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MULTIVARIANTE ANALYSES OF VEGETATION IN THE SALINE PLAIN OF LOWER-CHELIFF, ALGERIA

Ababou A.[*], Chouieb, M.[**], Khader, M.[***],
Mederbal, K.[***] and Mahmoud A. Essa[****]

*** Dept. of Biology, Faculty of Biology and Agronomy, University Hassiba Ben Bouali, Chlef, Algeria**
E-mail: ab_adda@yahoo.fr
****Dept. Agronomy, Faculty of Engineer Science, University Abd El Hamid Ibn Badis, Mostaganem, Algeria**
*****Dept. of Biology, Faculty of Science and Sciences of the Ground, University Mustapha Stambouli, Mascara, Algeria.**
****** Dept. of Geology, Faculty of Science, Assiut University, Assiut, Egypt**

ABSTRACT:

The plain of Lower-Cheliff is among the largest saline plains of Northwestern Algeria, located between 35.750° - 36.125°N of latitude and 0.5° -1°E of longitude. It is characterized by a semi-arid climate and reduced number of little studied vegetal species. The study of this vegetation in relation to environmental variables shows that the vegetation distribution in this plain is closely related to both altitude and electrical conductivity. Redundancy analysis (RDA) revealed that these two variables are opposed on the first canonical axis. Separation of relevés into similar groups according to their contribution and their coordinates on the first two axes of RDA provided 4 vegetation units, each one composed of several diagnostic species with a highly significant fidelity value according to Fisher test. The kriging revealed a close relationship between these vegetation units and salinity.

INTRODUCTION:

The vegetal association is "a plant community characterized by definite floristic and sociological features" which shows, by the presence of diagnostic species "a certain independence" (Braun Blanquet, 1928) and grows in uniform habitat conditions (Flahault & Schroter, 1910). These plant communities are recognized by diagnostic species as defined by Westhoff and Van der Maarel (1978). In this context, the term diagnostic species is an important concept in the vegetation classification. It is a plant of a high fidelity to a particular community which it serves as a criterion of the recognition of that community (Curtis, 1959). The relative constancy or abundance of the vegetation classification distinguishes one association from another (Whittaker, 1962; Chytry & Tichy, 2003). Vegetal association includes species which preferably occurs in a single vegetation unit (character species) or in a few vegetation units (differential species) (Chytry *et al.*, 2002). The presence, abundance, or vigor of some species indicates certain site conditions (Gabriel & Talbot, 1984). To relate

the species data to the site conditions, the direct gradient analysis is the most prominent method, where either redundancy analysis (RDA) or canonical correspondence analysis (CCA) could be applied (Leps & Smilauer, 2003; Zuur *et al.*, 2007). Also statistical fidelity measures (Chytry *et al.*, 2002) such as phi coefficient can be employed to characterize the floristic composition of that site independently of the environmental conditions. In this context, our study proposes to analyze the vegetation assemblage and community structure in the disturbed site of lower-Cheliff, Algeria, in relation and independently to the site conditions.

MATERIALS AND METHODS:

Study Area:

Covering approximately 450 km^2, the lower-Cheliff (Fig. 1) is one of the largest Quaternary alluvial plains of the Northwestern Algeria. This plain, located between 35.750°-36.125° N of latitude and 0.5°-1°E of longitude, is about 35 km far from the Mediterranean Sea with an average altitude of 70 m. It is syncline framed in north by Dahra's hills and Benziane's hills in the south that both composed of clayey silt, schist and saline marls. These geological characteristics are accentuated by a semi-arid climate with an average annual temperature of 20°C and a weak annual pluviometry (approximately 250 mm/yr) that explain the high salinity of the plain.

Soil and Vegetation Sampling:

Vegetation relevés were recorded during spring 2006, 2007 and 2008 (March 21st - May 21st) by using the Braun-Blanquet (Maarel Van der, 1975) seven-degree scale of abundance dominance. A total of 133 relevés were recorded with adding up 40 species, among them 11 rare species that were excluded from the analysis. Also a total of 133 soil samples were collected at a depth of 30 cm. The measured soil properties were of physical (granulometry, altitude, soil structure and soil color) and chemical nature (electrical conductivity, $CaCO_3$, pH, Ca^{++}, Na^+, Cl^-, organic matter and CaMg). In order to use geostatistical analysis, the geographical position of each site was determined by using GPS.

Data Analysis:

Initially, a colinearity test (Appendix 1) performed between environmental variables showed a strong correlation coefficient (R>0.9) between sand and silt as well as Na^+ and Cl^-. Also, Cl^- and silt were eliminated. Then, the remaining variables were subject to a normality test (Shapiro-Wilk); those with non normal distribution were log transformed. For the determination of the most significant variables, an individual preselection (Okland & Eilertsen, 1994) was performed by using Monte Carlo test (999 permutations without restriction); except sand, they were all significant (p-value<0.05) with variance inflation factors (Erkel-Rousse, 1995; Besse, 2001) < 4 (Appendix 2).

In order to establish the main links between environmental variables and vegetation assemblage, a redundancy analysis (RDA) (Ter Braak, 1994; Legendre & Legendre, 1998; Leps & Smilauer, 2003) was performed. First, a detrended correspondence analysis (DCA) (Hill & Gauch, 1980) was conducted to test if a model with unimodal (CCA) (Ter Braak, 1986) or linear (RDA) response curve should be used in ordination analysis. Results of the DCA showed that the gradient length was 3.95 for axis one to 2.53 for axis four (Table1); thus, both RDA and CCA may give correct results (Leps & Smilauer, 2003; Jongman *et al.*, 1996). As the percentage of the total variance explained by

RDA (21%) that was higher than CCA (17.2%), it was appropriately considered to perform an RDA, as linear responses. However, the presence of double zeros strongly affects the RDA with another potential problem due to the arch effect (Zuur *et al.*, 2007). An alternative is to apply either chord (Orloci, 1967) or Hellinger (Rao, 1995) distance transformation. Legendre and Gallagher (2001) showed that this approach is less sensitive to double zeros and, therefore, to the arch effect. After several comparisons, Hellinger transformation was chosen followed by the RDA.

The most significant variables were determined by using the method of Wilk's lambda (Butler & Wood, 2004; Marques de Sa, 2007).

To cluster samples into similar groups and to identify the characteristic vegetation unit of each group, relevés were separated in groups, according to their contribution and coordinates according to the first two canonical axes obtained by RDA. Finally, four predefined groups were used because they showed major ecological relevance and were easily interpretable. Then, the phi coefficient of association was used (Sokal & Rohlf, 1995; Chytry *et al.*, 2002) to identify species discriminating among the four groups. This coefficient is a statistical measure of association which can be used as a measure of fidelity. It can be defined as:

$$\Phi = \frac{N.n_p - n.N_p}{\sqrt{n.N_p.(N-n).(N-N_p)}}$$

The same notation as that used by Bruelheide, (2000) and Chytrý *et al.*, (2002) is used in this study:

N = number of relevés in the data set;
N_p=number of relevés in the particular vegetation unit;
n= number of occurrences of the species in the data set;
n_p= number of occurrences of the species in the particular vegetation unit.

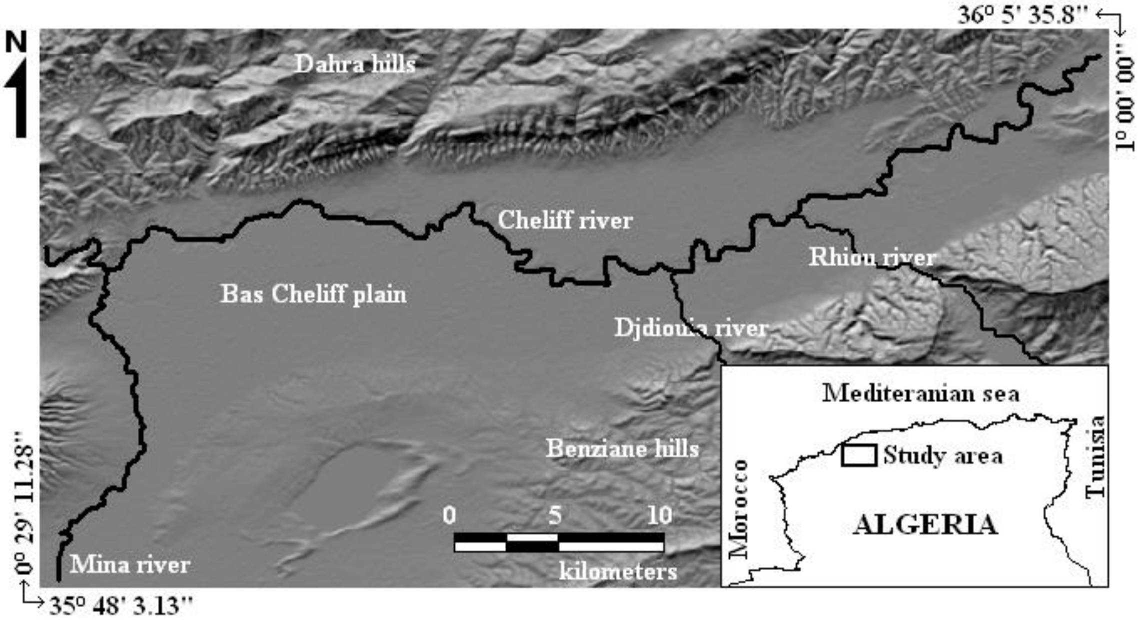

Fig. (1): Location of the study area, showing the Lower Cheliff plain and the surrounding hills of Dahra in the north and Benziane in the south

Traditionally, the phi coefficient considers only the presence/absence of vegetation, so that fidelity values calculated using this coefficient are not influenced by species cover or abundance. The advantage of phi coefficient is its independence of data set size. The phi coefficient values range from –1 to 1. The highest phi value of 1 is achieved if the species occurs in all relevés of the vegetation unit and is absent elsewhere. A positive value that lowers than 1 means that the species is absent from some relevés of the vegetation unit. A value of 0 indicates no relation between the target species and the target vegetation unit.

Finally in order to establish the relation between vegetation and salinity, a cartography is carried out using Kriging (Krige, 1951; Matheron, 1963; Journel & Huijbregts, 1978; Legendre & Legendre 1998; Stein *et al.*, 2002).

RESULTS AND DISCUSSION:

Important Variables:

The marginal effects (Appendix 3) indicate that altitude, conductivity and soil structure are best explanatory variables, followed by Ca^{++}, pH, and Na^{+}, whereas the remaining variables play a secondary role. The highly significant ($p < 0.01$) increases in the total sum of eigenvalues during the forward selection indicated by the conditional effects (Appendix 4) are successively shown by altitude, conductivity, Na^{+} and soil structure according to Monte Carlo test (999 permutations). Calcium carbonate ($CaCO_3$), Ca^{++} and CaMg point out significant increases ($p<0.05$), whereas the contribution of the remaining variables are non significant.

Best Predictors of Vegetal Distribution:

The variance of species data explained by each variable according to the partial RDA is in the order of altitude (8.8%)>conductivity (7.7%)>soil structure (6.5%)>Ca^{++} (4.6%)> pH (4.5%)> Na^{+} (3.5%)> Clay (2.3%)> OM (1.7%) > $CaCO_3$ (1.4%) = RGB (1.4%)> CaMg (1.2%) > Sand (0.9%). This means that vegetation distribution of Lower-Cheliff is highly related to altitude, conductivity and soil structure.

Redundancy Analysis:

The total variance of species data explained by the first four axes of the RDA is 21.0% (Table 1). Although the Monte Carlo permutetion test indicates that all canonical axes are highly significant with the set of variables used, only the first two canonical axes are used because they include the maximum variability expressed by the environmental variables. Almost all variables that are significant on axes 3 and 4 are also significant on axes 1 and 2. The first axis (13.6% of the variation explained) is mainly negatively correlated to the conductivity then to Ca^{++}, Na^{+} and clay, while it is positively correlated mainly to altitude (Fig. 2), then soil structure, pH, organic matter and $CaCO_3$. This means that sampling sites situated to the right of the first axis are characterized by higher altitudes, and lower conductivity values. On the left, the sampling sites are those with higher conductivity values. Thus, axis 1 shows a gradient of decreasing altitudes and increasing conductivity values. This axis could be interpreted as a conductivity environmental gradient. So, the relative high altitude observed in the lower-Chelif has a considerable effect on the spatial distribution of the salinity and consequently on the vegetation. Low altitudes are accompanied by salt deposits worsened by a high percentage of clay which prevents salt drainage. This process leads to the degradation of soil structure and high conductivity with appearance of halophytes species such as Chenopodiaceae and Caryophyllaceae that

characterize the extreme conditions (Fig. 2). Relative high altitudes are characterized by healthy soils with low conductivity and a slightly high organic matter level, which improve the soil structure and appear to be more diversified floristic composition (Asteraceae, Fabaceae, Géraniaceae, Apiaceae, Brassicaceae, Primulaceae, Plantaginaceae). The second axis (only 4.2% of the variation explained) is negatively correlated to RGB, pH and sand, but positively correlated mainly to the conductivity and Na^+, with a notable appearance of Chenopodiaceae and Caryophyllaceae.

Table (1): Eigenvalues and percentage of variance explained by RDA, with Pearson correlations (r) between environmental variables and the four canonical axes, and results from the Monte Carlo test checking for axis significance in RDA

	Axis 1	Axis 2	Axis 3	Axis 4
RDA:				
Eigenvalues	0.136	0.042	0.021	0.012
Species-environment correlations	0.815	0.683	0.519	0.481
Cumulative percentage variance of species data	13.6	17.8	19.9	21.0
Cumulative percentage variance of species-environment relation	54.9	71.8	80.3	85.0
Environmental variables:				
Altitude	0.70 **	0.40	0.632	-0.22
Soil structure (S.S)	0.57 **	0.22	0.74	-0.46
pH	0.52 **	-0.25	0.025	-0.00
Organic matter (OM)	0.21*	0.05	0.33	-0.16
$CaCO_3$	0.21*	0.23	0.28	-0.34
Sand	0.11	-0.10	-0.06	-0.39
RGB (soil colors, Red-green-blue)	-0.09	-0.29	-0.38	0.06
CaMg	-0.13	0.17	0.07	0.21
Clay	-0.44 **	0.16	-0.25	-0.11
Na^+	-0.46 **	0.41	-0.01	0.04
Ca^{++}	-0.50 **	0.06	-0.43	0.4
Conductivity (EC_e)	-0.75 **	0.52	-0.09	-0.00
Monte Carlo test (999 permutations)	F	p-value		
Significance of first canonical axis	18.85	0.0010		
Significance of all canonical axis	3.286	0.0010		

** $p < 0.01$; * $p<0.05$

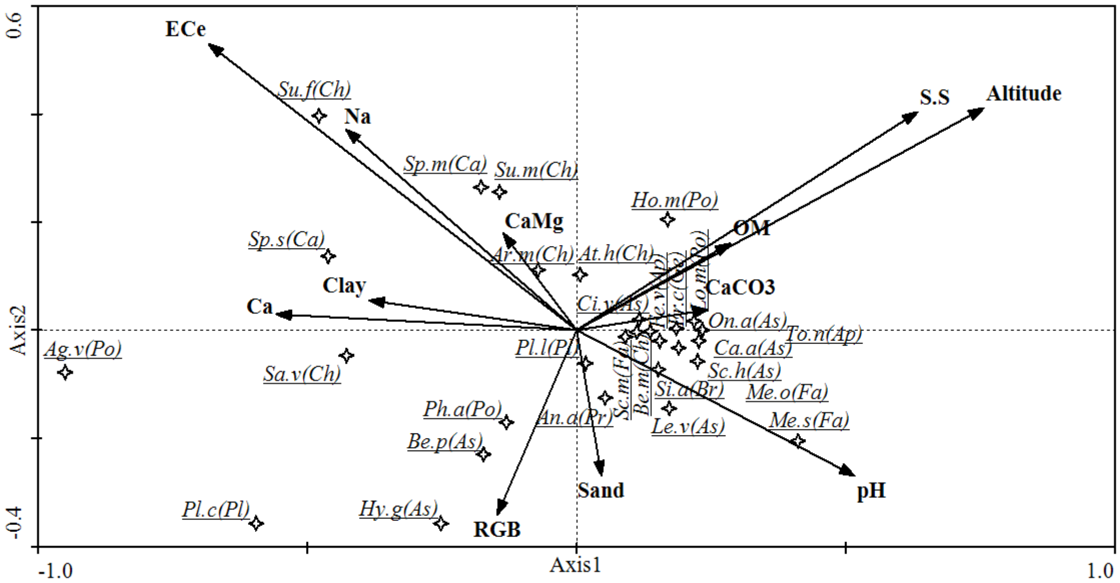

Fig. (2): Constrained ordination biplot (RDA) of vegetation, 133 sites, 29 species and 12 environmental variables selected using foward selection and Monte Carlo permutation test. For species names see code tab.4, letters between bracket represent the families (*Ch*: Chenopodiaceae, *Ap*: Apiaceae, *As*: Astéraceae, *Br*: Bromeliaceae, *Ca*: Caryophyllaceae, *Fa*: Fabaceae, *Ge*: Geraniaceae, *Pl*: Plantaginaceae, *Po*: Poaceae et *Pr*: Primulaceae)

Vegetation Units According to Fidelity Coefficient:

The two first canonical axes are used in the classification of sites cluster to all samples, because they include the maximum variability expressed by environmental variables. As a result, four distinct groups of sites with similar floristic composition were identified. Group A is composed of 43 sites. These sites are differentiated by the presence of 6 diagnostic species, that on the basis of phi coefficient results are *Plantago coronopus (L), Bellis perennis (L), Hypochaeris glabra (L), Phalaris arundinacea (L), Spergula sp (L)* and *Beta vulgaris maritima (L)* (Table 2). The diagnostic species that are present in this group are generally associated with the lowest altitudes and saline soils as indicated by the normal distribution (Fig. 3). Group B includes 25 sites. This group is characterized by four diagnostic species of *Torilis nodosa (L), Erodium cicutarium (L), Onopordum acanthium (L) and Lolium multiflorum (Lam)*. The diagnostic species of this group are associated with the highest altitudes and lowest conductivity (Fig. 4). Group C with the highest diversity according to Shanon-Weiner index (Table 2) is composed of 30 sites that are slightly saline (Fig. 5) with intermediate altitudes and characterized by eight diagnostic species such as *Sinapsis arvensis (L), Plantago lanceolata (L)* and *Scolymus hispanicus (L)*. Finally, group D includes 35 sites of highly saline soils (Fig. 6). The five diagnostic species of this group exclusively belong to Chenopodiaceae and Caryophyllaceae such as *Suaeda maritima (L) Dumort, Arthrocnemum macrostachyum Moric, Suaeda fruticosa (L) Forssk, Atriplex halimus (L), Spergularia marina (L) Griseb.* Group A and D are the less diverse groups according to Shanon-Weiner index (Table 2); indeed, a great number of species sensitive to high salinity is eliminated with the exclusive appearance of halophytes.

Table (2): Synoptic table of 133 relevés and 29 species, based on fidelity coefficient. Diagnostic species (values grey-shaded) are those with significant phi value according to the test of Fisher ranked by decreasing value of Φ

Synoptic table	Code	Coefficient Phi en pourcent			
Group No.		**A**	**B**	**C**	**D**
No. of relevé		**43**	**25**	**30**	**35**
Number of diagnostic species		**6**	**4**	**8**	**5**
Shannon-Weiner index		**1.40**	**1.51**	**1.55**	**1.40**
Diagnostic species of the vegetation unit A:					
Plantago coronopus L.	***Pl.c (Pl)***	50.9***	-	-	-
Bellis perennis L.	***Be.p (As)***	49.6***	-	-	-
Hypochaeris glabra L.	***Hy.g (As)***	36.5***	-	-	-
Phalaris arundinacea L	***Ph.a (Po)***	29.2***	-	-	-
Spergula sp L.	***Sp.s (Ca)***	25.2**	-	-	19.6*
Beta vulgaris maritima L.	***Be.m (Ch)***	14.9*	-	-	-
Diagnostic species of the vegetation unit B:					
Torilis nodosa L.	***To.n (Ap)***	-	27.4**	-	-
Erodium cicutarium L.	***Er.c (Ge)***	-	21*	-	-
Onopordum acanthium L.	***On.a (As)***	-	19.2*	-	-
Lolium multiflorum Lam.	***Lo.m (Po)***	-	17.3*	17.3	-
Diagnostic species of the vegetation unit C:					
Sinapsis arvensis L.	***Si.a (Br)***	-	-	41.4***	-
Plantago lanceolata L.	***Pl.l (Pl)***	-	-	29.9**	-
Scolymus hispanicus L.	***Sc.h (As)***	-	-	22.2**	-
Anagallis arvensis L.	***An.a (Pr)***	-	-	20.3*	-
Calendula arvensis L.	***Ca.a (As)***	-	-	19.6*	-
Medicago sativa L.	***Me.s (Fa)***	-	-	18.7*	-
Melilotus officinalis (L.) Lam	***Me.o (Fa)***	-	-	17.5*	-
Leucanthemum vulgare Lam.	***Le.v (As)***	-	-	16.4*	-
Diagnostic species of the vegetation unit D:					
Suaeda maritima (L.) Dumort	***Su.m (Ch)***	-	-	-	35.4***
Spergularia marina (L.) Griseb.	***Sp.m (Ca)***	-	-	-	29.6**
Arthrocnemum macrostachyum Moric.	***Ar.m (Ch)***	-	-	-	25.6*
Suaeda fruticosa (L.) Forssk	***Su.f (Ch)***	20.3*	-	-	25.1**
Atriplex halimus L.	***At.h (Ch)***	-	3.5	0.3	11.5*
Common diagnostic species of vegetation units A and D with the same significance level:					
Agrostis vulgaris L.	***Ag.v (Po)***	43.3***	-	-	38.4***
Salsola vermiculata L.	***Sa.v (Ch)***	31***	-	-	27.7***
Species with no significant fidelity coefficient to any vegetation unit according to fisher test:					
Cirsium vulgare (Savi) Ten.	***Ci.v (As)***	-	17.5	3.7	-
Foeniculum vulgare L.	***Fe.v (Ap)***	-	13.3	9.2	-
Scorpiurus muricatus L.	***Sc.m (Fa)***	-	8.5	4.9	-
Hordeum murinum L.	***Ho.m (Po)***	-	7.7	-	4.9

***** p<0.001; ** p<0.01; *p<0.05**

Electrical Conductivity:

All theoretical variograms used to estimate the electrical conductivity show a high nugget effect, high variance and a strong variation coefficient (Table 3). The electrical conductivity is consequently unpredictable and slightly structured variable, with a strong variability even at very short distance. This supposes a high density of sampling to predict the electrical conductivity.

On the basis of variographic analysis (Table 3 and Fig. 7) and cross validation (R^2=0.73 and S.E.E = 4 dS/m) (Fig. 8), the exponential model is the best theoretical one to estimate the electrical conductivity (Fig. 9).

The conductivity map (Fig. 9) first shows an increasing conductivity from east to west and from the periphery to the center of the plain. This corresponds to a decreasing altitude from east to west and from the periphery to the center. Secondl, a very large surface of the lower-cheliff plain belongs to the range of non-saline to highly saline soils.

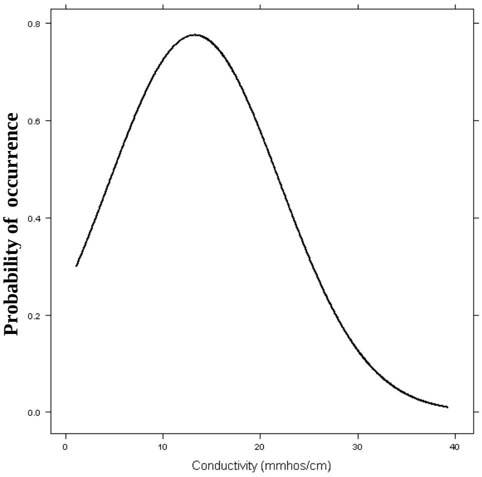

Fig. (3): Normal distribution of vegetation unit A represented by *Plantago coronopus L.*

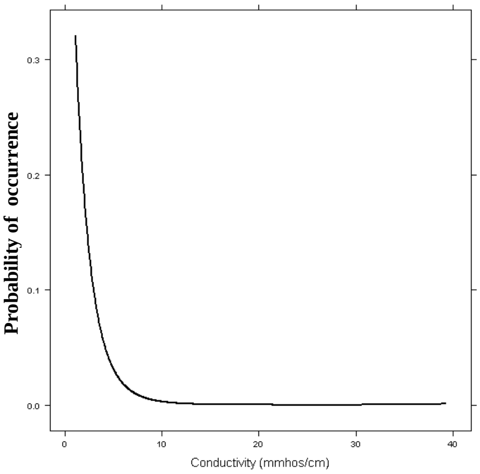

Fig. (4): Normal distribution of vegetation unit B represented by *Torilis nodosa L.*

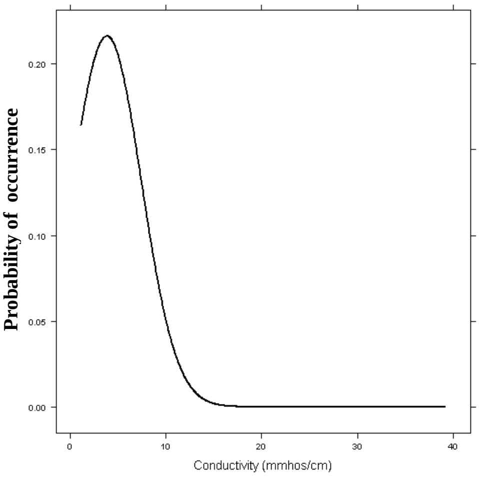

Fig. (5): Normal distribution of vegetation unit C represented by *Sinapis arvensis L.*

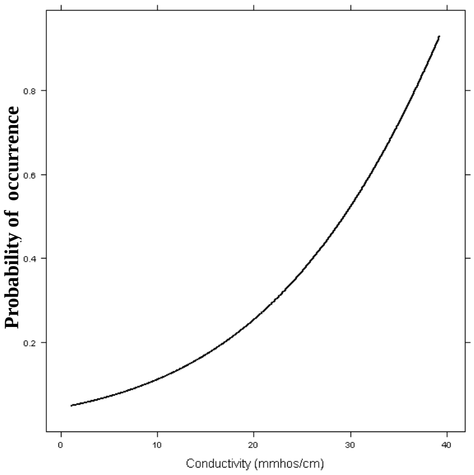

Fig. (6): Normal distribution of vegetation unit D represented by *Suaeda maritima (L.) Dumort*

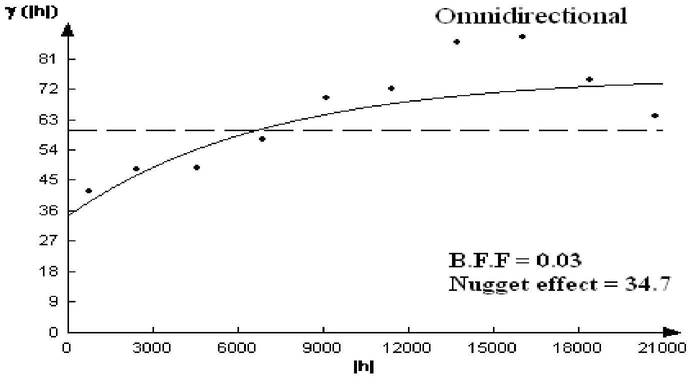

Fig. (7): Exponential model

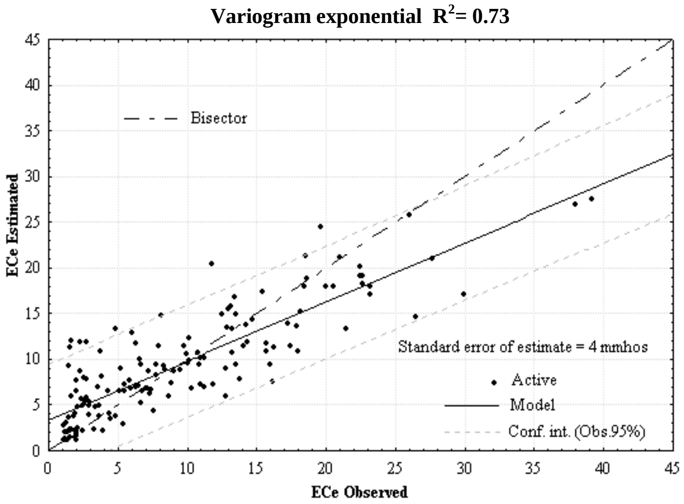

Fig. (8): Cross validation of electrical conductivity estimated by exponential model

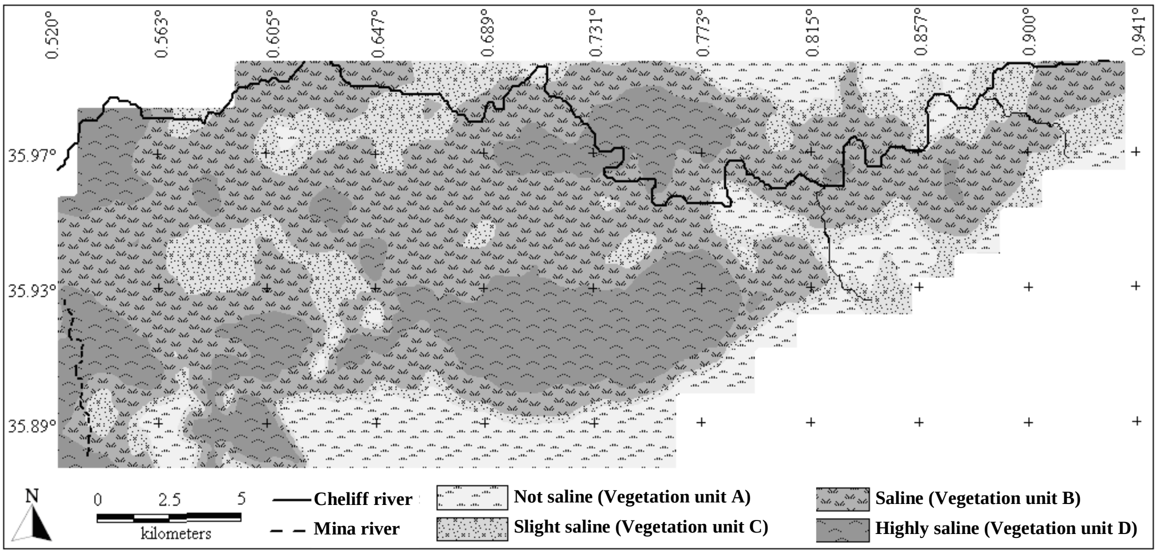

Fig. (9): Electrical conductivity map of the Lower-Cheliff obtained by kriging and estimated by the exponential model

Table (3): Summary of theoretical variograms

Model	Effect of nugget	Variance	Coefficient of variation (%)
Exponential	**34.7**	**42.51**	**69.63**
Spherical	**38.4**	**54.83**	**79.08**
Power	**41.4**	**58.34**	**82.83**
Gaussian	**42.6**	**59.7**	**81.65**

Spatial Distribution of Vegetation Units According to Conductivity:

Transformations of species abundance from Braun Blanquet scale to 0-9 Van der Maarel scale enable us to cartography the spatial distribution of the vegetation units by using kriging. As a result, Figures 10, 11, 12 and 13 show a close relation between the vegetation units and the electrical conductivity values. Vegetation unit A (Fig. 10) is distributed throughout the saline soils according to the same gradient of salinity, from the periphery to the center and from the west to the east. Vegetation unit D (Fig. 13) occupies the highly saline soils, whereas vegetation unit B (Fig. 11) is completely absent from the western side of the plain that is characterized by saline soils and low altitudes. Vegetation unit C (Fig. 12) is especially localized at the periphery of the plain and characterized by slightly saline soils.

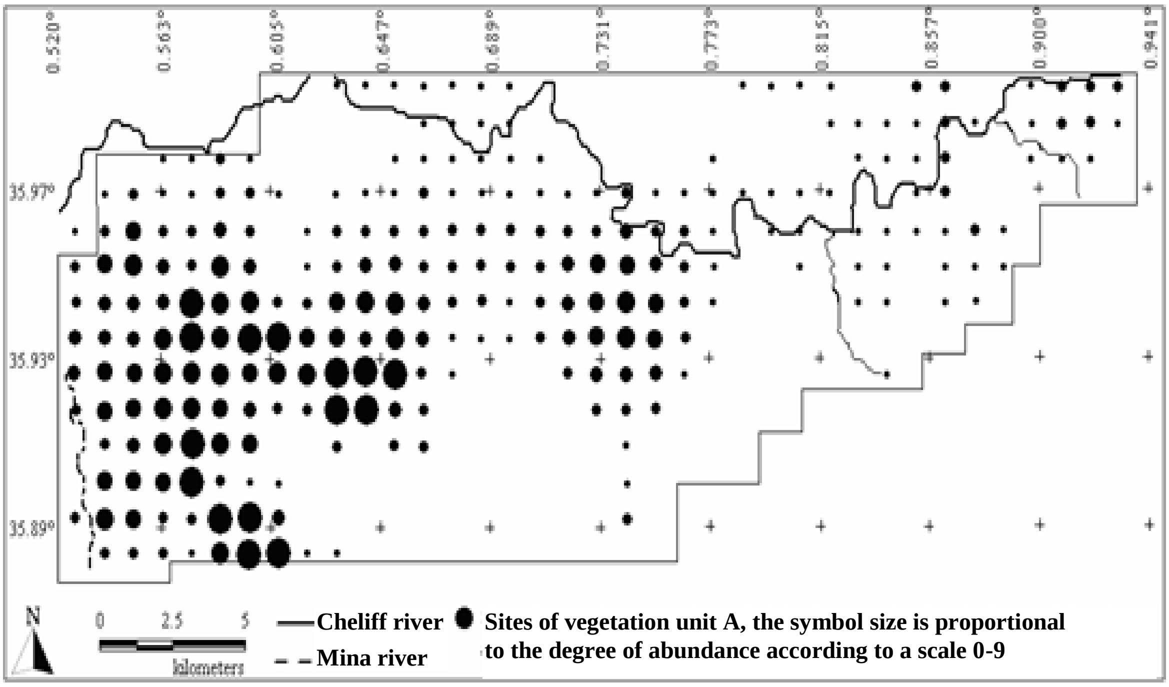

Fig. (10): Distribution map of vegetation unit A

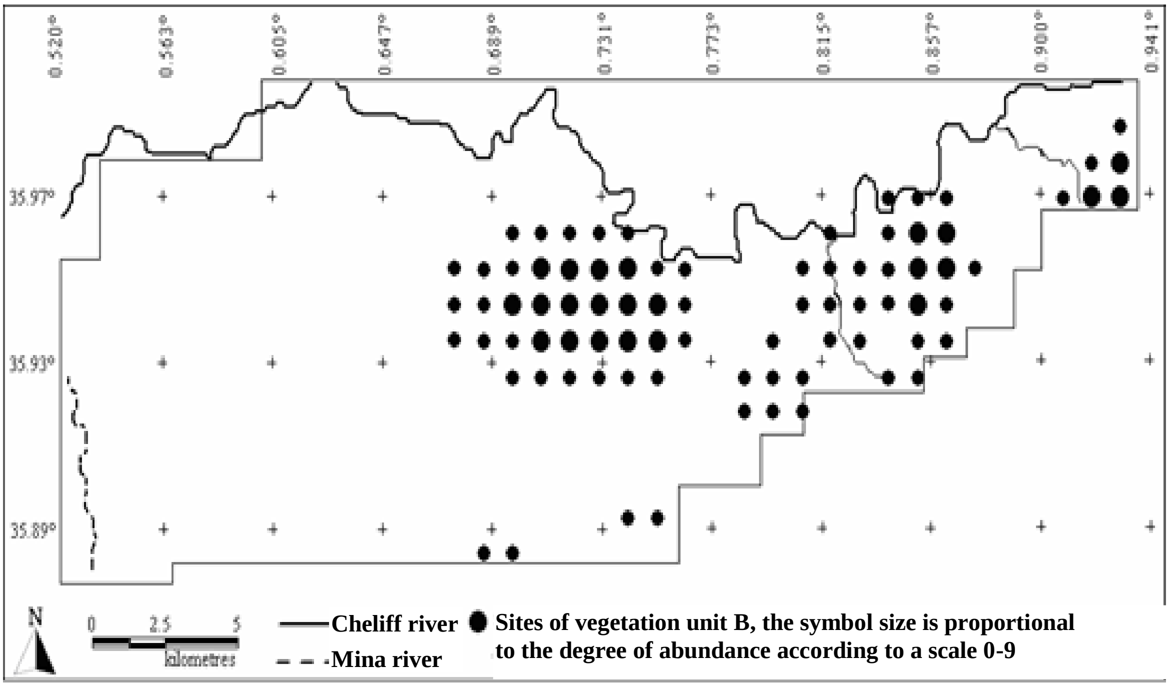

Fig. (11): Distribution map of vegetation unit B

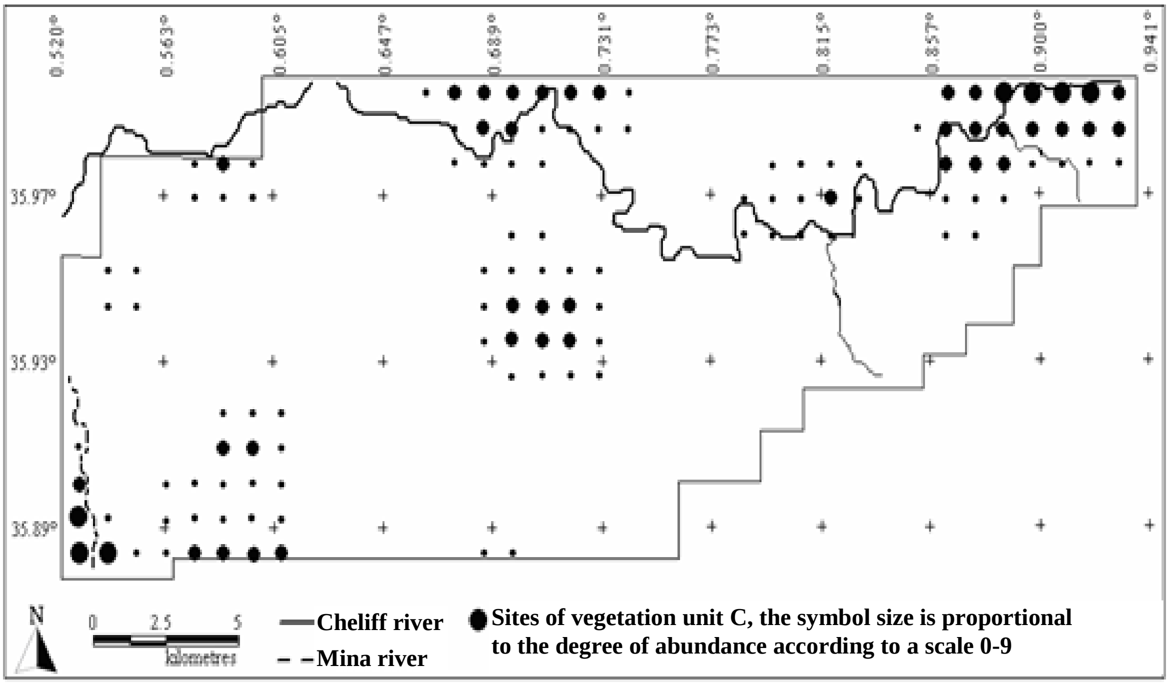

Fig. (12): Distribution map of vegetation unit C

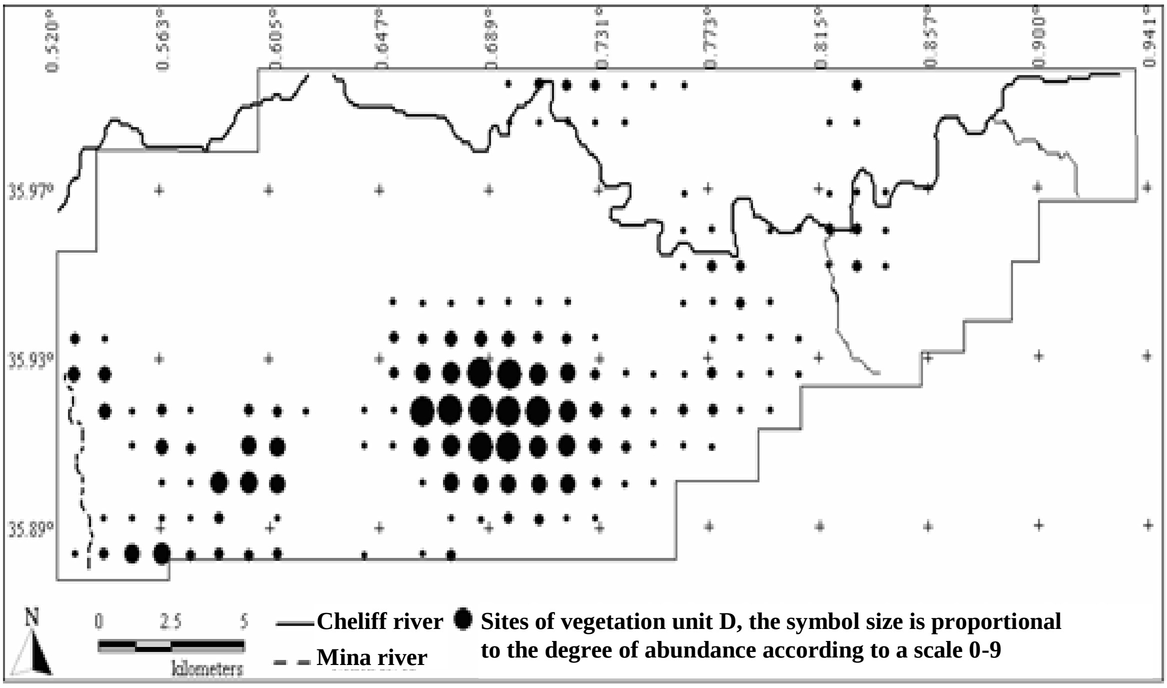

Fig. (13): Distribution map of vegetation unit D

CONCLUSION:

The plain of lower-Chelif is an ecosystem weakened by particular edaphic constraints and hard climatic adversities. These constraints strongly reduce the vegetal diversity. Thus, during three years of this study, we counted only 40 species through 133 relevés.

With an aim of reasonable management of this ecosystem, traditional methods of evaluation of site conditions are expensive and time consuming, especially in areas as large as the lower-Cheliff. Thus, recognition of vegetation ecology and biology is the easiest way limiting cost and time to assess environmental conditions. The present study provides baseline information about the environmental variables affecting the distribution patterns of vegetation assemblages in one of the largest plain in Algeria. It is clear that understanding the local scale factors is needed to assess the importance of factors structuring vegetal communities. The key factors that determine the distribution of vegetation in lower-Cheliff are altitude, electrical conductivity, sodium and soil structure. However, in this study, one of the most important factors that influence the composition of vegetation assemblages is the electrical conductivity. Indeed, it was able for us to differentiate among the four vegetation units in relation to the influence of the main environmental variable. Less diverse vegetation units composed of halophytes species and distributed throughout the saline soils as well as more diverse vegetation units that are very sensitive to salinity occupying the non saline to slightly saline soils were distinguished. Thus, the assessment of vegetal communities is a useful tool to classify salinity, especially in terms of revealing the spatiotemporal changes of this variable. It would be interesting to compare these results with other vegetation studies at the same conditions.

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APPENDICES

Appendix (1): Pairplot for the 12 environmental variables. The lower diagonal part shows the absolute correlation coefficient. Significant correlations are indicated in bold

Variable	S.S	OM	EC_e	Na^+	Ca^{++}	$CaCO_3$	pH	Clay	Sand	CaMg	Altitude	RGB
S.S	1											
OM	0,54	1										
EC_e	-0,19	-0,01	1									
Na^+	-0,22	-0,14	0,21	1								
Ca^{++}	-0,37	-0,16	0,25	0,54	1							
$CaCO_3$	0,03	0,03	-0,07	-0,15	0,04	1						
pH	0,18	-0,01	-0,76	0,08	-0,22	-0,06	1					
Clay	-0,23	-0,06	0,15	0,15	0,15	-0,02	-0,14	1				
Sand	0,16	0,15	0,08	-0,30	0,22	0,23	-0,17	-0,12	1			
CaMg	0,10	0,08	0,20	0,46	0,63	-0,04	-0,09	-0,13	0,32	1		
Altitude	0,55	0,24	-0,34	0,04	-0,33	-0,03	0,48	-0,42	-0,12	0,08	1	
RGB	-0,23	-0,21	-0,12	-0,08	-0,02	0,23	0,03	0,10	-0,17	-0,24	-0,19	1

Appendix (2): Variance inflation Factors < 4 for the 12 variables indicating no colinearity

N°	1	2	3	4	5	6	7	8	9	10	11	12
Variable	S.S	OM	EC_e	Na^+	Ca^{++}	$CaCO_3$	pH	Clay	Sand	CaMg	Altitude	RGB
VIF	2.4	1.5	3.02	2.7	3.2	1.2	3.3	1.3	1.8	2.7	2.47	1.27

Appendix (3): Marginal effects for our data. The second column shows the eigenvalue using only one explanatory variable

Variable	Eigenvalue of each variable used individually Lambda-1
Altitude	0.09
EC_e	0.08
S.S	0.07
Ca^{++}	0.05
pH	0.04
Na^+	0.04
Clay	0.02
OM	0.02
$CaCO_3$	0.01
RGB	0.01
CaMg	0.01
Sand	0.01

Appendix (4): Conditional effects for our data. The second column shows the increase in explained variation due to adding an extra explanatory variable. The 3rd and 4th column shows the P-*value and F-statistic* obtained by Monte Carlo test (999 permutations)

Variable	Increase in the eigenvalue Lambda-A	P	F
Altitude	0.09	0.001	12.56
EC_e	0.05	0.001	7.66
Na^+	0.02	0.001	3.75
S.S	0.02	0.001	2.67
CaMg	0.01	0.025	1.84
Ca^{++}	0.01	0.024	1.85
$CaCO_3$	0.01	0.023	1.88
Sand	0.01	0.058	1.55
RGB	0.01	0.242	1.22
pH	0.01	0.368	1.07
OM	0.00	0.766	0.66
Clay	0.01	0.852	0.67

تحليلات التغيرات المتعددة للنباتاتِ في السهلِ الملحيِ لمنخفض الشليف ، الجزائر

أبابو* ، غويب** ، خادير***، ميدربال*** ، عيسى****

***قسم عِلْمِ الأحياء – كليّة عِلْمِ الأحياء وعِلْمِ الزراعة – جامعة حسيبه بن بوالي – الشليف – الجزائر.**
****قسم عِلْمِ الزراعة – كليّة الهندسِة – جامعة عبد الحميد إبن باديس – موستاجانيم – الجزائر.**
*****قسم عِلْمِ الأحياء – كليّة العُلُومِ وعُلومِ الأرضِ، جامعة مصطفى إستامبولى – ماسكرا – الجزائر.**
******قسم الجيولوجيا – كليّة العُلُومِ – جامعة أسيوط – مصر.**

يعتبر سهلَ منخفض الشليف من أكبر السهولِ الملحيةِ فى شمال غرب الجزائر، ويقع بين خطى ٣٥.٧٥٠ ° ٣٦.١٢٥° شمالاً، وبين خطى طول ٠.٥°، ١° شرقا. ويتميز هذا السهل بمناخ شبه جاف وعدد محدود مِنْ الأنواعِ النباتية التى تم دراستها. وقد أوضحت دراسة هذه النباتاتِ فيما يتعلق بالمتغيّراتَ البيئيةَ أن توزيعَ النباتاتَ في هذا السهلِ وثيق الصلةُ بكلا من الإرتفاع والتوصيل الكهربائي. وقد أوضح تحليل فصلِ (RDA) بِأَنَّ هذين المتغيّرين متضادان على المحورِ القانونيِ الأولِ. وقد أوضح فصل النباتات إلى مجموعات متشابهة طبقا لمساهمتهم وتناظرهم على المحورين الأولين لكشف RDA وجود أربعة مجموعات نباتية. حيث تتكون كل مجموعة نباتية من عدة أنواع مميزة مَع وجود قيمة إرتباط هامّةِ جدا بينهاً طبقاً لإختبارِ فيشر. وقد كَشفت الدراسة وجود علاقة وثيقة بين هذه المجموعات النباتية ودرجة الملوحةِ.