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Food habits of fishes and food trophic organizations of the Sô River in Benin

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Abstract
The study of food habits of fishes and Food Trophic Organizations was undertaken on the Sô River in Benin. Fish were sampled monthly over an annual period from October 2015 to November 2016. In total, the stomach contents of 991 fish specimens belonging to 14 species were analyzed in the laboratory. This analysis shows that 9 preys were generally consumed by the fish of Sô river, namely: fish fry, insect larvae, aquatic insects, molluscs, shrimps, plant debris, detritus, phytoplankton and zooplankton. Three main consumer groups have been defined, namely piscivores, benthivores and detritivores. The upper reaches of the river showed a complexity of the trophic relationships dominated by the zoophagous spécies (piscivores, benthivores) which represent 83% of the abundance weigth of ichthyofauna; while the lower and middle courses of the river subjected to anthropogenic pressures were dominated by a high proportion of the detritivores which represent 42.7% of the abundance in weigth of ichthyofauna.

Keywords: Fish, detritivores, trophic relationships, anthropogenic pressures, proportion

1. Introduction
In Africa, rivers are of vital importance in food security, job creation, trade, navigation and culture. Moreover, these ecosystems play an essential role in the conservation of biodiversity [1]. Living organisms that inhabit rivers are like sentinels and early warn of the risks of environmental degradation [2]. Among these organisms, the fish fauna they contain is a good indicator of the quality and health of the environment [3, 4, 5, 6, 7, 8].
The study on fish feed ecology provides an overall understanding of the dynamics of aquatic ecosystems [9]. It provides indications on the presence, abundance and availability of prey but also on the trophic potential of the environment [10]. In addition, food search strategies, changes in the diet of a fish species from the environment to another and / or from one season to another provide information on strategies of fish adaptation to constraints environment [11].
Studies on the trophic ecology of fishes on the Sô River remain fragmentary; the existing information is that of [12] on *Heterotis niloticus*. This river is under threat from several entropic pressures: destruction of habitats by déforetation and for fishing activities, many branches are used to make the acadjas that abound the river [27].
The objective of this work was to identify the major trophic groups of the Sô River fishes based on the study of their dietary habits and to use them in the interpretation of the structure of the fish populations of this river.

2. Material and Methods
2.1 Study area
The river Sô (6° 34.97 N; 2° 23.75 E), 84.5 km long, is a river in southern Benin that originates in Hlan Lake. It crosses the town of Adjohoun in the department of Ouémé and that of Sô-Ava in the department of the Atlantic where it flows down into Lake Nokoué the largest estuarine system of Benin. This region is located in the sub equatorial zone characterized by two raining seasons (March to July and September to October) and two dry seasons (November to March and August to September). The highest flows observed during the floods are due to rainfall in the north of the country where the river Sô communicates with the river Ouémé, the largest river in Benin.

2.2 Choice of stations

From upstream to downstream, the Sô River is subdivided into Upper (CS), Middle (CM) and Lower (CI) course, seven sampling stations are retained along the river, namely:

Upper course (CS) : Rhlampa, Kinto Oudjra,
Middle course (CM): Ahomey-Lopko, Ahomey-Glon
Lower course (CI) : Dogodo, Sindomey, Vêky

Table 1: Sampling sites of the Sô River.

Different sectors	Sites	Names	Geographic coordinates
Lower course	ST1	Vêky	N07°16'98.4'', E004°35'82.2''
	ST2	Sindomey	N07°15'84.3'', E004°32'50.0''
Average course	ST3	Dogodo	N07° 18'40.2'', E004°33'56.3''
	ST4	Ahomey-Gblon	N07°22'65.2'' ; E004°34'02.2''
	ST5	Ahomey-Lokpo	N07°27'28.3'' ; E004°33'17.7''
Upper course	ST6	Kinto Oudjra	N07°33'84.3'' ; E004°35'81.2''
	ST7	Rhlampa	N07°48'45.4'' ; E004°37'47.9''

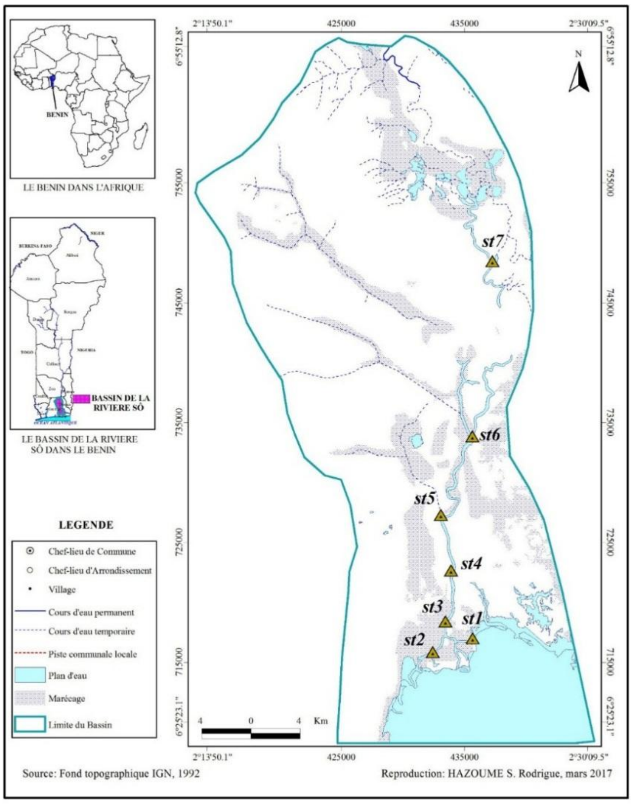

Fig 1: Map of the Sô river basin showing the sampling stations.

2.3 Sampling methods for ichthyofauna

In order to ensure the representativeness of each sample, catches of fish were made by fishermen (artisanal fisheries) and by experimental fishing. For the experimental fishing, a battery of nine (9) monofilament threads of 8, 10, 12, 15, 20, 25, 30, 35, 40 and 45 mm sides were used. Each gill net was 30 m long and 1.5 m high (fall). This diversity of meshes of the nets allows to take into account all the sizes of fish. The nets were set for night fishing at 5pm and visited the next day at 07h and for the fishing of the day; they were laid at 07h30 and raised at 15h. As regards artisanal fisheries, fishermen use a variety of fishing gear, namely: gill nets, traps, hawk nets, palanges, seines and acadjas. Sampling was carried out at each station where all species of fish were identified in the catches of the fishers by category of fishing gear used and the operation of the acadjas. The fishes were identified using the identification keys [13, 14].

2.4 Stomach sampling and stomach contents analysis

2.4.1 Stomach sampling

Fish from both experimental and artisanal fisheries are dissected using a pair of scissors vertically from the anus to the lower jaw to remove the stomach. The fresh stomachs are removed, weighed using a 0.01 g precision electronic scale and stored in 60 ml vials containing 4% formalin for laboratory analysis.

2.4.2 Analysis of stomach contents in the laboratory

In the laboratory, the stomach pocket of each specimen is opened and its contents emptied into a petri dish. In the laboratory, the stomach pocket of each specimen is opened and its contents emptied into a petri dish. The stomach contents are firstly observed with a binocular lens at magnification (x 100) in order to identify its precise nature and also possibly to proceed to the tri-enumeration of large prey. These prey are then spun on filter paper and weighed by category. In a second step, the stomach contents are diluted in 10 ml of 90% alcohol, a 1 ml syringe is used to take 1 ml (repeat up to 10 times) of the diluted solution and spread on a counting slide and then observed at microscope at magnification (x100).

The operation were repeated up to 10 times, i.e. ten (10) sets of observations; it allowed identification and enumeration of microscopic prey such as plankton.

2.4.3 Identification and estimation of planktonic biomasses

The identification of plankton species (phyto and zooplankton) and the estimation of their corresponding biomass were made on the basis of determination keys and various documents [50, 51, 52, 53, 54, 55, 56, 57, 58, 59].

2.4.4 Parameters on trophic ecology

After the stomach contents were analyzed, the number of individuals (ni) and the weight (pi) of each prey category in each stomach and the frequency (Ni) within the sample were recorded. These baseline data were used to calculate dietary indices to characterize diets [15].

There is a wide range of indices commonly used to describe the diet based on stomach contents [16, 15, 17, 18, 19]. These indices can be subdivided into two broad categories: simple indices and mixed indices. Mixed indices can be distinguished by mathematical formulas incorporating two or more simple indices and those resulting in graphic representations.

From these indices, Zander's Main Food Item (MFI) was chosen to propose a simple and linear classification of prey [15].

Simple Food Indices

Occurrence index (F)

It consists of counting the number of stomachs containing a category of prey i (Ni) and expressing it as a percentage of the total number (Nt) of stomachs containing at least one prey [16].

$$Fi = \frac{Ni \times 100}{Nt}$$

Numerical abundance index (N)

The total number of individuals in food category i (prey) in all stomachs (ni) is noted and expressed as a percentage of the total number of individuals (nt) of all prey categories [16].

$$Ni = \frac{ni \times 100}{nt}$$

Abundance index (P)

An essential element in the understanding of trophic structures, the abundance index is the percentage composition of the weight of the diet. It is determined by the relation or pi is the mass of a prey i and pt the total mass of the prey [16, 10].

$$Pi = \frac{Pi}{Pt} \times 100$$

2.4.5 Mixed Food Indices: Main Food Item (MFI)

The Main Food Item (MFI) of [60] shows the relationship where Pi, Ni and Fi represent respectively the abundance index, the numerical abundance index and the frequency of occurrence of the prey I, MFii denotes the values of the Zander index [15]. The latter propose to express the results of the MFI as a percentage of the sum of the values of the MFIi. For a species with n prey in its regime, the index percentage of the prey i (MFIi %) is calculated according to the formula:

$$MFI_i = \sqrt{Pi(Ni + Fi)/2} \qquad MFI_i = \frac{MFIi}{\sum_{i=1}^{n} MFIi} \times 100$$

After this transformation, the values of the MFI% are, in a first step, ordered in descending order. Then, starting from the prey of rank 1, the indices of each of the preys are added in order to obtain 50% or more of the total index, these preys are called main. Secondary prey are those whose sum of the MFI% values added to that of the main prey reaches at least 75%. All other preys on the list represent accidental prey.

Trophic groups of the main fish species of the Sô River

The general trophic guilds that make up the river are identified from fish species with similar diets. To do this, it was carried out from the analysis of the overall diet of all fish studied a hierarchical analysis and obtain a dendrogram.

3. Results

3.1 Diet of the main fish species of the Sô River

In total, the stomach contents of 991 specimens distributed in 14 species were analyzed (Table 2). These fish are most dominant in catches and represent 90% of the abundance of fish caught by experimental fishing in the Sô River. In the Sô River, 09 food sources were distinguished: plant debris, detritus, phytoplankton, zooplankton, insect larvae, insects, molluscs, fish fry, and shrimp. Table 3 presents the qualitative and quantitative composition of the stomach contents of 14 species of fish in the Sô River. For each species, percent occurrence, weight percentage, numerical percentage and Main Feed Index were calculated for each type of feed.

Insects (MFI = 56%) and insect larvae (MFI = 28.6%) are the preferred prey of *Synodontys Shall*; the vegetable debris constitute these secondary prey. Insects (MFI = 44.58%) and fish fry (14.72%) are the preferred prey of *Clarias gariepinus*; plant debris (MFI = 13.18%) and insect larvae (MFI = 12.42%) are secondary prey, whereas molluscs, shrimps and detritus are accidental prey. Fish fry (MFI = 44.57%, MFI = 38.16%) and shrimp (MFI = 38.55%, MFI = 26.41%) are the preferred prey of the species *Parachanna obscura* and *Hemichromis fasciatus* respectively insect larvae (MFI = 13.9%, MFI = 11.47%) plant debris (MFI = 3.05%, MFI = 19.43) are the secondary prey of these two species respectively. Fish fry are the main prey of *Hepsetus odoe* (MFI = 75.91%) and *Eleotris vittata* (MFI = 55.77%); whereas insect larvae are the secondary prey of *H. odoe* (MFI = 19.84%). *Bryenomirus niger* preferentially consume insect larvae (MFI = 54.78%) and secondarily plant debris (MFI = 28.46%) and detritus (MFI = 16.79%). *Chrysichthys auratus* preferentially consume insect larvae (MFI = 33.4%) and insects (MFI = 18%), while zooplankton and detritus are its secondary prey. *Tilapia guineensis* and *Pellonula leoneensis* are mainly plant debris (MFI = 37.32% and MFI = 41.43% respectively) and phytoplankton (MFI = 21.54% and MFI = 23.86% respectively); zooplankton and insects constitute their secondary prey. Species *Sarotherodon melanotheron* and *Tilapia marie* consume mainly detritus (MFI = 44.32% and MFI = 47.83% respectively) and secondarily plant debris and phytoplankton. The species *Heterotis niloticus* preferentially consumes molluscs (MFI = 38.89%) and insect larvae (MFI = 22.27%); plant debris, detritus and insects constitute these secondary prey. The species *Protopterus annectens* has as its preferred food the molluscs (MFI = 40,36%) and the detritus (29,38%); the vegetable debris constitute these secondary prey.

Table 2: Average numbers and lengths of individuals studied for each species of fish under consideration.

Species	Number	size range (Cm)	average length (Cm)	Coefficient of variation (CV)
S. melanotheron	321	5.5-26	10.16	0.22
T. guineensis	419	3.2-25.6	10.3	0.25
C. gariepinus	27	18.3-27.5	22.6	0.13
E. vittata	37	12.6-19.6	16.88	0.16
P. obscura	31	17.6-30.9	25.5	0.19
S. shall	12	17.8-24.3	18.64	0.11
B. niger	06	11.5-13.4	13.1	0.09
C. auratus	25	21.2-36	24.92	0.23
H. fasciatus	27	10.3-12.1	11.72	0.11
P. annectens	11	36-45.2	41.7	0.14
T. marie	08	8-16.2	12.8	0.08
H. niloticus	32	21.9-36.2	28.3	0.16
H. odoe	22	17.6-30.1	22.9	0.13
P. leonensis	13	7.2-11,4	10.3	0.12

Table 3: Food composition of 14 species of fish from the Sô River.

Species	Item	%F	%P	%N	MFI	
S. shall	Insects	51	74.2	33.6	56,0	Preferencial
(Sshal)	Insect larvae	72	12.6	58.2	28,6	Secondary
	Plant debris	35	13.2	8.2	16,9	Accidental
P. obscura	fish fry	56.30	51.20	21.30	44.57	Preferencial
(Pobsc)	shrimp	54.20	40.60	19.00	38.55	Preferencial
	Insect larvae	10.00	7.40	42.20	13.90	Secondary
	Plant debris	5.80	0.80	17.50	3.05	Accidental
H. odoe	fish fry	90	90.4	37,5	75.91	Preferencial
(Hodoe)	Insect larvae	37.5	9	50	19.84	Accidental
	Plant debris	37.5	0.6	12.5	3.87	Accidental
E. vittata	fish fry	65.1	65.4	30	55.77	Preferencial
(Evitt)	Insects	22.4	12.4	55	21.91	Secondary
	shrimp	30	22.2	15	22.35	Accidental
B. niger	Insect larvae	77.6	38.7	77.5	54.78	Preferencial
(Bnige)	Plant debris	28.7	40.1	11.7	28.46	Secondary
	Detritus	15.8	21.2	10.8	16.79	Accidental
C. auratus	Insect larvae	54.2	33.6	12.0	33.4	Preferencial
(Caura)	Insects	26.6	20.2	5.5	18.0	Preferencial
	zooplankton	12.5	11.0	21.5	13.7	Secondary
	Detritus	12.0	15.4	9.0	12.5	Secondary
	phytoplankton	25.6	3.6	45.0	11.3	Accidental
	Plant debris	8.0	16.2	7.0	11.0	Accidental
T. guineensis	Plant debris	50.8	44	12.5	37.32	Preferencial
(Tguin)	phytoplankton	69.2	8.5	40	21.54	Preferencial
	Insects	19.8	17.5	12,5	16.81	Secondary
	Detritus	13.25	17.5	10	14.26	Secondary
	zooplankton	10	7	20	10.25	Accidental
	fish fry	3	5	5	4.47	Accidental
S. melanotheron	Detritus	54.3	56.6	12	43.32	Preferencial
(Smela)	Plant debris	27.8	18.9	11.5	19.27	Preferencial
	phytoplankton	47.5	4	46.5	13.71	Secondary
	zooplankton	27.75	8.05	26	14.71	Accidental
	fish fry	3.5	8.15	1.5	4.51	Accidental
	Insectes	12.6	4.3	2.5	5.70	Accidental
H. fasciatus	fish fry	58.8	32.4	31.1	38.16	Preferencial
(Hfasc)	shrimp	28.5	25.8	25.6	26.41	Preferencial
	Plant debris	16.5	30	9.2	19.63	Secondary
	Insect larvae	9	7.2	27.6	11.47	Accidental
	Detritus	4	4.6	6.5	4.914	Accidental
C. gariepinus	Insects	52.5	41.8	42.6	44.58	Preferencial
(cgari)	fish fry	12.6	16	14.5	14.72	Preferencial
	Plant debris	16.4	13.6	9.14	13.18	Secondary
	Insect larvae	10	9.8	21.5	12.42	Secondary
	Mollusc	15	6.3	4.1	7.76	Accidental
	shrimp	14.6	8.7	8.1	9.94	Accidental
	Detritus	0.05	3.8	0.06	0.46	Accidental
H. niloticus	Mollusc	52.5	31.8	42.6	38.89	Preferencial
(Hnilo)	Insect larvae	25.6	18.2	30.4	22.57	Preferencial
	Plant debris	14.5	22.6	4.1	14.50	Secondary
	Detritus	8.6	17.2	10.5	12.82	Accidental
	Insects	12.5	10.2	12.4	11.27	Accidental
P. annectens	Mollusc	58.5	26	66.8	40.36	Preferencial
(Panne)	Detritus	38.6	39.4	5.146	29.38	Preferencial
	Plant debris	28.4	18.1	5.38	17.48	Secondary
	fish fry	8.8	11.2	16.7	11.95	Accidental
	Insects	18.6	5.3	5.28	7.95	Accidental
T. marie	Detritus	67.5	60.6	8.2	47.83	Preferencial
(Tmari)	phytoplankton	75	9.4	49.8	24.24	Preferencial
	Plant debris	38.6	23.8	2.6	21.98	Secondary
	zooplankton	24.8	6.2	35.4	13.62	Accidental
P. leonensis	Plant debris	58.6	52.1	10	41.41	Preferencial
(Pleon)	phytoplankton	58.6	12.3	55	23.86	Preferencial
	Insects	22.4	28.6	5	20.27	Secondary
	zooplankton	32.8	8.7	30	17.72	Accidental

3.2 Trophic groups of main species over the year.

The Figure 2 shows a dendrogram that gathers groups of species with neighboring diets; thus allowing the retention of three groups of consumers. Primary consumers regroup herbivorous and detritivor species. The herbivores are represented by the species *P. leoneenis* and *T. guinneensis* which preferentially consume the plant debris. The detritivores are constituted by *S. melanotheron* and *T. marie* species which preferentially consume the sedimented detritic film.

Secondary consumers are benthophagous species. The species *C. auratus*, *B. niger* consume mainly larvae of insects. The species *S. shall*, *C. gariepinus* preferentially consume aquatic and terrestrial insects. The species *H. niloticus* and *P. annectens* preferentially consume the molluscs.

Tertiary consumers, which include the strict piscivores and piscivores who consume aquatic invertebrates. The strict piscivores consist of the species *H. odoe*; *E. vittata* which consume a significant quantity of fish fry whereas the species *H. fasciatus*; *P. obscura* in addition to fish fry also consume shrimp.

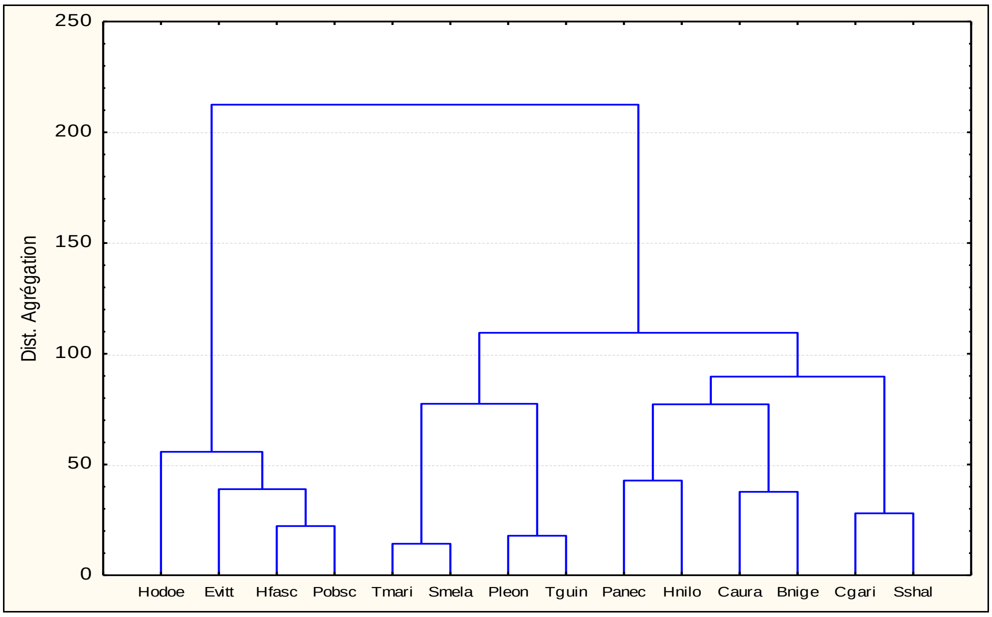

Fig 2: Dendrogram of similarity showing the trophic groups of the fish of the Sô River.

3.3 Seasonal variation in diet of different species of fish studied

Seasonal variations in the diet of fish in the Sô River are shown in figures (3 and 4). At low water levels, a large amount of shrimp is observed in the diet of *H. fasciatus*, *E. vittata*, *C. gariepinus*, and *P. obscura*, but this quantity decreases considerably during high water periods. In the dry season, *C. gariepinus* preferentially consumes fish fry and aquatic insects, while during periods of high water, it consumes preferentially aquatic insects.

Similarly, at low water levels, there is a significant amount of zooplantons and phytoplankton in the diet of *T. guineensis*, *S. melanotheron*, *T. marie*, but these species decrease considerably during the high water period. *H. odoe*'s diet may vary from one season to another, but during periods of high water, insect larvae can increase in the food bowl of the latter. During the rainy season, *H. niloticus* and *P. annectens* preferentially consume small molluscs but these two species of fish become rare in the dry season. In *C. auratus*, the amount of detritus is high in the dry season (MFI = 15.5%), but decreases during the rainy season in favor of insect larvae (41%) which become abundant in the food bowl.

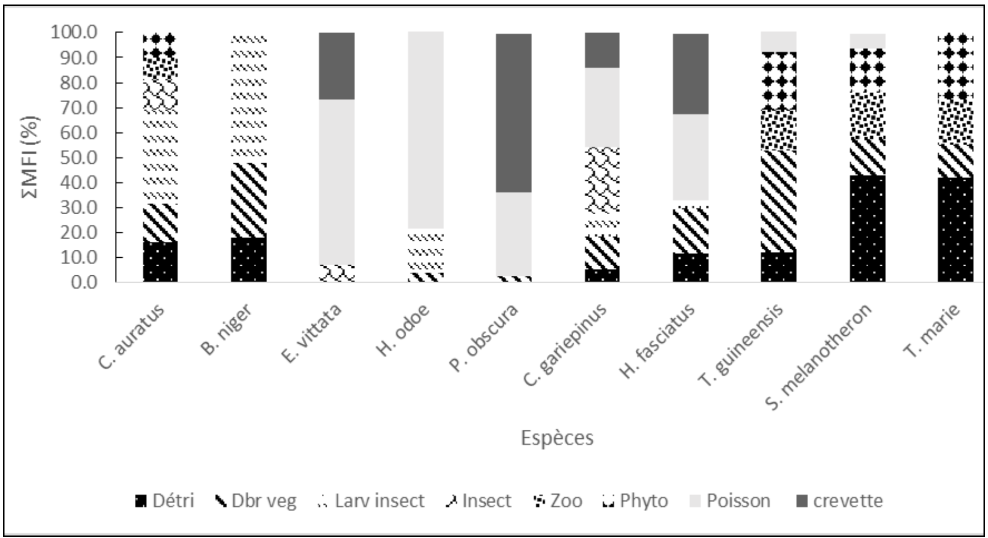

Fig 3: Diet of fish species studied in the dry season

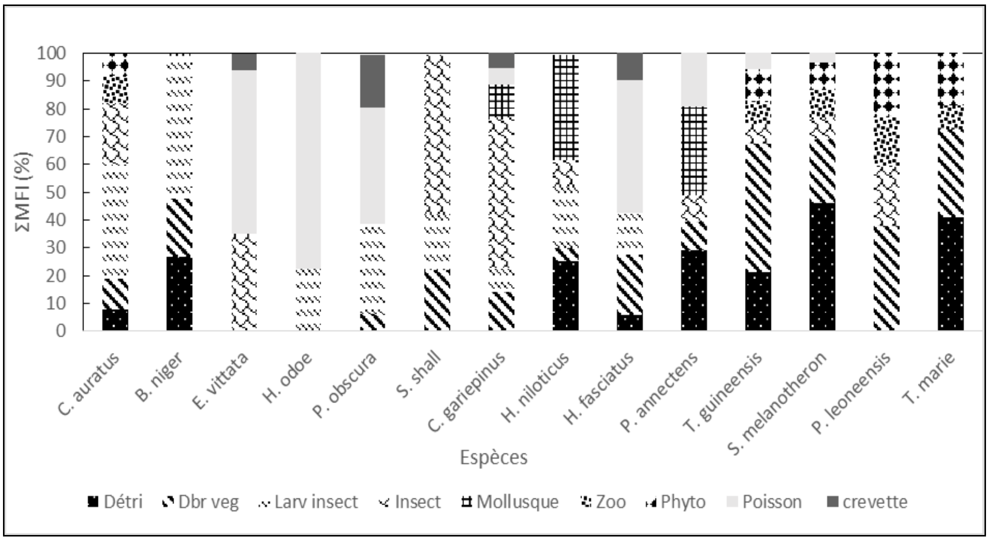

Fig 4: Diet of fish species studied in the rainy season.

3.4 Trophic organization of the Sô River fish

Analysis of the data from the experimental fishery shows that trophic relationships in the upper reaches of the river are complex. Fish populations are constituted by a significant proportion of secondary consumers (61.2% of fish biomass) dominated by *H. niloticus*, *C. gariepinus*, *S. shall B. niger* and *P. annectens*. Piscivores constitute 21.8% of the fish biomass mainly *H. odoe, P. obscura, H. fasciatus*. Primary consumers who are represented by herbivores (12.4% of the biomass) that are dominated by the *T. guineensis* species.

Secondary consumers dominate the average course of the river with 48.6% of the fish biomass and are mainly composed of *C. auratus*, *C. gariepinus*, *H. niloticus*. Primary consumers are herbivores (18.4% of fish biomass) consisting mainly of *T. guineensis*; the detritivores represent 14.3% of the fish biomass and are composed of the species *S. melanotheron* and *T. marie*. Piscivores represent 19.7% of the fish biomass and are composed of *P. obscura* and *H. odoe*.

In the lower reaches of the river, the trophic relations are direct; the fish population is dominated mainly by detritivorous species (42,7% fish biomass), which are mainly composed of *S. melanotheron* and *T. marie* and the herbivores represent 16.3% of the fish biomass and is represented by *T. guineensis*. Secondary consumers are low and constitute 22.4% of the fish biomass and are composed of the species *C. auratus* and *S. shall*. Piscivores constitute 18.6% of the fish biomass and are composed of the species *H. odoe*, *E. vittata*, *P. obscura* and *H. fasciatus.*

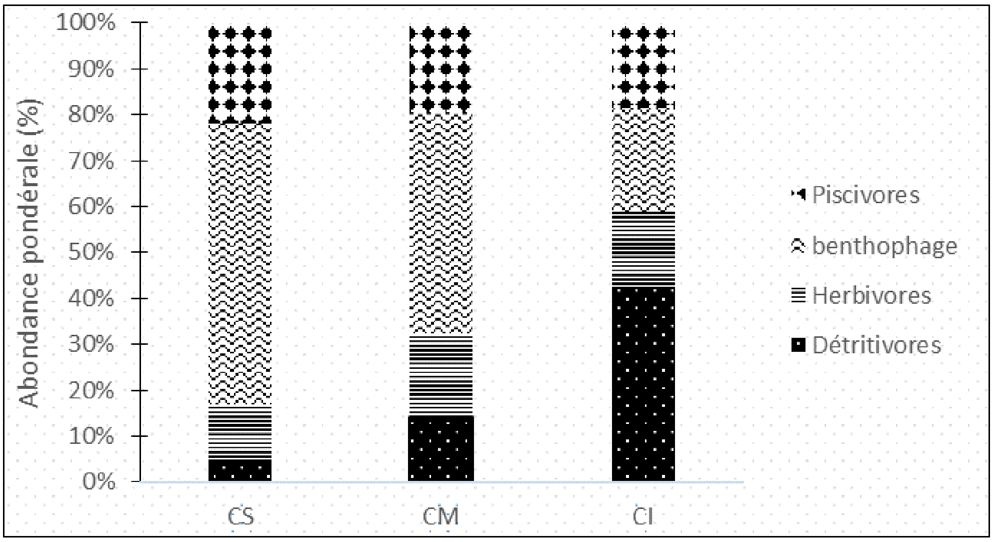

Fig 5: Trophic organization of fish along the Sô River.

4. Discussion

Feeding of *S. melanotheron* is dominated by detritus and zooplankton. This may be due to the fact that this species mainly inhabits the lower reaches of the river, where there is virtually no edge vegetation and where activities are not negligible. The detritic fraction assumes high proportions in aquatic environments subjected to high anthropogenic pressures [20, 21]. These results are consistent with those found by [20, 22] to *S. melanotheron* in Nokoué Lake in southern Benin and in the contrasting estuary of Casamance in Senegal [21]. These results are contrary to those of [23] in Lake Ayamé and Aby lagoon in Côte d'Ivoire where *S. melanotheron* consumes mainly phytoplankton and zooplankton.

The stomach content of *T. guineensis* is dominated by plant debris and phytoplankton. This could be explained by the abundance of *T. guineensis* in the upper reaches of the river, which is an area where vegetation cover is fairly present (forestry training and aquatic vegetation). These results are quite similar to those obtained from the work of [23, 24, 21, 25]; at *T. guineensis* in the rivers and lakes of West Africa.

The abundance of plant fragment in the stomach of *T. guineensis* may be due to its high availability in this part of the river [26]. found similar results in *T. guineensis* in protected rivers with a high density of forest formations along the banks (rivers of the Banc d'Arguin National Park in Mauritania). The strong presence of phytoplankton and zooplanton in the stomach contents of *T. guineesis* and *S. melanotheron* during the dry season is explained by the decrease of the water current, which favors the high availability of these prey for these species [27].

The diet of species *C. auratus* and *B. niger* in the present study consists mainly of plant debris and insect larvae in the dry season, but in the rainy season, their diet is specialized in insect larvae. Our results are similar to those obtained by several authors who describe these two species as consumers of aquatic invertebrates [28, 29, 29, 30]. Our results are contrary to those obtained in the Cross River in Nigeria [31] and in Lake Nokoué [32] or *C. auratus* preferentially consumes detritus.

In the Sô River, *S. shall* consume mainly insects and insect larvae in both the dry and the rainy seasons. These results are consistent with those obtained by [33] in the Tovè River in Benin; to those obtained by [31] in the Cross River in Nigeria and those in [34] in Lake TChad. Our results are similar to those obtained by [35] in *Synodontis koensis* in the Sassandra River in Côte d'Ivoire where the species preferentially consumes insect larvae. Our results are contrary to those obtained by [36] in the Bénue River in Nigeria where *S. shall* preferentially consume the detritus. The strong presence of plant debris in the stomach of *C. auratus*, *B. niger* and *S. shall* be explained by its high availability in upper river stations characterized by high vegetation cover.

In *C. gariepinus*, it predominantly consumes fish fry, insects and insect larvae in the dry season, but in the rainy season it mainly consumes aquatic insects. Similar results were observed in the Tovè River in Benin [33]. Our results are consistent with those of [32] who describe *Clarias gariepinus* as an insectivore in Lake Nokoué during the vintage period. This seasonal variation in the diet of *C. gariepinus* is due to its ability to exploit flooding during flooding [37].

In the Sô River, specimens *H. odoe* preferentially consume fish fry and secondarily insect larvae in the dry season and in the rainy season. According to [33, 31, 38], this species has been described as having a piscivore diet.

In the river Sô the species *P. obscura*, *E. vittata*, *H. fasciatus* are carnivorous. These results are similar to those obtained in Lake Nokoué in Benin [32, 39] and in the Cross River in Nigeria [31].

Molluscs and insect larvae are the preferred prey by specimens of *H. niloticus* during periods of flood. Such observations were made by [12] in this river. Our observations are consistent with those of [40] in the Agnébie River in Côte d'Ivoire. Specimens of *P. annectens* consume mainly molluscs and detritus. These results are similar to those of [31] in the Cross River in Nigeria and those of [32] in the Toho Todougba lagoon.

A total of 04 trophic groups were obtained from the classification of the different fish species according to the MFI of the different prey consumed in the Sô River. It is the group of piscivores, benthivores, herbivores and detritivores. Our results are close to those obtained in Lake Nokoué where five groups were obtained: detritivores, microbentivores, macrobenthivores, zooplanctivores and piscivores [39]. The absence of zooplanktivores in the Sô River could be explained by the fact that zooplankton is not abundant in running water [41, 23, 24, 21, 25]. Our results are contrary to those obtained by [33] in the Tovè River in Benin where five food groups were obtained: invertivores, piscivores, planctivores, herbivores and omnivores. Our results are contrary to those obtained in the watersheds of Côte d'Ivoire by [29] where four trophic groups, namely: piscivores, insectivores (or invertivores), phytophagous and omnivores have been observed.

In the upper reaches of the Sô River, all trophic groups are well represented. The group of benthophages is the most dominant and represents 61.4% of the catch biomass of the experimental fishery. This group is mainly represented by the species *H. niloticus* which represents 43.2% in abundance weight. This distribution shows a relatively stable environment with complex trophic relationships in this part of the river. The presence of a vast floodplain, the coverage of the water surface by aquatic vegetation and a low presence of human activities allows the exploitation of both aquatic and terrestrial resources during periods of flood. The high presence of the macrophytes leads to a complexity of habitats: through the high diversity of the macro invertebrates they shelter serving as food for fish, it constitutes the living environment of herbivorous fish. It serves as a refuge for larvae and fry against predators [42, 43].

The average course of the river is characterized by a decrease in the biomass of the benthophage species and an increase in the biomass of the detritivores species. The lower course of the river is dominated by detritivores species 42.7% in abundance which are represented by the species *S. melanotheron*; follow the benthivores 22,4% in abundance weight and the piscivores representing 8,1% of abundance which are represented by the species *E. vitatta* and *H. fasciatus*. The occurrence of detritivores is the consequence of the strong presence of particulate organic matter resulting from the high mineralization underway in this part of the river. These organic materials naturally result from their transport from upstream to downstream [44], but above all from anthropogenic activities: the practice of the acadjas and the deforestation of the banks in this part of the river. According to [45], aquatic ecosystems are affected by anthropogenic activities through deterioration in the physico-chemical quality of water, reduction in habitat heterogeneity and changes in ecological functioning. These new conditions are often unfavorable to aquatic fish life and cause them to adapt to new conditions through modification of their specific composition and trophic structures [10, 7, 20, 46, 39, 47]. The practice of acadja causes a strong decomposition of organic matter, modifies the physicochemical characteristics of the water, and contributes to the reduction of the specific richness of the fish by promoting the recruitment of the detritivores species and by disadvantaging piscivorous species [48]. According to [49], tilapia dominate in areas of high organic matter content such as "acadjas". In the lower reaches of the river there are extensive acadjas which prevent the migration of estuarine and marine species of high trophic level towards the middle and upper reaches of the river in search of habitats favorable to their reproduction, and invasion of detritivorous species.

5. Conclusion

In view of the present study results, the ichtyofauna of the Sô River is divided into four groups: detritivores, herbivores, benthophages, and piscivores. Diets show temporal and spatial variations related both to food availability and the life cycle of fish requiring migration to the floodplain. The practice of the acadjas and the deforestation of the banks have for corollaries the reduction of the complexity of the trophic reactions in the environment.

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7. References

1. Aguilar IA. Les peuplements de poissons comme outil pour la gestion de la qualité environnementale du réseau hydrographique de la Garonne. Thèse de Doctorat, I.N.P./Ecole Nationale Supérieure Agronomique de Toulouse, France. 2004, 178.
2. Karr JR, Fausch KD, Angermeier PL, Yant PR, Schlosser IJ. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication. 1987; 5:1-28.
3. Schlosser IJ. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs. 1982; 52:395-414.
4. Karr JR. Ecological integrity and ecological health are not the same. In Schulze C (eds.). Engineering Within Ecological Constraints. National Academy Press, Washington. 1996, 97-109.
5. Kestemont P, Didier J, Depiereux E, Micha JC. Selecting ichthyological metrics to assess river basin ecological quality. Archiv fuer Hydrobiologie Supplementband Monographic Studies. 2000; 121:321-348.
6. McDowall RM, Taylor MJ. Environmental indicators of habitat quality in a migratory freshwater fish fauna. Environmental Management. 2000; 25:357-374.
7. Oberdorff T, Pont D, Hugueny B, Chessel D. A probabilistic model characterizing riverine fish communities of French rivers: a framework for environmental assessment. Freshwater Biology. 2001; 46:399-415.
8. Degnbol P. Indicators as a means of communicating knowledge. Journal of Marine Science. 2005; 62:606-611.
9. Oueda A. Zooplancton et écologie alimentaire des poissons des lacs artificiels de Bagré et de Loumbila (Burkina Faso). Thèse de doctorat, Université de Ouagadougou. 2009, 178.
10. Paugy D. et Lévêque C. Régimes alimentaires et réseaux trophiques. *In*: Les poissons des eaux continentales africaines: Diversité, écologie, utilisation par l'homme. C. Lévêque et D. Paugy (Eds), Editions IRD. 1999; 2-7099-1432-8:167-190.
11. Oueda A. Zooplancton et écologie alimentaire des poissons des lacs artificiels de Bagré et de Loumbila (Burkina Faso). Thèse de doctorat, Université de Ouagadougou. 2009, 178.
12. Adite A, Winemiller KO, Fiogbe ED. Population structure and reproduction of the African bonyt0ngue *Heterotis niloticus* in the Soˆ River-floodplain system (West Africa): implications for management, Ecology of Freshwater Fish. 2006; 15:30-39.
13. Paugy D, Lévêque C, Teugels GG. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, T0me 1, MRAC, Tervuren. 2003a.
14. Paugy D, Lévêque C, Teugels GG. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, T0me 2, MRAC, Tervuren. 2003b.
15. Rosecchi E. et Nouaze Y. Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux. Rev. Trav. Inst. Pêche marit. 1987; 49:111-123.
16. Hyslop EJ. Stomach contents analysis - a review of methods and their application. Journal of Fish Biology. 1980; 17:411-429.
17. 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.
18. Cortés E. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. Canadian Journal of Fisheries and Aquatic Sciences. 1997; 54:726-738.
19. DE Crespin DE, Bily V, Doledec S, et Chessel D. Biplot presentation of diet composition data: an alternative for fish stomach contents analysis. Journal of Fish Biology. 2000; 56:961-973.
20. Villanueva MCS. Biodiversité et relations trophiques dans quelques milieux estuariens et lagunaires de l'Afrique de l'Ouest : Adaptations aux ressources environnementales. Thèse de doctorat Sciences Agronomiques. Institut national Polytechnique de Toulouse. 2004, 194.
21. Ndour F, Le Loc'h O, Thiaw J, Ecoutin M, Laë R, Raffray J *et al*. Étude du régime alimentaire de deux espèces de Cichlidae en situation contrastée dans un estuaire tropical inverse d'Afrique de l'Ouest (Casamance, Sénégal), J. Sci.n Halieut. Aquat. 2011; 4:120-133.
22. Gnohossou P. La faune benthique d'une lagune ouest africaine (le lac Nokoué au Bénin), diversité, variations spatiales, place dans la chaine trophique. Thèse de doctorat, Université d'Abomey-Calavi. 2006, 184.
23. Kone T, Teugels GG. Food habits of brackish water tilapia *Saroterodon melanotheron* in riverine et lacustrine environnements of West African coastal basin. Hydrobiologia. 2003; 490:75-85.
24. Ayode AA. et Ikulala AOO. Length weight relationship, condition factor and stomach contents of *Hemichromis bimaculatus*, *Sarotherodon melanotheron* and *Chromidotilapia guentheri* (Perciformes: Cichlidae) in Eleiyele Lake, Southwestern Nigeria, Rev. Biol. Trop. 2007, 969-977
25. Ndimele PC, Kumolu-Johnson A, Aladetohun NF, et Ayorinde OA. Length-weight relationship, condition factor and dietary composition of *Sarotherodon melanotheron*, Rüppell, 1852 (Pisces: Cichlidae) in Ologe Lagoon, Lagos, Nigeria, Agriculture and Biology Journal of North America. 2010; 1:584-590.
26. Kidé NG, Dia M, Yarba L, Koné Y, Khalil F, Salhi G *et al*. Ecologie trophique de *Sarotherodon melanotheron heudelotii* et de *Tilapia guineensis* (Perciformes : Cichlidae) du parc national du Banc d'Arguin, Mauritanie. Rev. Ivoir. Sci. Technol. 2015; 25:188-203.
27. Koudenoukpo ZC, Chikou A, Adandedjan D, Hazoume R, Youssao I, Mensah GA *et al*. Caractérisation physico-chimique d'un système lotique en région tropicale: la rivière Sô au Sud-Bénin, Afrique de l'Ouest. Journal of Applied Biosciences. 2017; 113:11111-11122. https://dx.doi.org/10.4314/jab.v113i1.1
28. Fagade SO, et Olaniyan CIO. Seasonal distribution of the fish fauna of the Lagos Lagoon. Bulletin de l'IFAN. 1974; 1:244-252.
29. Lauzanne L. Régimes alimentaires et relations trophiques des poissons du lac Tchad. Cah. O.R.S.T.O.M., sér. Hydrobiol. 1976; 4:267-310.
30. YAO S. Contribution à l'étude de la diversité biologique

et de l'écologie alimentaire de l'ichtyofaune d'un hydrosystème ouest africain : Cas du bassin de la Comoé (Cote d'Ivoire). Thèse de Doctorat. Université de Cocody, Abidjan Côte d'Ivoire. 2006, 280.

31. Kamelan TM. Biodiversité des poissons de la rivière Dodo et étude des relations trophiques entre les différentes espèces (Cote d'Ivoire). Mémoire de DEA. Université de Cocody, Abidjan Côte d'Ivoire. 2010, 75.
32. Offem BO, Samsons YA, Omoniyi IT. Trophic ecology of commercially important fishes in the Cross River, Nigeria The Journal of Animal & Plant Sciences. 2009; 19(1):37-44.
33. Adite A, Winemiller KO. Trophic Ecology and Ecomorphology of Fish Assemblages in Coastal Lakes of Benin, Ecoscience. 1997, 6-23.
34. 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.
35. Yatabary NT. Contribution à l'étude du régime alimentaire de *Synodontis schall* (Bloch-Schneider, 1801) dans le delta central du Fleuve Niger. Rev. Hydrobiol. trop. 1983; 3-277-286.
36. Yao S, Kouame KA, Ouattara NI, Goore bi G, Kouamelan EP. Preliminary data on the feeding habits of the endemic species Synodontis koensis Pellegrin, 1933 (Siluriformes, Mochokidae) in a West African River (Sassandra River Basin, Cote d'Ivoire) Knowledge and Management of Aquatic Ecosystems. 2010, 396-04.
37. Akombo PM, Akange ET, Adikwu IA, Araoye PA. Length-weight relationship, condition factor and feeding habits of *Synodontis schall* (Bloch and Schneider, 1801) In river Benue at Makurdi, Nigeria. IJFAS, 2014, 42-48.
38. Chikou A. Etude de la démographie et de l'exploitation halieutique de six espèces de poissons-chats (Teleostei, Siluriformes) dans le delta de l'Ouémé au Bénin. Thèse de doctorat, Université de Liège. 2006, 459.
39. Winemiller KO, Kelso-Winemiller LC. Comparative ecology of the African pike, Hepsetus odoe, and tigerfish, Hydrocynus forskahlii, in the Zambezi River floodplain Journal of Fish Biology. 1994; 45:211-225.
40. Kouakou IK, Kone T, Agnissan JP, Soro Y, N'da K. Regime et ethologie alimentaires de Heterotis niloticus (Cuvier, 1829) dans la riviere Agneby. International Journal of Innovation and Applied Studies. 2016; 2028-9324;14(3):721-732.
41. Lévêque C, Paugy D. Régimes alimentaires et réseaux trophiques *In* Les poissons des eaux continentales africaines. Diversité, Écologie, Utilisation par l'homme. IRD, Paris. 2006, 191-215.
42. Thomaz SM, Cunha ER. The role of macrophytes in habitat structuring in aquatic ecosystems: methods of measurement, causes and consequences on animal assemblages' composition and biodiversity. Acta Limnologica Brasiliensia. 2010; 22:218-236.
43. Koudenoukpo CZ, Chikou A, Imorou Toko I, Zebaze Togouet SH, Tchakonté S, Hazoume R *et al*. Diversity of aquatic macroinvertebrates in relationship with the environmental factors of a lotic ecosystem in tropical region: the Sô river in South-East of Benin (West Africa) Journal of Entomology and Zoology Studies. 2017; 5(4):01-10.
44. Angelier E. Ecologie des eaux courantes. Technique et documentation. 2000; 2-7430-0376.
45. Tchakonte S, Ajeagah GA, Camara A, Diomandé D, Lie N, Tchatcho N *et al*. Impact of urbanization on aquatic insect assemblages in the coastal zone of Cameroon: the use of biotraits and indicator taxa to assess environmental pollution, Hydrobiologia. 2015; 755:123-144. doi 10,1007/s10750-015-2221-5
46. Balcombe SR, Bunn SE, Mckenzie FJ, et Davies PM. Variability of fish diets between dry and flood periods in an arid zone floodplain river. Journal of Fish Biology. 2005; 67:1552-1567.
47. Konan KF, Bony KY, Edia OE, Aliko NG, Ouattara A, Gourene G. Predicting factors that influence fish guild composition in four coastal rivers (southeast Ivory Coast) using artificial neural networks. Croatian Journal of Fisheries. 2015; 73:48-57. doi: 10.14798/73.2.816
48. Niyonkuru C, Lalèyè PA. Moreau J. Impact of acadja fisheries on the population dynamics of *Sarotherodon melanotheron* and *Hemichromis fasciatus* in a Lake Nokoué (Benin, West Africa) Knowledge and Management of Aquatic Ecosystems. 2010; 397:01.
49. Lalèyè P, Niyonkuru C, Moreau J, Teugels GG. Spatial and seasonal distribution of the ichtyofauna of Lake Nokoué, Bénin, West Africa. African Journal of Aquatic Science. 2003; 28(2):151-161.
50. Laplace-Treyture C, Peltre MC, Lambert E, Rodriguez S, Vergon JP, Chauvin C. Guide pratique de détermination des algues macroscopiques d'eau douce et de quelques organismes hétérotrophes. Les Editions d'Irstea Bordeaux, Cestas, 2014, 204.
51. Niamien-Ebrottié JE, Konan KF, Edia OE, Ouattara A, Gourène G. Composition et variation spatio-saisonnière du peuplement algal des rivières côtières du Sud-est de la Côte d'Ivoire. Journal of Applied Biosciences. 2013; 66:5147-5161.
52. Konan ES, Philippe DK, et Maryse AN. Etude systématique des : Conjugatophyceae, Chlorophyceae et Euglenophyceae d'une lagune tropicale : la lagune de Fresco (Côte d'Ivoire), Journal of Applied Biosciences. 2012; 49:3406-3414.
53. Kouassi AT. Taxinomie, composition floristique et dynamique Spatio-saisonnière des algues périphytiques de la retenue d'eau d'Adzopé (Côte d'Ivoire). Thèse de doctorat, Université Félix Houphouët-Boigny. 2013, 206.
54. CEAEQ. Identification, dénombrement et estimation du biovolume des cyanobactéries et des algues, MA. 800 – Cya.alg 1.0, Ministère du Développement durable, de l'Environnement et des Parcs du Québec. 2012, 22.
55. Komoé K, Kouassi AM, Adingra AA. Les Euglènes de la lagune Grand-Lahou (Côte d'Ivoire). F. Tech. & Doc. Vulg. 2008, 6-9.
56. Janse van Vuuren S, Taylor J, Gerber A, van Ginkel C. Easy identification of the most common freshwater algae. A guide for the identification of microscopic algae in South African freshwaters. 2006; 621-35471-6.
57. Rumeau A, Coste M. Initiation à la systématique des diatomées d'eau douce pour l'utilisation pratique d'un indice diatomique générique. Bull. Fr. Pêche Plscic. 1988; 309:1-69.
58. Compère P. Algues de la région du lac Tchad. Cah. et Hydrobiol. 1968; 3:165-198.
59. Iltis A. Algues nouvelles des mares du Kanem (Tchad). Rev. Mg. 1971; 2:172-176.
60. Zander CD. Feeding ecology of littoral gobiid and blennioid fish of the Banyuls area (Mediterranean Sea). I Main food and trophic dimension of niche and ecotope. Vie et Milieu. 1982; 32:1-10.