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Fish distribution in sector IV and V of the Ebrié Lagoon (Côte d'Ivoire)

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Abstract

The distribution profile of fish populations has long been ignored but, it could provide solutions to sampling plans. 14404 fish specimens have been sampled at Layo, N'djem, Songon and Taboth (sector IV) and Ahua (sector V) using gillnets, castnets and commercial fish from February 2014 to January 2015. 57 species were collected. The "Self-Organizing Maps (SOM)" was used to order study sites according to species assemblages. The distribution profile of each of the taxa of the different groups defined by the SOM shows that group (I) composed of the stations of Songon and N'djem contains marine species with estuarine affinity. The second group (II) includes Layo station is distinguished by the presence of essentially continental species. The third group (III) with Taboth station is characterized by the strictly estuarine species. Group IV composed by Ahua station, is dominated by of estuarine species of marine origin or affinity.

Keywords: Ichthyofauna, distribution profile, Kohonen Map, Ebrié lagoon, Côte d'Ivoire

1. Introduction

Ivoirian Lagoons are characterized by a great specific diversity. This specific richness is due to the fact that these Lagoons are places of exchange between river and sea: to that extent that one can find all sorts of species (marines, brackish and continentals. The Ebrié Lagoon is divided into six sectors on the basis of morphological and hydrological criterion ^[1] (figure 1). The fish population in the Ebrié Lagoon are well-known mainly by two great works. The first is the Ichthyological inventory of the Lagoon from 1958 to 1962, made by ^[2]. The inventory made by these authors is based on multiple observations and assemblages were carried out by the Lagoony Biology Laboratory and the Lagoony Fishing and Pisciculture section of the Waters and Forests Ministry of Côte d'Ivoire. The second is the global study of the Ichthyological population of the Lagoon carried out between 1980-1981 by ^[1]. Other researches particularly those of ^[3] and of ^[4] focused on biodiversity.

These researches concerned all sectors of the Ebrié Lagoon. The study area, i.e. sectors IV and V of Ebrié lagoon, has been the subject of numerous researches carried out on the biology and ecology of the main species of aquaculture interest ^[5, 6, 7]. However, the study at the spatial scale of fish populations in the geographical area has not been really studied. Whereas, the study of the geographical distribution of fish has given rise to numerous works since the beginning of the century and ideas have evolved considerably according to the progress made in regional inventories and taxonomic knowledge ^[8]. Indeed, spatial organization is involved in the ecology of populations, their demographic dynamics, their management, the procedures for estimating their abundances and preserving their habitat ^[9]. It is an attribute of populations and therefore an indicator of their state. Moreover ^[9], pointed out that abundance plays a major role in the spatial distribution of fish populations. But, the fish fauna is not evenly distributed. The aim of this study is to determine the distribution profile of fish communities in sectors IV and V of the Ebrié lagoon.

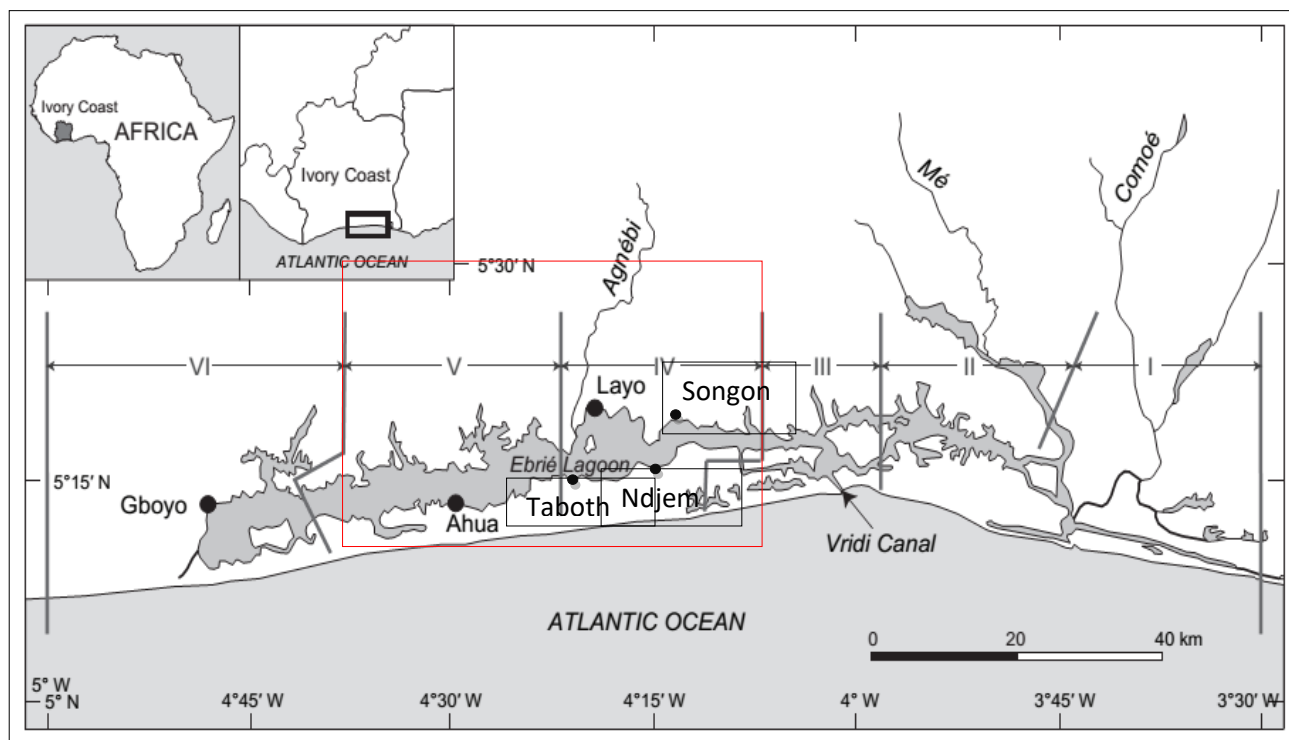


Fig 1: Ebré lagoon Complex ^[1] and location of sampling stations

2. Material and Methods

2.1 Study area

The sampling sites are located in sectors IV and V of the Ebré lagoon, in the localities of Jacquville and Dabou. Its surface is of 256 km² for a water volume of 1.24 km³.

Five sites (Figure 1) were chosen based on the magnitude and frequency of mortality that occurs seasonally in this portion of the Ebré lagoon. They are the villages of N'djem, Songon, Layo and Taboth for sector IV, and the village of Ahua for sector V.

2.2 Sampling fish

The fish were collected between February 2014 and January 2015 using gillnets and castnets. Each gillnet measures 30 m long with a drop height of 1.5 m. Ten weighted gillnets, 30 in length, 1.5 m in height, and of 6, 8, 10, 15, 18, 20, 25, 30, 35 and 40 mm stretched mesh size were employed to capture fish. Nets were set at 5 p.m. and fish were removed at 7 a.m. and again at 12 a.m. In the field the fish caught were identified following ^[10, 11], counted and standard length (mm) and body weight (g) were recorded for each specimen. Fish specimens have also been bought from the fishermen working on the sampling sites chosen in this study.

2.3 Data Treatment

A classification of the lagoon ichthyofauna in ecological category according to ^[12] was made. Some descriptors of fish population structure were calculated. These are the specific richness ^[13], the percentage of occurrence ^[14], the numerical abundance (n).

The Self Organizing Maps (SOM) algorithm or Kohonen maps ^[15, 16] was used to order the study sites according to species assemblages. Indeed, this nonlinear classification technique is able to show simplified patterns from complex databases by identifying similar groups ^[17]. This method imperatively searches for similarities among the observed data and represents them in the output map while preserving the neighborhoods. At the end of the analysis, a map is

obtained and in each hexagon there are virtual objects for which the values of the descriptors have been calculated. And the groups are formed from the Euclidean distance according to the method of ^[18]. The Kohonen self-organizing map was used, in this study, to analyze the species abundance matrix.

3. Results

3.1 Specific composition

Fifty-seven (57) species have been recorded in the study area, including 56 species in zone IV and 32 species in zone V belonging to 50 genera, 33 families and 13 orders. The distribution of fish species in the different stations shows, 41 species in Layo, 39 species in N'djem, 24 species in Songon and 18 species in Taboth for sector IV and 32 species in Ahua, sector V (Table 1).

The important family in number of species is the Cichlidae with 11% of the total number of species in sector IV and 18% of the species in sector V. Eight ecological categories of fish are represented in the two sectors. In sector IV, all ecological categories are represented with, 13 strict estuarine species (EES), 11 estuarine species of marine origin (EEM), eight continental species with estuarine affinity (ECE), seven marine species with estuarine affinity (EME), seven occasional continental species (ECO), five estuarine species of continental origin (EEC), four accessory marine species (EMA) and one occasional marine species (EMO) (Table 1). But, in sector V, six ecological categories have been noted with nine strict estuarine species, nine estuarine species of marine origin, two continental species with estuarine affinity, four estuarine marine species, five estuarine species of continental origin and three accessory marine species. No occasional continental and occasional marine species were collected.

The analysis of the percentage of occurrence of each species allowed to identify 25 constant species ($F \geq 50\%$), 11 accessory species ($25\% \leq F < 50\%$) and 21 accidental species ($F < 25\%$) (Table 1). Accessory species were more collected at the N'djem and Layo stations (sector IV) and less at the Ahua

station (sector V). In addition, accidental species were found in all stations but mostly in Layo and N'djem stations, but none were collected at Taboth station.

Table 1: List of fish species sampled in the stations of Layo (LA), N'djem (ND), Songon (SO), Taboth (TA) and Ahua (AH), in sectors IV and V of the Ebrié lagoon (Ivory Coast)

Family	Sectors Species	IV					V	Ecological Category	Percentage Occurrence
		Stations							
		LA	ND	SO	TA	AH			
Dasyatidae	<i>Dasyatis margarita</i>		+				EME	20	
Polypteridae	<i>Polypterus endlicheri</i>	+					ECE	20	
Elopidae	<i>Elops lacerta</i>	+	+	+	+	+	EME	100	
Ophichthyidae	<i>Myrophis plumbeus</i>					+	EMA	20	
	<i>Dalophis cephalopeltis</i>	+					EMA	20	
Clupeidae	<i>Ethmalosa fimbriata</i>	+	+	+	+	+	EEM	100	
	<i>Sardinella rouxi</i>	+		+	+	+	EMA	80	
	<i>Sardinella aurita</i>	+		+	+	+	EMA	80	
	<i>Pellonula leonensis</i>	+	+	+		+	EEC	80	
Arapaimidae	<i>Heterotis niloticus</i>	+					ECO	20	
Mormyridae	<i>Marcusenius senegalensis</i>	+					ECO	20	
	<i>Marcusenius ussheri</i>	+					ECO	20	
	<i>Mormyrus rume</i>	+					ECO	20	
Hepsetidae	<i>Heptesus odoe</i>	+	+				ECE	40	
Alestidae	<i>Brycinus nurse</i>	+	+				ECE	40	
Claroteidae	<i>Chrysichthys maurus</i>	+	+	+	+	+	EEC	100	
	<i>Chrysichthys nigrodigitatus</i>	+	+	+	+	+	EEC	100	
Bagridae	<i>Bagrus docmak</i>	+					ECO	20	
Schilbeidae	<i>Schilbe mandibularis</i>	+	+	+		+	ECE	80	
	<i>Schilbe intermedius</i>	+				+	ECE	40	
Clariidae	<i>Clarias gariepinus</i>	+		+			ECE	40	
	<i>Heterobranchus longifilis</i>	+	+				ECE	40	
Mochokidae	<i>Synodontis schall</i>	+					ECE	20	
Hemiramphidae	<i>Hyporhamphus picarti</i>		+			+	EEM	40	
Belontiidae	<i>Strongylura senegalensis</i>		+		+	+	EES	60	
Syngnathidae	<i>Microphis brachyurus</i>	+				+	EES	40	
Channidae	<i>Parachanna obscura</i>	+					ECO	20	
Carangidae	<i>Caranx hippos</i>			+			EME	20	
	<i>Caranx crysos</i>		+	+			EMO	40	
	<i>Chloroscombus chrysurus</i>		+				EME	20	
	<i>Trachinotus teraia</i>	+	+	+	+	+	EEM	100	
Lutjanidae	<i>Lutjanus goreensis</i>		+				EMA	20	
Gerreidae	<i>Eucinostomus melanopterus</i>	+	+	+	+	+	EME	100	
	<i>Gerres nigri</i>	+	+	+	+	+	EES	100	
Haemulidae	<i>Plectorhynchus macrolepis</i>	+	+				EEM	40	
	<i>Pomadasys jubelini</i>	+	+	+	+	+	EEM	100	
Monodactylidae	<i>Monodactylus sebae</i>	+	+	+		+	EES	80	
Cichlidae	<i>Tylochromis jentinki</i>	+	+	+	+	+	EES	100	
	<i>Sarotherodon melanotheron</i>	+	+	+	+	+	EES	100	
	<i>Oreochromis niloticus</i>	+				+	EEC	40	
	<i>Tilapia guineensis</i>		+			+	EES	40	
	<i>Tilapia guineensis</i> × <i>Tilapia zillii</i>	+	+	+	+	+	EES	100	
	<i>Hemichromis fasciatus</i>	+	+	+	+	+	EEC	100	
Mugilidae	<i>Liza falcipinnis</i>	+	+	+		+	EEM	80	
	<i>Mugil cephalus</i>	+	+	+		+	EEM	80	
Sphyraenidae	<i>Sphyraena afra</i>	+	+			+	EME	60	
Polynemidae	<i>Polydactylus quadrifilis</i>	+			+	+	EME	60	
Anabantidae	<i>Ctenopoma petherici</i>		+				ECO	20	
Gobiidae	<i>Gobioinellus occidentalis</i>		+				EEM	20	
	<i>Porogobius schlegelii</i>		+				EES	20	
	<i>Bathygobius casamancus</i>		+				EES	20	
Eleotridae	<i>Bostrychus africanus</i>		+			+	EES	40	
	<i>Kribia kribensis</i>		+				EES	20	
	<i>Eleotris vittata</i>		+				EES	20	
Paralichthyidae	<i>Citharichthys stampflii</i>	+	+	+	+	+	EEM	100	
Soleidae	<i>Synaptura lusitanica</i>	+	+			+	EEM	60	
Cynoglossidae	<i>Cynoglossus senegalensis</i>	+	+	+	+	+	EEM	100	
33 Families	57 Species	41	39	24	18	32			

A total of 14404 fish were examined in both sectors IV and V. The most abundant species were *Ethmalosa fimbriata* (18%), *Chrysichthys maurus* (15%), *Pelloluna leonensis* (13%) and *Gerres nigri* (11%).

Sector IV with 8588 individuals presents the highest abundance. Taboth and Layo stations have 2620 and 2322 individuals respectively. The lowest numbers were recorded at N'djem (1810 individuals) and Songon (1836 individuals). The most abundant species in the catches in sector IV are, *Chrysichthys maurus* (21%), *Gerres nigri* (16%), *Ethmalosa fimbriata* (11%), *Tylochromis jentinki* (10%). In sector V, the sampling allowed to collect 5816 individuals. Two species quantitatively dominate the catches in this sector, respectively *Pellonula leonensis* (33%) and *Ethmalosa fimbriata* (29%).

3.2 Fish distribution profile

Figure 2 presents the hierarchical classification of the 16 cells of the Kohonen self-organizing map. These cells are divided into four groups (I to IV) at the Euclidean distance of 0.8. On

the Kohonen map, the groups are illustrated by different patterns. The summary of this distribution is shown in Figure 3. Groups I and III record the lowest richness with nine and 16 species respectively. Group II (24 taxa) and group IV (22 taxa) are the most important. Figure 4 shows the distribution profile of each species in the groups defined by the SOM. Group I mainly includes samples from N'djem (N) and Songon (S). Group II is essentially composed of samples from Layo (L) while group III consists mainly of samples from Taboth (T). Finally, group IV contains the samples from Ahua (A).

Group I is characterized by the presence of the species are marine with estuarine affinity. With regard to group II, the presence of essentially continental species has been noted. As for group III, it is distinguished by the presence of strictly estuarine species. The last group (IV) is composed of species characteristic of estuarine species of marine origin or affinity (Figure 4).

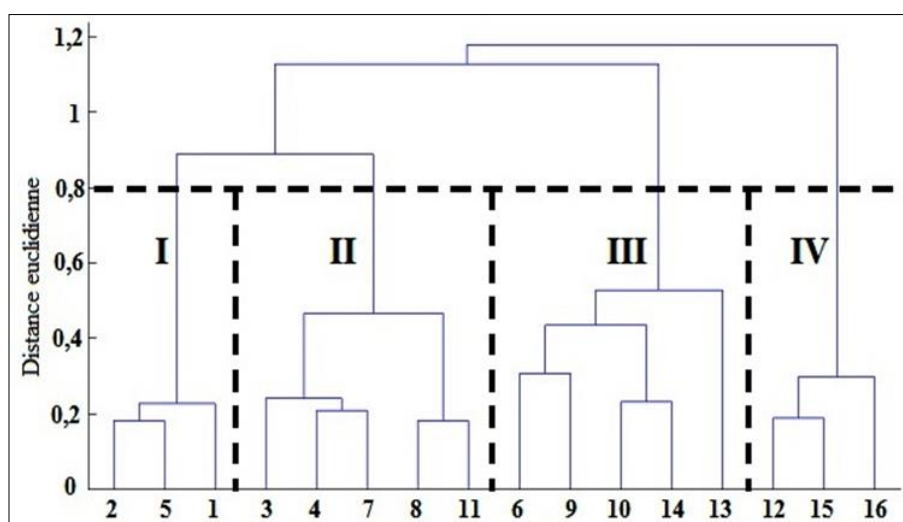


Fig 2: Hierarchical classification of SOM cells I, II, III and IV = defined groups

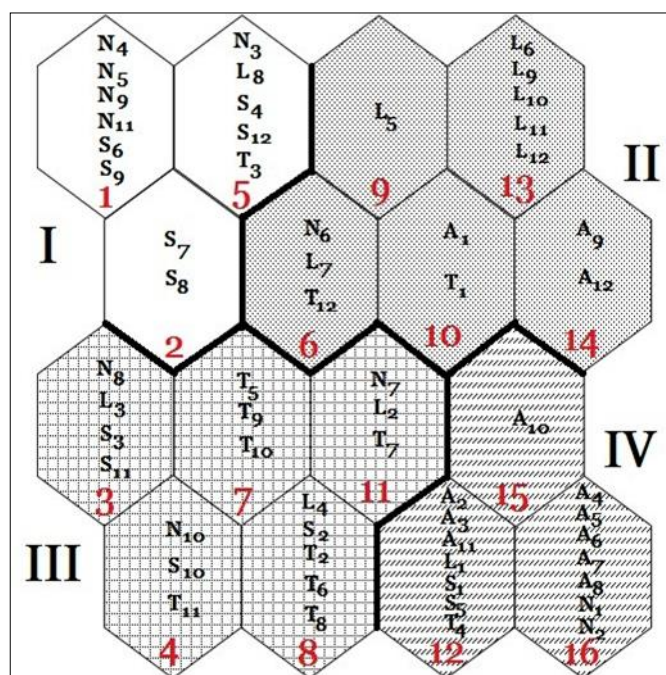
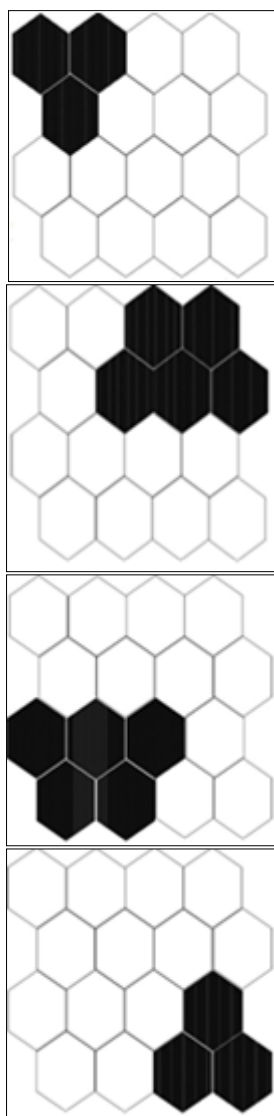


Fig 3: Distribution of species in the SOM from the abundance matrix of fish caught in sectors IV and V of the Ebrié lagoon (Côte d'Ivoire): I to IV = identified groups; A = Ahua, N = N'djem, L = Layo, S = Songon, T = Taboth; Index 1 to 12 = sample numbers; the Arabic numerals 1 to 16 in red at the base of each hexagon correspond to the cell numbers of the SOM

**Group I**

Dasyatis margarita, *Schilbe intermedius*, *Caranx crysos*, *Lutjanus goreensis*, *Plectorhynchus macrolepis*, *Pomadasys jubelini*, *Monodactylus sebae*, *Liza falcipinnis*, *Cynoglossus senegalensis*.

Group II

Polypterus endlicheri, *Sardinella rouxi*, *Heterotis niloticus*, *Marcusenius senegalensis*, *Marcusenius ussheri*, *Mormyrus rume*, *Hepsetus odoe*, *Brycinus nurse*, *Bagrus docmak*, *Schilbe mandibularis*, *Schilbe intermedius*, *Clarias gariepinus*, *Heterobranchus longifilis*, *Synodontis schall*, *Parachanna obscura*, *Caranx hippos*, *Sarotherodon melanotheron*, *Oreochromis niloticus*, *Hemichromis fasciatus*, *Tilapia guineensis*, *Tilapia guineensis x Tilapia zillii*, *Polydactylus quadrifilis*, *Ctenopoma petherici*, *Gobioides africanus*.

Group III

Dasyatis margarita, *Dalophis cephalopeltis*, *Chrysichthys maurus*, *Chrysichthys nigrodigitatus*, *Trachinotus teraia*, *Lutjanus goreensis*, *Gerres melanopterus*, *Gerres nigri*, *Monodactylus sebae*, *Tylochromis jentinki*, *Mugil cephalus*, *Gobioides africanus*, *Gobioinellus occidentalis*, *Bathygobius casamancus*, *Kribia kribensis*, *Eleotris vittata*.

Group IV

Elops lacerta, *Myrophis plumbeus*, *Ethmalosa fimbriata*, *Pellonula leonensis*, *Sardinella aurita*, *Hyporhamphus picarti*, *Strongylura senegalensis*, *Microphis brachyurus*, *Gerres melanopterus*, *Gerres nigri*, *Pomadasys jubelini*, *Monodactylus sebae*, *Tylochromis jentinki*, *Hemichromis fasciatus*, *Tilapia guineensis*, *Tilapia guineensis x Tilapia zillii*, *Sphyraena afra*, *Polydactylus quadrifilis*, *Porogobius schlegelii*, *Bostrychus africanus*, *Citharichthys stampflii*, *Synaptura lusitanica*

Fig 4: Distribution of fish species caught in sectors IV and V of the Ebrié lagoon (Côte d'Ivoire) in each group defined by the SOM (darkened color = high frequency; light color = low frequency or even absent)

4. Discussion

In the present study, 57 species have been identified in the sectors IV and V of the Ebrié Lagoon. This specific diversity of the Lagoon fish is highly reduced compared with the one obtained in the anterior studies on the Ebrié Lagoon.

Indeed, the works of [1] on 65 stations scattered across the lagoon allowed to identify 145 species of fish. The Ichthyological inventory of the Ebrié lagoon, which was carried out by [12] includes 153 species belonging to 71 families. This difference may be due to the fact that our study only covered four stations in sector IV and one station in V of the Ebrié lagoon. Besides, comparing this study to that of [19], all sampled species were listed except for *Antennarius striatus*, *Pentanemus quinquarius*, *Pseudotolithus senegalensis*, *Trachinotus lepturus*, species that were not caught during our sampling. However, the *Bagrus dockmac*, was reported for the first time in the Ebrié lagoon in our study. This species of the Bagridae family was reported in the Niger basin by [20] and by [21] in the Bagoé River in northern Côte d'Ivoire.

Sector IV contains a diversity of ecological categories and species than sector V. This difference would be due to the fact that sector IV is the place of exchange between marine waters and continental waters so that all forms of marine, brackish and continental species are found there [22], while sector V is a

more confined environment. Our results, similar to those of [19], showed that the stations upstream of the Gambia estuary, and that towards the mouth of the Sine-Saloum (in Senegal) harbor the same species as the one we have collected in sectors IV and V of the Ébrié lagoon.

The fish community of sectors IV and V of the Ebrié lagoon is characterized by a strong spatial structure. The SOM allowed to identify 16 nodes in which 4 groups have been defined. This classification is essentially due to the geographical location of the stations and the influence of the waters feeding the lagoon. Furthermore, the biological distribution established by the SOM could be closely dependent on climatological, hydrological and hydrochemical cycles as [23] [24] reported. Group I, composed of the Songon and N'djem stations, contains marine species with estuarine affinity. It is characterized by high salinity. This group not far from the Vridi channel, is influenced by the tide. The high salinity in these stations would explain the predominance of marine species [25]. Group II composed of the Layo station is distinguished by the presence of essentially continental species. It is characterized by and low salinity. This station is influenced by the flow of water from the Agnéby River and runoff water from banana fields [24]. Group III, composed of the Taboth station, is differentiated by the presence of strictly estuarine species. This station, located not far from Layo, is

not influenced by the migration of continental species during the flood season. Indeed, ^[12] indicated that the influence of the Agnéby River, which is sensitive during periods of flooding, remains localized in the mouth area. Group IV characterized by the Ahua station is dominated by marine species with estuarine affinity and estuarine species of marine origin. This group far from Agnéby and the Vridi canal is less influenced by marine and continental waters. This gives this station a confined character. This results in the production of carbon dioxide, hydrogen sulphide, ammonia and methane ^[26]. These highly toxic elements for aquatic organisms could explain the cause of the massive fish mortality recorded at this station in May 2013.

5. Conclusion

This study shows that sectors IV and V of the Ebrié lagoon are lagoon environments which vary considerably according to the connections with the sea and the river inputs. 56 species were collected in sector IV including 41 in Layo, 39 in N'djem, 24 in Songon and 18 in Taboth and 32 species in Ahua, the only station in sector V. The Self Organizing Maps (SOM) presented the distribution profile of each species in the four groups defined with group I mainly comprising the samples from N'djem and Songon, group II, III and IV, respectively those from Layo, Taboth and Ahua. The SOM allowed to highlight the confrontation of water masses of various origins which constitutes an essential element of the ecology of the study area, involved in the specific composition, the structure and the spatio-temporal distribution of the communities but also, on the dynamics of the various species.

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