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A Multivariate Analysis in Relation to Edaphic and Environmental Factors of Rangelands Vegetation of Mugla Province

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ABSTRACT
This study was carried out in order to compare in 20 different rangeland sample areas that determined in order to environmental variables, vegetation and soil properties by multivariate ordination analysis in Mugla province. Cluster analysis was made to determine the similarity and species compositions of sample areas, and as a result of this analysis, three different groups have occurred. Additionally, detrended correspondence analysis (DCA) was made after the indicator species analysis. The interaction between environmental and soil-borne factors as altitude, distance to village, soil depth, pH in saturated soil with water, lime and surface stoniness were found to be significant and this significance was expressed by graphs. Moreover, it was indicated that relationship with species in the vegetation of the variables that were determined as significant by tables and figures. The relationship with the species in the vegetation of the variables that were determined as significant was also indicated. The result of the study showed that environmental variables as soil depth, soil pH saturated with water, stony surface, altitude and distance to villages had a significant effect on the species diversity and distribution in the samples areas.

Keywords: Clustering analysis; Multivariate analysis; Rangeland

1. Introduction

The best way to learn about habitat, niche, and vegetation beside the different interaction between plants in an ecosystem is an investigation of plant biodiversity (Khan et al 2016). Biodiversity is defined as species richness that consisting of the influence of different environmental characters (Khan et al 2018). It is important that examination of the relationship between environmental factors and plants in these ecosystems for better understanding and management rangeland ecosystems, which are among the areas with the richest vegetative biodiversity in the world. The impact of environmental factors on plant communities has been the subject of many ecological studies in recent years (Amiri & Saadatfar 2009; Altın et al 2011; Ispirli et al 2016). Determination of the interaction between different biotic and abiotic components of an ecosystem is an important part of ecological studies (Rahman et al 2016; Khan et al 2017). The species composition, which is one of the main components of rangeland ecosystems, is highly controlled by environmental factors. Climate,

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topography, and soil characteristics are the main environmental factors (Hoveizeh 1997; Clark & Mann 1999; Escudero et al 2000; Solon et al 2007; Altın et al 2011; Surmen & Kara 2018). When the relationship between environmental factors and vegetation is investigated, it is thought that the location of plants is not a coincidence. Therefore, researchers investigate various factors (Abiotic and Biotic) that interact in the formation of plant community structure. These factors contribute to understanding the distribution, composition, and diversity of plant species and communities (Brown 1984). It is difficult to state which factors actually cause changes in vegetation when a large number of environmental factors are extremely effective (Partridge & Wilson 1989). Researchers have stated that each of the ecological factors had many effects on plant distribution (Clark & Mann 1999). The most important factors that cause the vegetation to dissipate due to the soil characteristics of different species in ecosystems are topographic parameters such as slope and aspect. Additionally, variations in the composition of the plant species throughout the altitude and latitude are one of the most effective environmental variables in the classification of plant species in these regions (Kitayama 1992; Altın et al 2011). Quantitative classification and ordination analysis methods are used to understand the basic relationship between environmental characteristics and plant communities. These methods help to identify ecological similarities between different vegetations and finding the environmental factors that are important in ecological structure determination (Zhang et al 2006; Amiri & Saadatfar 2009). Scientists, who are interested in ecology, use a multivariate approach to investigate and summarize the ecological data set related to environmental variables. Statistical analysis of these data helps to find the actual position of plant species in rangelands (Curtis & McIntosh 1950). Multivariate analysis methods are commonly used to qualitative and quantitative relationships with botanical composition and environmental factors (Villers-Ruiz et al 2003; Kargar-Chigani et al 2017). One of these methods, the ordination analysis, is a commonly used method to study the vegetation-environment relationships (Jin-Tun & Oxley 1994; Siefert et al 2012). Multivariate statistical analytical programs contribute to ecologists to analyze the effects of environmental variables on all species and to know the structure in the data set (Anderson et al 2006). Mugla province, where the study was conducted, is located in the southwestern of Turkey, has rich biotope and biota, endemic species, and it is one of the few provinces in terms of natural resources and environmental-conservation areas. For this reason, the effects of different environmental variables on rangeland botanical composition were investigated by multivariate analysis methods in 20 different sample areas in Mugla province that has rich biodiversity.

2. Material and Methods

The experiment was carried out in 20 different rangeland areas within the borders of Mugla province. The general characteristics of environmental factors that are important in the ordination analysis are given in Table 1. In the vegetation study, wheel point method (Gokkus et al 1995) and adapted loop method were used (Koc & Cakal 2004). In this study; soil texture properties were determined according to the hydrometer method by Gee & Bauder (1986), pH-saturated soil in the water was determined according to the pH meter method by McLean (1982), $CaCO_3$ content was determined that according to the Scheibler calcimeter by Nelson & Sommers (1982), soil P_2O_5 content was determined that according to the molybdosophosphoric blue color method by Olsen & Sommers (1982), the K_2O content was determined that according to the flame photometry by Thomas (1982) and the organic matter content was determined that according to the Smith-Weldon method (Nelson & Sommers 1982). In the result of the vegetation study, 116 species in 20 sample areas were determined, however, the species which were below 5% frequency according to coverage ratio were removed before analysis (Table 2). Cluster analysis was performed to determine the similarity characteristics of the sample areas using the PC-ORD package program in the study. Before the analysis, the remaining 5% of the species detected in the sample areas were eliminated and the analysis was continued with the remaining species. The Cluster Euclidean Ward's method was used for the analysis and distinction groups were determined by MRPP (Multi-Response Permutation Procedures) test (McCune & Mefford 1999). After the separation groups, DCA was preferred for ordination analysis (Hill & Gauch 1980).

Table 1- General characteristics of pasture areas that are important in the ordinate analysis in 20 different pasture areas of Mugla Province

Locations	*Altitude*	*pH in soil saturated with water*	*Lime (%)*	*Distance to the Village (km)*	*Stoniness*	*Soil depth*	*County*	*Village*	*Site*	*Latitude*	*Longitude*
MUG001	1384	6.10	0.72	5.0	1	4	Seydikemer		Seki	35S0741063	UTM4079330
MUG002	1420	5.94	0.72	5.0	2	3	Seydikemer		Seki	35S0741213	UTM4079257
MUG003	2	6.40	0.97	2.0	4	2	Bodrum		Kudur	36S0648581	UTM3018040
MUG004	9	6.71	1.08	2.0	2	3	Ortaca		Tepearası	35S0648780	UTM4082848
MUG005	10	7.43	0.97	2.0	1	4	Koycegiz	Donusbeleni	Donusbeleni	35S0641815	UTM4095054
MUG006	17	7.97	17.58	2.5	1	4	Ortaca		Tepearası	35S0649092	UTM4083032
MUG007	12	5.46	0.84	1.0	1	4	Milas		Koru	35S0563867	UTM4122029
MUG008	20	7.57	11.59	2.0	1	4	Ortaca	Tepearası	Tepearası	35S0648947	UTM4083120
MUG009	6	7.39	7.10	1.0	1	4	Milas	Gurcamlar	Alagun	35S0544972	UTM4126429
MUG010	13	6.82	1.04	1.0	1	4	Ortaca	Ortakoy	Tepearası	35S0649005	UTM4083015
MUG011	10	7.43	8.72	1.0	1	4	Milas		Koru	35S0563635	UTM4122702
MUG012	1400	5.61	0.07	5.0	1	3	Seydikemer	Seki	Seki	35S0741086	UTM4079742
MUG013	9	6.89	0.91	1.0	4	4	Milas		Koru	35S0563565	UTM4122805
MUG014	12	7.61	10.91	1.0	4	2	Milas	Gurcamlar	Alagun	35S0544824	UTM4126451
MUG015	9	7.98	13.45	1.0	4	4	Milas		Koru	35S0563565	UTM4122805
MUG016	9	7.36	1.29	2.0	4	4	Koycegiz	Donusbeleni	Donusbeleni	35S0641716	UTM4094888
MUG017	0	6.16	1.11	2.0	3	2	Bodrum	Kudur	Yalıkavak	35S0523593	UTM4108970
MUG018	14	7.35	30.17	1.0	1	2	Milas	Gurcamlar	Gurcamlar	35S0544989	UTM4126614
MUG019	12	5.48	0.91	1.0	1	3	Milas		Koru	35S0563737	UTM4122000
MUG020	30	8.07	13.45	2.0	3	2	Ortaca	Ortakoy	Ortakoy	35S0648668	UTM4082804

Table 2- Correlation values of Detrended Correspondence Analysis (DCA) depending on the species of matrix axis

Axis	*1*			*2*			*3*		
Species	r	r-sq	*tau*	*r*	*r-sq*	*tau*	*r*	*r-sq*	*tau*
Aegilops neglecta	-0.384	0.147	-0.069	0.536	0.287	0.382	-0.149	0.022	-0.260
Avena sativa	-0.017	0.000	-0.030	0.516	0.266	0.500	-0.123	0.015	-0.114
Bromus danthoniae	-0.558	0.312	-0.562	-0.275	0.075	-0.069	0.096	0.009	-0.082
Bromus tectorum	0.177	0.031	0.307	-0.199	0.039	-0.244	-0.073	0.005	-0.244
Cantaurea iberica	0.041	0.002	-0.036	0.239	0.057	0.226	-0.184	0.034	-0.139
Cardopatium corymbosum	0.193	0.037	0.168	0.355	0.126	0.343	0.102	0.010	0.139
Carex acuta	-0.175	0.031	-0.065	0.217	0.047	0.182	0.025	0.001	0.000
Carex atrata	0.466	0.218	0.434	-0.156	0.024	-0.217	0.606	0.368	0.375
Cynodon dactylon	0.356	0.127	0.251	-0.110	0.012	-0.195	0.622	0.387	0.463
Festuca ovina	0.718	0.516	0.560	0.301	0.091	0.248	-0.337	0.114	-0.248
Hordeum bulbosum	0.087	0.008	-0.006	0.417	0.174	0.536	-0.145	0.021	-0.211
Hordeum marinum	0.190	0.036	0.206	-0.089	0.008	-0.039	0.366	0.134	0.318
Juncus acutus	0.291	0.085	0.302	0.287	0.082	0.315	0.153	0.023	0.178
Lolium multiflorum	-0.383	0.147	-0.314	-0.560	0.313	-0.284	-0.103	0.011	-0.080
Lolium perenne	-0.539	0.291	-0.386	-0.361	0.131	-0.168	0.206	0.043	0.314
Notobasis syriaca	0.073	0.005	0.134	0.004	0.000	0.134	-0.065	0.004	-0.055
Pistacia terebinthus	-0.324	0.105	-0.276	-0.693	0.480	-0.474	-0.452	0.204	-0.375
Plantago atrata	-0.189	0.036	-0.143	0.271	0.073	0.195	0.224	0.050	0.235
Poa bulbosa	0.628	0.395	0.494	0.059	0.003	-0.020	-0.297	0.088	-0.276
Polypogon monspeliensis	-0.422	0.178	-0.194	-0.212	0.045	-0.081	0.302	0.091	0.293
Trifolium campestre	0.634	0.402	0.261	-0.075	0.006	-0.274	-0.281	0.079	-0.117
Trifolium hirtum	-0.284	0.081	-0.178	0.105	0.011	0.138	0.096	0.009	0.020

3. Results and Discussion

According to the results of cluster analysis, similar 3 groups occurred. Among these groups, the first group consisted of MUG001, MUG012, MUG005, MUG016, second group consisted of MUG003, MUG013, MUG017, MUG018, MUG004, MUG020, MUG014, MUG006, MUG010 and third group consisted of MUG007, MUG009, MUG011, MUG015, MUG008, MUG019 (Figure 1). Indicator species in segregation groups were determined by indicator species analysis in PC-ORD program. According to the results of the indicator species analysis, *Carex atrata* (60.0), *Poa bulbosa*

(60.0) and *Trifolium campestre* (73.1) were the indicator species of the first group, while *Bromus danthoniae* (57.9) was the inductor species of the second group and finally, the indicators of the third group were *Avena sativa*, *Cardopatium corymbosum*, *Hordeum bulbosum* (70.7), *Juncus acutus* (87.4), *Notobasis syriaca* (57.5). After Multi-Response Permutation Procedures (MRPP) analysis, detrended correspondence analysis was preferred for the ordination analysis and the correlation of both variables with the axes was calculated (Tables 3-4). As a result of the analysis, it was found that 1st axis explanation of the percentage 0.54110, 2nd axis explanation of the percentage of 0.37308 and 3rd axis explanation 0.14921 (Table 4). When the correlation between vegetation data matrix and environmental data matrix was investigated, it was seen that environmental variables such as pH in water-saturated soil, lime, surface stoniness, altitude, usable potassium, distance to village, soil depth are important. It is seen that the species of *Bromus tectorum*, *Cardopitum corymbesum*, *Carex atrata*, *Cynodon dactylon*, *Festuca ovina*, *Juncus acutus*, *Poa bulbosa*, and *Trifolium campestre* have an increase and growth potential with increasing elevation, distance to village and soil depth variables. Among these characteristics, the correlation between altitude (r= 0.624) and *Festuca ovina* (r= 0.718), *Poa bulbosa* (r= 0.628) and *Trifolium campestre* (r= 0.634) was determined as the closest positive relationship. Furthermore, the species that the highest negative relationship with altitude was determined as *Bromus danthoniae* (r= -0.558) and *Lolium perenne* (r= -0.539). *Carex atrata* (r= 0.466) was observed that closest positive relationship with village distance (r= 0.541) and soil depth (r= 0.532) variables. Considering other variables; when pH in saturated with water, lime and surface stoniness increase *Aegilops neclecta*, *Bromus danthoniae*, *Lolium multiflorum*, *Lolium perenne*, *Pistacia terebinthus*, *Polygonum monspeliensis*, and *Trifolium hirtum* species also show an increase. While lime variable parameter was significantly positive correlated to negative position with *Aegilops neclecta* (r= -0.384), *Bromus danthoniae* (r= -0.558), *Lolium multiflorum* (r= -0.383), *Lolium perenne* (r= -0.539) and *Polygonum monspeliensis* (r= -0.422) species, pH in saturated with water (r= -0.350) parameter significantly positive correlated to negative position with *Aegilops neclecta* (r= -0.384), *Lolium multiflorum* (r= -0.383) and *Pistacia terebinthus* (r= -0.324) species. It was observed that surface stoniness (r= -0.241) and *Trifolium hirtum* (r= -0.284) showed the highest positive correlation (Tables 3-4, Figure 2). When the groups were examined together, while the altitude, distance to village and depth of soil were determined as a high in the sample areas belonging to the first group, soil depth was found to be high in the second group of sample areas. Finally, in the third group in the sample areas, the pH in the water-saturated soil, lime and surface stoniness variables were found to be high (Figure 3). According to the results, it was observed that soil factors were closely related to vegetation. It has been determined that soil factors with soil chemistry changes have positive or negative effects on the species in vegetation. Similar results were reported by other researchers (Kumar 1996; Ridolfi et al 2008; Amiri & Saadatfar 2009; Kabir et al 2010; Kirkpatrick et al 2014). It has been determined that different species have different effects depending on the change in altitude, which is one of the environmental factors and has a close relationship with vegetation change. This result was in accordance with Ispirli et al (2016). Many researchers also have investigated the effects of environmental factors on vegetation change (Zhang & Dong 2009; Mofidi et al 2012; Surmen et al 2013; Zhengchao et al 2016).

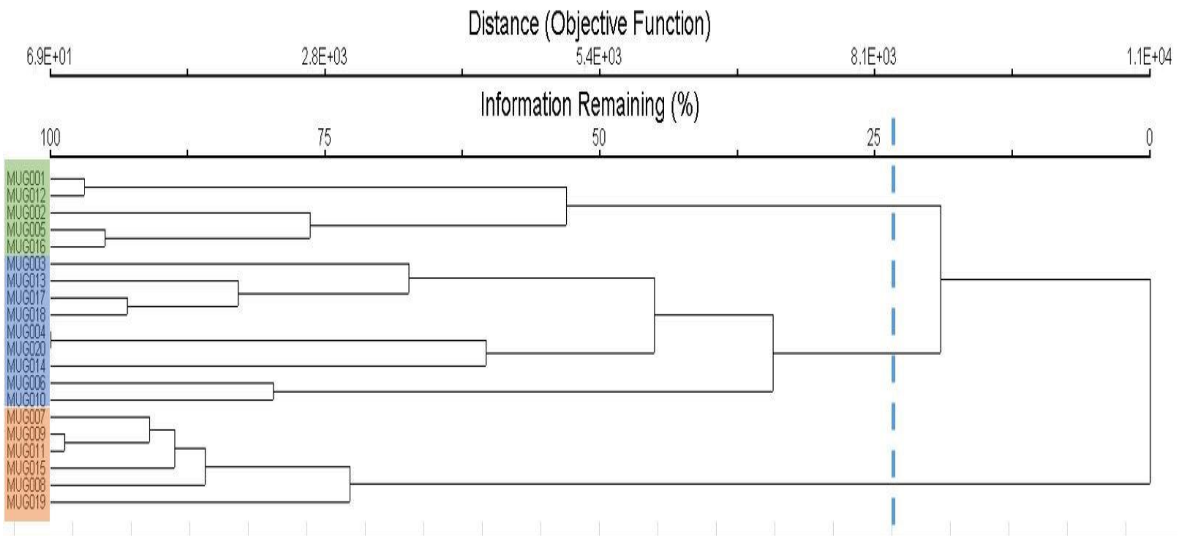

Figure 1- Dendrogram obtained by hierarchical cluster analysis of 20 samples areas

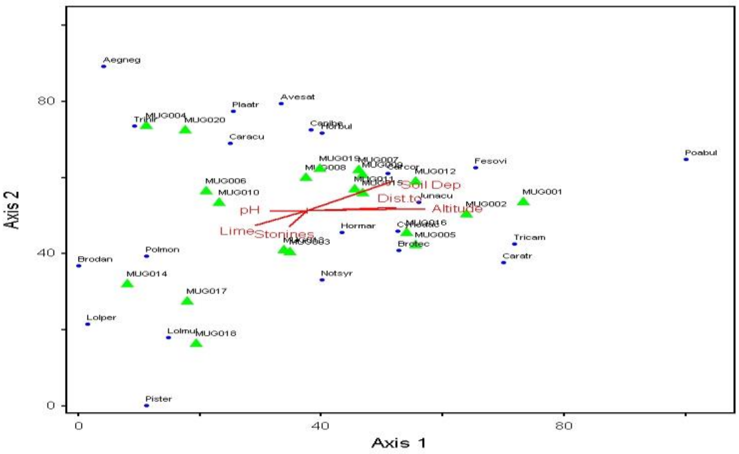

Figure 2- Ordinate distribution according to Detrended Correspondence Analysis (DCA) influenced by environmental factors in species detected in 20 sample areas

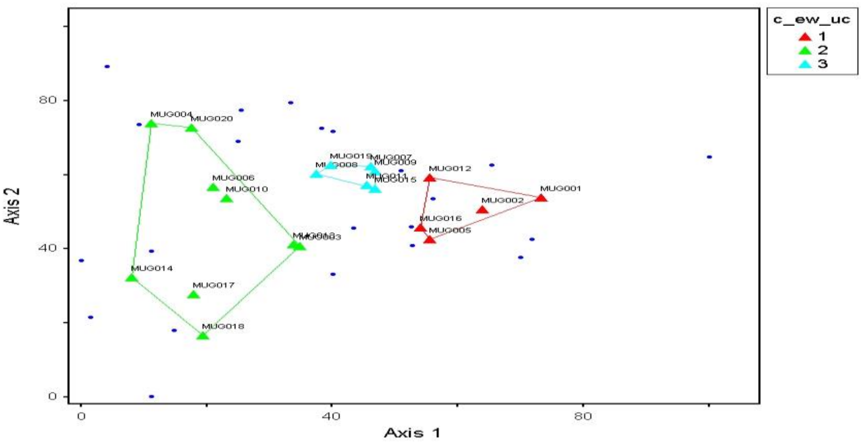

Figure 3- Group distribution of 20 sample areas by Cluster Euklidien Ward's in Detrended Correspondence Analysis (DCA)

Table 3- Correlation values of Detrended Correspondence Analysis (DCA) depending on the environmental data of matrix axis

Axis		*1*			*2*			*3*	
Soil properties in pastures	*r*	*r-sq*	*tau*	*r*	*r-sq*	*tau*	*r*	*r-sq*	*tau*
Altitude	0.624	0.389	0.108	0.100	0.010	0.162	-0.358	0.128	-0.184
pH in soil saturated with water	-0.350	0.123	-0.206	-0.049	0.002	-0.037	0.363	0.131	0.237
Lime	-0.414	0.172	-0.415	-0.274	0.075	-0.053	-0.092	0.008	0.128
Total salt	0.073	0.005	-0.016	-0.188	0.035	-0.144	0.670	0.449	0.485
EC	-0.051	0.003	-0.032	-0.228	0.052	-0.189	0.570	0.325	0.432
Plant-available potassium	0.234	0.055	0.175	0.176	0.031	0.027	-0.152	0.023	-0.111
Organic matter	-0.023	0.001	0.016	-0.045	0.002	0.005	0.168	0.028	0.132
Erodibilite	-0.073	0.005	-0.105	-0.045	0.002	-0.082	-0.390	0.152	-0.269
Hydraulic conductivity	-0.011	0.000	0.053	-0.091	0.008	-0.021	-0.021	0.000	-0.074
Field capacity	-0.011	0.000	-0.011	0.016	0.000	0.063	0.309	0.096	0.242
Permenent wilting	-0.079	0.006	-0.032	-0.041	0.002	0.063	0.336	0.113	0.242
Bulk density	0.002	0.000	0.048	-0.030	0.001	-0.069	-0.192	0.037	-0.143
Distance to village	0.541	0.293	0.242	0.134	0.018	0.038	-0.222	0.049	-0.064
Slope	-0.146	0.021	-0.130	0.081	0.007	-0.020	-0.241	0.058	-0.266
Erosion	-0.148	0.022	-0.218	0.099	0.010	0.008	-0.071	0.005	-0.121
Stoniness	-0.241	0.058	-0.216	-0.288	0.083	-0.268	0.076	0.006	0.164
Soil depth	0.532	0.283	0.392	0.388	0.151	0.166	0.106	0.011	0.126

Table 4- The results of the length and eigenvalues in Detrended Correspondence Analysis (DCA)

	Axis 1	*Axis 2*	*Axis 3*
Eigen value	0.54110	0.37308	0.14921
Gradient length	3.473	2.975	2.923

4. Conclusions

Rangeland areas have had a great impact on every period of human history from ancient times to the present day. For the suitable management of rangeland areas that have biodiversity and supply the nutritional needs of livestock, it is very important to know the species of plants in the area and investigate their relationship with environmental factors. For this purpose, the species and environmental variables were examined by vegetation study in 20 different sample areas by ordination analysis, especially in Mugla province, where is located in a known ecology with its rich in biodiversity. According to the results, it was determined that many environmental variables had an effect on botanical species composition. The results of the study revealed the species that have a growing potential in the regions. The data obtained from this study will be a resource for future studies about rangeland management and improvement in these areas.

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Abbreviations and Symbols	
DCA	Detrended Correspondence Analysis
MRPP	Multi-Response Permutation Procedures
TAGEM	General Directorate of Agricultural Research and Policies
BUGEM	General Directorate of Plant Production
TUBITAK	The Scientific and Technological Research Council of Turkey
MUG	Mugla Province
pH	Stands for the potential of Hydrogen
$CaCO_3$	Calcium Carbonate
P_2O_5	Phosphorus Pentoxide
K_2O	Potassium Oxide
r	Correlation Coefficient

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