First Data on Zooplankton Community Structure and Abundance of Kankelaba River in Côte d'Ivoire (Bagoe Tributary, Basin Niger)

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Abstract: This study constitutes a contribution to produce baseline data on zooplankton diversity of Bagoe tributary in Côte d'Ivoire (Kankelaba River). A total of 31 taxa were inventoried for the first time in the Kankelaba River which is a tributary of Bagoe River in Côte d'Ivoire. This community belongs to copepod (5 taxa), rotifer (20), cladocera (5) and chironomid larva (1). Rotifera was the most diversified group represented by 20 taxa belonging in 8 families and 12 genuses. Brachionidae presented the highest genus diversity, with 4 genuses and 9 species. Zooplankton community was marked by numerical dominance of rotifers (55-61% of total zooplankton abundance), following by copepods (31-44%). *Keratella tropica* was the main species (25-39% of total zooplankton abundance). Zooplankton community abundance showed spatio-temporal variation with dry season values always highest (17-149 ind.L^{-1}) than during the wet season (4-67 ind.L^{-1}). The highest total zooplankton densities were always obtained in the sampling site Sobala (67-149 ind.L^{-1}) while lowest abundance was obtained in the sampling the others sampling, with < 40 ind.L^{-1}.

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1. Introduction

The Niger stream is represented in Côte d'Ivoire through the headwaters with the tributaries Gbanhala or Kouroukélé, Baoulé, Kankélaba and Bagoé (Anonyme, 2008) (*Etude pour la mise en place d'un réseau de recherche et développement à l'échelle du basin du Niger, 109p*). On the portion of the Niger watershed in Côte d'Ivoire, the anthropogenics activities which breeding, agriculture and mining intensified these last years. These anthropogenics activities could constitute some threats for the biodiversity of these ecosystems.

Among this biodiversity, zooplankton is ecologically an important group of aquatic organisms. Zooplankton plays a significant role in aquatic food web by linking the primary producers and higher trophic levels (Ferdous *et al.*, 2009 in Eyo *et al.*, 2013). It is important consumers of bacterioplankton (Wikner *et al.*, 1990) and phytoplankton organisms (primary producer) (Atienza *et al.*, 2006; Mehner *et al.*, 2008). They also constitute a food source for organisms of the upper trophic levels such as planktivorous fish and carnivorous invertebrates (Pinel-Alloul, 1995). Besides, can be used as biological indicators for pollution (Webber *et al.*, 2005) and water quality (Mialet *et al.*, 2010). The examination of variation in zooplankton assemblage composition according to environmental gradients may help to clarify the role of biotic and abiotic factors for community organization, a major issue in aquatic ecology (Etilé *et al.*, 2009).

In Côte d'Ivoire the study of zooplankton in freshwater ecosystems has been mainly performed in south part: in ponds (N'douba, 1985; Kouassi, 1989; N'douba *et al.*, 1996), lake Ayamé I (Yté *et al.*, 1982a, b; Yté *et al.*, 1983; N'douba and Kouassi, 1995; Nobah, 1998); lake Buyo (Yté *et al.*, 1996), Bandama stream watershed (De Ridder and Pourriot, 1984), Agneby and Bia rivers (Ouattara *et al.*, 2007), coastal rivers Bodoua, Boulo, and Ehania (Monney *et al.*, 2015). Such studies have focused on descriptive ecology as fauna composition, spatial-temporal distribution, composition and abundance variation in relation with environmental factors. In the north part, scientific researches on aquatic ecosystems biodiversity are scarce. The only works of research achieved the aquatic ecosystems of the north of the Côte d'Ivoire are those of Aka *et al.* (2000) on zooplankton of 49 shallow agro-pastoral reservoirs, N'da *et al.* (2013) on fish diversity in Bagoe river, N'da *et al.* (2015) on Bagoé river zooplankton, Yao *et al.* (2015) on zooplankton in the Comoé stream to the level of the Comoé National Park.

Therefore, zooplankton studies on Niger watershed are rare and concerned only Bagoé tributary. Surveys on the zooplankton of the other Niger tributaries (Gbanhala or Kouroukélé, Dégou, Baoulé, Kankélaba) remain unknown and the inventory of the zooplankton community of these ecosystems rests therefore to make. In the present study, our goal was to give the first zooplankton composition and spatial variation in relation to environmental variables of Kankélaba River (Niger tributary in Côte d'Ivoire). This study constitutes a contribution to produce baseline data on biodiversity of Niger tributaries in Côte d'Ivoire.

2. Material and methods

Study area

The river system of the Niger watershed in Côte d'Ivoire comprises the sub-tributaries of the Sankarani and the Bani that are the Baoulé, the Banifing, the Bagoé, and the Gbanhala. These lotic waters in Côte d'Ivoire flow in South-North direction and are undergone the influence soudano-guineen climate characterized by only one rainy season (May to October) with maximum precipitation in July-September, and one dry season (November to April). Zooplankton and environmental variables were recorded during the rainy (June 2017) and the dry seasons (November 2017) in four sampling sites: Sobala (St_1: 10°14.906' N; 6°42.004' W), Tokala (St_2: 10°14.695' N; 6°37.625' W), Missasso (St_3: 10°21.833' N; 6°38.625' W) and Débété (St_4: 10°37.842' N; 6°39.484' W) (Figure 1).

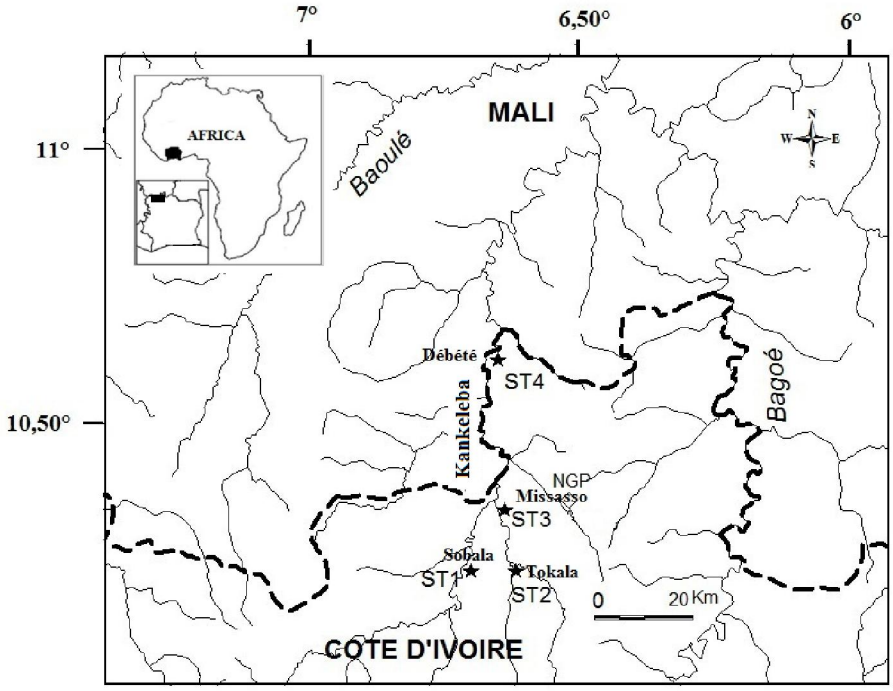

Figure 1: Map of the Kankélaba River in Côte d'Ivoire with sampling sites position

Data collection

The zooplankton sampling was made using a cylindro-conical net (65 µm in mesh opening size) by filtration. Two hundred liters of subsurface water were collected by sampling site and filtered through the plankton net. Samples were immediately preserved in a mixture of river's water and borax neutralized formalin at a final concentration of 5%. Zooplankton organism was identified using the following works: De Mannuel (2000); Dussart and Defaye (2001); Sharma (2010); Kotov et al. (2012). The taxa were identified and counted under a dissecting microscope.

The physical and chemical parameters as water temperature (°C), pH, dissolved oxygen concentration ($mg.L^{-1}$), electrical conductivity ($\mu g.cm^{-1}$) were measured in surface, with a portable multi-parameter probe Lovibond Senso Direct 150. Water transparency was measured using a Secchi disk. Sampling site depth (cm) and width of the river (m) were measured with a graduated cord.

Flow velocity in sampling site was also estimated with a floating object (small bottle of 50 ml of capacity containing liquid soap). The time taken by the floating object to move past two fixed points was recorded three times. Waters velocity was calculated

and expressed as the time taken (in second) to flow through 1 m ($m.s^{-1}$).

Analytical procedure

The zooplankton community structure was described through density and ecological diversity indices (Shannon diversity index, Pielou's equitability index). Zooplankton densities, expressed as number of taxa per liter ($ind.L^{-1}$), were calculated by dividing the number of organisms estimated in each sample by the volume of water filtered in the field.

The calculation of the Shannon diversity index was made through the formula:

$$H' = -\sum_{i=1}^{i=S} p_i \times \log_2 p_i$$

where S is the total number of species and p_i the proportion of individuals in the ith species (i = 1, 2,…, S) (Shannon and Weaver, 1963).

The Pielou's equitability index (E) is:

$$E = \frac{H'}{\log_2 S}$$

In which H' is the Shannon diversity index and S the species richness (Hill, 1973).

Analyses of ecological diversity indices were conducted using Past 2.04 computer package. The relationships between the zooplankton taxa and environmental parameters of the Kankelaba River were assessed by using a ReDundancy Analysis (RDA). The RDA was carried out using CANOCO 4.5 software was used to explore the principal patterns of zooplankton distribution and their relation with the environmental variables. Environmental variables and zooplankton taxa were log10 (x + 1) transformed prior analysis.

3. Results

We exhibit, in this section results data obtained from environmental parameters, zooplankton composition, distribution and ecological index on the one hand, and relationship between zooplankton taxa and Kankelaba River environmental parameters by multivariate analysis (ReDundancy Analysis, RDA).

Environmental parameters

Spatial variations of environmental parameters recorded during this study in the Kankeleba River were showed in table 1.

Table 1. Environmental parameters measured in Kankélaba river (Niger tributaries in Côte d'Ivoire) during the wet (June 2017) and the dry (November 2017)

Stations Codes	Seasons	width (m)	Depth (cm)	Flow velocity ($m.s^{-1}$)	T (°C)	pH	DO ($mg.l^{-1}$)	Cond ($\mu g.cm^{-1}$)	Trans (cm)
St1	DS	15.50	131	0.15	23.40	6.53	3.70	30.10	52.00
	WS	16.00	138	0.00	29.15	5.41	2.05	86.60	55.50
St2	DS	17.50	72	0.00	29.95	6.28	2.90	38.25	56.00
	WS	13.50	77.5	0.00	27.73	5.38	2.80	77.60	65.00
St3	DS	30.00	90	0.00	23.95	6.50	2.30	38.75	30.00
	WS	45.00	152	0.00	30.88	5.40	6.40	82.00	30.00
St4	DS	50.00	95	0.00	24.40	6.40	5.00	33.90	87.00
	WS	50.00	223	0.00	33.86	7.49	3.64	53.50	87.00

(T: Temperature, DO: Dissolved oxygen, Cond: Conductivity, Trans: Water transparency)

Sampling sites are characterized by low depth (72 to 223 cm). The stations 1 and 2 have the weakest widths (< 20 m), while, the stations 3 and 4 presents the most important widths (30 to 50 m). Water temperature varied between 23.40 and 33.86 °C according to the stations and seasons. Lowest temperature was observed during the dry season (23-30 °C), whereas highest temperatures were obtained during the wet season (27-34°C). Water pH was generally acid (< 7) in all stations during the dry and the wet seasons excepted during the wet season in station 4 where pH slightly above neutral value (7). Dissolved oxygen concentration varied between 2.05 (station 1) to 6.40 $mg.L^{-1}$ (station 3).

Generally, water dissolved oxygen concentration during the wet season were weak (2-6.4 $mg.L^{-1}$) than during the dry season (2.9 to 5 $mg.L^{-1}$). Flow velocity is hopeless in all stations during the two sampling periods.

Taxonomic composition and distribution spatio-temporal pattern

Thirty-one (31) taxa of zooplankton were identified in Kankelaba river during this study. Zooplankton community was composed of Copepoda (5 taxa), Cladocera (5 taxa), Rotifera (20 taxa) and others zooplanktonic organisms (1 taxon) (Table 2).

Rotifera was the most diversified group with 20 taxa split into 12 genuses and eight families. Brachionidae presented the highest diversity (for genuses and nine species: *Anuraeopsis fissa*, *Brachionus angularis, B. caudatus, B. falcatus*, *B. plicatilis, Platyias quadricornis, P. leloupi, Keratella tropica* and *K. lenzi*). It is followed by Filinidae (3 taxa: *Filinia longirostris, F. opoliensis* and *F.*

terminalis) and by Trichocercidae (*Trichocerca chattoni* and *trichocerca* spp.) and Colurellidae (*Lepadella patella* and *Colurella* sp.).

Copepoda were represented by Diaptomidae (*Tropodiaptomus* sp. and *Thermodiaptomus yabensis*) and by Cyclopidae (*Thermocyclops decipiens* and *Mesocyclops* sp.). Besides, unidentified copepod nauplii were also unregistered in all sampling site during this study. Cladocera was represented by five taxa belonging to five genuses and 5 families.

During this study in Kankélaba river, zooplankton species richness varied according to station and season. During the wet season, it varied from 6 to 19 taxa (total diversity: 21 taxa), while it varied from 9 to 20 taxa during the dry season (total diversity: 26 taxa). Thus, diversity indices obtained varied according to stations. Shannon's diversity index varied from 1.16 bit.ind^{-1} to 1.36 bit.ind^{-1} (Mean: 1.26 bit.ind^{-1}) during the wet season and from 1.62 to 2.26 bit.ind^{-1} during the dry season (Mean: 1.98 bit.ind^{-1}). Equitability index varied between 0.46 and 0.71 during the wet season versus 0.70 to 0.86 during the dry season. Therefore, Kankélaba river zooplankton community diversity index values were always higher during the dry season than the rainy season.

Table 2. Zooplankton taxa collected in the Kankélaba River (Niger tributaries in Côte d'Ivoire) during the wet (June 2017) and the dry (November 2017)

Groups	**Families**	**Taxa**	**Codes**	**Sampled sites**			
				St_1	**St_2**	**St_3**	**St_4**
Copepoda	Diaptomidae	*Tropodiaptomus* sp.	Trop	+			+
	"	*Thermodiaptomus yabensis*	Tyab				+
	Cyclopidae	*Thermocyclops decipiens*	Tdec	+		+	+
	"	*Mesocyclops* sp.	Meso	+	+		+
	Undetermined	Nauplii	Ncop	+	+	+	+
Cladocera	Moinidae	*Moina micrura*	Mmic	+	+		+
	Sididae	*Diaphanosoma excisum*	Dexc	+		+	
	Macrothricidae	*Macrothrix* sp.	Macro			+	
	Daphnidae	*Ceriodaphnia cornuta*	Ccor	+		+	
	Bosminidae	*Bosmina longirostris*	Blon	+	+		
Rotifera	Brachionidae	*Anuraeopsis fissa*	Anur	+		+	
	"	*Brachionus angularis*	Bang	+		+	+
	"	*Brachionus caudatus*	Bcau	+	+		+
	"	*Brachionus plicatilis*	Bpli	+			
	"	*Brachionus falcatus*	Bfal	+			
	"	*Platyias quadricornis*	Pqua	+		+	
	"	*Platyias leloupi*	Plel	+			+
	"	*Keratella tropica*	Ktro	+	+	+	+
	"	*Keratella lenzi*	Klen	+		+	+
	Colurellidae	*Colurella* sp.	Colu	+			
	"	*Lepadella patella*	Lpat	+			
	Filiniidae	*Filinia longiseta*	Flong	+		+	+
	"	*Filinia opoliensis*	Fopo	+	+	+	+
	"	*Filinia terminalis*	Fter	+			
	Hexarthridae	*Hexarthra* sp.	Hexa	+		+	
	Trichotriidae	*Trichotria* sp.	Trich		+		
	Synchaetidae	*Synchaeta* sp.	Sync	+			+
	Trichocercidae	*Trichocerca chattoni*	Tcah	+	+		
	"	*Trichocerca* spp.	Tricho	+	+	+	+
	Lecanidae	*Lecane* spp.	Leca	+	+	+	+
Other	Chironomidae	Insect Larvae	Ilarv		+	+	
Diversity	16	31		27	12	16	16

Zooplankton structure and abundance spatial variation

Zooplankton abundance obtained in Kankelaba river during this study varied, according to sampling site and seasons, between 4.5 to 149 ind.L^{-1}, with dry season values (17 to 149 ind.L^{-1}) significantly highest than (p–*value* < 0.05) the wet season abundance (4.5 to 67 ind.L^{-1}) (Figure 2).

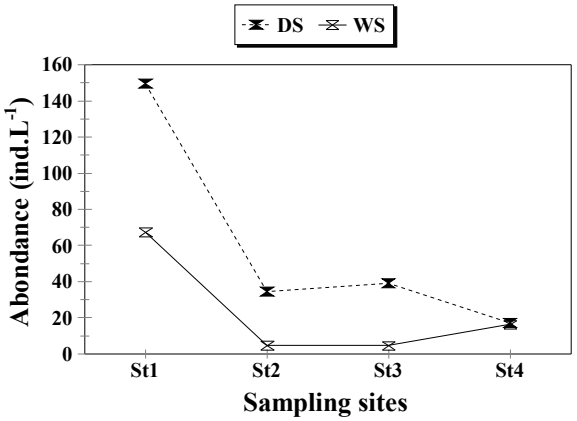

Figure 2. Spatial variations of the total zooplankton abundance collected in the Kankélaba River (Niger tributaries in Côte d'Ivoire) during the wet (WS, June 2017) and the dry (DS, November 2017) seasons.

In Kankelaba river, zooplankton community was dominated by Rotifera (Mean: 55 to 61%) and Copepoda (mean: 31 to 44%). These two groups, as for the total zooplankton abundance presented highest abundance at station 1 (67 to 149 ind.L^{-1}) while in the other sampling sites, zooplankton abundances were relatively low (< 40 ind.L^{-1}) (Figure 3A, B). Rotifera was mainly represented by *Keratella tropica* (41 and 71% respectively during the dry and the wet season), followed by *Trichocerca* spp. (16%) during the wet season and by *Filinia longiseta* (21%). *Keratella tropica* was obtained with highest abundance in station 1 during the dry (43 ind.L^{-1}) and the wet (30 ind.L^{-1}). *Trichocerca* spp. showed highest abundance in stations 1 and 3 (2-5 ind.L^{-1}) during the wet season while *Filinia longiseta* was obtained with highest in stations 1 and 3 (10-18 ind.L^{-1}) during the dry season (Figure 3C, D).

Copepods were comprised mainly nauplii stages (58-94%). Copepodid and adult stages (6-42% total copepod abundance) were constituted by *Tropodiaptomus* sp. (26.42%), *Thermodiaptomus yenbesis* (18.87%), *Thermocyclops decipiens* (24.53%), and *mesocyclops* sp. (30.19%) during the wet season. During the dry season, copepods were represented by *Thermocyclops* sp. and *mesocyclops* sp. *Thermocyclops* sp. was mainly observed at station 1 (13 ind.L^{-1}) and 3 (8 ind.L^{-1}) while *mesocyclops* sp. was obtained in stations 1 (5 ind.L^{-1}) (Figure 3E, F).

Environmental parameters influence on zooplankton

The relationship between Kankelaba river zooplankton density and environmental parameters setting in evidence through the multivariate redundancy analysis (RDA) is shown in the ordination diagram illustrated by the figures 4 and 5. This analysis showed that the first two axes expressed respectively 54.9 % and 69 % of the cumulated variance percentage. Thus, only these axes have been considered in the interpretation of the results.

During the wet season, three groups of sampling sites was distinguished in relation to both CCA axes I and II (Figure 4). The analysis was shown that station 1, positively correlated with axis I, was mainly characterized by high value of conductivity, depth and transparence. The main zooplankton associated to sampled site (St_1) were Rotifers taxa *Brachionus angularis*, *B. plicatilis*, *Platyias quadricornis*, *Filinia terminalis*, *Lecane* sp., *Keratella lenzi*, and *Trichocerca* sp.; by Copepod *Mesocyclops* sp. and by Cladocera *Diaphanosoma excisum* (Group A). The second axis divided the other sampling sites (Group B), negatively with axis 1 correlated in two groups (B_1 and B_2). The station 2 (group B_1), positively correlated with axis II, were characterized by the value of width and water temperature (St_2). The station 3 (group B_2), negatively correlated with axis II, was correlated by higher value of dissolved oxygen. These two groups were marked by low taxonomic richness.

During the dry season (Figure 5), as during the wet season, two main zones were distinguished: sampling site 1 (zone A) positively correlated with axis I versus the other three sites (zone B) negatively correlated with axis I. The first zone (A) was positively correlated to pH, depth, and current velocity. Taxa associated to this sampled site (St_1, Zone A) were Copepod *Thermocyclops decipiens*, Nauplii stade, *Mesocyclops* sp. and Rotifers taxa *Brachionus caudatus, B. falcatus*, *B. angularis*, *Platyas quadricornis*, *Filinia longirostris, Filinia opoliensis*, *Keratella tropica*, *K. lenzi*, *Lecane* sp., *Synchaeta* sp., *Hexarthra* sp., *Lepadella patella*, and *Colurella* sp., and Cladocera *Diaphanosoma excisum*, *Ceriodaphnia cornuta*, *Moina micrura* and *Bosmina longirostris*. As during the wet season, the axis I, negatively correlated to the other sampling sites (sampling sites group B) subdivide them into two subgroups B_1 (St_3) and B_2 (St_2 and St_4). The first subgroup B_1 was positively correlated to conductivity and redox while the second subgroup B_2 was positively correlated temperature and transparency. Taxa associated to the subgroup B_1 were *Lecane* sp., *Anuraeopsis fissa*, and *Macrothrix* sp. while second subgroup B_2 was characterized on a biologic level by *Thermodiaptomus yabensis* and *Trichotria* sp.

4. Discussion

This work represents the first study of zooplankton communities on Kankelaba River (Niger River tributary) and its relationship to environmental parameters. Thirty-one (31) taxa of zooplankton made up of 20 Rotifera (64.5%), 5 Copepoda (16%), 5 Cladocera (16%) and one insect larva (3.5%) were

recorded during the present study in the Kankelaba River. Zooplankton community obtained in Kankelaba River during this study includes 16 families and 22 genuses, in addition to copepods Nauplii whose genus have not been determined. Zooplankton diversity obtained during the present study (n = 31 taxa) in Kankelaba River is relatively lower than zooplankton diversity mentioned by N'da *et al.* (2015) in the Bagoé River (Niger tributary in Côte d'Ivoire) (n = 38 taxa). It is also lower than the one reported by Aka *et al.* (2000) in 49 shallow reservoirs of the north of Côte d'Ivoire (n = 30 taxa).

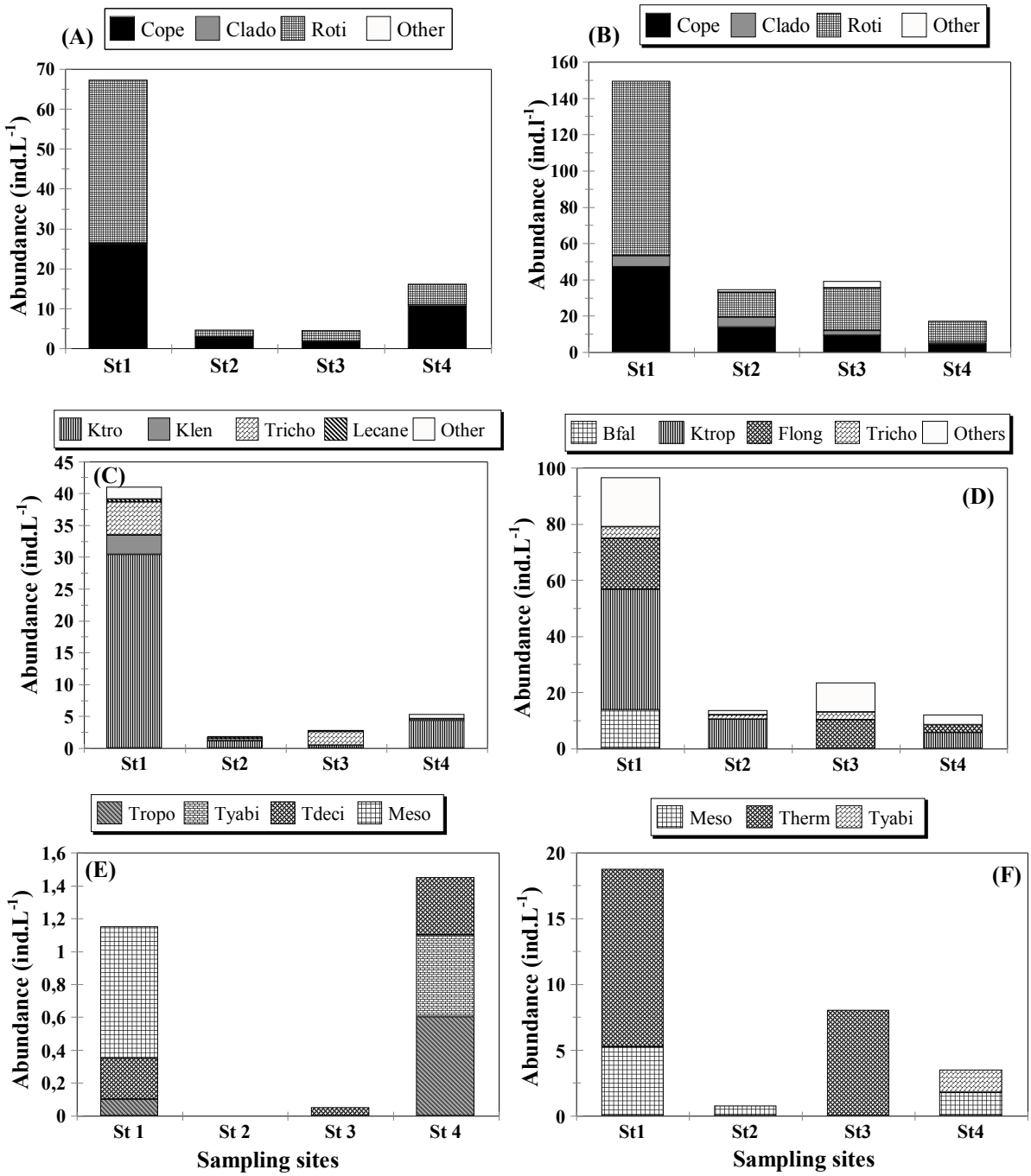

Figure 3. Spatial variations of the total zooplankton abundance (A, B), of the abundance of the main Rotifera (C, D) and Copepoda (E, F) taxa collected in the Kankeleba River (Niger tributaries in Côte d'Ivoire) during the wet (right, June 2017) and the dry (left, November 2017) seasons (Clado: Cladoceran, Cope: Copepoda, Roti: Rotifera, Others: others zooplankton / Copepoda / Rotifera; See Table II for the codes of zooplankton taxa).

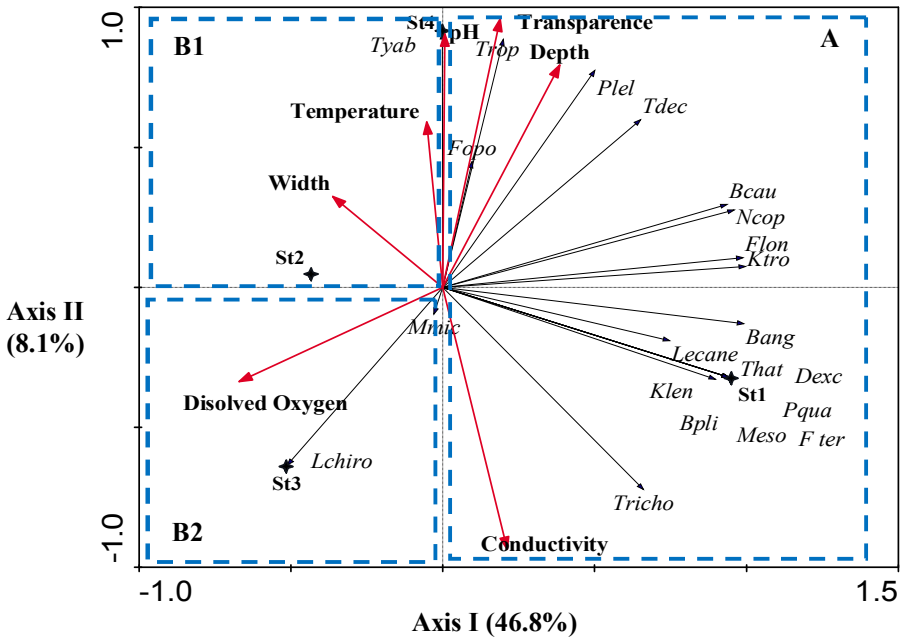

Figure 4. ReDundancy Analysis (RDA) of data from environmental factors and zooplankton taxa collected in the Kankélaba River (Niger tributaries, Côte d'Ivoire) during the wet season (June 2017)

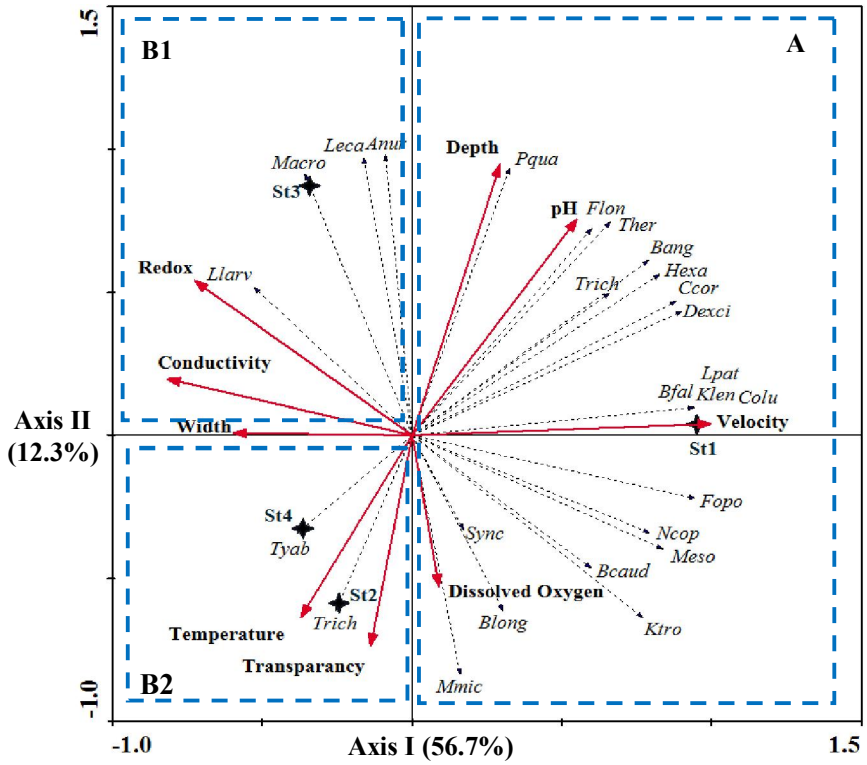

Figure 5. ReDundancy Analysis (RDA) of data from environmental factors and zooplankton taxa collected in the Kankélaba River (Niger tributaries, Côte d'Ivoire) during the dry season (November 2017)

This richness is, on the other hand, higher than to the one recorded in the Comoé stream upper reaches in the Comoé national Park (north of Côte d'Ivoire) by Yao *et al.* (2015) (n = 20 taxa). Compared to zooplankton diversity of other tributaries of the Niger stream, diversity in the present study (n = 31 taxa) is lower than those reported by several studies focus in the Niger delta (Nigeria): 79 species in Orogodo river (Arimoro and Oganah, 2010), 58 taxa in Ekpan river (Iloba and Ruejoma, 2014), 45 taxa in Mbo river (Essien-Ibok and Ekpo, 2015). But, it is comparable to the one reported by Ikhuoriah *et al.* (2015) in the Ossiomo river (Niger delta, Nigeria) (n = 22 taxa).

The difference between the zooplankton diversity in the present study and others studies cited below may due to the natural condition in the water bodies and times of sampling. Indeed, according to Yao *et al.* (2015), Ezekiel *et al.* (2011) reported that zooplankton distribution vary from place to place, and year to year due to the dynamic nature of the aquatic systems. Besides, zooplankton diversity difference in these aquatic ecosystems may be attributed to their length and depth difference. Indeed, Graça *et al.* (2004) reported that, according to the length and the depth of lentic water, they offer or no a large variety of microhabitats capable to shelter a diversity of species. Several others factors as sampling duration, the catchment area of the aquatic ecosystem, activities performed on the watershed, can also explain difference in richness observed between this study and studies cited below: Aka *et al.*, 2000; N'da *et al.*, 2015; Yao *et al.*, 2015.

Zooplankton community obtained in this study is common to the traditional ones in tropical and sub-tropical freshwater with greatest diversity in Rotifera phylum (20 taxa, 64% of total diversity) and with Branchionidae as family presenting the most important diversity (9 taxa). The most representative genus belonged to the Rotifera Phylum, were *Brachionus* (4 species) and *Filinia* (3 species) followed by *Platyias*, *Keratella* and *Trichocerca*, with 2 taxa each. Similar observations were also mentioned by N'da *et al.* (2015) in Bagoé river (Niger tributary in Côte d'Ivoire) and by Aka *et al.* (2000) and Yao *et al.* (2015) in freshwater ecosystem of the north of Côte d'Ivoire. Qualitative dominance of Rotifera phylum, Brachionidae family and *Brachionus* genus in zooplankton community is also reported in several other tropical freshwater ecosystems as Agunpa and Ona rivers (Nigeria) (Akin-Oriala, 2003), Tiga lake (Kano, Nigeria) (Akindele, 2013), Ekpan river (Nigeria) (Iloba and Ruejoma, 2014). Similar observations were also obtained in Niger delta (in Nigeria): Orogodoa river (Arimoro and oganah, 2010) and Mbo river (Essien-Ibok and Ekpo, 2015).

On the other hand, the results of the present study contrast with studies of Ezekiel et al. (2011) and Ikhuoriah *et al.* (2015) in Niger delta, respectively in Sombreiro and Ossiomo rivers, who reported that highest diversity was observed in Cladocera and Copepoda groups. According to Arimoro and Oganah (2010), Rotifers constitute the largest group of zooplankton recorded in some aquatics ecosystems because of their ability to undergo vertical migration, which minimizes competition through niche exploitation and food utilization.

This survey revealed for the first time the presence of the Diaptomidae (*Tropodiaptomus* and *Thermodiaptomus*) in the Niger tributary in Côte d'Ivoire. This result confirms the presence of Diaptomidae family's species in the freshwater ecosystems in the north of the Côte d'Ivoire (Aka *et al.*, 2000; Yao *et al.*, 2015). Presence of Diaptomidae family's species is also signaled in other affluents of the Niger watershed, notably in the Niger delta (Nigeria) (Arimono and Oganah, 2010).

Besides, this study revealed 3 species (*Brachionus plicatilis*, *Platyias leloupi*, *Keratella lenzi*) no signaled in Bagoé river (Niger tributary in Côte d'Ivoire) by N'da *et al.* (2015). In contrast, 13 taxes signaled previously by N'da *et al.* (2015) in the Niger watershed in Côte d'Ivoire have not been sampled during the present survey. These are: *Alona* sp., *Bosminopsis* sp., *Moinodaphnia* sp., *Ascomorpha* sp., *Asplanchna* sp., *Brachionus calyciflorus*, *Keratella javana*, *Conochilus* sp., *Epiphanes* sp., *Euchlanis* sp., *Monommata* sp., *polyarthra* sp., *Testudinella* sp., and Ostracoda. These taxa are already signaled in freshwater ecosystems of the north of Côte d'Ivoire (Aka *el al.*, 2000; Yao *et al.*, 2015), so their absence in the result of the present survey could not explain itself that by weakness of our sampling period (only two sampling periods in 4 sampling stations).

This study shows that in Kankélaba river, Rotifera phylum was the most abundant zooplankton group (55 to 61% of total abundance), followed by copepod group (31 to 44%).

It also revealed the predominance of taxa of small sizes as *Keratella tropica* (25 to 39% of total zooplankton abundance according to seasons), Copepods nauplii (18 to 42%), *Trichocerca* sp. (3-9%), *Filinia longiseta* (13%). Predominance of smaller zooplankton species in freshwater ecosystems may possibly be due to predation pressure from planktivorous fishes and other invertebrates that selectively prey on larger sized zooplankton (Lampert, 1993; Dumont *et al.*, 1994).

Indeed, the vertebrate zooplanktivorous as fish exercise a selective prey on large size individuals dragging to long terms a community with

predominance zooplankton of small size (Post and Mcqueen, 1987; Masson *et al.*, 2001). In tropical zone, predation by the vertebrates is essentially the fact of fish larvae and juveniles and like their recruitment is continuous (Lazzaro, 1987), their impact on zooplankton community may be very important. Besides, zooplankton community structure unregistered in Kankeleba river during this study, with predominance of smaller zooplankton taxa like rotifera (*Keratella tropica*, *Trichocerca* sp., etc,) may also be due to environmental parameters effect on zooplankton population. According to Garcia *et al.* (1998), dissolved oxygen and pH were seems to be as limiting factors for species like *Brachionus calyciflorus*, *Lecane luna* and *Keratella tropica*.

This may be the reason for the inverse relationship between *Keratella tropica* and the dissolved oxygen concentration revealed by the RDA analysis in the present study on the one hand and the highest density of this species in the sampling site 1 where dissolved oxygen concentration is low (2.05 $mg.L^{-1}$) on the other hand. This weak value of dissolved oxygen concentration in the sampling site 1 could be bound to the waters eutrophication. According to Badsi *et al.* (2010) cited by Monney *et al.* (2015), a strong representation of rotifers in aquatic ecosystem may be due to its ability to ingest small particles such as bacteria and organic detritus often abundant in eutrophic environments. In addition, the predominance of rotifer species was attributed to the fact that they are opportunistic, small size, with short life cycles and high tolerance to a variety of environmental factors. So rotifers can be considered as an indicator of high biological trophic level.

Conclusion

This study constitutes a contribution to produce baseline data on biodiversity of Niger tributaries in Côte d'Ivoire. It comes to complete the informations on the zooplankton diversity of the Niger stream tributaries in Côte d'Ivoire with 5 new species, of which two copepods (*Tropodiaptomus* sp. and *Thermodiaptomus yabensis*) and three rotifers (*Brachionus plicatilis*, *Platyas leloupi* and *Keratella lenzi*). Zooplankton community unregistered in this study is common to the traditional taxa obtained in tropical and sub-tropical freshwaters with greatest diversity in Rotifera phylum (20 taxa, 64% of total diversity), and with Branchionidae as family presenting the most important diversity (9 taxa).

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