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Ecological parameters of habitat of Diptera Chironomidae in Southern Ivory Coast, West Africa

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Une étude a été menée dans 5 fermes piscicoles du sud de la Côte d'Ivoire en vue de contribuer à la connaissance des Chironomidae. L'échantillonnage a été effectué tous les mois de Décembre 2007 à Novembre 2008. Dans chaque ferme, 3 étangs ont été choisi au hasard. Dans chaque étang, 6 échantillons de sédiment ont été prélevés à l'aide d'une benne Van Veen. Les variables environnementales telles que la transparence, température, le pH, l'oxygène dissous et la conductivité ont été mesurées *in situ*. Les six échantillons de sédiment ont été mélangés pour constituer un seul échantillon de chaque étang. Au total 11 taxons appartenant à 3 sous-familles (Chironominae, Orthocladiinae *and* Tanypodinae) ont été identifiées. La faune Chironomidienne est quantitativement et qualitativement dominée par les Chironominae. *Nilodorum fractilobus*, *Chironomus imicola*, S*tictochironomus* sp. et *Tanypus fuscus* sont les taxons les plus abondants. Les valeurs de l'indice de diversité de Shannon-Wiener et de l'équitabilité ont été enregistrées à la station d'Anyama II. Une analyse canonique a été effectuée pour montrer l'influence des paramètres environnementaux sur la distribution des taxons. Les Chironomidae peuvent être utilisés en tant que potentiel instrument d'une prochaine étude écologique dans les écosystèmes aquatiques ivoiriens.
Mots clés : Chironomidae, Chironominae, Orthocladiinae, Tanypodinae, étangs piscicoles, structure, Côte d'Ivoire.

The aims of this study were to contribute to the knowledge of Chironomidae. Monthly samplings have been conducted from December 2007 to November 2008in five fish farms (Layo, Banco, Azaguié, Anyama I and Anyama II) in southern Ivory Coast. In each farm, sediments were collected in three ponds using a Van Veen grab. In each pond, environmental variables such as transparency, temperature, pH, dissolved oxygen and conductivity were measured *in situ*. Samples were taken in six replicates which were pooled to constitute a sample for each pond. A total of 11 taxa belonging to 3 subfamilies (Chironominae, Orthocladiinae *and* Tanypodinae) were recorded. Chironomid fauna is clearly dominated quantitatively and qualitatively by Chironominae. *Nilodorum fractilobus*, *Chironomus imicola*, S*tictochironomus* sp.and *Tanypus fuscus* were the most abundant taxa within the Chironomid assemblage. Anyama II station recorded the maximum values of Shannon-Wiener diversity index and evenness. Chironomid community structure was visualized using Canonical Correspondence Analysis to show the affinities of each specie for selected environmental parameters. Chironomidae can be used as a potential instrument in future ecology studies in Ivorian aquatic ecosystems.
Keywords *:* Chironomid, Chironominae, Orthocladiinae, Tanypodinae, fishfarm ponds, structure, Ivory Coast.

1 I NTRODUCTION

The family Chironomidae (Order: Diptera) have a wide distribution throughout the world and a regional endemism (Frouz *et al*., 2003). They are more than 15 000 taxa throughout the world (Armitage *et al*., 1995). They are quite known in the temperate regions of the Northern Hemisphere. In the southern Hemisphere, particularly in West Africa, Dejoux (1984) lists 96 species in Togo and Benin and 31 species in Niger. Chironomidae constitutes an important group of aquatic insects, they are the most widely distributed and frequently the most abundant insects in freshwater environments, including temporary aquatic systems (Cranston, 1995). Their larvae often display high density and diversity in most habitats (Coffman & Ferrington, 1984). Chironomidae is a family raising a lot of interest both for its diversity of ecological interest, particularly in the study of climate and environmental change (Rosenberg & Resh, 1993), and the water quality of lakes and rivers (Callisto *et al*., 2002; Evrard, 1996). They have been used as reliable bioindicators of aquatic pollution and related perturbations (Victor & Dickson 1985). Despite their obviously important function in tropical aquatic ecosystems, and despite their role as a substantial food source for numerous entomophagous fishes, the African chironomids remain a little studied or even unstudied group (Déjoux, 1984). Many studies on aquatic insects in Ivory Coast were undertaken (Edia *et al*., 2010; Kouadio *et al.,* 2011; Camara *et al.,* 2012), Yapo *et al*. (2012, 2013, 2014a, 2014b, 2015). Although few studies have examined chironomidae communities in Ivory Coast (Diomandé *et al.,* 2000, Diomandé *et al*, 2014), and none have been conducted in fish farm pond. Our objective was to contribute to the knowledge of Chironomidae in this country by making the survey of Chironomidae composition in five fish farm pond in South of Ivory Coast and relate its distribution to physical and chemical variables.

2 MATERIALS AND METHODS

2.1 Study Site

This study was undertaken in five fish farms in the southern region of Ivory Coast characterized by two seasons (dry and rainy seasons). The dry season extends from December to March and from August to September while the rainy season extends from April to July and from October to November. Sampling sites were Aquaculture Testing Station of Layo (05º19'N; 04º18'W), fish farms of Banco (05º23'N; 04º03'W), Azaguié (05º39'N; 04º05'W), Anyama I (05º33'N; 04º03'W) and Anyama II (05º34'N; 04º02'W) (**Figure 1**). They were assigned to habitat types according to environmental and ecological features. Banco site is located in the National Reserve of Banco which is mainly constituted of primary forests. In Azaguié, Anyama I and Anyama II, ecosystems are constituted by agricultural landscape, while at Layo site, immediate environment is characterized by habitations. The main water supplies were different in the sites: ponds in Anyama I and Azaguié were fed respectively by a man-made lake and a stream, ponds in Banco by Banco river, ponds in Anyama II by groundwater and ponds in Aquaculture Testing Station of Layo by coastal aquifer. Ponds located in this last site were fed by brackish water (salinity ranging from 0 to $10 mg.L^{-1}$) (Legendre *et al*., 1987) while in the four others sites, ponds were supplied with fresh water. The ponds in the five fish farms were permanent and were shallow (depth<1 m). In each fish farm, three ponds which area varied from $280 m^2$ to $500 m^2$ were randomly selected. Bottom sediment were mostly composed by sand in Layo and Azaguié stations, by silt in Banco, sand and clay in Anyama I while in Anyama II station, silt and sand were the dominant substrates. All ponds contained tilapia *Oreochromis niloticus* Linnaeus, 1758 except Banco where ponds were abandoned. Fish were reared at a density of 3-5 fish/m^2 (Layo), 6 fish/m^2 (Azaguié and Anyama II) and 7 fish/m^2 (Anyama I) and fed on rice bran.

2.2 Sampling Procedures

In each pond, monthly samples were collected in six replicates using a Van Veen grab of 0.09 m^2internal area, from December 2007 to November 2008. The six samples were pooled, sieved through 1 mm aperture size sieve and the remaining materials were preserved in plastic bottles containing 10% formalin. The total area sampled per station is 1.62 m^2 (3 ponds x 6 replicates x 0.09 m^2). In the laboratory, specimens were sorted and identified under a stereo binocular microscope to the lowest possible taxonomic level (species, genus), by use of systematic and classification key (Déjoux *et al*., 1981). Insects were counted and the number of each species was expressed as organisms.m^{-2}. Biomass (dry weight; mg.m^{-2}) was estimated after desiccation to constant weight for 24 h at 60 °C according to Mathooko (2001).

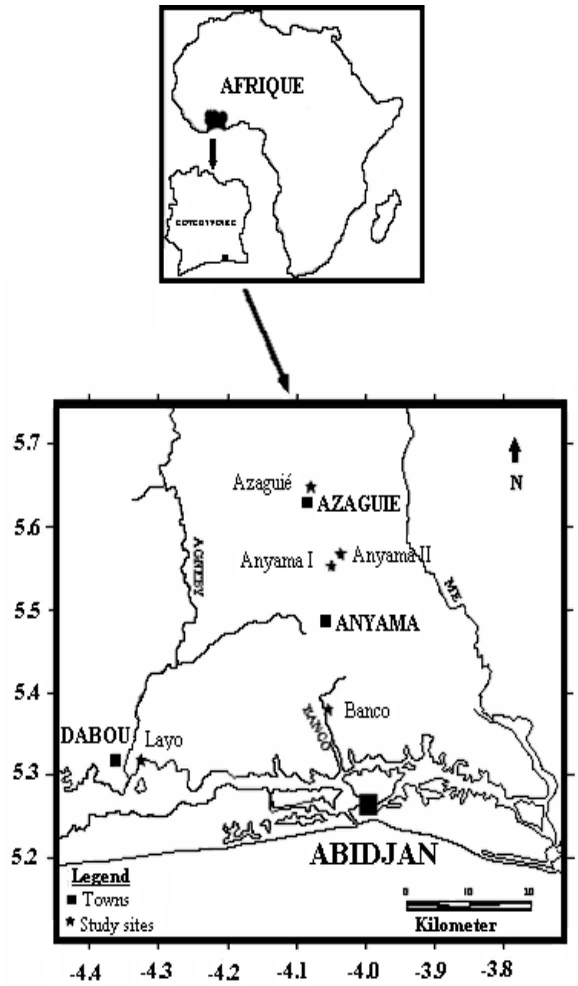

Figure 1: Location of the study area showing the different sampling stations

Mean densities (individuals.m^{-2}) and biomass were calculated for each season and for overall total study period.

2.3 Measurement of Environmental Variables

On each sampling date, environmental variables such as transparency, temperature, pH, dissolved oxygen and conductivity were measured *in situ* between 08.00 and 10.00 a.m. Water temperature, pH and electric conductivity were measured using a multiparameter digital meter (WTW pH/Cond 340i). Dissolved oxygen concentration was measured with a WTW Oxi 92 oxygen meter and water transparency was measured using a 20-cm-diameter Secchi disk. Water samples were collected on every sampling day, filtered through GF/C Whatman® filters, frozen upon arrival at laboratory. Analyses of dissolved inorganic nutrients (ammonium, NH_{4+}; nitrite, NO^{2-} and soluble reactive phosphorus, $PO4^{3-}$) from filtered samples were carried out according to (Grasshoff *et al.*1983). The substrate rate was visually estimated in percentage of sand, clay and silt according to Gordon *et al.* (1994).

2.4 Statistical Analysis

In each sampling station, abundance, density, Shannon-Wiener diversity index (bits) (Spellerberg & Fedor, 2003) and Pielou Evenness (Pielou, 1969) were calculated. Shannon-Wiener diversity index was used to quantify taxonomic richness and distribution of taxa in the communities. Evenness was used to determine chironomid distribution, regardless of species richness. Coefficient of similarity among stations was estimated following Sorensen (1948). Sorensen index was used to assess the similarity of chironomid communities between different stations. Analysis of variance (ANOVA) was used to determine effects of stations and seasons on environmental variables, Shannon-Wiener diversity, evenness, density and biomass. Before performing the comparison test, the normality of data was checked by Kolmogorov-Smirnov test. Data were log10 (X+1) transformed prior to analysis. Comparison of data collected at different stations was made using one-way ANOVA and Tukey's *post hoc* test. Relationships between the distribution of chironomid taxa and environmental variables in all sampling stations were determined by Canonical Correspondence Analysis (CCA) using CANOCO 4.5 software. The importance of CCA was tested by the Monte Carlo test at *P-value*=0.024 (F- ratio=2.93) for 499 permutations. Eight environmental parameters were returned for the analysis.

3 RESULTS

3.1 Physical and Chemical Variables

The variations of environmental parameters are given in **Table 1**. The electric conductivity varied from 35.85 ± 2.88 µs.cm^{-1} (Banco) to 3037.83 ±2980.25 µs.cm^{-1} (Layo). Water temperature ranged between 27.20 ± 0.60 °C (Banco) and 28.97 ± 1.10 °C (Azaguié). The lowest dissolved oxygen values were recorded in Banco (4.18 ±1.15 mg. L^{-1}) and the highest values were observed in Anyama I (6.33 ± 0.44 mg. L^{-1}). Banco presented low values of pH (6.75 ± 0.19), while high values (7.08 ± 0.12) were recorded in Anyama I. Water transparency fluctuated between21.65 ± 6.84 cm (Layo) and 30.14 ± 4.25 cm (Banco). Nitrite values varied between 0.62 ± 0. 52mg.L^{-1} (Anyama I) and 1.26 ± 0.84 mg. L^{-1} (Layo). Phosphorus oscillated between 1.09 ± 0.69 mg. L^{-1} (Anyama I) and 2.47 1.44 mg. L^{-1} (Layo). Banco ammonium was significantly greater compared to other stations.

Table 1: Seasonal variation of the environmental variables (mean ± (SD)) in the sampling stations

Parameters	Stations									
	Banco		Layo		Azaguié		Anyama I		Anyama II	
	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS
Secchi disk transparency (cm)	28.73^{a} (4.66)	31.55^{b} (3.38)	23.26^{a} (7.42)	20.05^{a} (5.99)	22.63^{a} (9.07)	21.47^{a} (6.14)	22.63^{a} (9.07)	21.47^{a} (6.14)	22.75^{a} (4.53)	22.78^{a} (3.04)
Temperature (°C)	27.41^{b} (0.41)	26.98^{a} (0.69)	28.6^{a} (0.72)	28.07^{a} (1.36)	29.31^{a} (0.97)	28.63^{a} (1.58)	28.88^{a} (1.17)	28.71^{a} (0.98)	29.15^{b} (0.74)	28.46^{a} (0.90)
Dissolved oxygen ($mg.L^{-1}$)	4.81^{b} (0.88)	3.56^{a} (1.07)	6.02^{b} (1.55)	5.08^{a} (0.83)	5.58^{a} (0.77)	6.57^{a} (0.38)	6.57^{a} (0.38)	6.08^{b} (0.36)	6.33^{b} (0.27)	6.00^{a} (0.44)
pH	6.68^{a} (0.18)	6.83^{b} (0.18)	6.91^{a} (0.11)	6.95^{a} (0.11)	6.87^{a} (0.11)	6.94^{b} (0.09)	7.02^{a} (0.13)	7.14^{b} (0.09)	7.02^{a} (0.19)	7.05^{a} (0.14)
Conductivity (µs.cm-1)	36.75^{a} (2.83)	34.95^{a} (2.70)	4604.61^{b} (3485.66)	1471.05^{a} (968.53)	40.05^{a} (2.84)	36.04^{b} (4.20)	72.18^{a} (10.62)	70.26^{a} (17.17)	52.31^{a} (16.18)	45.97^{a} (17.00)
Nitrite (mg.L-1)	1.15^{a} (1.02)	0.70^{a} (0.46)	0.99^{a} (0.38)	1.15^{a} (1.02)	0.99^{a} (0.62)	1.05^{a} (0.50)	0.55^{a} (0.61)	0.70^{a} (0.54)	1.03^{a} (0.45)	1.09^{a} (0.44)
Ammonium (mg.L-1)	0.37^{a} (0.34)	0.20^{a} (0.25)	0.29^{b} (0.21)	0.37^{a} (0.34)	0.07^{a} (0.08)	0.24^{b} (0.32)	0.14^{a} (0.12)	0.18^{a} (0.26)	0.07^{b} (0.08)	0.16^{a} (0.19)
Phosphate (mg.L-1)	2.34^{a} (0.81)	1.81^{a} (0.84)	2.41^{a} (1.86)	2.34^{a} (0.81)	2.39^{a} (0.92)	1.70^{a} (1.38)	0.92^{a} (0.56)	1.25^{a} (0.78)	2.41^{b} (0.72)	1.78^{a} (0.74)

DS: dry season; RS: rainy season.
$^{a,\ b}$: letters on the same line show the difference between seasons at the same station as regards to parameter indicated

Seasonal variations showed that the mean values of temperature, dissolved oxygen and electric conductivity were low during the rainy season in all stations. By contrast, the mean values of pH obtained in all stations were lower in the dry season. Concerning nitrites, the mean values recorded in Layo and Banco stations were lower during the rainy season. Ammonium and phosphorus mean values recorded in all stations were higher during the dry season except for Banco and Anyama I stations.

3.2 Taxa Richness and Composition

The list of Chironomid species are given in (**Table 2**). A total of 11 taxa belonging to 3 subfamilies were recorded. Chironominae, Tanypodinae and Orthocladiinae, were represented by 7,3 and 1 taxon, respectively. Banco station has the highest composition and richness. This site is not exposed to human interference. *Nidolorum fractilobus* Kieffer 1923, *Tanypus fuscus* Freeman 1955 and *Chironomus imicola* Kieffer 1913 were collected at all stations both in dry and rainy season. Chironomidae seasonal richness varied from 6 (RS) to 10 (DS) at Banco station. At Layo station, the seasonal richness was higher in dry season (4) compared to rainy season (3). In Azaguié station, 8 taxa were recorded in all the seasons. Concerning Anyama I station, the richness fluctuatedbetween 6 (RS) and 8 (DS). At last, in Anyama II station, chironomidae richness oscillated between 7 (DS) and 8 (RS).

3.3 Abundance, Density and Biomass

A total of 7164 Chironomid were collected, which consists of three subfamilies namely Chironominae, Tanypodinae and Orthocladiinae. Chironominae was the most dominant subfamily and represents 62.06% (4446 individual) of the total chironomid collected. Tanypodinae subfamily was the second abundant followed by Orthocladiinae, which recorded 2710 and 8 individual respectively. *Tanypus fuscus*, *Stictochironomus* sp. Kieffer, *Nilodorum fractilobus* and *Chironomus imicola* were the four most abundant taxa within the chironomid assemblage, contributing 34.68%, 30.10%, 15.15% and 12.14% of total abundance.

Table 2: List of Chironomid identified in the sampling stations, + = presence; **-** = absence.

SubFamilies	Taxa	Stations				
		Banco	Layo	Azaguié	Anyama I	Anyama II
Chironominae	*Nilodorumfractilobus*(kieffer)	+	+	+	+	+
	Nilodorumbrevipalpis(Kieffer,)	+	-	+	+	+
	*Polypedilum*sp. (Kieffer)	+	+	+	+	+
	Chironomusimicola (Kieffer)	+	+	+	+	+
	*Stictochironomus*sp. (Kieffer)	+	-	+	+	+
	*Cryptochironomus*sp. (Kieffer)	+	-	+	-	-
	*Stenochironomus*sp. (Kieffer)	+	-	-	+	-
Tanypodinae	*Tanypusfuscus* (Freeman)	+	+	+	+	+
	Clinotanypusclaripennis (Kieffer)	+	-	+	+	+
	Ablabesmyiadusoleili(Goetghebuer)	+	-	-	-	+
Orthocladiinae	*Cricotopuskisantuensis* (Goetghebuer)	-	-	-	-	+
Total=3	**11**	**10**	**4**	**8**	**8**	**9**

Spatial distribution of Chironomid showed that they were present in all stations but with inegal proportions. The highest and the lowest insect abundance were recorded respectively at the stations of Azaguié and Layo. The spatial distribution patterns of Chironomid density ($F_{4,180}$=15.30, *P*=0.0000) and biomass ($F_{4,180}$=10.44, *P*=0.0000) showed significant difference among stations. Nearly similar to abundance estimates, Azaguié station supported the highest annual mean biomass, followed by Anyama II. Layo recorded the lowest mean biomass. Chironomid abundance (**Table 3**) were significantly higher in dry season compared to rainy season at the stations of Anyama I ($F_{4,180}$=*6.53*, *P*=0.0152) and Anyama II ($F_{4,180}$=7.45, *P*=0.0099). Concerning Density significant difference was observed in dry and rainy season in Anyama I ($F_{4,180}$=7.26, *P*=0.0108) and Anyama II ($F_{4,180}$=7.33, *P*=0.0105) stations. Nearly similar to abundance and density estimates a significant difference in biomass was observed in dry season and rainy season in Anyama I ($F_{4,180}$=10.18, *P*=0.0030) and Anyama II ($F_{4,180}$=6.22, *P*=0.0175). At Banco station, *Stictochironomus* sp. was dominant (in terms of abundance) in all the seasons. At Layo station, *Chironomus imicola* (RS) and *Nilodorum fractilobus* (DS) were the most dominant. In Azaguié station, *Tanypus fuscus* and *Nilodorum fractilobus* were the most dominant respectively in dry and rainy seasons. Concerning Anyama I, *Stictochironomus* sp. and *Tanypus fuscus* dominated in dry and rainy season respectively. At last, in Anyama II station, *Tanypus fuscus* was abundantly recorded both in dry and rainy seasons. In Banco station, *Chironomus imicola* (DS) and *Tanypus fuscus* (RS) recorded the important biomass. In Layo station, *Chironomu simicola* dominated the biomass in both dry and rainy seasons. In Azaguié station, *Tanypus fuscus* was the most dominant in term of biomass in both the dry and rainy seasons. *Stictochironomus* sp and *Tanypus fuscus* dominated the biomass respectively in dry and rainy season at Anyama I station. Concerning Anyama II station, *Tanypus fuscus* recorded the highest biomass in dry season while *Chironomus imicola* was the most important in rainy season.

3.4 Diversity and Similarity Indices

Shannon-Wiener diversity ($F_{4,180}$=25.79, *P*=0.0000) and Evenness ($F_{4,180}$=5.40, *P*=0.0003) indexes showed significant difference among the stations. The highest values of Shannon-Wiener diversity and Evenness indexes were recorded at Anyama II station. Seasonal variation showed significant difference in Shannon-Wiener index in Banco ($F_{4,180}$=5.02, P=0.0315), Azaguié ($F_{4,180}$=4.62, *P*=0.0387) and Anyama I ($F_{4,180}$=5.24, *P*=0.283) station (**Table 3**). The Sorensen similarity index showed important similarity between Banco and Azaguié and between Banco and Anyama I (**Table 4**).

3.5 Relationships Between Environmental Variables and Chironomidae Taxa

Most of the data variability was explained by the two first axes of Canonical Correspondent Analysis (**Figure 2**) (65.84 % axis I and 24.66 % axis II).

Table 3 : Spatiotemporal variations of abundance, density, biomass, Shannon-Wiener diversity (bits) and evenness of Chironomid communities among stations (mean ± (SD)). DS= dry season; RS= rainy season.

Parameters	Banco		Layo		Azaguié		Anyama I		Anyama II	
	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS
Richness	10	6	4	3	8	8	8	6	7	8
Abundance (ind.)	873	852	128	137	1193	1276	860	392	905	548
Density ($ind.m^{-2}$)	368.51[a] (254.43)	368.51[a] (376.35)	54.16[a] (27.30)	62.03[a] (31.72)	538.88[a] (251.36)	569.44[a] (519.96)	393.51[b] (331.00)	171.75[a] (11.07)	409.25[b] (239.63)	245.83[a] (90.30)
Biomass ($mg.m^{-2}$)	1.45[a] (0.90)	1.35[a] (1.43)	0.43[a] (0.21)	0.50[a] (0.25)	2.45[a] (1.09)	3.28[a] (4.26)	1.71[b] (1.38)	0.63[a] (0.39)	1.98[b] (1.10)	1.26[a] (0.51)
Shannon-Wiener index	1.65[b] (0.52)	1.30[a] (0.42)	0.64[a] (0.52)	0.57[a] (0.49)	1.71[b] (0.47)	1.38[a] (0.45)	1.35[b] (0.42)	0.92[a] (0.66)	1.61[a] (0.39)	1.74[a] (0.48)
Evenness	0.77[a] (0.16)	0.76[a] (0.19)	0.57[a] (0.43)	0.54[a] (0.45)	0.81[a] (0.13)	0.71[a] (0.18)	0.76[b] (0.13)	0.56[a] (0.35)	0.79[a] (0.13)	0.84[a] (0.13)

[a, b]: letters on the same line show the difference between seasons at the same station as regards the parameter indicated.

Table 4: Sorensen similarity index of Chironomid communities recorded in the different stations.

	Banco	Layo	Azaguié	Anyama I	Anyama II
Banco		57.14	88.88	88.88	84.21
Layo			66.66	66.66	61.54
Azaguié				87.5	82.35
Anyama I					82.35
Anyama II					

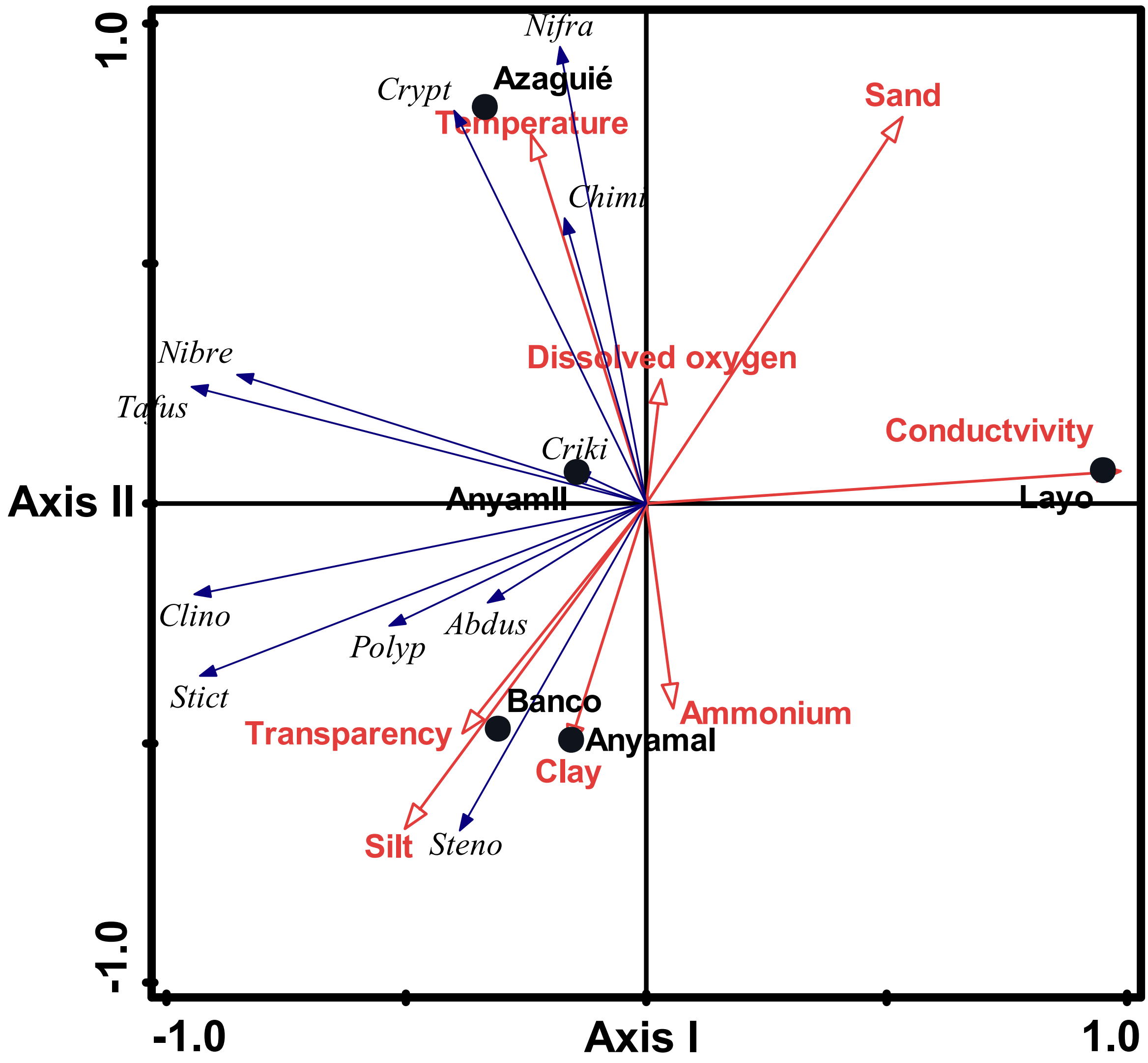

Figure 2: Canonical correspondence analysis carried out with selected environmental variables and with Chironomid taxa. Taxa codes :
Abdus=*Ablabesmyia dusoleili*, ***Chimi***=*Chironomus imicola*, ***Clino***=*Clinotanypus claripennis*, ***Crypt***=*Cryptochironomus* sp., ***Criki***=*Cricotopus kisantuensis*, ***Nibre***=*Nilodorum brevipalpis* ***Nifra***=*Nilodorum* fractilobus, ***Polyp***=*Polypedilum* sp, ***Steno***=*Stenochironomus* sp., ***Stict***=*Stictochironomus* sp., ***Tafus***=*Tanypus fuscus*

The first axis separates stations and species from more salty and sandy environments (Layo), in the right side of this axis, from freshwater stations with sediments composed essentially of sand, silt and clay, in the left side of this axis. High values of temperature and dissolved oxygen were observed in Anyama II and Azaguié stations, whereas transparency, clay, ammonium and silt are quite important in Banco and Anyama I station. In Layo station, high conductivity values wereregistered and the substrate is mostly composed by sand. *Chironomus imicola*, *Nilodorum fractilobus* and *Cryptochironomus* sp. Kieffer select environments with higher temperature and higher dissolved oxygen concentrations. *Stenochironomus* sp. Kieffer preferred higher transparent waters and sediments with higher silt content.

4 DISCUSSION

Three subfamilies (Chironominae, Orthocladiinae, Tanypodinae), and 11 taxa were identified from family Chironomidae in this study. These subfamilies are the most commonly found in West Africa aquatic habitats (Diomandé *et al.,* 2000; Hilde *et al*., 2005) and are known to have worldwide distribution (Rosin *et al.,* 2009). The comparison of taxonomic richness between the different stations indicates that Banco station recorded the highest number of taxa. This would be linked to environmental conditions of the stations. Indeed, Banco station is located in the Banco National Park, which is a primary forest. This station is not disturbed by human activities. Furthermore, the ponds of this station were abandoned. These characteristics could act in favor of the greater taxonomic richness that this station hosts from those stations in operation. Cereghino *et al*. (2008) point out that abandoned ponds tend to support a greater number of taxa. The other stations are located in agricultural landscapes and are subject to human influence. This disturbance could explain the low taxonomic richness observed in these habitats. In term of taxonomic richness Banco was followed by Anyama II station in this study. These two stations are characterized by a substrate consisting mainly of silt that may contain a significant amount of organic matter. These habitat units are preferred by a lot of species because they offer refugia and adequate conditions for feeding. At Layo station, we have surveyed only four genera. So Chironomid family is poorly represented in this station. This is justified by the fact that only a few species of this family live in brackish waters (Tachet *et al*., 2003). Our results showed that some genera of Diptera such as *Tanypus, Nilodorum* and *Chironomus* were recorded in different stations. According to (Arslan *et al*., 2010) genera *Tanypus* and *Chironomus* have worldwide distributions and occur in freshwater systems. In addition, *Tanypus fuscus* is reported as ecologically tolerant (Florencio *et al*., 2009) and has an extensive geographical range (Çamur-Elipek *et al*., 2010). The highest diversity was registered in Anyama II station, due to the high evenness of the assemblages living in this station. According to Maqboul *et al*. (2001.), the station of Anyama II had diverse taxa with balanced abundances. This is the consequence of its ecological heterogeneity and stability. Seasonal variation showed significant difference in Shannon-Wiener index in Banco, Azaguié and Anyama I station indicating that ponds ecosystems presented fewer disturbances during the dry season in these stations. The Sorensen index revealed that there was a minimum similarity between Layo and the others stations. This observation might be due to the low specie richness harvested in this station. On the other hand, the insect population identified in the others stations had high similarity. Of 3 subfamilies of chironomidae observed from our study sites, Chironominae were the most abundant. This observation is supported by previous studies in Ivorian (Diomandé *et al*., 2014) and Malaysian (Ahmad *et al*., 2014) aquatic ecosystems. Chironominae contributed the greatest generic diversity. Chironominae were also the most frequently observed subfamily among all study sites. Our results suggest that the average contribution of chironominae to total abundance and generic richness was 62.06% and 63.64% respectively. The dominance of Orthocladiinae subfamily in terms of abundance and generic richness was demonstrated by Chaib *et al*. (2013) in Algerian hydrosystems. On the otherhand in our study this subfamily recorded the lowest abundance and richness. The dominance of Chironominae is also reported by other studies about Brazilian lotic systems (Sanseverino & Nessimian, 2001; Suriano & Fonseca-Gessner, 2004). *Tanypus fuscus* was the most abundant and widely distributed taxon, confirming that this specie can tolerate a wide range of substrate size (with a preference for the sandy substrate). In contrast *Cricotopus kisantuensis* Goetghebuer was the least abundant, present only in very fine clay substrate. The seasonal variation showed that the highest density of chironomid was recorded in the dry season at the stations of Anyama I and Anyama

II, due to presence of *Chironomus imicola, Clinotanypus claripenis* Kieffer*, Stictochironomus* sp. and *Tanypus fuscus* in these stations. In contrast, densities of *Chironomus imicola* and *Nilodorum fractilobus* (Layo), *Polypedilum* sp. Kieffer, *Stictochironomus* sp. (Banco) and *Nilodorum fractilobus* (Azaguié) were higher during the rainy season. During the dry season, biomass was significantly higher at all stations except Azaguié. This situation is due to the high biomass of *Clinotanypus claripennis*, (Banco), *Nilodorum fractilobus* (Layo), *Chironomus imicola*, *Nilodorum fractilobus* (Anyama I), *Chironomus imicola* and *Tanypus fuscus* (Anyama II) in dry season. In this study, the pattern distribution according to environmental variables indicates that *Chironomus imicola*, *Nilodorum fractilobus* and *Cryptochironomus* sp. were associated to high value temperature, and dissolved oxygen. Edia (2008) reported significant relationships between species composition and pH, temperature, and dissolved oxygen in the Soumié, Ehania, Tanoé and Eholié rivers in southern Ivory Coast. Similar result was observed by Diomandé *et al*. (2009) in Bia River in southern Ivory Coast. Ogbeibu (2001) observed a significant positive correlation between density and water temperature in temporary pond in Okomu Forest Reserve, in southern Nigeria. According to Ross *et al*. (1982), temperature is one of the most important environmental factors controlling aquatic insect density. In addition, high water temperatures might accelerate the feeding activity of benthic predators *Nilodorum fractilobus* and *Chironomus imicola.*

5 CONCLUSION

In conclusion, the present study reports 11 aquatic insect taxa (Chironomidae) in the different inventoried stations. Chironominae was the most diversified group. This group was numerically the most abundant and dominated also aquatic insect biomass in fishponds. Importance of abiotic factors in distribution of aquatic insects hosted by farm ponds was also shown. Chironomid communities are quite diverse and stable among stations except Layo. Consequently, these communities are similar among the stations except Layo. In addition, community parameters are correlated to environmental variables such as water temperature.

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