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Response of benthic macroinvertebrates communities to seasonal changes in the Grand-Lahou lagoon (Côte d'Ivoire, West Africa)

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Abstract: The response of benthic macroinvertebrates communities to seasonal changes was studied in the Grand-Lahou lagoon (Côte d'Ivoire, West Africa). The organisation of macroinvertebrates was recorded at eight (8) stations across the whole lagoon in four seasons (the Long Rainy Season (June 2006), the Short Dry Season (September 2006), the Short Rainy Season (November 2006) and the Long Dry Season (March 2007)).Each faunal sampling was coupled with *in situ* measurements of abiotic parameters and samples were also collected for granulometry analyses. A total of 1 747 individuals representing 54 taxa belonging to 27 families and 7 orders of benthic macroinvertebrates were identified during this study. Of this number of taxa, molluscs constituted 37.03%, crustaceans 35.18% and polychaetes 24.07%. Other taxa recorded included oligochaetes and undetermined, together constituted 3.7%. The distribution patterns of density and diversity over seasons in the Grand-Lahou lagoon indicated periodic changes ranging from rich community during the Long Rainy Season to impoverished one in the Long Dry Season. However, these variations were not significantly different. Temperature, dissolved oxygen, pH, water depth and percentage of fine and coarse sand in that order were the major significant variables structuring the macroinvertebrates assemblages in the Grand-Lahou lagoon.

Keywords: Benthic macroinvertebrates, Seasonal changes, Grand-Lahou lagoon, Côte d'Ivoire

Introduction

The West African coast is dominated by a series of shallow costal lagoons as on many other coastlines of the world (Marcovecchio *et al*., 2005; Lamptey and Armah, 2008). Most of these lagoons are oriented parallel to the shore and are highly dynamic and unpredictable systems and considered distinct from other coastal systems such as estuaries (Kjerfve, 1994). In Côte d'Ivoire, such ecosystems are rather well represented. Indeed, three large lagoons in communication with the Atlantic Ocean can be noticed. It is about the Ebrié lagoon, the vastest (566 km^2) localised in the central part of the littoral frontage, the Aby lagoon (424 km^2) in the eastern and in the west, the Grand-Lahou lagoon (190 km^2), the smallest one (Sankaré *et al*., 1999). These lagoons are known for their high halieutic productivity and ecological value (Ecoutin *et al*., 1994; Seu-Anoï *et al*., 2014). They are often characterised by strong spatial gradients in the physical and chemical characteristics of the water and biological populations present (Sankaré *et al*., 1999; Kouassi *et al*., 2005, Konan *et al*., 2008; Koné *et al*., 2009; Kouadio *et al*., 2011).

Among them, the Grand-Lahou lagoon is subjected to natural variations of the climatic conditions (lowers pluviometry) and of the increasing of anthropic disturbances (Sankaré *et al*., 1999; Bleu *et al*., 2011; Seu-Anoï *et al*., 2014). According to Konan *et al*. (2008) and Koné *et al*., (2009), the exchange and mixture of saltwater and freshwater from Bandama and Boubo rivers is irregular and the hydrography of the lagoon may show fluctuations daily, seasonally and over longer periods of time in this lagoon. Such situation could have an influence on the faunistic composition in general and particularly the benthic macroinvertebrates (Agostinho *et al*., 2005). Benthic macroinvertebrates play an important ecological role in maintaining the structure and function of aquatic ecosystems (Wallace and Webster, 1996; Figueroa *et al*., 2003; Moya *et al*., 2007). Indeed, biological assessments of lagoon ecosystem integrity routinely include benthic macroinvertebrates due to their ubiquity (Barbour *et al*., 1992; Rosenberg and Resh, 1993; Barbour *et al*., 1999). Previous studies on this group were only devoted to the Aby and the Ebrié lagoons (Kouadio *et al*., 2008; 2011) and the composition and structure of benthic fauna in

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the Grand-Lahou lagoon remains unknown. Thus, the present study fialls the gaps and aims to appreciate the response of benthic macroinvertebrates community to seasonal changes and identify the abiotic parameters driving the structure and the functioning of the communities.

Material and Methods

Study area

The study was conducted in the Grand-Lahou lagoon of Côte d'Ivoire (Fig.1). This ecosystem is located between 5°25' and 5°10' W and 5°15' and 5°11' N (Durand and Skubich, 1982). It covers an area of 196 km² and stretches for 50 km with a maximum width of 1.4 km and average depth of 3 m (Laë, 1992). The lagoon of Grand-Lahou is composed of four small lagoons such as Tadio (90 km^2), Tagba (57 km^2), Mackey (28 km^2), and Nyouzomou, parallel to the littoral with an area of 15 km^2.

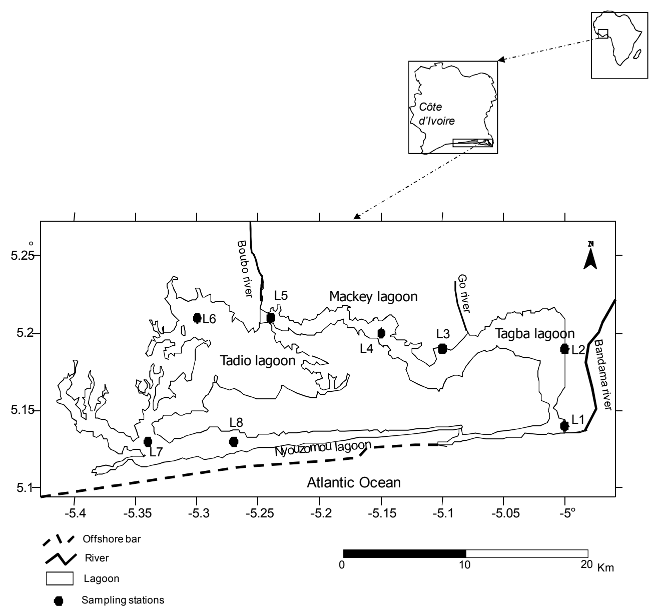

Fig. 1: Location of the sampling sites in the Grand-Lahou lagoon.

The lagoon is connected to the sea in its southern part by an artificial channel (Grau) and receives fresh water from large catchment areas including runoff from Bandama river and runoff from Boubo river (Konan *et al*., 2008).

The surrounding vegetation is dominated by a mangroves forest (*Rhizophora racemosa*, *Avicennia germinans*, *Conocarpus erectus*), alternating with palm tree (*Elaeis guineensis*) and coconut (*Cocos nucifera*) cultures. According to Sankaré *et al.,* (1999), two main sedimentary habitats can be identified within the lagoon. The first, which is the sandy bottom, is primarily of oceanic origin. Its presence is related to wave action and tidal currents. The second, which is muddy with high organic content and shell fragments, is found at the Bandama and Boubo rivers mouths to the lagoon.

Like all parts to the south of Côte d'Ivoire, the climate in the study area is equatorial-like with an annual rainfall ranging between 1500 and 1800 mm. It is characterised by two rainy seasons and two dry seasons (Durand and Skubich, 1982). The Long Rainy Season (LRS) extends from April to July, the Short Dry Season (SDS) from August to September, the Short Rainy Season (SRS) from October to early December and the Long Dry Season (LDS) from December to March.

Sampling and data analysis

Sampling stations were selected by using criteria such as accessibility, water depth, sediment characteristics and in order to reflect the lagoon's different sedimentary and watershed habitats. Thus, eight (8) stations (L1 to L8) at a rate of two (2) stations in each part of the lagoon were selected (Fig. 1). The coordinates of the sampling stations were geo-referenced using a hand-held GPS. The sampling was undertaken seasonally during four cruises (June 2006, September 2006, November 2006 and March 2007). At each station and time, six samples were collected for benthic macroinvertebrates analyses using a 0.05 m^2 Van Veen grab. Each sample was sieved *in situ* through a 1 mm mesh. The organisms retained by the sieve were immediately fixed in formaldehyde 10% solution. At the laboratory, macroinvertebrates were sorted with the aid of a hand lens, grouped into broad taxonomic units such as polychaetes, molluscs, crustaceans and oligochaetes. These broad taxa were identified to genus or species levels as possible and counted. Identifications were based on taxonomic guides and manuals (Nicklès, 1965; Day, 1967a, b; Tachet *et al*., 2003; Dejoux *et al.,* 1981; Diomandé *et al*., 2000, FAO, 1992; Intès and Le Loeuff, 1975).

Each faunal sampling was coupled with *in situ* measurements of abiotic parameters including water salinity, temperature, pH, dissolved oxygen, transparency and water depth. Salinity and temperature data were measured by using a portable conductivity meter (WTW Cond-340) with a precision of $\pm$ 0.1 and 0.1°C, respectively. pH data were measured with a pH meter (WTW pH-330). Dissolved oxygen data were obtained by using a portable oxymeter (WTW OXI-340) while a Secchi disc was used for water transparency measures. At each station, sediment samples were also collected for granulometry analyses (AFNOR, 1996) using three sediment grain-size classes: mud (size < 63 µm), very fine sand (125 µm > size > 63 µm) and fine and coarse sand (size > 125 µm).

The structure of benthic macroinvertebrates was studied through the species richness (S), the Shannon-Wiener diversity index (H') and the Pielou evenness index (E). Significant differences in species richness, diversity indices and abundances were performed using Kruskal-Wallis ANOVA, a non parametric analysis of variance, followed by Rank multiple comparison tests (Zar, 1999). The analyses were carried out using the STATISTICA 7.1 software computer.

A Redundancy analysis (RDA) was performed taking into account the abundance data of the dominant taxa as biotic variable and the abiotic parameters in order to determine the possible factors influencing the benthic macroinvertebrate assemblages in the Grand-Lahou lagoon (ter Braak, 1986). To remove any undue effects of rare species on the ordination, taxa with an occurrence rate smaller than 5% were excluded from analysis (Bachelet *et al*., 1996). Species data were log(X + 1) transformed to prior analysis (ter Braak and Smilauer, 2002). The statistical significance of the first 4 axes and of the sum of all constrained eigenvalue of the RDA model was tested using a Monte-Carlo permutation test (499 unrestricted permutations) (ter Braak and Verdonschot, 1995; ter Braak and Smilauer, 1998). RDA was conducted using the CANOCO 4.5 software program. The results of this analysis were presented as ordination diagrams containing continuous explanatory variables plotted as vectors with points for sites and taxa.

Results

Environmental variables

The mean values of environmental variables measured during seasons were mentioned in Table 1. The mean for abiotic parameters showed significant seasonal variation ($p < 0.05$). The variables that exhibited marked significant differences where temperature, salitnity, dissolved oxygen and transparency (Tab. 1). Except water depth, mean values of these parameters where higher in Long Dry Season (LDS) and lower in Long Rainy Season (LRS). Conversely, the mean for water depth was substantially higher in Long Rainy Season and lower in Long Dry Season.

Tab. 1: The mean and standard deviation (in parenthesis) for environmental variables in the seasons. LRS = Long Rainy Season, SDS = Short Dry Season, SRS = Short Rainy Season, LDS = Long Dry Season.

Environmental Variables	LRS	SDS	SRS	LDS	*p* value
Temperature (°C)	27.73 (2.04)	28.07 (0.97)	28.93 (0.41)	31.03 (1.14)	<0.001
Salinity	1.41 (1.71)	6.91 (4.45)	8.12 (3.49)	19.26 (6.23)	<0.001
pH	7.65 (0.94)	7.76 (0.25)	7.78 (0.30)	7.89 (0.18)	>0.05
Dissolved oxygen (mg/L)	4.53 (0.87)	5.19 (0.92)	6.04 (0.20)	7.27 (0.54)	<0.001
Transparency (m)	0.54 (0.12)	0.65 (0.16)	0.80 (0.11)	0.80 (0.24)	<0.05
Water depth (m)	2.51 (1.14)	2.41 (1.11)	2.33 (0.61)	2.10 (0.68)	>0.05

Faunistic composition

In the whole of the Grand-Lahou lagoon a total of 1,747 individuals representing 54 taxa belonging to 27 families and 7 orders of benthic macroinvertebrates were identified during the study (Tab. 2). Of this number of taxa, molluscs constituted 37.03%, crustaceans 35.18% and polychaetes 24.07%. Other taxa recorded included oligochaetes and undetermined, together constituted 3.7%. Stations L4, L6, L7 and L8 containing each more than 20 taxa were the most rich. Four taxa were only present in one station. It was about *Tympanotomus fuscatus* in station L3, *Melanoïdes tuberculata* and *Cardiosoma armatum* in station L6 and *Eulalia viridis* in station L7. Contrary to these species, *Neritina glabrata*, *Pachymelania aurita*, *Corbula trigona* and *Hedis diversicolor* were present in 80% of the stations. Molluscs were encountered at all the stations. Their richness remains low in stations L1, L2 and L5 and high at stations L4, L6 and L7.

Crustaceans were not very present at stations L1 to L2. However, their richness was high at stations L4, L6 and L7. Relatively to Polychaetes, high richness was obtained in stations L5, L7 and L8.

Spatial and seasonal patterns of macroinvertebrates

Taxonomic richness

Seasonal distribution of taxonomic richness presented a great variability between the seasons (Fig. 2). High values were obtained in Long Rainy Season and in Short Dry Season with a maximum in Long Rainy

Tab. 2: List of benthic macroinvertebrates found at the stations in Grand-Lahou lagoon; symbol * means the presence of the taxon at the station.

Class	Order	Family	species	Acronym	Stations							
					L1	L2	L3	L4	L5	L6	L7	L8
Mollusca	Mesogastropoda	Neritidae	*Neritina afra* (Morelet, 1848)	Nafr		*	*	*	*	*		
			Neritina adansoniana (Récluz, 1841)	Nand					*			*
			Neritina cristata (Morelet, 1874)	Ncri			*				*	
			Neritina glabrata (Sowerby, 1849)	Ngla	*	*	*	*		*	*	*
			Neritina kuramoensis (Yoloye & Adegoke, 1977)	Nkur		*				*	*	*
			Neritina rubricata (Morelet, 1858)	Nrub	*			*	*	*	*	
		Thiaridae	*Melanoides tuberculata* (Müller, 1774)	Mtub						*		
			Pachymelania aurita (Dartevelle, 1956)	Paur	*		*	*	*	*	*	*
			Pachymelania byronensis (Wood, 1828)	Pbyr		*		*		*		
			Pachymelania fusca (Gmelin, 1791)	Pfus				*		*	*	*
			Pachymelania fusca quadriseriata (Gray, 1831)	Pfuq				*		*		
			Potadoma freethii (Gray, 1834)	Pfre				*		*		
		Potamididae	*Tympanotomus fuscatus* (Linnaeus, 1758)	Tfus			*					
			Tympanotomus fuscatus radula (Linnaeus, 1758)	Tfur				*		*		*
		Littorinidae	*Littorina africana* (Philippi, 1847)	Lafr	*						*	
	Eulamellibranchia	Arcidae	*Anadara senilis* (Linnaeus, 1758)	Asen							*	*
		Corbulidae	*Corbula trigona* (Hinds, 1843)	Ctri	*	*	*	*	*	*	*	*
		Donacidae	*Iphigenia laevigata* (Gmelin, 1791)	Ilae							*	*
		Ostreidae	*Crassostrea gasar* (Dautzenberg, 1891)	Cgas			*	*		*	*	*
		Tellinidae	*Tellina ampullacea* (Linnaeus, 1767)	Tamp							*	
Crustacea	Amphipoda	Corophiidae	*Corophium acherusicum* (Costa, 1857)	Cach				*		*	*	*
			Corophium curvispinum (Sars,1895)	Ccur			*		*			
			Corophium orientale (Schellenberg, 1928)	Cori				*		*		
			Corophium sp.	Cosp				*		*	*	*
		Gammaridae	*Echinogammarus* sp.	Ecsp				*		*	*	
			Gammarus chevreuxi (Sexton, 1913)	Gche			*	*		*	*	*
			Gammarus pulex (Linnaeus, 1758)	Gpul				*		*	*	*
			Gammarus roeseli (Gervais, 1835)	Groe			*	*	*	*	*	*
			Gammarus sp.	Gasp				*	*	*	*	*
	Isopoda	Cirolanidae	*Excirolana latipes* (Barnard, 1914)	Elat			*	*		*	*	*
		Ligiidae	*Ligia exotica* (Roux, 1828)	Lexo				*		*	*	*
		Sphaeromatidae	*Sphaeroma terebrans* (Bate, 1866)	Ster			*	*		*	*	*
	Decapoda	Alpheidae	*Potamalpheops monodi* (Sollaud, 1932)	Pmon				*		*	*	
		Diogenidae	*Clibernhardius africanus* (Burgis et Symoens, 1987)	Cafr	*	*	*	*		*	*	
			Clibernhardius cooki (Rathbun, 1900)	Ccoo	*			*				*
		Gecarcinidae	*Cardiosoma armatum* (Herklots, 1851)	Carm						*		
		Palaemonidae	*Nematopalaemon hastatus* (Aurivillius, 1898)	Nhas				*		*	*	*
		Penaeidae	*Penaeus notialis* (Perez-Farfante, 1969)	Pnot				*	*	*	*	
		Portunidae	*Callinectes* sp.	Casp			*	*		*	*	*
Oligochaeta				Oligo	*	*		*	*	*	*	*
Polychaeta	Capitelliformia	Capitellidae	*Capitella capitata* (Fabricius, 1780)	Ccap							*	*
			Notomastus latericeus (Sars, 1850)	Nlat				*		*	*	*
		Philodocidae	*Eulalia viridis* (Linnaeus, 1767)	Evir							*	
	Nereidiformia	Amphimonidae	*Hermodice carunculata* (Pallas, 1766)	Hcar			*		*		*	*
		Eunicidae	*Marphisa sanguinea* (Montagu,1815)	Msan			*				*	
		Glyceridae	*Glycera convoluta* (Keferstein, 1862)	Gcon					*		*	*
			Glycera gigantea (Quatrefages, 1866)	Ggig					*			*

Tab. 2: continued.

Class	Order	Family	Species	Acronym	Stations							
					L1	L2	L3	L4	L5	L6	L7	L8
Polychaeta	Nereidiformia	Nephtidae	*Nephthys caeca* (Fabricius, 1780)	Ncae						*		*
			Nephthys inermis (Ehlers, 1887)	Nine			*		*	*	*	*
			Nephthys polybranchia (Fauvel, 1932)	Npol	*		*		*	*		
		Nereidae	*Hedis diversicolor* (Müller, 1776)	Ndiv		*	*	*	*	*	*	*
			Nereis indica (Kinberg, 1866)	Nind	*			*	*	*	*	*
			Perinereis cultrifera (Grube, 1840)	Pcul			*	*	*	*		*
Unspecified				Unsp					*			
Total		**27**	**54**		**10**	**8**	**20**	**33**	**19**	**38**	**37**	**33**

Season (S = 34). In Short Rainy Season and Long Dry Season, taxonomic richness was low. A minimum value (S = 14) was recorded in Long Dry Season.

Seasonal patterns of taxonomic richness in Grand-Lahou lagoon was significantly different (Kruskall-Wallis test, $p < 0.05$). Taxonomic richness in Long Rainy Season and Short Dry Season where significantly higher than Short Rainy Season and Long Dry Season (Rank Multiple Comparison test, $p < 0.05$).

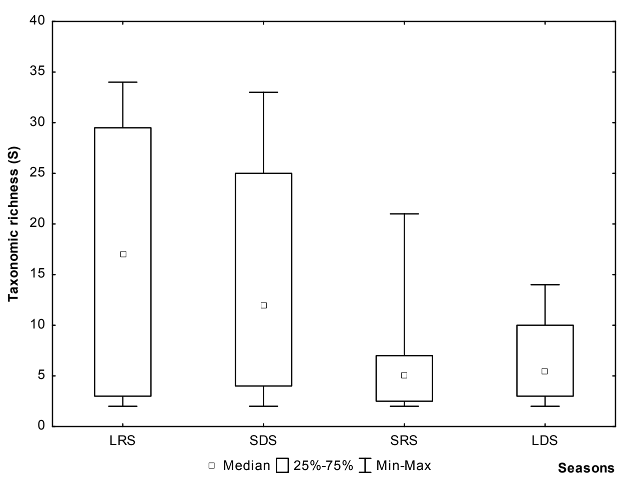

Fig. 2: Seasonal variation of taxonomic richness of benthic macroinvertebrates in Grand-Lahou lagoon. LRS = Long Rainy Season, SDS = Short Dry Season, SRS = Short Rainy Season, LDS = Long Dry Season.

Density

Figure 3 presented seasonal variation of macroinvertebrates densities in each sampling sites of Grand-Lahou lagoon. Lowest values of this parameter were obtained in station L1 and L5 with a minimum of 13.33 ind./m^2 at station L5 in Short Rainy Season. In return, highest densities were in general encountered at stationsL3, L4, L6, L7 and L8 in Short Dry season and in Long Rainy Seasonwith a maximum value of 570 ind./m^2 at station L7 in Long Rainy Season.

Spatial and seasonal variations of densities of benthic macroinvertebrates were not significantly different in Grand-Lahou lagoon (Kruskall-Wallis test, $p > 0.05$).

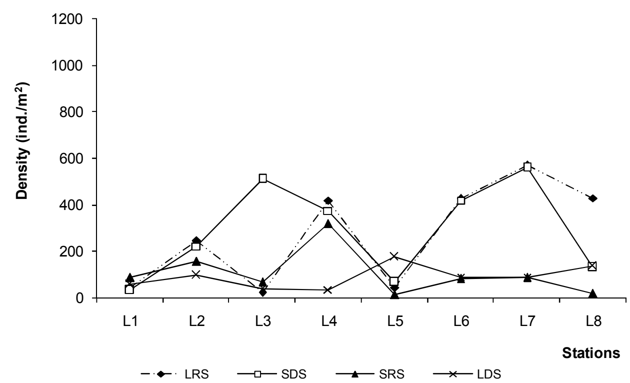

Fig. 3: Spatial and seasonal variation of benthic macroinvertebrates densities in Grand-Lahou lagoon. LRS = Long Rainy Season, SDS = Short Dry Season, SRS = Short Rainy Season, LDS = Long Dry Season.

Diversity and Evenness

Diversity remains low at station L2 during all seasons (Fig. 4). High values were obtained at stations L7 during Long Rainy Season (H' = 3.18) and Short Dry Season (H' = 3.15). In Short Rainy Season and Long Dry Season, this parameter was high at stations L4 (H' = 2.76) and L5 (H' = 2.36) respectively. Evenness values were low at station L2 ($E < 0.40$) during all the seasons. In return this parameter was high ($E > 0.80$) in most of the stations except L5 inLong Rainy Season (E = 0.69) and L3 in Short Dry Season (E = 0.57).

Seasonal variations of diversity and evenness were not significantly different (Kruskall-Wallis test, $p > 0.05$). In contrast, spatial variations of these parameters were significantly different (Kruskall-Wallis test, $p < 0.05$). Significative difference was recorded between station L2 and station L7 (Rank Multiple Comparison test, $p < 0.05$).

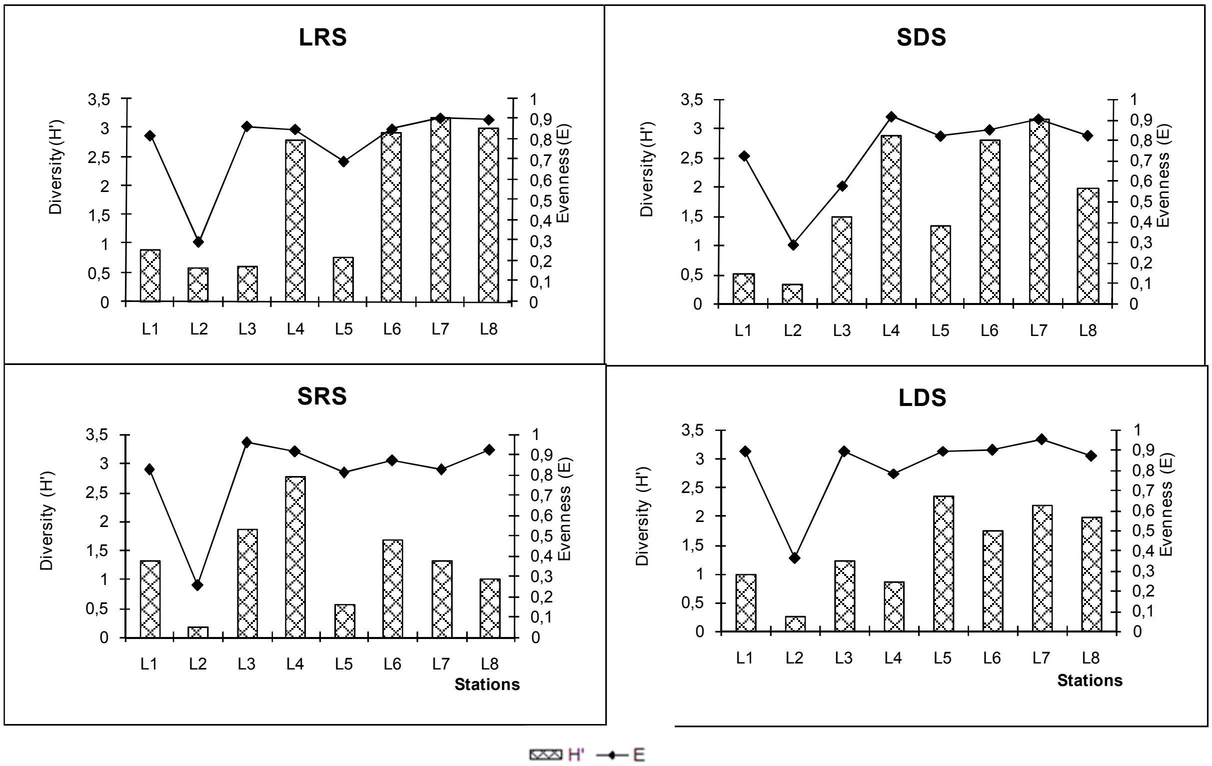

Fig. 4: Spatial and seasonal trends of diversity index and Evenness of Pielou in Grand-Lahou lagoon. LRS = Long Rainy Season, SDS = Short Dry Season, SRS = Short Rainy Season, LDS = Long Dry Season.

<u>Benthic macroinvertebrates and abiotic parameters relations</u>

In order to have a closer approach of the species distribution according to the environmental variables, the characteristic taxa of the benthic macroinvertebrates of the lagoon were determined on the basis of their dominance during the study. The Redundancy Analysis (RDA) resulted in a significant model as depicted by a Monte Carlo permutation tests (n = 1000 permutations, $p < 0.05$). In the RDA, a total of 70% of the variance were explained by the first and second axes chosen for the interpretation of the analysis (Tab. 3).

Tab. 3: Variances and cumulated variances expressed by the four first axes of the Redundancy Analysis.

Axes	1	2	3	4
Variances	0.49	0.21	0.122	0.074
Cumulated variances (%)	49	70	82.2	89.6

The environmental variables are shown as arrows, the lengths of which indicate the relative importance and the directions of which are obtained from the correlation of the variable to the axes (Fig. 5). Among these variables, temperature, dissolved oxygen, pH, water depth and percent of fine and coarse sand were the most important variables explaining the macroinvertebrates distribution, while percentage of muddy sand appeared to be the least important factor affecting the distribution.

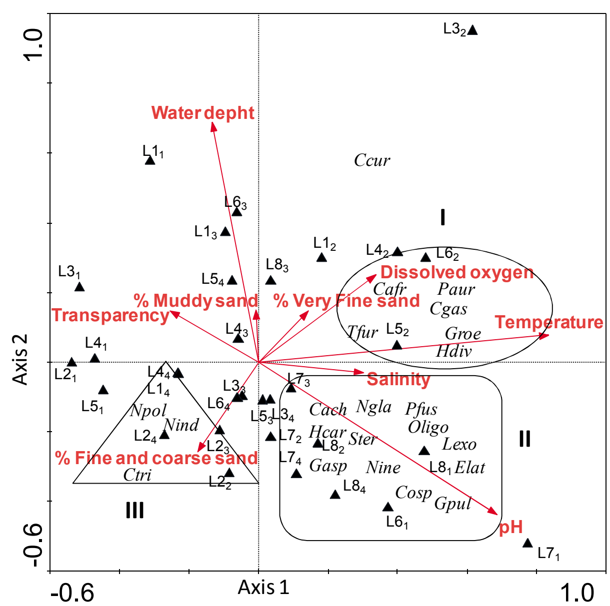

Fig. 5: ReDundancy analysis showing the dominant taxa and the stations with respect to the abiotic variables, relative to axis I and II; I to III represented the groups identified by hierarchical classification; L1 to L8 = stations; in index: 1 = LRS (Long Rainy Season), 2 = SDS (Short Dry Season), 3 = SRS (Short Rainy Season), 4 = LDS (Long Dry Season).

The first ordination axis (Axis 1) reflected samples with a gradient related to temperature, dissolved oxygen, percentage of very fine sand and salinity in that order of importance at the positive end of the axis and transparency at the negative end. The second axis (Axis 2) was associated with water depth and percentage of muddy sand at the positive end while the negative end was related to percentage of fine and coarse sand and pH. In addition, tree groups of samples and taxa can be distinguished in the graph: (I) samples of stations L4, L5 and L6 in short dry season characterised by high temperature and dissolved oxygen and sediment characterised by very fine sand. In this group the most dominant taxa were *Pachymelania aurita* (Paur), *Hediste diversicolor* (Hdiv), *Crassostrea gasar* (Cgas), *Gammarus roeseli* (Groe), *Clibernhardius africanus* (Cafr) and *Tympanotomus fuscatus radula* (Tfur); (II) samples of stations L7 and L8 in all the seasons. In this group, high value of salinity and pH were obtained and the dominant taxa of macroinvertebrates were *Hermodice carunculata* (Hcar), *Nereis inermis* (Nine), *Corophium* sp. (Cosp), *C. acherusicum* (Cach), *Excirolana latipes* (Elat), *Ligia exotica* (Lexo), *Sphaeroma terebrans* (Ster), *Gammarus pulex* (Gpul), *Pachymelania fusca* (Pfus), *Neritina glabrata* (Ngla) and Oligochaeta (Oligo); (III) samples of stations L1, L2 and L3 with sediment characterised by fine and coarse sand in which *Nephtys polybranchia* (Npol), *Nereis indica* (Nind) and *Corbula trigona* (Ctri) were the abundant taxa.

Discussion

The present study showed significant seasonal variation of abiotic parameters such as temperature, salinity, dissolved oxygen and transparency. Mean values of these parameters where higher in Long Dry Season. This situation could be explained by the combined effects of high evaporation and the reduction of freshwater inflow in the lagoon during this season (Mistri *et al*., 2000; Munari *et al*., 2003; Konan *et al*., 2008). In contrast, the input of fresh waters from the nearby rivers such as Bandama and Boubo into the lagoon involves a fall of these parameters particularly the salinity in Long Rainy Season (Durand and Chantraine, 1982; Dounas and Koutsoubas, 1996; Koné *et al*., 2010). This result was also confirmed by low values of salinity in study sites closed to the both rivers entering in the lagoon. The same case was observed in Aby lagoon with the influence of Bia and Tanoé rivers and in the Ebrié lagoon with the influence of Comoé river (Kouadio *et al*., 2008; Kouadio *et al*., 2011).

The taxonomic composition of benthic macroinvertebrates of Grand Lahou lagoon is characterised by Gastropoda, Bivalves, Amphipoda, Isopoda and Polychaetes. This taxonomic list is common to the traditional ones obtained in the lagoonar environment as suggested by Bazaïri *et al.,* (2003) in Merja Zerga lagoon (Moroco), Gnohossou (2006) in Nokoué lake (Benin), Lamptey and Armah (2008) in Keta lagoon (Ghana), Kouadio *et al*., (2008) and Kouadio *et al*., (2011) respectively in Aby lagoon and Ebrié lagoon (Côte d'Ivoire). However, the species richness of the Grand-Lahou lagoon appears to be less rich in comparison to those lagoons. This fact could be attributed to the small surface area of the lagoon which reduces the heterogeneity of habitats (Sankaré *et al*., 1999; Palmer *et al*., 2000).

Spatial variations of taxa composition and community structures were significantly different. Stations L7 and L8 located in the sector of Nyouzomou (littoral zone) was richer than the other stations throughout the study period certainly due to the influence of seawater which results in high species richness following the intrusion of marine species such as polychaetes and crabs in the lagoon (Menif and Ben Hassine, 2003). Therefore, the presence of mangroves forests used as habitats and nurseries for many species in this sector of the Grand-Lahou lagoon could explain high diversity of macroinvertebrates. Indeed, many authors have shown that a high degree of habitat heterogeneity favours biotic diversity, especially for invertebrates (Gilmore and Snedaker, 1993; Palmer *et al*., 2000; Kouadio *et al*., 2008).

Contrary to the sector of Nyouzomou (Station L7 and L8), low species richness and diversity indices in station L2 could be explained by the influence of Bandama river in which high concentrations of nutrient obtained suggested organic pollution from sources such as domestic sewage, industrial wastes and fertilizer run-off (Konan *et al*., 2008; Seu-Anoi *et al*., 2014). According to Moss (1998) and Kemka *et al*., (2004) there is generally a reduction of the number of species and an increase in the number of individuals per species in the eutrophic ecosystems.

Seasonal variations of density and diversity were not significantly different at the stations in the Grand-Lahou lagoon. However, the distribution patterns over seasons indicated periodic changes ranging from rich community during the Long Rainy Season to impoverished one in the Long Dry Season. The highest abundances in Long Rainy Season could be explained by an important sedimentation of organic matter with recirculation and the habitat productivity (Kisielewski, 1986; Zebaze Togouet, 2000). In return, lowest values in the Long Dry Season could be attributed to the intense environmental stress, such as hypersalinity. Such conditions probably affected the physiological responses of the organisms, leading to a reduction in the number (Posey *et al*., 1998).

The ordination technique used to perform a characterisation of the Grand Lahou lagoon based on the benthic macroinvertebrates distribution according to abiotic parameters revealed that temperature, dissolved oxygen, pH, water depth and percentage of fine and coarse sand were the most important variables explaining the macroinvertebrates distribution. This result seems to agree with several studies which showed that species richness, abundance and distribution of benthic macroinvertebrate's assemblages are extremely influenced by physicochemical water quality (Rempel *et al*., 2000; Sousa *et al*., 2006; Fujii, 2007; Morrissey *et al.*, 2013; Colas *et al.*, 2014; Arimoro *et al*., 2015). According to Culp *et al*., (1983), Hagberg and Tunberg, (2000) and Rempel *et al*., (2000), the grain size of the bottom sediments is one of the most important parameters determining the composition of benthic communities.

This study on the response of benthic macroinvertebrates communities to seasonal changes is the first of the kind in the Grand-Lahou lagoon and has contributed to identify 1 747 individuals representing 54 taxa respectively dominated by Molluscs, Crustaceans and Polychaetes. Compared to the taxonomic list of similar other ecosystems, species richness of the Grand-Lahou lagoon appears to be less rich. The distribution patterns of density and diversity over seasons in this lagoon indicated periodic changes ranging from rich community during the Long Rainy Season to impoverished one in the Long Dry Season. However, these variations were not significantly different. Therefore, long-term monitoring should be initiated to better unravel the postulated effects of environmental factors on the composition of benthic macroinvertebrates in the Grand-Lahou lagoon.

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