Effective Environmental Factors on Plant Distribution in Semnan Rangelands of Iran

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***Abstract*—**The aim of this study was to classification and ordination of vegetation communities to understand the environmental factors that determine their composition and structure. We sampled plant density, cover, soil texture, lime, available moisture, gypsum, pH, electrical conductivity (EC), organic matter (OM) and gravel and topography variables using randomized-systematic method within Semnan rangeland, Iran. After using the Two-Way Indicator Species Analysis (TWINSPAN), vegetation was classified into 6 different groups. Principal component analysis (PCA) showed that the vegetation distribution pattern was mainly related to soil characteristics such as salinity, texture, available moisture, lime and gypsum. We used Canonical Correspondence Analysis (CCA), to examine the effect of soil factors on plant communities. CCA axis 1 was highly associated with silt and sand content, gravel, available moisture, gypsum, pH and electrical conductivity in two depths and lime of second layer and slope and elevation while CCA axis 2 was associated with lime in second layer. These gradients were related closely to the first two canonical axes, and accounted for 97.2% of the species–environment relationship in the study sites.

***Keywords*—**Environmental factors, Principal Component Analysis (PCA), Canonical Correspondence Analysis, Semnan rangelands.

I. Introduction

THE effects of environmental variables on plant communities have been the subject of many ecological studies in recent years (13, 23). For over a century, ecologists have attempted to determine the factors that control plant species distribution and variation in vegetation composition (6). Landform and vegetation are indicators of the influence of important environmental factors such as water availability, soil, aspect and climate (23). Soil characteristics play major role in distribution of plant species (22). Studying the vegetation distribution pattern is a basic aspect of the design and management. Quantitative separation was studied by previous scholars to investigate the contribution of environmental factors to the whole or different layers of plant community distribution pattern. (21). The objectives of this study are to examine the spatial distribution pattern of vegetation communities and analyses the ecological relationships between these communities and their environment.

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II. Materials and Methods

A quantitative survey of the vegetation is carried out during 2009-2010 in Daryan rangelands. In each of the studied types, soil and vegetative attributes were described within quadrats located along three 150m transverse transects. Quadrat size was determined for each vegetation type using the minimal area method. Sampling method was randomized systematic. Considering variation of vegetation and environmental factors, forty five quadrats with a distance of 50m from each other were established in each vegetation type. Floristic list, density and canopy cover percentage were determined in each quadrat. Six soil samples (0–80 cm) are collected from each type. Soil samples were collected from 0–20 and 20–80 cm layers. Measured soil factors included texture, gravel and available moisture, soil organic matter, pH, electrical conductivity (ECe), lime. Data were analysed by multivariate techniques i.e. principal component analysis (PCA).

III. Results

The results of the PCA ordination are presented in Table 1 and Fig. 3. Broken-stick eigenvalues for data set indicate that the first two principal components (PC1 and PC2) resolutely captured more variance than expected by chance. The first two principal components together accounted for 86% of the total variance in data set. Therefore, 61% and 25% variance were accounted for by the first and second principal components, respectively. This means that the first principal component is by far the most important for representing the variation of the six vegetation types. Considering the correlations between variables and components, the first component includes silt and gravel in 20-80 depth, sand, available water, gypsum and EC of both the depths. The second component consists of lime in both depths. In the study area, environmental conditions in *Halocnemum strobilaceum* type differ from the others. With attention to the position of this type in the fourth quarter of the diagram, it has a high correlation with the axis. Therefore, this type has the most relation with available moisture, EC, lime, gypsum and texture. *Artemisia sieberi-Eurotia ceratoides* and

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Seidlitzia rosmarinus types have inverse relation with indicator environmental characteristics of the first and second axes except for sand and gravel. *Artemisia aucheri–Astragalus. spp.-Bromus tomentellus* type has more relation with indicator characteristics of the first and second axes.

Indicator environmental factors of the first and second axes in *A. sieberi–Zygophyllum eurypterum* and *Z. eurypterum-A. sieberi* types are approximately similar. These types have a direct relationship with gravel and sand, and an inverse relationship with EC, silt, available moisture and gypsum. While *Ar. aucheri-As. spp.-B. tomentellus* type has a direct relationship with clay and inversely related to lime.

IV. Conclusion

The results of PCA analyses showed that, among different environmental factors (topographic and edaphic variables), the distribution of vegetation types in the study area was most strongly correlated with some soil characteristics such as salinity, texture, available water, lime and gypsum. Spatial distribution of plant species and communities over a small geographic area in desert ecosystems is related to heterogeneous topography and landform pattern (10). Because of soil texture effects of plants available moisture and elements and root distribution depth, the soil texture has an important role in the distribution of vegetation. The PCA ordination graph showed that the *A. sieberi-E. ceratoides*, *A. sieberi–Z. eurypterum, Z. eurypterum- A. sieberi* and *S. rosmarinus* types was positioned in the direction of coarse sand and gravely dry sites. Whereas *H. strobilaceum* type was positioned in the direction of fine and heavy soils and *Ar. aucheri-As.sp.* type was positioned in the semi-heavy textured soils. Although the classification was based on plant species data only, it reflects differences in the underlying environmental factors, such as soil texture, physiographic of the landscape, saltiness and moisture. The *H. strobilaceum* type was dominant in the saline areas, while the other vegetation types were found in the low gypsum areas. It has shown that the distribution of *H. strobilaceum* type is more strongly related to gypsum and EC factors.

In arid and semi-arid regions, the relation between species distribution and salinity gradient has been reported by many investigators (3, 5, 10, 17, 20, 22). Abu-Ziada (1) also showed strong relationships between vegetation pattern and soil moisture- salinity gradient in the Kharga and Dakhla Oases. Available moisture is the most important factor limiting plant growth and distribution of plants. Water availability is the main limiting factor of desert vegetation (18). Thus, moisture related variables such as elevation and soil texture are most important for the species composition in desert steppe (4). Analysis of the CCA and PCA was showed that the available moisture has a direct relation with the *H. strobilaceum* type, while *A. sieberi-E. ceratoides*, *A. siberi-Z. eurypterum*, *Z. eurypterum-A. siberi* and *S. rosmarinus* types have an inverse relation with available moisture and these types were also inversely related with the salinity.

Lime is common feature in soils of arid and semi-arid regions if the lithological materials contain a high quantity of this component. *A. sieberi–Z .eurypterum* and *Z. eurypterum-A. sieberi* types showed the direct relationship with lime percent.

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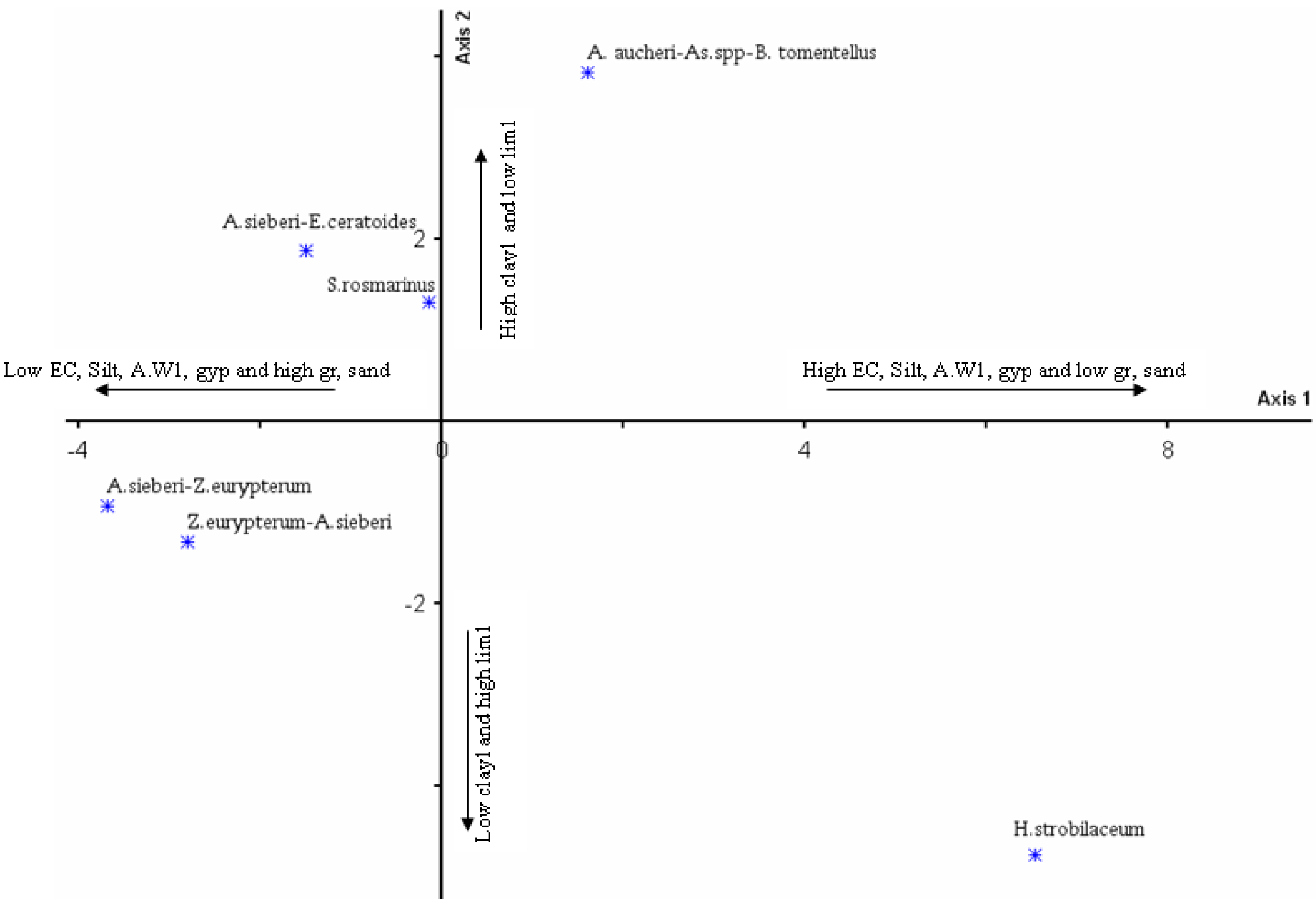

Fig 3. PCA–ordination diagram of the vegetation types related to the environmental factors in the study area

TABLE 1
PCA APPLIED TO THE CORRELATION MATRIX OF THE ENVIRONMENTAL FACTORS IN THE STUDY AREA

AXIS	Eigenvalue	% of Variance	Cum.% of Var.	Broken-stick Eigenvalue		
1	13.494	61.335	61.335	3.691		
2	5.512	25.053	86.388	2.691		
3	1.460	6.636	93.024	2.191		
4	0.968	4.398	97.422	1.857		
5	0.567	2.578	100.000	1.607		
6	0.000	0.000	100.000	1.407		
7	0.000	0.000	100.000	1.241		
8	0.000	0.000	100.000	1.098		
9	0.000	0.000	100.000	0.973		
10	0.000	0.000	100.000	0.862		
Factor	1	2	3	4	5	6
gr$_1$	-0.2636	0.0012	-0.0447	-0.0562	0.3161	0.1371
gr$_2$	-0.2589	0.0904	0.0166	-0.1657	0.2022	0.0355
clay$_1$	0.1792	0.3148	0.1002	-0.0093	0.1005	-0.1242
clay$_2$	0.1504	0.2595	-0.3168	-0.3208	-0.3702	-0.2055
silt$_1$	0.2476	0.0278	-0.1910	0.3450	0.0191	0.1166
silt$_2$	0.2691	0.0624	-0.0028	0.0323	0.0133	-0.0807
sand$_1$	-0.2437	-0.1583	0.0828	-0.2235	-0.0573	-0.0706
sand$_2$	-0.2356	-0.1862	0.1819	0.0264	0.1395	0.0824
lim$_1$	0.0828	-0.3939	-0.0644	-0.0424	0.2794	0.0946
lim$_2$	0.1606	-0.3190	0.0101	-0.1881	0.3162	0.0212
O.M$_1$	-0.0253	0.3944	-0.0388	-0.0561	0.4768	0.0649
O.M$_2$	-0.0768	0.2109	0.2962	0.3680	0.0688	-0.0525
A.W$_1$	0.2840	0.1148	-0.2614	0.1038	0.2249	0.1069
A.W$_2$	0.2453	0.1306	-0.2399	0.0725	0.1501	0.1342
gyp$_1$	0.2662	-0.0688	0.0925	-0.0716	0.0125	-0.1236
gyp$_2$	0.2662	-0.0688	0.0925	-0.0716	0.0125	-0.1257
EC$_1$	0.2662	-0.0693	0.0957	-0.0628	0.0188	-0.1148
EC$_2$	0.2653	-0.0729	0.1017	-0.0773	0.0127	-0.1281
pH$_1$	-0.1360	-0.1130	-0.6739	0.0644	-0.1513	0.2438
pH$_2$	-0.2205	-0.1334	-0.2747	0.3324	0.2260	-0.8329
elevat	-0.1945	0.2594	0.0252	0.3383	-0.1141	0.0904
sl	-0.1345	0.2559	-0.1863	-0.5878	0.1327	-0.1505

*Non-trivial principal component as based on broken-stick eigenvalues