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ECOLOGICAL CHARACTERIZATION AND PHYLOGENY OF HALOPHILOUS PLANT COMMUNITIES. EXAMPLE OF SOUTHERN SPAIN AND NORTHERN ALGERIA

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Abstract

Description of the subject: Halophilic ecosystems are among the habitats of greatest interest because they contain plant stands that are able to cope to considerable salt stress that cannot be supported by the rest of the vegetation, including glycophytes.

Objective : The objective of this study is to understand which are the variables that determine the structure of halophilic plant communities, in order to create a tool for conservation.

Methods : We made an ecological approach, based on floristic surveys at two sites known by the presence of salt, also called salt lakes. In order to better understand the structure of this type of plant, and on the basis of the results obtained, the variables which have more weight in the multivariate analysis are the species, adaptation and biotype criteria.

Results : The biological aspect reveals dominance in these ecosystems of the euhalophytes species 24% to 30%. For biological types, the therophyte aspect prevails in the Sebkha of Messerghine (Algeria) with 54%. On the other hand, it is the nanophanerophytes that dominate the Saladar de Mata (Spain) with 41%. Finally, the analysis of the phylogenetic structure of the two stations on both sides of the Mediterranean Sea, offers a strong correlation between the botanical families of Amaranthaceae followed by the families of Poaceae, Cyperaceae and Juncacea.

Conclusion : Given the results of this work, it can be concluded that in all the variables studied. The adaptation of the species to the clean saline environment is the one that has the most weight in the development of the halophilic community, compared to other ecological variables.

Keywords : Ecology-Phylogenetic-Halophytes-Algeria-Spain

CARACTERISATION ÉCOLOGIQUE ET PHYLOGENIQUE DES COMMUNAUTÉS VÉGÉTALES HALOPHILES. EXEMPLE DU SUD DE L'ESPAGNE ET DU NORD DE L'ALGÉRIE

Résumé

Description du sujet : Les écosystèmes halophiles figurent parmi les habitats qui suscitent le plus d'intérêt, car ils abritent des peuplements végétaux qui sont capable de faire face à un stress salin parfois considérable, et qui ne peut être supporté par le reste de la végétation, notamment les glycophytes.

Objectifs : L'objectif de cette étude est de comprendre quelles sont les variables qui déterminent la structure des communautés végétales halophiles, afin de créer un outil pour la conservation.

Méthodes : Nous avons réalisés une approche écologique sur deux sites connu par la présence du sel, appelés aussi lacs salés. Afin de connaitre mieux la structure de ce type de végétaux, et sur la base des résultats obtenus, les variables qui ont plus de poids dans l'analyse, sont les critères espèce, adaptation et biotype.

Résultats : L'aspect biologique révèle une dominance au niveau de ces écosystèmes des espèces euhalophytes 24% à 30%. Pour les types biologiques l'aspect thérophytes l'emporte au niveau de la Sebkha de Messerghine (Algérie) avec 54% par contre, c'est les nanophanérophytes qui dominent au niveau du Saladar de Mata(Espagne) avec 41%. Enfin l'analyse de la structure phylogénétique des deux stations de part et d'autre de la méditerranée offre une forte corrélation entre les familles botaniques qui peuplent les écosystèmes salins. La famille qui possède la plus grande présence est celle des Amaranthaceae suivie par les familles des Poaceae, Cyperaceae et Juncacea.

Conclusion : Compte tenu des résultats de ce travail, il peut être conclu que dans toutes les variables étudiées l'adaptation de l'espèce au milieu salin propre, est celle qui a le plus de poids dans l'élaboration de la communauté halophile, par rapport à d'autres variables écologiques.

Mots clés : Ecologie, Phylogénétique, Halophytes, Algérie, Espagne.

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INTRODUCTION

The Mediterranean basin is recognized as a region of great interest, as in all its geographical areas, several have been designated as hot spots [1].

In the Mediterranean vegetation stands, there is a type of vegetation that often develops in the salt zones, occupying the endoretic basins, in this case the Chotts, Sebkhas, Dayas and the Saladars, areas of migration of many birds.

The appearance of halophyte species is essentially linked to the evaporation of phreatic waters which deposit the salts on the surface [2].

The study of the structure of these ecosystems and the comparison with fragments of similar ecosystems on a wider geographical scale is fundamental for studying the structural and evolutionary dynamics of these taxa. This theme is necessary for conservation biology [3]. The concept of meta-community not only proposes the study of the ecosystem as a unit, but also as a flow of information between neighboring communities, and how they relate to one another [4]. According to the concept of, a meta-community is a set of communities that interact through migrations between different patches of information transmission. It includes the concept of dynamics of metapopulations, set interactions and local populations [5].

The objective of this study is to understand the variables that determine the structure of halophyte plant communities, in order to highlight the ecological parameters that have a direct influence on the configuration of these halophyte plant communities in these types of ecosystems.

To achieve this objective, the methodology that has been used is that of the study of metacommunities.

The flora and halophilic vegetation of southeastern Spain and northwestern Algeria are very similar for geological, geographical and bioclimatic reasons (Le Floc'h 2001) [6].

This study provided the first data on the comparison of these two distinct zones, characterized by ecovicariant metacommunities.

The localities analyzed share a large number of genera and species, which could provide the basis for producing different models in order to provide new views (panoramas) to be given to the phenomena of climate change [7].

MATERIALS AND METHODS

2.1. Study zone

The study was conducted on two distinct areas. La Laguna de la Mata (Alicante) in the southeast of the Iberian Peninsula (Spain) and the Sebkha of Messerghine (Oran) in northwestern Algeria, Loc. 1 and Loc. 2 (Fig. 1). These study sites were chosen according to different criteria, including a similar biotope. The two saline lakes are close to the coast (coastline), but do not belong to coastal salines fed by sea water. They share the same bioclimat mediterranean semi-arid (www.globalbioclimatics.com).

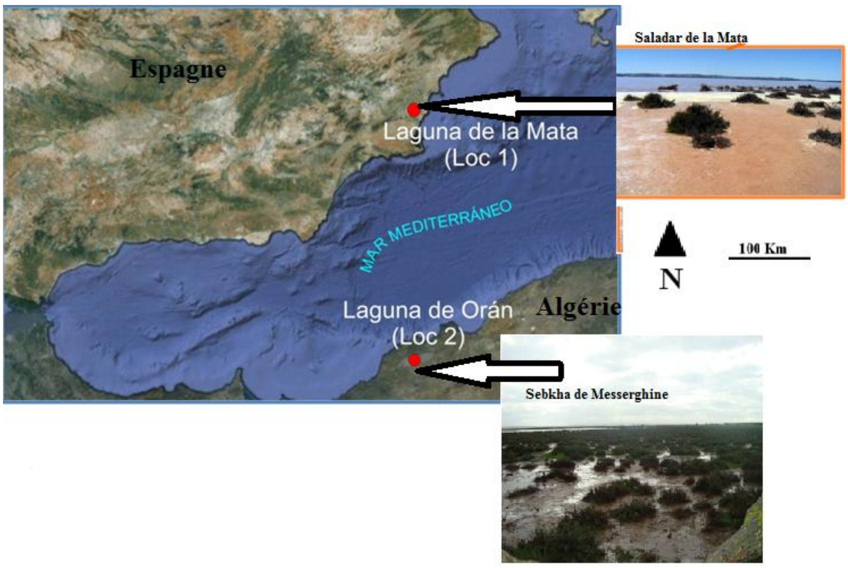

Figure 1: Station location (Loc 1 and Loc 2).

This choice is guided by the presence of halophytic stands at the two stations on both sides of the two banks. This type of vegetation is locally common on gypsum substrates in the Maghreb. It represents only a small flora and rare structures of vegetation, with the exception of the steppes of Sparta and Atriplex indicated at the more continental level [8].

2.2. Electrical conductivity

The electrical conductivity of the soil (C.E) was measured by the saturated pulp method. To extract 1/5 (20 g of soil + 100 ml of distilled water). At each station we sampled soil at the nutrient horizon of the taxa inventoried. Many authors agree that in a salt environment, the root system is superficial [9, 10, 11, 12].

2.3. Florist characteristics

We have done floristic surveys on areas occupied by a halophilous vegetation along the sebkha of Messerghine (Oran) and the Saladar de Mata (Alicante). The Stigmatiste method was used for the sampling of vegetation [13, 14]. The minimum area of the station Messerghine is 32 m^2. On the other hand of in the Saladar de Mata it is about 60 m^2. We considered the abundance index for each species in reference to the [15]. The taxa were determined from the new flora of Algeria and the southern desert regions of Quezel & Santa [16], Bonnier [17], and the vascular flora of eastern Andalusia [18].
The elaboration of floristic tables in which the inventoried species appear is joined by an introduction of four-letter codes in lower case, taken from the vernacular name of each species. Example: *Limonium furfuraceum* (lifu) (Tab. 1). This approach will facilitate the processing of the variable at the level of the variable matrices [2].For each taxon, we will also consider the biological type Raunkier [19], and its adaptation [20].

Genkel [21], divided the halophytes into three groups: euhalophytes, crinohalophytes, and glycohalophytes, but this classification has been modified by Nagalevskii [22], and Zhao et *al.* [23]. Salt tolerance in euhalophytes is based on accumulation, as they accumulate salts in their tissues, crinohalophytes depend on excretion of toxic ions like Na^+ and Cl^- as they are capable of excreting salts out of the plant body, and glycohalophytes rely on avoiding mechanism by preventing the accumulation of excess salts [24].

2.4. Phylogenetic characterization.

Phylogeny can be defined as "the historical course of the descendants of organized beings" based on the basic concept of descent with modification. The formal support of representation, admitted by all, is the phylogenetic tree [25]. This representation is the formal support of the "resemblance" or the difference between the different taxa. From anatomy to molecular biology, to ontogeny and paleontology, the concept of resemblance was approached in different ways according to the school of systematic [26].
There are several algorithms or heuristics to subject the construction of trees to computers. Before proceeding to the molecular phylogenetic construction, it is necessary to have an alignment of the sequences since each position will be a putative character [27]. In our study, the sequences were obtained from Genbank © public access database. http: //www.ncbi.nlm.nih.gov/genbank.
The sequencing of I.T.S (Internal Transcribed Spacer) will be exploited. We used MEGA software v.5.05 to align the sequences and perform a phylogenetic tree through the Neighbor-Joining [28].

2.5. Treatment of ecological variables

In each of the studied sites, Algerian and Spanish, the different parcels were selected for analysis, in which we studied several variables that constructed four tables (Fig. 2).

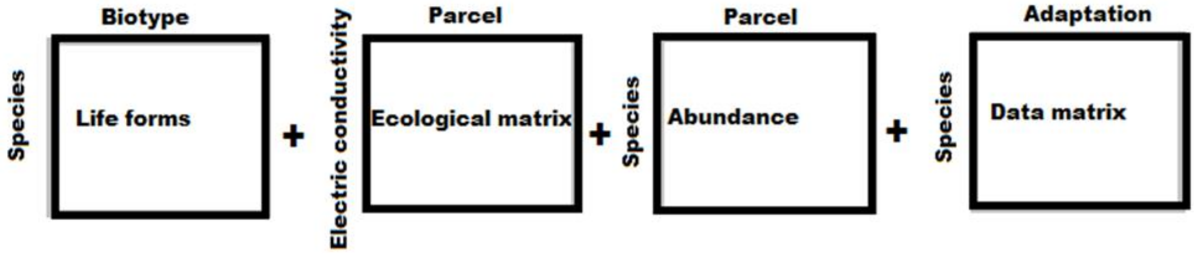

Figure 2 : Tables of matrices

Table 1: Coding of taxa listed by station

Loc. 2 Messerghine (Algérie)	
Code	Taxons
dagn	*Daphne gnidium*
tepo	*Teucrium polium*
Amma	*Ampelodesma mauritanicum*
cial	*Cistus albidus*
Lade	*Lavandula dentata*
civi	*Cistus villosus*
aval	*Avena alba*
parh	*Papaver rhoeas*
sami	*Sanguisorba minor*
mavu	*Marrubium vulgare*
ermo	*Erodium moschatum*
brni	*Brassica nigra*
alro	*Allium roseum*
homu	*Hordeum murinum*
brdi	*Brachypodium distachyum*
brru	*Bromus rubens*
Aetr	*Aegilops triuncialis*
Alca	*Alyssum campestre*
memi	*Medicago minima*
avst	*Avena sterilis*
euun	*Eurucaria uncata*
sasi	*Salsola sieberi*
salo	*Salsola longifolia*
sate	*Salsola tetragona*
saka	*Salsola kali*
sufr	*Suaeda fruticosa*
haam	*Halopeplis amplexicaulis*
atha	*Atriplex halimus*
arsc	*Arthrophytum scoparium*
lipr	*Limonium pruinosum*
save	*Salsola vermiculata*
atdi	*Atriplex dimophostegia*
lysp	*Lygeum spartum*
hasa	*halogeton sativus*
peha	*Peganum harmala*
maae	*Malva aegyptiaca*
aspen	*Astragalus pentaglottis*
taaf	*Tamarix africana*
taca	*Tamarix canariensis*

Loc. 1 Saladar de Mata (Espagne)	
Code	Taxons
arma	*Arthrocnemum macrostachyum*
safr	*Sarcocornia fruticosa*
hapo	*Halimione portulacoides*
frco	*Frankenia corymbosa*
lica	*Limonium caesium*
lysp	*Lygeum spartum*
suve	*Suaeda vera*
lyin	*Lycium intrincatum*
arba	*Artemisia barrelieri*
lipa	*Limonium parvibracteatum*
lisa	*Limonium santapolense*
lifu	*Limonium furfuraceum*
lico	*Limonium cossonianum*
plcr	*Plantago crassifolia*
icri	*Inula crithmoides*
juma	*Juncus maritimus*
spme	*Spergularia media*
elel	*Elymus elongatus*
scni	*Schoenus nigricans*
juac	*Juncus acutus*
agla	*Atriplex glauca*
sapa	*Salicornia patula*
susp	*Suaeda spicata*
hypr	*Hymenolobus procumbens*
spdi	*Sphenopus divaricatus*
pain	*Parapholis incurva*
liec	*Limonium echioides*

The choice of the variables was made on the basis of the characteristics that determine a saline environment. It has been demonstrated in the literature by numerous authors [29, 20]. The variables are: The electrical conductivity of the soil (C.E). The presence of the species. The biotype [19]. Adaptation to salinity [30] and abundance (according to the Braun-Blanquet method [31]. The matrices formed are:

- A first matrix called forms life matrix, which treats the life of the species and the biotype.
- A second ecological matrix that treats parcels and electrical conductivity.
- A third matrix of abundance that opposes parcels to species.
- A final matrix called the matrix of traits which treats species and adaptation to salinity.

The processing of all these matrices was treats in an analysis of the multiple correspondences with the SPSSv.15. software.

RESULTS

1. Electrical conductivity

At each station, two samples were taken at the feeder horizon of the taxa inventoried (Tab. 2).

Table 2: Electrical conductivity

Loc. 1 :Saladar de Mata (Espagne)		Loc. 2 : Messergine (Algérie)	
N° Ech.	Conductivity C.E.(dS/m)	N° Ech.	Conductivity C.E.(dS/m)
1.1	120	1.1	130
1.2	110.5	1.2	130
1.3	108.5	1.3	120
1.4	88.6	1.4	160
1.5	65	1.5	170
1.6	26	1.6	180
1.7	18.7	1.7	200
1.8	71.5	1.8	200
1.9	20.6	1.9	120
1.10	18	1.10	130
1.11	15.4	1.11	140
1.12	12.8	1.12	160
1.13	11.7	1.13	130
1.14	10.9	1.14	100
1.15	8.5	1.15	70

The pH is alkaline it oscillates between 07.20 and 8.00 at the level of the two stations. The electrical conductivity is higher in the Sebkha of Messerghine where it varies between 70 and 200 dS / m. On the Saladar de Mata, it fluctuates between 26 and 110 dS / m, characterizing a saline soil.

The salinity of the soil has a certain influence on the development of vegetation. The presence of large quantities of salts in the soil solution lowers the water potential and greatly reduces the availability of water for plants. This is called a physiologically dry medium [32].

We note that the salinity is high. The organic matter content is very low, it does not exceed 1.2%. This is certainly due to the low vegetation cover [33].

2. Floristic diversity

The plant stands at the two stations are halophytic. Adaptation to high levels of salts is largely explained by the dominance of euhalophytes in the Spanish zone with 33%, followed by glandular crinohalophytes and glycohalophytes respectively with 30%. Downy crinohalophytes account for only 7%. In the Algerian zone the euhalophytes and glycohalophytes dominate with a percentage of 30% each. They are followed by the crinohalophytes with glands 23% and lastly the crinohalophytes with down 17%. The biotype aspect in the Saladar de Mata (Spain) knows the dominance of the nanophanerophytes 41%, followed by the chamephytes 19% and the therophytes 18%. Inthe last comes the geophytes and the hemicryptophytes with 11% (Fig. 3).

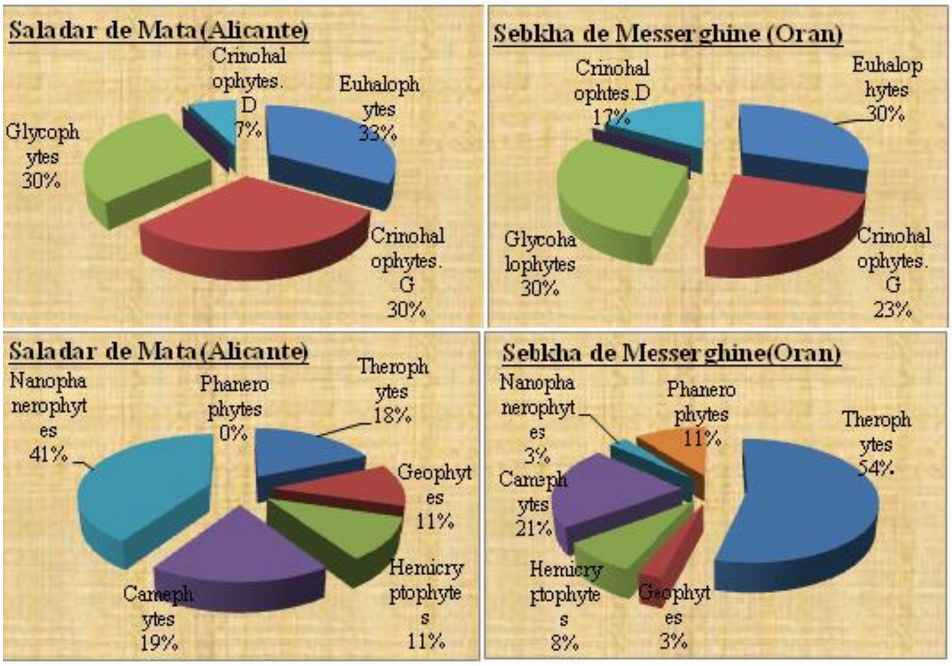

Figure 3 : Floristic diversity

The influence of stress phenomena in these zones is felt on species with a long life expectancy [8].The strong expression of the nanophanerophytes and the chamephytes in particular at this station is reinforced by the disjunction of area, by the formation of endemo-vicariants in the Mediterranean zone (schisoendemism) [34].

Therefore, in the Sebkha of Messerghine (Oran), the therophytes are the most dominant with a percentage of 54%. They are followed by the chamephytes 21%, the phanérophytes 11%, the hemicryptophytes 8%, and lastly the geophytes and the nanophanérophytes 3%.

Thus, one reason for the dominance of therophytes in these areas, in the Mediterranean region and in the Maghreb, seems to be the aridity of the climate and in particular the summer water stress that provides this speciation [35].

This phenomenon favors short cycle species (therophytes) and accelerates the rate of genetic exchange. It is indeed one of the most important factors in the process of taxon formation in these ecosystems [8].

3. Phylogenetic characterization

The results obtained show that the phylogenetic structure of the two ecosystems offers a strong correlation between botanical families that are part of saline ecosystems with a type of adaptation that occurs (Fig. 4).

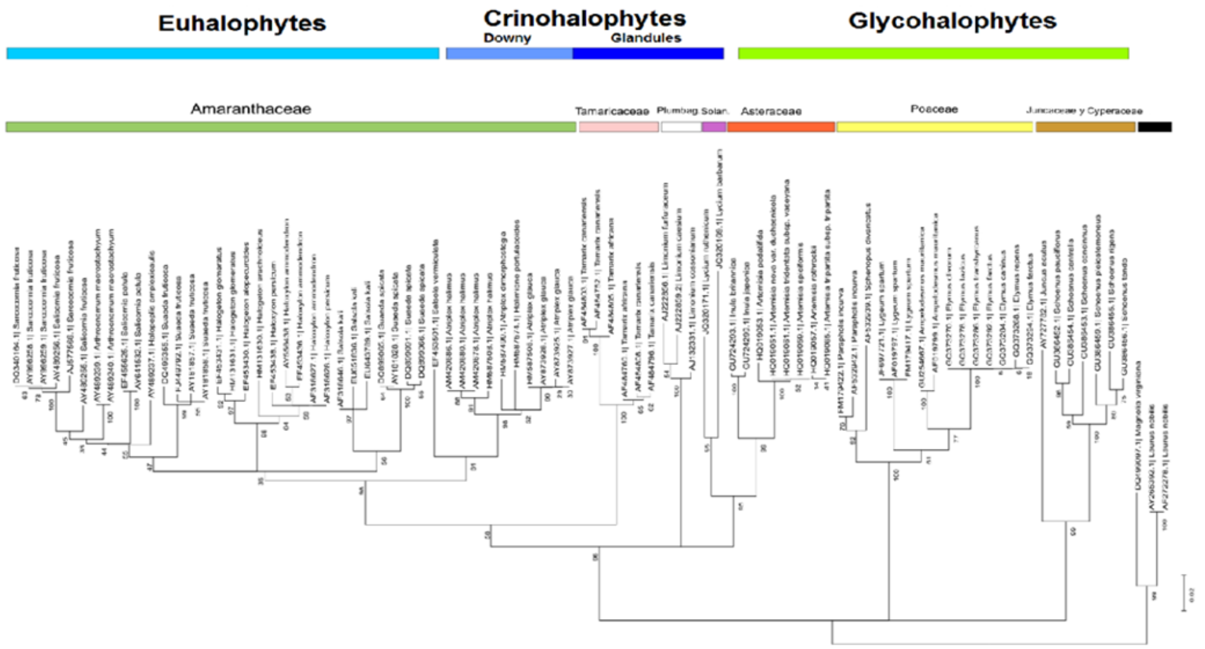

Figure 4: Structure of the phylogenetic tree

The family that has the greatest presence is the Amaranthaceae followed by the Poales which is the phylogenetic group (sensu APGIII), which includes the families Poaceae, Cyperaceae and Juncacea.

Despite the recent interest in the taxonomy and classification of the Amaranthaceae family. There is always a need to study phylogeny. Previous studies of the Amarantheceae have shown that this is the sister group of Chenopodiaceae in the order Caryophyllales [36], and should be merged [37, 38]. APG (Group Angiosperm Phylogeny) 1998 and 2003.

It should be noted that for both stations on both sides of the Mediterranean, we note a similarity in the genera and species that colonize the two sites. The diversity centers for the Amaranthaceae are more oriented towards south-western Africa and south of the Sahara desert. Most species occur in tropical Africa and North America [39].

4. Multi-varied analysis

As a result of multiple factorial analysis of correspondence. We obtained measures of discrimination between the variables of the study of the two sites (La Mata and Oran) (Fig. 5 and 6).

This linkage of different variables selected for the study provides a model of a unified saline environment structure that includes ecosystem analyzes in general.

On the basis of the results obtained, the variables that have more weight in the analysis and explain more the structure of the community are the species, adaptation and biotype.

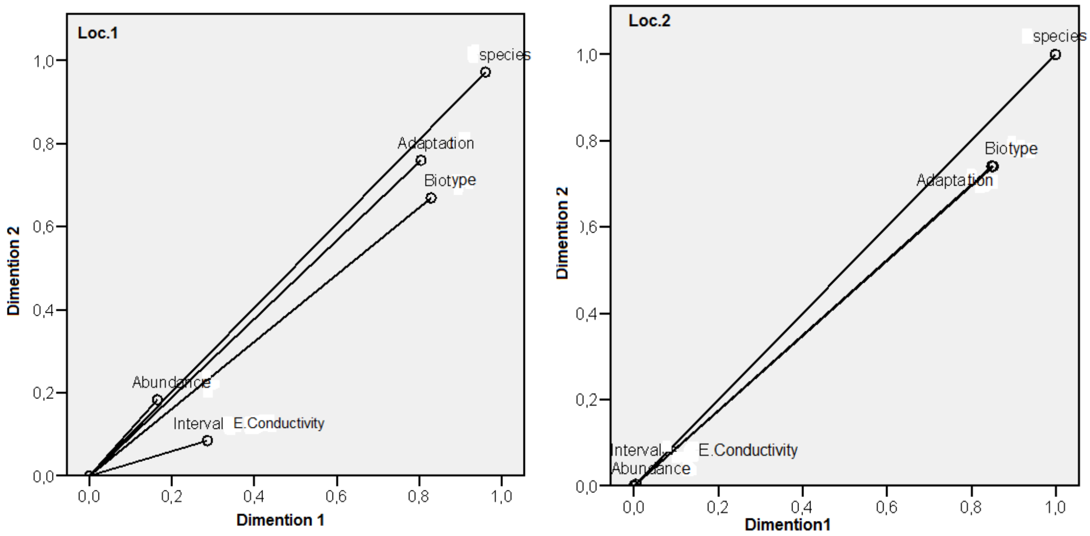

Figure 5 : Discrimination measures of the variables studied

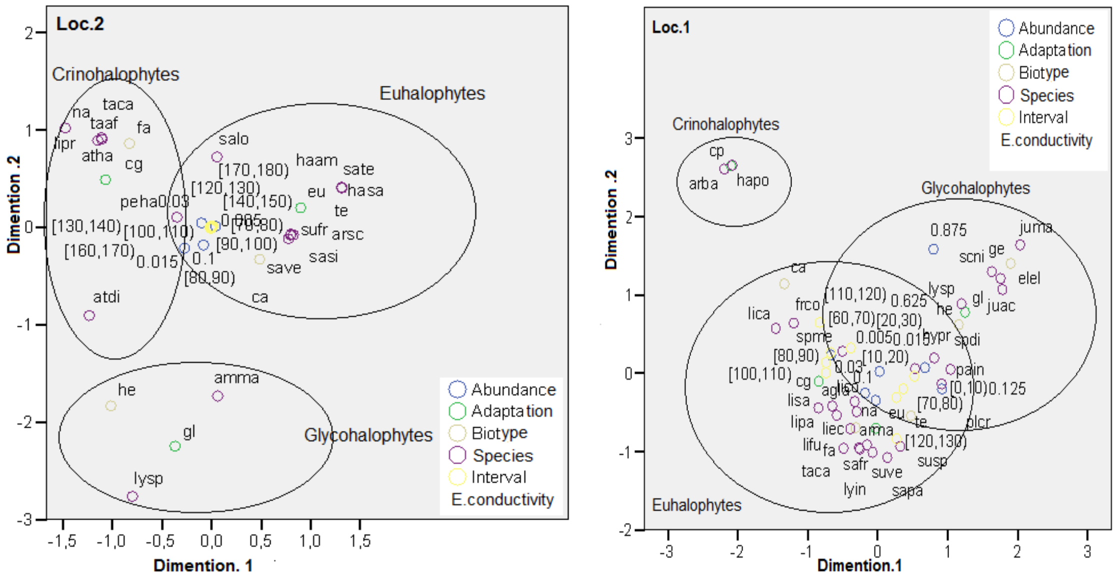

Figure 6: Diagrams of centroides of ecological variables

Repeating this pattern in both places. It proves that the variables that are not discriminated are the electrical conductivity of the soil and the abundance of species (Fig. 5). Moreover, the factor analysis of the multiple correspondences performed shows two joint diagrams of centroids of variables, each belonging to different localities.

In both diagrams several groups of halophyte species are clearly visible and differentiated separately (Fig. 6). We obtained a total of three groups of species at both sites, this explains a view of the various adaptations of halophyte species to the saline environment [40]. The variables that have more weight in this analysis are adaptation, species and biotype. From this analysis, two dimensions were obtained for each of the studied sites, each of which are explained so far by the mean of the variance and represent the amplitude of this variance. A sample of degree of importance of this dimension in the overall solution.

For Loc; 1 (Spain) these dimensions are 60.9% and 53.4%, respectively, with an average reliability index of 0.82.Whereas for Loc 2 (Algeria), the dimensions are 54.1% and 49.7% respectively, with an index alpha of Cronbach of 0.77 (Tab. 3).

Table 3: Discrimination measures models of both localities

	Loc 1 :Saladar de Mata (Espagne)		Loc2 : Messerghine (Algérie)	
	% de variance	Alfa de Cronbach	% de variance	Alfa de Cronbach
Dimention 1	60.9	0.84	54.1	0.79
Dimention 2	53.4	0.78	49.7	0.75
Avreage	57.2	0.82	51.9	0.77

We observe that the two dimensions are of approximately the same importance since the two eigen values are very beside in both cases. Thus the Cronbach alpha coefficients for the different dimensions laguna of La Mata (Loc; 1) are 0.84 for dimension 1 and 0.78 for dimension 2. However, a fidelity index of 0.79 is related to the dimension 1 of the Oran lagoon (Loc. 2) and one of 0.75 is related to the dimension 2 of the same locality.

DISCUSSION AND CONCLUSION

This study established a global approximation of halophile communities in order to determine the main variables governing the spatial succession of this type of vegetation. There are many studies on plant communities in salt ecosystems. But very few who take these ecosystems as a whole without establishing a bias band [20].

With the results obtained in this study, we demonstrate that the coverage of a particular species does not determine the structure of the ecosystem. Taking into account the results, and taking into account the distribution of these species, which have a similar presence according to the presence of the salts, with average adaptations. This parameter seems to have the greatest weight in the structure of this plant community. Thus, the appearance of the different forms that halophyte species have developed to adapt to the salt concentration is itself a determining factor in the spatial structure of the ecosystem. Consequently, other works give more importance to the conductivity of the soil in this strand [41]. It should also be noted that many studies work only in relation to the fluctuation of the conductivity spectrum as a function of the seasons. Measurements are made throughout the year [29, 42].

Using the measured conductivity as a variable may also explain the structure of this type of vegetation. But that would not be enough to make it the unique determining variable. And the observation is clear in this work. It is worth noting the use of the Cronbach alpha coefficient which is indicated as a control index to evaluate these analyzes. The average coefficient obtained for Loc. 2 is greater than 0.7, whereas that obtained for Loc. 1 is greater than 0.8.

It can therefore be considered that the fidelity of this model is acceptable for the lagoon of Oran, and good for the lake of La Mata, since the more the value of this index tends to 1, the more it acquires a high reliability [43].

On the basis of these results, it can also be concluded that in all the variables studied, the adaptation of the species to the clean saline environment is the one that has the most weight in the development of the halophilic community, compared with other ecological variables, including electrical conductivity. This does not appear to be considerably constant, as it varies seasonally throughout the year. It also depends heavily on periods of flooding, drought and heavy rainfall [44].

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