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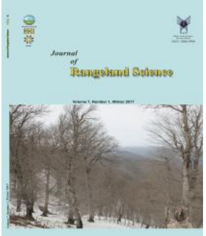

**Research and Full Length Article:**

# Relationships between Environmental Factors and Plant Communities in Enclosure Rangelands (Case study: Gonbad, Hamadan)

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**Abstract.** Exclusion and not using of rangeland in the long term affects the composition and homogeneity of vegetation and consequently leads to the improvement of plants status. In this study, the characteristics and structural changes of the rangeland of Gonbad, Hamadan province, Iran, in 2014 (after 20 years of enclosure) were evaluated using Braun-Blanquet plot, Phytosociology and multivariate analysis by the software PC-Ord5. According to clustering diagram and Indicator Species Analysis, it was found that the studied region had 10 vegetation types and 17 Indicator Species. Detrended Correspondence Analysis (DCA) showed that in the first axis the variables: stone and gravel percentage, Electrical Conductivity (EC), clay, and organic carbon were important and in the second axis canopy cover of grasses, total canopy cover, and pH were important. Principal Component Analysis (PCA) confirmed the relationship between plant communities and environmental factors in the enclosure region. It was found that there are correlations between the echo logical units and the factors: stone and gravel (0.25), clay (-0.26), sand (0.28), silt (0.38), slope (-0.36), total neutralizing value (0.34), and plant species indicators that resulted to the separation of the units. The results showed that in the long-term enclosure, plant communities tend towards a uniform and homogeneous composition and consequently led to the improvement of the rangeland vegetation conditions. Therefore the density, composition and the class I plant species have increased.

**Key words**: Cluster, DCA, PCA analysis, Enclosure

## Introduction

Rangelands constitute the largest natural ecosystem in the world, and play the most important role in producing protein and balancing ecosystems. More than 5.3 billion ha of rangeland exist in the world, 903 million ha of which are located in Asia (excluding the Middle East). The rangelands of the Middle East cover 303 million ha, of which 86.1 million ha belong to Iran (Eskandari *et al.*, 2008). Because of livestock overgrazing, species diversity has currently decreased in Iran's rangelands. The good management of natural resources requires knowledge of flora and its changes. Understanding the relationship between plants and the environment and determining the factors affecting vegetation composition are important issues. Without a historical record of rangeland productivity, differences in yields cannot be precisely quantified (Haynes *et al.*, 2012). The parameters of soil, bed rock, land form, climate, decomposition, consumers, and manufacturers affect the ecosystem. These variables must be determined and recognized on their own and/or in interaction with other parameters. Describing vegetation on both small and large scales can produce a mental image for those who have not seen the region and allow different vegetation units to be compared and classified (Kershaw, 1973). Accurate knowledge of spatial distribution of soil physical and chemical properties is needed for suitable management and proper use of rangelands (Rostami *et al.*, 2015). Anthropogenic pressures, heavy grazing, and natural calamities have led to the degradation of the natural habitats of many species. Such practices are discouraging for high–valued, moisture–loving, native species and promote hardy, non-native, exotic species that have little value for the local ecosystem (Pant and Samant, 2012). Mountain ecosystems are hot spots for plant conservation efforts, because they hold high overall plant diversity as communities replace each other (Mulk Khan *et al.*, 2013). Zhang *et al.* (2008) described and compared the SOFM (Self-Organizing Feature Map) ordination were with DCA (Detrended Correspondence Analysis), and PCA (Principal Component Analysis), in analysis of plant communities in the midst of Taihang Mountains in China. They showed SOFM, DCA, and PCA produced consistent results, i.e. their axes were significantly correlated with elevation, soil organic matter, N, P, K, and slope (Zhang *et al.*, 2008). Therefore, describing the vegetation is essential for reaching conservation and management objectives (Coetzee, 1993). Mirdavodi *et al.* (2013) found that three main variables (climate, land type, and land aspect) with a total Eigen value of 82.8% were the most important factors affecting rangeland vegetation. Asadian *et al.*, (2010) studied the effects of a four-year enclosure on the vegetation of Giyan Nahavand, Iran, They found that inside the enclosure, the total canopy cover of perennial species increased by about 80%. Jianshuang *et al.* (2013) showed that short-term grazing exclusion changed the aboveground biomass and coverage at both community and species levels. In studying the effects of grazing and non-grazing conditions on the dynamics of plant communities of a southwestern Utah desert rangeland over 59 years, Alzerreca *et al.* (1998) found that grazing affected the variability and dynamics of plant communities more than climate. In another study, Amiri and Basiri (2008) found that enclosure increased the cover and density of vegetation. Mcnew *et al.* (2012) found that the probabilities of colonization and local extinction were impacted by different sets of environmental factors. Haynes *et al.* (2012) conducted a study in the Deakin rangelands of northern Greece and found that the animal effect was clearly visible and consistent with grasses. They also explained the reduced amount of bare ground and increased bush and forbs even with increasing distance from the hut. The ordination of species and environmental variables revealed that grazing intensity influenced the composition of the plant community by significantly affecting the palatability of plants. Jafari *et al.* (2006) conducted a study on 14 rangelands in Qom province, Iran. Their results showed that the most important soil properties influencing the differentiation of plant species were soil texture, EC, and limestone content. Gorgine Karaji *et al.* (2006) conducted a study in the Saral rangelands of Kurdistan, Iran. Their study resulted in the identification of four vegetation types. The relationship between physical and chemical properties of soil and vegetation showed that *Bromus tomentellus*, *Achillea vermicularis,* and *Eryngium sp.* needed more sand and silt and less clay, while, *Chaerophyllum macrospermum* and *Cephalaria microcephala* needed more silt and clay and less sand. The species *Ferula haussknechtii*, *Acantholimon sp.*, *Prangos ferulacea,* and *A. vermicular* needed lower pH, but higher silt and moisture content. According to DCA analysis, the loam percentage differed among the plant communities in the first axis. Environmental factors including height, clay, stone, gravel, and slope were different among the plant communities in the second axis. The environmental factors affecting the distribution of plant species included organic carbon, organic matter, stone and gravel, height above sea level, nitrogen content, canopy cover, slope, loam, and phosphorus content. Ariapour *et al.* (2012) studied the ecology of *Hulthemia persica* in Gonbad, Hamedan, Iran. They found a negative correlation between the canopy cover of *H. persica* and slope ($P<0.05$). In other words, as the slope increased, the canopy cover of *H. persica* was decreased. Height, slope, and slope direction had the greatest impact on the distribution of *H. persica.* Tatian (2013) conducted a study in the Vezvar rangelands of Galoogah, Mazandaran province, Iran. According to the results, the grasses showed a severe reaction to grazing intensity, while forbs and woody plants reacted severely to topography. In total, the effect of intense grazing on vegetation was almost similar in all topographical circumstances. On the other hand, slope and slope direction acted as grazing-limiting factors with a more marked effect on a rangeland's status and trend. The current study purposed to study relationships between plant community in enclosure areas and environmental factors affecting vegetation composition, changes in vegetation, and the effects of the enclosure on increasing canopy cover.

## Materials and Methods

### Study Area

The current study was carried out on 154 ha at the Gonbad Research Station, Hamadan, Iran. Its geographical coordinates is: longitude (48°41′0″ to 48°42′ 15″), latitude (34° 41' 15″ to 34°41'50″), and elevation 2086 to 2433m above sea level (Fig. 1). According to the Emberger curve (Fig. 2), the climate of the region is cool and arid with annual mean temperature 5.89°C. The minimum absolute, maximum absolute were, -32.8°C and 39.6°C, respectively. Minimum and maximum relative humidity was 41.8%, and 75.5%, respectively. Annual average evaporation and precipitation were 1408 and 304 mm, respectively.

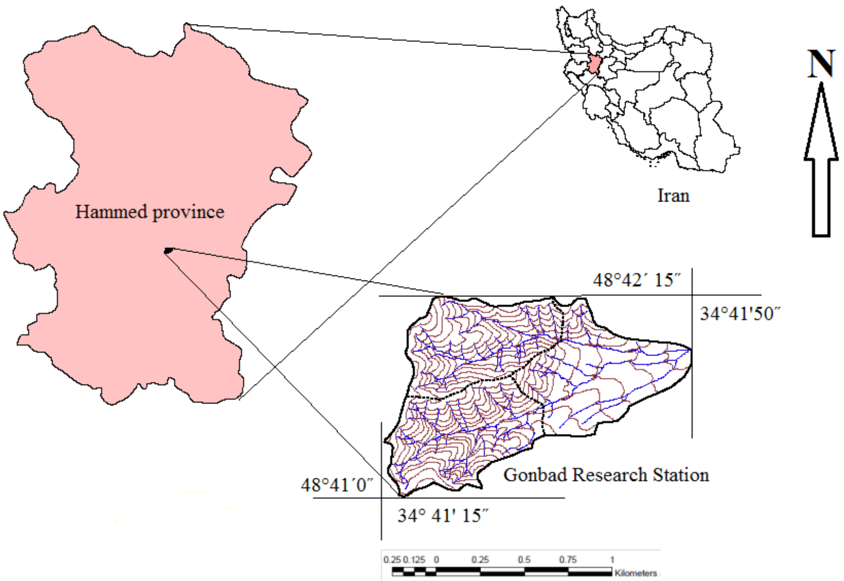


**Fig. 1.** Map of project location

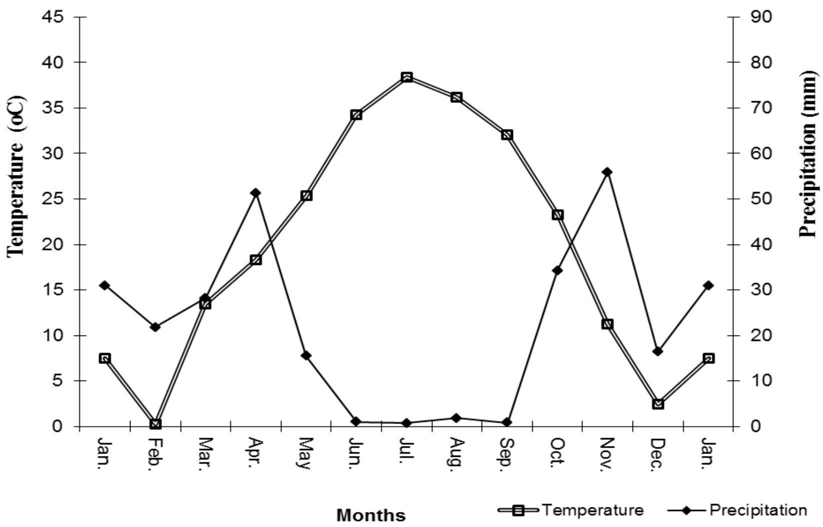


**Fig. 2.** Emberger Curve of Gonbad Research Station, Hamadan, Iran (2005-2014)

## Sampling Methods and Data Analysis

Gonbad vegetation enclosure areas were measured via 59 measurement plots, in which each plot had a minimal area of 4 $m^2$. The plant factors measured were cover canopy, vegetation density, vegetation sociability; grasses, forbs, shrub cover canopy, productivity, litter, floristic list, and plant type. The soil factors were measured for EC, acidity (pH), organic carbon, nitrogen, phosphor, potassium, total neutralizing value, sand, silt, clay, the ratio of carbon to nitrogen, erosion, sediment, bare soil, stone and gravel, conservation, and saturation. The land form factors measured were slope, aspect, and elevation (Table 1).

In the study area, the percentage of canopy cover, vegetation density, and sociability of 89 plant species in 59 plots were also measured (Table 1). The data were collected for Slope and Elevation according to Zakharov (1931). The aspect was measured using Beers *et al.* (1966) method. Erosion and Sediment were measured according to Tongway and Ludwigehod (2002).

Using Wiedeman and Trask (2001) method, the distance between the plants, the percentages of Stone and gravel, Bare soil, Grasses, Forbs and Shrubs canopy cover were measured. The percentages of Sand, Silt and Clay were determined using Wang *et al*. (2012) method. Nitrogen, Potassium, Phosphor and Organic carbon were measured using, Nelson and Sommers, (1980), Knudsen *et al*. (1982), Bray and Kurtz (1954) and Lo *et al*. (2011) methods, respectively. Total Neutralizing Value and Carbon to Nitrogen ratios were measured using Ahyaei and Behbahani (1993) method. Power Hydrogen, Electrical Conductivity and Saturation Percent were measured using Thomas (1996), Rhoades (1996) and Wilcox (1951) procedures, respectively. A total of 6844 collected pieces of data, after data normalization, were analyzed for cluster analysis, DCA and PCA analysis using SPSS.19 and PC-ORD.5 software.

**Table 1.** List of Plant Species in Enclosure Rangelands, Gonbad, Hamadan

| Scientific name | Abbreviation | Growth form | Life form | Species name | Abbreviation | Growth form | Life form |
|---|---|---|---|---|---|---|---|
| *Aasyneama sp.* | Aas. sp. | P.F | H | *Phragmites australis* | Phra. sp. | P.G | G |
| *Acanthophyllum crassifolium Boiss.* | Acph.sp2 | S | P | *Glycyrrhiza glabra L.* | Glise.glabe | P.F | C |
| *Acanthophyllum microcephalum Boiss.* | Acph.sp1 | S | P | *Gundelia tournefortii* | Gond.ton | P.F | H |
| *Acantholimon bromifolium Boiss* | Acl oli | S | P | *Hypericum perforatum* | Haypericum.sp. | P.F | H |
| *Achillea millefolium* | Achil mli | P.F | H | *Helichrysum sp.* | Heli. Sp. | A.F | T |
| *Acinos graveolens* | Acinos | AF | T | *Heteranthelium piliferum* | Het.sp. | A.G | T |
| *Agropyron elongatum* | Agropy Ele | P.G | H | *Hordeum anuale* | Hordum. anu | A.G | T |
| *Agropyron intermedium* | Agropy int | P.G | H | *Hordeum bulbosum* | Hord.bol | P.G | H |
| *Agropyron trichophorum* | Agropy tir | P.G | H | *Juncus bufonius* | Juncus.sp. | P.G | G |
| *Alcea Koelzii I. Reidl* | Althaea sp. | P.F | T | *Lactuca orientalis* | Luct.ori | P.F | G |
| *Allium haemanthoides Boiss. et Reut* | Alium sp. | P.F | G | *Linum catharticum L.* | Linum.sp. | A.F | T |
| *Alyssum lanigerum* | Alisum sp2 | A.F | H | *Marrubium astracanicum* | Marabium.sp. | P.F | C |
| *Alyssum meniocoides* | Alisum sp1 | F. | H | *Noaea mucronata* | Noea.sp. | P.F | H |
| *Anchusa italica Mill.* | Anchusa sp. | P.F | H | *Ononis spinosa* | Onanise. Spi | P.F | C |
| *Arenaria serpyllifolia* | Arenaria.sp. | AF | T | *Onopordum acanthium L* | Onopr.sp. | P.F | T |
| *Artemisia aucheri* | Artemi ush | S | P | *Onosma araraticum* | Onos.ara | A.F | T |
| *Astragalus gossypinus* | As.gos | S | P | *Panicum sp.* | Panicum .sp. | P.G | G |
| *Astragalus. Sp.* | As. sp. | S | P | *Phalaris sp.* | Phalaris.sp. | P.G | G |
| *Astragalus kohrudicus Bge.* | As.kur | S | P | *Phlomis olivieri Benth.* | Phlom.oli | F.P | C |
| *Astragalus verus* | As.ver | S | P | *Phloem sp.* | Phluem. sp. | P.G | C |
| *Boissiera squarrosa* | Boisera. sp. | A.G | T | *Picnemon acarna* | Picn.aca | P.F | T |
| *Bromus danthonia* | Bro.dan | A.G | T | *Picris sp.* | Picris. .sp. | P.F | H |
| *Bromus japonica* | Bro.jap | A.G | T | *Poa bulbosa* | Poa.bul | G.P | G |
| *Bromus tectorum L.* | Bro.tec | A.G | T | *Polygonum aridum Boiss.* | Polygonu.sp. | P.F | H |
| *Bromus tomentellus Boiss.* | Bro.tom | P.G | H | *Sanguisorba minor* | Poterium san | P.F | H |
| *Centaurea iberica* | Cen.ieb | P.F | H | *Prangos pabularia* | Prangos.sp | P.F | H |
| *Centaurea virgata* | Cen.ver | P.F | H | *Rosa persica* | Rosa.pers | S | P |
| *Centaurea bruguierana DC.Hand* | Cen.sp. | P.F | H | *Salsola canescens* | Salsola.sp | S | C |
| *Crataegus.sp.* | Ceratagu.sp. | Tr | P | *Salvia multicaulis L.* | Salvia.mul | P.F | C |
| *Chirophylum macropodum* | Chiroph.sp. | P.F | H | *Scariola orientalis* | Scariola.sp. | P.F | T |
| *Cirsium congestum* | Syrsi.con | P.F | H | *Scrophularia subaphylla* | Scaroph.sp. | P.F | H |
| *Cirsium lappaceum* | Syrsiu.lap | P.F | H | *Silent commelinifolia Boiss.* | silen.sp. | P.F | T |
| *Cousinia bijarensis* | Cosina.sp. | P.F | H | *Sophora alopecuroides* | Sophora.sp | P.F | C |
| *Cerasus microcarpa* | Crocus.sp. | S.T | P | *Stachys inflata* | Stachys. Inf | P.F | C |
| *Cynodon dactylon* | Cynid. Dac | P.G | C | *Stachys setifera* | Stachys.sp. | P.G | C |
| *Dactylis glomerata L* | .Dactelis.glo | P.G | H | *Stipa barbata* | St.bar | P.G | H |
| *Dendrostellera lessertii* | Dendro.str | P.F | C | *Taeniatherum crinitum* | Tin.sp | A.G | T |
| *Echinops ritro des Bunge.* | Echino.sp. | P.F | H | *Tamarix sp.* | Tamarex sp | S.T | p |
| *Eremopoa persica* | Eremopoa | P.G | T | *Taraxacum bessarabicum* | Trax.bes | P.F | |
| *Eremostachys mollucelloides Bunge* | Ermost.sp. | P.F | H | *Teucrium oriental L.* | Tocrum.ori | S | C |
| *Eryngium billardieri* | Ereng.sp. | P.F | H | *Thymus daenensis Celak.* | Tymus.sp. | S | C |
| *Euphorbia macroclada* | Eup.mac | P.F | H | *Verbascum cheiranthifolium* | Ver.sp. | P.F | H |
| *Euphorbia sp.* | Eup.sp. | P.F | H | *Ziziphora tenuior L.* | Zizi.sp. | P.F | C |
| *Festuca ovina* | Fest.ovi | P.G | H | | | | |

Annual Grass=A.G, Perennial Grass=P.G, Annual Forbs=A.F, Perennial Forbs= P.F, Shrub=S, Bushy Trees=B.T, Tree=Tr, Terophytes=T, Hemicryptophytes=H, Geophytes=G, Phanerophytes=P, Camophytes=C

## Results and Discussion

### Cluster analysis

According to clustering analysis based on the 17 indicator species and the lowest index value of p value, 10 vegetation types were identified (Figs. 3 and 4 and Table 2). Type specification indicates environmental factors such as stone, gravel, soil texture, slope, Total Neutralizing Value (TNV), and plant species were indicators of the effect of ecological separation units. *Astragalus verus* was present in all types as well as perennial grasses (*Fescue ovina*, *Stipa barbata and Bromus tomentellus*) with different density distribution in the area are grazed. Extend the plants closely represents the percentage of canopy cover area uniformity and tends to be stable. Result of cluster analysis (Fig. 3) showed plots uniformly in the ecological unit and vegetation types have been developed in the same condition. The results suggest that homogenous and uniform conditions exist in the enclosure. This represents the proximity of the plant community to the stable stage. *A. verus* was placed in a separate category as the dominant species. Results showed that the condition and trends of rangeland was good and positive. The uniformity in enclosure rangeland, indicating the tendency of plant communities towards the stability stage. According to ecological tendency and environmental conditions, the species were specifically located in a plot. The presence of different species in the plots represents the difference in various environments. Thus, the differential species represent specific ecological conditions in a certain class of plots. Because of the removal of grazing pressure in enclosure zone, the plant species which were naturally placed in the stability stage gradually supersede the invading species and their recoveries were improved so their distributions were widened. Thus the plant composition tends toward homogeneity. Results Table 2, Figs. 3 and 4 show 10 vegetation types in the enclosure area are separated. *A. verus* was the dominant species, that can be seen at 90% of vegetation types, The second dominant species was *Acanthophyllum microcephalum*, that can be seen at 70% of vegetation types, and Perennials grasses (*B. tomentellus*, *S. barbata* and *F. ovina*) as the third species was observed in the 70% of vegetation types. The average composition of these perennial grasses, were 9.44, 3.87 and 3.28 Percentage, respectively.

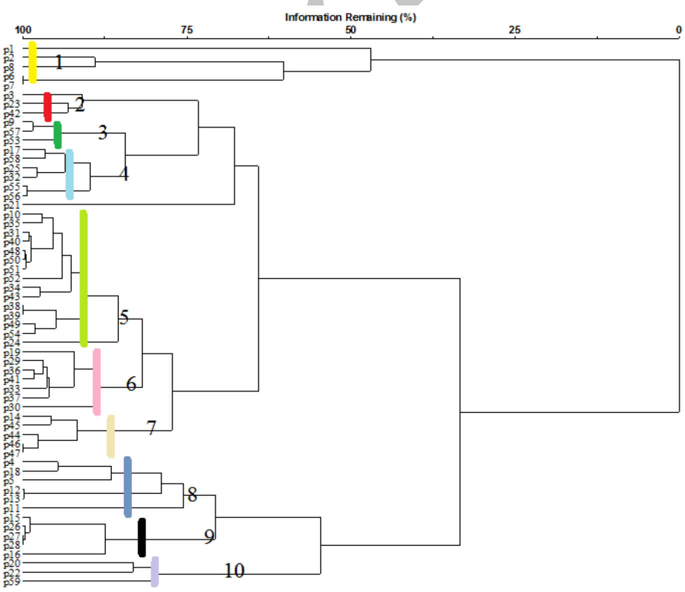


**Fig. 3.** Cluster analysis and grouping of sites in Gonbad enclosure

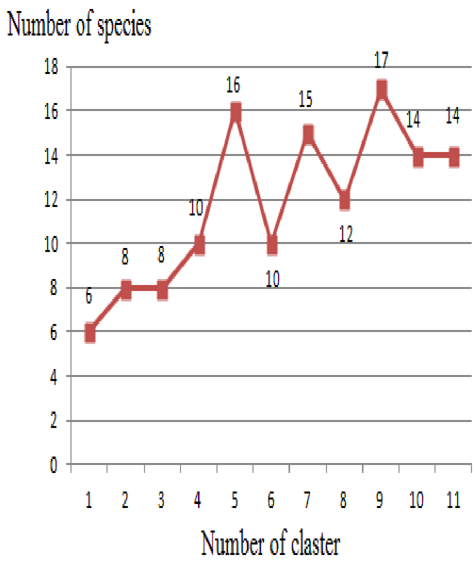


**Fig. 4.** Number of cluster with 17 Indicator plant species in Gonbad enclosure

**Table 2.** Profile of vegetation types of the clustering

| Vegetation Types | Cluster No. | Plot Number | N0 Indicator species | Dominant Species 1 (%) | Dominant Species 2 (%) | Dominant Species3 (%) |
|---|---|---|---|---|---|---|
| *Astragalus verus- Acanthophyllum microcephalum -* Perennial Grass | 1 | 1, 2, 6,7, 8 | 6 | *Astragalus* (25%) | *Acanthophyllum* (5%) | Perennial Grass (5%) |
| *Astragalus verus – Acanthophyllum microcephalum-Stipa barbata* | 2 | 3, 23, 42 | 8 | *Astragalus* (8%) | *Acanthophyllum* (5%) | *Stipa* (3%) |
| *Astragalus verus- Acantholimon bromifolium -* Perennial Grass | 3 | 9, 53, 57 | 8 | *Astragalus* (7%) | *Acantholimon* (4%) | Perennial Grass (3%) |
| *Astragalus verus – Acanthophyllum microcephalum – Bromus tomentellus* | 4 | 17, 25, 32, 55, 56, 58 | 10 | *Astragalus* (6%) | *Acanthophyllum* (2%) | *Bromus* (2%) |
| *Acantholimon bromifolium - Acanthophyllum microcephalum - Bromus tomentellus* | 5 | 21 | 16 | *Acantholimon* (10%) | *Acanthophyllum* (7%) | *Bromus* (6%) |
| *Astragalus verus – Acanthophyllum microcephalum - Acantholimon* | 6 | 10, 24, 31,34, 35, 38,39,40, 43,48, 49,50, 51, 52, 54 | 10 | *Astragalus* (4%) | *Acanthophyllum* (2)% | *Acantholimon* (1%) |
| *Astragalus verus- Acanthophyllum microcephalum - Stipa* | 7 | 19, 29, 30, 33, 36, 37, 41 | 15 | *Astragalus* (5%) | *Acanthophyllum* (4%) | *Stipa* (2%) |
| *Astragalus verus- Acanthophyllum microcephalum -* Perennial Grass | 8 | 14, 44, 45, 46, 47 | 12 | *Astragalus* (4%) | *Acanthophyllum* (2%) | Perennial Grass (2%) |
| *Astragalus verus-* Perennial Grass | 9 | 4, 5,11,12, 15, 16, 13, 18, 26, 27,28 | 17 | *Astragalus* (16%) | Perennial Grass (5%) | - |
| *Astragalus verus –Bromus tomentellus* | 10 | 20, 22, 59 | 14 | *Astragalus* (10%) | *Bromus* (5%) | - |

## DCA Analysis

The relationships between vegetation and environmental variables were evaluated using DCA analysis. The first and the second axes in the DCA ordination showed Eigen values of 0.252 and 0.143, respectively. DCA bipolt separated plant communities into eight groups based on environmental factors (Fig. 5). Pearson and Kendall Correlations with Ordination axes are presented in Table 3. The changes along the first axis were functions of changes in the environmental factors of stone and gravel, EC, clay content, and organic carbon. The changes along the axis2 were related to canopy cover of grasses, canopy cover of vegetation, and pH. In the first quarter, three environmental factors of EC, slope, and altitude affected the formation of plant species. However, the effects of these factors were not significant. In the second quarter, grass vegetation played an important role in the differentiation of plant community groups, and there was a significant correlation between grass canopy cover and this group (r= -0.451, Table 3). Moreover, total production and vegetation canopy were not significantly correlated with plant classification (r= -0.425, Table 3). In the third quarter, TNV, soil conservation, and pH were correlated with the differentiation of this group with correlation coefficients of -0.523, -0.458 and -0.333, respectively (Table 3). In the fourth quarter, stone and gravel, distance between plants, and clay content had significant impacts on the differentiation of this group with correlation coefficients of 0.548, 0.415 and 0.321 (Table 3), respectively. However, in each quadrant, other groups could be differentiated with different correlation coefficients as shown in Fig.5. Pearson and Kendall correlations with ordination showed that among 27 environmental factors, grass vegetation, TNV, and stone and gravel made the highest contributions to the differentiation of the first and second groups. Result indicated that TNV had a significantly negative correlation with both the first and second axes in the third quarter (r=-0.34 and -0.51), respectively and affected in the differentiation of this group. In agreement with current results, Alah Quli and Asri (2013) found that both climatic factors and soil footers as EC, pH, soil texture, lime and sodium adsorption ratios were important in plant distribution. Plant species also played a significant role in the separation of plant communities and could be considered as an important factor causing such differentiation. For example, *Bromus tomentellus* was negatively correlated with the first axis (r=0.54) and affected the differentiation of plots and plant communities in the second quarter. *Astragalus verus* had a significant negative correlation with the first and second axes (r=-0.470 and -0.490), respectively, and affected the differentiation of plant communities in the third quarter. *Echinops sp.* was correlated with the first axis (r=0.526) and affected the differentiation of plant communities in the fourth quarter. *Picnemon acarna* is correlated with the first axis (r=0.622) and affected the differentiation of plots and plant communities in the fourth quarter. *Festuca ovina* was correlated with the second axis (r=0.441) and affected the differentiation of plots and plant communities in the second quarter. In general, the changes along the first axis were the function of environmental factors. The changes along the second axis were the function of gradual changes of vegetation appropriate to sea level, stone and gravel, slope, loam, and clay contents, which are separated into two groups (Table 3). McDonald's (1987) reported the classification of the Swart vegetation resulted in the description of 21 plant communities. The relationships between the plant communities and the environment were, however, not clear. The classification suggested that the plant communities are related to soil geology and soil moisture status, indicating a need for further data analysis using ordination. Ahmad's (2010) obtained DCA Eigen values for the first two axes as 0.59 and 0.46. These values suggest a good dispersion of data along the axes. However, scatter diagram was more easily interpretable in ecological terms. Karimian *et al.*, (2004) suggested that enclosure is a practical tool for finding the best way to revitalize and reform the management of pastures. Desirable species were increased in enclosure areas (Asadian *et al.,* 2005), and over long term, enclosure caused significant changes in vegetation (Akbarzadeh, 2005). The results reported by Asadian *et al.* (2005), Alzerko *et al.* (1998), Haynes *et al.* (2012), and Motamedi *et al.* (2013) are consistent with those obtained in this study.

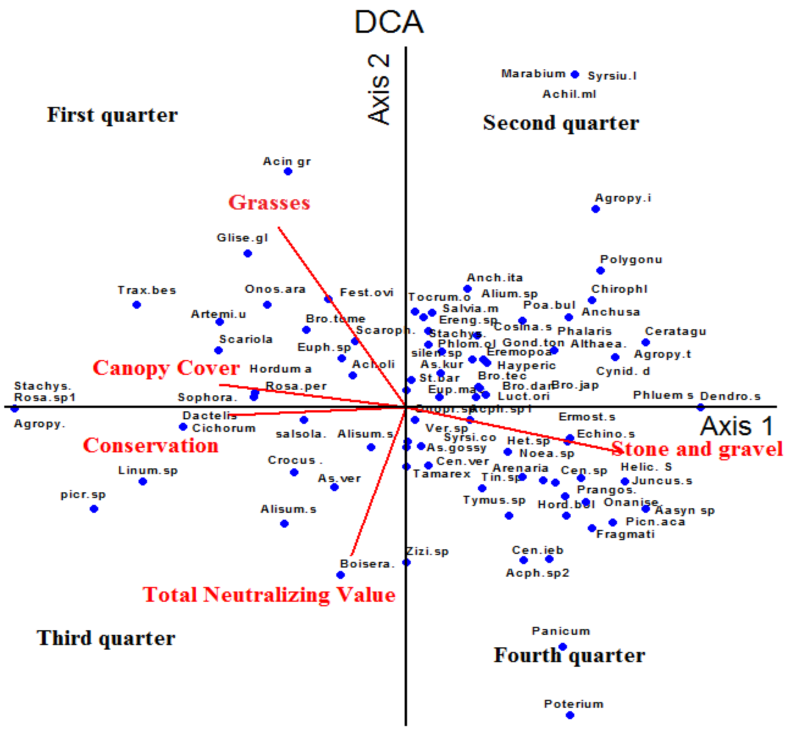


**Fig. 5.** DCA ordination for relationships between vegetation and environmental variables in Enclosure Rangelands (Case study: Gonbad, Hamadan)

**Table 3.** Pearson and Kendall Correlations with Ordination Axes

| **Environmental Factors** | | **Axis:1** | | | **Axis:2** | | | **Axis:3** | |
|---|---|---|---|---|---|---|---|---|---|
| | ***r*** | r-sq | tau | r | r-sq | tau | r | r-sq | tau |
| Slope | 0.056 | 0.003 | 0.028 | 0.300 | 0.090 | 0.174 | 0.309* | 0.095 | 0.145 |
| Aspect | -0.260 | 0.068 | 0-.217 | 0.001 | 0.000 | -0.024 | 0.073 | 0.005 | 0.015 |
| Elevation. | 0.169 | 0.028 | 0.164 | 0.218 | 0.047 | 0.095 | -0.043 | 0.002 | -0.102 |
| Erosion | 0.098 | 0.010 | 0.022 | 0.043 | 0.002 | 0.033 | 0.185 | 0.034 | 0.125 |
| Sediment | 0.086 | 0.007 | 0.010 | 0.070 | 0.005 | 0.040 | 0.291 | 0.085 | 0.133 |
| The Distance between plants | 0.415* | 0.173 | 0.305 | -0.237 | 0.056 | -0.262 | -0.114 | 0.013 | -0.054 |
| Litter | -0.196 | 0.038 | -0.132 | 0.172 | 0.030 | 0.162 | 0.164 | 0.027 | 0.115 |
| Stone and gravel | 0.548* | 0.301 | 0.436 | -0.206 | 0.042 | -0.211 | -0.202 | 0.041 | -0.163 |
| Bare soil | 0.103 | 0.011 | 0.085 | -0.100 | 0.010 | -0.051 | 0.005 | 0.000 | -0.014 |
| Canopy cover | -0.509* | 0.260 | -0.364 | 0.194 | 0.038 | 0.167 | 0.139 | 0.019 | 0.079 |
| Conservation | -0.458* | 0.209 | -0.331 | -0.097 | 0.009 | 0.029 | -0.022 | 0.000 | 0.001 |
| Productivity | -0.425* | 0.180 | -.316 | 0.198 | 0.039 | 0.191 | 0.122 | 0.015 | 0.105 |
| Grasses | -0.451* | 0.203 | -0.321 | 0.507* | 0.257 | 0.319 | 0.179 | 0.032 | 0.093 |
| Forbs | 0.160 | 0.025 | 0.079 | 0.180 | 0.033 | 0.122 | 0.273 | 0.074 | 0.113 |
| Shrub cover canopy | -0.254 | 0.064 | -0.213 | -0.110 | 0.012 | -0.180 | 0.022 | 0.000 | -0.053 |
| Sand | -0.145 | 0.021 | -0.026 | 0.137 | 0.019 | 0.066 | -0.024 | 0.001 | -0.003 |
| Silt | -0.078 | 0.006 | -0.072 | 0.041 | 0.002 | 0.013 | -0.037 | 0.001 | -0.017 |
| Clay | 0.321 | 0.103 | 0.199 | -0.268 | 0.072 | -0.161 | 0.078 | 0.006 | 0.074 |
| Nitrogen | 0.092 | 0.008 | 0.216 | -0.023 | 0.001 | 0.169 | -0.103 | 0.011 | -0.074 |
| Potassium | 0.176 | 0.031 | 0.106 | -0.035 | 0.001 | -0.047 | 0.008 | 0.000 | 0.016 |
| Phosphor | 0.214 | 0.046 | 0.210 | 0.079 | 0.006 | 0.051 | 0.123 | 0.015 | -0.023 |
| Organic carbon | 0.256 | 0.065 | 0.246 | 0.201 | 0.040 | 0.143 | 0.007 | 0.000 | -0.014 |
| Total neutralizing value | -0.334* | 0.112 | -0.276 | -0.523* | 0.273 | -0.239 | 0.036 | 0.001 | -0.070 |
| Acidity | -0.333* | 0.111 | -0.290 | -0.222 | 0.049 | -0.144 | -0.123 | 0.015 | -0.055 |
| Electrical conductivity | 0.337 | 0.114 | 0.242 | 0.162 | 0.026 | 0.085 | 0.010 | 0.000 | 0.007 |
| Saturation Percent | 0.146 | 0.021 | -0.001 | -0.209 | 0.044 | -0.154 | 0.086 | 0.007 | 0.156 |
| Carbon to Nitrogen Ratio | 0.143 | 0.021 | 0.071 | -0.389* | 0.151 | -0.222 | 0.283 | 0.080 | 0.132 |

## PCA Analysis

Results of principal component analysis (PCA) of soil properties and environmental factors are presented in Table 4. Result indicated that the first six axes accounted for 72.8% variation. In the first component, the variables of stone and gravel, soil conservation, productivity and canopy cover were accounted for 27.39% of total variation. Regarding the second component, vegetation density, litter, sand, clay, nitrogen and organic carbon were more important traits and explained a 13.85% variation. In the third component, the variables of slope, erosion, sediment, TNV and pH with the 10.20% variation were considered as third priority factors. The elevation and soil saturation with the 8.80% variation were considered as forth priority factors (Table 4). The results of biplot for the first and second components of PCA (Fig. 6) showed the association of plots (plant communities )with environmental factors. Result showed that in the first component, stone and gravel positively and, soil conservation, productivity and canopy cover negatively correlated with the first axis. Therefore, species in the left hand side of the first axis had good adaptability with soil productivity. In the second component, sand% had positive correlation with the second axis and negatively correlated with vegetation density, litter, nitrogen and organic carbon therefore, the species in upper part of biplot had a good adaptability with sandy soils. In contrast, the species in the lower part of biplot had a positive relationship with fertile soil. According to the results of PCA analysis, species *Hordeum anuale, B. danthonia, B. japonica and B. tectorum*, were correlated with stone and gravel and soil pH. The species of *Taeniatherum crinitum, Onosma araraticum, Glycyrrhiza glabra, Gundelia tournefortii, Acanthophyllum microcephalum, Cousinia bijarensis, Allium haemanthoides, Centaurea virgata, Eremopoa persica, Acinos graveolens, Verbascum cheiranthifolium, Eryngium billardieri, Stipa barbata, Phlomis Olivier, Alyssum lanigerum, Scrophularia subaphylla* and *Salvia multicaulis* were associated with slope, aspect and TNV. The species *Echinops ritrodes, Cynodon dactylon, Agropyron trichophorum, Agropyron intermedium, Ononis spinosa, Anchusa italic* and *Phragmites australis* were correlated with Sediment environmental factor. The species *Juncus bufonius, Ceratagus sp., Dendrostellera lessertii* and *Aasyneama sp.* were correlated with stone and gravel. The species of *Alcea Koelzii, Eremostachys mollucelloides, Achillea millefolium, Tamarix sp., Hypericum scabrum, Centaurea iberica, Sanguisorba minor, Thymus daenensis, Arenaria serpyllifolia, Centaurea bruguierana, Helichrysum sp, Hordeum bulbosum, Marrubium astracanicum* and *Cirsium lappaceum* were correlated with, C/N. The species *Acanthophyllum crassifolium, Panicum sp., Chirophylum macropodum* and *Stachys inflate* were correlated with EC and species *Noaea mucronata, Onosma araraticum, Stachys setifera, Agropyron elongatum and Rosa persica* were correlated with, EC, Silt, Clay, K, P and S.P. Finally, the species of *Dactylis glomerata, Onopordum acanthium, Scariola orientalis, Astragalus kohrudicus, Picris sp., Linum catharticum, Silent commelinifolia, Cirsium congestum, Salsola canescens*, were correlated with, soil conservation, canopy cover, litter, shrubs and forbs environmental factor. Jafari *et al.* (2002) in a study with PCA analysis on Poshtkouh Rangeland, Yazd province, Iran founded the vegetation distribution pattern was mainly related to such soil characteristics as salinity, texture, soluble potassium, gypsum and lime. Generally, each plant species depending on the habitat conditions, ecological need and tolerated species showed a significant relation with some soil properties. Shafagh Kolvanagh *et al.* (2014) in the a study in Khalat Poshan Rangelands of Tabriz province suggested that soil low fertility, lack or imbalance of nitrogen, phosphorus and potassium were essential elements required by plants in rangeland, thereby reducing of the useful and palatable pasture species and increased of invasive species and non palatable and the rangeland sustainability will afoul threat of serious injury. Therefore, the sustainable management palatable species of rangelands constant attention is necessary to the balance of NPK in rangelands soil.

**Table 4.** Results of principal component analysis of soil properties and environmental factors

| Factors | Axis 1 | Axis 2 | Axis 3 | Axis 4 | Axis 5 | Axis 6 |
|---|---|---|---|---|---|---|
| Canopy cover | -0.33 | -0.14 | -0.12 | 0.09 | 0.04 | -0.02 |
| Conservation | -0.31 | -0.13 | 0.04 | 0.06 | -0.08 | -0.04 |
| Productivity | -0.29 | -0.04 | -0.18 | -0.11 | -0.03 | -0.16 |
| Stone and gravel | 0.25 | 0.12 | 0.02 | -0.12 | 0.02 | -0.21 |
| Nitrogen | 0.19 | -0.32 | 0.08 | -0.25 | 0.13 | -0.11 |
| Organic carbon | 0.22 | -0.30 | 0.09 | -0.24 | 0.08 | -0.12 |
| Litter | -0.24 | -0.26 | -0.06 | 0.02 | -0.02 | -0.18 |
| Clay | 0.18 | -0.26 | 0.07 | 0.23 | -0.25 | -0.17 |
| Vegetation density | 0.24 | 0.27 | -0.03 | 0.01 | -0.08 | -0.11 |
| Sand | -0.18 | 0.28 | -0.20 | -0.29 | -0.10 | 0.21 |
| Slope | -0.02 | 0.09 | -0.36 | 0.15 | 0.19 | -0.27 |
| Sediment | 0.19 | 0.17 | -0.33 | 0.19 | 0.05 | -0.19 |
| Erosion | 0.18 | 0.24 | -0.32 | 0.15 | 0.04 | -0.18 |
| Acidity | -0.18 | 0.26 | 0.31 | -0.05 | 0.03 | -0.16 |
| Total neutralizing value | -0.13 | 0.09 | 0.34 | 0.34 | -0.14 | -0.18 |
| Carbon to nitrogen | 0.05 | 0.09 | 0.27 | 0.09 | -0.15 | -0.26 |
| Elevation. | 0.09 | -0.02 | 0.20 | -0.34 | 0.14 | -0.13 |
| Saturation. | 0.16 | -0.16 | -0.09 | 0.40 | -0.16 | -0.01 |
| Potassium | 0.13 | -0.25 | -0.20 | -0.06 | -0.35 | -0.11 |
| Phosphor | 0.10 | -0.22 | -0.15 | -0.26 | -0.32 | -0.02 |
| Shrub cover canopy | -0.23 | -0.03 | 0.17 | 0.13 | -0.30 | 0.02 |
| Grasses | -0.20 | -0.22 | -0.19 | 0.01 | 0.26 | -0.12 |
| Aspect | -0.14 | 0.08 | 0.05 | -0.06 | 0.32 | -0.21 |
| Electrical conductivity | 0.16 | -0.14 | 0.06 | 0.14 | 0.32 | 0.32 |
| Silt | 0.11 | -0.17 | 0.22 | 0.22 | 0.38 | -0.16 |
| Bare soil | 0.22 | 0.11 | 0.13 | 0.06 | -0.08 | 0.37 |
| Forbs | -0.05 | -0.17 | -0.12 | 0.23 | 0.15 | 0.40 |
| Eigen values | 7.397 | 3.741 | 2.756 | 2.378 | 1.783 | 1.613 |
| Percent of variance | 27.39 | 13.85 | 10.2 | 8.8 | 6.6 | 5.97 |
| Cumulative variance | 27.39 | 41.25 | 51.45 | 60.26 | 66.87 | 72.84 |
| Broken-stick Eigen value | 3.891 | 2.891 | 2.391 | 2.058 | 1.808 | 1.608 |

The underlined and bold data has significant correlation with relative axis

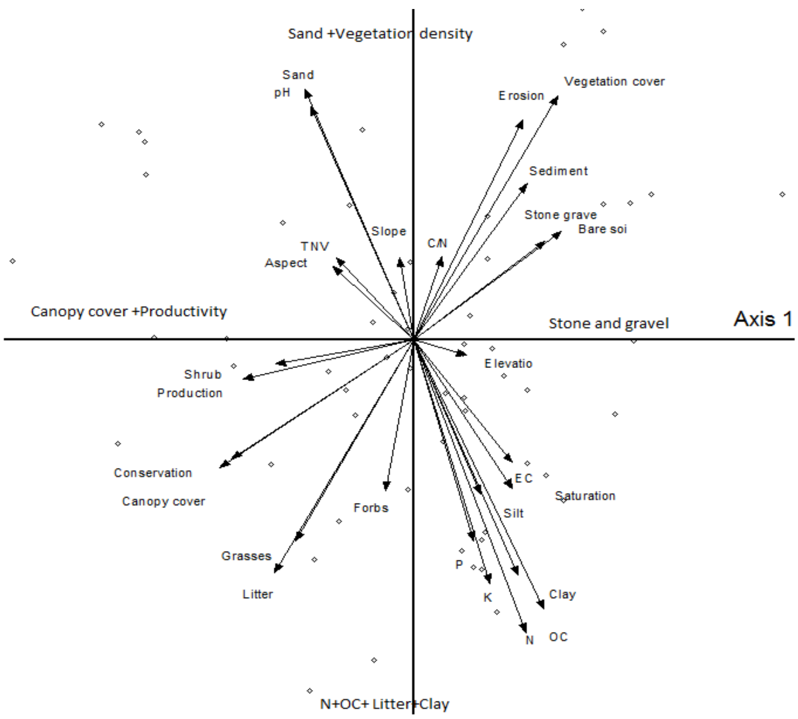


**Fig. 6.** Bipolt of the first two principal component axis for relationships between soil properties and environmental factors and vegetation types using PCA analysis in Enclosure area of Gonbad Rangelands (the ° symbol is species name that is no shown)

## Conclusion

According to the results, it is clear that in methods of DCA, PCA and cluster analysis, the environmental factors such as stone and gravel, T.N.V, canopy cover, soil conservation and organic carbon, were important and had significant effects on the separation of plant *communities. Other environmental factors such as soil texture, slope, EC, pH, C/N ratio, Erosion* and Sediment were placed in the second ranked for plant distribution. Plant characteristics such as; plant species, canopy cover of grasses, canopy cover of vegetation, productivity, density, litter, were also important and had significant impact on the separation of ecological unit. The vegetation types *Astragalus*- perennial Grass and *Astragalus*- *Bromus* were correlated with stone and gravel, high pH and bare soil. The vegetation types *Astragalus verus - Acanthophyllum microcephalum* - Perennial grass, *Astragalus verus- Acantholimon bromifolium* -Perennial grass, *Astragalus verus- Acanthophyllum microcephalum– Bromus tomentellus, Acantholimon bromifolium- Acanthophyllum microcephalum- Bromus tomentellus*, *Astragalus verus- Acanthophyllum microcephalum– Stipa barbata* and *Astragalus verus- Acanthophyllum microcephalum* - Perennial grass were correlated with slope, aspect, T.N.V, C/N, EC, Silt, Clay, K, P and S.P. The vegetation type *Astragalus-Acanthophyllum-Acantholimon* was correlated with soil conservation, canopy cover, litter, shrubs and Forbs. According to the results, the enclosure zone came to stability stage during the past 20 years without grazing pressure and the effects of animal traffic. In addition to grazing management, increasing the vegetation canopy cover requires the management of environmental factors such as soil conservation, precipitation maintenance, and the planting of appropriate species from Class I plants in the rangelands to increase production and preservation of the ecosystem in a positive direction.

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# روابط بین عوامل محیطی و جوامع گیاهی در مراتع قرق (مطالعه موردی: گنبد همدان)

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**چکیده.** قرق و عدم استفاده از مرتع در بلند مدت بر ترکیب و یکنواختی پوشش گیاهی تاثیر می‌گذارد و منجر به بهبود وضعیت گیاهان می‌شود. از این رو در این مطالعه، ویژگی‌ها و تغییرات ساختار گیاهی در مراتع گنبد استان همدان، پس از ۲۰ سال قرق، با استفاده از پلات برون-بلانکه و روش جامعه‌شناسی گیاهی و تجزیه و تحلیل چند متغییره با استفاده از نرم افزار PC-Ord5 در سال ۱۳۹۳ ارزیابی شد. نتایج بر اساس نمودار خوشه‌بندی و آنالیز گونه‌های شاخص، نشان داد منطقه دارای ۱۰ تیپ گیاهی با ۱۷ گونه شاخص می‌باشد. آنالیز تطبیق قوس‌گیر نشان داد متغیرهای محور اول تابع درصد سنگ و سنگریزه، هدایت الکتریکی، رس و کربن آلی است، متغیرهای محور دوم تابع، تاج پوشش گراس‌ها، تاج پوشش کل و pH است. آنالیز مولفه‌های اصلی ارتباط جوامع گیاهی با عوامل محیطی در منطقه قرق را تائید کرد و مشخص شد واحد های اکو لوژیکی با عوامل سنگ و سنگریزه، (۰/۲۵)، رس (۰/۲۶-)، شن (۰/۲۸)، لای (۰/۳۸)، شیب (۰/۳۶-)، ارزش مواد خنثی کل (۰/۳۴) و گونه‌های گیاهی شاخص همبستگی دارند و منجر به تفکیک واحدهای اکولویک می‌شوند. همچنین نتایج نشان داد در قرق بلند مدت، جوامع گیاهی به سوی یک ترکیب یکنواخت و همگن میل کرده و وضعیت پوشش گیاهی بهتر شده است. بنابراین تراکم، ترکیب و گونه‌های گیاهی کلاس I افزایش یافته است.

**کلمات کلیدی**: خوشه‌بندی، DCA، PCA، تجزیه و تحلیل، قرق