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Composition and dynamic of benthic macroinvertebrates community in semi-arid area rivers of Burkina Faso (West Africa)

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ABSTRACT

The benthic macroinvertebrates communities dynamic were investigated in rivers from Burkina Faso in the purpose to analyze the taxonomic composition, the structure of benthic macroinvertebrates community and the composite environmental variables that correspond to the major distribution patterns of this community. The results showed that a total of 132 taxa was recorded and the large majority of these (103 taxa) belonged to 57 families from 8 orders of insects that represent 95% of relative abundance. We also observed some distinct differences relative to the spatial and temporal variation in the taxonomic composition. The canonical correspondance analysis (CCA) revealed a strong correlationship between Chironomidae, Syrphidae, Culicidae, Psychodidae, as well as the Pulmonates molluscs and organic nutriments feeding dynamics. These findings showed the sensitivity of benthic macroinvertebrates at different level: sensitivity which could be attributable to man-induced activities.

Keywords: Benthic macroinvertebrates, enviromental variables, dynamic, Burkina Faso.

INTRODUCTION

The benthic macroinvertebrates assemblages are widely recognised as the most important group living in rivers and lakes (Covich et al., 1999). They play a key role for the understanding of the structure and functioning of these rivers and lakes ecosystems, due to their wide distribution and limited migration ability and resiliency (Barbour et al., 1999). The benthic macroinvertebrates have been widely used in biomonitoring program, due to several attributes that make them particularly beneficial (Moog et al., 1999; Marzin, 2013). In Addition, they are a primary food source for many fish species, amphibians and birds (Voshell and Reese, 2002). Despite the benefits and the services that they provide to

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humans, waters quality and its living organisms are threatened by human activities such as rapid expansion of urban areas and agriculture (Moore and Palmer, 2005; Kaboré et al., 2016). These pressures caused many changes in the structure of macroinvertebrates community and lead to the decline of biodiversity due to habitat fragmentations and the water pollution in many developing countries. Though, in tropical area, specially in West Africa, the knowledge on these organisms and their ecology is still fragmentary (Sharma et al. 1993; George et al., 2010; Camara et al., 2012; Mesa et al., 20013; Edia et al., 2013). In Burkina Faso, only a few studies have been conducted with benthic macroinvertebrate communities. These studies mainly concerned the inventory of macroinvertebrates in the Mouhoun river (Guenda, 1985, 1996) and the response of benthic macroinvertebrates to anthropogenic interferences (Koblinger and Trauner, 2013; Sanogo et al., 2014; Kaboré et al., 2016). However, the spatial and temporal dynamic changes in macroinvertebrates were not clearly addressed in these earlier studies. The key aims of the present study is to identify and describe the composition, the diversity of benthic macroinvertebrates in Burkina Faso and to determine the enviromental factors that influence the macroinvertebrates distribution.

MATERIALS AND METHODS

Study area

The study was undertaken in three main rivers in Burkina Faso described in Kaboré et al. (2016): Volta rivers (Mouhoun and Nakambé) and Comoé river (Figure 1). Volta river covers an estimated area of 400,000 km² and spread over six West African countries (Sanwidi, 2007). Located between the north latitudes of 5° 30’N in Ghana 14°30’N in Mali and the longitudes 5°30’W to 2°00’E, the Volta rivers basin is drained mainly by two main sub-basins in the northern part which belong to Burkina Faso. In Burkina Faso the Volta rivers names changed to Nakanbé (formerly White Volta) and the Mouhoun (formerly Black Volta). Natural vegetation, mostly savanna grasslands, uses the major part of the rainfall (around 80%) throughout the basin. River discharge is highly sensitive to variations in annual rainfall (Sanwidi, 2007). The geological formations of the basin are dominated by the Voltaian system consisted of Precambrian to Paleozoic sandstones, shales and conglomerates. Water resources and agricultural activities in the basin are therefore unpredictable. However, 18.6 million people (Barry et al., 2005; Sanwidi, 2007) with an annual growth rate of 2.4% rely on these activities.

The Comoé (area of 17,590 km² covering 6.4%) is a perennial river in the extreme south-west of Burkina Faso where the annual rainfall exceeds 1000 mm (Sally et al., 2011) with annual evaporation rate of 2000 mm (Kabré et al., 2002). Bordering Mali and Ivory Coast, it is located in the Sudanian climatic zone with tropical characteristics (Sirima et al., 2009). Temperatures in the basin vary, from 24 to 25 °C minimal and 31 to 32 °C the maximal. The area drained by Comoé river is called “Cascades” due to the abundance of water. Dams were also constructed in the area to secure sugar production and also guarantee the municipal water supply to the town of Banfora (Sally et al., 2011). The basin is drained by the Léraba and Comoé rivers, which are perennial, and by several temporary rivers such as Kodoum, Baoué and Iringou. The total annual surface discharge is estimated at 1.6 billion cubic meters of which 85 million cubic meters are retained by dams.

Sampling sites lay within a continuum ranging from low to very high intensity of anthropogenic impacts in the floodplain area (Kaboré et al., 2016). Three sampling campaigns were conducted according to the rivers hydrology. The first sampling was conducted in 2012 from July to September corresponding to high water flow (rainy reason), and low water flow (end of rainy season) from October to December of the same year. The third sampling was conducted from March to June 2014, corresponding at lowest water flow (dry season).

Physicochemical parameters sampling and analysis methods

In situ parameters such as, pH, electrical conductivity (cond), temperature and dissolved oxygen (O2) were measured with field multimeters (WTW 340i) before the macroinvertebrate sampling, and the velocity (m/s) with Global Water Flow Probe FP111. For the other parameters such as nutrients, 1.5 L of water was taken in a plastic bottle , stored on icefor further analysis in the laboratory. Nutrients was determined by molecular absorption spectrophotometry for Nitrate, Ortophosphate, Ammonium. All these parameters were measured with an accuracy ranking from 1 to 2% in the Laboratoire National d'Anlyse des Eaux which belong to the Ministère de l'Environment et du Development Durable [MEDD].

Benthic macroinvertebrates sampling

The benthic invertebrates were sampled with a hand net (rectangular opening: 25 cm x 25 cm, mesh size: 500 µm) and sorted following the same protocol as Kaboré et al. (2016). Multi-habitat sampling approach (Moog, 2007) was used, a pooled sample, consisting of 20 sampling units, was taken from all habitat types occupying a minimum of 5% or more of the study area. The number of sampling units allocated to each habitat type was proportional to the areal coverage of the latter. The habitats were composed of macrophytes (emerged and submerged plants), sediment (sand, mud, litter) and coarse substrate. The sampling started from downstream to upstream , the net was bumped against the bottom substrate to dislodge and collected organisms. The samples were kept in the alcohol (90%) for detailed examination in the laboratory. Prior to sorting out the organisms, samples were sieved and the animals were separated. The animals were identified with the dichotomic microinvertebrates keys manuals of Tachet et al. (2003), Merrit et Cummins (1984), Lévêque et Durand (1981) and Moisan et Pelletier (2008) and with direct taxonomic expert support.

Data analysis

The total taxa richness (R) was simply taken as a count of number of species present in each site. We used Non-metric multidimentional scaling (NMS) scatter plot (presence-absence, distance measure: Bray-Curtis similarity) of all sampling site and taxa to visualize possible predictors of faunal variation. The diversity indices provide more information about community composition, about scarcity and commonness of species in a given community; Shannon-Wiener index (H), Equitability index are commonly used to characterize species diversity in a community. Shannon-Wiener diversity index was expressed following the equation [1] below, where pi is the proportion of individuals found in the ith taxon, S is the number of taxa in the samples.

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \qquad [1]$$

Species equitability or evenness (E) was determined by the equation [2].

$$\text{Equitability (E)} = \frac{H}{\ln S} \qquad [2]$$

Where;
H was the Shannon-Wiener index, S was the number of species in samples.

The density is an important tool to measure benthic community production in aquatic ecosystems (Barbour et al., 1996). The density was estimated following the equation [3]

$$D\left(\frac{\text{ind.}}{m^2}\right) = \frac{\text{Total Number of animals}}{\text{Area of samling units}} \qquad [3]$$

We conducted a Kruskal–Wallis ANOVA and Mann-Whitney tests with a software (SPSS, version 2.1) followed by pairwise comparison tests to compare taxa richness (R), Shannon-Wiener Diversity (H), equitability (E) and biomass (D) between different rivers and seasons, and then between ecoregions. Finally, the canonical correspondence analysis (CCA) was performed to define composite environmental variables that correspond to the major patterns of community occurrence.

RESULTS

Physicochemical parameters

Table 1 summarizes the physical and chemical conditions of the study stations. Most of the sampled sites had warm waters (mean temperature of 29.9 °C). The pH values was slightly alkaline (mean pH of 7.24), with high conductivity (≥100 µS.cm^{-1}). Some picks of variations in organic ions concentrations were observed between sampling sites.

Benthic macroinvertebrates composition

A total number of 33,357 specimens of benthic macroinvertebrates were collected. Eight orders of insect were recorded in the running water of the three rivers in Burkina Faso (Figure 2). All the sites were dominated by insects (relative abundance of 95%), represented mostly (80.3%) by midges and flies (Diptera). The mayflies (Ephemeroptera) and caddisflies (Trichoptera) made up 7.3% of abundance. The Lepidoptera and Plecoptera, as well as the Bivalvia, Ostracoda and Arachnida were found in frequencies lower than 0.5%.

Taxa richness

A high diversity of benthic macroinvertebrates with a total of 132 taxa was recorded in this study (Table 1). A large majority of these (103 taxa) belonged to 57 families from 8 orders of insects: Ephemeroptera, Odonata, Diptera, Coleoptera, Trichoptera, Lepidoptera, Plecoptera and Hemiptera. The remaining 27 taxa belonged to 11 families of Decapoda (Crustacea), Gastropoda and Bivalvia (Mollusca). Coleoptera represented the most diversified group of insects with the following families (taxa): Hydrophilidae (8), Elmidae (7), Dytiscidae (6) and the Noteridae (3). They were followed by Diptera (23), dominated by Chironomidae (4) and Simuliidae (4). Within the non-insect fauna we found an important diversity in Molluscs, with several species reported for Burkina Faso (Table 1). Thus, a total of 15 taxa of gastropod composed of Bulinidae (6), Thiaridae (3), Planorbidae (2), Ampullaridae (2), Lymnaeidae (1) and the Viviparidae (1) were observed. In the Bivalvia class, 3 families including seven species were recorded. Finally, we also found two species of freshwater shrimps belonging to the Palaemonidae and Atyidae families (Table A1).

Seasonal and spatial variation on benthic macroinvertebrates community

Figure 3 shows Non-metric multidimentional scaling analysis with spatial and temporal variation of all sampling sites. The three scatter plots did not reveal a clear difference between the three rivers (a), ecoregions (b), seasons (c) respectively based on the taxa occurrence (Figure 3). But, some distinct differences relative to the basins watersheds could be observed in the taxonomic composition (Figure 4 I). This mean overall taxonomic richness (R=19.63±3.77) and Shannon–Wiener diversity index (H=2.00± 0.33) were highest in Comoé and reached a minimum of R=8.30 ± 1.05 and H=1.12 ± 0.12 in Nakanbé River (Figure 4 I). While both Nakanbé (means of R= 12.23±1.55, D=446.12±198.69, E= 0.63±0.05) and Mouhoun (means of R=8.30 ±1.05, D=410.93±126.03, E=0.57±0.05) basins watersheds were distinguished by slightly high overall taxonomic richness, densities , Shannon–Wiener diversity and Equitability, respectively (Figure 4 I).

The overall taxonomic richness (mean of R= 12.68± 1.40), Shannon–Wiener index (mean of H=1.51±0.15), Equitability (mean of E= 0.63±0.04) and density (mean of D= 458.53±178.23) tended to increase in Lower Soudanian eco-region compared to Upper Soudanian eco-region (mean of R= 10.19±1.53, H= 1.2±0.13, E= 0.6±0.04, D= 343.12±106.68, respectively see Figure 4 II).

In the Figure 4 III, the lowest density (mean of D= 82.19±15.69) was recorded in rainy season while the highest was recorded in dry season (mean of D= 629.81). In contrast, the high Shannon–Wiener index (mean of H= 1.6 ± 0.20), taxa richness (mean of R= 13.31±2.04) and Equitability (mean of E= 0.64±0.06) were recorded in the rainy season. The taxa richness (R=10.31± 1.37; 12.44 ± 2.42), Shannon–Wiener index (H= 1.29 ± 014; 1.39 ± 0.16), Equitability (E= 0.61± 0.05; 0.59 ± 0.05) did not reveal a big difference between the dry season and the end of rainy season, respectively ($p>0.05$, pairwise comparison tests, Figure 4 III e, f and g).

Influence of physicochemical parameters on benthic macroinvertebrate assemblage

Figure 5 shows the biplots of species and physico-chemical parameters with eigenvalues for axis 1 (0.36) and axis 2 (0.23); both axis explained 59.4% of the variance of overall variables. The first two axes of CCA captured about 82.2% information of species-environment correlations according to Monte Carlo test (pvalue <0.05). Thus, nitrate and orthophosphate (r=0.6 all, respectively), ammonium (r=0.7) and the conductivity (r=0.8) are positively related to axis1. The Diptera including Chironomidae, Syrphidae, Culicidae, Psychodidae, and the Pulmonates molluscs frequency showed a strong correlation with the organic pollution; in contrast the Ephemeroptera, Plecoptera and Trichoptera are correlated with dissolved oxygen and water current.

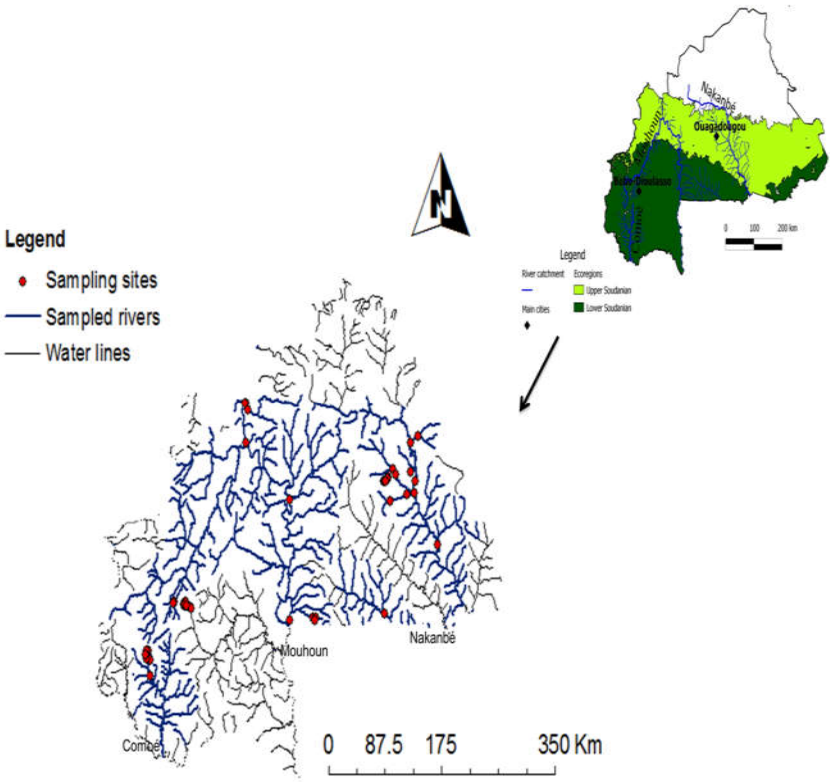

Figure 1: Map of study areas showing the Burkina Faso and the three rivers where the samples were taken.

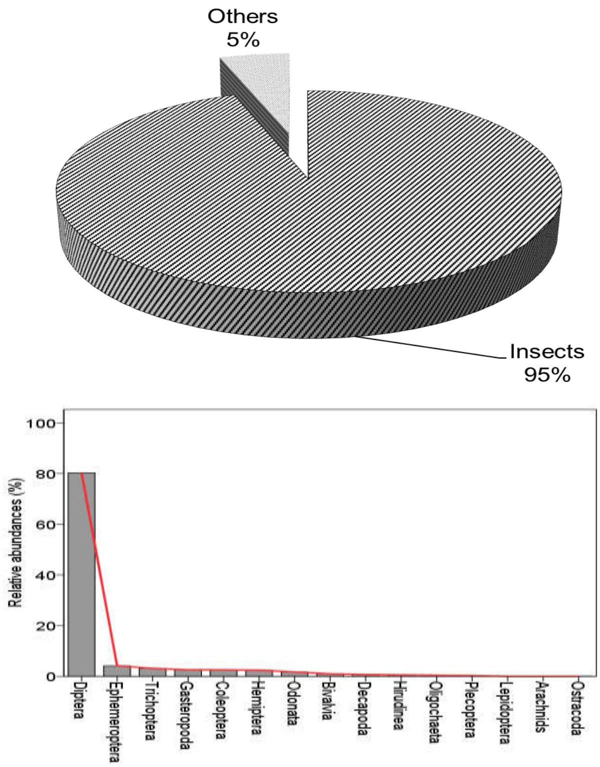

Figure 2: The relative abundances (%) of benthic macroinvertebrate groups.

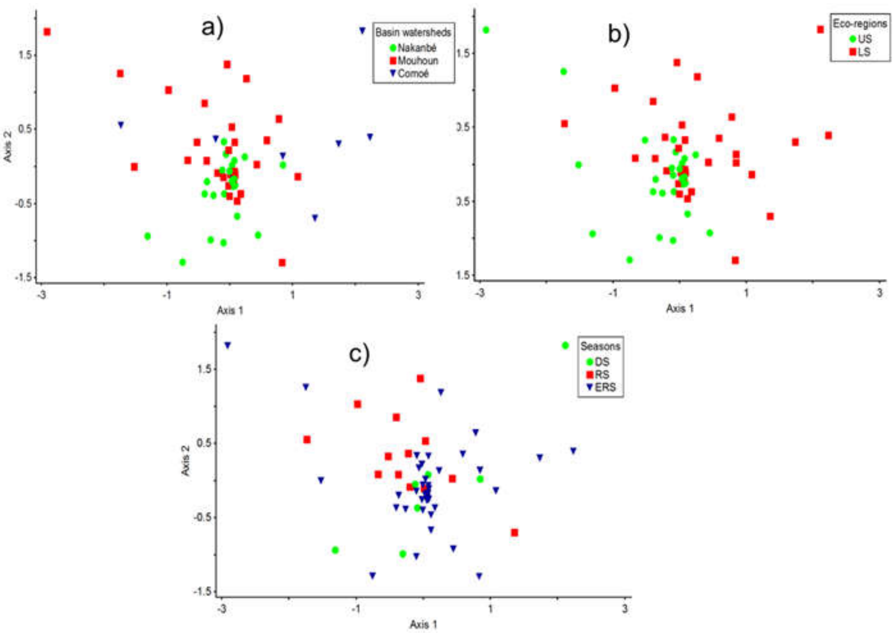

Figure 3: NMS-scatter plot of all samples (N=66) showing the spatial and temporal variation of benthic macroinvertebrates communities (Distance measure: Sorensen (Bray Curtis) using presence-absence transformed. a) = indicates ecoregions, b)=seasons and c)= basins watersheds. (17.57265 = final stress for 2-dimensional solution, 0.00000 = final instability, 194 = number of iterations).

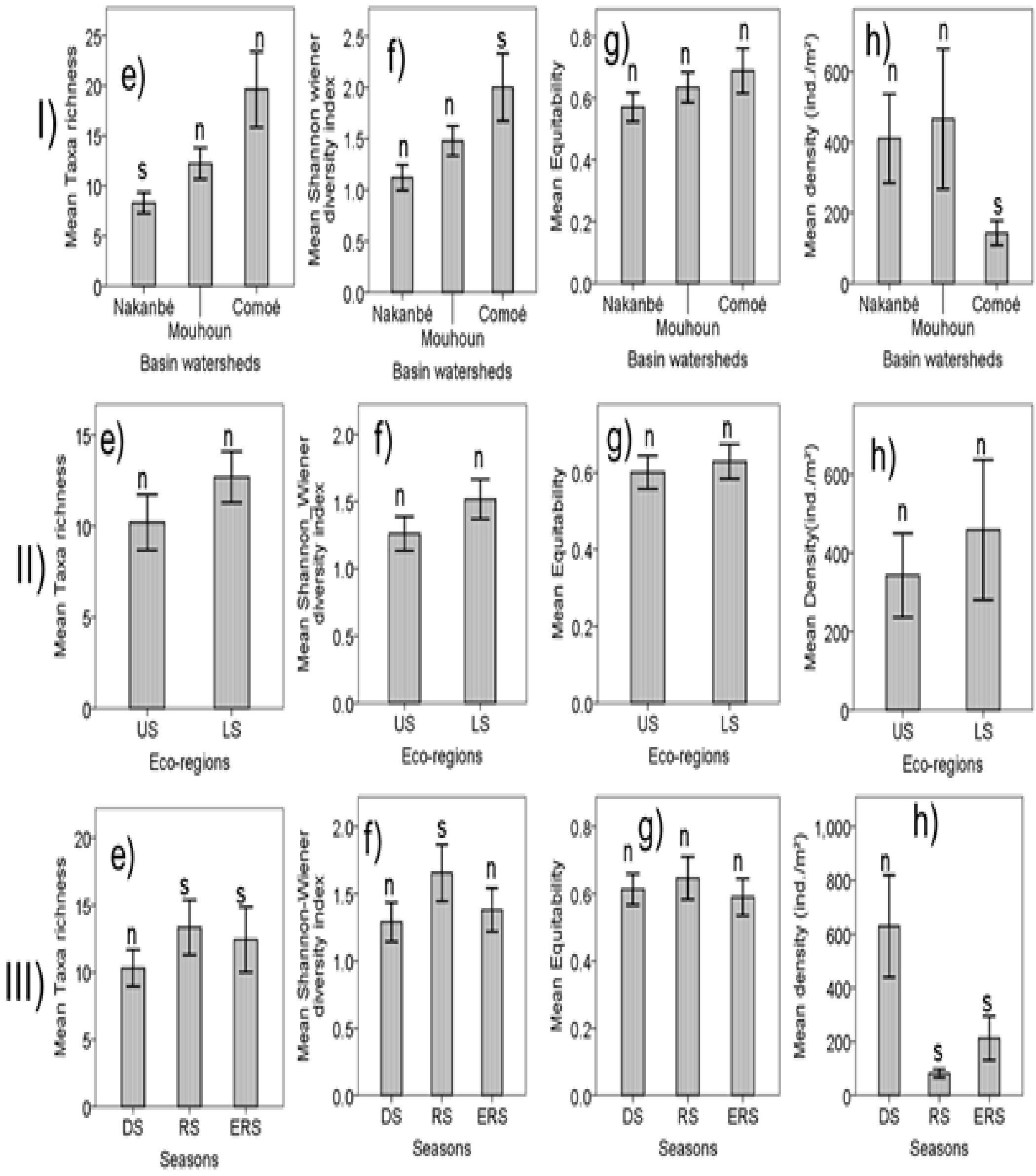

Figure 4: Diagram showing variation of taxa richness (e), Shannon–Wiener index (f), Equitability (g) and density (h) in different basin watersheds. Nakanbé, Mouhoun and Comoé (I), (II) R (e), H (f), E (g) and D (h) between different eco-regions. US: Upper Soudanian ecoregion, LS: Lower Soudanian ecoregion and III) R (e), H (f), E (g) and D (h) between different seasons. DS: dry season, RS: rainy season and ERS: end of rainy season. Letters above diagrams indicate statistical significance of differences between environmental factor types (pairwise comparison tests): only respective pairs with different alphabetical letters differ significantly ($P<0.05$).

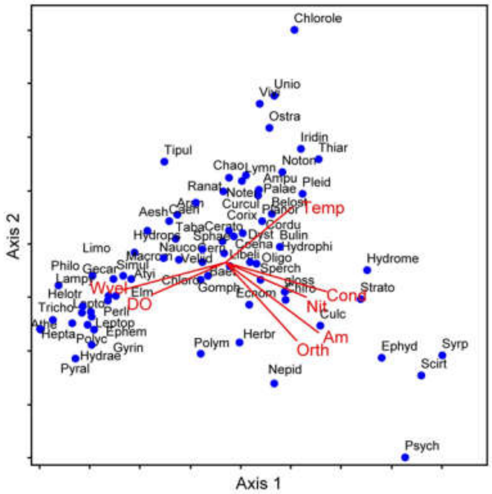

Figure 5: Relationship between physico-chemical variables and benthic macroinvertebrates based on canonical correspondance analysis (CCA). Aran =Araneae ,Limo= Limoniidae, Chiro=Chironomidae, Cerato=Ceratopogonidae, Chao=Chaoboridae, Culc=Culicidae, Ephyd=Ephydridae, Tipul=Tipulidae, Strato=Stratomyiidae, Syrp=Syrphidae, Taba=Tabanidae, Athe=Athericidae, Simul=Simuliidae, Psych=Psychodidae, Gecar=Gecarcinucidae, Atyi=Atyidae, Ostra=Ostracoda, Palae=Palaemonidae, Caen=Caenidae, Bae=Baetidae, Ephem=Ephemerelliidae, Hepta=Heptageniidae, Leptop=Leptophlebiidae, Tricho=Trichorythidae, Polym=Polymitarcyidae, Ecnom=Ecnomidae, Hydrops=Hydropsychidae, Lepto=Leptoceridae, Philo=Philopotamidae, Polyc=Polycentropodidae, Gomph=Gomphidae, Aesh= Aeshnidae, Chloro=Chlorocyphidae, Chlorole= Chlorolestidae, Coena=Coenagrionidae, Cordu=Cordullidae, Libeli=Libelilludae, Macrom=Macromiidae, Curcul=Curculionidae, Dyst=Dytiscidae, Elm=Elmidae, Lampy=Lampyridae, Hydrophi=Hydrophilidae, Hydrae=Hydraenidae, Gyrin=Gyrinidae, Noter=Noteridae, Sperch=Spercheidae, Scirt=Scirtidae, Corix=Corixidae, Gerri=Gerridae, Helotr=Helotrephidae, Herbr=Herbridae, Hydrome=Hydrometridae, Belost=Belostomatidae, Nauco=Naucoridae, Nepid=Nepidae, Noton=Notonectidae, Veliid=Veliidae, Pleid=Pleidae, Ranat=Ranatridae, Bulin=Bulinidae, Lymn=Lymnaeidae, Planor=Planorbidae, Ampu=Ampullaridae, Thiar=Thiaridae, gloss=glossiphoniidae, Oligo=Oligochaeta, Perli=Perlidae, Pyral=Pyralidae, Iridin=Iridinidae, Sphae=Sphaeriidae, Unio=Unionidae, Vivi=Viviparidae.

Table 1: Summary of physicochemical parameters of study sites in Burkina Faso water bodies

Water variables	Rivers	Mean
	Comoé	26.92 (± 0.46)
Temperature (ºC) [Tem]	Mouhoun	30.55 (± 0.42)
	Nakanbé	29.95 (± 0.65)
	Comoé	7.94 (± 0.27)
PH	Mouhoun	6.97 (± 0.11)
	Nakanbé	7.33 (± 0.12)
	Comoé	57.97 (± 15.56)
Conductivity (µS/cm) [Cond]	Mouhoun	167.80 (± 24.05)
	Nakanbé	440.71 (± 79.54)
	Comoé	6.47 (± 0.85)
	Mouhoun	4.36 (± 0.43)
Dissolved Oxygen (mg/l) [DO]	Nakanbé	5.16 (± 0.62)
	Comoé	0.74 (± 0.07)
Nitrate (mg/l) [Nit]	Mouhoun	5.90 (± 1.72)
	Nakanbé	12.20 (± 3.07)
	Comoé	0.26 (± 0.05)
	Mouhoun	2.31 (± 0.58)
Ortophosphate (mg/l) [Orth]	Nakanbé	2.83 (± 0.65)
	Comoé	1.52 (± 0.85)
Ammonium (mg/l) [Amm]	Mouhoun	2.05 (± 0.45)
	Nakanbé	5.19 (± 1.86)
	Comoé	0.68 (± 0.12)
Water velocity (m/s) [Wvel]	Mouhoun	0.32 (±0.07)
	Nakanbé	0.08 (±0.03)

Table A1: List of the aquatic benthic macroinvertebrates taxa recorded in this study.

Embranchement	Classes	Orders	Families	Taxa	Abundances	Densities (ind/m²)	Frequencies
			Curculionidae	*Stenolophus angolensis*	4	3.2	4.55
				Bidessini sp.	10	8	3.03
				Hydrovatus sp.	136	108.8	21.21
				Methles sp.	9	7.2	4.55
	Insecta	Coleoptera	Dytiscidae	*Laccophilus* sp.	41	32.8	15.15
				Neptosternus sp.	142	113.6	7.58
				Yola sp.	9	7.2	4.55
			Elmidae	*Dubiraphia* sp.	16	12.8	7.58

Table A1. (Continued)

Embranchement	Classes	Orders	Families	Taxa	Abundances	Densities (ind/m²)	Frequencies
				Elmis sp.	20	16	3.03
				Stenelmis sp.	14	11.2	6.06
				Microdinodes sp.	3	2.4	3.03
				Leptelmis sp.	8	6.4	4.55
				Potamodytes sp.	7	5.6	3.03
				Pseudomacronychus sp.	73	58.4	15.15
			Gyrinidae	*Orectogyrus* sp.	16	12.8	3.03
			Hydraenidae	*Hydraenopsis* sp.	6	4.8	3.03
			Hydrophilidae	*Amphios* sp.	28	22.4	15.15
				Berosus sp.	26	20.8	7.58

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
				Enochrus sp.	20	16	7.58
				Sternolophus sp.	36	28.8	4.55
				Helochares sp.	49	39.2	19.70
				Helocharimorphus sp.	4	3.2	1.52
				Ceolostoma sp.	6	4.8	6.06
				Regimbartia sp.	11	8.8	6.06
			Lampyridae	Lampyridae	2	1.6	3.03
				Hydrocanthus sp.	20	16	7.58
			Noteridae	*Neohydrochantus* sp.	12	9.6	3.03
				Canthydrus sp.	79	63.2	15.15
			Scirtidae	Scirtidae	30	24	3.03

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
			Spercheidae	*Spercheus* sp.	21	16.8	4.55
			Athericidae	*Atherix* sp.	6	4.8	3.03
			Ceratopogonidae	*Bezzia* sp.	28	22.4	15.15
			Chaoboridae	*Chaoborus* sp.	14	11.2	10.61
				Chironomini sp.	4097	3277.6	43.94
		Diptera	Chironomidae	*Chironomus* sp.	15468	12374.4	33.33
				Tanypus sp.	126	100.8	25.76
				Tanytarsus sp.	37	29.6	9.09
			Culicidae	Culicidae	3208	2566.4	25.76
				Aedes sp.	159	127.2	10.61
			Ephydridae	Ephydridae	174	139.2	4.55

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
			Limoniidae	*Antocha* sp.	1	0.8	1.52
			Macromiidae	*Macromia* sp.	3	2.4	3.03
			Psychodidae	Psychodidae	1508	1206.4	13.64
			Simuliidae	*Simulium* sp.	1516	1212.8	18.18
				Simulium aureosimile	2	1.6	1.52
				Simulium ruficorne	7	5.6	1.52
				Simulium adersi	6	4.8	1.52
			Stratomyiidae	Stratomyiidae	4	3.2	4.55
			Syrphidae	*Chrysogaster* sp.	68	54.4	1.52
				Eristalis sp.	314	251.2	13.64
			Tabanidae	*Chrysops* sp.	19	15.2	13.64
				Tabanus sp.	4	3.2	3.03

Table A1. (Continued)

Embranchement	Classes	Orders	Families	Taxa	Abundances	Densities (ind./m²)	Frequencies
			Tipulidae	Tipulidae	5	4	3.03
		Hemiptera	Belostomatidae	*Diplonycus* sp.	30	24	16.67
				Appasus sp.	92	73.6	3.03
				Belostoma sp.	37	29.6	9.09
			Corixidae	*Micronecta* sp.	255	204	24.24
			Gerridae	*Limnogonus* sp.	4	3.2	6.06
				Hynesionella sp.	10	8	3.03
				Rhagadotarsus sp.	22	17.6	16.67
			Nepidae	*Laccotrephes* sp.	12	9.6	3.03
			Ranatridae	*Ranatra* sp.	7	5.6	7.58
			Notonectidae	*Notonecta* sp.	106	84.8	13.64

Table A1. (Continued)

Embranchement	**Classes**	**Orders**	**Families**	***Taxa***	**Abundances**	**Densities (ind./m²)**	**Frequencies**
			Pleidae	*Plea* sp.	12	9.6	4.55
			Hydrometridae	*Hydrometra* sp.	19	15.2	4.55
			Helotrephidae	*Esakiella* sp.	100	80	12.12
			Naucoridae	*Naucoris* sp.	9	7.2	7.58
				Macrocoris sp.	28	22.4	13.64
			Herbridae	*Herbrus* sp.	6	4.8	3.03
			Veliidae	*Rhagovelia* sp.	71	56.8	15.15
		Hephemeroptera	Baetidae	*Baetis* sp.	926	740.8	50.00
				Centroptilum sp.	86	68.8	13.64
				Cleon sp.	4	3.2	3.03
			Caenidae	*Caenomedea* sp.	73	58.4	18.18
			Ephemerelliidae	Ephemerelliidae	6	4.8	3.03

Table A1. (Continued)

Embranchement	**Classes**	**Orders**	**Families**	***Taxa***	**Abundances**	**Densities (ind./m²)**	**Frequencies**
			Heptageniidae	*Notonurus* sp.	61	48.8	7.58
			Leptophlebiidae	*Euthraulus* sp.	204	163.2	12.12
			Polymitarcyidae	*Ephoron* sp.	18	14.4	6.06
			Tricorythidae	*Trichorythus* sp.	15	12	3.03
		Lepidoptera	Pyralidae	Pyralidae	7	5.6	4.55

			Aeshnidae	*Anax* sp.	2	1.6	3.03
			Chlorocyphidae	*Chlorocypha* sp.	21	16.8	6.06
				Coenagrion sp.	108	86.4	25.76
		Odonata	Coenagrionidae	*Enallagma* sp.	20	16	1.52
				Ishnura sp.	62	49.6	6.06
				Pseudagrion sp.	124	99.2	13.64
			Corduliidae	*Phyllomacromia* sp.	19	15.2	10.61

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
				Oxygastra sp.	38	30.4	4.55
				Paragomphus sp.	14	11.2	10.61
			Gomphidae	*phyllogomphus* sp.	8	6.4	3.03
				Onychogomphus sp.	2	1.6	1.52
				Orthetrum sp.	6	4.8	3.03
			Libellulidae	*Zygonix* sp.	130	104	27.27
				Bradinopyga sp.	13	10.4	4.55
			Macromiidae	*Macromia* sp.	3	2.4	1.52
		Plecoptera	Perlidae	*Neoperla spio.*	99	79.2	9.09
		Trichoptera	Dipseudopsidae	Dipseudopsidae	4	3.2	1.52
			Ecnomidae	*Ecnomus* sp.	6	4.8	3.03

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
			Hydropsychidae	*Cheumatopsyche digitate*	878	702.4	16.67
				Macronematini	2	1.6	1.52
			Leptoceridae	*Leptocerus* sp.	69	55.2	10.61
				Oetis sp.	32	25.6	6.06
			Philopotamidae	*Chimarra petri*	51	40.8	3.03
			Atyidae	*Caridina africana*	135	108	13.64
	Malacostraca	Decapoda	Gecarcinucidae	Gecarcinucidae	14	11.2	7.58
			Palaemonidae	*Macrobranchium dux*	90	72	12.12
	Ostracoda			Ostracoda	4	3.2	6.06
Mollusca	Bivalvia	Unionoida	Iridinidae	*Aspatharia* sp.	7	5.6	1.52
				Chambardia wahbergi	4	3.2	1.52

Table A1. (Continued)

Embranchement	Classes	Orders	Families	*Taxa*	Abundances	Densities (ind./m²)	Frequencies
			Unionidae	*Mutela rostrata*	14	11.2	6.06
				Mutela sp.	5	4	1.52
				Coelatura aegyptiaca	2	1.6	1.52
				Coelatura sp.	279	223.2	4.55
		Veneroida	Sphaeridae	*Sphaerium* sp.	17	13.6	12.12
	Gastropoda	Architaenioglossa	Ampullaridae	*Lanistes ovum*	10	8	3.03

	Lanistes varicus	23	18.4	10.61
Lymneidae	*Lymnae natalensis*	46	36.8	10.61
Planorbidae	*Biomphalaria* sp	9	7.2	6.06
	Biomphalaria pfeifferi	172	137.6	13.64
Bulinidae	*Bulinus camerunensis*	30	24	4.55
	Bulinus troncatus	2	1.6	1.52

Table A1. (Continued)

Embranchement	**Classes**	**Orders**	**Families**	***Taxa***	**Abundances**	**Densities (ind./m²)**	**Frequencies**
				Bulinus forskali	6	4.8	4.55
				Bulinus globosus	5	4	4.55
				Bulinus jousseaumei	23	18.4	3.03
				Bulinus senegalensis	44	35.2	12.12
			Viviparidae	*Bellamya unicolor*	48	38.4	4.55
				Cleopatra bulimoïdes	233	186.4	9.09
		Sorbeoconcha	Thiaridae	*Cleopatra* sp.	212	169.6	6.06
				Potamoda sp.	1	0.8	1.52
Annelida	Clitellata			Hirudinea	182	145.6	10.61
				Oligochaeta	149	119.2	28.79
	Arachnid			Arachnid	6	4.8	6.06

DISCUSSION

Freshwater benthic macroinvertebrates was characterized by the Arthropoda=> Mollusca => Annelida (Akindele and Liadi, 2014; Tampo et al., 2015), as confirmed by this study. This taxonomic list recorded is common to the traditional one reported in freshwaters of Burkina Faso (Guenda, 1996; Sanogo, 2014) and other Afrotropical regions (Edia et al., 2013; Kouadio et al., 2008; Okorafor et al., 2012). Compared to the others studies in some West Africa rivers, Burkina Faso streams appears rich in benthic macroinvertebrates. These results are similar to those reported by Vinson and Hawkins (1996), Camara et al. (2012), Kearns and Stevenson (2012) and Kaboré et al. (2016) who have demonstrated that the sampling technique employed and the types of habitats (e.g. natural habitats, multi-habitats) can explain the high number of taxa found in a given study. The benthic macroinvetrebrates composition presents a strong seasonal and spatial effects variation which can be justified by the variation of water quantity and mouvement. The year can be divided into three sub-hydrological periods to characterize the benthic maxroinvertebrates structure. Although we recorded high number of taxa and the lowest biomass in the rainy season. This may be explained by the fact that the runoff brings a great quantity of foods consisted of organic matter, bacteria, phytoplakton and Zooplankton (Ouéda et al., 2007) into the water bodies; which improve food condition for benthic macroinvertebrates. In Addition, the high taxa richness could also be attributed to abundance of macrophytes that enhance environmental heterogeneity, provide protection from predators and reduced competition betweeen species (Uwadiae, 2013; Gong et al., 2000; Kaboré et al., 2016). However the lowest density at the same time is due to enlargement of ecological niche (e.g. expanding of flooded areas). Comparing the three basin watersheds benthic macroinvertebrates, we found that Nakanbé bears the low taxa richness. The similar trend was observed in Upper Soudanian ecoregion mainly drained by Nakanbé river. Melcher et al. (2012) and Ouedraogo (2010) have demonstrated that Nakanbé basin watershed is the most populated and dammed area with intensly anthropogenic activities and urbanisation; as a consequence, these pressures deteriorate the water quality and the river systems and finally lead to multiple biodiversity extinctions. The poor water quality could be attributed to several man-induced activities such as urban runoff to surface river water, the waste dumps into the rivers (Wright et al., 1995; Aggrey-Fynn et al., 2011; Kaboré et al., 2016). The benthic macroinvetebrates may have different levels of sensitivity to pollution and many abiotic factors in the river ecosystems. The high values of conductivity, nitrate, ammonium , orthophoshate and the low values of dissolved oxygen observed in somes sites are indications of deteriorated water quality as a result of various anthropogenic activities in that sites (Amiro et al., 2010; Tampo et al., 2015). Such anthropogenic pollution corroborates with the use of agricultural fertilizers and urban sewage both pollutants are believed to increase the concentrations of organic ions in the water bodies (Sanogo and Kabré, 2014; Ouedraogo et al., 2015). Ouéda et al. (2007) and Kaboré et al. (2016) observed similar trend of organic ions in density inhabited area and urban streams where wastes (e.g. domestic, industrials and urban) are constantly discharged into the stream/rivers. Which, should justify the relationship between these variables with tolerant taxa such as Syrphidae, Culicidae, Psychodidae, as well as the Pulmonates molluscs that increase with increasing disturbance (Nkwoji et al., 2010; Moya et al., 2012; Tampo et al., 2015). Through the sensitive taxa Ephemeroptera (Heptageniidae, Ephemerelliidae), Plecoptera and Trichoptera taxa are often the most abundant insects encountered in sites with a sufficiently high dissolved oxygen concentration and good habitats condition (Arimoro et al., 2010; Shelly et al., 2011).

Conclusion

This study described the benthic macroinvertebrates community dynamic in three main rivers in Burkina Faso. We recorded high taxa richness, indicating that the streams/rivers of Burkina Faso appear very rich. Among the factors potentially important that explain the possible predictors of faunal relationships, we observed some differences in community structure suggesting that environmental factors such as the seasons, the activities in basins watershed and the physicochemical variables could play a key role in the distribution pattern of benthic macroinvertebrates in Burkina Faso. In further study, it is allowed, from this present work to address on the one hand the nutritional role of each available habitats and physicochemical factors on the aquatic communities and on the other hand the role of the aquatic macroinvertebrates as biological indicators of detoriated habitats.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

IK: Conception, field work design, manuscript writing, systematic, data processing. IO: Field work, systematic, manuscript reading and editing. LT: Manuscript review and editing, data processing. AO: Study design, data processing, manuscript review. OM: Field work design, manuscript review and editing, supervision. WG: Systematic and Supervision. AHM: Supervision, manuscript review and editing, project leader.

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