

Diversity and Community Structure of Benthic Insects in Fish Farm Ponds in Southern Côte d'Ivoire, West Africa.

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Authors' contributions

This work was carried out in collaboration between all authors. MLY designed the study, wrote the protocol and the first draft of the manuscript; BCA managed the analyses of the study; PK managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

Aims: The objective of this study is to identify the commonly occurring benthic insect fauna and workout their abundance, diversity, evenness, and degree of similarity in five fish farm ponds in southern Côte d'Ivoire.

Study design: Sampling was done in three ponds per station. In each pond, samples were collected monthly in sediment using a Van veen grab.

Place and Duration of Study: Benthic insect diversity and community structure were studied from December 2007 to November 2008 in five fish farm ponds (Layo, Banco, Azaguié, Anyama I and Anyama II) in Southern Côte d'Ivoire.

Methodology: Samples were taken in six replicates which were pooled to constitute a sample for each pond.

Results: In total, 31 taxa belonging to 18 families and 7 orders have been recorded. Insect benthic fauna is clearly dominated by Chironomid Diptera. *Nilodorum fractilobus*, *Chironomus imicola*, *Stictochironomus* sp., *Tanytus fuscus* and *Ceratopogon* sp. were the dominant taxa. Anyama II station recorded the maximum values of Shannon-Wiener diversity index and evenness. Insect community structure was visualized using Canonical Correspondence Analysis to show the affinities of each species for selected environmental parameters.

Conclusion: The species reported for the first time contributed the list of insects' species from Ivorian aquatic ecosystems.

Keywords: fish farm ponds, benthic insects, diversity, community structure

1. INTRODUCTION

Aquatic insect species form complex communities with multiple functional feeding groups that fulfil essential ecological roles at several trophic levels (Merritt et al., 1996). Insects with their abundance and diversity dominate fresh water ecosystem (Jana et al., 2009). However, the insect fauna of aquatic ecosystem in Côte d'Ivoire is rather poorly documented. Few studies have been carried out on the ecological and systematic aspects of aquatic entomofauna. Unfortunately the vast majority of this work was undertaken in running water and was also carried out in the northern part of the country. In the south part, there is very little literature on aquatic insects (Dejoux et al., 1981; Diomandé et al., 2009; Diétoa, 2002; Edia et al., 2007, 2010; Edia, 2008; Kouadio et al., 2008,). Fishpond

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complexes are important hot-spots for biodiversity (Anonyme, 2012; Yapo et al., 2012, Yapo et al., 2013). Aquatic invertebrates play a central role in the fishpond ecosystem as a major food resource for many predatory organisms (Broyer and Curtet, 2010). Ponds are habitats of critical importance for many aquatic insect species. However, very little attention has been given to natural or artificial ponds ecosystems in Côte d'Ivoire. To our knowledge, so far, no work has been done on the quantitative aspect of the aquatic insects in artificial ponds. The present study was carried out with the objective to identify the commonly occurring insect fauna and workout their abundance, diversity, evenness, and degree of similarity in five fish farm ponds in southern Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1 Study Site

This study was undertaken in five fish farms in the southern region of Côte d'Ivoire 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 assigned to habitat types according to environmental and ecological features: Aquaculture Experiment Station of Layo (05°19'N; 04°18'W), fish farms of Banco (05°23'N; 04°03'W), Azaguié (05°39'N; 04°05'W), Anyama I (05°33'N; 04°03'W) and Anyama II (05°34'N; 04°02'W) (Fig. 1). The immediate environment is composed of coconut tree, Ebrie lagoon and some houses (Layo). Banco site is located in National Park of Banco. The surrounding ecosystem of this station comprised of primary forest, Banco River and a few houses. In Azaguié, Anyama I and Anyama II, surrounding ecosystems comprised of agricultural landscape. The immediate environment was characterized by a banana plantation and a degraded forest with grass cover consists largely of Poaceae (Azaguié), by a banana plantation, a teak plantation and a degraded forest (Anyama I) and a rubber plantation, some orange tree and a degraded forest (Anyama II). 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 Experimental 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. All ponds at all sites were permanent and were shallow (depth < 1 m). In each site, three ponds were randomly selected for this study. Pond area varied from 280m² to 500m². Bottom sediment are mostly composed by sand in Layo and Azaguié stations, by mud in Banco, sand and clay in Anyama I while in Anyama II station, mud and sand were the dominant substrat.

Tilapia Oreochromis niloticus Linnaeus, 1758 is the only fish species breeded in the different fish farm ponds except Banco where pond were abandoned. In each site, pond were originally man-made. The rice bran was the food provided to the fish. Feeding frequency was 3 sessions per day. Density of loading is from 3 to 5 fish/m² (Layo), 6 fish/m² (Azaguié and Anyama II) and 7 fish/m² (Anyama I).

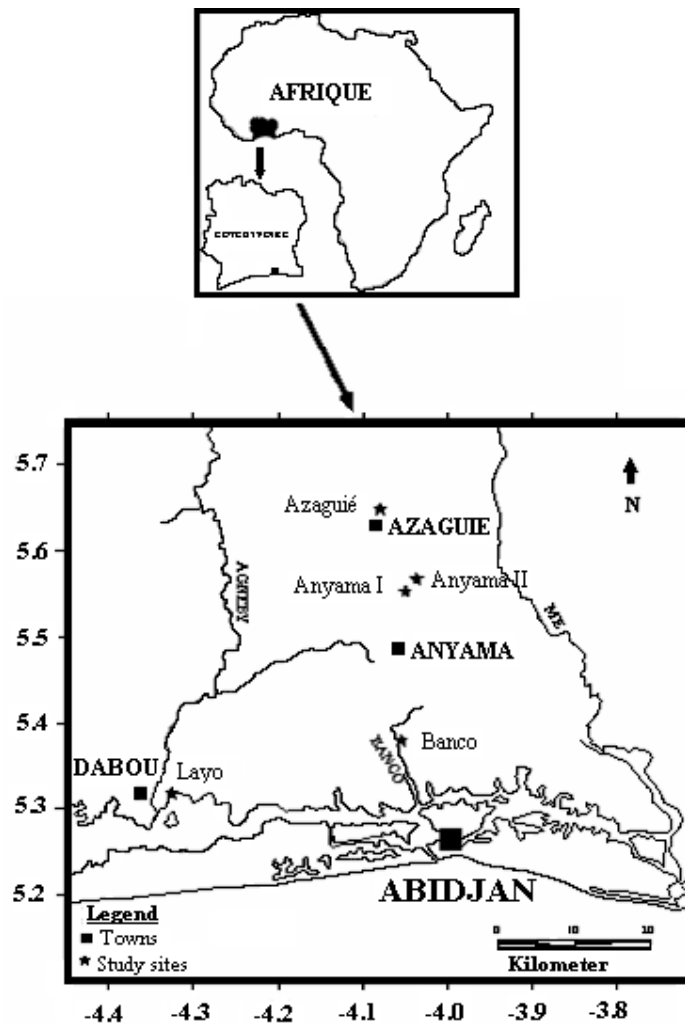


Fig.1. Location of the study area showing the different sampling stations

2.2 Sampling Procedure

In each pond, monthly samples were taken in six replicates using Van veen grab (area = 0.09 m^2) between December 2007 and November 2008. Each farm environmental variables and insects were respectively measured and sampled on the same day. One farm is sampled per day. The samples collected were sieved through 1 mm aperture size sieve. The six samples were pooled to form a sample of the pond per month and the remaining materials were preserved in plastic bottles containing 10% formalin. In the laboratory, specimens were sorted and identified under a stereo binocular microscope to the lowest possible taxonomic level (species, genus, family), by use of systematic and classification keys (Dejoux et al., 1981; Tachet et al., 2003; de Moor et al., 2003 a; 2003 b). Insects were counted and numbers of each species were expressed as organisms. m^{-2} . Biomass (dry weight; $\text{mg}.\text{m}^{-2}$) was estimated after desiccation to constant weight for 24 h at 60°C

according to Mathooko (2001). Mean densities (individuals.m⁻²) and mean biomass were calculated for each season and for overall total study period.

2.3 Measure 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 determined using a 20-cm-diameter Secchi disk. Water samples were collected on every sampling day and conducted at laboratory. Analyses of dissolved inorganic nutrients (ammonium, NH₄⁺; nitrite, NO₂⁻ and soluble reactive phosphorus, PO₄³⁻) from filtered samples were carried out according to Grasshoff et al. (1983).

2.4 Statistical Analysis

In each sampling station, abundance, density, Shannon-Wiener diversity index (bits) (Spellerberg & Fedor, 2003), and Pielou Evenness (Pielou, 1969) were estimated. Shannon-Wiener diversity index was used to simultaneously quantify the taxonomic richness and distribution of taxa in the communities. Evenness was used to measure the distribution of individuals within species, regardless of species richness. Coefficient of similarity between stations was estimated following Sorensen (1948). Sorensen (1948) index was used to assess the similarity of insect communities between different stations. Analysis of variance (ANOVA) was used to determine the 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 the Kolmogorov-Smirnov test. Data were log₁₀ (X+1) transformed prior to analysis. A comparison of the data collected at different stations was made using one-way ANOVA and Tukey's *post hoc* test. Analyses were conducted using R 2.13.1 software. Dominance (Do) as most abundant taxa numerically of different species was described on the basis of relative abundance. Moreover, relationships between the distribution and abundance of aquatic insects and environmental variables for all the five sampling stations were determined by Canonical Correspondence Analysis (CCA) using CANOCO 4.5 software. Taxa which obtained at least 0.2% of the total abundance in benthic environment were included in the analysis. These taxa were considered as principal taxa. This was done to minimize the influence of rare taxa (15 taxa). Detrended Correspondence Analysis (DCA) was first performed on taxa. The minimum length of the gradient is less than 3 SD. The linear method RDA appears most appropriate for analyzing our data. The importance of the canonical correspondence analysis was tested by the Monte Carlo test which showed a significance (*P-value* = 0.024, *F-ratio* = 2.93) for 499 permutations. Eight environmental parameters were returned for the analysis.

3. RESULTS AND DISCUSSION

3.1. Physical and chemical variables

The temporal variation of the environmental variables is shown by Fig. 2. The average temperature oscillated between 27.2°C (Banco) and 28.9°C (Azaguié). The temporal variation showed that the maximum values of this parameter were recorded in the dry season during March (Layo, Banco, Azaguié and Anyama I) and during August (Anyama II). Overall, the different ponds were well oxygenated. The mean values were greater than to 4.18 ± 1.15 mg/l. The maximum values of dissolved oxygen were recorded during March (Layo, Banco, Anyama I), during July (Azaguié) then during September and October (Anyama II). The mean values of pH fluctuated between 6.75 ± 0.19 (Banco) and 7.08 ± 0.12 (Anyama I). The maximum values of pH were recorded in the dry season during September (Layo, Banco and Anyama II) and in the rainy season during October (Azaguié) and during November and July (Anyama I). The station of Layo recorded the highest value of electrical conductivity (3037.83 ± 2980.25 µS/cm) due to its brackish water source. This

fact is attributed to a high concentration of dissolved salt in ponds water, but also to the nature of the lagoon water. Indeed, the lagoon are loaded dissolved salts than fresh water. The value of conductivity observed in the others stations were 35.85 ± 2.88 (Banco), 38.05 ± 4.08 (Azaguié), 71.22 ± 14.10 (Anyama I) and 49.14 ± 16.67 (Anyama II). The highest values were monthly observed in the dry season during February (Azaguié (41.66 ± 2.33), Anyama I (84.30 ± 35.65) and March (Layo (8246.66 ± 424.54), Banco (39.66 ± 0.57), Anyama II (71.30 ± 19.78)). Concerning the secchi transparency, Banco presented the clearest water (30.14 ± 4.26 cm). The monthly variation indicated that the clearest waters were observed in the dry season, during February (Layo), during August (Anyama II) then during September (Azaguié, Anyama I and Banco). The maximum average values of nitrite were recorded in Layo station. The temporal variation indicated that the maximum values were obtained in the dry season during March (Layo, Banco, Azaguié and Anyama II) and in the rainy season during November (Anyama I). The average values of ammonium oscillated between 0.12 ± 0.16 mg/l (Anyama II) and (0.31 ± 0.36) mg/l (Banco). The great values of this parameter were recorded in the dry season during January (Banco) and September (Layo) then in the rainy season during November (Azaguié, Anyama I and Anyama II). The content phosphorus varied from 3.16 ± 7.94 mg/l (Anyama I) to 5.56 ± 8.35 mg/l (Layo). Overall, the highest values were obtained during November (Layo), October (Banco), June (Azaguié) and December (Anyama I). On the other hand, in Anyama II station, the average was high in the rainy season during December. In ponds, nutrients are released by mineralization of rice bran (Dabbadie, 1996). The highest values of nutrients unregistered in Layo station compared to those of Azaguié, Anyama I and II Anyama is due to the fact that in Layo (experimental station), food is regularly supplied to fish. In contrast, other active farms owned by individuals. The excessive cost of inputs often causes breaks in the distribution of the food which is not given optimal amount. The difference in the amount of food distributed to fish would be the basis of the difference observed between the content of nutrients. Ponds of Layo and Banco are aging compared to other stations. These ponds are no longer priests. Accumulation of sediment could increase the nutrient content in these ponds, particularly for Banco station. In Layo station, lagoon nature of pond water could also be in favor of increasing the nutrient content.

3.2 Taxonomic richness

In Table 1 the list and dominance of the benthic insect species collected from December 2007 to November 2008 is reported. A total of 31 taxa belonging to 18 families and 7 orders were identified. This is the first report on aquatic insects in fishponds of Côte d'Ivoire, using quantitative data. During the sampling periods, three of inventoried taxa (*Macrolea* sp., *Valleriola* sp. and *Corydalidae*) were reported for the first time in the Côte d'Ivoire aquatic ecosystems. It is a contribution to the list of insect species from Ivorian aquatic ecosystems. In all stations, benthic insect fauna was dominated by Diptera. This order is typical of many freshwater systems (Arslan et al., 2010). The family Chironomidae had the highest number of taxa (11 taxa). In addition, 87.29% of Dipterans in terms of abundance were Chironomidae. Thus this situation confirms the dominant position of Chironomids among Dipterans (Sharma et al., 1993). Similar result was observed by Ogbeibu (2001) in a temporary pond in southern Nigeria, by Diomandé et al. (2009) in Agnéby river (Ivory Coast) and by Foto et al. (2011) in Biyéme river (Cameroon). Kouamé et al. (2011) reported that the Chironomidae populations are almost always found to be numerically predominant, both in lotic and lentic environments, due to their tolerance of extreme conditions. Moreover, Merritt and Cummins (1996) reported that the life environmental conditions of Chironomids were more extensive than those of any other group of aquatic insects. Their wide ecological amplitude is related to their very extensive array of morphological, physiological and behavioural adaptations (Kouamé et

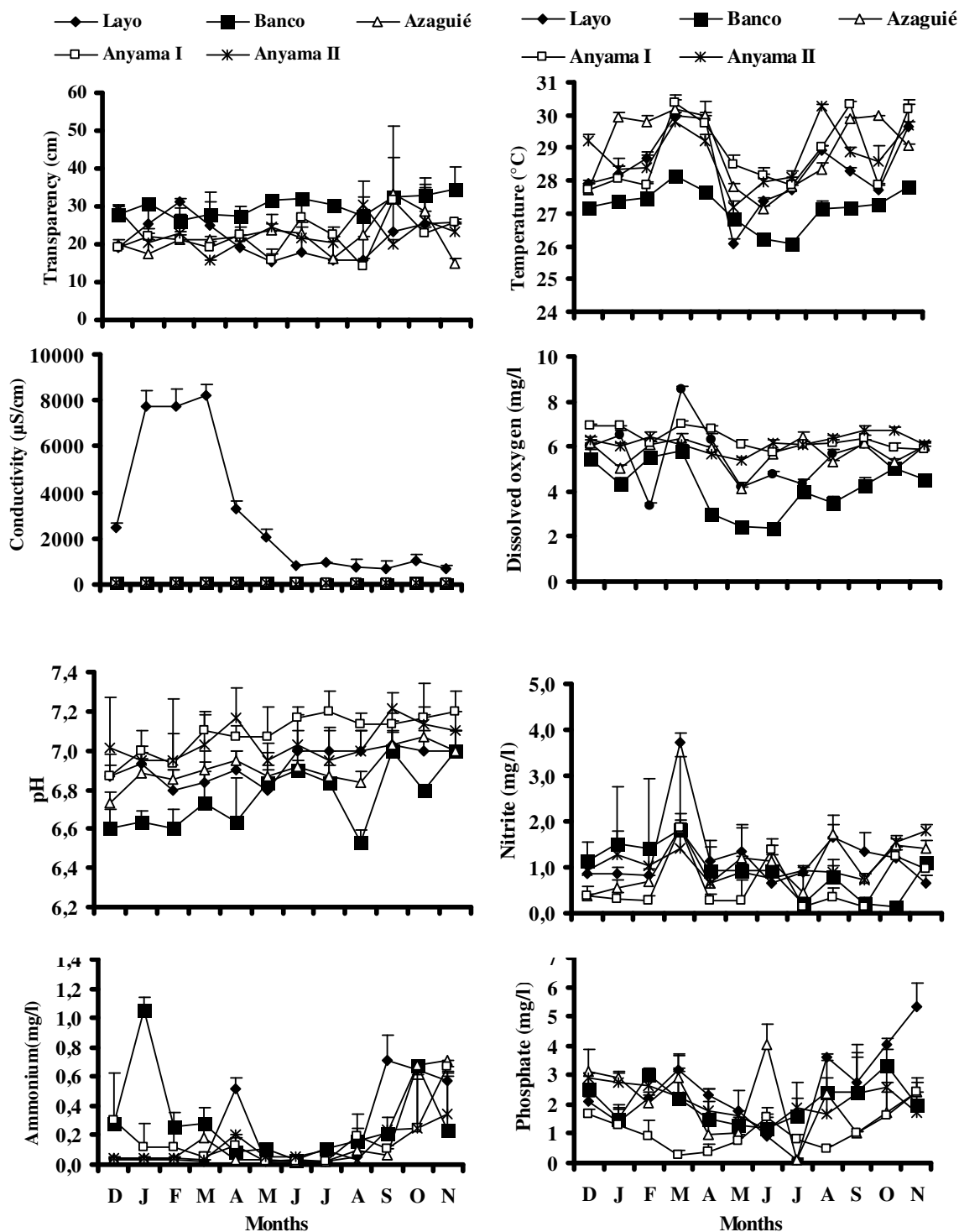


Fig. 2. Temporal variation of environmental variables in the different stations.

Table 1. List of benthic insects and dominance in percentage in the different stations during december 2007 to november 2008
La= Layo; Ba=Banco; Az= Azaguié; An I= Anyama I; An II= Anyama II
Number in bold: the dominant taxa per station

Taxa	Stations				
	Ly	Bc	Az	An I	An II
Ephemeroptera					
Caenidae					
<i>Caenis</i> sp.			0.15	2.33	0.47
Polymitarcyidae					
<i>Povilla adusta</i>		0.59	0.04	0.07	0.21
Odonata					
Gomphidae					
<i>Ictinogomphus</i> sp.				0.55	
Libellulidae					
<i>Orthetrum</i> sp.			0.04	0.34	
<i>Libellula</i> sp.		0.21	0.07	0.21	0.37
<i>Pantala flavescens</i>			0.04		
<i>Brachythemis</i> sp.	10.56	0.70	1.15	1.44	0.79
Hemiptera					
Hydrometridae					
<i>Hydrometra</i> sp.				0.07	
Leptopodidae					
<i>Valleriola</i> sp.				0.07	
Megaloptera					
Corydalidae		0.05			

Table 1. Extended

Taxa	Stations				
	Ly	Bc	Az	An I	An II
Coleoptera					
Hydrophilidae					
<i>Hydrochara rickseckeri</i>			0.04		
Chrysomelidae					
<i>Macrolea</i> sp.		2.09			
Dytiscidae					
<i>Laccophilus vermiculosus</i>			0.07		0.05
Trichoptera					
Ecnomidae					
<i>Ecnomus</i> sp.				0.34	
Hydropsychidae					
<i>Protomacronema</i> sp.		0.11			
Polycentropodidae					
<i>Dipseudopsis capensis</i>		2.63			0.21
Hydroptilidae					
<i>Hydroptila</i> sp.		0.05			
Diptera					
Chironomidae					
<i>Ablabesmyia dusoleili</i>		0.48			0.90
<i>Chironomus imicola</i>	46.13	4.83	7.28	8.44	15.87
<i>Clinotanytus claripennis</i>		3.92	1.55	2.54	2.32
<i>Cryptochironomus</i> sp.		0.27	2.48		
<i>Nilodorum fractilobus</i>	40.85	4.83	25.38	1.65	7.06
<i>Nilodorum brevipalpis</i>		2.20	1.18	0.75	1.05
<i>Polypedilum</i> sp.		4.67	0.96	0.82	0.32
<i>Stenochironomus</i> sp.		0.16		0.07	
<i>Stictochironomus</i> sp.		51.93	10.27	38.78	16.50
<i>Tanytus fuscus</i>	1.41	12.19	40.08	30.75	30.15
<i>Cricotopus kisantuensis</i>					0.42
Ceratopogonidae					
<i>Ceratopogon</i> sp.	1.06		1.92	3.16	17.24
Chaoboridae					
<i>Chaoborus anomalus</i>		7.63	7.31	7.62	5.96
Tabanidae					
<i>Tabanus</i> sp.		0.48			0.11

al., 2011). Some genera of Diptera such as *Tanytus*, *Nilodorum* and *Chironomus*, were recorded in all stations. According to Arslan et al. (2010), genera *Tanytus* and *Chironomus* have worldwide distributions and commonly occur in freshwater standing systems. *Tanytus fuscus* have been reported as ecologically tolerant (Florencio et al., 2009) with an extensive geographical range (Çamur-Elipek et al., 2010). Our result supported this knowledge. By contrast, especially *Valleriella* sp., *Hydrometra* sp. (Hemiptera), *Hydroptila* sp. (Trichoptera) and Corydalidae (Megaloptera) were represented by only one specimen. These species were not particularly abundant during this study. According to Taylor and McPherson (2006), pond habitats may be marginal for these species. The large variation in the abundance of aquatic insects between Layo and the other stations may be due to the low taxonomic richness observed in this station. This low taxonomic richness in Layo could be due to the abiotic conditions such as conductivity and nitrite which are higher in this station.

3.3 Abundance, density and biomass

The highest and the lowest benthic insects abundance were respectively recorded in Azaguié and Layo stations (Table 2). The spatial distribution patterns of benthic insect's density ($F_{4, 180} = 16.40$; $P = .00$) and biomass ($F_{4, 180} = 6.65$; $P = .00$) show significant difference between the stations. Benthic insect density and biomass were significantly higher in the dry season compared to the rainy season in stations Anyama I ($F_{1,180} = 6.47$; $P = .01$) and Anyama II ($F_{1,180} = 6.43$; $P = .01$). In these stations, the highest density and biomass were observed during the dry season (Table 3). On the other hand, significant difference between seasons in the others stations was not documented. The overall density of benthic insect varied spatially and temporary in response to environmental variables. The overriding influence of conductivity in the distribution and abundance of benthic insect fauna can explain the significantly lower density in Layo. Concerning the temporal variation, higher densities of benthic insects were recorded during the dry season in Anyama I and Anyama II stations. This is due to high density of taxa such as *Chironomus imicola*, *Clinotanypus claripennis*, *Stictochironomus* sp. and *Tanypus fuscus* during the dry season in these stations. In the other hand, the highest densities recorded during the rainy season in Layo, Banco and Azaguié stations is due to the high density of *Chironomus imicola* and *Nilodorum fractilobus* (Layo), *Polypedilum* sp., *Stictochironomus* sp. and *Chaoborus anomalus* (Banco) and *Nilodorum fractilobus* (Azaguié). The highest biomass was unregistered during the dry season in all station except Azaguié. This situation is due to the high biomass of *Macroplea* sp., *Brachythemis* sp., *Clinotanypus claripennis*, *Tabanus* sp (Banco), *Brachythemis* sp. and *Nilodorum fractilobus* (Layo), *Ictinogomphus* sp., *Chironomus imicola*, *Nilodorum fractilobus* (Anyama I), *Chironomus imicola* and *Tanypus fuscus* (Anyama II) in this season.

Table 2. Spatial variation of number of taxa, abundance, density, biomass, Shannon-Wiener diversity index (bits), and evenness among stations (mean $\pm$ (SD)).

Parameters	Stations				
	Layo	Banco	Azaguié	Anyama I	Anyama II
Number Of taxa	5	19	18	19	18
Abundance	284	1863	2707	1456	1897
Density (ind.m ⁻²)	87.65 ^a (46.89)	575.00 ^b (438.22)	835.49 ^c (598.03)	449.38 ^b (397.66)	585.49 ^{bc} (327.27)
Biomass (mg.m ⁻²)	0.89 ^a (0.75)	1.97 ^b (1.51)	3.38 ^c (3.33)	2.32 ^b (2.47)	2.14 ^b (1.16)
Shannon- Wiener Index	0.86 ^a (0.52)	1.88 ^{bc} (0.57)	1.89 ^{bc} (0.49)	1.65 ^b (0.59)	2.13 ^c (0.49)
Evenness	0.68 ^a (0.36)	0.76 ^{ab} (0.17)	0.74 ^{ab} (0.14)	0.75 ^{ab} (0.13)	0.83 ^b (0.11)

^{a, b, c, d} letters in the same row show differences among stations ($P = .05$).

Table 3. Seasonal variation of abundance, density, biomass, Shannon-Wiener diversity index and evenness of aquatic insects among stations (mean $\pm$ (SD)). DS= dry season; RS= rainy season

Parameters	Stations									
	Layo		Banco		Azaguié		Anyama I		Anyama II	
	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS
Density (ind.m ⁻²)	83.33 ^a (45.93)	91.97 ^a (48.77)	570.98 ^a (352.48)	579.01 ^a (520.66)	824.07 ^a (351.20)	846.91 ^a (782.76)	606.17 ^b (487.47)	292.59 ^a (189.44)	714.19 ^b (402.44)	456.79 ^a (153.24)
Biomass (mg.m ⁻²)	0.91 ^a (0.84)	0.87 ^a (0.67)	2.17 ^a (1.21)	1.77 ^a (1.76)	3.20 ^a (1.56)	3.56 ^a (4.50)	3.42 ^b (2.94)	1.22 ^a (1.15)	2.61 ^b (1.34)	1.67 ^a (0.73)
Shannon- Wiener index	0.95 ^a (0.54)	0.77 ^a (0.50)	2.03 ^a (0.60)	1.74 ^a (0.53)	2.09 ^b (0.47)	1.69 ^a (0.44)	1.78 ^a (0.57)	1.52 ^a (0.60)	2.08 ^a (0.42)	2.17 ^a (0.56)
Evenness	0.71 ^a (0.35)	0.65 ^a (0.37)	0.77 ^a (0.16)	0.74 ^a (0.18)	0.77 ^a (0.11)	0.72 ^a (0.17)	0.74 ^a (0.13)	0.76 ^a (0.14)	0.82 ^a (0.09)	0.84 ^a (0.13)

a, b, letters in the same row show differences among seasons within station ($P=.05$).

3.4 Diversity and similarity indices

We found a significant difference ($F_{4,180} = 29.80$; $P=.00$) among stations in Shannon-Wiener diversity index (Table 2). The Evenness followed a similar pattern. The Evenness was significantly different among stations ($F_{4, 180} = 2.42$; $P= .04$). The lowest value of Evenness was observed in Layo compared to this unregistered in Anyama II. Anyama II station recorded the highest value of Shannon- Wiener diversity index and Evenness. This station had diverse taxa with balanced abundances (Maqboul et al., 2001). The significantly higher diversity in Anyama II is a reflection of its ecological heterogeneity and stability. The high evenness index justify this situation. Indeed, the higher the evenness the higher the diversity (Victor & Ogbeibu 1985). Our results are similar to those obtained by Ogbeibu (2001) regarding the spatial variation of Shannon- Wiener diversity index and Evenness. With regard to Shannon- Wiener diversity index values, the values obtained in the course of our study are in the majority of the cases above of those of the same author. The results of this author range from 0.74 to 0.98, while ours oscillate between 0.86 and 2.13. Seasonal variation showed significant difference in Shannon-Wiener index in Azaguié station (Table 3) indicating that ponds ecosystems presented fewer disturbances during the dry season in this station. The Sorensen similarity index showed that Azaguié and Anyama II were strongly similar ($QS=77.77$) (Table 4). This index revealed that minimum similarity was 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.

Table 4. Sorensen similarity index of benthic insect's communities recorded in the different station

	Layo	Banco	Azaguié	Anyama I	Anyama II
Layo		33.33	43.47	41.66	43.47
Banco			64.86	63.15	75.67
Azaguié				75.67	77.77
Anyama I					70.27
Anyama II					

3.5 Relationships between environmental variables and benthic insect communities

The results of Canonical Correspondence analysis revealed that the relationships between insect' taxa and their habitat conditions follow mainly the first two axes (Fig. 3). These two axes accounted for 85.4% of the total variance. These axes expressed 57.4% (axis I) and 28.4% (axis II). Following the axis I, are positively correlated electrical conductivity and the sand. The mud and transparency and clay are negatively correlated to this axis. Temperature, pH, and dissolved oxygen are negatively correlated to the axis II. *Ceratopogon* sp., *Cryptochironomus* sp. *Stictochironomus* sp. *Chaoborus anomalus* are positively correlated to pH, sand, mud and clay respectively. *Brachythemis* sp. and *Chironomus imicola* are positively correlated to conductivity. Positive correlation was observed between transparency and *Polypedilum* sp. and *Clinotanypus claripennis*. In the other hand, *Caenis* sp., *Povilla adusta*, *Nilodorum brevipalpis*, *Macroplea* sp., *Dipseudopsis capensis* and *Ablabesmyia dusoleili* are negatively correlated to pH, temperature and Dissolved oxygen. Then *Nilodorum fractilobus* is negatively associated to clay. High values of pH, temperature and dissolved oxygen were observed in Anyama II and Azaguié stations, whereas transparency and mud are quite important in Banco station. In Layo station, high value of conductivity was unregistered and the substrate is mostly composed by clay in Anyama I station.

Nilodorum fractilobus and *Chironomus imicola*. Likewise positive correlation was observed between both *Ablabesmyia dusoleili* and *Cryptochironomus* sp. and phosphorus. *Macrolea* sp. and *Dipseudopsis capensis* were positively correlated to ammonium.

4. CONCLUSION

The present study reported 31 benthic insect taxa in the different stations. Three of these taxa (*Macrolea* sp., *Valleriella* sp. and *Corydalidae*) were recorded for the first time in Côte d'Ivoire aquatic ecosystem. Diptera was the most diversified and numerically the most abundant group. The family *Chironomidae* was quantitatively the most important among Diptera. The insect community in the different stations is quite diverse and stable except Layo. The insect communities are similar between Anyama I, Anyama II, Azaguié and Banco.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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