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Contribution to the study of soil macrofauna under Palm groves in the North-East of the Algerian Sahara (Oued Souf area)

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Abstract

Our research is a contribution to the aims of soil macrofauna for deeping our quantitative and qualitative knowledge in Oued Souf area. Oued Souf is located in the north east of the Algerian Sahara with a Saharan bioclimatic stage with a mild winter. For the realization of our study we followed the Barber method (traps for cave). Sampling captures 26 species divided into three classes of arthropods: Insecta, Crustacea and Arachnida. In the modern palm grove the census allowed to have 18 species, followed by 16 species in the abandoned palm grove and 13 species in traditional palm grove. The most dominant order is that of Hymenoptera with 2735 individuals, followed by the order of Coleoptera with 983 individuals distributed over four families, the order of Diptera with 700 individuals distributed on two families and the order of Isopoda with 103 individuals presented by one family. Finally, the following orders are weakly presented hang sampling, Hemiptera with 26 individuals, Scorpiones with 13 individuals, Dermaptera with 7 individuals, Orthoptera with 3 individuals and Blattaria with a single individual. The calculation of the specific diversity gives a value of "3.07" bit following an equitability of 67%, reflecting a significant structuring of the environment.

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Introduction

In the Maghreb, the date palm cultivation occupies an important place in the agro-oasian system, including Algeria, Morocco, Tunisia and Mauritania (Nixon, 1950; 1952). The date palm was named phoenix dactylifera by Linne in 1734, it is an Angiosperm monocotyledon tree, pertaining to the order of Palmales, Arecaceae family and Coryphoideae subfamily (Moore, 1973 and Deleuze, 1995).Currently, its cultivation area extends in the arid and semi-arid hot regions, from the Indus valley in the East to the Atlantic coast in the West. These zones have about 90% of the full number of palms and give the essence of the worldwide production (Djerbi, 1994).

The date palm is the fruit tree of the Saharan desert where he plays at the same time an economic role through to the production of dates which are the basis of human and animal food and an ecological role because it confers his structure to the oasis (Diana *et al.*, 1995). The oasis by its microclimate is a favorable environment to the Saharan agriculture, the flora and the fauna (Daddi Bouhoun, 2010). However, the date palm production in quantity and quality is influenced by several factors which can be related to the climate, the soil, the age of the palm trees, the water quality, the fertilization, the irrigation, the drainage, the diseases, the ravagers, and to the care taken to the modes from pollination to harvest (Munier, 1973; Benabdallah, 1990 and Babahani, 1998).

The biodiversity is currently a major stake of research in ecology, at the same time concerning its role in the ecosystems, its determinism and its valorization in the field of the environmental preservation (Solbrig *et al.*, 1994 and Rapport 1995). The soil represents one of the most important tanks of the biodiversity; indeed, the biological diversity of soils corresponds several times to that observed on the surface of the soil (Heywood, 1995). The biodiversity varies much according to the type of Soil and geographic regions. Among soil organisms only 170000 species have been identified, but this medium is not well known because it is difficult to determine the real number of species (Dajoz, 2000). In deserts, the insects are numerous in spite of the unfavorable living conditions. They often show remarkable adaptations (Dajoz, 2000).

Soil macrofauna exerts an essential action on the organization of the soil and on the nutritive elements cycles (Oades, 1993 and Blanchart *et al.*, 1997). The role of macrofauna on the soil structure has been demonstrated under various pedoclimatic conditions (Kooistra, 1991; Blanchart, 1992 and Oades, 1993).

Taking into account the effect of soil fauna on soil properties and its primary production, the majority of studies related to the vertical distribution of the soil fauna in particular the microarthropods (Andre *et al.*, 2002) and earthworms (Jimenez and Decaëns, 2000; Garcia and Fragoso, 2002), but few studies have been focused on macroarthropods communities (Dowdy 1944 and Frouz *et al.*, 2004), particularly in arid ecosystems, We can cite Achour and Behamra (2010) on the arthropodologic fauna of the palm grove of El-Kantara, Moussi *et al.*, (2011) on desert fauna locust in the steppe habitats and oasian in Algeria. In the area of Oued Souf, no study on the biodiversity of soil fauna has been made except for inventory work focused on arthropods (Beggas, 1992; Mosbahi *et al.*, 1995; Alia *et al.*, 2008; Labbi, 2009; Bousbia, 2010).

Our contribution aims, highlighting the biodiversity of soil fauna related to the age, health status and modes of monitoring of palm groves. It is in the area of Oued Souf where we conducted this study; the choice of the area is dictated by the existence of three mediums (palm groves) ecologically different. The approach is based on using the method of traps for cave (Barber, 1931). The results can be a significant contribution in order to look further into our quantitative and qualitative knowledge of the soil macrofauna, particularly that which can be harmful for the palm groves of the North-East of Algerian Sahara (Oued Souf area).

Materials and methods

Presentation of the study area

Geographical location

The region of Oued Souf is located in the north east of the Algerian Sahara with an altitude of 70m in Fig. 1. Its latitude is of 33° to 34° north and its longitude is of 6° to 8° east. It is limited to north by the mounts of the Saharian Atlas, and to the east by the Tunisian border, on the south by the great Eastern erg and on the west by the Oued Righ valley. Let us note in the north west of the study area the presence of Chotts Melghir and Mermouane (Voisin, 2004).

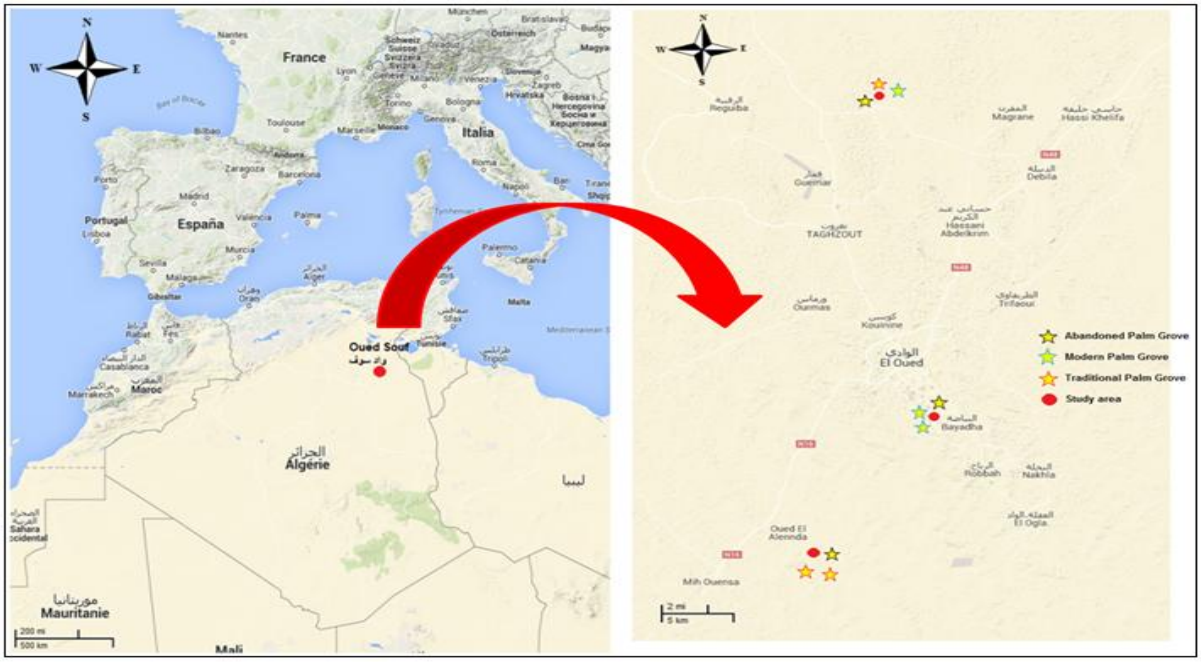

Fig. 1. Geographical location of the studied area and the stations (Google Earth, 2014).

Climatic characteristics

The study area is put under the influence of Saharan climate, which is characterized by low rainfall along the year and very high daytime temperatures and very low nocturnal. The dry wind blows throughout the year. It is cold from autumn to spring, while in summer it becomes dry and hot (sirocco). The Ombrothermique diagram shows a dry period that spans the entire year in Fig. 2.

Edaphic characteristics

The soils of the Oued Souf region are generally unsophisticated. The arable layers consist of permeable sandy soil, low in organic matter and rich in limestone and gypsum and sometimes of Clay (Voisin, 2004).

The vegetable cover

The vegetable cover of Oued Souf is open, represented by spontaneous plants which are adapted to the edaphic and climatic conditions of the area. In general, flora is represented by 50 species belonging to 30 families dominated by Poaceae (Nadjah, 1971; Kachou, 2006 and Leghrissi, 2007 in Bousbia, 2010) (Voisin, 2004 and Hlisse, 2007).

Presentation of study stations

Criteria for selecting stations

Sampling makes it possible to obtain starting from a surface given, as restricted as possible, a faithful image of the whole population (Lamotte and Bourliere, 1969). To carry out our work and because of the distribution of fauna, the stations are selected according to the following criteria: the soil nature, the type and age of vegetation, the altitude, the exposure, and accessibility to the sampled stations. According to these criteria three types of palm groves divided into nine stations were worked.

Modern palm grove

It is a palm grove of median age between 10 to 25 years. The palm trees are well aligned with intervals of 6 m between the feet. They are in association with fruit trees: fig tree, pomegranate, olive-tree and vine.

Traditional palm grove

It is a palm grove of median age from 60 years and more, of random form. It exceeds 150 feet per hectare. The distance between the feet is different with 6 and 10 m.

Abandoned Palm grove

It is a palm grove completely abandoned after an old practice. This station is characterized by sterile or deed palm trees with intervals of 5 m between the feet. It is overgrown with weeds.

Sampling of Macrofauna

Experimental protocol

We used the trapping of the macrofauna applying the Barber method (traps for cave). The Barber method is used for sampling invertebrates which move on the soil surface (Benkhelil, 1992). This kind of trap allows especially the capture of the various arthropods which break on the ground and a large number of flying species which are attracted by moisture and/or the odor of the detergent diffused by the trap (Leberre, 1969 in Bousbia, 2010).

Experimentation monitoring

We carried out our experimentation over a period of 12 months, by carrying out regularly a regular monitoring each month and by visiting the three types of the palm groves.

Samples conservation

Petri dishes were used to preserve the captured Macrofauna. Thus the dead macrofauna are placed on a layer of cotton to avoid their destruction.

The test tubes containing alcohol (70%) are used to preserve the species caught in the traps.

Laboratory identification

The samples are identified with the assistance of experts in the field and by exploiting manuals and specialized determining keys (Chopard, 1943; Carter and Hargreaves, 1988 and Leraut, 2003).

Results

The Macrofauna description parameters

Effective and Abundance (N)

In the area of Oued Souf, 4573 individuals of the soil macrofauna are inventoried. They are divided in three classes (Arachnida, Crustacea and Insecta), 10 orders, 14 families and 26 species. The class of Insecta dominates largely with 24 species and 4457 individuals, followed by the class of Crustacea with one specie and 103 individuals and the class of Arachnida with one specie and 13 individuals.

In the class of Insecta, the order of Hymenoptera has two families represented by 2737 individuals. The family of Formicidae contributes with a large number of individual; among the most represented species in this family we quote *Componotus sp* with 966 individuals, *Messor arenarius* with 973 individuals, *Cataglyphis bombycina* with 705 individuals and *Fourmis brunes* with 91 individuals. In second position, we note that the order of Coleoptera is well represented with 983 individuals distributed over four families, the order of Diptera with 700 individuals set out again on two families and the order of Isopoda with 103 individuals presented by one family. In the order of Coleoptera, there are four species of the Tenebrionidae family the best noted are *Mesostena angustata* with 295 individuals, *Pimelia angulate* with 272 individuals, *Zophosis plana* with 135 individus and *Pimelia grandis* with 129 individuals. In continuation, the order of Diptera is well presented by *Musca domestica* of the Muscidae family with 697 individuals and *Culex pipiens* from the Culicidae family with 3 individuals. Finally, the following orders are weakly presented hang sampling, Hémiptera with 26 individuals, Scorpiones with 13 individuals, Dermaptera with 7 individuals, Orthoptera with 3 individuals and Blattaria with only one individual (table 1).

Table 1. Abundance of species inventory with Barber method in each station.

Species	MP	TP	AP	N
Andractonus sp	4	5	4	13
Isopoda sp	65	7	31	103
Blatta orientalis	0	0	1	1
Anthia sexmaculata	0	7	10	17
Cicindela flexuosa	73	0	0	73
Coccinella septempunctata	10	1	0	11
Podalgus cuniculus	0	9	0	9
Erodius sp	8	0	4	12
Mesostena angustata	128	67	100	295
Mesostena puncticollis	1	9	1	11
Pimelia angulata	46	148	78	272
Pimelia grandis	100	26	3	129
Prionotheca coronata	7	3	4	14
Saprinus,sp	0	5	0	5
Zophosis plana	43	70	22	135
Anisolabis mauritanicus	7	0	0	7
Culex pipiens	3	0	0	3
Musca domestica	568	111	18	697
Zicrona caerulea	24	0	2	26
Apis mellifera	2	0	0	2
Cataglyphis bombycina	423	218	64	705
Componotus sp	5	231	730	966
Fourmis brunes	15	72	4	91
Messor arenarius	107	379	487	973
Acrotylus patruelis	1	0	0	1
Schistocerca gregaria	1	0	1	2
Total				4573

Specific richness (S)

The total wealth S is equal to 26 species of the macrofauna in all the types of the palm grove sampled in the area. It is equal to 18 species in the modern palm grove, 13 species in the traditional palm grove and 16 species in the abandoned palm grove (table 2).

Constancy (F)

Generally, the accidental species are the best represented with 9 species, followed by 7 additional species in all studied palm groves. However we recorded 6 species constants with *Cataglyphis bombycina, Musca domestica, Messor arenarius, Pimelia grandis, Andractonus sp and Zophosis plana*. In addition we recorded 2 ubiquitous species (*Mesostena angustata and Pimelia angulata*) and two regular species (*Isopoda sp* and *Componotus sp*).

Ecological diversity (H) and equitability (E)

The value "3.07" bit calculated of H' reveals an important diversity. The calculation of potential diversity gives a value of "4.57" bit leading to an equitability of 67%, representing a good structuring of the medium.

Homogeneity of macrofauna (T)

The degree of total homogeneity intra-biotope of the soil macrofauna studied is measured from the

variation of the average wealth relative to total wealth. This variation is equal to 48% shows that the studied group is more homogeneous.

Data analysis

On the got results we carried out a Factorial Analysis of Correspondences (F.A.C). The contribution of species of macrofauna for the construction of the axis is equal to 63.07% for the axis F1 and 36.93% for axis F2. Their sum is equal to 100.00% and makes it possible to retain only these two axes for the interpretation of results.

Table 2. Global List of species captured using Barber method.

Class	Order	Family	species
Arachnida	Scorpiones	Buthidae	*Andractonus sp*
Crustacea	Isopoda	Isopoda,ind	*Isopoda sp*
Insecta	Blattaria	Blattidae	*Blatta orientalis*
	Coleoptera	Carabidae	*Anthia sexmaculata, Cicindela flexuosa*
		Coccinellidae	*Coccinella septempunctata*
		Scarabaeidae	*Podalgus cuniculus*
		Tenebrionidae	*Erodius sp, Mesostena angustata, Mesostena puncticollis Solier, Pimelia angulata, Pimelia grandis Prionotheca coronata, Saprinus, sp Zophosis plana*
	Dermaptera	Labiduridae	*Anisolabis mauritanicus*
	Diptera	Culicidae	*Culex pipiens*
		Muscidae	*Musca domestica*
	Hémiptera	Pentatomidae	*Zicrona caerulea*
	Hymenoptera	Apidae	*Apis mellifera*
		Formicidae	*Cataglyphis bombycina, Componotus sp Fourmis brunes, Messor arenarius*
	Orthoptera	Acrididae	*Acrotylus patruelis, Schistocerca gregaria*

The contributions of the different mediums for the formation of the two axis are the following ones.

Axis F1: modern palm grove (MP) contributes to a total value of 52.9%, followed by the traditional (TP) 44.8% and the abandoned (AP) 2.4%.

Axis F2: the maximum of contribution is provided by the abandoned palm grove (66.1%), followed by the traditional one (25.4%), and finally by the modern palm grove (8.5%). The graphical representation of axis F1 and F2 (Fig. 3) shows that the different types of palm groves found in different quadrants that is due to the existence of species list characteristic specific of each medium.

The analysis of the distribution of the captured species (table 3) shows the existence of three groups (I, II and III) specific to each medium and a group composed of four subgroups formed by the commune species between the various palm groves.

Discussion

In our study we identified 26 species of the macrofauna, including, 18 species belonging to the modern palm grove, 13 species to the traditional palm grove and 16 species to the abandoned palm grove. We noted, in all the types of the palm grove, the predominance of the Insecta class with 24 species, followed by the Arachnida class and the Crustacea class represented by one specie for each one.

The Insecta are represented by seven orders which are, the Coleoptera represents four families distributed over twelve species. According to Auber (1945) the diversity of the form and color and the facility of harvest of the Coleoptera, are all criteria sought by entomologists. Some kinds with strictly

soil-dwelling life have an extraordinary endemism (Coiffait, 1960). According to this author, favorable soils to the development of the soil-dwelling Coleoptera would be soils having a high percentage of fine elements likely to maintain their favorable humidity. The action of the Coleoptera in the soil is expressed mainly through the influence which they have on its biological balance. Always according to Coiffait (1960), 80% of soil Coleoptera behaves like predators, as well at the larval state as in an adult state. Hymenoptera counts two families and five species. Ants are undoubtedly among the most common insects and they meet in the majority of the terrestrial ecosystems (Passera and Aron, 2005). Their world biomass would exceed even that of the human beings (Hölldobler and Wilson 1996; Passera and Aron 2005). With more than 12500 species described to date (Agosti and Johnson, 2005), this group of insects is of great interest such as biodiversity indicator (Alonso, 2000).

Table 3. List of different groupment of specific species listed and common of three types of the palm groves.

Species specific for each type of palm grove			Common species between two types of palm grove			Common species for the three types of palm grove
I (MP)	II (TP)	III (AP)	A (MP-TP)	B (TP-AP)	C (AP-MP)	D (MP-TP-AP)
Anisolabis mauritanicus (ANI)*Apis mellifera* (APIS)	*Saprinus sp* (SAPR) *Podalgus cuniculus* (POD)	*Blatta orientalis* (BLT)	*Coccinella septempunctata* (COCC)	*Anthia sexmaculata* (ANTIA)	*Erodius sp* (EROD) *Zicrona caerulea* (ZICRO) *Schistocerca gregaria* (SPHI)	*Zophosis plana* (ZOP) *Mesostena angustata* (MESO-A) *Mesostena puncticollis* (MESO-P) *Pimelia angulata* (PIM-A) *Pimelia grandis* (PIM-G) *Prionotheca coronate* (PRIO) *Musca domestica* (MUSC) *Cataglyphis bombycina* (CATA) *Componotus sp* (COMT) *Fourmis brunes* (BRUN) *Messor arenarius* (MESS) *Andractonus sp* (SCO) *Isopoda sp* (ISO)
Cicindela flexuosa (CIC) *Culex pipiens* (CULX)						
Acrotylus patruelis (ACRO)						

Diptera are represented by two families and two species. According to Bornebusch (1950) estimate that there exist in soils between 250 and 1000 Diptera larvae per square meter. These larvae of Diptera would correspond to a biomass from 1 to 7 g, and from the respiratory viewpoint, they would consume between 0.5 to 2.3 Mg of oxygen per hour at 13°C. This last explains that the majority of fauna soil is occupied by the larvae of the Diptera. Orthoptera are represented by a family and two species. According to Hamdi (1992), the Orthoptera are xerophilous, thermophilous and exclusively vegetarians. Blattaria, Dermaptera and Hémiptera are represented by only one family and only one specie. Arachnida are represented by only one specie of the Buthidae family. Crustacea are represented by one specie of the Isopoda order among them the Isopods which are omnivorous, but they nourish especially with organic matters of vegetable origin (Bachelier, 1978). Our results are comparable with those are got under similar conditions by Labbi (2009), Aggab (2009), Bousbia (2010) and which shows that the Insecta class dominates in all the mediums with a diversity on the level of the orders.

In the light of the results got, it turns out that species with strong mobility (Luff, in Holland, 2002) and a high density (Dufrênes, 1992) they will be found captured more. In 2007 Fountain observes that at many taxed with invertebrates, the majority of the

species are sténoèces (have a range of very restricted distribution of habitat). That explains the need to provide a considerable effort of sampling to reach the maximum of specific diversity (Gotelli and Colwell, 2001).The distribution of soil fauna in our region is according to the pedological characteristics (humidity, porosity, temperature and pH) as elements of selection that may play in their determinism (Bachelier, 1978).Multiples are still the other abiotic factors which can influence the organisms of the soil fauna, such: the soil texture, the degree of acidity or pH, the chemical nature of the litters, the oxidation-reduction potential (Redox potential) , salinity, The osmotic capacity of solutions, the nature of clays, the light and even the electric fields (Bachelier, 1978).

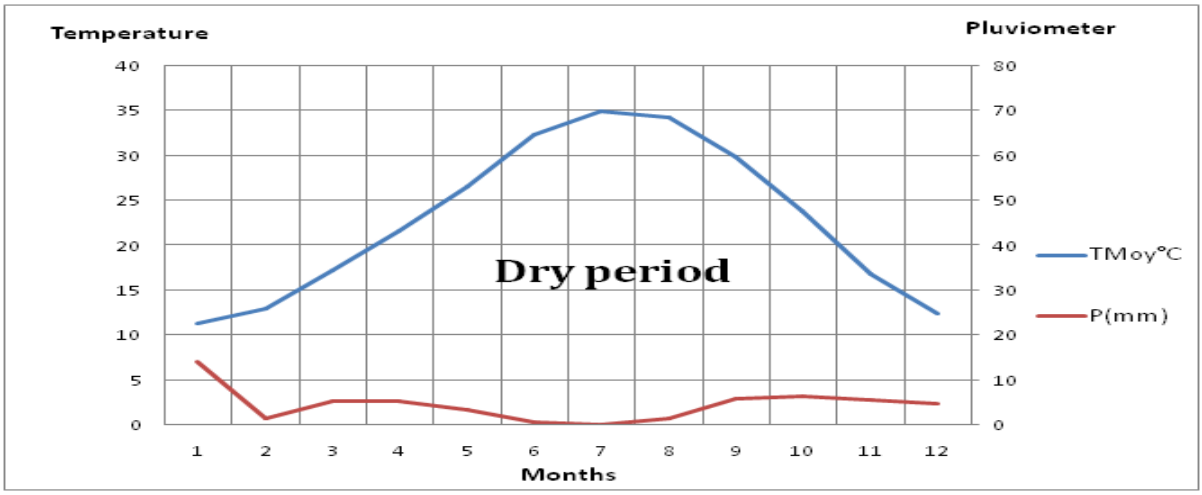

Fig. 2. Ombrothermique diagram of Oued Souf area (1990-2012).

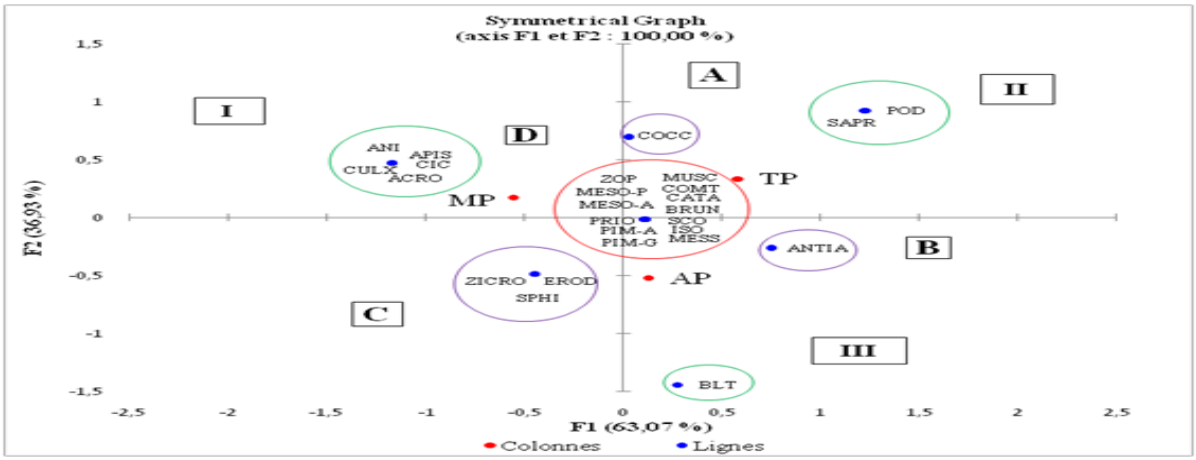

Fig. 3. Factorial Analysis of Correspondence applied to species of macrofauna.

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