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Functional Feeding Groups responses of temporary ponds macroinvertebrates in Natiokobadara dam lake area (North of Côte d'Ivoire)

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ABSTRACT

Temporary ponds are small, shallow bodies of water, rich in biodiversity, but most often neglected. The aim of this study was to investigate the Functional Feeding Groups (FFGs) responses of the macrofauna of three ponds in Natiokobadara dam lake. On each pond, a three month samplings of macroinvertebrates from January to March 2022 using a kick-net was carried out. Similarly, on each pond and during each campaign, measurements of environmental variables were carried out either *in situ* or in the laboratory. A total of 64 taxa of aquatic macroinvertebrates belonging to 33 families, 11 orders and 04 classes were recorded. Insects were the most diversified, accounting for 79.68% of the taxonomic richness. Five major FFGs were identified in this study: predators, scrapers, shredders, gatherers-collectors and filter-collectors, with predators dominating, followed by gatherers-collectors. The P/R ratio indicated that all three ponds were heterotrophic. The predator top-down ratio revealed an overabundance of predators. Only the riparian zones of pond P1 were functional. The Focused Principal Component Analysis found a correlation between low pH values and the abundance of predators and scrapers. There was also a correlation between high nitrate levels and gatherers-collectors abundance. The FFGs and aquatic macroinvertebrate attributes used to describe the state of these ponds revealed that they were highly disturbed.

Keywords: Temporary ponds, Natiokobadara dam lake, Functional Feeding Groups, Macroinvertebrates.

INTRODUCTION

In order to cope with the severe drought that raged in the north during the 1970s, Côte d'Ivoire developed several hydro-agricultural dams (Silué and Dago, 2014). One of these dams is the Natiokobadara, which borders the town of Korhogo. Over time, this dam lake has gradually shrunk in size, reaching a surface area of 14 ha in 2013 (Silué and Dago, 2014). Today, it has been reduced to a trickle of water, exposing the lake area to sand dredging activity. The pits left by sand collection retain water during the rainy season, forming temporary ponds that are home to a large community of aquatic organisms, including macroinvertebrates, the organisms most commonly used to assess the overall health of aquatic ecosystems (Chessman, 2003;

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Camargo et al., 2004; Moretti and Callisto, 2005; Abbou and Fahde, 2014; Agblonon Houelome et al., 2016). To facilitate their use in assessing water quality, macroinvertebrates are classified into different functional feeding groups (FFGs) based on the behavioural and physiological mechanisms of food acquisition and habitat use (Merritt et al., 2008).

These temporary ponds are small, shallow, lentic bodies of water that normally retain water for a certain period of time. They are characterised by alternating flooding and drying up. Temporary ponds are abundant in many parts of the world (Boix et al., 2016). Despite their wide distribution in most parts of the world, they receive no research attention. They are therefore very little studied compared with other freshwater hydrosystems in the world (Williams, 2006), particularly in Côte d'Ivoire. Yet they are considered to be reservoirs of biodiversity (Della Bella et al., 2005), and can even support endangered and endemic species (Zedler, 2003; Boix et al., 2016). This biodiversity contrasts with their sensitivity and vulnerability to external disturbances (Williams, 2006).

In Côte d'Ivoire, a great deal of work has been done on the macrofauna of certain permanent ponds (Yapo et al., 2016; Yapo et al., 2017a; Yapo et al., 2017b; Yapo et al., 2017c), but very little data exists on the study of the macrofauna of temporary ponds. Given the importance of the functional feeding groups approach in biomonitoring and conservation, and the assessment of the functional organisation of macroinvertebrate communities (Principe et al., 2010), particularly in the study of organisms in temporary ponds, which are very little explored, it would be important to consider a study of these vulnerable and neglected environments with a view to their conservation.

The aim of this work was therefore to study the response of macroinvertebrate FFGs in three temporary ponds in Natiokobadara dam lake. Specifically, the variation and composition, abundance and attributes of the various FFGs present were examined. Also to understanding the potential links between these FFGs and environmental variables was important. The results of this study will help to fill the current knowledge gaps on the macrofauna of temporary ponds in dam lake areas in Côte d'Ivoire. This information will also be useful for assessing the impact of hydraulic developments on biodiversity and for developing water resource management strategies in the region.

MATERIALS AND METHODS

Study area and sampling ponds

The study area was Natiokobadara dam lake. This dam lake is located in the north of Korhogo (Côte d'Ivoire), between 09°29'38.5" N and 005°37'13.6" W with an altitude of 331m above sea level. Korhogo belongs to the Sudanese climate and is marked by an alternation of two seasons: - The dry season, marked by the harmattan between December and January and peaks of heat in March and April, extending from November to april ; -The rainy season extending from May to October with maximum rainfall in July and August.

Natiokobadara dam lake is bordered by grassland and cashew nut plantations. The riparian zone of this lake is used to collect sand. The sand collection areas retain rainwater and form temporary ponds. Three of these temporary ponds, subject of this study, were chosen in this area (Figure 1).

Data collection

Environmental variables

Environmental variables such as temperature, pH, TDS, dissolved oxygen and conductivity were measured *in situ* using a multiparameter (HANNA HI 9828). These variables were measured in each pond sampled in the dry season during three months (January to March 2022). Water samples were also taken for nutrient analysis. To do this, water samples were taken at each pond in 500 ml plastic bottles and kept in a cooler for transport to the laboratory, where the concentration of dissolved salts was determined. The nutrients measured were Phosphates (phos), Nitrites (Ni), Nitrates (Na) and Ammonium (Am).

Aquatic macroinvertebrates sampling and identification

Macroinvertebrates were sampled on the 3 ponds using a kick-net. This device, fitted with a collector at the base of the net, is used to collect organisms after they have been dragged along the bottom of the water using its sleeve. In each pond, the organisms collected in the net were dumped into containers. The material obtained was washed on a 500 µm mesh sieve using pond water, the sieve reject was placed in pillboxes and preserved with 10% formalin. In each pond sampled, six randomly repeated samples were taken from different habitats.

In the laboratory, samples were sieved, washed under running water and then screened. The organisms were sorted pond by pond using a light source and identified to the lowest possible taxonomic level under a binocular magnifying glass using a series of identification keys (Déjoux et al., 1981; Danish Bilharziasis Laboratoiry, 1981; De Moor and Day, 2002; De Moor et al., 2003a; De Moor et al.,2003b; Tachet et al.,2003; Stals and De Moor, 2007).

Functional Feeding Groups (FFGs) classification

Functional Feeding Groups (FFGs) of aquatic macroinvertebrates were identified based on Cummins et al. (2005) and Tachet et al. (2010). In this study, 5 categories of FFGs were employed: Predators (pre), Scrapers (scr), Shredders (shr), filterers-collectors (fc) and Gatherers-collectors (gc).

Data analysis

Medians, minimums and maximums of the environmental variables were calculated. Shapiro's normality test was used to assess the distribution of these data. Following this test, the Kruskal-Wallis test was used to compare the series of values between the ponds. When a significant difference was found ($p<0.05$), the Mann-Whitney test was used for a pairwise comparison of the distributions to determine which distributions were responsible for the heterogeneity. All analyses were performed using R software.

The analysis of the Functional feeding groups (FFGs) included calculation of the relative abundance of each Functional Feeding Group (FFG), Top-down predator control (ratio of predators to all other FFGs), calculation of the balance between autotrophy and heterotrophy (production [P] / respiration [R]) and Coarse particulate organic matter (CPOM) to fine particulate organic matter (FPOM) Index (CPOM/ FPOM). Table 1 below, derived from Cummins et al. (2005), represents the calculated ratios with their general criteria ratio levels.

Focused Principal Component Analysis (FPCA) was used to assess relationships between FFGs abundance and environmental variables. Focused Principal Component Analysis (FPCA) is a variation of the traditional principal component analysis. It uses the same types of matrix as the PCA but differs from it in that it is centred or focused on a variable xi (Falissard, 1999). Indeed, it allows a graphical representation of the correlations that exist between this variable xi and the other variables. The graph provides access not only to the nature (positive or negative) but also to the significance ($p < 0.05$) of the correlations between variable xi and the other variables. It is also possible to observe on the graph the correlations between the other variables.

In this study, the FPCA was used to determine the variables that influence the abundance of FFGs. This analysis was performed using the *psy package* on the R software.

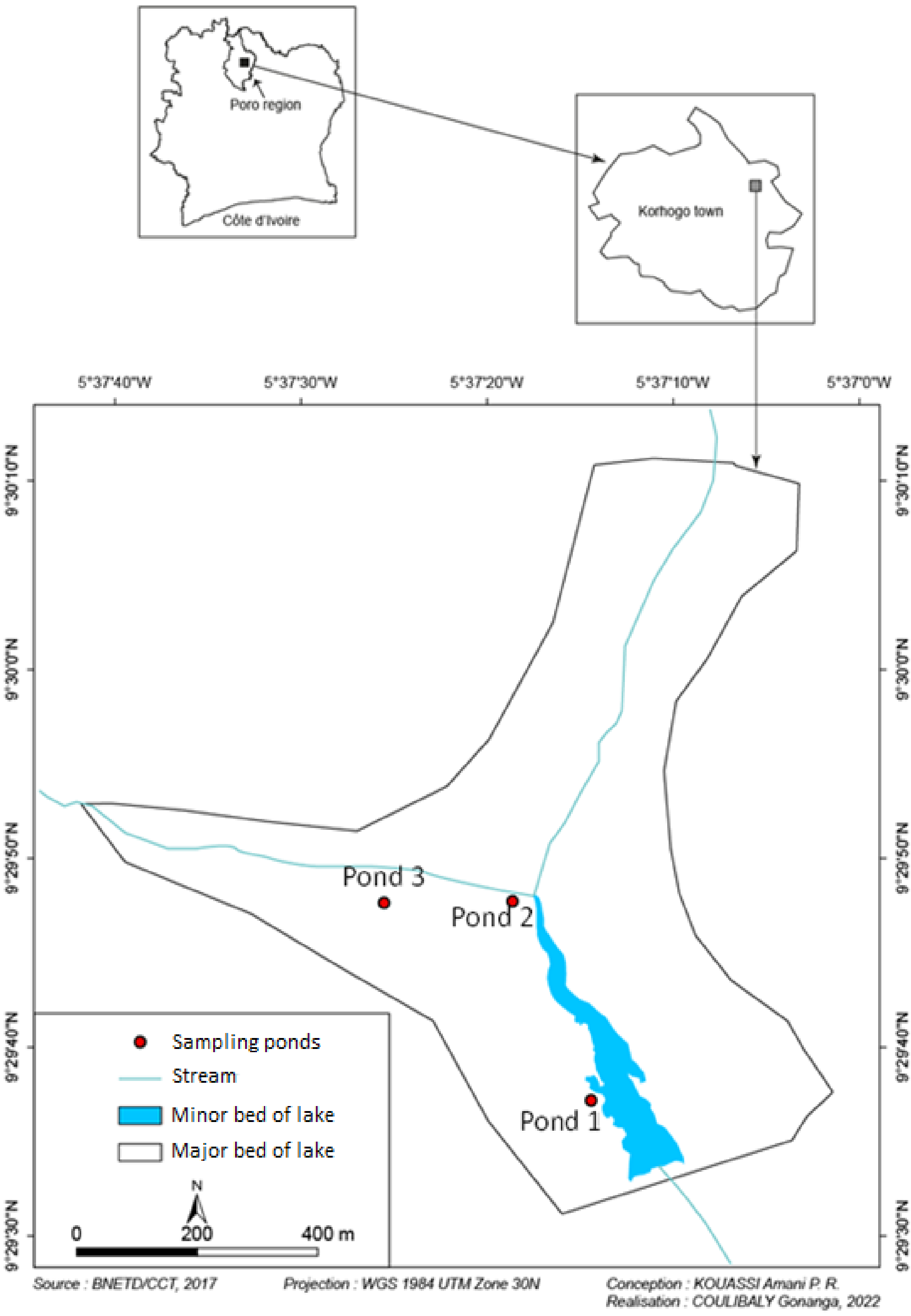

Figure 1: Location of the study area showing the three sampling ponds of Natiokobadara dam lake (Northern Côte d'Ivoire).

Table 1: Examples of the Functional feeding groups (FFGs) ratios as indicators of aquatic ecosystem attributes (Cummins et al., 2005).

Ecosystem Parameter	Symbols	FFG Ratios	General Criteria Ratio Levels
Autotrophy to heterotrophy Index or gross primary production (P) to community respiration (R) Index	Auto/Hetero or P/R	Scrapers to Shredders+Total Collectors	Autotrophic > 0.75
Coarse Particulate Organic Matter (CPOM) to Fine Particulate Organic Matter (FPOM) Index	CPOM/FPOM	Shredders to total collectors	Normal shredder association linked to functioning riparian > 0.25
Top-down predator control	Top-down control	Predators to total all other FFGs	Normal Predator to Prey balance 0.10-0.20

RESULTS

Environmental variables

Medians, minimums and maximums of the environmental variables for each pond are shown in Table 2. The median temperature ranged from 24.40°C (P1) to 27.70°C (P3). This parameter does not show a significant variation between the different ponds (Mann-Whitney; $p>0.05$). The conductivity, which varied from 130 µS/cm (P1) to 360 µS/cm (P3), is significantly higher at pond P3 (Mann-Whitney; $p<0.05$). Median dissolved oxygen ranged from 4.80 mg/l at pond P2 to 5.10 mg/l at pond P3. The median pH fluctuated between 6.80 (P3) and 7.09 (P1) and the median TDS values are between 0.06 mg/l (P1) and 0.18 mg/l (P3). Ponds P2 and P3 recorded the highest levels of Phosphates (0.2 mg/l). The median values of nitrites and nitrates are equal to all the ponds with 0.2 mg/l for nitrites and 1.01 mg/l for nitrates. Apart conductivity, no parameter varied significantly from one pond to another.

Composition and distribution of aquatic macroinvertebrates

The list of aquatic macroinvertebrates taxa inventoried in the various ponds of Natiokobadara dam lake is presented in Table 3. Across the three ponds sampled, 64 taxa belonging to 33 families and 11 orders were recorded. These organisms belonged to four (04) classes: Clitelleta, Arachnida, Insecta and Gastropoda. Insects were the best represented with five (05) orders, 25 families and 51 taxa (79.68% of taxonomic richness).

Heteroptera order was the best represented in terms of numbers with 22.58% of individuals collected, followed by Coleoptera (22.19%). These orders were followed by organisms of Diptera (20.46%) and those of the Basomatophora, the Oligochaeta and the Odonata which recorded respectively 14.71%, 7.79% and 6.63%. The other orders were poorly represented with proportions ranging from 0.34% to 1.90 %. Table 4 summarises the qualitative sampling data for the sampling ponds of the Natiokobadara dam lake.

Functional Feeding Groups and aquatic macroinvertbrates' attributes

Five major FFGs were identified in this study: predators (pre), scrapers (scr), shredders (shr), gatherers-collectors (gc), and filter-collectors (fc). Analysis of the FFGs revealed that the first month (January) was dominated by gatherers-collectors (48.12%), followed by predators (36.84%). In the second month (February), the predators dominate the population with more than half (56.71%). Predators and gatherers-collectors with equal proportions (31.25%) dominate the population in the third month (March) (Figure 2).

At the spatial level, the predators dominated all the ponds during the three months with the exception of P2 where the first month was dominated by the gatherers-collectors. P1 and P2 did not register any FFG at the third month (Figure 3). The value of the autotrophic heterotrophy index was less than 0.75 at all sites. Only in pond P1 the index (CPOM / CPOM) was greater than 0.25. For the Top-down predator control, the values were all greater than 0.2 in all the three ponds (Table 5).

Correlation between FFGs and environment variables

Relationships between the environmental variables and the FFGs of macroinvertebrates in the three ponds of the Natiokobadara dam lake were established using Focused Principal Component Analysis (FPCA) (Figures 4). This analysis showed that predators' abundance was significantly and negatively correlated with pH. The scrapers were negatively correlated with this same parameter at the limit of significance. The abundance of gatherers-collectors was positively correlated with nitrates at the limit of significance. The other two FFGs, namely shredders and filter-collectors, did not show significant relationships with environmental variables.

Table 2: Spatial variations of environmental variables measured at the three ponds of Natokobadara dam lake (Northern Côte d'Ivoire).

Environmental variables	Ponds		
	P1	**P2**	**P3**
Temperature (°C)	24.40 ^{a} (18.10-25.90)	26.80 ^{a} (20.40-27.10)	27.70 ^{a} (23.20-29.30)
Conductivity (µS/cm)	130 ^{a} (120-250)	140 ^{a} (130-190)	360 ^{b} (200-370)
Dissolved Oxygen (mg/l)	4.90 ^{a} (3.60-5.80)	4.80 ^{a} (3.90-5.20)	5.10 ^{a} (3.10-5.70)
pH	7.09 ^{a} (6.62-7.16)	7.01 ^{a} (6.46-7.05)	6.80 ^{a} (6.31-7.55)
TDS (mg/l)	0.06 ^{a} (0.05-0.09)	0.07 ^{a} (0.04-0.10)	0.18 ^{a} (0.15-0.18)
Ammonium (mg/l)	0.01 ^{a} (0.01-0.01)	0.01^a (0.01-0.01)	0.01^a (0.01-0.01)
Phosphate (mg/l)	1.50 ^{a} (1.5-2.50)	2 ^{a} (1.50-2.50)	2 ^{a} (1.50-3.0)
Nitrites (mg/l)	0.2 ^{a} (0.2-0.2)	0.2 ^{a} (0.10-0.3)	0.2 ^{a} (0.20-0.2)
Nitrates (mg/l)	1.01 ^{a} (1.0-±1.10)	1.01 ^{a} (1.01-1.10)	1.10 ^{a} (1.01-1.10)

Values are median (minimum and maximum are in parentheses). Different superscript letters (a, b) in a row show significant differences (Mann-Whitney, < 0.05) between ponds.

Table 3: List of the aquatic macroinvertebrates' taxa found in the three ponds of Natiokobadara dam lake with their FFGs and their relative contribution (Northern Côte d'Ivoire).

Class	Orders (%)	Famillies	Taxa	Ponds			Feeding groups	Relative contribution (%)
				P1	P2	P3		
Clitellata	Oligochaeta (7.79%)	Tubificidae	*Tubifex* sp.		*	*	gc	7.79
	Arhynchobdellida (1.9%)	Hirudinidae	*Hirudo medicinalis.*		*	*	pre	1.9
Arachnida	Araneae (0.68%)	Pisauridae	*Thalassius* sp.		*		pre	0.68
	Trombidiformes (1.19%)	Hydrachnidae	*Hydrachna* sp.			*	pre	1.19
Insecta	Heteroptera (22.58%)	Nepidae	*Ranatra linearis*	*	*	*	pre	1.02
			Laccotrophes sp.	*		*	pre	1.36
			Nepa sp.			*	pre	0.17
		Belostomatidae	*Diplonychus* sp.	*	*	*	pre	7.57
			Limnogeton sp.		*		pre	0.34
		Corixidae	*Micronecta* sp.		*	*	scr	1.02
		Notonectidae	*Anisops* sp.	*		*	pre	1.36
			Enithares sp.			*	pre	0.17
			Nychia sp.	*		*	pre	1.02
		Baetidae	*Cloeon* sp.	*	*	*	gc	1.88
			Centroptilum sp.		*		gc	0.85
			Pseudocloeon sp.		*		gc	0.17
		Gerridae	*Gerisella* sp.		*		pre	0.17
			Limnogomus sp.			*	pre	0.17
		Veliidae	*Rhagovelia* sp.		*		pre	4.63
		Mesoveliidae	*Mesovelia* sp.			*	pre	0.17
		Naucoridae	*Naucoris* sp.	*		*	pre	0.51
	Odonata (6.63%)	Coenagriodae	*Pseudagrion* sp.	*	*	*	pre	2.89
			Ceriagrion sp.			*	pre	0.17
		Aeshnidae	*Anax* sp.			*	pre	0.51
			Agriocnemis sp.	*			pre	0.17

			Gynacantha sp.	*			pre	0.17
		Libellulidae	*Orthetrum* sp.	*	*	*	pre	1.36
			Palplopleura sp.	*		*	pre	0.51
			Crocothemis sp.			*	pre	0.17
			Urothemis sp.			*	pre	0.17
			Brachythemis sp.			*	pre	0.17
			Chalcostephia sp.	*		*	pre	0.34
	Lepidoptera (1.53%)	Crambidae	*Acentria* sp.	*	*	*	shr	1.02
			Cataclysta sp.			*	shr	0.51

Table 3 (Continued)

Class	**Orders (%)**	**Famillies**	**Taxa**	Ponds			Feeding groups	Relative contribution (%)
				P1	P2	P3		
	Coleoptera (22.19%)	Hydrophilidae	*Amphiops* sp.	*	*	*	pre	2.72
			Berosus sp.			*	pre	7.74
			Hydrochara sp.	*	*	*	pre	3.91
			Enochrus sp.	*		*	pre	1.19
			Hydrophilus sp.	*	*		pre	2.04
		Gyrinidae	*Dineutus* sp.		*		pre	0.17
		Hydraenidae	*Limnebius* sp.	*			pre	0.17
		Haliplidae	*Haliplus* sp.	*			shr	0.68
		Dytiscidae	*Laccophilus* sp.	*		*	pre	1.19
			Cybister sp.	*		*	pre	0.34
			Agabetes sp.	*			pre	0.17
			Yola sp.	*			pre	0.17
			Coptotomus sp.	*			pre	0.17
		Noteridae	*Hydrocanthus* sp.	*			pre	0.34
		Curculionidae	*Pseudobagous* sp.			*	shr	0.17
		Chrysomelidae	*Donacia* sp.		*	*		1.02
	Diptera (20.46%)	Chironomidae	*Tanypus* sp.	*	*	*	gc	2.21
			Chironomus sp.	*	*	*	gc	14.87
		Culicidae	*Culex* sp.		*	*	fc	1.86
		Tabanidae	*Tabanus* sp.	*		*	pre	1.35

		Chaoboridae	*Chaoborus* sp.	*			pre	0.17
Gastropoda	Basomatophora (14.71%)	Planorbidae	*Biomphalaria pfeifferi*		*		scr	0.34
			Gyraulus sp.		*	*	scr	2.21
			Bulinus globosus	*		*	scr	4.85
			Bulinus forskalii	*		*	scr	0.34
			Bulinus sp.	*	*		scr	1.02
		Limnaeidae	*Lymnaea natalensis*		*	*	scr	3.91
		Bithyniidae	*Gabbiella* sp.		*		scr	0.34
			Gabbiella africana		*		scr	1.7
	Mesogastropoda (0.34%)	Ampullariidae	*Pila africana*	*			scr	0.34
4	11	33	64	34	29	42		
Taxonomic richness								

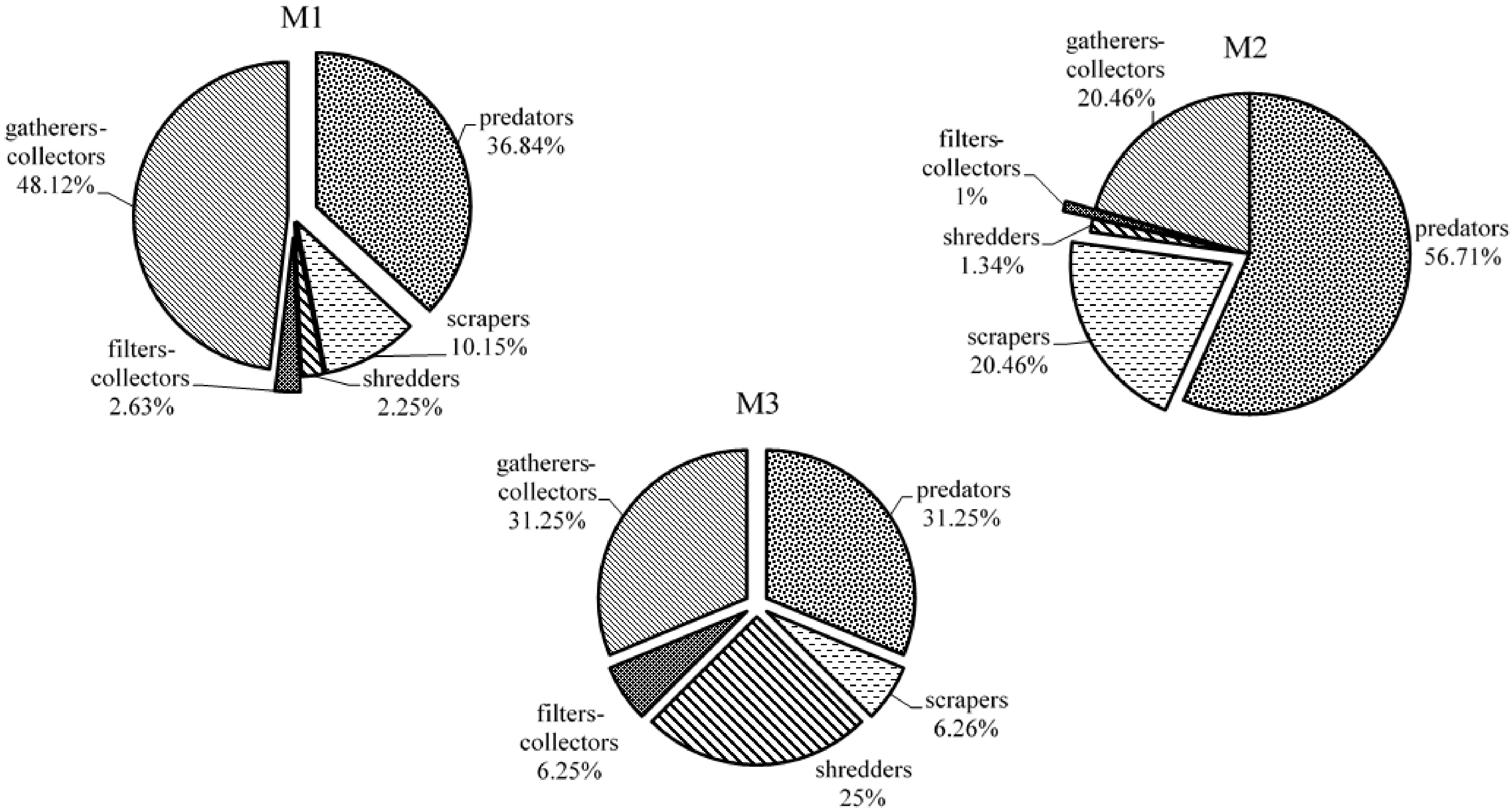

Figure 2: Overall percentage representation of the Functional Feeding Groups (FFGs) recorded each month in three ponds of Natiokobadara dam lake.
M1=1rst month (January); M2=2nd month (February); M3=3rd month (March).

Table 4: Synthesis of qualitative sampling data from sampling ponds in Natiokobadara dam lake.

Diversity measures	Sampling ponds		
	Pond1	**Pond2**	**Pond3**
Number of taxa	34	29	42
Families	19	20	24
Orders	7	9	9
Common taxa	10		

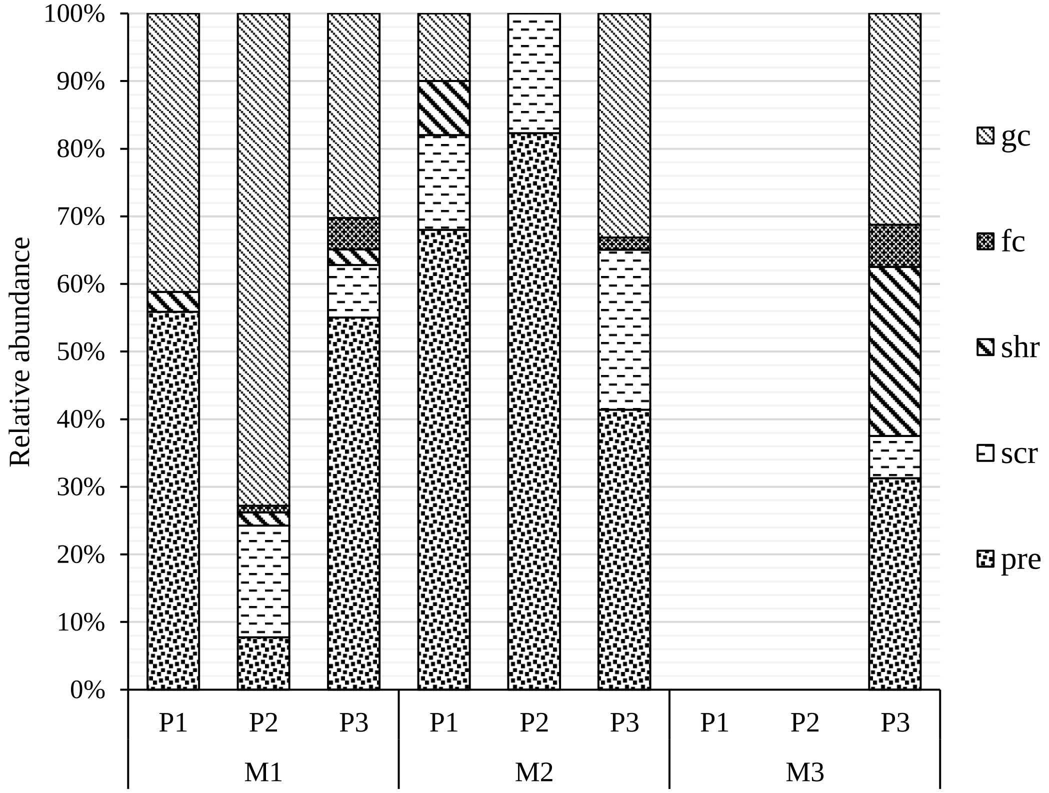

Figure 3: Percentages of aquatic macroinvertebrates Functional Feeding Groups (FFGs).
predators= pre; scrapers=scr; shredders=shr; gatherers-collectors=gc; filter-collectors=fc.
Months: M1=1rst month (January); M2=2nd month (February); M3=3rd month (March).

Table 5: Ratios of aquatic macroinvertebrates' Functional Feeding Groups in the three ponds of Natiokobadara dam lake.

Ponds	P/R	CPOM/FPOM	Top-down predator control
P1	0.29	0.26	1.70
P2	0.39	0.026	0.67
P3	0.43	0.06	0.86

Ratios are based on numerical abundance of Functional Feeding Groups (FFGs).

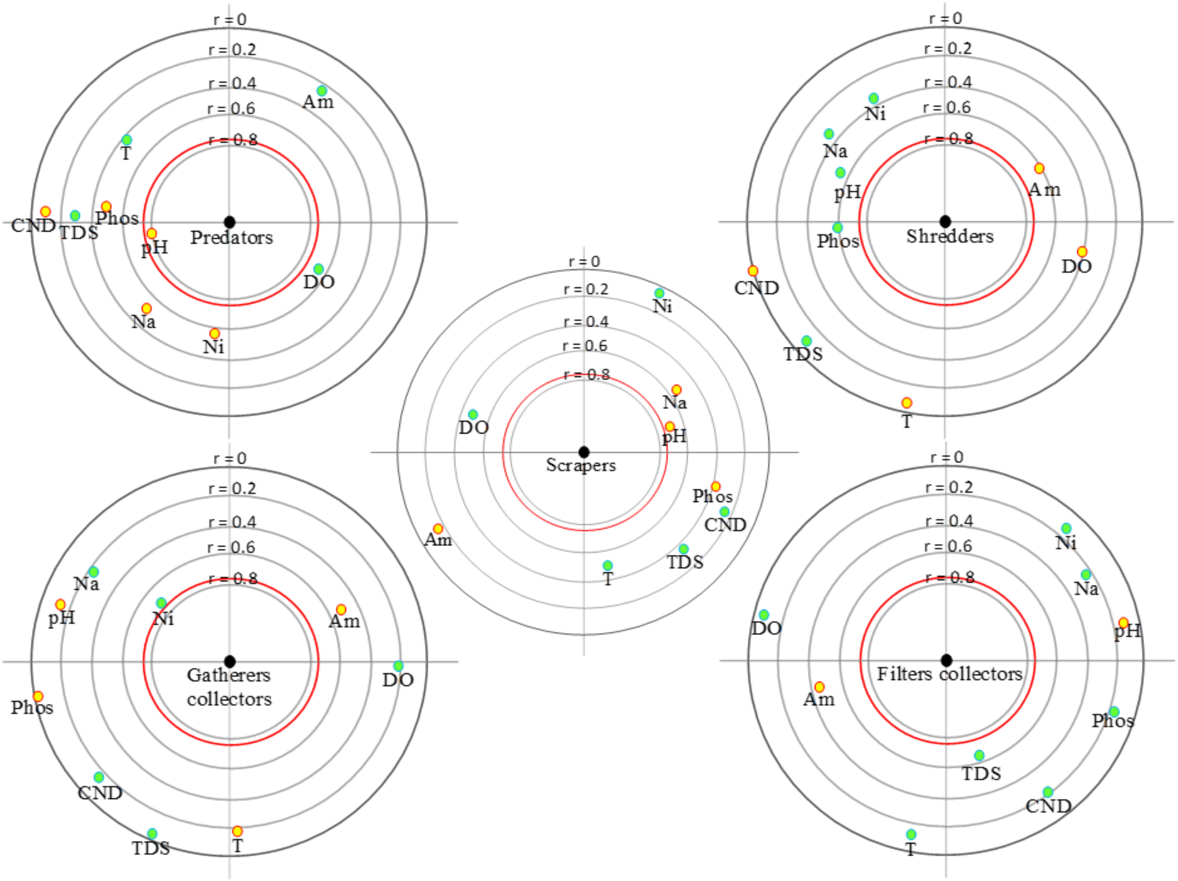

Figure 4: Graphs showing the results of the Focused Principal Component Analysis (FPCA) based on the abundance of FFGs as a dependent variable and environmental variables as independent variables. Yellow dots correspond to items negatively correlated to taxa abundance; green dots indicate items positively correlated to taxa abundance. The dots inside the red circle represent items significantly correlated ($p<0.05$) with taxa abundance. The uncorrelated points form right angles to the center of the circle. T = temperature; CND = conductivity; pH = hydrogen potential; DO = dissolved oxygen; Na = nitrates; Ni= nitrites; phos = phosphate; Am=ammonium; TDS=Total Dissolved Solids.

DISCUSSION

During this study, the environmental variables such as temperature, conductivity, dissolved oxygen, pH, TDS, ammonium, phosphates, nitrites and nitrates measured did not vary significantly from one pond to another, with the exception of conductivity, which was significantly higher in pond P3. The range of median values for this parameter (130-360 µS/cm) shows that the waters of these three ponds were mineralised overall, with the highest mineralisation in pond P3. According to Eblin et al. (2014), water with an electrical conductivity less than or equal to 100 µS/cm is weakly mineralised, and water with a conductivity greater than 100 µS/cm is considered mineralised. This high mineralisation is thought to be linked to the enrichment of these ponds in salts due to agricultural activities near Natiokobadara dam lake. The temperature range (24.40°C - 27.70°C) obtained shows that the water is relatively warm. This temperature range reflects that of water in tropical zones. It is close to those observed in most Ivorian hydrosystems (Kouamé et al., 2010; Camara et al., 2012; Simmou et al., 2015; Yapo et al., 2016; Kra et al., 2018). With regard to dissolved oxygen, the median values oscillate between 4.80 and 5.10 mg/l. The water in these ponds is relatively well oxygenated. This good oxygenation is linked to the shallow depth of these ponds, which facilitates the mixing of the water by the wind (Hoverman and Johnson, 2012). The pH values (6.80 - 7.09°C) are close to neutral. These values are harmless to aquatic life. Low levels of ammonium (0.01 mg/l), phosphates (1.5 - 2 mg/l), nitrites (0.2 mg/l) and nitrates (1.01 mg/l) were recorded. These low mineral values were thought to be due to the fact that the water in these ponds receives very little effluent.

A total of 64 taxa of aquatic macroinvertebrates belonging to 33 families, 11 orders and 04 classes were collected. These results are broadly similar to those obtained in three reservoirs in the Volta basin in Burkina Faso by Sanago et al. (2014) during the dry season. For all three reservoirs, these authors recorded 71 taxa and 33 macroinvertebrate families. The macroinvertebrate community of these three ponds is composed mainly of Insects representing 51 of the 64 taxa inventoried, i.e. 79.68%. This same observation was made by Sanogo et al. (2023), in the hippopotamus pond of Bala in Burkina Faso where they noted 76.98% insects. In most studies, insects constitute the most diverse taxonomic group among aquatic macroinvertebrates (nearly 95%) (Gagnon and Pedneau, 2006). The preponderance of insects is undoubtedly due to their high ecological value, which enables them to colonise different types of aquatic environment. In fact, the short life cycle of insects, with several generations per year, gives them an exceptional ability to adapt, hence the diversity of habitats colonised (Casa and Pincebourde, 2017).

Five functional feeding groups were identified in the three temporary ponds of the Natiokobadara dam lake: predators (pre), scrapers (scr), shredders (shr), gatherers-collectors (gc) and filter-collectors (fc). Overall, the percentage of predators was higher than the other groups in the ponds, followed by gatherers (gc), scrapers, then shredders and filter collectors (fc). The preponderance of predators is always linked to the availability of prey, such as gatherers (gc), the second most dominant FFGs. According to Beroual (2015), the growth rate of predators is a function of the growth of prey. Similar results were obtained by Camara et al. (2020) in Lake Kodjoboué in south-eastern Côte d'Ivoire.

Shredders, filter collectors and scrapers had the lowest proportions in the total abundance. This low proportion of shredders in these ponds is linked to the fact that in tropical zones, temperatures are high, which increases the decomposition of litter and leaves by microbial activity (Barman and Gupta, 2015; Deemool and Prommi, 2015). Microbial activity therefore replaces the role of shredders in tropical zones, leading to the low proportion of shredders. Several studies have shown the low proportion of shredders in the tropics (Gonçalves et al., 2006; Li and Dudgeon, 2009; Masese et al., 2009; Kaboré et al., 2016; Madomguia et al., 2016; Camara et al., 2020;

Addo-Bediako, 2021). The weak presence of specialists such as shredders and scrapers in favour of generalists such as gatherers, is the result of a disturbed environment (Fried et al., 2010). Activities near Natiokobadara dam lake therefore have a considerable impact on the aquatic community of the three ponds.

The P/R ratio revealed that all the ponds were heterotrophic (P/R < 0.75). Only pond P1 provided a sufficient load of fine particulate organic matter for the filters (CPOM / CPOM > 0.25) suggesting that the riparian zones of ponds P2 and P3 are non-functional (Cummins et al., 2005). The three ponds had abnormal predator-prey ratios, with values all greater than 0.2. There was therefore an imbalance between predators and prey in these ponds (Masese et al., 2014).

The analysis using Focused Principal Component Analysis (FPCA) showed that only predators, scrapers and gatherers showed a significant relationship with the environmental variables. Predator abundance was related to low pH values. Scrapers were negatively correlated with pH at the limit of significance. The abundance of gatherers-collectors was related to high nitrate levels at the limit of significance. Predators and scrapers, consisting mainly of Heteroptera, Odonata and Coleoptera, were to some extent resistant to acid pH. As for gatherers, their strong correlation is linked to the resistance of these generalists to various forms of disturbance. The link between nitrate and the abundance of gatherers-collectors has already been established by Camara et al. (2020) in Kodjoboué lake.

Conclusion

A total of 64 taxa of aquatic macroinvertebrates belonging to 33 families, 11 orders and 04 classes were recorded in the three temporary ponds of Natiokobadara dam lake. Insects were the most diverse, accounting for 79.68% of the taxonomic richness. Five major FFGs were identified in this study: predators (pre), scrapers (scr), shredders (shr), gatherers-collectors (gc) and filter-collectors (fc). Among the different functional feeding groups, the percentage of predators was higher than that of the other groups on the three ponds followed by gatherers. The P/R ratio indicates that the three ponds are heterotrophic. The top-down predator control ratio revealed an overabundance of predators. Only the riparian zones of pond P1 were functional. The FFGs and aquatic macroinvertebrates attributes used to describe the condition of these ponds reveal that they are highly disturbed.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

LMY was the instigator of this article and did the data collection work in the ponds; MKK contributed to the drafting of the manuscript, the analysis and the interpretation of the data; JYS assisted in writing the manuscript; DD provided technical support and advice.

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