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Full Length Research Paper

Ecological factors affecting the distribution of zooplankton community in the Massa Lagoon (Southern Morocco)

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In this study, the zooplankton structure and the water quality of Massa Lagoon were investigated. Samples were collected biweekly at the three stations for 6 months from winter to summer 2008. Results show that the state of the lagoon is a hyper-eutrophic environment, characterized by high levels of chlorophyll-*a* and nitrogen. Pollution-tolerant zooplankton such as *Brachionus* was the dominant species in the lagoon. A total of 61 taxa were recorded, including 35 rotifers, 13 copepods, 5 ostracods, 6 protozoa and 6 cladocera. Salinity and nutrients in the water were the main environmental factors that affected the distribution of the zooplankton species.

Key words: Massa Lagoon, zooplankton, environmental factors.

INTRODUCTION

Aquatic ecosystems are closed or semi-closed, as the site of the study appears to be a finite and vulnerable resource threatened by catches in the environment (Aspe and Pont, 1999), and are considered a siege of several biological, chemical and physical phenomena. Evaluation of factors controlling the distribution of zooplankton species is, by its central position and its dual control by resources and predation, a central point in the biological and ecological functioning of aquatic ecosystems, which must be taken into account in the context of the management of these environments through the manipulation of the food web (Pinnel-Alloul et al., 1996). It is difficult to identify the main causes that explain the variation in zooplankton abundance (Velho et al., 2001), while abiotic factors such as salinity (Ayad, 2002), precipitations or turbidity, have been identified as critical factors in the development of zooplankton (Dejen et al., 2004). Other authors (Wetzel, 2001; Fernández-Rosado and Lucena, 2001) have also mentioned the influence of environmental and biotic interactions on the composition, abundance and dynamics of zooplankton. However, there has been no hydrobiological study of the Massa Lagoon and its development for conservation requires the completion of such study.

The lagoon of the biological reserve of Massa is situated in the heart of the National Park of Souss Massa in southern Morocco. It offers a unique wetland included in 2005 on the list of Ramsar sites and also as a natural environment that has international significance. However, it is one of the most important migration routes and stopover site of wintering birds. This area is also the last refuge for the last wild population of bald ibis (*Geronticus eremita*) in the world, which is a rare and endangered species.

The environment of the Massa Lagoon was indeed more severely affected by pollution and in particular with the silting of the mouth. It forms a barrier beach sand to prevent any communication with the sea and the installation of the dam (Youssef Ben Tachfine) upstream. Also, recurrent droughts have been experienced by the region in recent decades and agricultural pollution is ever increasing.

These hydrological and environmental issues have accentuated and accelerated the eutrophication of the downstream part of the Massa Lagoon (lack of oxygen, increasing temperature, high algal development and

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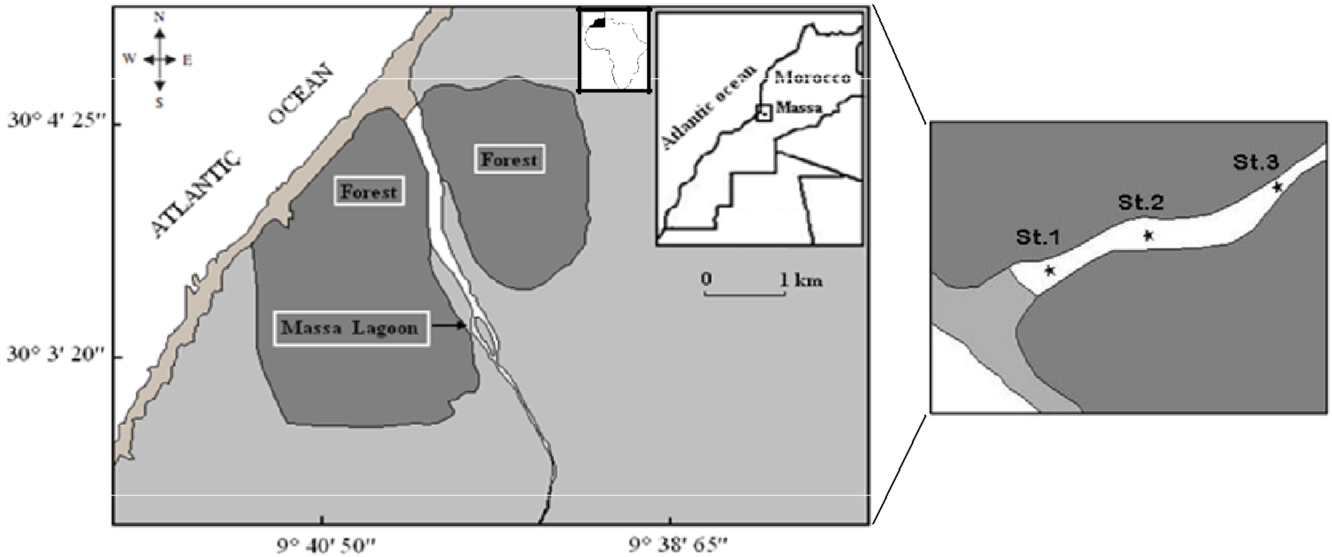


Figure 1. Location of the region of Souss Massa and the three study sites.

mortality of fish).

These threats to the area, declared in the area protected by the Ramsar Convention in 2005, which include wetlands of Morocco, have consequences for the loss of biodiversity, thus leading to impairment of the biological equilibrium of the lagoon and even destruction of the ecosystem and serious disturbances in the intercontinental migration routes of birds.

Given this situation, an ecological analysis was conducted through an initial study by the hydrobiological study of the physical chemistry of water. The study of zooplankton, which is its key position in the trophic chain, gives a fundamental role in zooplankton, and as a consequence, its study seems essential to better understand the functioning of aquatic systems. So the development for its conservation requires the realization of this kind of study.

MATERIALS AND METHODS

Study sites

The Massa Lagoon is located along the south- east coast of Morocco, about 60 km south of Agadir (Figure 1). The choice of sampling stations was conducted according to the gradient of salinity, agricultural areas, significant anthropogenic activities and places of wintering birds.

Station 1: Located at the (Lat. 30°04'20, 29'' N: long.9°40'03, 23''O) downstream of the lagoon near the sea and where shorebirds are abundant and sedentary.
Station 2: Located at 2 km of station 1, which is located at Lat. 30°03'53, 25''N: long. 9°39'51, 09'' O. It is approximately in an intermediate zone, deeper, near the position of the forest and is influenced by human activities.

Station 3: This has Lat. 30°3'23, 04'' N: long. 9°39'25, 91''O and is located along the southern boundary. It has special features since it is localized near the farming areas of alfalfa and corn.

Sampling

At each site, qualitative samples have been realized over a period of 6 months (from February to July, 2008). The horizontal sampling, conducted in each site was created using empty mesh 80 m plankton net. At each site, we apply two vertical lines upward. The fauna recovered in the first line is filtered through a nylon sieve of 40 m mesh vacuum and then placed in a pillbox and preserved in 5% formalin immediately after collection. The second feature is kept alive for the determination of some species difficult to identify after fixation (protozoans and rotifers) and also for observation after the return to the laboratory. The vertical sampling was done using a closing bottle with a capacity of two liters of type WILDCO valves. Two samples, filtered through a filter of 40 m, were fixed in 5% formalin and this type of sampling was also used for water samples in the physical chemistry study.

Abiotic variables

***Situ measurements**

Measurement in *situ* field measurements were for temperature, dissolved oxygen, salinity, pH and water transparency. Water temperature and dissolved oxygen were measured by a thermo-oximeter; salinity, by a salinometer; pH, by a pH meter and transparency, by a secchi disk.

***Laboratory analysis**

The methodology followed for analyses of nutrients (mg/L) are presented in summary in Table 1.

***Measures of chlorophyll-a**

Measuring the concentration of chlorophyll-a was achieved by

Table 1. The methodology followed for analyses of nutrients (mg / l).

Ammonium (mg/l)	Colorimetric: ndophenols blue (AFNOR T90-015, 1994).
Nitrate (mg/l)	Sodium salicylate method (Rodier, 1984).
Orthophosphates (mg/l)	Formation of a phosphomolybdic complex absorbing at 700 and 880 nm after reduction with ascorbic acid (AFNOR T90-015, 1994).
Suspended solids (mg/l)	Filtration on a glass fiber filter 0.45 m, then drying in an oven at 105°C for 24 h.
Chemical oxygen demand (mg/l)	Potassium dichromate oxidability 3 (AFNOR T90-015, 1994).

filtration on a filter Whathman GF/C (0.45 mm). It was stored and extracted in 90% acetone for 24 h and kept at 4°C in order to protect it from light. Chlorophyll was calculated using a spectrophotometer with a formula created by Lorenzen (1967).

$$[Chl.a] = 26.7(A664^{na}-A665^{a})*v/V*1$$

Where na: before acidification; a: after acidification; v: volume of extraction solvent (ml); V: volume of water filtered (L).

Biotic variables

After homogenization of the sample, the counting of the number of specimens of each species was done in a Dollfus cuve under a stereoscopic microscope after staining with Rose Bengal. To facilitate the enumeration of species, few milliliters of a solution of alcohol (10% glycerol) were added to the contents of the tanks. After evaporation of the alcohol, water species were immobilized in glycerine that can counted easily. Species identification was made with reference to the key determination (Pourriot and Francez, 1986) of rotifers, (Dussart, 1967, 1969) copepods and (Amoros, 1984) and cladocera.

Statistical analysis

To study the variations of zooplankton, a PCA was conducted. The principal component analysis (PCA) was one of the most used analyses (Giraudel and Lek, 2000). It is a factorial method of statistical analysis, and a linear and multidimensional part of descriptive statistics. It can synthesize, describe and classify data from one table to provide a summary.

Factorial correspondence analysis (FCA) (Benzécri, 1973) is a first step in the harvestable matrices stations sword. AFC has been coupled with a hierarchical clustering (AHC) using a Euclidean distance and the diameter "complete linkage". The AFC and HFA are two complementary approaches: the first brings to light gradients or changes, while the second is the interpretation of ordination for retaining groups actually formed on the factorial axis (Leprêtre, 1988).

RESULTS AND DISCUSSION

Physico-chemical environment

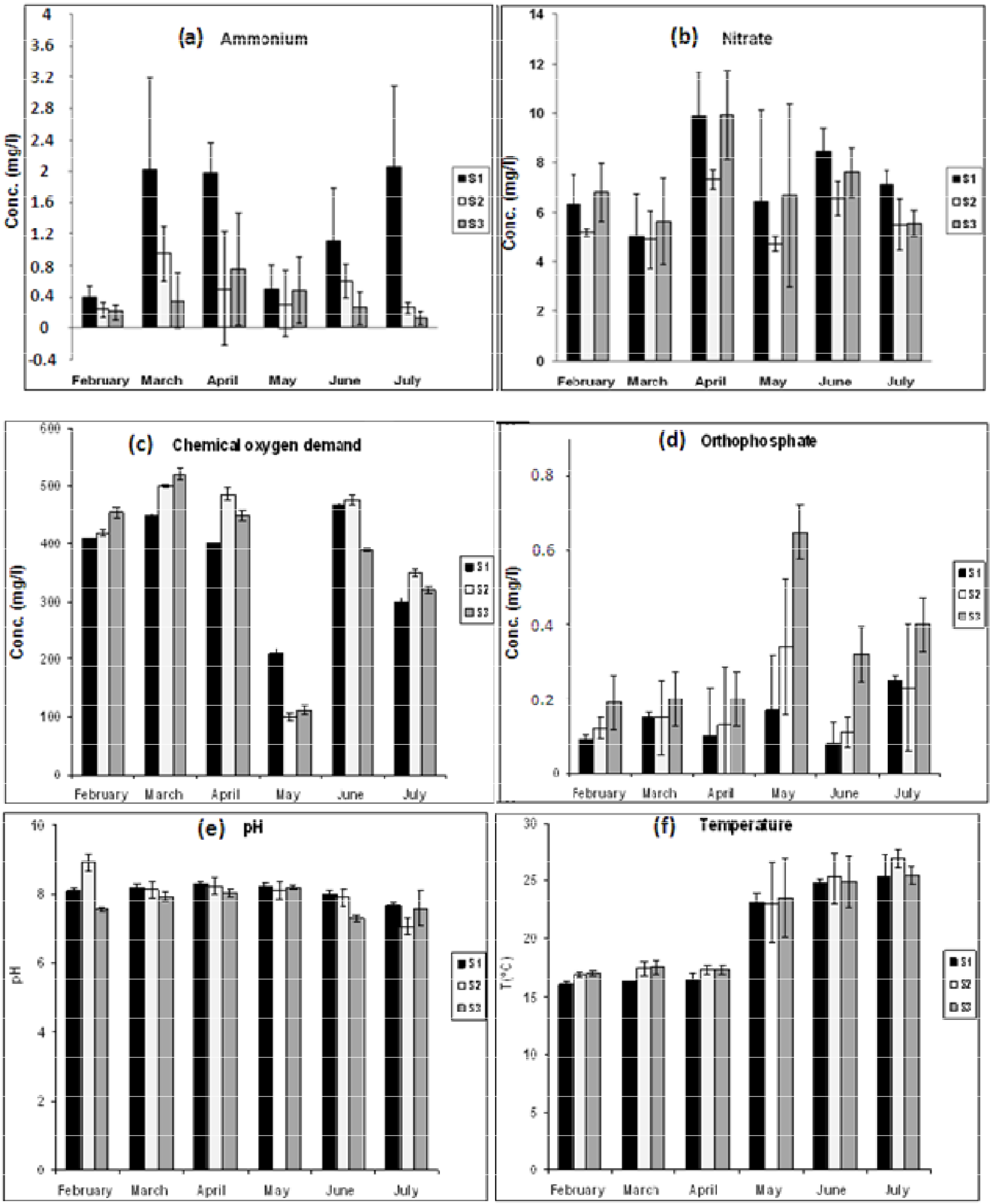
The physico-chemical results during the study period are presented in Figure 2, while the inventories of zooplankton in the three sampling stations are summarized in Table 3.

The temperature is one key factor that regulates the growth of zooplankton populations (Ban and Binoda, 1992). During the study period, water temperature ranged from 16.1 to 26.95°C with the minimum value in spring and the maximum in summer. It showed significant positive correlation with salinity (r = 0.65) and significant negative correlation with pH (r = -0.65). The pH values indicated that the nature of the water was slightly alkaline. It showed significant positive correlation with suspended solids (r = 0.19) and negative correlation with water temperature (r = -0.65). The same values are recorded by (Chaouti, 2005) at the Smir Lagoon. The dissolved oxygen values ranged from 3 to 6.356 mg l^{-1} and showed significant positive correlation with chlorophyll-a (r = 0.57) and negative correlation with chemical oxygen demand (r = -0.39).

The comparison results show a variability of these parameters. At Site II, the high value of the water temperature in summer (26.95°C), due to arid climate, has caused a sharp decrease in dissolved oxygen (3 mg/l) and decreased pH. The interaction between these parameters at this station can be explained by the microbial activity that was high in sludge sediment, resulting in a decrease in the concentration of dissolved oxygen and an increase of nitrate and phosphate. Kagalou et al. (2006) demonstrated that the decom-position of organic matter occurs at the sediment-water interface.

During the study period, the salinity of the lagoon ranged from 12.01 to 24.6 mg l^{-1}. A gradient of increasing salinity is observed from Site III to I. The high evaporation caused by the highest values was recorded in summer. The values of COD vary between 100 and 520 mg l^{-1} and showed a negative correlation with water temperature (r = -0.48). However, the high values of COD were probably due to the addition of waste (Mishra and Saksena, 1989; Pandey et al., 1989). Nitrates are nitrogen forms that are preferentially absorbed when the algae have the same time of NH_4^+ and NO_3^- Ait (Salah, 1997). The values ranged from 4.08 to 8.64 mgl^{-1}.

The transparency (0.44 to 1.76 cm) showed significant positive correlation with water temperature (r = 0.41) and significant negative correlation with ammonium nitrogen (r = 0.62). The concentration of orthophosphate in the lagoon water varies from 0.09 to 0.65 mg l^{-1}. However, it increases upstream because of the prevailing agricultural effluents to the environment of the lagoon and the


(a) Ammonium
Conc. (mg/l)
S1
S2
S3
February
March
April
May
June
July
(b) Nitrate
(c) Chemical oxygen demand
(d) Orthophosphate
(e) pH
pH
(f) Temperature
T (°C)

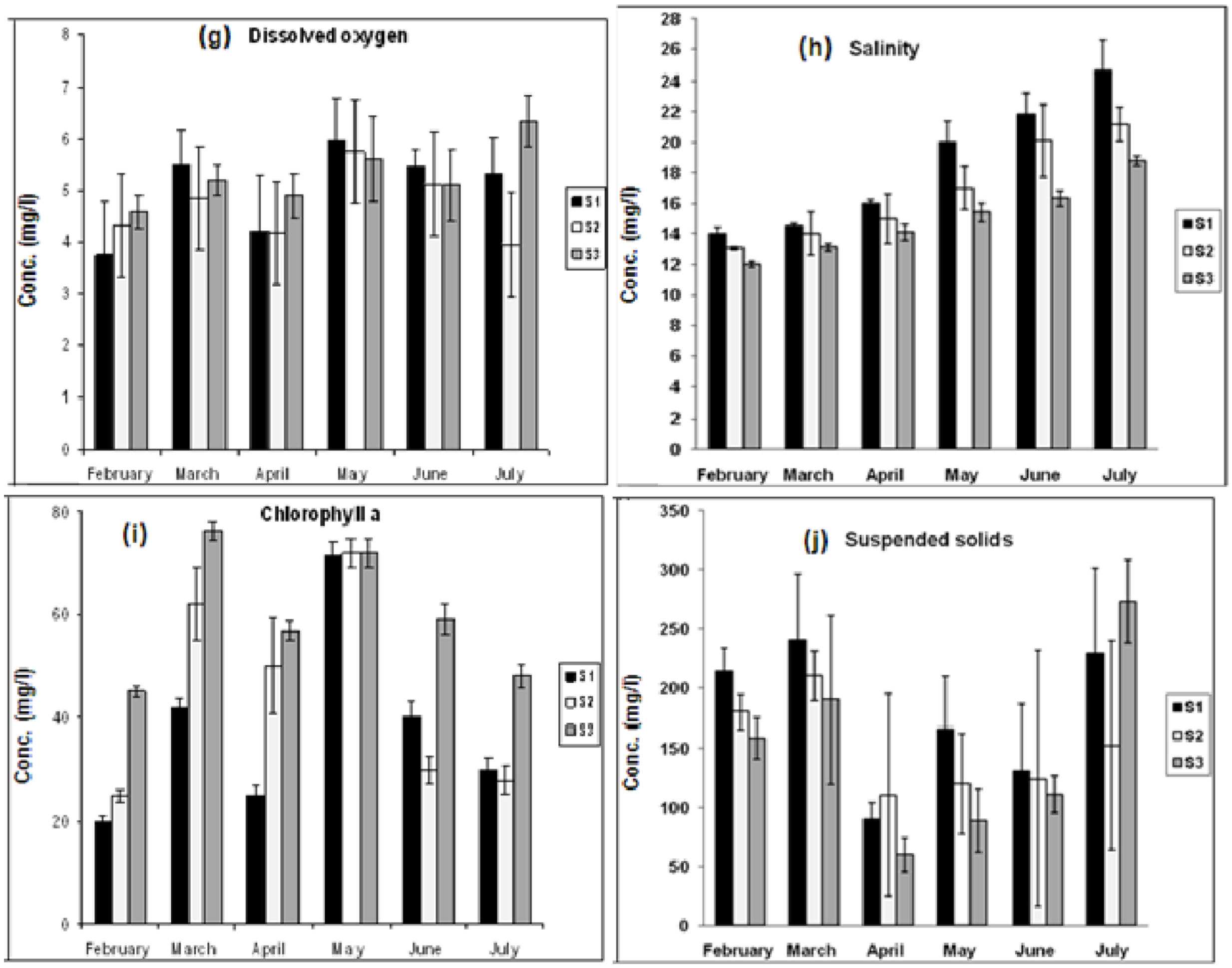


Figure 2. Monthly variations in (a) Ammonium nitrogen (b) Nitrate nitrogen (c) Chemical oxygen demand (d) Orthophosphate (e) pH (f) Temperature (g) Dissolved oxygen (h) Salinity (i) Chlorophyll-a and (j) Suspended solids, respectively recorded from stations 1, 2 and 3.

Table 2. Correlation matrix among the physico-chemical properties and zooplankton density (organism $l^{-1)}$ of the water of Massa Lagoon.

	WT	pH	DO	SAL	Chl a	SS	PO4	NH4	COD	NO3	TRNS	ZOO
WT	-	-0.6545	0.31296	0.65577	0.05615	-0.3422	-0.3707	-0.1597	-0.4842	-0.0836	0.41376	0.2465
pH		-	0.00645	-0.512	0.10617	0.19789	-0.0431	-0.0423	-0.0164	-0.1438	-0.4866	-0.0550
DO			-	0.06544	0.57652	0.10238	-0.3417	0.07305	-0.3901	-0.1243	-0.2409	-0.0002
SAL				-	-0.326	-0.152	-0.3206	0.36702	-0.1866	0.07456	0.10486	0.6803
Chl a					-	0.06233	-0.2875	-0.3105	-0.3469	-0.1669	-0.229	-0.0743
SS							-0.1175	0.44445	0.2639	-0.401	-0.463	-0.0441
PO4								-0.2402	0.15313	-0.0161	0.27145	-0.2670
NH4									0.12943	0.31633	-0.6266	0.3921
COD									-	0.18485	0.13834	0.3353
NO3											-0.0979	0.0905
TRNS												-0.3502
ZOO												-

'-' indicate negative correlation, WT= Water temperature, DO = dissolved oxygen, Sal salinity, Chl a= chlorophyll a, SS = suspended solids, PO_4=orthophosphate, NH_4 = ammonium nitrogen, NO_3= nitrate nitrogen, COD = chemical oxygen demand, TRNS = transparency, ZOO = zooplankton.

livestock, which are the main socio-economic activities. Indeed, in the irrigated valley of Massa, 700 ha are devoted to vegetables and banana. Moreover, the lagoon is eutrophic and shallow. Ruggiero et al. (2004) note that in this type of ecosystem, the availability of phosphorus is mainly determined by the internal load of this element in the sediment, and its mobility in the sediment depends on oxygen and redox potential.

Suspended solids are crucial in the biogeochemical cycle of many pollutants in aquatic systems by limiting the chemical exchanges between the dissolved and particulate (Maldiney and Mouchel, 1995). The values fluctuated between 272.97 and 50 mg l^{-1}. Indeed, the ammonium ion content of the lagoon shows a decreasing gradient of sites I to III, which fluctuated between 0.1 and 2.05 mg l^{-1}. These are the excretions of shorebirds that are very abundant in site 1.

Concentrations of chlorophyll-a vary from 20 to 76.33 mg/m^3 and are due to significant development of algae. Comparison with other similar ecosystems indicates that the Massa Lagoon levels of chlorophyll a were similar to that found in the Nador Lagoon by Lefebvre et al. (1993).

Evaluation of the trophic level of the Massa Lagoon by model O. C. D. E., class lagoon, is in a hyper-eutrophic state.

Zooplankton community

The data represented in Table 2 reveal that the greatest numbers of zooplankton were noted for 54 species at Site III, followed by Site IV (45) and II (37).

In the three stations, the rotifers form the bulk of the zooplankton population and they represent respectively 62, 59 and 50% of the total abundance (Figure 3). The copepods forming the second group of zooplankton, a qualitative point of view with a large diversity at the third station (26%), to the detriment of protozoa and ostracods are poorly represented. This high species richness downstream indicates a favorable environment for the successive development of several species.

Figure 3 has shown comparatively, high values of temperature. Nitrate, salinity and low values of pH and DO are responsible for relatively higher abundance of zooplankton species at Site I and II. In Site III, zooplankton population is less as compared to Site I and II, which may have fewer nutrients available there. The relative contributions of abiotic factors have been determined in the spatiotemporal distribution of zooplankton species collected at three sites].

Abundance of zooplankton

The abundance of zooplankton is largely dominated during this study by Rotifers and Copepods. The average relative importance of the major taxonomic groups in the three sampling sites is presented in Figure 4.

In general, the zooplankton population was very low. Densities of zooplankton ranged between 551 and 4217 organism l^{-1} (Figure 4). Rotifers ranged between 503.5 and 4198 organism l^{-1} and were dominant always during the study. The densities of copepods are low and fluctuated between 18 and 76 organism l^{-1} (Figure 4).

Distribution of rotifers

The rotifers are the most important animal group belonging to the ecological niche of small filters (Margalef, 1983). The rotifers are able to ingest small particles such as bacteria and organic detritus that are often abundant in eutrophic environments. The result, according to Margalef (1983) and Orcutt and Pace (1984), is that a strong representation of rotifers in aquatic freshwater can be considered as an indicator of a high biological trophic level. Brachionides is the most dominant presence of the genus *Brachionus,* which is common in tropical waters. Furthermore, Gannon and Stemberger (1978), Sladecek (1983) and Maemets (1983) have all been able to establish a relationship between a high number of species of the genus *Brachionus* and a high trophic level. In this study, *Brachionus plicatilis* (4198 org/l), which was among the rotifers, was the most common and quantitatively dominant species. These species are essentially herbivore and what appears to corroborate to the status assigned to hypereutrophic lagoon. Analysis of the stands at three stations, to describe the composition and distribution of rotifers that are present in the spring, are found in small numbers in summer and winter.

Overall, the rotifer appears to be continuing into the surface and, as pointed out, this is due to the wet available algal surface, where chlorophyll a is important. Indeed, one of the characteristics of the population of rotifers living in the lagoon is low fertility. There are one or two eggs, which may be a characteristic of eutrophic environments as already noted by several authors (Lair et al., 1996) and its feature would reflect the importance of using the detrital food despite a good use of algae food. The predominance of one rotifer species was attributed to the fact that these organizations have a strategy r. They are opportunistic, small size, with short life cycles and high tolerance to a variety of environmental factors.

Distribution of copepods

In this study, the copepods are poorly represented (Figure 4) . *Halicyclops neglectus,* which is a typical species of brackish coastal ponds and salt waters and which supports a salinity of 34g/l. according to Loffler (1961) in Dussart (1969), is always present during the study period with densities that exceed 38 org l^{-1}. The

Table 3. Occurrence of zooplankton sampling at three sites.

Nbr species	Site		
	I	II	III
Rotifera (35)	**33**	**26**	**20**
Ascomorpha sp.	-	+	-
Asplanchna priodonta	+	+	+
Brachionus angularis	+	+	-
Brachionus calyciflorus	+	+	+
Brachionus caudatus	+	+	-
Brachionus leydigi	+	+	+
Brachionus plicatilis	+	+	+
Brachionus quadridentatatus	+	+	+
Brachionus rotundiformis	+	+	+
Brachionus rubens	+	+	+
Brachionus strita	+	+	-
Brachionus urceolaris	+	+	+
Cluniobicularis	-	+	+
Collotheca sp.	+	+	+
Colurella sp.	+	+	-
Eosophora	+	-	-
Epiphanes clavulata	+	-	-
Euchlanis sp.	+	-	-
Gastropus sp.	+	-	-
Hexarthra fennica	+	+	+
Hexarthra mira	+	+	+
Lecane inermis	+	-	+
Lecane luna	+	-	+
Lepadella patina	+	-	-
Notholca squamula	+	+	-
Philodina	+	+	+
Pompholyx complanata	+	+	+
Pompholyx solcata	+	-	-
Rotaria	+	+	+
Synchaeta lokowitziana	+	+	-
Synchaeta oblonga	+	+	+
Synchaeta pectinata.	+	+	+
Synchaeta stylata	+	-	+
Synchaeta tremula	+	+	-
Trichocerca rosea	+	+	-
Crustacea	**1**	**0**	**0**
Cladocera			
Daphnia longispina	+	-	-
Copepoda (13)	**10**	**9**	**7**
Acanthocyclops robustus	+	+	+
Calanus helgolandicus	+	+	-
Centropages typicus	+	+	-
Cryptocyclops bicolor	+	+	-
Epactophanes richardis	-	-	+
Eurytemora affinis	-	-	+
Halicyclops magniceps	+	+	+
Halicyclops neglectus	+	+	+

Table 3. Cont.

Macrocyclops albidus	+	+	+
Moraria sp.	-	-	+
Oithona nana	+	+	-
Paracalanus typicus	+	-	-
Paracyclops fimbriatus	+	+	+
Larvae (1)	**1**	**1**	**1**
Nauplii	+	+	+
Ostracoda (6)	**4**	**4**	**5**
Cyprideis littoralis	+	+	+
Cypridopsis aculeata.	+	+	+
Cypridopsis vidua	+	+	+
Eucypris stagnalis	+	+	-
Hemicythere villosa	-	-	+
Herpetocypris chevreuxi	-	-	+
Protosoa (5)	**5**	**5**	**4**
Euplotes sp.	+	+	+
Didinium sp.	+	+	+
Zoothamnium sp.	+	+	+
Vorticella sp.	+	+	-
Codonella cratera	+	+	+

carnivore species copepod, Acanthocyclops robustus (Geraldes et al., 2004), is dominant in spring with high densities (57 org l^{-1}).

The Harpacticoida, with *Epactophanes richardi* species, are present only at Site III. It is, therefore, clear that there is a preference of these species to "low salinity" water. However, the literature calls them species with wide ecological valence.

The scarcity of copepods is certainly not due to lack of food resources, but could be attributed to the phenomenon of predation and competition with rotifers colonizing the environment throughout the study period with high densities (4200 org l^{-1}) and biomasses (178.36 µg l^{-1}), which is calculated by the equations of length-weight regressions (Ruttner-Kolisko, 1977).

The absence of oval females was noted. This is due to predation by larvae of the dipteran Chaoborus gender met at Station III, which is a major predator of oval females that are larger and more visible (Rabette and Lair, 1998).

Distribution of cladocera

The only species of cladocera recorded at site I was *Daphnia longispina*, which is very common in small collections of eutrophic water (Amoros, 1972) and very scarce in the media of high degree of eutrophication (Amengal, 1987).

The scarcity of cladocera is explained by the planktivore predatory fish action inhabiting the lagoon as

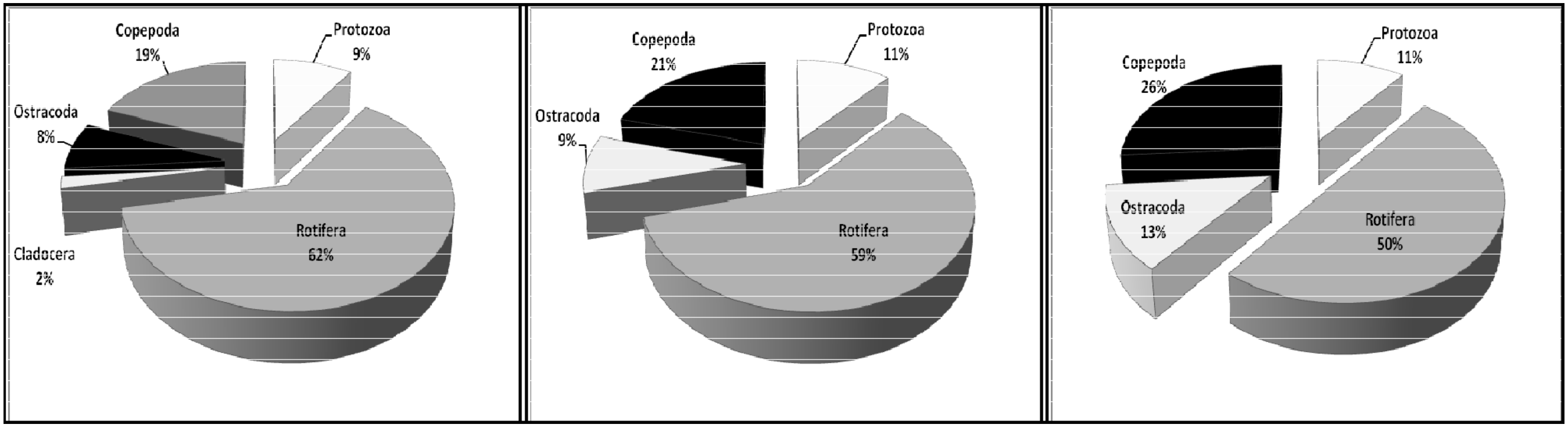


Figure 3. Relative importance of the abundance of the different zooplanktonic groups observed during the study in the Massa Lagoon woks.

it has been demonstrated in several similar environments (Persson, 1988; Pascal Francisco, 1999). Besides, increasing concentrations of suspended solids can block the filtering apparatus and impede their nutrition (Kirk and Gilbert 1990).

Distribution of ostracoda

Ostracoda were recorded at all sites indicating that they are tolerant to the extreme environmental conditions prevailed in this region.

Statistical treatment of data

A factorial axis 1 accounts for 34.02% of the total inertia and the factorial axis 2 accounts for 25.78% of the total inertia.

The factorial axis 1 opposes spring in its positive side, while in the negative side, it opposes summer and winter.

The factorial axis 2 opposes spring and summer in its negative side (Figure 5) and winter in its positive side.

The projection of both months and species in the factorial axes [1-2] shows that a factorial axis opposes the three types of species:

Spring was represented by the following species, Mv, Ns, R, Ar, Pc and Li; summer by Ap, Sp and Er; and winter by Er, Ma, Ar and Bu. All other species namely: Bp, Hn, Ma, Er and Bu are always present during the study period (Figure 5).

Agglomerative hierarchical classification (AHC) is made from the coordinates of the months on the first three axes of the AFC, which play a role of filter information and stabilizes the clusters. Agglomerative hierarchical classification allows, more clearly, the visualization of the similarities between the months. The dendrogram classification shows two groups which are individualized and isolated. The first group is composed of spring month's surveys (March, April and May), while the second group consists of summer month's surveys (June and July). February, which represents winter, is isolated from other months.

In conclusion, the analysis of all inventoried species of rotifers and copepods confirms the existence of a temporal gradient with seasonal effect.

The influence of ten environmental variables and chlorophyll a on the total zooplankton groups in the Massa Lagoon were assessed using the 'principal component analysis'.

After logarithmic transformation of variables, the first and second axis of PCA accounted for 25.35 and 19.7% of the total variance. The first factorial axis (PC1) was strongly associated with chlorophyll-a, while the second factorial axis (PC2) was closely related with nitrate nitrogen (Figure 7).

Table 1 shows the Pearson correlation matrix of different physico-chemical variables including total zooplankton density. The total zooplankton density showed highly significant positive correlation

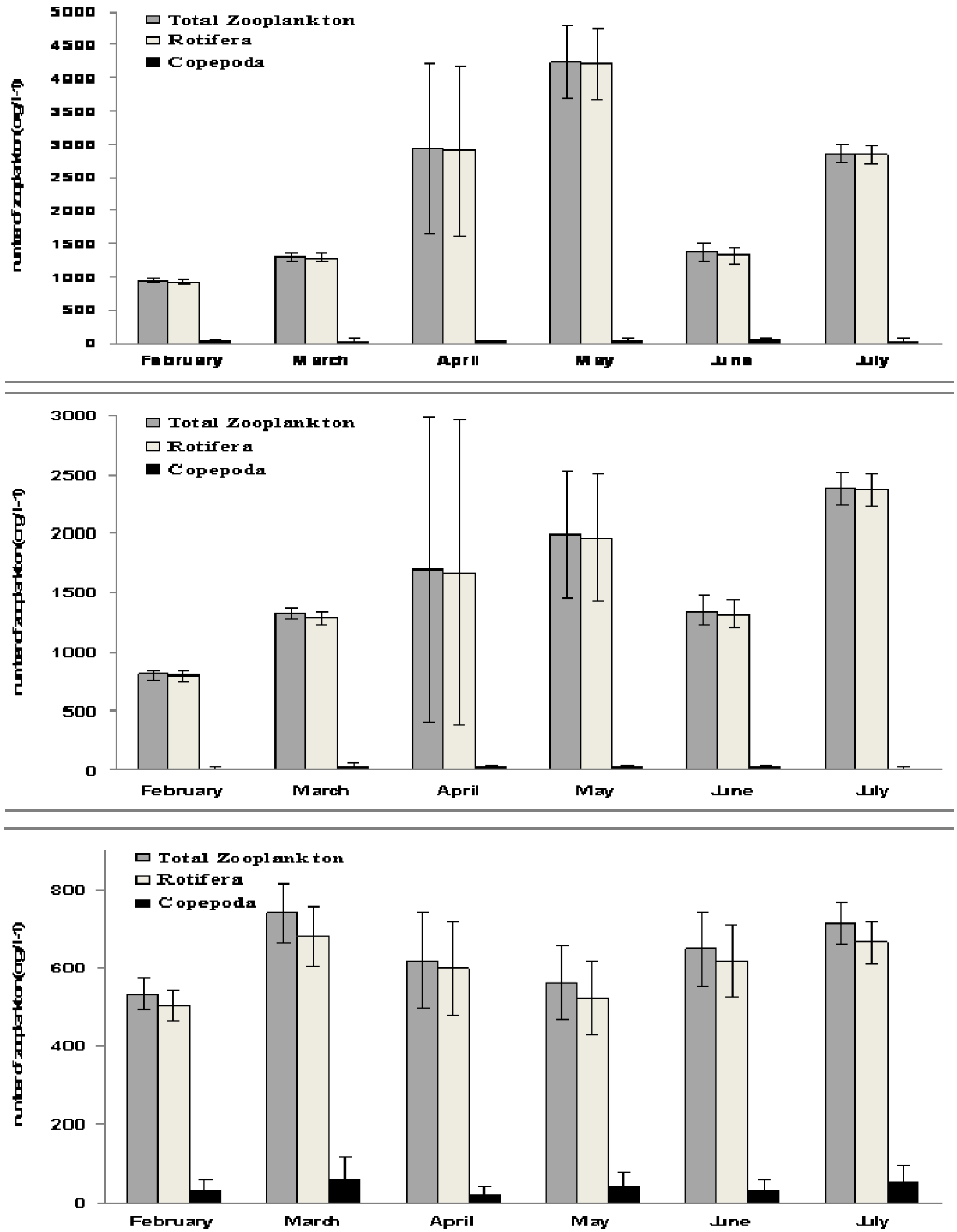


Figure 4. Average density of zooplankton groups (org/l^{-1}) determined in Massa Lagoon during the study.

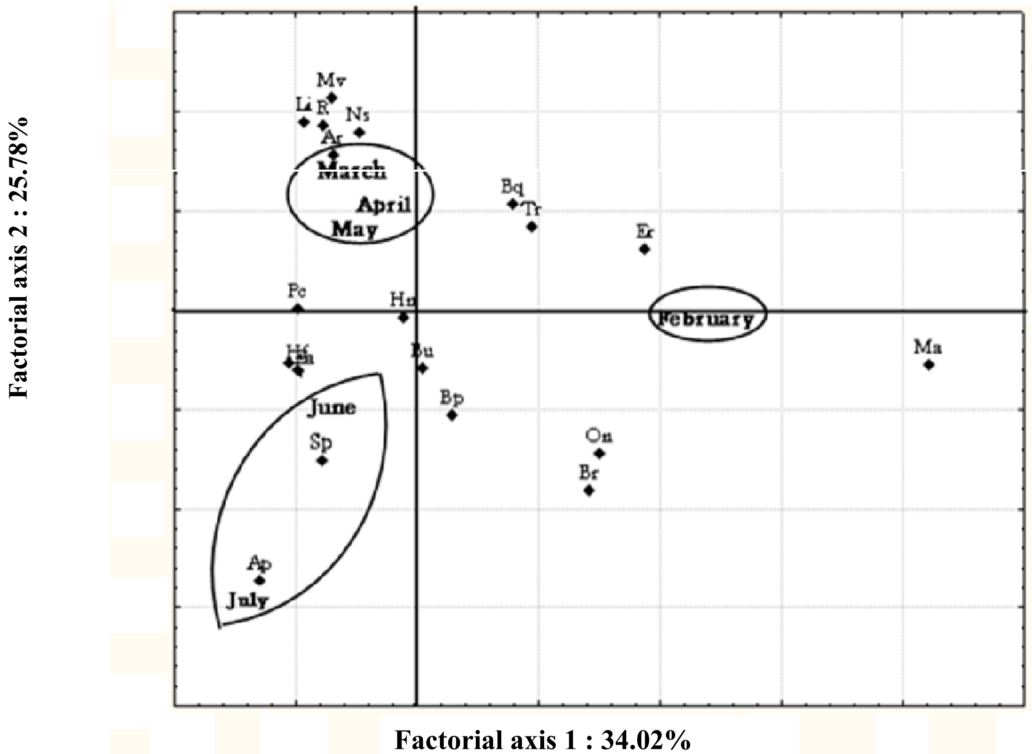


Figure 5. Plan [1-2] species and months of the correspondence analysis performed on the matrix composed of 48 species (rotifers and copepods) and 6 records (months). Bp: Brachionu splicatilis, Ma: Macrocyclops albidus, Ns: Notholca squamula, Br: Brachionus rubens, Bu: Brachionus urceolaris, Hn: Halicyclops neglectus, Bq: Brachionus quadridentatus, Tr: Trichocerca rosea, Ap: Asplanchna priodenta, Sp: Synchaeta pectinata, Hf: Hexarthra fennica, Er: Epactophanes richardi, Mv: Morarira varica, Ar: Achanthocyclops robustus, On: Oithona nana, R: Rotatoria, Li: Lecane inermis, Pc: Pompholyx complanata and Er: *Eurytemora affinis.*

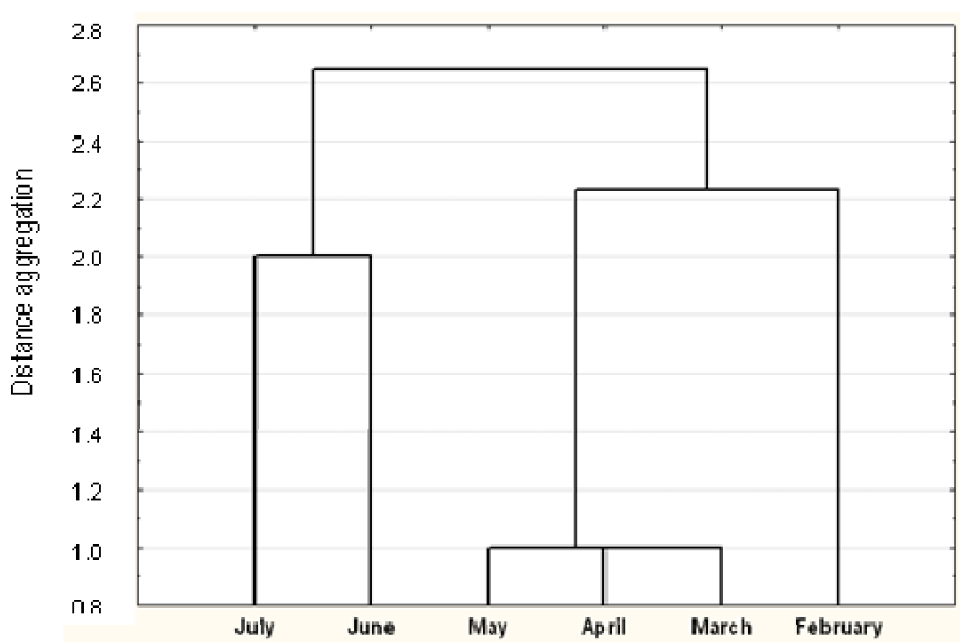


Figure 6. Dendrogram obtained by hierarchical cluster analysis performed in six months from their coordinates on the first three axes of correspondence analysis

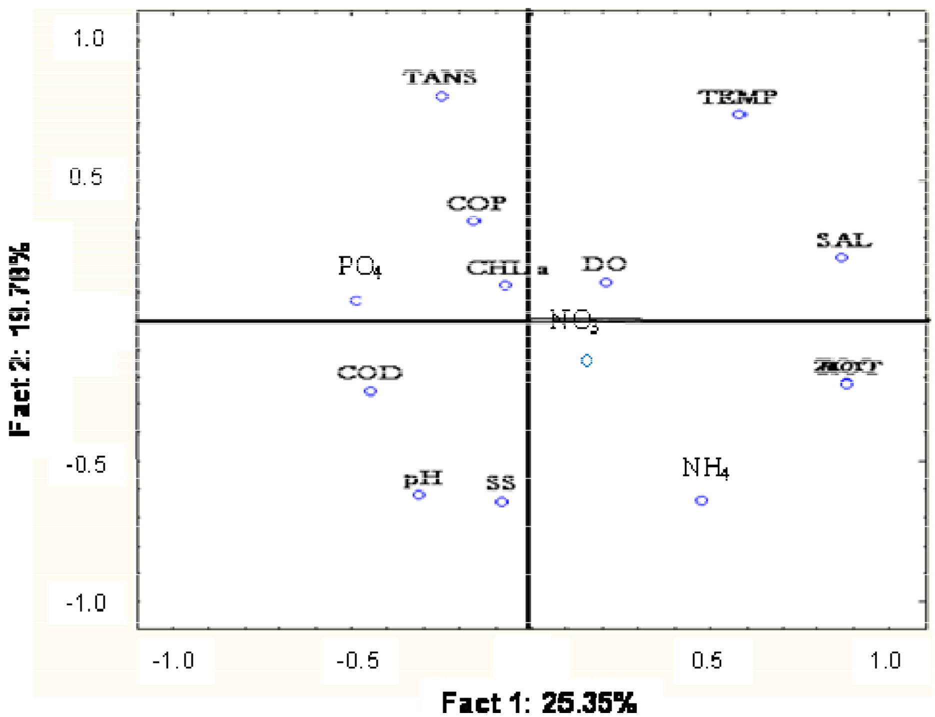


Figure 7. Principal component analysis (PCA) of physico-chemical variables and the main total zooplankton. CHL a: chlorophyll a, DO: dissolved oxygen, NH_4: ammonium nitrogen, PO_4: orthophosphates, COD: chemical oxygen demand, SS: suspended solids, NO_3: nitrate nitrogen, TRNS; nitrate nitrogen, TEMP: temperature, ZOO: total zooplankton, Rot: rotifer and COP: copepod.

with salinity (r = 0.68); so, the dynamics of zooplankton populations present in the Massa Lagoon is controlled by this parameter. The selective effect of this parameter, binding significantly, reduces the richness and species diversity. Thus, the overall results of this study leads us to conclude that the salinity is, in conjunction with the resources, a factor in determining the control and selectivity for the diversity and dynamics of planktonic populations in Massa Lagoon.

Conclusion

The analysis of physicochemical parameters indicates that certain environmental factors are essential to the operation and evolution of the closed lagoon of the biological reserve of Massa. These parameters include nutrients (nitrate, orthophosphates), dissolved oxygen, pH and temperature.

Rotifers were the most dominant zooplankton group observed during the study period in Massa Lagoon. The studies of the distribution of zooplankton population in the three stations are characterized by the importance of rotifers that are better represented. The zooplankton is represented by a majority of smaller species of rotifers dominated in abundance and they contribute to a large share in the total zooplankton biomass. This illustrates both their role and importance in energy transfer. This rich zooplankton may be a source of important food for wading birds and sedentary abundant downstream.

A better understanding of the structure, evolution and functioning of the aquatic and natural ecosystem is certainly a better preservation of biodiversity. The interactions between the components of biodiversity are fundamental to the understanding of how this ecosystem functions.

This study would still be continued to better understand the structure, functioning and ecology of zooplankton community of the biological reserve of Massa.

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