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Ecological factors and Dictyoptera (Blaberidae) association - benthic macroinvertebrates, in some forest streams in the Centre region of Cameroon

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Abstract

A study was conducted from January 2016 to January 2017 in four forest streams of the Mefou watershed (Abouda, Fam, Nkoumou and Nga) to determine the ecological factors that affect the organization of the coupling of the Benthic macroinvertebrate Dictyoptera. Physicochemical data indicates good-oxygenation, low-acidity, low-mineralization and poor suspended solids, although some significant differences were observed for temperature, dissolved oxygen, suspended solids, pH, oxidability, nitrogen and ammonium ions ($p < 0.05$). The collection of the organisms was done according to multihabitat approach and the analysis of the results showed a fauna which proliferates in a well-oxygenated stream (saturation rate> 70%). The Principal Component Analysis (PCA) shows affinities between Blaberidae, benthic macroinvertebrates and dissolved oxygen. This affinity is confirmed with Tetrachoric Correlation Coefficient, which shows positive correlation between Blaberidae and benthic macroinvertebrates. The Hierarchical Ascending Classification (HAC) allows to classify the stations in three affinity groups comprising physicochemical, hydro-morphometric and biological.

Keywords: Dictyoptera (Blaberidae), forest streams, physicochemical, benthic macroinvertebrates, Mefou.

Introduction

African tropical and equatorial forests are under increasing anthropogenic pressure due to the excessive, uncontrolled and poorly regulated destruction of many plant species for various purposes, including export for production wooden objects (Nke Ndih, 2008; Tchatchou et al.,2015). In addition, the stripping of layers of land and the establishment of quarries in most cases has led to the widening and the raising of the minor beds of rivers, under the effect of the erosion (Mary, 1999; Foto Menbohan et al., 2017). However, most forested aquatic ecosystems remain immune to natural or man-made disturbances. Such environments still retain their more or less natural state and can thus be described as streams with a good ecological health status. This preservation of the natural state confers them the status of reference watercourse. These aquatic ecosystems are characterized by a high plasticity of microhabitats, which are thus likely to host a macrofauna, particularly polluent-sensitive, highly diversed, showing characteristic of reference environments (Foto et al., 2011). A certain functional equilibrium is thus established and maintained between this biotope, governed by the multiplicity of ecological niches, and a macrobenthic biocenosis whose taxonomic richness is appreciable, through a certain number of processes including the flow of matter and energy (Qazi Hussain and Ashok Pandit 2012). However, this balance can only be maintained if these ecosystems are constantly monitored for their ecological health.

Although many aquatic organisms are involved in assessing the health status of these ecosystems (Friedrich et al.1992; Macneil et al., 2002), benthic macroinvertebrates occupy a prominent place because of their taxonomic diversity, their abundance, their rather long life cycle (up to 3 years), their sedentary lifestyle, their ability to bioconcentrate heavy metals and to colonize several environments (Chessman 1996; Colas et al., 2014). A diversity of Dictyoptera (Blaberidae) remains poorly known and far from complete, despite the work undertaken in the knowledge and documentation of fauna diversity of some African streams and that of Cameroon in particular. However, research is carried out on Orthopteroides and particularly Dictyoptera (Chopard 1929, 1943; Cherairia 2004; Habes et al., 2006, Habbachi 2013), are focused on terrestrial fauna. In fact, there is no study concerning semiaquatic Dictyoptera which are yet found in most african streams, and particulary in some Cameroon forest rivers. The study of this group of benthic organisms and some ecological factors regulating their distribution would fill this gap and contribute to the development and implementation of a matrix of benthic macroinvertebrates bioindicators well adapted to our environmental context.

Material and Methods

This study was conducted, from January 2016 to January 2017, in the Centre-South forest region of Cameroon, located between 3°30' - 3°58' of latitude Nord and 11°20' - 11°40' of longitude East. The average altitude is close to 750 m, which a relief is globally accidental, an urban area made up of many hills of 25 m to 50 m below the plateau (Santoir 1995). This region is dominated by an equatorial climate of a specific type, known as "the Yaounde Climate", characterized by moderate precipitations (1576 mm/year) (Kodjo 1998) and four unequal seasons which vary from one year to another are observed: a long dry season (Mid November to mid-March), a small rainy season (Mid-March to the end of June), a small dry season (July to Mid-August) and a long rainy season (Mid-August to mid-November. The average atmospheric temperature is 23.5ºC (Mulder 2009). The soil is made up of more or less tiny quartzo-feldspathic materials (Pelletier 2002), with acidic pH varying between 4.5 and 5.5 in the superficial layers. The vegetation is of secondary dense forest type and the river basin is dense with different streams flowing towards the Nyong river. The Mefou watercourse that supplies part of the city of Yaounde with potable water is one of the main tributaries of Nyong. As part of this study, four forest tributaries on its right bank (Abouda, Fam, Nkoumou and Nga) were selected, and 11 stations whose choice took into account accessibility, the presence of current thresholds, plates and microhabitats (Figure 1).

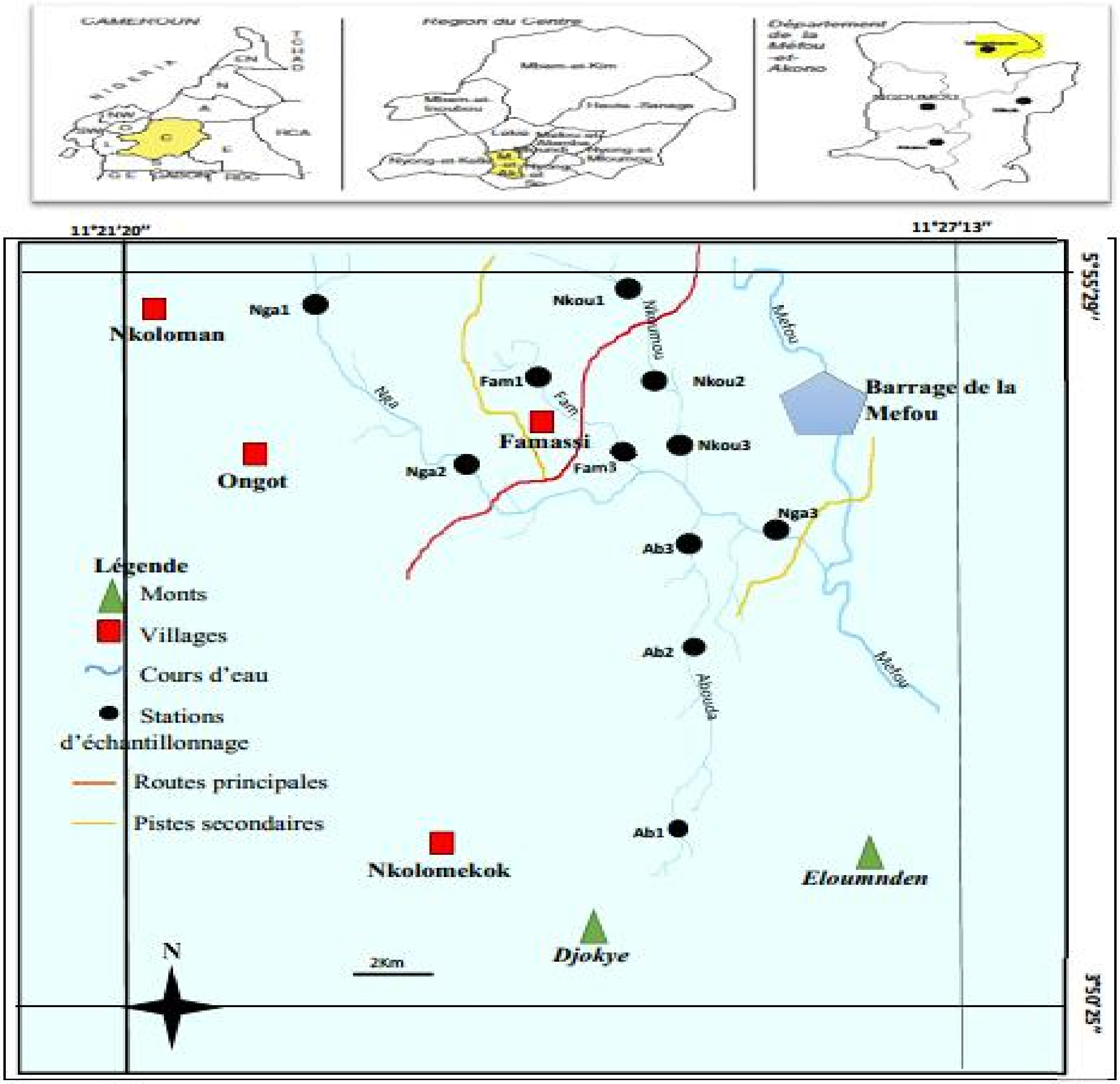

Figure 1: Map of the Mefou catchment showing the different sampling stations (NIC 1979 modified)

Hydro-geomorphometric variables

In this study, Hydro-geomorphometric parameters considered are the flow velocity of the water, the width of the wet section, the thickness of the water column and the height of the loose substrates. For each of these parameters, two series of measurements were carried out *in situ* in each station, one in the dry season (February) and one in the rainy season (October) and the average values considered.

Physicochemical variables

The evaluation of physicochemical parameters was done monthly, following the recommendations of APHA (1998) and Rodier (2009). Thus, the temperature (° C) and the dissolved oxygen saturation rate (%) were measured *in situ* using a portable multimeter HANNA HI 98130 and a portable oxymeter brand HANNA HI 9147 respectively.

In the laboratory, orthophosphate, ammoniacal nitrogen and turbidity were determined by colorimetry using the HACH DR 2800 spectrophotometer, followed by dissolved CO_2 and oxdability by volumetry. The results were expressed in mg / L and NTU.

The sampling of benthic macroinvertebrates

The sampling of benthic macroinvertebrates was carried out monthly, according to the multi-habitat approach (Stark et al., 2001), handle from January 2016 to January 2017. Samples were taken using kick-net (30 cm x30 cm side, 400µm mesh size). Samplings were done in a 100 m stretch for each station, following protocols described by Stark et al., 2001.Thus in each station, 20 drags of the kick-net were done in different microhabitats, each corresponding to a surface of $0.15m^2$(30 cm x 50 cm). Then the total sampled surface in each station was 3 m^2($0.15m^2$ x 20).Organisms collected were introduced into polyethene vials containing 10% formalin. In the laboratory, samples were rinsed with tap water using a 400µm sieve and all specimens caught were identified under a stereomicroscope WILD M5, with the use of appropriate literature (Durant and Levêque (1981); Tachet et al., 2006; Moisan (2006) and Roth (2003c, 2007).

Data analysis

Data analysis were performed using the non-parametric Kruskal-Wallis test and the Mann Withney test, which verify significant differences between spatial and seasonal variations of environmental parameters and macroinvertebrates abundances.

The Spearman correlation test and Principal Component Analysis (PCA) established the relationship between environmental variables and taxonomic richness and abundance of macroinvertebrates, at the 95% level of significance ($p < 0.05$). The Shannon and Weaver index and the Pielou equitability index respectively assessed taxonomic diversity and equidistribution of species. The XLSTAT version 2007 software was used for this statistical analysis. The Tetrachoric correlation coefficient (rψ) permit to measure the degree of affinity between the dominant species and then to establish the degree of associations between some benthic macroinvertebrates called "companion" and the Dictyoptera (Blaberidae).

Results

Hydro-morphological variables

The values of water flow velocity, minor bed width, water depth, and substrate thickness are summarized in Table 1. It is appears that the width of the bed generally increases from upstream to downstream, the Nga watercourse having the highest values (almost 7 m wide), the other parameters (water flow velocity, water depth and mud thickness) are changing in a more or less regular way from upstream to downstream.

Table 1: Values of the hydro-geomorphological variables found in the different stations during the study period.

Variables	Ab1	Ab2	Ab3	Fam1	Fam3	NK1	NK2	NK3	Ng1	Ng2	Ng3
Width (m)	2,3	2,5	3,6	2	2,5	2,3	2,2	2,1	4,5	5,45	6,95
Depth(cm)	45,86	20	18,2	26,71	20	19,4	19,9	26,71	53	70,9	82,25
Substrate thickness (cm)	16,71	9	4,2	24,4	15	13	17	13,6	23,16	5,78	30,4
Velocity (m/s)	0,17	0,23	0,17	0,31	0,27	0,4	0,17	0,23	0,55	0,25	0,42

Physicochemical variables

Maximum, minimum, mean and standard deviations of physicochemical variables are shown in Table 2.

Table 2: Summary of data collection of physicochemical variables during the study period at the different stations

Parameters		AB1	AB2	AB3	FAM1	FAM3	NK1	NK2	NK3	NG1	NG2	NG3
O_2 (%)	Min	48,000	54,000	50,000	52,000	44,000	44,000	48,000	56,000	58,000	44,000	46,000
	Max	92,000	98,000	98,000	97,000	97,000	97,000	96,000	93,000	90,000	87,000	96,000
	M	74,846	75,577	80,485	73,854	67,862	73,862	75,585	73,438	78,154	71,308	72,346
	σ	3,993	3,665	4,505	3,741	4,232	4,286	4,647	3,350	2,803	3,404	4,332
Temp (°C)	Min	20,600	21,000	20,200	21,000	21,000	21,900	22,000	21,000	21,800	21,100	21,000
	Max	23,300	23,700	23,400	23,600	23,300	24,000	23,900	23,800	23,700	23,600	23,300
	M	22,415	22,723	22,100	22,615	22,608	22,977	22,892	23,000	22,762	22,877	22,631
	σ	0,209	0,201	0,209	0,184	0,164	0,177	0,172	0,211	0,154	0,178	0,170
$PO4^{3-}$ (mg/L)	Min	0,130	0,010	0,010	0,050	0,030	0,010	0,020	0,010	0,010	0,060	0,040
	Max	1,020	1,100	0,860	0,660	0,960	0,700	0,650	0,900	0,410	0,670	0,910
	M	0,486	0,337	0,276	0,295	0,339	0,288	0,179	0,292	0,195	0,203	0,317
	σ	0,076	0,081	0,078	0,063	0,090	0,067	0,049	0,081	0,040	0,051	0,096
Turb (NTU)	Min	1,000	2,000	3,310	2,800	7,450	6,220	7,460	3,000	11,000	16,000	4,000
	Max	52,000	49,000	55,000	144,000	115,000	64,000	81,000	169,000	214,000	252,000	124,000
	M	22,000	21,923	30,408	32,062	42,342	29,555	41,112	39,652	70,915	63,277	35,162
	σ	3,958	3,815	5,229	10,199	7,993	4,880	6,872	12,203	20,414	18,189	8,360
CO_2 (mg/L)	Min	1,760	1,760	1,760	3,520	1,760	1,760	3,520	3,520	1,760	1,760	3,520
	Max	15,840	12,320	12,320	10,560	14,080	12,320	12,320	12,320	12,320	12,320	14,080
	M	7,717	6,769	7,305	7,852	6,774	7,717	8,252	7,446	7,711	7,969	8,665
	σ	1,083	1,013	0,888	0,762	1,192	1,027	0,900	0,776	1,007	1,081	1,044
$NH4^+$ (mg/L)	Min	0,020	0,090	0,050	0,110	0,020	0,060	0,020	0,150	0,040	0,110	0,140
	Max	0,510	0,630	0,690	0,500	0,430	0,800	0,620	0,800	0,700	0,900	0,770
	M	0,288	0,348	0,342	0,245	0,211	0,350	0,272	0,394	0,374	0,486	0,467
	σ	0,036	0,051	0,048	0,033	0,036	0,069	0,059	0,063	0,065	0,066	0,058
Oxyd (mg/L)	Min	0,790	0,790	0,970	1,120	1,120	1,480	1,340	1,140	2,120	2,180	1,680
	Max	11,500	9,700	11,600	29,000	21,100	17,600	19,000	17,300	10,700	22,700	16,000
	M	6,101	5,436	6,392	7,463	7,843	7,848	8,114	7,812	6,387	7,648	6,286
	σ	1,091	0,962	1,280	2,188	1,848	1,610	1,754	1,597	1,105	1,683	1,201
MES (mg/L)	Min	2,000	1,000	6,000	3,000	0,000	1,000	7,000	6,000	9,000	4,000	2,000
	Max	30,000	20,000	30,000	65,000	51,000	67,000	69,000	47,000	67,000	67,000	70,000
	M	11,077	12,000	16,308	20,077	19,462	21,077	29,308	25,154	30,308	30,846	23,538
	σ	2,095	1,772	1,962	4,234	4,418	4,763	4,973	3,566	5,431	5,629	5,714

Max= maximun, Min= minimum, M= average, σ=standard deviation, MES= suspended solids, Oxyd= oxydability, $NH4^+$= ammonium nitrogen, CO_2= disolve carbonne dioxyde, Turb= turbidity, $PO4^{3-}$= phosphate, O_2= dissolve oxygen, Temp= temprature.

The waters of all these streams are highly oxygenated with saturation levels reaching 90% in all stations. The highest values are obtained in the Abouda stream, particularly in Ab 2 and Ab 3 stations with 98% each. The temperature varies from one watercourse to another and from one station to another, the highest value being recorded in the Nkoumou stream at the Nk 3 station (23.8°C). The thermal amplitude remains below 4°C. Other parameters such as turbidity, suspended solids, orthophosphates, ammonia nitrogen, dissolved carbon dioxide and oxidability are illustrated by relatively low values. Thus, even if some extreme values can be observed for the turbidity (252 NTU at the Ng 2 station), the average value is close to 70.915 ± 20.414 NTU at the Ng 1 station. The same is true for suspended solids (MES) culminate at 70 mg / L at the Ng 3 station for an average value of 30.846 ± 5.629 mg / L in all the rivers. Orthophosphate levels were 1.1 mg / L at station Ab 2, with a mean value of 0.489 ± 0.076 mg / L at the Ab 1 station. Ammonium ions (NH4 +) was 0.9 mg / L at station Ng 2, against a mean value pivoting around 0.486 ± 0.066 mg / L at the same station. Dissolved CO_2 showed relatively high values at Ab1 station (15.84 mg / L) for an average of around 8.67 ± 1.044 mg / L at the Ng 3 station. Organic matter contents as reflected by oxidability are relatively high at the Fam1 station (29 mg / L), the average overlaps around 8.11 ± 1.75 mg / L at the Nk 2 station (Figure 2). No significant difference was observed between the values from one station and from one watercourse to another.

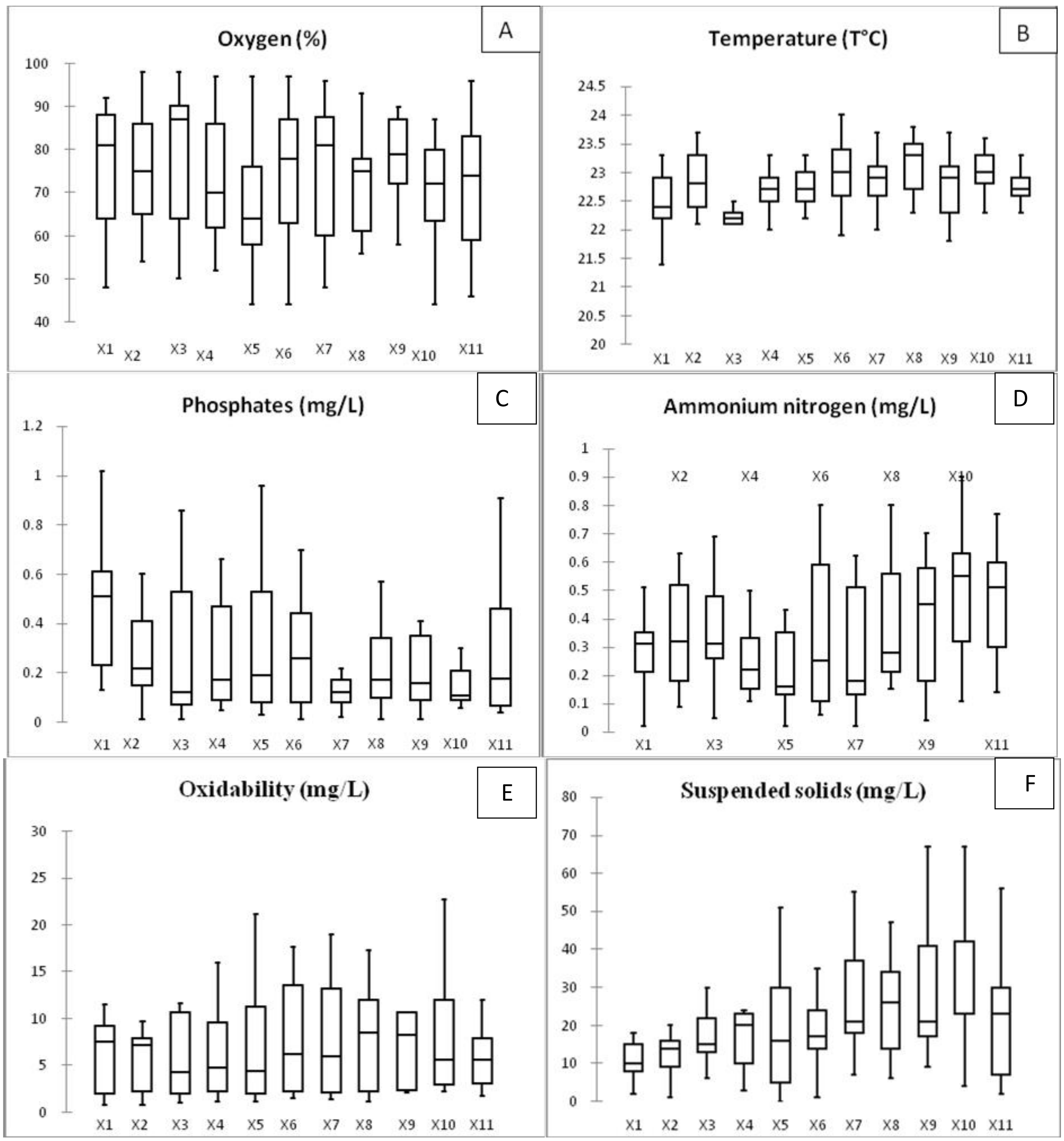

Figure 2: Spatial Variations of Oxygen (A), Temperature (B), CO_2 (C), Turbidity (D), Orthophosphate (E), Ammonium Nitrogen (F), the oxidability (G) and MES (H) during the study period With x1 = Ab1, x2 = Ab2, x3 = Ab3, x4 = Fam1, x5 = Fam3, x6 = Nk1, x7 = Nk2, x8 = Nk3, x9 = Ng1, x10 = Ng2, x11 = Ng3

Taxonomic richness and abundance of benthic macroinvertebrates

During this study, 143 samples were taken and 3647 individuals harvested. These organisms belong to the phylum of Arthropoda, class of insecta, orders of Dictyoptera, Hemiptera, Trichoptera, Ephemeroptera and Plecoptera, and to the families of Blaberidae, Naucoridae, Veliidae, Pleidea, Gerridae, Hydropsychidae, Ephemeridae, Ephemerellidae and Perlidae. The Order of Hemiptera is predominant with 1884 individuals for relative abundance of 51.65%. It is followed by Dictyoptera (Blaberidae) with 1102 individuals forrelative abundance of 30. 21%, Ephemeroptera with 370 individuals for relative abundance of 10.14%, Trichoptera with 196 individuals for relative abundance of 5.37%, and Plecoptera with 95 individuals for relative abundance of 2.6%. The Abouda stream had the highest abundance with nearly half of the total organisms belonging to it (1618 individuals),for relative abundance of 44.36%, and the lowest abundance in Nga stream (538 individuals), for the relative abundance of 14.75% of the workforce. The families of Naucoridae, Veliidae, Ephemeridae and Ephemerellidae are well represented in all stations, while Pleidae family is appears sporadically in Fam, Nkoumou and Nga streams. However, the Kruskal-Wallis test showed no significant difference between streams and stations values.

Correlations between environmental variables and benthic macroinvertebrates

Positive and significant correlations were found between Suspended Solid and oxidability ($r = 0.27$, $p < 0.05$), dissolved oxygen rate and Blaberidae, Pleidae, Ephemeridae and Ephemerellidae ($r = 0.47, 0.59, 0.54, 0.53$, $P < 0.05$). Furthermore, significant and negative correlations were observed between Suspended Solid and Blaberidae ($r = -0.6$, $P < 0.05$), Suspended Solid and Veliidae ($r = -0.43$, $P < 0.05$), Naucoridae and Blaberidae ($r = -0.59$, $P < 0.05$), flow velocity and Ephemeridae, Ephemerellidae, Blaberidae and Perlidae respectively ($r = -0.522, -0.442, -0.658, -0.595$),depth and Blaberidae, Ephemeridae, Hydropsychidae and Perlidae respectively ($r = -0.311, -0.247, -0.014, -0.228$).

Hierarchical Classification Analysis (ACH)

The Hierarchical Classification Analysis (HCA) distinguishes three groups of stations according to their hydro-morphometric and physicochemical characteristics. Group 1, consisting of the stations Ab 2, Ng 2, Ab 3, Ab1 and Nk 3, characterized by relatively small widths ($l < 5m$) and rocky substrate; Group 2, consisting essentially of the station Fam1 and Fam 3,and had a substantially rocky substrate. Group 3, which included the Ng 3, Ng 1, Nk 1 and Nk 2 stations, is characterized by an essentially muddy substrate (Figure 3A).

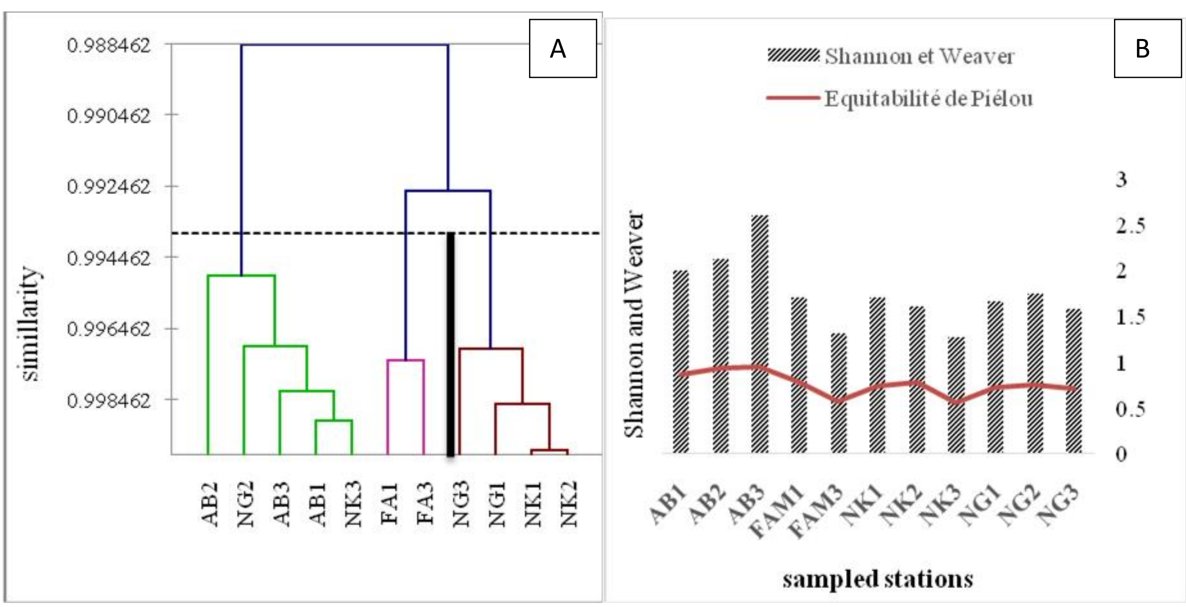

Figure 3: Hierarchical Classification Analysis (A) from the values of the hydro-morphometric and physicochemical variables,(1, 2 and 3) indicate the groups formed, and Shannon and Weaver (B) diversity indices obtained at the different stations during the study period.

Shannon and Weaver diversity index and Pielou's evenness

The diagrams of Shannon and Weaver diversity index and Pielou's evenness show asynchronous evolution. Thus, these indexes take relatively higher values in the Abouda stream at the Ab 3 station (2.59 and 0.94 bits respectively), followed by the Nga and Nkoumou streams (Figure 3B).

Principal Component Analysis and Dictyoptera (Blaberidae) distribution

The results of Principal Component Analysis (PCA) revealed that the relationship between aquatic insect metrics and in-stream habit conditions follow mainly the first two axis (F1 = 34.41%; F2 = 21.71%) which accounted for 51.12% of the total cumulative percentage expressed (Figure 4A). Following the first axis (F1), habitats characterized by good oxygenated water, low organic matter imputes, low values of values of parameters indicating mineralization, are conducive for the installation and proliferation of a great number of taxa, especially, Hydropsychidae, Ephemerellidae, Blaberidae and Perlidae (Figure 4B). Likewise, flow velocity, temperature, nature of the substrate, oxidability and Naucoridae are significantly and positively correlated with each other, and negatively correlated with the F1 axis and the previous group of variables. Ammonia nitrogen contents, depth, width and Suspended Solid are positively and significantly correlated with the F2 axis. On the other hand, CO_2, Rhagoveliidae and Veliidae are significantly and negatively correlated to the F2 axis.

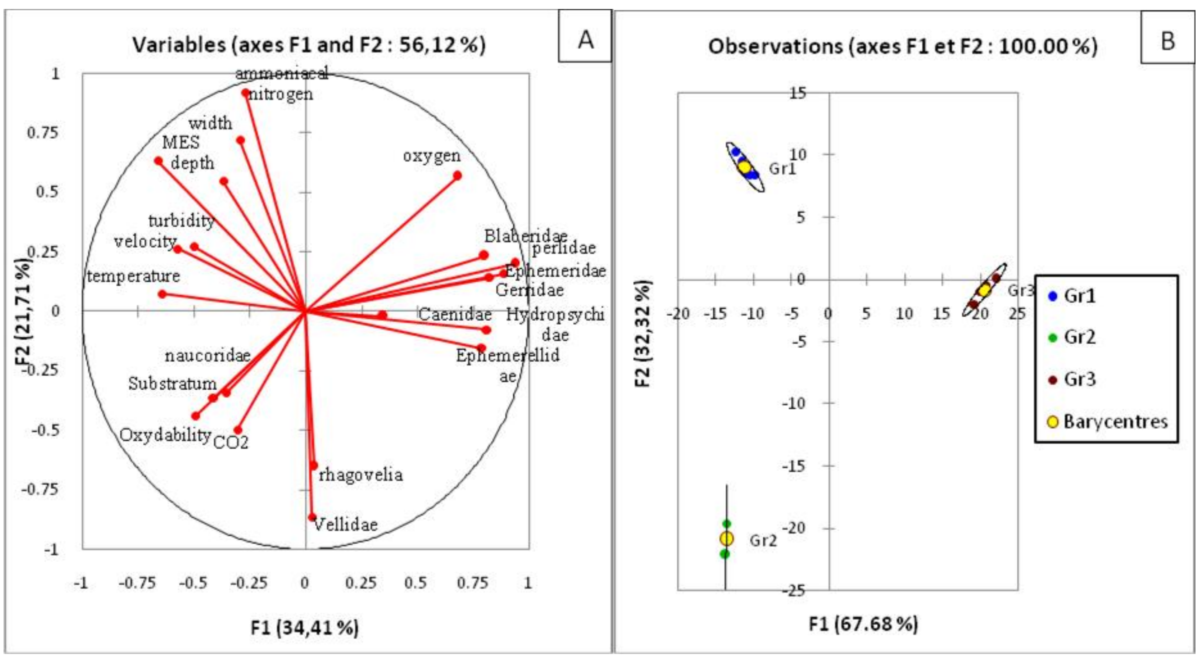

Figure 4: Distribution of parameters that regulate the distribution of organisms (A), and Grouping of stations according to hydro-geomorphological, physicochemical and biological similarities (B).

Tetrachoric correlation coefficient

The application of the tetrachoric correlation coefficient to the benthic macroinvertebrate community revealed some affinities between Blaberidae and other macrobenthic groups. Thus, when the coupling of Naucoridae / Blaberidae is used, where taxa mutually exclude each other by means of a negative tetrachoric correlation coefficient, the affinities between Blaberidae and other taxa are more or less strong. To that purpose, the Blaberidae / Hydropsychidae, Blaberidae / Perlidae and Blaberidae / Veliidae couplings lead with respective coefficients of 0.19 and 0.12 followed by Blaberidae / Ephemerellidae, Blaberidae / Gerridae, Blaberidae / Ephemeridae and Blaberidae / Pleidae couplings with coefficients ranging from 0.07 to 0.03 (Table 3).

Table 3: Tetrachoric correlation coefficient data between Blaberidae and companion taxa

	Blaberidae	Rψ
Naucoridae	-0,17	Predation
Veliidae	0,12	Mutual Cohabitation
Pleidae	0,03	
Gerridae	0,07	
Hydropsychidae	0,19	
Ephemeridae	0,05	
Ephemerellidae	0,07	
Perlidae	0,12	

Station typology based on hydro-geomorphological, physicochemical and biological variables.

The factorial map of the upward discriminant analysis (FDA), performed on the basis of hydro-geomorphological, physicochemical and biological data, makes it possible to group the stations according to their affinities. Thus, three affinity nuclei are obtained (Figure 2B). The nucleus 1 (Gr 1) is positively correlated with the F1 axis and consists of Ab 2, Ng 2, Ab 3, Ab 1 and Nk 3 stations, characterized by shallow waters that are, well oxygenated and with a very diverse fauna; the nucleus 2 (Gr 2), which groups together the Fam 1 and Fam 3 stations, is negatively correlated with the F2 axis and characterized by weakly turbid waters and a diversified fauna, the nucleus 3 (Gr 3), positively correlated with the axis F1, includes the Ng 3, Ng 1, Nk 1 and Nk 2 stations, characterized by deep, turbid waters and an undiversified fauna.

Discussion

Hydro-geomorphological characterization is an important biotic component (Baudoin et al.,2015), which makes it possible to understand the functioning of the aquatic hydro system. Taking into account the size quality of the bottom substrate particles in the assessment of the biological quality of the watercourses is essential, as it has an influence on the dynamic of installation of benthic fauna (Beauger, 2008), and the habitat productivity (Baudoin et al., 2015). In this study, the hydro-geomorphological analysis shows significant differences between the different streams. In the Abouda, Nkoumou and Nga streams, the bottom substrate is mainly dominated by rocks and sand, which are favourable for the development of aquatic macrofauna and the maintenance of ecological balance (Beauger, 2008; Foto Menbohan et al., 2017). In the Fam stream, the substrate consists mainly of silt, which is a background component that is not conducive to the development of benthic macroinvertebrate.

Concerning the environmental variables, results show that, the low-temperature values are due to microclimates created by the canopy, which reduces the amount of light rays reaching the surface of the water. This observation is in agreement with those of Foto Menbohan et al. (2012, 2017) and Tchakonté et al. (2014) obtained on the Nga, Mabounié and Nsapè streams respectively. The high saturation rate recorded in the streams reflects the low disturbance of forest watercourses, characterized by anintense photosynthetic activity of the watershed. Furthermore, the lack of input of organic matter of anthropogenic origin contributes to the maintenance of good oxygenation of these waters (Tchakonté, 2016). In addition, significant and positive correlations observed between dissolved oxygen saturation rate, Ephemeridae, Perlidae, Hydropsychidae and Ephemerellidae, polluant-sensitive groups (EPT), as well as Blaberidae, show that such a combination reflects the ecological integrity of these rivers, oxygenation appearing as the key environmental factor regulating their development. This assertion is supported by the tetrachoric correlation coefficient which shows a high relationship between Blaberidae and the groups of predefined organisms. The relatively low values of organic pollution indicators such as oxidability and dissolved CO_2 levels reflect the poorly disturbed nature of these aquatic ecosystems. The predominance of arthropods in these streams is similar to the observations of Foto Menbohan et al. (2012) in the Mefou and Tchakonté et al. (2014) in Nsapè, forest streams. The high taxonomic richness found in Abouda watercourse is linked to the nature of the substratum and the diversification of ecological niches.

The Principal Component Analysis highlights significant and positive correlations between some polluant-sensitive benthic macroinvertebrates such as Hydropsychidae, Ephemeridea, Ephemerellidea and perlidea, and Dictyoptera (Blaberidea) also showing that physicochemical and biological factors such as dissolved oxygen, ammonium ions,suspended solids, and oxidability influence the distribution of the benthic fauna. In addition, Eurymetra, Hydropsyche, Ephemera, Ephemerella and Perla, would constitute true taxa companions of Dictyoptera Blaberidae taxa. Naucoridae, on the other hand, appears as predators of Dictyoptera and play a regulating role towards the Dictyopterian population. This observation is confirmed by the negative value of tetrachoric correlation coefficient obtained between Blaberidae and Naucoridae.

Conclusion

The hydro-geomorphological variables such as substrate,water depth andcurrent velocity influence the installation of the benthic macrofauna associated with Dictyoptera. Good oxygenation of water, low concentrations of Suspended Solids, ammonium ions, oxidability and dissolved CO_2 are ecological factors conducive to the distribution of benthic macroinvertebrates fauna. The high taxonomic diversity recorded in Abouda and Nkoumou streams is imputable to the diversity of microhabitats. Dictyoptera grows in forest streams, described as references in which Perlidae, Ephemerellidae, Ephemeridae and Hydropsychidae develop harmoniously. This harmonious coexistence makes it possible to place the Dictyoptera (Blaberidae) and their companion taxa in the group of good ecological health indicators of Cameroon's streams.

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