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Benthic macroinvertebrates community composition, abundance and distribution in three Lagoons (Aby, Tendo and Ehy) (Côte d'Ivoire)

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Abstract
Benthic macroinvertebrates community composition, abundance and distribution was studied in three Lagoons of Côte d'Ivoire (Aby, Tendo and Ehy). Sampling was conducted monthly between February 2012 through March 2013 on 6 sampling stations. The macrofauna surveyed consisted of 21.015 macroinvertebrates individuals belonging to 86 taxa (genera and species), 44 families, 15 orders and 6 classes. The most predominant group was Gasteropoda which make up 64.7% of the taxonomic richness observed. Insecta were the second most predominant. The diversity of macroinvertebrates varied between lagoons (29-33 taxa Aby Lagoon), (56-70 taxa Tendo Lagoon) and (58-68 taxa Ehy Lagoon). Multivariate analyses (RDAs) revealed that benthic macroinvertebrates community composition and abundance variations were mainly controlled by the environmental parameters of the three lagoons, in particular the salinity and conductivity of the water. Thus, two ecological zones were noted: an area influenced by marine waters and another area under influence by waters of Tanoé river and Tanoé-Ehy swamp forest.

Keywords: benthic macroinvertebrates, abundance, Aby-Tendo- Ehy lagoons, Côte D'ivoire

1. Introduction

Coastal lagoons support a range of natural services that are highly valued by society, including fisheries productivity, storm protection, tourism, and others (Gönenç and Wolflin 2005) [19]. They contribute to the overall productivity of coastal waters by supporting a variety of habitats, including salt marshes, seagrasses, mangroves and also provide essential habitat for many fish and invertebrates.

The Aby-Tendo-Ehy lagoon plays an important role in the south-eastern of Cote d'Ivoire in fishing and tourism activities. The watershed is occupied by large plantations and cities, with several rivers entering the north and west face of the lagoon, such as Bia and Tanoé rivers. It provides many ecosystem services to surrounding populations but it is exposed to many threats such as overexploitation of aquatic resources, deforestation of the watershed and riverbanks (Charles-Dominique *et al*., 1980) [11]. According to several works (Rodriguez *et al*. 2007, Bilkovic and Roggero 2008) [35, 7], anthropogenic activities such as land-use change, freshwater withdrawal from ground and surface water sources, sedimentation and overfishing can have profound and sudden impacts on coastal ecosystems. Three parts of the lagoon complex have different environmental parameters (Koffi *et al*., 2014) [22]; Aby lagoon is closer to sea and saltier than Ehy lagoon, farther from sea (Seu-Anoi *et al*., 2011) [39], these environment variables can affect the distribution of aquatic macroinvertebrates. For example, distribution of benthic invertebrates in the Gambia River estuary is influenced by salinity (Ceesay *et al.*, 2019) [8]. Moreover, coastal lagoons are formed and maintained through sediment transport processes (Nichols and Boon, 1994) [32]. Thus, sediment carried by rivers, waves, wind and tides accumulates in the lagoon affecting habitats and benthic fauna diversity. Indeed, rivers flowing into the lagoon complex are likely to carry a significant amount of sediment and allochthonous matter from farmland, which are liable to alter invertebrate habitats.

Aquatic macroinvertebrates serve multiple functions in aquatic ecosystems. In addition to their role as primary consumers processing live organic material, they also serve as detritivores, consuming decomposing organic matter; predators, consuming macroinvertebrates and other small organisms; and prey, serving as food for fish, amphibians, reptiles, aquatic birds, and mammals (Fisher and Gray, 1983; Covich *et al*., 1999) [17, 13]. Species are differentially sensitive to many biotic and abiotic factors in their environment. Consequently, macroinvertebrate community structure has commonly been used as an indicator of the condition of an aquatic system (Armitage *et al*., 1983; Rosenberg and Resh, 1993) [4, 36].

Several studies have been conducted on the diversity of macroinvertebrates and their structure in lagoons (Sankaré and Etien, 1991, Aggrey-Fynn *et al*. 2016) [37, 2], rivers and estuaries (Diomandé *et al*., 2009, Simmou *et al*., 2015, Ceesay *et al.*, 2019) [14, 40, 8], of West Africa. However, data on the Aby complex are still insufficient, only data available concern the taxonomic diversity (Kouadio *et al.*, 2008) [24]. Information on the environmental characteristics and structure of the benthic macroinvertebrates community is scarce.

The aim of this study is therefore to determine the assemblage structure and the spatial distribution of macrobenthic invertebrates in relation to environmental variables in three parts of lagoon.

2. Materials and Methods

2.1 Study area

The Aby Lagoon system is located in south east Côte d'Ivoire (2°51'-3°21'W and 5°01'-5°22' N) (Figure 1). It is the most extended on the studied Lagoon system and covers 305 km² and stretches for 24.5 km north to south and 56 km east to west with a maximum width of 15.5 km and maximum depth of 17 m (Avit *et al*., 1996; Kouadio *et al*., 2008) [5, 24]. The Tendo Lagoon, which is median part of the studied system, is more stretched with a length of 22 km and a width varying between 1.5 and 3.5 km, its surface is 74 km^2. The Ehy Lagoon is located in the eastern side of the Lagoon and has a surface area of 45 km^2 (Chantraine, 1986) [9]. Seu-Anoi *et al*. (2011) [39] describes the salinity gradients found in the Lagoon. Sampling zone1 (in Aby Lagoon) were greatly influenced by marine water and corresponded to the closest zone to the ocean. Zone2 (Tendo Lagoon) sampling sites were transition position within study area, while zone 3 (Ehy Lagoon) in the most inland part of the system had no marine water influences, but under a considerable contribution of freshwater from the Tanoe Ehy swamp Forest and the Tanoé River.

The study area is characterized by four seasons: a long rainy season (April to July), a short dry season (August to September), a short rainy season (October to November), and a long dry season (December to March).

2.2 Sampling

A total of 6 sampling sites were selected by using criteria such as accessibility, water depth, and in order to reflect the lagoon's different sedimentary and watershed habitats (Figure 1).

Benthic macroinvertebrates samples were collected monthly from February 2012 through March 2013. Samples were collected using a 0.05 m^2 Van Veen grab. At each station, ten samples were collected for analyses. Each sample was sieved *in situ* through a 1 mm mesh. The organisms retained by the sieve were fixed in formaldehyde 10% solution. At the Laboratory, macroinvertebrates were sorted, identified to the lowest possible taxonomic level and counted. The identification keys of Durand and Levêque (1981) [15], Tachet *et al*. (2010) [43] and Moisan (2010) [32] were used.

On each sampling date, environmental variables such as temperature (°C), dissolved oxygen (mg/l); conductivity (µS/cm) and pH were measured *in situ* using a Sper scientific multiparameter. Salinity (‰) and transparency (cm) were recorded with hydrobios refractometer and Secchi disc respectively. The depth (cm) was also recorded at each sampling station,by introducting a graduated rule to the bottom of the water.

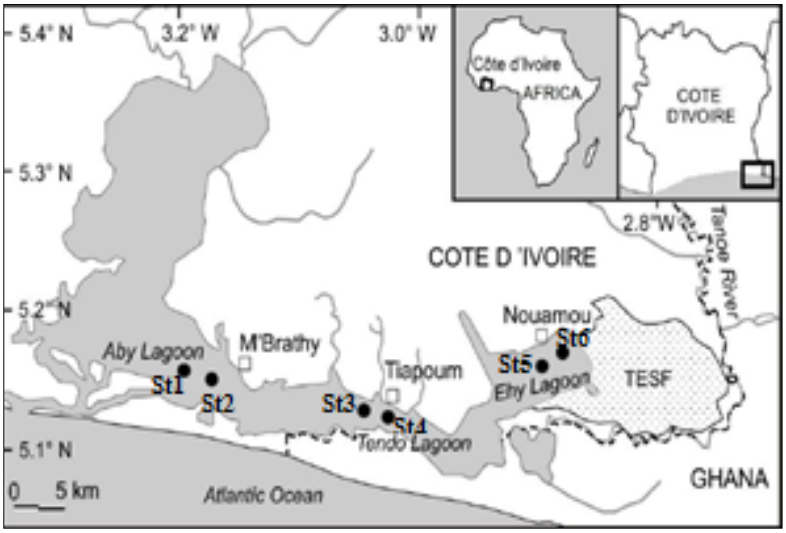

Fig 1: Sampling sites (●) in the Aby Lagoon system (Aby,Ehy,Tendo). TESF = Tanoe Ehy Swamp Forest

2.3 Data Analysis

The assemblage's structure was studied through the species richness (Rs), the Shannon-Weaver diversity index (H) and the Pielou evenness index (E). Benthic macroinvertebrates similarities among the stations sampled were investigated using cluster analysis based on the faunal compositions (Ward linkage, Euclidian distance) using the abundance matrix. Data on abundances were square-root transformed to avoid over-domination of the analysis by the very abundant taxa and to allow taxa of intermediate and rarer abundances to contribute to the analysis. Significant differences in species richness, diversity index and abundances were performed using a Kruskal-Wallis test followed by Rank multiple comparison tests. The analyses were carried out using the STATISTICA 7.1 software computer. In order to determine the possible factors influencing the benthic macroinvertebrate assemblages, a Redundancy analysis (RDA; ter Braak 1986) [42] was performed taking into account the abundance of the dominant taxa as biotic variable and the abiotic factors. Taxa with an occurrence rate smaller than 5% were excluded from analysis (Bachelet *et al*. 1996) [6]. RDA was performed using CANOCO 4.5 (ter Braak and Smilauer, 2002) [43] whereas STATISTICA 7.1 computer package was used for the other tests. In the ordination diagram produced by CANOCO, the importance of environmental factors is indicated by the relative length of vectors, i.e. the longer of the vector, the greater the influence on species distribution (ter Braak and Verdonschot, 1995) [44]. The results of this analysis are presented as ordination diagrams containing continuous explanatory variables plotted as vectors with points for sites and taxa. The parametric and non parametric analysis of variance tests (One way ANOVA and Kruskal-Wallis) were used to compare physical and chemical parameters values between stations, The level of statistical significance was maintained at 95% ($P < 0.05$).

3. Results

3.1 Environmental factors

The mean and ranges values of environmental variables are shown in (Table 1). Water temperature varied from 27.02±1.37 ºC (St6) to 30.71±3.64ºC (St5). The lowest dissolved oxygen values were recorded in station St4 (51.73±10.24 mg/l) and the highest values were observed in station St1 (80.26±14.01). pH values varied between 6.07±1.08 (St2) and 7.44±0.72 (St5, St6). Salinity was nil at station (St3, St4, St5 and St6), while the highest value (1.38±1.11) was recorded at station St2. Conductivity ranged between 58.52±11.27µS/cm (St5) and 836.33±480.59 µS/cm (St2). The lowest values of transparency (38.05±8.29 cm) were recorded in station (St4), whereas the highest were registered at St1 (77.90±12.64 cm). As for water's depth, lowest value (136.94±60.25) was observed in St6 while the highest values (420.76±82.86 cm) were obtained at station (St3).

3.2 Taxonomic diversity and abundance

Overall benthic macroinvertebrates species composition and abundance are showed in table 2. A total of 21015 individuals of benthic macroinvertebrates comprising 5 classes (Mollusca, Crustacea, Insecta, Oligochaeta and Polychaeta); 44 families and 86 species was recorded. The class of Mollusca ranked first in abundance with 13922 individuals comprising 3 orders, 10 families and 17 taxa constituting 66.24% of the total benthic macroinvertebrates. The dominant species observed among the gastropod was *Pachymelia byronensis*, which recorded 4489 specimens and constituted 21.36.% of the benthic macroinvertebrates population. Other gastropods recorded in large numbers include *Pachymelania aurita* (3680 individuals 17.51%) and *Tympanotomus fuscatus* (1002 individuals; 4.76%). A total of 6326 individuals of Insects made up of 8 orders, 27 families and 56 species were encountered in this study. Insects accounted for 30.10% of the total benthic macroinvertebrates count. The class of crustacean contributed to 579 individuals while Oligochaeta contributed to 52 individuals. Polychaeta had 136 individuals represented.

3.3 Density

Spatial variation in the densities of macroinvertebrates collected in the three lagoons in each season are showed by figure 2. The highest densities were observed during the rainy season at all stations. Additionally the minimum (294 ind/m²) and maximum (1383 ind/m²) densities values were recorded at the stations St4 (Ehy Lagoon) and St1 (Aby Lagoon) respectively in dry and rainy seasons (Figure 2 A and B). The differences between stations are statistically significant (Kruskal-Wallis test, $p < 0.05$). Significant differences were obtained between station St1 and stations (St2, St3, St5 and St6) on the one hand and, between station St2 and stations (St3, St4, St5 and St6) on the other hand (Rank multiple comparison tests, $p < 0.05$).

3.4 Shannon-Weaver diversity and evenness

Spatial and seasonal values of Shannon-Weaver diversity index and equitability are mentioned in table III. The Shannon-Weaver diversity index values range from 1.7 in Aby Lagoon (St1) to 2.17 in Tendo Lagoon (St3). These extreme values were both obtained in rainy season. The Shannon-Weaver diversity index does not show any significant difference between stations in the same Lagoon (Kruskall-Wallis test, $p > 0.05$). On the other hand, there is a significant difference between the stations of Aby Lagoon and the stations of Ehy and Tendo Lagoons (Rank multiple comparison tests, $p < 0.05$. For the seasonal variation, there is no significant difference between seasons for this index. Concerning equitability the minimum and maximum values were also observed in St1 and St6 respectively. At stations St1 and St2 the higher values were obtained during the dry period. In stations St3, St4, St5 and St6 the high equitability values were observed during the rainy season. Equitability has a significant difference between the seasons only in St2 (Kruskall-Wallis test, $p < 0.05$).

3.5 Cluster identification

The cluster analysis (Figure 3) showed 2 mains groups. Cluster I (St6, St5, St4 and St3) is mostly consisted of samples of Ehy lagoon and Tendo Lagoon. Ehy lagoon sampling sites had no marine water influences, but were under a contribution of freshwater from the Tanoe Ehy Swamp Forest and Tanoe River. Tendo lagoon sampling sites were near the mouth of Tanoé River. Group II (St1 and St2) is consisted of samples from the Aby Lagoon. This part of lagoon is influenced by seawater.

3.6 Correlation between abiotic factors and main taxa of benthic macroinvertebrates

According to the ReDundancy Analysis (RDA), the two axes (1 and 2) explained 74, 1% of the observed variance in macroinvertebrates community structure. The first axe represents more 52, 2%. Theses axes were selected for graphical representation (Figure 5). The direct ordination on the dry season distinguished two zones, differentiated mainly by salinity first zones formed by St1 and St2 (Aby Lagoon) (salinity = 0 ‰**)** was positively correlated to the axis I of " the environment" system as opposed to the second zones formed by St3,St4, St5 and St6 (Tendo and Ehy lagoons (salinity = 0 ppt). The first zone correlated to salinity, transparency, dissolved oxygen and conductivity, was characterized by *Pachymelania aurita*, *Pachymelania byronensis*, *Pachymelania fusca* and *Tympanotomus fuscatus*. Whereas, the second group (St3,St4 and St5) in Tendo and Ehy Lagoons is correlated to pH and temperature, and characterized by *Planorbis gibbonsi Chironomus* sp. *Centroptilum* sp. *Diplonychus* sp. and *Potadoma rahmi.*

These two species assemblages could be distinguished within this group according to the second axis. One group of station formed by St1 was correlated to depth. This group was characterized by *Pachymelania aurita*, *Pachymelania byronensis* and *Planorbis gibbonsi*. The other group defined by St3, St4, St5 and St6 (Tendo and Ehy lagoons) was correlated to temperature and depth by *Chironomus* sp., *Centroptilum* sp., *Potadoma rahmi*, *Diplonychus* sp. *Pachymelania fusca* and *Tympanotomus fuscatus.*

4. Discussion

Comparison of the variation of the physico-chemical parameters according to the different Lagoon zones showed no significant difference between the stations of the same Lagoon. For parameters such as temperature, dissolved oxygen, conductivity and transparency as well as salinity, the higher values were noted during the dry season. The zero salinity values were recorded in the Ehy Lagoon and

Tendo Lagoon. The Ehy Lagoon receives continuous water supplies from the Tanoé River and theTanoe Ehy Swamp Forest which are significantly under-saturated in dissolved oxygen and high in suspended solids (Konan, 2014) [23]. These processes of mixing different water masses result in a reduction of dissolved oxygen, salinity and transparency. Similar results were obtained in Ivorian lagoons by Seu-anoï (2012) [38]. The lack of salinity in the Tendo and Ehy lagoons is due to the fact that they are very far from the sanitation pass that connects the Aby with the sea while they are continuously supplied with continental water.

In contrast, in the marine-influenced Aby Lagoon, the salinity values are higher. In fact, the entry of marine waters into the Aby Lagoon leads to an increase in salinity and conductivity. The mean salinity in the Aby Lagoon is relatively low (0-2.88 ‰) compared to the Grand-Lahou Lagoon Complex (0-31 ‰) (Etilé *et al.*, 2009) [16]. This difference could be related to the limitation of trade between the Aby and the sea (Wango, 2009) [48] due to the narrowing of the Assinie pass over time (Kambiré *et al.*, 2014) [21]. However, a complete closure of the Assinie Canal would transform the Aby Lagoon into a freshwater lake.

The study also identified 86 benthic macroinvertebrates taxa in the three lagoons. The fauna is composed of Mollusca, Crustaceans, Polychaetes, Oligochaetes and Insects. The composition of the benthic macroinvertebrates assemblages of the three lagoons (Aby, Tendo and Ehy), changes significantly with the seasons. Severals studies on the distribution of macroinvertebrates taxa of Kouadio *et al.* (2008) [24] in the Aby Lagoon in Côte d'Ivoire, Gnohossou (2006) [18] in Lake Nokoué in Benin, reported the same trends.

Our study on macroinvertebrates identified two ecological zones. An area under marine influence constituted by the Aby Lagoon and an area under continental influence characterized by zero salinity (Tendo and Ehy Lagoons). Indeed, Coimbra *et al.* (1996) [12] showed that populations of benthic macroinvertebrates in lagoons, particularly exposed to large interannual variations of environmental characteristics, and mainly hydrological conditions, are subject to seasonal fluctuations. The area under continental influence, consisting of the Tendo and Ehy Lagoons, is characterized by higher taxonomic richness. This situation is linked to the massive presence of insects in these two parts. The Insects largely dominate the macroinvertebres harvested in the Tendo and Ehy lagoons, under influence of fresh water.

According to the survey of Kouadio *et al.* (2008) [24] in the Aby Lagoon, insects were generally recorded at the mouth of rivers such as Tanoe and Bia. In addition, most of the insects harvested in these Lagoons are chironomids (Diptera). According to Menif and Ben Hassine (2003) [29], these organisms are generally found in fresh water.

Taxa richness in these Lagoons is higher than those mentioned by Allouko *et al*. (2016) [3] in sector I of Ebrié Lagoon (Aghien Lagoon) (Côte d'Ivoire), Kouadio *et al*. (2008) [24] in Aby Lagoon (Côte d'Ivoire) (62 taxa) but is lower than the taxa collected by Adandedjan *et al*. (2013) [1] in the Porto novo lagoon (Benin) (150 taxa). The high number of species in the three lagoons may be explained by high variability of environmental and trophic and combined low influence of freshwater and marine water (Monney *et al*., 2015) [31] and by the difference between the scope settings, the sampling period, and environments nature. In fact, this study showed that the stations near of Tanoe Ehy Swamp Forest and Tanoe and Bia rivers (St5 and St6) were characterized by high diversity of macroinvertebrates community. That could be explained by the intrusion of freshwater species to Lagoon (Zabi and Le Loeuff, 1993) [49]. The taxonomic composition of benthic macroinvertebrates taxa inventoried in the three lagoons during this study was characterized by highest richness of insecta with 56 taxa, followed by Mollusca (17 taxa), the Crustacean (7 taxa), Oligochaeta and Polychaeta represented the lowest richness, (3 taxa). These various listed macroinvertebrates groups are similar with those reported by previous studies in other Lagoon ecosystems of Côte d'Ivoire (Kouadio *et al*., 2011) [25]; Nigeria (Uwadiae, 2014) [46] and Benin (Odountan and Abou, 2016) [34]. Dominance of insect was also reported in Ebrié Lagoons (sector 1: Aghien Lagoon) (Côte d'Ivoire) by Allouko *et al*. (2016) [3] (70 taxa) in Lake Nokoue (Benin) by Odountan and Abou (2016) [36] (45 taxa). On the other hand, some other studies report qualitative dominance of Mollusca in Aby Lagoon (Côte d'Ivoire) (64% of total taxonomic richness) (Kouadio *et al*., 2008) [26], in Ebrié Lagoon (Côte d'Ivoire) (61% of total taxonomic richness) (Kouadio *et al*., 2011) [27], in the Lagos lagoon (Nigeria) (up to 99%) (Nkwoji *et al*., 2010, Uwadiae *et al*., 2012) [33, 47] and Epe Lagoon (Nigeria) (Uwadiae, 2009) [45], in Saquarema Jaconé lagoonal system (Brazil) (Mendes and Soares-Gomes, 2011) [28]. Our study shows that insecta class with 56 taxa belonging to 7 orders, 20 families, was the most diversified. Chironomidae family presented the highest richness (10 taxa), followed by Baetidae (7 taxa), Discidae (5 taxa) and others families (1-3 taxa). Gastropoda class devided to three orders (Bivalvia, Mesogastropoda and Basommatophora), 10 families and 17 taxa.Thiaridae and Lymnaeidae represented the families the most richness (respectively 5 and 3 taxa).

This difference in macroinvertebrate qualitative composition and structure may be linked to environment factors as salinity level, with high macroinvertebrates richness occurring at low salinities, and low diversity occurring at high salinities (Gordon, 2000, Lamptey and Armah, 2008) [20, 26]. According to Little (2000) [29] reported by Mendes and Soares-Gomes (2011) [30], salinity influence composition and number of species is well known as it imposes severe conditions to organisms, rendering difficulties in maintaining osmoregulation. In this study, salinity fluctuation might be explainetaxonomic richness difference between St1-St2 (33-29 taxa), Aby Lagoon and St3-St4 (70-76 taxa), Tendo Lagoon and St5-St6(68-58 taxa), Ehy Lagoon. The samples sites St3, St4, St5, and St6 were characterized by low salinities (0 ‰) while the other sites were marked by relative higher salinities (0-3 ‰). Lowest salinities observed in Tendo and Ehy lagoons are favourable to insect taxa development (56-70 taxa), versus (29-33 taxa) in Aby Lagoon.

Table 1: Environmental variables (mean and standard deviation) measured at different sites in Aby Lagoon in South East Côte d'Ivoire from March 2012 through February 2013 [a, b]: letters on the same line show the difference between seasons at the same station as regards to parameter indicated

Parameters	Aby Lagoon				Tendo Lagoon				Ehy Lagoon			
	St1		St2		St3		St4		St5		St6	
	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS	RS	DS
Temperature (°C)	28.23^{a} (1.68)	28.80^{a} (1.01)	28.34^{a} (1.71)	28.73^{a} (1.01)	28.43^{a} (1.54)	28.39^{a} (1.63)	28.29^{a} (2.17)	28.82^{a} (1.46)	29.46^{a} (3.21)	30.71^{a} (3.64)	27.02^{a} (1.37)	29.37^{b} (2.44)
Dissolved oxygen (mg/l)	71.30^{a} (7.80)	80.26^{a} (14.01)	65.87^{a} (5.16)	74.39^{a} (17.15)	68.90^{a} (10.45)	73.14^{a} (9.52)	51.73^{a} (10.24)	58.20^{a} (14.57)	63.74^{a} (22.33)	69.75^{a} (13.47)	60.24^{a} (11.38)	65.90^{a} (19.39)
pH	6.90^{a} (0.70)	6.38^{a} (1.12)	6.91^{a} (0.74)	6.07^{a} (1.08)	6.80^{a} (0.74)	7.19^{a} (0.93)	6.66^{a} (0.70)	6.88^{a} (0.72)	6.94^{a} (0.75)	7.44^{a} (0.72)	6.94^{a} (0.51)	7.44^{a} (1.04)
Salinity (‰)	0.38^{a} (0.92)	1.37^{b} (1.00)	0.54^{a} (0.95)	1.38^{a} (1.11)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conductivity (µS/cm)	337.31^{a} (191.75)	684.85^{a} (572.78)	617.91^{a} (411.10)	836.33^{a} (480.59)	128.09^{a} (154.42)	218.20^{a} (220.13)	124.00^{a} (126.54)	317.88^{b} (257.42)	58.52^{a} (11.27)	65.39^{a} (11.01)	65.76^{a} (14.15)	67.13^{a} (13.41)
Secchi disck transparency (cm)	57.25^{a} (14.76)	77.90^{a} (12.64)	58.18 (14.00)	68.33^{a} (19.87)	41.51^{a} (13.07)	50.52^{a} (16.25)	38.05^{a} (8.29)	51.67^{a} (22.48)	51.27^{a} (27.44)	44.00^{a} (10.76)	40.03^{a} (10.74)	49.83^{b} (11.53)
Depth (cm)	205.50^{a} (26.09)	207.90^{a} (11.86)	162.45^{a} (82.17)	150.67^{a} (84.02)	420.76^{a} (82.86)	371.00^{a} (92.62)	152.80^{a} (83.34)	195.58^{a} (120.14)	147.80^{a} (60.59)	161.30^{a} (72.21)	136.94^{a} (60.25)	138.08^{a} (72.06)

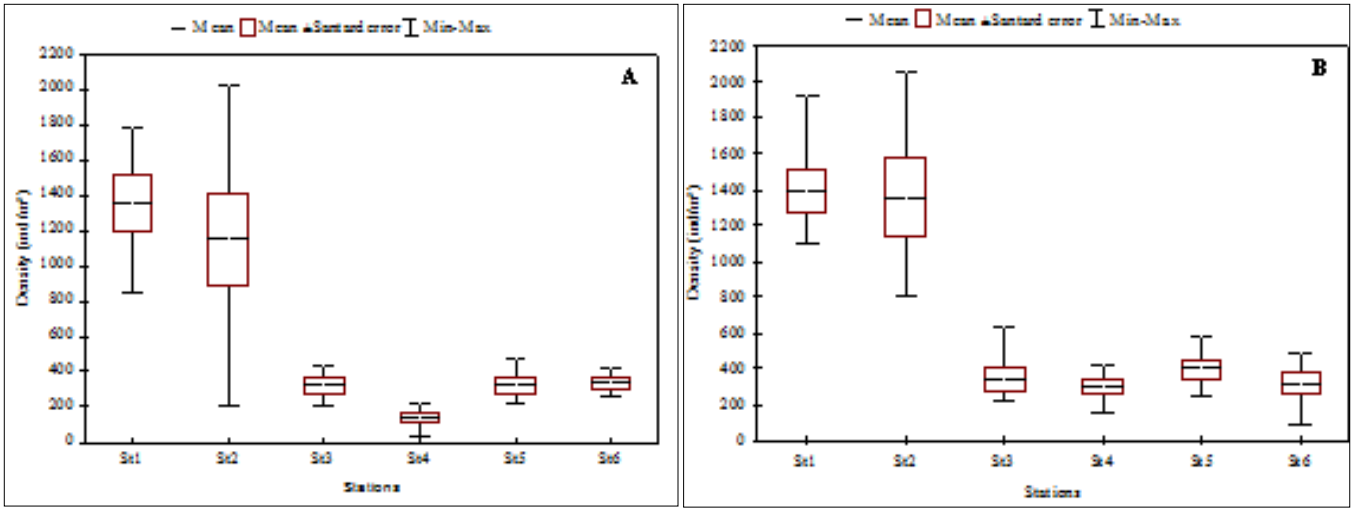

Fig 2: Spatial and seasonal variation of benthic macroinvertebrates densities in Aby,Tendo and Ehy Lagoons

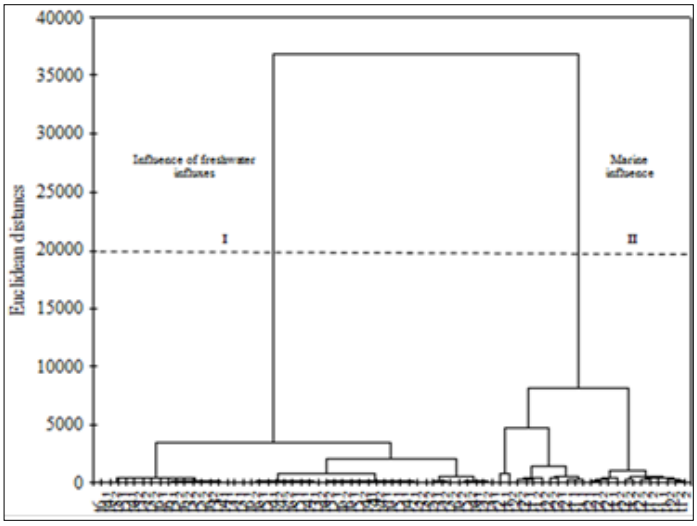

Fig 3: Cluster analysis of benthic macroinvertebrates showing similarities between the sampling stations in Aby,Tendo and Ehy Lagoons. I and II = Clusters; St1 to St6 = stations; in index: 1 = DS (Dry Season), 2 = RS (Rainy Season)

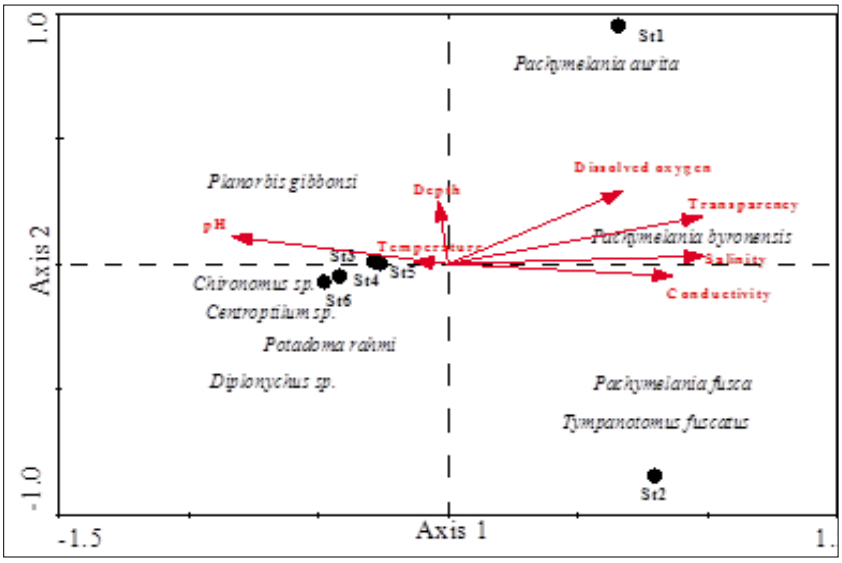

Fig 4: Redundancy analysis showing correlation between environmental variables and principal taxa collected in the study site Sample codes: St1-St2 from Aby lagoon; St3-St4 from Tendo Lagoon and St5-St6 from Ehy Lagoon

Table 2: List and abundance of macroinvertebrates organisms collected in the sampling stations between March 2012 and February 2013

				Aby Lagoon		Tendo Lagoon		Ehy Lagoon		TOTAL
Class	Orders	Families	Taxons	St1	St2	St3	St4	St5	St6	
Crustacea	Amphipoda	Corophiidae	*Corophium* sp.	40	0	36	0	0	0	76
		Gammaridae	*Echinogammarus* sp.	48	0	28	0	0	0	76
			Gammarus chevreuxi	0	8	0	34	0	0	42
			Gammarus pulex	12	0	24	0	0	0	36
			Gammarus sp.	28	0	10	0	0	0	38
	Decapoda	Desmocrididae	*Desmocaris trispinosa*	0	54	134	0	0	0	188
		Paleamonidae	*Macrobrachium dux*	0	0	0	72	30	21	123
Mollusca	Eulamellibranchia	Corbulidae	*Corbula trigona*	16	84	0	0	0	0	100
		Neritidae	*Neritina* sp.	72	24	0	0	0	0	96
		Sphaeridae	*Pridium* sp.	24	0	36	0	0	0	60
		Unionidae	*Anodonta anatina*	0	0	0	0	42	12	54
	Basommatophora	Physidae	*Physa marmorata*	0	0	71	68	0	0	139
		Planorbidae	*Biomphalaria Pfeifferi*	0	0	0	87	0	0	87
	Mesogastropoda	Hydrobiidae	*Potamopyrgus ciliatus*	272	188	0	0	0	0	460
		Lymnaeidae	*Lymnaea natalensis*	0	0	68	4	0	0	72
			Gyraulus costulatus	0	0	0	44	0	0	44
			Planorbis gibbonsi	0	0	0	0	211	0	211
		Potamidae	*Tympanotomus fuscatus*	124	780	28	70	0	0	1002
			Tympanotomus fuscatus radula	136	146	24	0	0	0	306
		Thiaridae	*Pachymelania aurita*	3634	0	30	16	0	0	3680
			Pachymelania byronensis	2664	1799	14	12	0	0	4489
		Thiaridae	*Pachymelania fusca*	660	1232	19	32	0	0	1943
			Pachymelania fusca quadriseriata	204	416	0	0	0	0	620
			Potadoma raimi	0	0	0	0	111	448	559
Insecta	Coleoptera	Curculionidae	*Lipanus coronatus*	0	0	28	136	14	12	190
		Dytiscidae	*Bidessus* sp.	0	0	0	0	0	8	8
			Cantilydrus xanthinus	0	0	0	0	23	28	51
			Clypeodite sp.	0	0	0	0	4	24	28
			Hydaticus sp.	0	0	0	32	36	0	68
			Hydrocanthus micans	0	0	0	0	12	0	12
		Hydrophilidae	*Amphiops* sp.	0	0	24	19	32	12	87
			Enochrus sp.	0	0	0	0	4	36	40
			Laccophilus sp.	0	0	4	0	0	0	4
	Dermaptera	Forficulidae	*Forficula auriculaire*	0	0	0	0	84	0	84
	Diptera	Ceratopogonidae	*Ceratopogon* sp.	0	0	56	0	0	0	56
		Chaoboridae	*Chaoborus* sp.	0	0	0	0	118	0	118
		Chironomidae	*Chironomus* sp.	88	32	333	156	208	232	1049
			Cryptochironomus sp.	0	40	96	0	102	4	242
			Nilodorus sp.	0	0	72	0	0	0	72
			Polypedilum sp.	0	32	112	47	62	24	277
			Procladius sp.	0	0	30	0	0	0	30
			Stenochironomus sp.	88	60	149	32	149	96	574
			Stictochironomus sp.	84	12	91	12	3	32	234

	Diptera		*Tanypus* sp.	0	0	32	16	0	40	88
			Tanytarsus sp.	0	0	0	0	8	0	8
			Xenochironomus sp.	0	0	12	48	6	0	66
		Culicidae	*Culex* sp.	0	0	0	0	0	38	38
	Ephemeroptera	Baetidae	*Baetis* sp.	0	0	28	8	48	24	108
			Centroptioides sp.	0	0	4	0	0	0	4
			Centroptilum sp.	0	0	97	187	4	96	384
			Cloeon sp.	0	0	12	12	0	0	24
			Economus venosus	0	0	78	0	0	0	78
			Procloeon sp.	0	0	0	0	33	0	33
			Pseudocloeon sp.	0	0	12	40	3	4	59
		Caenidae	*Caenis* sp.	0	0	4	20	52	36	112
		Capniidae	*Capnia* sp.	0	0	0	0	4	36	40
		Ephemerellidae	*Ephemerella ignita*	0	0	4	0	0	52	56
			Ephoron vigo	0	0	0	0	0	15	15
		Leptophlebiidae	*Adenophlebiodes*	0	0	0	0	0	4	4
			Tricaudius sp.	0	0	8	0	0	0	8
		Polymitarcyidae	*Povilla* sp.	0	0	0	0	9	48	57
	Heteroptera	Belostomidae	*Diplonychus* sp.	0	0	81	165	138	255	639
		Naucoridae	*Ilyocoris cimicoides*	0	0	0	0	4	0	4
			Laccocoris sp.	0	0	0	0	108	32	140
			Naucoris sp.	0	0	0	0	96	24	120
		Notonectidae	*Anisops* sp.	0	0	4	0	0	0	4
		Veliidae	*Microvelia* sp.	0	0	0	0	74	93	167
	Odonata	Aeschnidae	*Anax* sp.	0	0	0	0	57	45	102
		Calopterygidae	*Phaon iridipennis*	0	0	0	0	0	4	4
		Coenagrionidae	*Ceriagrion* sp.	0	0	12	44	4	88	148
			Pseudagrion sp.	0	0	44	36	4	0	84
			Pseudagrion wellani	0	0	0	82	0	4	86
		Corduliidae	*Cordulia* sp.	0	0	4	0	12	8	24
		Libellulidae	*Brachinopyga strachani*	0	0	4	0	31	0	35
			Libellula sp.	0	0	25	32	68	0	125
			Sympetrum sp.	0	0	0	0	23	0	23
		Macromiidae	*Phyllomacromia* sp.	0	0	0	48	97	12	157
	Plecoptera	Perlidae	*Neoperla spio*	0	0	0	0	0	8	8
			Perlodes sp.	0	0	0	0	24	18	42
		Taeniopterygidae	*Taeniopteryx* sp.	0	0	0	0	0	8	8
Oligochaeta	Haplotaxida	Lumbricidae	*Lumbricus* sp.	0	0	36	4	0	0	40
	Turbificinas	Tubificidae	*Tubifex* sp.	0	12	0	0	0	0	12
Polychaeta	Nereiditformia	Nereidae	*Hediste diversicolor*	8	12	0	0	0	0	20
			Nereis indica	8	0	0	0	0	0	8
			Nereis sp.	12	28	16	4	0	0	60
		Eunicidae	*Marphysa* sp.	0	0	32	16	0	0	48
6	15	44	86	8222	4959	2066	1635	2152	1981	21015

Table 3: Spatio-temporal variation of Number of taxa, Shannon-Weaver diversity and evenness indexes among stations (mean ± (SD)) [a, b]: letters on the same line show the difference between seasons at the same station as regards to parameter indicated

Lagoons	Stations	Seasons	Shannon-Weaver	Equitability
Aby Lagoon	St1	RS	1.17[b] (0.31)	0.62[a] (0.05)
		DS	1.31[b] (0.31)	0.72[a] (0.11)
	St2	RS	1.40[b] (0.18)	0.71[a] (0.10)
		DS	1.42[b] (0.06)	0.83[b] (0.07)
Tendo Lagoon	St3	RS	2.17[a] (0.18)	0.91[a] (0.03)
		DS	2.02[a] (0.25)	0.88[a] (0.04)
	St4	RS	2.04[a] (0.27)	0.85[a] (0.06)
		DS	1.93[a] (0.33)	0.88[a] (0.05)
Ehy Lagoon	St5	RS	2.02[a] (0.19)	0.91[a] (0.03)
		DS	2.06[a] (0.30)	0.85[a] (0.08)
	St6	RS	1.97[a] (0.13)	0.90[a] (0.08)
		DS	1.76[a] (0.47)	0.82[a] (0.12)

5. Conclusion

The present study is a contribution to the knowledge of diversity and structure of of benthic macroinvertebrate in Aby-Tendo-Ehy system. Physico-chemical analyses showed a difference between the three Lagoons sampled. The salinity of the water appeared to be higher in the Aby Lagoon, especially in the dry season than in the Tendo and Ehy Lagoons, which remain strongly influenced by continental freshwater supplies Tanoé River and Tanoé- Ehy swamp forest. The 86 macroinvertebrate taxa sampled are divided into large zoological groups such as Crustacea, Molluscas, Polychaeta, Oligochaeta, and Insecta. Two zones emerge in these three Lagoons: an area under marine influence that is characterized by relatively high salinity values (Aby Lagoon) and an area under the influence of rivers with low, sometimes zero, salinity values (Tendo and Ehy Lagoons).

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