INDONESIAN JOURNAL OF SOCIAL AND ENVIRONMENTAL ISSUES (IJSEI)
Journal Homepage: https://ojs.literacyinstitute.org/index.php/ijsei
ISSN: 2722-1369 (Online)
Research Article

Volume 2	Issue 2	August (2021)	DOI: 10.47540/ijsei.v2i2.191	Page: 86 – 97

Preliminary Study on Water Quality and Heteropterans Diversity in a Semi-Urban Stream (Central Region of Cameroon)

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ARTICLE INFO

Keywords: Physico-Chemical Parameters; Semi-Urban Stream; Water Bugs; Water Quality.

Received : 13 March 2021
Revised : 23 June 2021
Accepted : 25 June 2021

ABSTRACT

A study was conducted in the Konglo stream for six months to make an inventory of aquatic heteroptera, following a monthly sampling frequency. Some hydrological and physicochemical parameters such as water width, current velocity, and water flow, water temperature and pH, electrical conductivity, dissolved oxygen, total hardness, phosphates, nitrates, and ammonia were measured according to standard methods. For an inventory of the heteropterans, the multihabitat approach was used during sampling, but only heteropterans representing 3.15 % of total abundance are considered in this study. The hydrological variables were different in each station. The water width and flow were increased from upstream to downstream. The results showed that pH, total hardness, nitrites, phosphates, and ammonia values were weak and no significant differences were observed. Among physicochemical variables, only dissolved oxygen and electrical conductivity were different between upstream and downstream. The conductivity increased from upstream to downstream while the dissolved oxygen was very low downstream. 62 individuals were collected and counted belonging to 11 taxa, the most abundant being *Ranatra linearis*. The other taxa such as *Anisops* sp., *Aphelocheirus aestivalis*, *Gerris* sp., Gerridae Nd., *Hydrometra* sp., *Ilyocoris cimicoides*, *Naucoris* sp., *Nepa* sp., Notonectidae Nd., and *Velia* sp. were poorly represented. High abundance was recorded at the upstream (38 individuals), but the taxonomic richness (3 taxa) and diversity (0.24 bits/ind) remain low, unlike the stations located downstream (7 taxa and 1.82 bits/ind).

INTRODUCTION

Aquatic heteropterans are an important component of benthic macroinvertebrates. They are involved in the carbon cycle and appear to be hosts of microorganisms such as *Mycobacterium ulcerans*, a pathogenic bacteria causing Burili ulcer in humans (Ebong et al., 2012; Marion et al., 2011; Marsollier et al., 2002). According to Papacek, 2001 and Usinger, 1956, some Notonectidae, Corixidae, and Pleidae groups can be used in the biological control of mosquitoes.

In Mexico and Egypt, eggs and adults of Corixidae are eaten by humans or used as food for poultry and fish farming (Dethier, 1981). In countries such as Thailand, Colombia, and China, the families of Gerridae, Nepidae, and Belostomatidae are consumed by the population (Hanboonsong et al., 2013). Morse et al., (1994) mention that heteropterans can be used for monitoring water quality as saprobity indicators. Aquatic heteropterans are divided into two sub-orders: the Gerromorpha and the Nepomorpha. Gerromorpha is semi-aquatic and spends most of its life on the water. Nepomorpha is a true aquatic heteropterans (Chen et al., 2006).

Most of heteropterans are predators and can feed on small vertebrates such as fishes and amphibians or other invertebrates (Ohba, 2019).They inhabit diverse freshwater (Fernández & López Ruf, 2006; Usinger, 1956). In Central Africa, some data showed their presence. Many authors have studied and described the ecology, the distribution, and the adaptation of these heteropterans (Ohba, 2019; Esenbekova et al., 2015; Mbogho & Sites, 2013; Cianferoni & Mazza, 2012; Naranjo et al., 2010; Zack, 1990; Beutler & Frutiger, 1988; Hynes, 1955).

In Cameroon, some published studies (Dethier, 1981; Durand & Levêque, 1980; Poisson, 1929) reveal the presence of heteropterans. The recent data on Cameroon aquatic system showed the presence of the families of Gerridae Leach 1807, Velidae Amyot & Serville 1843, Hydrometridae Bilberg 1820, Mesoveliidae Douglas & Scott 1867, Naucoridae Fallen 1814, Belostomidae Leach 1815, Nepidae Latreille 1802, Helotrephidae Ezaki & China 1928, Corixidae 1815, Notonectidae Leach 1815 and Aphelocheiridae Fieber 1860 (Biram à Ngon et al., 2020; Ebong et al., 2016; Tchakonté et al., 2015b; Ajeagah Aghaindum et al., 2013; Foto Menbohan et al., 2010; Onana et al., 2016). This work was a contribution to the knowledge of the aquatic heteropterans with the aim to evaluate physicochemical water quality and diversity of aquatic heteropterans along the gradient of Konglo stream. Specifically, we compare each sampling station by using hydrological and physiochemical parameters, and water bug's diversity.

MATERIALS AND METHODS

Study area and sampling sites

The Konglo watershed is located in Nyong and So'o Division, between latitude 3°25' and 3°40' North and between 11°28' and 11°32' East longitude (Figure 1). It takes its source in the south of Zoatoupsi village and is oriented in the North-South direction. With an 11.5 km length, this stream receives many tributaries along its routes such as Nkengue and Mbebime. The average altitude is around 750 m and its relief is generally less uneven (Santoir, 1995). The climate is of the equatorial type with bimodal pluviometry characterized by moderate precipitations (1576 mm/year) varying between 1500 mm and 1700 mm per year, with fewer temperatures variation over the year (Suchel, 1987). There are four seasons of varying length (Kuete, 1987): a long dry season from mid-November to mid-march, a short rainy season from mid-March to the end of June, a short dry season from July to August, and a long rainy season from September to mid-November.

The vegetation is of the secondary dense forest type and the hydrographic network is dense with water flowing towards the Nyong. The soils are in various forms: ferralitic soils located at the top of the interfluves and the bottom of the slopes; hydromorphic and little evolved soils respectively in marshy valleys and on steep mountainous reliefs (Ndam Ngoupayou, 1997; Onguene, 1993). The activities carried out in the watershed include subsistence agriculture (cassava, peanuts, plantain, plums, etc.) and export agriculture (cocoa, coffee, wood). We also note the extraction of sand from the Konglo stream, upstream of station 2 (K2), and various urban activities in and around the stream in the city of Mbalmayo. Station 1 (K1) is completely covered by vegetation consisting of large trees, lianas, and bushy grasses that completely cover the stream, allowing very little light to pass over the surface of the water.

Its geographic coordinates are 03°34'N and 011°30'E at 672 m *a.s.l* in the non-anthropized area. It is located in the upper course around 3.81 km from the source. The second station (K2) is characterized by the presence of dense shrubs and trees that retain the light that arrives on the surface of the water. With the geographical coordinates of 03°32'N and 011°30'E, it is located at an altitude of 646 m *a.s.l* in the middle course about 9.58 km from the source. At the third station (K 3), a portion of the stream is used by the population for what needs. Villagers used for carwash and laundry. Not far from the course, the town had set up a household waste discharge. The K3 station is located at 03°31'N and 011°31'E at an altitude of 642 m *a.s.l* in the lower course, 13.34 km from the source, after crossing the town of Mbalmayo before flowing into the Nyong.

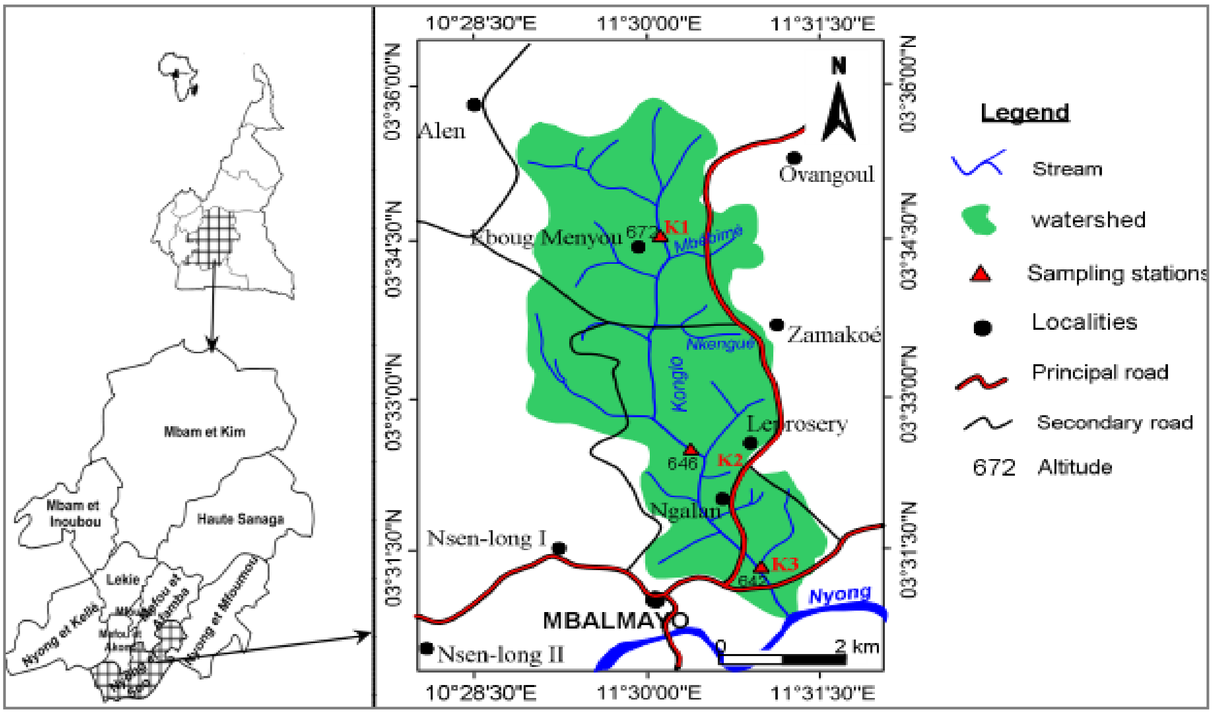

Figure 1. Cartography of Konglo watershed presenting the three sample stations on Konglo stream.

Measurement of environmental variables

Eleven variables were measured at each station. Three variables were determined to characterize the station. For this purpose, the average width was measured at each station using a graduated string and the average depth using a graduated stake. The runoff speed was measured using polystyrene of negligible mass traveling a given distance concerning time. The physicochemical analyzes were carried out according to the recommendations of the American Public Health Association et al. (2017), Rodier et al. (2009). On the field, temperature and electrical conductivity were measured by the HANNA Hi 99300 Conductivity Meter while dissolved oxygen and pH were measured using a HACH HQ 30d Flexi Oximeter and a HANNA pH Meter, respectively. For laboratory analyzes, water samples were collected using double-closure polyethylene bottles of 1000 ml previously washed in concentrated HCL and rinsed with distilled water. These samples were transported to the laboratory in a refrigerated enclosure. Nitrates and phosphates were measured using a HACH DR / 2010 spectrophotometer.

Sampling and identification of heteropterans

The sampling technique chosen in this study is the multi-habitat approach described by Barbour et al. (1999) and modified by Stark et al. (2001). The collection of heteropterans was carried out from February to August 2014 (between short rainy season and short dry season) using a square-shaped blower of 30 cm inside, fitted with a conical net of 500 µm of mesh opening and 50 cm in depth. For each sampling, around twenty haul nets of 50 cm length, equivalent an area of 3 m^2 were done in different habitats characterized by the substrate/ speed pair.

This technique made it possible to collect all the benthic macroinvertebrates. The organisms retained by the net were collected in plastic bottles using a pair of fine forceps and fixed in 10% formalin. In the laboratory, the specimens were washed with tap water and stored in 70 ° ethanol. For each station, the organisms were introduced into Petri dishes and grouped according to their size and morphology, then identified under a binocular microscope Wild M5, using identification keys of Dethier (1981), Poisson (1957), and Tachet et al. (2010). In total, 1969 individuals were collected belonging to 16 orders, 9 of which were present in all the stations. The heteropterans represented 3.15% of the total abundance.

Data analysis

In this study, one-way and multiple-way variable analysis methods were performed with XLStat 2020. With only 21 samples, nonparametric tests were used. The Man-Whitney test was used to identify the difference in variables between stations. The dendrogram and canonical redundancy analysis were used to confirm the observed results.

Diversity index (H') of Shannon and Weaver (1948)

The Shannon and Weaver H diversity index is calculated using PAST software version 1.0.0.0 using this formula:

$$H' = -\sum_{i=0}^{n} Pi \log_2 Pi \quad (3)$$

with Pi = relative abundance of taxon i (pi = ri / r); H is between 1 and 5 bits.

Piélou's Equitability Index (J) (1966)

This index shows the link between the observed diversity and the maximum theoretical diversity, or the equidistribution of the species present. It, therefore, reflects the degree of diversity obtained compared to the theoretical maximum. J is between 0 and 1, and is calculated using PAST software version 1.0.0.0.

$$J = \frac{H'}{\log_2 S} \quad (4)$$

with S = taxonomic richness and H'= Shannon and Weaver index

Rarefaction curve

The rarefaction curve shows the cumulative number of new species found in each sample. This representation can help to distinguish the level of new taxa of heteropterans in samples. It was carried out using PAST software version 1.0.0.0.

Sörensen similarity coefficient (S)

The calculation of the Sörensen similarity coefficient allowed to evaluation on a biological level, the degree of similarity of the taxa collected in the different sampling stations two by two by the formula:

$$S = \frac{2C}{(a+b)} \times 100 \quad (1)$$

With S= similarity coefficient, a = number of taxa present at the 1st station, b = number of taxa present at the 2nd station, C = number of taxa common to the two stations.

Simpson's dominance index (1-D)

Simpson's dominance index D measures the probability of two randomly selected individuals belonging to the same taxon. The value of 1 indicates the maximum diversity and a value of 0 indicates the minimum diversity. The Simpson index was calculated using PAST software version 1.0.0.0.

$$1 - D = 1 - \sum_{i=0}^{n} p^2 i \quad (2)$$

where Pi = ni / N, is the relative abundance of species i of the sample S, Ni = number of individuals of species i and N the number of individuals of the whole community; S = specific richness.

RESULTS AND DISCUSSION

Results

Hydrological and physicochemical parameters

The width of the stream varied from 2.92 m to 6.35 m with an average of 4.84 m. The speed fluctuated between 0.059 m/S and 0.187 with an average of 0.133 m/S. The water temperature values fluctuated between 20 °C and 28.9 °C with an average of 24.157 ± 2.37 °C. The pH varied from 6.70 CU to 9.46 CU with an average of 7.33 CU. The minimum, maximum, and mean values of each station are presented in table 1.

Relative abundance of heteropterans

Among the 62 individuals collected, 11 taxa were identified. The *Ranatra linearis* was the most abundant with representing over half of the total abundance (58.06 %). The taxa *Gerris* sp., Gerridae Nd., *Naucoris* sp., *Nepa* sp. And *Velia* sp. were represented by only one specimen (1.62 %). The other taxa showed relative abundance between 3.22 % and 6.45 % of total abundance as described in figure 2.

Table 1. Statistical summary of hydrological and physicochemical parameters

	Variables	Minimum	Maximum	Average	±SD
K1	Temperature [T]	20.000	28.400	23.457	0.981
	Electrical conductivity [EC]	15.000	29.000	22.000	2.093
	Total hardness [TH]	10.000	30.000	18.571	2.827
	Potential hydrogen [pH]	6.720	9.040	7.453	0.303
	Dissolved oxygen [O2]	5.080	7.310	6.394	0.297
	Water width [W]	2.920	2.920	2.920	0.000
	Ammonia [NH4]	0.488	2.501	0.997	0.265

	Current velocity [V]	0.187	0.187	0.187	0.000
	Phosphates [P2O5]	0.008	0.345	0.089	0.044
	Nitrites [NO2]	0.000	0.089	0.038	0.014
	Water flow [F]	0.014	0.014	0.014	0.000
K2	Temperature [T]	21.000	28.900	24.114	0.942
	Electrical conductivity [EC]	17.000	35.000	23.571	2.192
	Total hardness [TH]	10.000	30.000	17.500	2.938
	Potential hydrogen [pH]	6.740	9.460	7.423	0.354
	Dissolved oxygen [O2]	5.620	7.450	6.600	0.255
	Water width [W]	5.250	5.250	5.250	0.000
	Ammonia [NH4]	0.049	1.452	0.557	0.172
	Phosphates [P2O5]	0.008	0.570	0.114	0.078
	Water flow [F]	0.078	0.078	0.078	0.000
	Nitrites [NO2]	0.003	0.330	0.078	0.043
	Current velocity [V]	0.059	0.059	0.059	0.000
K3	Electrical conductivity [EC]	31.000	83.000	61.714	6.788
	Total hardness [TH]	15.000	50.000	27.500	4.398
	Temperature [T]	22.000	28.800	24.900	0.807
	Potential hydrogen [pH]	6.700	7.900	7.116	0.172
	Water width [W]	6.350	6.350	6.350	0.000
	Dissolved doxygen [O2]	0.980	5.850	4.043	0.591
	Ammonia [NH4]	0.207	2.391	0.872	0.279
	Water flow [F]	0.464	0.464	0.464	0.000
	Nitrites [NO2]	0.000	0.660	0.235	0.113
	Current velocity [V]	0.154	0.154	0.154	0.000
	Phosphates [P2O5]	0.008	0.360	0.136	0.052

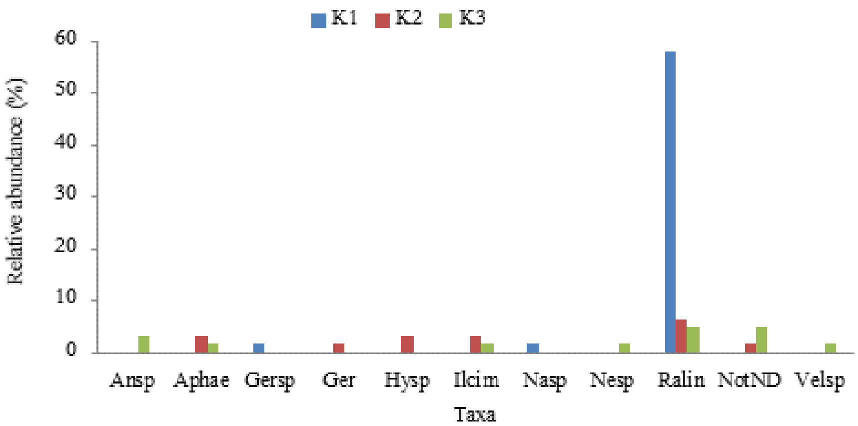

Figure 2. Distribution of relative abundance of water bugs along the Konglo stream. See table 2 for taxa abbreviation.

Sörensen similarity coefficient (S)

The Sörensen similarity coefficient in Table 2 shows a weak resemblance between the taxonomic taxa recorded from station to another. Only the station K2 and K3 seem to have resemblance for 30.76%.

Table 2. Sörensen similarity of taxonomic records between sampling stations.

	K1	K2	K3
K1	100		
K2	11.11	100	
K3	10	30.76	100

Diversity of heteropterans in Konglo stream

The station K3 was the richest and most diverse with 7 taxa. Despite the very high abundance of individuals, station K1 was the least diverse and had very poor distribution as showing in table 3.

Table 3. Statistical summary of richness, individuals, and diversity index of water bug by station and month.

Indices	K1	K2	K3
Taxa_S	3	6	7
Individuals	38	12	12
Simpson_1-D	0.1011	0.7917	0.8194
Shannon_H	0.2427	1.676	1.82
Equitability_J	0.2209	0.9355	0.9353

Rarefaction curve

The rarefaction curves (figure 3) showed a distinct evolution of the stands. The population curves of stations K2 and K3 show an increase in the number of taxa as the abundance increases, indicating a high taxonomic diversity. The stand curve of station K1 showed a low appearance of new taxa and taxonomic diversity.

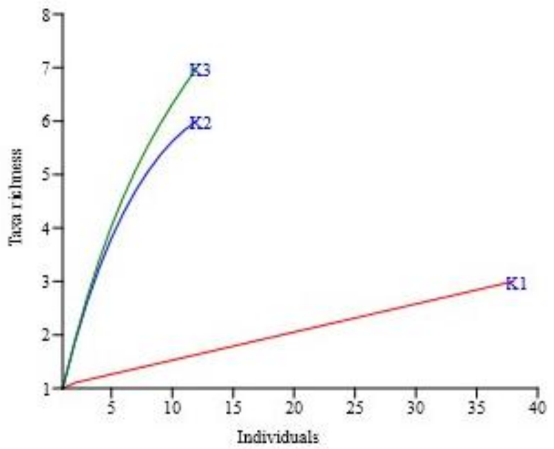

Figure 3. Rarefaction curve of stations.

Occurrence of taxa appearance

The species *Ranatra linearis* was present in the whole samples, although unevenly distributed. The species *Anisops* sp., *Nepa* sp. and *Velia* sp. were observed only at station K3 while Gerridae Nd was collected at station K2 in February. *Hydrometra* sp. was appeared only at station K2 in February and August. The species *Naucoris* sp. was present only at station K1 in February. The table 4 shows the occurrence of heteropterans in the Konglo stream.

Table 4. Occurrence of heteropterans appearance

Taxa	Abbreviation	K1	K2	K3
Anisops sp.	*Ansp*	-	-	+
Aphelocheirus aestivalis	*Apaes*	-	+	+
Gerris sp.	*Gesp*	+	-	-
Gerridae Nd	*GerND*	-	+	-
Hydrometra sp.	*Hysp*	-	+	-
Ilyocoris cimicoides	*Ilcim*	-	+	+
Naucoris sp.	*Nasp*	+	-	-
Nepa sp.	*Nesp*	-	-	+
Ranatra linearis	*Ralin*	+++	+	+
Notonectidae Nd	*NotND*	-	+	+
Velia sp.	*Vesp*	-	-	+

(0) ; + (1-5) ; ++ (6-10) ; +++ (11 and more)

Difference between stations

Table 5 shows the difference between stations according to the Man-Whitney test. All the values bearing star indicate the significant difference of variables between the sampling station during the study. Only temperature, pH, total hardness, nitrites, phosphates, and ammonia are not different between sampling station at the level of 5%. For all other variables, the difference is significant between the stations.

Table 5. p-values showing the difference of variables between sampling station

Variables \Station link (*p<0.05*)	K1 - K2	K1 - K3	K2 - K3
Anisops sp.	1.000	<0.0001*	<0.0001*
Aphelocheirus aestivalis	<0.0001*	<0.0001*	<0.0001*
Gerris sp.	<0.0001*	<0.0001*	1.000
Gerridae ND	<0.0001*	<0.0001*	1.000
Hydrometra sp.	<0.0001*	1.000	<0.0001*
Ilyocoris cimicoides	<0.0001*	<0.0001*	1.000
Naucoris sp.	<0.0001*	<0.0001*	1.000
Nepa sp.	1.000	<0.0001*	<0.0001*
Ranatra linearis	0.002*	0.001*	0.559
Notonectidae ND	<0.0001*	<0.0001*	1.000
Velia sp.	1.000	<0.0001*	<0.0001*
Water width	0.000*	0.000*	0.000*
Current velocity	0.000*	0.000*	0.000*
Water flow	0.000*	0.000*	0.000*
Temperature	0.514	0.128	0.456
Potential hydrogen	0.844	0.383	0.535
conductivity	0.832	0.002*	0.001*
Dissoved oxygen	0.737	0.002*	0.001*
Total hardness	0.878	0.143	0.091
Nitrites	0.710	0.360	0.689
Phosphates	0.506	0.361	0.361
Ammonia	0.097	0.456	0.334

The relation between environmental variables and heteropterans' community

The Spearman correlation test (table 6) showed that *Gerris* sp., Gerridae ND, and *Naucoris* sp. are positively and significantly correlated to current velocity, but correlated negatively and significantly to the water width and water flow ($p < 0.05$). *Hydrometra* sp. are negatively and significantly correlated to the current velocity ($p < 0.05$). Positive and significant links are also observed between the Notonectidae ND, the water width, and flow ($p < 0.05$). No significant correlation was observed between the environmental variables and *Anisops* sp., *Aphelocheirus aestivalis*, *Ilyocoris cimicoides*, *Nepa* sp., *Ranatra linearis,* and *Velia* sp. Overall, the low abundances and the rare presence of certain taxa would have influenced their weak correlation with environmental variables.

Table 6. Summary of Spearman correlation between freshwater bug abundances and environmental variables. See table 2 for taxa abbreviation.

Variables	*Ansp*	*Aphae*	*Gersp*	GerND	*Hysp*	*Ilcim*	*Nasp*	*Nesp*	*Ralin*	*NotND*	*Velsp*
W	-0.030	-0.055	-0.606*	-0.606*	0.374	-0.044	-0.606*	-0.030	-0.003	0.439*	-0.030
V	-0.030	-0.055	0.606*	0.606*	-0.462*	-0.044	0.606*	-0.030	0.175	0.393	-0.030
F	0.030	0.055	-0.606*	-0.606*	-0.374	0.044	-0.606*	0.030	-0.110	0.481*	0.030
T	0.000	-0.169	0.296	0.296	0.027	-0.278	0.296	-0.259	-0.175	0.163	0.222
pH	-0.369	-0.236	0.074	0.074	0.188	0.112	0.074	0.185	0.077	-0.252	-0.111
EC	0.351	0.056	0.074	0.074	-0.255	0.055	0.074	0.111	-0.377	0.216	0.185
O2	-0.369	0.067	0.185	0.185	0.429	0.076	0.185	-0.074	0.392	-0.168	-0.148
TH	0.075	0.136	-0.149	-0.149	-0.041	0.360	-0.149	0.168	-0.156	-0.092	-0.019
NO2	0.222	-0.158	0.185	0.185	-0.027	-0.133	0.185	-0.333	-0.059	0.299	0.351
P2O5	0.148	-0.056	-0.316	-0.316	-0.175	0.100	-0.316	-0.093	-0.260	-0.457*	0.037
NH4	0.185	-0.157	-0.074	-0.074	-0.027	0.237	-0.074	0.332	0.112	-0.319	0.222

*Only values bearing star are significant correlations; *: correlation is significant at the level p< 0.05*

The results of dissimilarity dendrogram and canonical redundancy analysis (RDA) confirmed the relationships between stations, aquatic heteropterans taxa, and environmental variables in graphical projection (figure 4). Following this presentation, each is distinguished to another. According to the environmental variables and taxa abundance, the dendrogram showed three different classes corresponding to each station (figure 4a). The triplot RDA explain 100 % of information following two main axes F1 = 65.05 % and F2 = 34.95 % (figure 4b). Along the F1 axis in positive coordinates, *Ranatra linearis*, *Gerris* sp., *Naucoris* sp. are associated with station K1. This station is characterized by high dissolved oxygen and pH. In negative coordinates, Notonectidae ND and *Ilyocoris cimicoides* are influenced by the phosphates and the water width. According to the second main axis (F2), in positive coordinates, *Aphelocheirus aestivalis* and *Hydrometra* sp. are strongly associated with station K2. In negative coordinates, a very strong influence of ammonia, total hardness, conductivity, and water flow on *Anisops* sp., *Nepa* sp. and *Velia* sp. was observed.

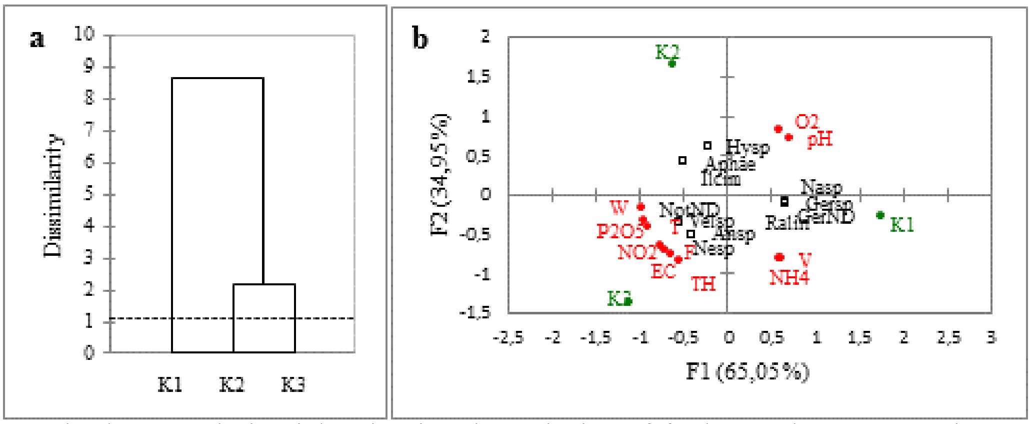

Figure 4. Redundancy analysis triplot showing the gathering of freshwater heteropterans in response to environmental variables.

Discussion

Environmental variables

The hydrological characteristics of the Konglo stream show variation from upstream to downstream. This variation participates in the distribution of other abiotic and biotic elements. Indeed, Elosegi & Sabater (2013) and Gob et al. (2014) state that hydromorphology allows us to understand the functioning of aquatic ecosystems and that the lotic facies of rivers better promote the development of great diversity than the lenthic facies. On the Konglo stream, the variables like current speed, flow, and width were very different from station to station. These variables would have contributed to the distinction of these three compartments of this stream.

For the physicochemical variables measured, very few varied significantly from upstream to downstream. This similarity of the values of these parameters would be linked to the forest and season in the watershed. In this regard, Foto Menbohan et al. (2013) and Tchakonté et al. (2014) believe that forest streams exhibit small fluctuations in physical and chemical parameters. However, the electrical conductivity and dissolved oxygen showed significant differences between the upper compartments (K1 and K2) and the downstream ones. The very significant variation in these two parameters could be caused by human activities in the downstream part of the watershed, in particular, the vehicle laundry and garbage depots. The high oxygen values in the upper reaches of the stream are said to be due to the large vegetation cover and the low anthropization of the basin (Adu & Oyeniyi, 2019).

Likewise, the low values of electrical conductivity noted in this part would testify to the low mineralization of organic matter and therefore a low contribution of exogenous organic matter. While in the lower part of the stream, high values of electrical conductivity and low levels of dissolved oxygen were noted. Indeed, the exogenous inputs in the anthropized part of the watershed would be the cause of changes in these variables. These same observations were reported by Tchakonté et al. (2015) on a forest stream, Nsapè, and the urban streams, Mgoua and Tongo'a-bassa. In the same time, Foto Menbohan et al. (2012) and Williams & Benson (2010) state that in disturbed streams, the value of dissolved oxygen decreases while the value of conductivity increases.

Heteropteran composition

The heteropteran fauna is made up of 62 individuals divided into 11 taxa. Analysis of their abundances shows the predominance and the presence along the Konglo stream of *Ranatra linearis*. This high abundance would be directly linked to the ecology of the environment. Indeed, some authors indicate that *R. linearis* thrives in calm, shallow waters, not very muddy and with banks (Dethier, 1986; Tachet et al., 2010). Some rare taxa (*Gerris* sp., *Naucoris* sp., *Nepa* sp., and *Velia* sp.) were represented by only one individual. *Gerris* sp. and *Naucoris* sp. were present only at upstream while *Nepa* sp. and *Velia* sp. were recorded at downstream. These groups would not have found favorable in these three compartments of the Konglo stream or the sampling effort could not have sufficient. Notonectidae ND, *Ilyocoris cimicoides* and *Aphelocheirus aestivalis* were recorded at the two down compartments (K2 and K3) with a weak abundance.

Stoianova et al. (2018) say that *Aphelocheirus aestivalis* has low dispersion and habitat changes threat his population. The diversity is low at all stations, although it increases from upstream to downstream. The Sörensen index shows little taxonomic resemblance between the stations. This indicates a distinction of taxa at the level of each station. Each station would therefore host taxa specific to the compartment or rare in the watercourse. The rarefaction curve explains the appearance of taxa at each station. In the upstream part, it takes more sampling effort to have more taxa, while in the middle and lower parts of the Konglo stream, there is more chance of having a lot of taxa in a small sample of heteropterans.

Environmental and biological variables relationship

The graphical representation of the evolution of the specific wealth of a community as a function of the number of individuals inventoried is given by the rarefaction curve. However, in this study, the curves do not stop growing, which makes the concept of the minimum area more complex because of the constant appearance of so-called rare or accidental species. Upstream, *Ranatra linearis* is the most abundant species and appears to be sensitive to changes in the environment. The taxa *R. Linearis* is abundant in February and June, corresponding to periods of low rainfall. This species thrives in stable rivers with sediment at the bottom and submerged plants. In those streams, diversity and abundance are very high (Foto Menbohan et al., 2013; Mboye et al., 2018). Ebong et al. (2012) noted that streams and ponds which were slow and stagnant showed the highest number of water bugs.

Downstream, low abundance of individuals is recorded and characterized by the appearance of Gerridae ND and *Hydrometra* sp. at the station K2 and *Anisops* sp., *Nepa* sp. and *Velia* sp. at the station K3. In this part of the stream, sand extraction activities (in K2) and domestic discharges (in K3) would have had effects on the ecology of the environment, leading to a drop in the abundance of taxa and the appearance of rare or accidental species. Despite the high abundance recorded at the station K1, the taxonomic richness and the diversity index remain low, unlike the stations located downstream. These observations have also been recorded by Tchakonté et al. (2015b) in the Wouri watershed that insects are very sensitive to water pollution and in-stream degradation. The same authors reported that heteropterans were found only at unpolluted stations and no taxa in urban streams. Ebong et al.(2012) have also mentioned that the high flow decreases the abundance and diversity of water bugs, but some taxa prefer moderate current velocity and flow.

The canonical redundancy analysis showed the variables that seem to characterize each taxon. The presence and abundance of *Ranatra linearis* are characterized by the speed of water and would, therefore, proliferate in very oxygenated waters with moderate current velocity. Tchakonté et al. (2015b) found that the species *R. Linearis* needs the high dissolved oxygen. The Notonectidae would rather prefer areas of high water flow and moderate hot waters.*Velia* sp. and *Anisops* sp. would proliferate in hard waters, rich in phosphates and nitrates. *Ilyocoris cimicoides*, *Nepa* sp., *Aphelocheirus aestivalis*, *Naucoris* sp., *Gerris* sp. and Gerridae ND thrive in acidic waters and are rich in ammonia.

CONCLUSION

This study shows that the Konglo stream is slightly polluted with the weak diversity of aquatic heteropterans. The current velocity, water flow, and water width increased from upstream to downstream. The electrical conductivity and dissolved oxygen were different between K1-K3 and K2-K3. The faunistic composition of the heteropterans showed 61 individuals divided and 11 taxa. All the taxa abundances were different in each sampling station during the study. Taxonomic wealth increases from upstream to downstream with the appearance of new taxa and the low abundance. Some environmental parameters such as phosphates, current velocity, water flow, and water width have characterized Gerridae ND, *Gerris* sp., *Naucoris* sp., Notonectidae ND. A study covering the four seasons of the year in this zone would be better suited to explain the spatial distribution of Heteroptera and water quality.

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