A. macrophthalmus* and *B. imberi*. The overlap of diet in each of the pairs of species present here, would be justified by the fact that all these species of fish have an omnivorous diet. Indeed, according to the conventional model of ecological niche theory, the first determinant of interspecific competition is the overlap in the resources used [48].

Variation of diet according to size height in *A. macrophthalmus* and *B. macrolepidotus*

The variation of diet according to size was studied in *A. macrophthalmus* and in *B. macrolepidotus* due to their high representation in the sampled population.

In *A. macrophthalmus*, fish of different size classes consume all invertebrates (Orthoptera, Coleoptera and Lepidoptera) as well as aquatic plants. The Pearson correlation test performed between the different size class intervals of the fish all approached the value one (01). This means a strong positive correlation between the different size classes. In other words, from one size class to another, the diet is roughly the same because it does not vary very significantly. This maintenance of the diet during growth may be due to the predisposition of a definitive and identical oral and digestive system in both small and larger individuals. Indeed, the variation in diet in a given species may be linked to the level of differentiation of the digestive system and to the habitat used [5].

In *B. macrolepidotus* from Boumba, small individuals (TL ≤ 9.8) only consume invertebrates (Lepidoptera) while large individuals (TL ≥13.9) also consume these invertebrates plus aquatic and terrestrial plants. This observation is similar to that made by Siaka et al. [49], where the adults of *Engraulis encrasicolus* (Linnaeus, 1758) had a broad spectrum by ingesting in addition to insects, macrophytes. Pearson's correlation test between short and tall individuals gives a negative value, this means that individuals of these two different size classes have different diets. In addition, in the same species in Kadei, individuals of small size (TL ≤ 9.8), have a food preference for aquatic plants while in those of large sizes (TL ≥ 11.9), it is invertebrates (Hymenoptera, Trichoptera, Crustaceans, Myriapods) which are the preferred foods.

However, in each size interval we found both plants and invertebrates, but this in different proportions. This would explain the negative value of the Pearson correlation coefficient observed between these two fish size slices. In other words, despite the presence of the same food items in both size classes, the diet is different. Thus, the proportions ingested change with the size of the fish, which is probably linked to changes in energy requirements and the establishment of a more elaborate predation strategy in large individuals [37]. According to Sylla *et al.* [39] and Castillo-Rivera [50], the progressive modification of the diet in many African fish would be linked to ontogenetic, anatomical and morphological modifications during their growth. Moreover, this observation made in *B. macrolepidotus* and in Boumba and Kadei differs from that made by Dietoa *et al.* [35], in the fluvio-lacustrine complex of Bia, where the eating habits of *B. macrolepidotus* did not change significantly with size. The differences observed here would probably be due to the absence of a great variety of prey in the Bia compared to the Boumba.

Conclusion

The study of the diet of Alestidae in Boumba and Kadei reveals that depending on their mode of feeding, Alestidae fishes can be carnivorous (*H. vittatus*) or omnivorous (*A. macrophthalmus*, *Bryconaethiops* sp., *B. macrolepidotus* and *B. imberi*). However, an overlap in diet has been observed in omnivorous species, especially between *A. macrophthalmus* and *Bryconaethiops* sp.; *A. macrophthalmus* and *B. macrolepidotus*; *Bryconaethiops* sp. and *B. macrolepidotus* at Boumba and between *A. macrophthalmus* and *B. imberi* at Kadei. In addition, the diet within the different species may or may not vary during growth.

Authors' contributions

Sandrine Jueya, Gifty A-T Attu, Leandro Castello, Emmanuel Frimpong and Arnold R. Bitja Nyom carried out the experimental design; Sandrine Jueya and Gifty A-T Attu conducted the field sampling; Sandrine Jueya and Arnold R. Bitja Nyom analyzed the data and writing original draft; all authors participated in the writing- review & editing.

Funding

The authors thank CIFOR (Center for International Forestry Research), the European Commission and the GML project for the funding of data collection.

Acknowledgments

The authors would like to thank fishermen of the localities of Biwala 1 and 2, Soné and Mindourou for their very good collaboration during the data collection. They also express their gratitude to Mr. Stephen Mbi for useful comments on the manuscript and to Pr Charles Félix Bilong Bilong for allowing us to perform this work in the Zoology laboratory at the University of Yaoundé 1.

References

1. Fricke R, Eschmeyer WN, Van der Laan R. The catalog of Fishes, on-line version. California Academy of Sciences, 2021. http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp
2. Food and Agriculture Organization (FAO). The state of world fisheries and aquaculture. Contribute to food security and nutrition for all. FAO, Rome, Italy, 2016, 224.
3. Paugy D. Ecology of tropical fish in a temporary watercourse (Baoulé, high basin of Senegal in Mali): adaptation to the environment and plasticity of the diet. Revue d'Hydrobiologie Tropicale,1994:27(2):157-172.
4. 4.
5. Hajisamae S, Chou LM, Ibrahim S. Feeding habits and trophic organization of the fish community in shallow waters of an impacted tropical habitat. Estuarine, Coastal and Shelf Science,2003:58:89-98.
6. Koné T, Kouamélan EP, Ouattara NI, Kicho AV. Régime alimentaire de Pomadasys jubelini (Pisces, Haemulidae) dans une lagune Ouest africaine (lagune Ebrié, Côte-d’Ivoire). Sciences & Nature,2007:4(1):65-73.
7. Wootton RJ. Ecology of Teleost Fishes. Fish and Fisheries Series 1, Chapman & Hall, London, England,2012:1-404.
8. Lévêque C, Paugy D. Régimes alimentaires et réseaux trophiques. In Lévêque C, and Paugy D (Eds), Les poissons des eaux continentales africaines: diversité, écologie, utilisation par l’homme. IRD, Paris, France, 2006, 191-215.
9. Poll M. Les poissons du Stanley-Pool. Annales du Musée Du Congo Belge, Zoologie,1939:(1):4(1):1-60.
10. Lauzanne L. The selection of prey in *Alestes baremoze* (Pisces, charac.). Cahiers ORSTOM, série Hydrobiologie,1970:4 (1):71-76.
11. Le Gouvello R, Simard F. Durabilité des aliments pour le poisson en aquaculture: Réflexions et recommandations sur les aspects technologiques, économiques, sociaux et environnementaux. UICN, Gland, Suisse et Comité français de l’UICN, Paris, France, 2017, 1- 296.
12. De Silva SS, Anderson TA. Fish Nutrition in aquaculture, Chapman and Hall, London, UK, 1995, 1-319.
13. Mahamba BR, Kangela KV, Kankonda BA, Ulyel APJ, Micha JC. Etude des peuplements ichtyologiques des rivières Yoko et Biaro (Réserve de Yoko, Province Tshopo, R.D. Congo). Revue Scientifique et Technique Forêt et Environnement du Bassin du Congo,2018:11:49-65.
14. Akenze ognimba RB, Lenga A, Akenze TR. Study of the feeding behavior of *Schilbe grenfelli* fish in the Congo River (around Brazzaville). Journal of Animal & Plant Sciences,2018:38(2):6231-6243.
15. Plan d’Action National de Gestion Intégrée des Ressources en Eau (PANGIRE). Etat des lieux du secteur eaux et environnement. Ministère de l’Energie et de l’Eau, Yaoundé, Cameroun, 2009, 1-235.
16. Olivry JC. Fleuves et rivières du Cameroun. MESRES – ORSTOM, Paris, France, 1986, 1-781.
17. Ministère de l’Environnement et de la Protection de la Nature (MINEP), Programme des Nations Unies pour le Développement (PNUD). Plan d’action National de Lutte Contre la Désertification (PAN–LCD), 2006, 1-202.
18. Paugy D. Alestidae. In: Paugy D, Lévêque C, Teugels GG (eds), The Fresh and Brackish Water Fishes of West Africa, Institut de Recherche pour le Développement (IRD), Paris, France; National Museum of Natural History, Paris, France; and Royal Museum for Central Africa, Tervuren, Belgium,2003:1:236-282.
19. Paugy D, Schaefer SA. Alestidae. In: Stiassny MLJ., Teugels GG., Hopkins CD (eds), The fresh and brackish water fishes of Lower Guinea, West-Central Africa, Tropical flora and fauna collection, IRD Paris, France; MNHN, Paris, France; MRAC, Tervuren, Belgium,2007:1:347-411.
20. Stiassny MLJ, Teugels GG, Hopkins CD. The Fresh and brackish water fish from Lower Guinea, West Central Africa. IRD editions, Paris, France, 2007, 1- 805.
21. Carter S, Doran B. Clé d’identification des macroinvertébrés aquatiques en Ontario. St. Lawrence River Institute of Environmental Sciences, 2005, 1-2.
22. Forcellini M, Mathieu C, Merigoux S. Atlas des Macroinvertébrés des eaux douces de l’île de la Réunion. Convention de recherche et développement. Programme d’étude et de recherche 2008-2011. Conception d’indices de bio-évaluation de la qualité écologique des rivières de l’Île de la Réunion à partir des poissons et macrocrustacés et des invertébrés benthiques. Office de l’Eau de la Réunion – CNRS, 2010, 1-137. Available in https://www.eaureunion.fr/fileadmin/user_upload/Etudes/ETUDE_00936.PDF.
23. Leclercq L, Solito de Solis M. Clé simple de détermination des macro-invertébrés d’eau douce à l’usage du petit « gardien de rivières ». Station Scientifique des Hautes-Fagnes Université de Liège, 2010, 1-62.
24. Mary N. Les macro-invertébrés benthiques des cours d’eau de la Nouvelle-Calédonie. Guide d’identification. Version révisée 2017. DAVAR Nouvelle-Calédonie, OEIL, CNRT, 2017, 1-182.

25. Moisan J. Guide d'identification des principaux macroinvertébrés benthiques d'eau douce du Québec – Surveillance volontaire des cours d'eau peu profonds, Direction du suivi de l'état de l'environnement, ministère du Développement durable, de l'Environnement et des Parcs, 2010, 1-82.
26. Natarajan AV, Jhingran AG. Index of preponderance - a method grading the food elements in the stomach analysis of fishes. Indian Journal of Fisheries,1961:8:54-59.
27. Amundsen PA, Gable HM, Staldvik FJ. A new approach to graphical analysis of feeding strategy from stomach contents data-Modification of the Costello (1990) method. Journal of Fish Biology,1996:48:607-614.
28. Horn HS. Measurement of overlap in comparative ecological studies. The American Naturalist,1966:100:419-423.
29. Dia M, Ghorbel M. Etude du régime alimentaire de *Pomadasys incisus* (Haemulidae) des cotes de Nouadhibou (Mauritanie). Bulletin de l'Institut National des Sciences et Technologies de la Mer de Salammbô,2010:37:31-40.
30. Rosecchi E, Nouaze Y. Comparaison de cinq indices utilises dans l'analyse des contenus stomacaux. Revue des Travaux de l'Institut des Pêches Maritimes,1987:49:111-123.
31. Hyslop EJ. Stomach contents analysis, a review of methods and their application. Journal of Fish Biology,1980:17:411-429.
32. Zaret TM, Rand AS. Competition in tropical stream fishes: Support for the competitive exclusive principle. Ecology,1971:52:336-342.
33. Scherrer B. Présentation des données. In Morin (G.) (Ed.). Biostatistique,1984:2-123.
34. Kamelan TM, Yao SS, Kouamé KA, N'Zi KG, Kouamélan EP. Ichtyofaune de la rivière Dodo, Côte d'ivoire: mise à jour et influence des variables environnementales sur la distribution des espèces. Journal of Applied Biosciences,2013:71:5773-5785.
35. Hugueny B, Pouilly M. Morphological correlates of diet in an assemblage of West African freshwater fishes. Journal of Fish Biology,1999:54:1310-1325.
36. Lauzanne L. Régimes alimentaires des principales espèces de poissons de l'archipel oriental du lac Tchad. Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie,1972:18:636-646.
37. Dietoa YM, Da Costa KS, Gourene G. Ecologie Alimentaire de Brycinus macrolepidotus (Pisces; Alestidae) dans le bassin de la Bia (Côte d'ivoire). Agronomie Africaine,2006:18(2):125-134.
38. Sanchez-Vazquez FJ, Martinez M, Zamora S, Madrid JA. Design and performance of an accurate demand feeder for the study of feeding behavior in sea bass, *Dicentrarchus labrax* L. Physiology & Behavior,1994:56:789-794.
39. Sylla S, Atsé BC, Kouassi NJ. Régime alimentaire de *Trachinotus teraia* (Carangidae) dans la lagune Ebrié (Côte d'Ivoire). Cybium,2008:32(1):81-87.
40. Ménard F, Stéquert B, Rubin A, Herrera M, Marchal E. Food consumption of tuna in the Equatorial Atlantic Ocean: FAD-associated versus unassociated schools. Aquatic Living Resources,2000:13(4):233-240.
41. Planquette P, Lemasson J. Le peuplement de poissons du Bandama blanc en pays Baoulé. Annales de l'Université d'Abidjan, Cote d'Ivoire, série E (Ecologie),1975:8(1):77-121.
42. Dietoa YM, Da Costa KS, Gourene G, Ouattara A. Habitudes alimentaires de Brycinus longipinnis dans le complexe fluvio-lacustre de la Bia, Côte d'Ivoire. Belgian Journal of Zoology,2007:137(1):3-9.
43. Djidohokpin G, Sossoukpe E, Adite A, Houndotossi ES, Honfo M, Fiogbe ED. Guildes trophiques relatives de l'ichtyofaune de la rivière Tovè au Sud-Bénin. Afrique Science,2017:13(1):75-90.
44. Lewis D. The food and feeding habits of Hydrocynus forskhalii Cuvier and Hydrocynus brevis Gunther in lake Kainji Nigeria. Journal of Fish Biology,2006:6:349-363.
45. Poll CM. Poissons non Cichlidae. Résultats Scientifiques de l'Exploration Hydrobiologique du Lac Tanganika,1953:3:5A:l-251.
46. Ricardo-Bertram CK. The fishes of the Bangweulu Region. The Journal of the Linnean Society of London, Zoology,1943:41:183-217.
47. Bowmaker AP. Contribution to the knowledge of the biology of *Aletes macrophthalmus* Günther (Pisces, Characidae). Hydrobilogia,1969:33:302-341.
48. Begon M, Harper JL, Townsend CR. Ecology, individuals, populations and communities. Blackwell Scientific Publations, Oxford, 1986, 1-876.
49. Duyck PF. Compétition interspécifique et capacités invasives. Le cas des Tephritidae de l'île de la Réunion., Sciences du Vivant [q-bio]. Université de la Réunion, Français, 2005, 1-158.
50. Siaka B, Kouamélan EP, Ouattara NI, Koné TN, Douba VN, Guessan JK. Régime alimentaire de Distichodus rostratus (Characiformes, Distichodontidae) dans un bassin Ouest africain (fleuve Bandama, Côte d'Ivoire). Sciences & Nature,2008:5(2):167-176.
51. Castillo-Rivera M. Influence of Rainfall Pattern in the Seasonal Variation of Fish Abundance in a Tropical Estuary with Restricted Marine Communication. Journal of Water Resource and Protection,2013:5:311-319.