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Trophic diversity and ecological balance of ichtyofauna in three lentic ecosystems of Côte d'Ivoire: Kossou, Taabo and Faé Lakes

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Abstract

Trophic diversity and ecological balance of fish fauna were studied in three lakes of Côte d'Ivoire, which present different characteristics, in order to assess their maturity state. Fishes were sampled every 45 days from November 2017 to October 2018, using gillnets. Stomachs contents were examined under binocular loop and optic microscope. Prey was quantified using Main Food Index. Fish classification in trophic guilds was based on analysis of 2892 stomach contents belonging to 43 species. Similarity of patterns was summarized by a non-metric Multi-dimensional Scaling analysis and tested statistically by a Permutational multivariate analysis of variance. Forage to carnivore ratio was calculated to assess ecological balance of fish community. Six trophic guilds were recorded: pisciviores, insectivores, molluscivores, herbivores, phytoplanktivores and omnivores. Molluscivores guild was exclusive to Taabo lake. According to specific richness and abundance, insectivores were the most important in three lakes. Fish community is unbalanced at Kossou and Taabo lakes. That of Faé is balanced and suitable. Kossou, Taabo and Faé lakes are aging ecosystems with fish communities subject to anthropic pressure. It could be recommend lowering fishing pressure, precisely in Kossou and Taabo lakes. Obtained results may help decision-making in favor of rational management of lacustrine fisheries.

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Introduction

Hydroelectic dams provide numerous goods and ecological services for human well-being including supplying water for population, irrigation, flood control and above all, support agricultural and fishing activities (Lacroix and Danger, 2008). Dam lakes became a magnet for many people. Thereby, lakes and their watersheds are mostly dominated by anthropical activities including urbanization, farming, agriculture, artisanal gold mining and fishing. These anthropical activities generate negative impacts on water quality and consequently on biological communities, particularly on fishes (Wandera and Balirwa, 2010; Nahar *et al.*, 2023). In these ecosystems, fishes availability is threatened owing to stocks overexploitation and habitat degradation (Conley *et al.,* 2009 ; Wandera and Balirwa, 2010). Inded, fishing is known to impact negatively lakes ecosystem functioning (Braga *et al.*, 2012). According to Gourène *et al.* (1999), fish overexploitation can lead to changes in food webs as a result of reduced average size or disappearance of large species. This represents a serious threat to fishing industry.

In Côte d'Ivoire, lacustrine fishing is a livelihood for many people (Diarra, 2020). However, according to Kien *et al.* (2018), lacustrine fishing creates a significant number of jobs through its various value chains. So, this activity helps reduce poverty and build resilience by providing food, income and jobs (Moreau *et al.*, 2019 ; Kanon *et al.*, 2022; Swargiary and Baruah, 2023). Fishing-based livelihoods are particularly important in rural and remote areas where there are few other professional outlets (FAO, 2018). Given its socio-economic importance, it is vital to ensure long-term viability of lake fishing. That is why Republic of Côte d'Ivoire in partnership with European Union initiated ecosystems management project. This project covered Kossou, Taabo and Faé hydroelectric dam lakes, among others. These lakes are important sites of fishing activities (Da Costa and Diétoa, 2008; Blé, 2008; Diarra, 2020). Their ichthyofauna are subject to anthropical pressures (Da Costa and Diétoa, 2008 ; Koné, 2012; Moreau *et al.*, 2019). This situation could represent a serious threat to the sustainability of fishing in these lakes. Thereby, sustainable fishing requires efficient management plan for their ichthyofauna. However, Gislason *et al.* (2000) summarized the overall objectives of more ecosystem-based management as including maintenance of a trophic balance. This is why knowledge of food webs became increasingly essential for ecosystem management. Thus, study of food webs provides information on state of ecosystems maturity, as well as on possible disturbances to environment. According to Simberloff and Dayan (1991), guilds distribution study can give information than the presence of species. As to ecological balance, its assessment can provide needful informations for a successful management approach (Taiwo *et al.*, 2018).

It has also been shown that characteristics such as age, lake size, water residence time, geographic position (Garnerot *et al.*, 2004; Taiwo *et al.*, 2018) influence lake ageing and should impact the structure of ichthyofauna.

Thought, Kossou and Taabo dams are of reservoir type while Faé dam is of run-of-river type. Furthermore, Kossou lake is the oldest and largest, with never renewed water. Taabo lake, on the other hand, is intermediate in age and size, with water renewed every 49 days. What's more, its operation is regulated by that of Kossou lake, located upstream. Faé lake is the youngest and smallest, whose water is constantly renewed.

This is why this study, which aims to provide scientific data for rational management of lacustrine resources of Côte d'Ivoire, intends to (1): determine trophic diversity of ichtyofauna in Kossou, Taabo and Faé lakes, (2): assess trophic balance of fish communities in each lake.

Material and methods

Study site

This study was performed in three man-made lakes of Côte d'Ivoire: Taabo, Kossou and Faé (Fig. 1). Taabo and Kossou lakes were built in the main-channel of Bandama River at approximately 120 km away from each over (Traoré, 1996).

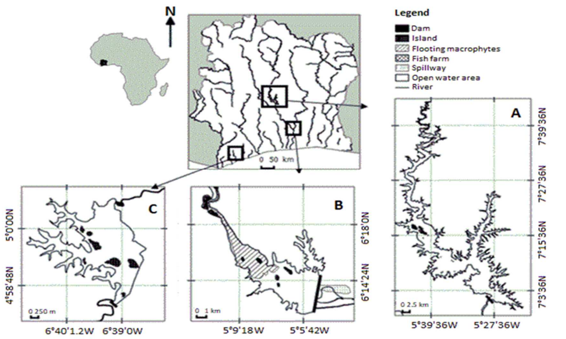

Fig. 1. Location of study areas (A: Kossou lake, B: Taabo lake; C: Faé lake)

There are respectively located at 6°20’ to 6°40’ N; 5° to 5°30’ W and 6°58’ to 8°08’ N ; 5°27’ to 5°45’ W (Aboua, 2012). Faé lake was built in principal course of San Pédro river and is located between 4°58’ to 5°02’ N and 6°38’ to 6°42’ W (Da Costa and Diétoa, 2008; Koffi, 2012). Kossou reservoir covers an area of 1700 km^2 in center part of the country. Those of Taabo and Faé cover respectively 62 km^2 and 16.28 km^2 and are situated in South and Southwestern of the country (Da Costa and Diétoa, 2008; Koné, 2012).

Kossou, Taabo and Faé dams were commissioned respectively in 1972, 1980 and 1983. Watershed of Kossou, Taabo and Faé reservoirs are mostly composed by rural area and agriculture (Koffi, 2012). Invasive aquatic plants are present and occupy a large part of the surface of different water bodies (Tiémoko *et al.*, 2020).

Fish sampling and stomach contents analysis

Fishes were collected each 45 days from November 2017 to October 2018, in three lakes. Fishes were sampled using gillnets, measuring 21.5 – 30 m in length and 1.5 – 3.5 m in height with mesh sizes varying from 6 to 80 mm. Nets were set at 5 p.m., visited the following morning at 7 a.m., for night fishing, and re-visited the same day at 1 p.m., for day fishing. For some species, to augment catches, additional fishes were sampled from fisher folks whenever necessary. Sampled fishes were identified using specialized manuals (Paugy *et al.*, 2003a, b). For each specimen, standard length (mm) and body weight (g) were recorded. Then, each specimen was dissected to remove stomach. For species with an undifferentiated stomach, the anterior third of the digestive tube was preleved. About analysis of stomach contents, all species for which we had a stomach containing food were used. Preleved stomachs were weighted and stored in 5% formalin solution for further analysis.

In laboratory, stomach contents were filtered through sieves (500 and 250 µm mesh void). Residue obtained, was observed under binocular loop model Olympus Z40 and the filtrate was observed through optic microscope model Carl Zeiss. Preys were identified to the lowest taxonomic level possible, using specific identification manuals: Dejoux *et al.* (1981) and Tachet *et al.* (2010), for macroscopic preys; Dussart (1980), Shiel (1995) and Ouattara (2000), for microscopic organisms (plankton). Then, macroscopic preys were counted and weighted using electronic balance (precision 0.001 g). However, planktonic organisms were quantified according to biovolume (Druart and Rimet, 2008) and biomass technics (Dumont *et al.*, 1975).

Data analysis

Importance of each prey was assessed quantitatively by using the Main Food Index (MFI) defined by Zander (1982) as follow:

$MFI = [((N + F)/2) \times W]^{1/2}$; With :

$$F = \text{Percentage of occurency} = \frac{Nsi*}{NS*} \times 100 ;$$

$$N = \text{Numeric percentage} = \frac{Ni*}{Nt*} \times 100$$

$$W = \text{Weight percentage} = \frac{Wi*}{Wt*} \times 100$$

*Nsi = Number of stomachs containing a prey “i”; NS = Total number of examined stomachs; Ni = Number of “i” prey category; Np = Total number of all prey categories; Wi = Total weight of “i” prey category; Wt = Total weight of all prey categories

Ingested preys were grouped in high taxonomic units according to MFI values (Zander, 1982) as follows: MFI > 75: preferential preys; 50 < MFI ≤ 75: main preys; 25 <MFI < 50: secondary preys; MFI ≤ 25: accessory preys.

Trophic guilds were determined from the matrix of stomach contents in each sampling lake and phased by an adapted procedure of Mérona *et al.* (2001) as described by Delariva *et al.* (2013). Specific richness, biomass and number of fish species into each trophic group were evaluated.

Ecological balance was then, assessed by calculating Forage/Carnivore (F/C) ratio by weight of fishes caught (Taiwo *et al.*, 2018) as follow:

F/C ratio = (Fbiom / Cbiom); with:

F/C: Forage/Carnivore; Fbiom: forage biomass; Cbiom: carnivore biomass.

Statistical analysis

Differences in proportions of specific richness and abundance of trophic guilds were tested by Chi-squared test. Mann-Whitney test was applied to compare food preferences of trophic guilds between them. To examine the dispersion of trophic guilds on a multidimensional scale, non-metric multidimensional scaling (nMDS), indicating the "stress" of representation, was applied (Clarke and Gorley, 2001). These analyses were performed using respectively R software (version 4.1.0.) and PAST software (version 4.3.0.) (R Development Core Team, 2019; Clarke and Gorley, 2006). A significance level of $p < 0.05$ was considered.

Results

Trophic diversity of ichtyofauna in Kossou, Taabo and Faé lakes

Trophic categorization

7258 fish individuals belonging to 43 species were studied in these three lakes. For analysis of trophic diversity, 3717 stomachs containing prey were examined.

In Kossou Lake, 1732 individuals belonging to 19 fish species were captured. Among 1039 stomachs collected from these fishes, 783 were full. As for Taabo lake, 3628 individuals belonging to 32 fish species constituted the sample. The number of stomachs examined at this lake amounts to 1479 with 1146 stomachs containing prey. Concerning Faé lake, the number of fish individuals sampled amounted to 1898. They belong to 28 species. Examined stomachs were 1199 and 963 were full.

The examination of stomach contents made it possible to inventory food items grouped into eight food categories, which are phytoplankton, macrophytes, zooplankton, insects, crustaceans, mollusks, fish and detritus (Table 1). This Table presents the main food with its MFI value and trophic group of each studied fish species, respectively in Kossou, Taabo and Faé lakes.

Based on the dominant food categories ingested, the 43 species shared into six trophic guilds, namely piscivores, insectivores, molluscivores, herbivores, phytoplanktivores and omnivores.

In Kossou and Faé lakes, fishes exhibited five trophic guilds (piscivores, insectivores, herbivores, phytoplanktivores and omnivores). However, in Taabo lake, the presence of a molluscivores species allows to distinguish six trophic guilds. *Chrysichthys nigrodigithatus,* which was insectivorous in Kossou Lake, presented molluscivores and Omnivores habits, respectively in Taabo and Faé lakes.

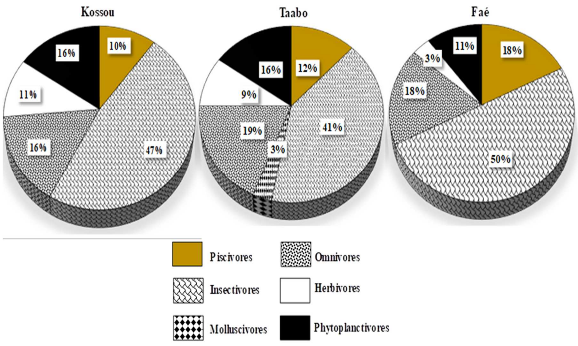

Fig. 2. Relative specific richness of trophic guilds of fishfauna sampled in Kossou, Taabo and Faé lakes, from November 2017 to October 2018.

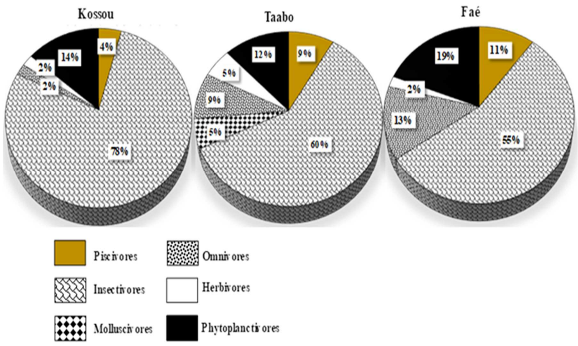

Fig. 3. Relative abundance of trophic guilds of fishfauna sampled in Kossou, Taabo and Faé lakes from November 2017 to October 2018.

Specific richness and relative abundance of trophic guilds

Considering both specific richness (Fig. 2) and abundance (Fig. 3) of trophic guilds, insectivores were significantly the most important, all over (Chi-squared test, $p < 0.05$).

Table 1. Main food, trophic guilds, biomass and abundances of fish species sampled in Kossou, Taabo and Faé lakes, from November 2017 to October 2018.

SL	Species	Kossou				Taabo				Faé			
		Main food (% MFI)	Tro Gui	Biom (g)	Abu	Main food (% MFI)	Tro Gui	Biom (g)	Abu	Main food (% MFI)	Tro Gui	Biom (g)	Abu
1	*Hemichromis fasciatus*	Fish (73.88)	Pisci	2086.45	73	Fish 68.87)	Pisci	5262.24	346	Fish (65.18)	Pisci	3575.39	89
2	*Schilbe intermedius*	Fish (61.14)	Pisci	69.1	2	Fish (58.3)	Pisci	34.75	3	Fish (64.97)	Pisci	21.9	1
3	*Auchenoglanis occidentalis*	Inse (72.63)	Insec	14150.55	41	-	-	-	-	-	-	-	-
4	*Marcusenius senegalensis*	Inse (90.06)	Insec	48.7	1	-	-	-	-	-	-	-	
5	*Chromidotilapia guntheri*	Inse (66.24)	Insec	203.8	12	Inse (58.81)	Insec	223.97	16	Inse (77.61)	Insec	227.5	9
6	*Hemichromis bimaculatus*	Inse (51.27)	Insec	1198.8	92	Inse (28.34) Macr (28.28)	Omn/ Gene	3367.2	268	-	-	-	-
7	*Clarias anguilaris*	Inse (45.36) Fish (20.83)	Omn/ Insec	6626.73	17	Inse (53.18)	Insec	8029.51	11	Inse (64.27)	Insec	301.05	3
8	*Clarias gariepinus*	Inse (36.26) Macr (20.38)	Omn/ Insec	1611.15	5	Inse (42.03) ; Fish (21.24)	Omn/ Insec	1240.85	8	-	-	-	-
9	*Chrysichthys nigrodigithatus*	Inse (52.38)	Insec	10243.47	96	Moll (54.51)	Mollu	10128.8	197	Inse (39.32) Moll (20.89)	Omn/ Insec	7433.93	131
10	*Chrysichthys maurus*	Inse (64.47)	Insec	7569.65	8	Inse (89.33)	Insec	1277.1	2	Inse (53.13)	Insec	1680.94	15
11	*Pellonula leonensis*	Inse (65.86)	Insec	508.94		Inse (70.04)	Insec	1124.56	510	Inse (77.3)	Insec	1295.34	766
12	*Enteromius macrops*	Inse (52.27)	Insec	1488.53	881	Inse (57.68)	Insec	7057.83	1548	Macr 46.06) Inse (41.57)	Omn/ Gene	298	74
13	*Pollimyris isidori*	Inse (70.76)	Insec	19.66	5	Inse (72.41)	Insec	14.2	3	Inse (90.09)	Insec	88.05	8
14	*Heterotis niloticus*	Macr (27.17) Moll (24.54)	Omn/ Gene	4455.85	14	Inse (33.05) ; Zoop (27.41)	Omn/ Gene	13219.65	8	Inse (43.44) Moll (21.44)	Omn/ Insec	21283.15	18
15	*Coptodon zillii*	Macr (78.67)	Herbi	1561.5	36	Macr (68.04)	Herbi	4937.75	148	Macr (45.4) Inse (36.06)	Omn/ Gene	2089.7	19
16	*Distichotus rostratus*	Macr (69.6)	Herbi	1600	1	Macr (75.13)	Herbi	2265.3	52	-	-	-	
17	*Coptodon hybride*	Phyt (67.3)	Phyto	5363.6	117	Phyt (64.01)	Phyto	6998.05	331	Phyt (55.76)	Phyto	8227.62	227
18	*Oreochromis niloticus*	Phyt (62.12)	Phyto	4573.55	26	Phyt (68.72)	Phyto	5235.08	37	Phyt (72.08)	Phyto	558.55	2
19	*Sarotherodon galilaeus*	Phyt (72.01)	Phyto	6897.84	100	Phyt (74.34)	Phyto	5878.05	52	-	-	-	
20	*Heterobranchus longifilis*	-	-	-	-	Fish (70.82)	Pisci	60.05	1	Fish (72.14)	Pisci	70.3	1
21	*Hydrocinus forskhalii*	-	-	-	-	Fish (85.57)	Pisci	132.4	3	-	-	-	-
22	*Alestes baremoze*	-	-	-	-	Inse (85.98)	Insec	1052.05	35	-	-	-	-
23	*Bricynus imberi*	-	-	-	-	Inse (80.54)	Insec	95.75	6	Inse (68.17)	Insec	156.75	7
24	*Bricynus longipinnus*	-	-	-	-	Inse (59.92)	Insec	52.9	5	Inse (77.28)	Insec	89.85	11
25	*Bricynus nurse*	-	-	-	-	Inse (56.07)	Insec	16.05	1	-	-	-	-
26	*Ctenopoma petherrici*	-	-	-	-	Inse (82.67)	Insec	117.01	4	-	-	-	-

27	*Synodontis bastiani*	-	-	-	-	Inse (59.5)	Insec	893.4	16	-	-	-	-
28	*Synodontis punctifer*	-	-	-	-	Inse (42.58) ; Macr (20.15)	Omn/ Insec	521.65	11	-	-	-	-
29	*Syndontis schall*	-	-	-	-	Zoop (29.18) Inse (28.94)	Omn/ Gene	77.55	3	-	-	-	-
30	*Marcusenius ussherri*	-	-	-	-	Inse (67.25)	Insec	77.65	4	Inse (76.26)	Insec	1490.17	30
31	*Schilbe mandibularis*	-	-	-	-	Inse (43.32) ; Mcr (37.01)	Omn/ Insec	415.95	12	Inse (60.04)	Insec	2565.07	153
32	*Bricynus macrolepidotus*	-	-	-	-	Macr (88.64)	Herbi	110.55	2	Macr (60.81)	Herbi	1351.77	38
33	*Labeo coubie*	-	-	-	-	Phyt (74.42)	Phyto	1130	14	-	-	-	
34	*Labeo parvus*	-	-	-	-	Phyt (67.92)	Phyto	362.8	14	-	-	-	
35	*Hepsetus odoe*	-	-	-	-	-	-	-	-	Fish (77.68)	Pisci	4907.87	62
36	*Parachanna obscura*	-	-	-	-	-	-	-	-	Fish (73.85)	Pisci	5989.9	45
37	*Clarias buettikoferi*	-	-	-	-	-	-	-	-	Inse (60.02)	Insec	620.15	10
38	*Heterobranchus isopterus*	-	-	-	-	-	-	-	-	Inse (61.6)	Insec	572.8	4
39	*Marcusenius furcidens*	-	-	-	-	-	-	-	-	Inse (76.93)	Insec	91.9	1
40	*Petrocephalus bovei*	-	-	-	-	-	-	-	-	Inse (82.39)	Insec	155.21	13
41	*Papyrochranus afer*	-	-	-	-	-	-	-	-	Inse (64.35)	Insec	1827	14
42	*Pelmatotilapia mariae*	-	-	-	-	-	-	-	-	Phyt 40.84) ; Macr (34.66)	Omn/ Phyto	768.5	10
43	*Sarotherodon melanotheron*	-	-	-	-	-	-	-	-	Phyt (70.32)	Phyto	12247.34	136

MFI : Main Food Index ; Abun : Abundance ; Inse : Insects ; Macr : Macrophytes ; Moll : Mollusks ; Phyt: Phytoplankton ; Zoop : Zooplankton ; Pisci : Piscivores ; Insec : Insectivores ; Herbi : Herbivores ; Phyto : Phytoplanktivores ; Mollu : Molluscivores ; Omn/Gene : Omnivorous with general tendency ; Omn/Inses : Omnivorous with insectivores tendency ; - : absence

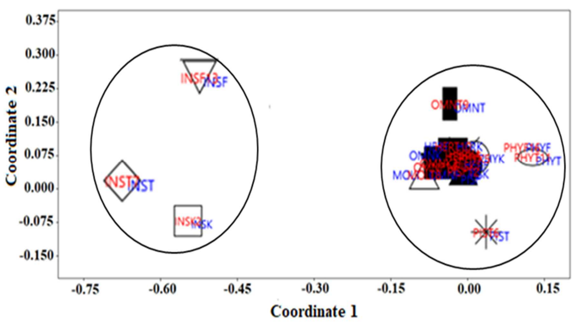

Fig. 4. Non-Multidimensional scaling plots of trophic guilds of fish fauna sampled in Kossou, Taabo and Faé lakes, from November 2017 to October 2018.

INSK : insectivores Kossou, INST: insectivores Taabo, INSF : insectivores Faé, PIST: piscivores Taabo, PISK: piscivores Kossou, PISF: piscivores Faé, OMNK: omnivores Kossou, OMNT: omnivores Taabo, OMNF: omnivores Faé, HERK: herbivores Kossou, HERT: herbivores Taabo, HERF : herbivores Faé, PHYK : phytoplanctivores Kossou, PHYT: phytoplanctivores Taabo, PHYF: phytoplanctivores Faé, MOLT : molluscivores Kossou.

There represented 47%, 41% and 50% of total specific richness; 78%, 60% and 56% of total abundance, respectively in Kossou, Taabo and Faé lakes.

Specialist feeders (piscivores, insectivores, molluscivores, herbivores and phytoplanctivores) dominated highly both specifically and numerically the omnivorous, in three lakes. There covered 84%, 81% and 82% of total specific richness 98%, 91% and 87% of total abundance respectively in Kossou, Taabo and Faé lakes.

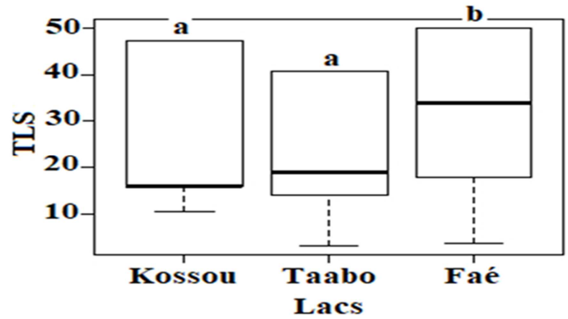

Fig. 5. Spatial variations of trophic level scores Kossou, Taabo and Faé lakes' fish fauna. TLS : trophic level score ; median values with common letter (a or b) do not differ significantly (Mann-Withney test, $p > 0.05$).

The nMDS (Fig. 4) highlighted a hight similarity in trophic structure of three lakes. Indeed, in each lake, insectivores which were significantly more abundant separate themselves from the other trophic guilds whose abundances were close (ANOSIM, global R = 0.03 < 0.25 ; *p* = 0.28). According to SIMPER test (global R = 0.03 < 0.25; p = 0.28), the main species contributing to the similarity between the three lakes are *Enteromius macrops* (62.22%) and *Pellonula leonensis* (14.28%) whose cumulative contribution reaches 76.69%.

Trophic level scores

Fish trophic level scores (Fig. 5) ranged from 10.52 (for piscivores and herbivores) to 47.36 (for insectivores), in Kossou lake. At Taabo lake, the lowest score (3.12) was recorded for molluscivores, while the highest score was for insectivores (40.62). For fish from Faé lake, insectivores had the highest score (50), while molluscivores had the lowest (3.57). Average trophic level scores were 29.63, 24.99 and 32.65 in Kossou, Taabo and Faé respectively. This average score for Faé Lake was 110.19% higher than for Kossou lake and 130.65% higher than for Taabo lake. This of Taabo lake was 118.56% higher than that of Kossou lake. There was significant difference in mean trophic level score between Kossou and Faé lakes, on the one hand, and between Taabo and Faé lakes, on the other (Mann-Withney *test, p* < 0.05).

Ecological balance

Table 2 summaries total biomass of forage (phytoplanctivores, herbivores, omnivores) and carnivores (insectivores, molluscivores, piscivores) fish species and values of forage/carnivory (F/C) ratio of ichtyofauna in prospected lakes. The estimated F/C ratio in Kossou (F/C = 0.87) and Taabo (F/C = 1.28) were outside the range of 1.4 – 10. Though, this value in Faé lake (F/C = 2.11) fell within the expected range of 1.4 – 10.

Table 2. Estimation of forage/Carnivores ratio by biomass of ichthyofauna sampled in Kossou, Taabo and Faé lakes, from November 2017 to October 2018.

Parameters	Lakes		
	Kossou	Taabo	Faé
Forage biomass (g)	32690.22	45760.43	54258.56
Carnivores biomass(g)	37587.65	35650.22	25727.14
F/C ratio	0.87	1.28	2.11

Discussion

Overall, fish species sampled in three lakes during this study fell into six trophic guilds, namely piscivores, insectivores, molluscivores, omnivores, herbivores and phytoplanctivores. Molluscivores guild was specific to Taabo lake. The difference observed in the trophic diversity of these lakes is due to the variation in diet habits of *Chrysichthys nigrodigitatus*, which went from an omnivorous diet (in Faé lake) to a more specialized diet (insectivorous and molluscivorous in Kossou and Taabo lakes, respectively). These results show that the fish fauna of three lakes presented hight trophic diversity (Mérona *et al*., 2003) and that these fishes exploited well all food resources available in their biotope (Séné, 1997). Globally, these findings are in line with those obtained by Paugy (1994) for ichthyofauna from West African ecosystems, which were portioned out six major trophic categories. This trophic diversity is, nevertheless, greater than that of most of the "satellite" lakes of Lake Victoria basin, whose ichthyofauna were globally shared into two (Kachera lake) or three trophic guilds (Mburo, Nabugabo and Kayugi lakes) (Mbabazi, 2000). According to Bram and Piet (2003), the trophic organization of fish fauna in Taabo Lake would be the most adequate. Indeed, these authors noted that for many studies, ecosystems containing 6-7 trophic groups were adequate. The high trophic diversity reflects the maturity of lake ecosystems studied since, according to Frontier (1978), in aging ecosystems trophic resources are abundant and increasingly well exploited.

Moreover, Mérona *et al.* (2003) pointed out that in young lakes, fish are the most abundant trophic resources due to the speed at which forage fish reproduce.

Present results also show that in the three lakes surveyed, insectivores represented the most diverse and numerically abundant trophic guild. This would be linked to high diversity and richness of Insecta class in these lakes, as reported by Aka *et al.* (2020); Konaté *et al.* (2021); Tanon *et al.* (2020), and to the opportunism of fishes that take advantage of abundance of insects (Paugy, 1994). Prevalence of insectivore guild indicates the less disturbed ecosystems (Aka *et al.*, 2020). Mbabazi (2000) in Victoria and Kyoga lakes, Aboua (2012) in Taabo and Kossou lakes, did similar observations concerning insectivore prevalence in lentic ecosystems. In contrast, our findings are opposite to those of Da Costa and De Morais (2004), who instead highlighted the predominance of omnivorous fish in lentic ecosystems in Noth of Côte d'Ivoire.

In these lakes, there are high proportions of fishes with specialized diets, namely piscivores, insectivores, molluscivores, herbivores and phytoplanctivores. This trophic specialization of fish fauna, highlighted in this study, would indicate the stability of surveyed ecosystems (Mérona *et al.*, 2003). That reflects ecosystems in ripe age and less disturbed (Frontier and Pichod-Viale, 1991; Surya *et al.*, 2018). These results are consistent with those of Aka (2020), Camara (2023) and Tiémoko *et al.* (2020) who asserted that although eutrophic, Kossou, Taabo and Faé lakes are still less disturbed.

The similarity of trophic structure revealed by the nMDS would be linked to the abundance of two insectivorous species namely *Enteromius macrops* and *Pellonula leonensis,* which predominated the fish community in three lakes surved.

Mean score of trophic level was higher in Faé lake than in Kossou and Taabo lakes. This result confirms that Faé lake fish community was less disturbed (Rapport, 1995) than those of Kossou and Taabo Lakes which were under ecological stress (Surya, 2018).

As to ecological balance, according to Blay (1985), values comprised in range of 1.4 – 10 represent those of F/C ratio corresponding to ecologically balanced fish communities. Thereby, values of F/C ratio obtained in Kossou and Taabo lakes (respectively 0.87 and 1.28) fell outside the expected range. This indicated the unsuitable ecological balance between carnivores and their prey populations in Kossou and Taabo lakes (Iyiola *et al.*, 2020). The pressure of fishing evocated by Blé (2008) and Diarra (2020) could explain this situation. Similar results, linked to overfishing, were observed in Volta lakes (Ofori-Danson, 2002) and Victoria (Ogwutu-Ohwayo, 2005). However, F/C ratio obtained in Faé Lake indicates an ecologically balanced fish fauna. It was the case in Orpa and Owalla Reservoir (Taiwo, 2010; Taiwo *et al.*, 2018).

Conclusion

This study highlighted ageing lakes characterized by trophically diverse fish communities. However, these communities are subject to anthropogenic pressures that affect their trophic balance and threaten biodiversity as well as the sustainability of fishing, mainly in Kossou and Taabo lakes.

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