SOCIAL SCIENCE AND HUMANITIES

Manuscript info:
Received November 4, 2018., Accepted November 17, 2018., Published November 30, 2018.

FIRST SURVEY OF AQUATIC MACROINVERTEBRATES DIVERSITY IN KODJOBOUÉ LAKE (SOUTH-EAST OF CÔTE D'IVOIRE)

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http://dx.doi.org/10.26739/2573-5616-2018-12-6

Abstract: This study aims to provide basic data of aquatic macroinvertebrates in Kodjoboue lake (South-East of Cote d'Ivoire) for their potential use for water quality assessment. four sites (K1-K4) were sampled during eight campaigns from June 2014 to May 2017. At each site macroinvertebrates were collected using a kick-net (25 x 20 cm, 500 χm mesh size). Environmental variables were recorded also. Water was collected from each sampling site for nutrient (phosphorus, nitrate) analysis in laboratory.

In total 74 taxa have been inventoried and subdivided into 4 classes (Malacostraca, Arachnida, Insecta, and Gasteropoda). The most diversified class was Insecta with 91.89% of the Taxa inventoried. Among the insects found, the most diverse order was the order of Coleoptera (19 taxa, 8 families) followed Diptera (15 taxa, 7 families) Heteroptera (13 taxa, 8 families) and Ephemeroptera (7 taxa, 5 families). The taxa identified as constant were Hydrachna sp., Ephemeroptera (Baetissp., Cloeon sp.), Odonates (Pseudagrionsp.), Heteroptera (Diplonychus sp., Eurymetrasp.), Coleoptera (Pseudobagous Longulus, Hydrovatus sp., Limniussp.), Chironomidae (Polypedilumdeletum, Dixa sp.). Taxa distribution was strongly influenced by environmental variables such as nitrate, phosphorus and temperature. kodjoboue lake was less disturbed.

Key words: Kodjoboue lake, aquatic Macroinvertebrates, taxonomic Diversity, Cote d'Ivoire

Recommended citation: Mathieu Kobenan KRA, Idrissa Adama CAMARA, Edia Oi EDIA, Mexmin Koffi KONAN, Allassane OUATTARA, Dramane DIOMANDE. First survey of aquatic macroinvertebrates diversity in Kodjoboute lake (South-East of Cote d'Ivoire). 67-80. American Journal of Research. P. 67-66 (2018).

1. Introduction:

Waterbodies play essential roles in the conservation of biodiversity, in the functioning of organisms and in the cycle of organic matter (Haouchine, 2011). Faunistic and ecological studies are of paramount importance in the understanding of the functioning and the management of natural systems on the one hand and on the other hand in the assessment of the ecological health status of hydrosystems (Haouchine, 2011). With the increasing adverse effects of pollution, it becomes important to be concerned about the health of aquatic ecosystems. In this context, aquatic macroinvertebrates are increasingly used to assess the health status of aquatic ecosystems. Indeed, these organisms are good bioindicators because of their sedentariness, their great diversity and their variable tolerance to pollution and habitat degradation (Moretti &Callisto, 2005). They reflect particularly well the ecological state of surface waters by reacting very quickly to changes in their environment (Ben Moussa et al., 2014). They serve as food for many aquatic organisms and contribute to the functioning of the lake ecosystem (Hershey et al., 2006).

In Côte d'Ivoire, numerous studies have been done on aquatic macroinvertebrates of some rivers (Ediaet al., 2007, Diomandéet al., 2009, Camaraet al., 2012, Camaraet al., 2014). Studies on Ivorian's lakes concern phytophilic macroinvertebrates of freshwaters in Ayamé lake II, Ayamé lake I and Taabo lake (Sankaré 1991, Kouaméet al., 2010, Kouaméet al., 2011, Diomandéet al., 2013).

Kodjoboué lake, our study area, is contiguous to the Grand-Bassam wetland, the largest in Côte d'Ivoire for its ecological and socio-economic role (Yaokokoré-Béibroet al., 2005). However, it is subject to several types of anthropogenic disturbances that threaten the aquatic species that live there, thus increasing the loss of biodiversity of aquatic ecosystems. In addition, no preliminary study has been done on the macroinvertebrates of this lake to determine the state of the quality of these waters. However, knowledge of biodiversity is the first step in a process of preservation and / or restoration of ecosystems (Heinoet al., 2005). In order to fill this lack of basic knowledge on the biodiversity of this lake, our investigations focused on the study of aquatic macroinvertebrates of Kodjobouélake. In addition, knowledge of this community is a basic element of the ecosystem approach to managing this lake.

This study aimed to:

i) determine the physicochemical characteristics of Kodjobouélake, ii) then qualitatively evaluate the aquatic macroinvertebrates of this lake and finally iii) establish the relationships between the environmental variables and the inventoried macroinvertebrates.

2. Material and methods

2.1. Study area and sampling sites

Kodjoboué lake, known as the

Kodjoboué "lagoon", is located insoutheastern Côte d'Ivoire in the South-Comoé region about 4 km south of the town of Bonoua between longitudes 3 ° 35 ' 9 "W and latitudes 5 ° 14'11" N. It belongs to the Grand-Bassam wetland and covers an area of 3,404 Km2. This lake communicates with the Como? river by a thin stream of water.This region has an average altitude of 90 m, its climate is subequatorial with an average annual temperature ranged between 25 °C to 33 °C. The rainfall varies from 1400 to 2500 mm/year and an annual rate of humidity about 80 to 90 % (Halle &Bruzon, 2006). This climate is characterized by four seasons: two dry seasons (mid-July to mid-September and December to March) and two rainy seasons (April to mid-July and mid-September to mid-November) (Brou, 1997).Four sampling sites were selected in Kodjobou? lake (K1 to K4) (Figure 1). These sites were sampled during eight sampling campaigns from June 2014 to May 2017. Table 1 summarizes the characteristics of these sampling sites.

2.2. Data collection

Aquatic macroinvertebratesof the native vegetation, covering the banks of the lake were sampled at the sites during the eight sampling campaigns with a kick-net (25 x 20 cm, 500 xm mesh size).At each site 5 net strokes are sampled. A net stroke consists of pulling the net over a distance approximately 1 m. The initial net is followed by two round trips on the surface to capture the dislodged organisms. Sampling was done by the same operator with a uniform sampling effort at all sites.Samples were fixed on 70 % ethanol and stored in labeled polyethylene flasks.

In the laboratory, specimens were sorted and identified to the lowest possible taxonomic level using a stereomicroscope Olympus SZ (40? magnification) and a series of identification keys (Dejouxet al., 1981 ; Day et al., 2001 ; Day et al., 2003;de Moor et al., 2003a ; de Moor et al., 2003b ; Stals et de Moor, 2007 ; Bony, 2007 &Tachetet al., 2010). In addition, temperature, pH, conductivity and dissolved oxygen were determined directly at the same sampling site with a portable multi-parameter (HANNA), water transparency was determined with a Secchi disc. Water was also collected with bottle of 1L at each sampling site for nutrients (phosphorus and nitrate) analysis in the laboratory using Rodier methods (Rodieret al., 2009).

2.3. Data analysis

In order to assess the structure of macroinvertebrate communities, Shannon-Weaver diversity index and Pielou evenness index were calculated. Taxonomic richness was rarefied in each site per sampling period. Precisely, rarefied richness was used to avoid any bias related to differences in abundances between samples (Grall et Coic, 2005). The Sorensen similarity index was used to evaluate the similarity of macroinvertebrate communities between sites.

Before performing comparison

analyses, data normality was checked using Shapiro test. Given the biotic and environment data distribution follow non-normal distribution (P?0.05), the non parametric test of Kruskal-Wallis was performed to compare data between sampling sites. When Kruskal-Wallis test is significant, Mann-Whitney test was used for pairwise comparison. The significance threshold was p = 0.05. Analyses were conducted using the R package.

The occurrence percentage (FO) was calculated using the following formula: FO = (Ni/Nts)≤100, with Ni = number of samples containing a given species i, and Nts = total number of samples collected. The FO was used to classify species following (Dajoz, 2000): FO>50: very frequent species; 25<FO≤50: frequent species; FO≤25: rare species.

A Monte Carlo permutation test was performed to assess the statistical significance of the environment variables and the full model to arrive at the significance of the first two axes. Multiple Regression step by step was used to determine the environment variables that significantly influence the distribution of macroinvertebrates. This analysis is performed on a continuous dependent variable according to continuous predictor. The step-by-step method is based on the ascending selection of predictors (environment variables in our case). For a given taxon, the inclusion coefficient F is calculated for each variable. The inclusion F value determines whether the contribution of a variable to the regression must be significant to be added to the equation (Younger, 1985; Stevens, 1986; Darlington, 1990). The influence of the predictors on the taxa considered is significant when the value of p associated with the coefficient F is less than or equal to 0.05. The magnitude of the Beta coefficients makes it possible to compare the relative contribution of each independent variable in the prediction of the dependent variable. The values of t and p give a good indication of the impact of the predictor variable on the dependent variable. A high absolute value of t and a low value of p suggest that the parameter in question has a strong impact on macroinvertebrates densities. This test was performed with the STATISTICA 7.1 software (Statsoft, 2005).

3. Results

3.1. Environment variables

The table 2 shows the variations of environmental variables measured in thefour studied sites.

Temperature ranged from 25.9°C to 31.9°C (K1). Conductivity varied between 14 S/cm and37.1 S/cm (K1). The dissolved oxygen variation was situated between 0.1 mg/L and 11.3 mg/L (K1). The water transparency of sites values varied from 10 cm to 218 cm (K1). Concerning the pH, it varied from 5.19 (K1) to 8.01 (K4). Regarding the Phosphorus and nitrate, their values were low, varied from 0.015 mg/L (K2) to 0.31 mg/L (K3) and from 0.1 mg/L (K2 and K4) to 2.65 mg/L (K2 and K3) respectively.

Analysis showed no significant differences of these parameters between sites(Kruskal-Wallis, p>0.05).

3.2. Composition and distribution of macroinvertebrates

During this study, 74 taxa of aquatic macroinvertebrates belonging to 37 Families, 11 Orders and 04 Classes. The most representative group were Insecta (68 taxa), followed by Malacostraca (3 taxa) and Gasteropoda with 2 taxa (Table 4). Coleoptera was the most diversified order representing 19 taxa, followed by Diptera(15 taxa), Heteroptera (13 taxa), Odonata (10 taxa) and Epheroptera (07 taxa). Libellulidae (Odonata) and Chironomidae (Diptera) were the most represented family (12.32 % of the taxa each), followed by Dytiscidae (Coleoptera) with 8.21 % of taxa.

3.3. Diversity indices

The Shannon-Weaver index revealed that most of the study sites presented high diversity values. The lowest diversity value was recorded at K4 (0.84), whereas the highest value was observed at K3 (2.41).

The Pielou's Evenness Index evolution is similar to Shannon-Weaver index with the lowest value in site K4 (0.43) and the highest at K3 (0.98).

Concerning the rarefied richness, it varied from 2.47 to 16.79 with the lowest in site K4. The highest values of rarefied richness correspond to site K3.

The rarefied richnesswas no significant differences ($p \leq 0.05$) between sites, as evidenced by the Mann-Whitney (Figure 2).

The Sorensen similarity index varies from 32.06% (K1-K2) to 42.86% (K2-K4), it showed that the sites are relatively similar (Table 3).

3.4. Frequency of occurrence

Table 5 shows the percentages of the very common, frequent and rare taxa at the six sites. The percentages of very common taxa vary between 06.06 % to 12.28 %. Those of frequent taxa varied between 24.24 % to 40.35 %. Regarding rare taxa, they are the most numerous at all sites with percentages ranging from 47.37% to 69.69%.

Eleven taxa were common to the four sites (Hydrachna sp., Baetissp., Cloeonsp., Pseudagrionsp., Diplonychussp., Eurymetrasp., Pseudobagous Longulus, Hydrovatussp., Limniussp., sp., Polypedilumdeletum, Dixasp.). These taxa had a high occurrence ($FO \leq 50$).

3.5. Correlation between macroinvertebrate community and environment variables

The result of Multiple Regression step by step indicates that in Kodjobouelake, only the presence of three taxa was significantly associated with environmental variables (Table 6). Nitrate concentration is negatively correlated with the presence of Gammarussp .. Phosphorus is positively correlated with the presence of Urothemis sp. Concerning Cryptochironomus sp., Its presence is related to the temperature variation.

4. Discussion

The analysis of environmental variables measured (temperature, conductivity, dissolved oxygen, transparency, pH and nitrate and phosphorus) at the different sampling site of Kodjobou? Lake show no significant variation between sites.

The temperature range recorded in Kodjoboué Lake is between 25.9 ° C and 31.9 ° C, the waters of this lake are relatively warm. Our results corroborate those of Kouaméet al., 2010on Taabolake. With regard to dissolved oxygen, the range is between 0.10 and 11.3 mg / l. This range is higher than that obtained in Taabo Lake (3.62 - 9.2 mg / l) by Kouaméet al., 2010. The range of variation in temperature and dissolved oxygen may be related to the lack of vegetation cover on the lake. The water transparency varies between 10 and 218 cm at Kodjoboué Lake. This range is higher compared to that observed (73 and 112 cm) at Ayam? Lake by Diétoa (2002). Low values of nitrate (0.1 - 2.65 mg / l) and phosphorus (0.015-0.31 mg / l) were recorded. Nitrate values are higher than those obtained in Lake Taabo (0.05 -1.95 mg / l) and those of phosphorus are low compared to those obtained in the same lake (0.24 - 28.47 xmol/ l) by Kouameet al., 2010.These low nutrient values are due to the fact that lake waters receive very little effluent. In fact, nutrient concentrations in surface waters that are free of human activities are less than 1 mg / l (Meybeck, 1989).

A total of 74 aquatic macro-invertebrate taxa belonging to 37 families, 11 orders and 04 classes were harvested. The taxonomic richness of Lake Kodjoboué was higher than those obtained in other Ivorian's lakes (Kouaméet al., 2010, Kouaméet al., 2011 and Diomandéet al., 2013). These authors recorded respectively 60, 68, 43 and 29 taxa. This strong taxonomic richness is undoubtedly indicative of low anthropic pressure on this lake. Macroinvertebrate community of Kodjoboué lake is composed mainly of insects that account for 68 of the 74 inventoried taxa, or 91.89%. This strong representativity of the insect group was reported by Diomandé&Gourône (2005) in Ayam? lake. According to Gagnon &Pedneau (2006), the most diverse taxonomic group among aquatic macroinvertebrates are insects (nearly 95%). Among the insects found, the most diverse order is the order Coleoptera (19 taxa, 8 families) followed Diptera(15 taxa, 7 families) Heteroptera (13 taxa, 8 families) and Ephemeroptera (7 taxa, 5 families).Among insects, the preponderance of the Coleoptera (19 taxa) is explained by the fact that they are the only holometabolous insects to occur in both the imaginal and larval form in aquatic environments. They colonize various habitats when conditions become hostile for other species decreasing interspecific competition (Ben moussaet al., 2014).

In this study, the Shannon-Weaver index calculated ranging

between 0.84 (K4) and 2.40 (K3). These results show that the waters had good ecological health. The Pielou's Evenness index calculated for the waters varying from 0.43 (K4) to 0.98 (K3).These results show that the distribution of benthic macroinvertebrates taxa is more or less balanced in Kodjoboué lake.The Shannon-Weaver index and Pielou's Evenness index values are confirmed by those of the Rariefed taxonomic richness with the highest value for the K3 site (16.79) and the lowest for the K4 site (2.47). Association of different indices studied, revealed that most of the sites of Kodjobou? lake have a good ecological status with K3 being the least disturbed station. However, K4 is the most impacted because the low values of these diversity indices are indicators of pollution or disturbance of environmental conditions.

The Shannon-Weaver Index and Pielou's Evenness Index shows significant variation between some sites. However, when there is no bias, the Rariefed taxonomic richness shows that there is no significant difference between the sites. These four sites of Kodjobouélake would therefore be subject to the same environmental conditions.

The taxa identified as constant are Trombidiformes (Hydrachna sp.), Ephemeroptera (Baetissp., Cloeon sp.), Odonates (Pseudagrionsp.), Heteroptera (Diplonychus sp., Eurymetrasp.), (Pseudobagous Longulus, Hydrovatus sp., Limniussp.), Chironomidae (Polypedilumdeletum, Dixa sp.).

This same observation was made by Kouaméet al. (2011) in Taabolake. The results of the work of Kouaméet al. (2011) showed that Chironomidae are the only taxa harvested very regularly in all the stations considered. Indeed, Merritt & Cummins (1996) reported that the variation in conditions under which Chironomidae are found is more extensive than that of other groups of aquatic insects. These organisms would thus have a broad spectrum of resilience and morphological, physiological and behavioral adaptations.

Based on Sorensen similarity index, the highest similarity was observed between K2 and K4. This relatively high similarity is probably related to the similarity of land use between the two sites.

Multiple Regression step by step indicates that in Kodjobouélake, only the presence of three taxa was significantly associated with environmental variables. The presence of Gammarus sp. is related to the decrease of nitrate, the high concentrations of phosphorus influences the presence of Urothemissp. As for Cryptochironomus sp., its presence is linked to high temperature value. Bond & Downes (2003) have shown that the composition and organization of aquatic macroinvertebrate communities is influenced by the physicochemical characteristics of water.

5. Conclusion

This study has made a first inventory of the macroinvertebrate community of Kodjobouélake.

The results for abiotic parameters do not reveal any spatially significant variation.

The taxonomic composition of macroinvertebrates shows the presence of 74 taxa, of which 68 belong to the class of Insects which is the most diversified.

The degree of organization and diversity of Kodjobouélake macroinvertebrate community was analyzed through The Shannon-Weaver index, Pielou's Evenness index and Rariefed taxonomic richness . K3, with its maximum values of Shannon-Weaver index (2.4), Pielou's Evenness index (0.98) and Rariefed taxonomic richness (16.79), appears as the most diversified site, the most stable and better organized.

Analysis of correlations between physicochemical parameters and macroinvertebrates indicates that the faunal distribution is more influenced by environmental parameters such as nitrate, phosphorus and temperature.

The different indices studied, show that overall, this lake is less disturbed. It is therefore necessary to protect the Kodjobou? lake in order to conserve its biodiversity.

6. Acknowledgement

This work was supported by the PASRES (Strategic Support Program Scientific Research (Côte d'Ivoire), under research project number 110 entitled " Approcheécosystémique de la péchecommemoyend' exploitationdurable desressourceshalieutiques dans la zone humidede Grand-Bassam " (Ecosystem approach to fisheries as a means of sustainable exploitation of fisheries resources in the Grand-Bassam wetland).

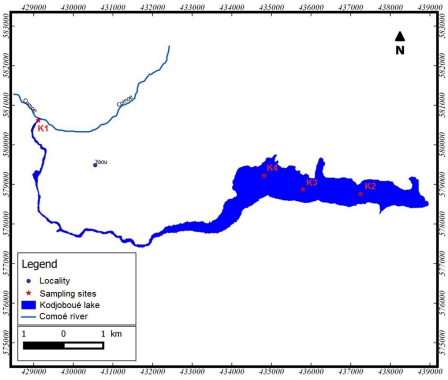

Figure 1: Location of the study area showing the four sampling sites of Kodjobouélake (Grand Bassam Wetland, Côte d'Ivoire)

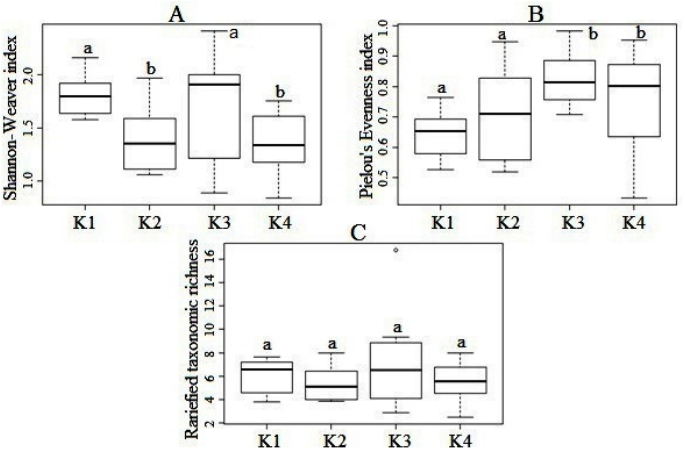

Figure 2. Box-plots showing variation of Shannon-Weaver index (A), Pielou's Evenness index (B) and Rariefed taxonomic richness (C) of Kodjoboué lake (K1-K4). Different letters (a and b) on box-plots denote significant differences between them (Mann-Whitney, $p<0.05$)

Table 1: Characteristics of the four study sampling sites in Kodjoboué lake (Grand Bassam Wetland, Côte d'Ivoire)

Sampling Sites	Geographical positions (UTM)		Land use	Substratum (%)	Canopy (%)
	X	Y			
K1	429117	580611	Rubbertree plantations	Sand (35%) Plant debris (40%) Mud (25%)	70
K2	436617	579119	Marshlanddominated by raffia,	Mud (95%)	0
K3	435800	579202	Marshy forest dominated by raffia	Sand (5%)	0
K4	435017	579456	Marshy forest dominated by raffia, housing		0

Table 2 : Environmental variables measured at four sampling sites of Kodjoboué lake (Grand Bassam Wetland, Cote d'Ivoire).

Parameters	K1	K2	K3	K4
Temperature (°C)	28.19 (25.9-31.9)	29.2 (27-32)	29.1 (27.2-31.6)	29.2 (27.2-31.3)
Conductivity (µS/cm)	29.3 (14-37.1)	22.5 (19-36)	21.94 (20-28.1)	22.6(21-27.2)
Dissolvedoxygen (mg/L)	1.50 (0.1-11.3)	6.4 (0.17-9.5)	6.31 (0.15-9.36)	6.26 (0.14-8.11)
Transparency (cm)	113 (10-218)	99.5 (50-125)	110 (51-190)	98 (73-124)
pH	6.4 (5.19-7.5)	6.48 (06-7.69)	6.63(5.3-7.66)	6.50 (6-8.01)
Phosphorus (mg/L)	0.078 (0.039-0.13)	0.07 (0.015-0.22)	0.059 (0.016-0.31)	0.08 (0.017-0.18)
Nitrate (mg/L)	1.22 (0.2-2.21)	0.83 (0.1-2.65)	0.64 (0.2-2.65)	0.70 (0.1-1.77)

Table 3. Values of Sorensen similarity index between the four sampling sites (K1-K4) of Kodjoboue lake (Grand Bassam Wetland, Côte d'Ivoire)

	K1	**K2**	K3	K4
K1		32.06	37.33	36.36
K2			34.95	42.86
K3				41.02
K4				

Table 4. List of the macroinvertebrates taxa found in the four sites of Kodjoboué (Grand-Bassam wetland, Côte d'Ivoire).

Class	Orders	Famillies	Taxa	Sampling sites			
				K1	K2	K3	K4
Malacostraca	Amphipoda	Gammaridae	*Gammarus* sp.			*	
	Decapoda	Palaemonidae	*Macrobrachiumvollenovenii*	**			
			*Macrobrachium*sp.	**			
Arachnida	Trombidiformes	Hydrachinidae	*Hydrachna*sp.	*	*	*	**
Insecta	Ephéméroptera	Baetidae	*Baetis*sp.	**	**	*	*
			*Cloeon*sp.	***	**	*	**
			*Procleon*sp.	*			
		Caenidae	*Caenis*sp.		**		
		Ephemeridae	*Eatonica*sp.			*	
		Polymitarcydae	*Povillaadusta*		**		*
		Tricorythidae	*Tricorythys*sp.	*			
	Odonata	Coenagrionidae	*Ceriagrion*sp.	**	*	*	*
			*Pseudagrion*sp.	*	*	***	***
		Libellulibidae	*Bradinopygas*sp.	**	*		
			*Chalcostephia*sp.	*			
			*Crocothemis*sp.	**		**	*
			*Libellula*sp.		*		
			Macrodiplaxcora	**	*	**	*
			Pantalaflavescens	*		*	*
			Trithemis dorsalis	**		*	*
			*Urothemis*sp.			*	
			Zygonyxtorridae	**			
	Heteroptera	Belostomatidae	*Diplonychus*sp.	***	***	***	**
		Gerridae	*Eurymetra*sp.	**	*	**	**
			*Limnogonus*sp.	**			
			*Rhagadotarsus*sp.	**			*
		Hydrometridae	*Hydrometra* sp.			*	
		Naucoridae	*Laccocoris* sp.	**		*	*
			*Naucoris*sp.	*	**	**	*
		Nepidae	*Ranatralinearis*		**		*
		Notonectidae	*Anisops*sp.			*	
			*Notonecta*sp.		*	*	
		Pleidae	*Plea* sp.	*		*	
		Veliidae	*Microvelia*sp.		*	**	**
			*Rhagovelia*sp.	*	*		*
	Trichoptera	Ecnomidae	*Ecnomus*sp.		*	**	*
		Hydropsychidae	*Polymorphanisus*sp.		*		**
			*Cheumatopsyche*sp.				*

Table 4.(Continued)

***** Very frequent (%OF>50); ** frequent (25<%OF≤50);* rare (%OF≤25)**

Class	Orders	Famillies	Taxa	Sampling sites			
				K1	K2	K3	K4
Insecta	Coleoptera	Curculionidae	*PseudobagousLongulus*	***	**	**	*
			*Notaris*sp.	*			
		Dytiscidae	*Agabus* sp.	**			
			*Bidessus*sp.	**			
			*Hydaticus*sp.	*	**	**	*
			*Hydrovatus*sp.	***	**	**	*
			Hyphydrus	*		*	*
			*Laccophilus*sp.	*	*		*
		Elmidae	*Esolus*sp.	*			
			*Limnius*sp.	**	*	*	*
			*Potamodytes*sp.	**			
		Gyrinidae	*Dineutus*sp.	*		*	
			*Orectogyrus*sp.	*	*		
		Haliplidae	*Haliplus*sp.	*			
		Hydrochidae	*Hydrochus*sp.	*			
		Hydrophilidae	*Amphiops*sp.	*		**	
			*Enochrus*sp.	***		**	*
			*Hydrobius*sp.	*		**	
		Noreridae	*Noterus*sp.	*			
	Diptera	Chaoboridae	*Mochlonyx sp.*	*			
		Ceratopogonidae	*Culicoides*sp.	*	*	*	
		Chironomidae	*Ablabesmyia*sp.	**	*		**
			Chironomus sp.	***		*	
			*Cricotopus*sp.	**			
			*Cryptochironomus*sp.	**	**		**
			Polypedilumabyssiniac		*	*	
			Polypedilumdeletum	***	***	***	***
			*Stenochironomus*sp.	*			
			*Clinotanypus*sp.	*		*	*
			*Stictochironomus*sp.	**	*		
		Culicidae	*Culex* sp.	**		**	
		Dixidae	*Dixa*sp.	**	**	**	*
		Rhagionidae		*			
		Syphiridae		*			
Gasteropoda	Basomatophora	Bithiyniidae	*Gabbiella*sp.	*			
	Archeagasteropoda	Neritidae	*Theodoxus*sp.	*			
Taxonomic richness			74	59	32	38	33

Table 5 :Proportions of aquatic macroinvertebrates very frequent (***), frequent (**) and rare (*) at the different sampling sites of the Kodjoboue lake (Grand Bassam Wetland, Côte d'Ivoire).

Sites	Very frequent (%)	Frequent (%)	Rare (%)
K1	12.28	40.35	**47.37**
K2	06.46	35.48	**58.06**
K3	08.34	38.89	**52.77**
K4	06.06	24.24	**69.69**

Table 6. Multiple regression step by steprelating environmental variables to the presence of taxa in Kodjobou? Lake (R2 = coefficient of determination, F = inclusion coefficient, t = coefficient of regression, p = probability).

Taxa	Environmental variables	t	R^2	F	P
*Gammarus*sp.	Nitrate	-2.072	0.251	F (2.29) = 4.873	0.014
*Urothemis*sp.	Phosphorus	3.28	0.318	F (4.27) = 3.154	0.029
*Cryptochironomus*sp	conductivity	-2.433	0.235	F (3.28) = 2.879	0.021

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