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Plant species diversity among ecological species groups in the Caspian Sea coastal sand dune; Case study: Guilan Province, North of Iran

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Abstract. *Ravanbakhsh M, Amini T, Hosseini SMN. 2015. Plant species diversity among ecological species groups in the Caspian Sea coastal sand dune; Case study: Guilan Province, North of Iran. Biodiversitas 16: 16-21.* Biodiversity is often discussed in terms of species diversity is concentrated. Species diversity is one of the important characteristics of biological communities and its as a function of the number and size represent populations of species in a special geographic region.The aim of this study was to identification of ecological species groups and investigates the diversity among ecological species groups. The research area comprises a coastal dune system in northern of Guilan Province, Iran. Vegetation sampling was carried out along 22 shore perpendicular transects, approximately 500-m long. A total of 62 plot of 25 square meters were taken in transects. In each sampled plot, the cover percentage value of each species was estimated using Bran-Blanquet scales. Vegetation classified using Two-Way Indicator Species Analysis (TWINSPAN). The comparison of diversity indices among groups were performed with ANOVA test. The results revealed that there were 232 plant taxa and 8 ecological species group in the region. Results of analysis of variance in species diversity indices showed significant differences among the groups in terms of biodiversity indices. The survey of variation in the groups showed that groups 5 and 6 had the highest and groups 1, 2, 3, and 7 had the lowest indices. Checking of the group's position with high diversity in comparison with other groups in this coastal area indicates that the group settled on the coastal land with stabilized soil and proper distance from the sea had higher diversity indices.

Key words: Coastal sand dune, ecological species groups, plant species diversity, Guilan, Iran.

INTRODUCTION

Iran is one of the centers of plant diversity is considered old world so that nearly 22 percent of the 8000 plant species of flora are the endemic (Ghahreman 1975). Despite to endangered state of coastal vegetation in Iran, some fragmented sandy areas are still natural. Some of these separated sandy patches often constitute parts of Caspian coastal ecosystems designed in Ramsar checklist of International Wetlands (Alagol, Ulmagol and Ajigol Lakes, Amirkelayeh Lake, Anzali Mordab (Talab) complex MR., Bujagh National Park, Gomishan Lagoon, Miankaleh Peninsula, Gorgan Bay and Lapoo-Zaghmarz Ab-bandan) and others are considered as part of protected areas, no hunting areas, wildlife refuges, biosphere reserves (Naqinezhad 2012b; Ramsar 2014).

During the last decades, a few studies were conducted on the Flora, identification of vegetation groups and ecological characters in these ecosystems. Most of these studies concentrated in the wetlands on the southern beach of the Caspian Sea (Riazi 1996; Asri and Eftekhari 2002; Ejtehadi et al. 2003; Asri and Moradi 2004, 2006; Shokri et al. 2004; Asri et al. 2007; Sharifnia et al. 2007; Khodadadi et al. 2009). Rarely floristic and vegetation grouping studies were carried out on the southern coastal area of the Caspian Sea (Frey 1974; Amini 2001; Akhani 2003; Ghahreman et al. 2004; Sobh Zahedi et al. 2005, 2007; Naqinezhad 2012b). Ecological species groups differ from individual indicator species, in that once vegetation-environment relationships are established the abundance of multiple species of a group may strongly indicate environmental site conditions than the abundance of individual species (Bergeron and Bouchard 1984; Spies and Barnes 1985).

This study was carried out to evaluate the significance of coastal dune habitats for biodiversity conservation. In order to achieve this gold, the vegetation of the nearly unaltered coastal sand dune between Roodsar and Astara, on the southern Caspian Sea, was described by means of ecological species groups and quantitative analysis of the vegetation by diversity indices.

MATERIALS AND METHODS

Study area

The research area comprises a coastal dune system in northern Guilan Province, Iran, between 48° 52´ 44´´ - 50° 35´ 59´´ E and 36° 56´ 4´´-38° 26´ 55´´ N. The study area was delimited using a Landsat 7ETM satellite image (Path 166/ Row 34) (Figure 1).The Caspian Sea constitutes the southern limit of the study area. The climate is humid and very humid with cool winter according to Eumberger climate classification (Abedi and Pourbabaei 2010). Guilan has a humid subtropical climate with by a large margin the heaviest rainfall in Iran reaching as high as 1,900 mm in

the southwestern coast and generally around1, 400 mm. Rainfall is heaviest between September and December because the onshore winds from the Siberian High are strongest, but it occurs throughout the year though least abundantly from April to July. Humidity is very high because of the marshy character of the coastal plains and can reach 90 percent in summer for wet bulb temperatures of over 26°C (Zarekar et al. 2012). Mean annual temperature is 15.8˚C and precipitation is 1506 mm. Maximum and minimum temperature is 27.8°C in August and 4.1°C in February, respectively. The Alborz range provides further diversity to the land in addition to the Caspian coasts (Zarekar et al. 2012).

Sampling methods

Data collection was performed from May 2011 to May 2012. Voucher specimens were submitted in Guilan University Herbarium (GUH). Prior to the commencement of fieldwork a short reconnaissance survey was undertaken to get an overview of the area (Mashwani et al. 2011). A total of 22 site were selected and one transect was established in each site. For detailed data collection line transect survey was selected which is a very popular vegetation survey technique (Kent and Coker ,1992). Vegetation sampling was carried out along 22 shore perpendicular transects between 100-500-m long (Figure 1). The length of transects was variable depended on the strip of the natural vegetation. Size of sampling plots was determined using nested plot sampling and species/area curve (Muller-Dombois and Ellenberg 1974). A total of 62 sampling areas were selected in stands of vegetation that were homogeneous to the eye in floristic composition and structure (Monserrat et al. 2012). In each sampled plot, the cover percentage value of each species was estimated using Braun-Blanquet scale (Braun-Blaunquet 1964, Muller-Dombois and Ellenberg 1974).

Data analysis

Vegetation analysis method

The floristic data matrix consists of 62 plots and 116 species. To classify vegetation types present in the study area, the vegetation data were analyzed using two-way indicator species analysis (TWINSPAN) using PC-ORD version 4.14 (Mc Cune and Mefford 1999).This analysis was used to produce a divisive classification of the stations and plant species matrix (Murphy et al., 2003). This method is a commonly employed program in ecological studies for the classification of vegetation types according to their floristic similarity (Kent and Coker, 1992).Classification was stopped at the fifth level, so that the result in groups would contain sufficient number of samples to characterize each vegetation groups (Vogiatzakis et al. 2003; Khaznadar et al. 2009). The names of identified vegetation types were derived from the dendrogram and importance of more frequent species into each group of plots (Abedi et al. 2011).

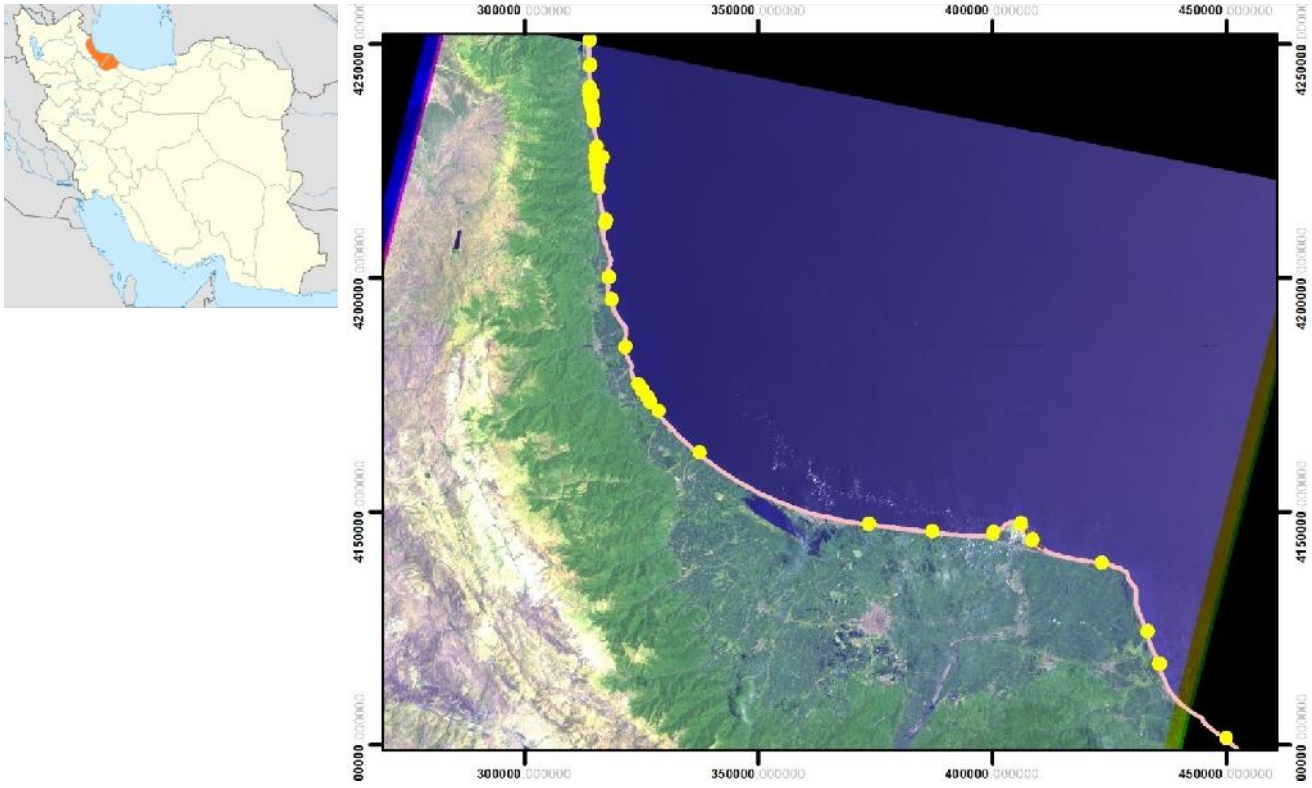

Figure 1. Location of Guilan Province in Iran and vegetation sampling in coastal sand dune.

Measuring plant diversity

To quantify the diversity of the plant species, The Shannon-Wiener's (H'), Simpson index (1-D), Margalef 's richness index (D_{Mg}) and Pielou 's evenness index (E_1) were used. The formulas are as follows.

$$1-D=\sum_{i=1}^{s} P_i^2 \qquad Pi=\frac{ni}{N}$$

$$D_{Mg}=\frac{S-1}{LnN}$$

$$H'=-\sum_{i=1}^{s} Pi\ ln\ Pi=-\sum_{i=1}^{s}(Pi)\ (\log pi)$$

$$E_1=\frac{H'}{Ln(s)}=\frac{Ln(N_1)}{Ln(N_0)}$$

H' = Shannon-Wiener's diversity index, D = Simpson's index, D_{Mg} = Margalef 's richness, E_1 = Pielou's evenness, Pi = relative frequency of i^{th} species, S = number of species, N = Total individual of species (Ludwig and Reynolds 1988).

Comparison of plant diversity

Normality of the data distribution was checked by Kolmogorov -Smirnov test, and Levene's test was used to examine the equality of the variances. One-way analyses (ANOVA) of variance were used to compare groups with normal distribution data. Duncan test was used to test for significant differences in the species richness, diversity and evenness indices among the groups. This analysis was conducted using SPSS 16.0.

RESULTS AND DISCUSSION

Vegetation groups

The application of TWINSPAN analysis led to identify vegetation groups associated with the distribution of these plants in the region (Figure 2). The classification was stopped at fifth level of division, leaving only groups with a sufficient number of samples to characterize the vegetation communities. Thus, 62 sampling plots were classified into eight groups. In the first level, 62 sampling plots were divided into two groups (Eigenvalue = 0.536). The indicator species which have been seen on the left side included: *Alnus subcordata, Oxalis corniculata* and *Scutellaria tournefortii*. The indicator species on the right side were *Crypsis schoenoides* and *Argusia sibirica*. In

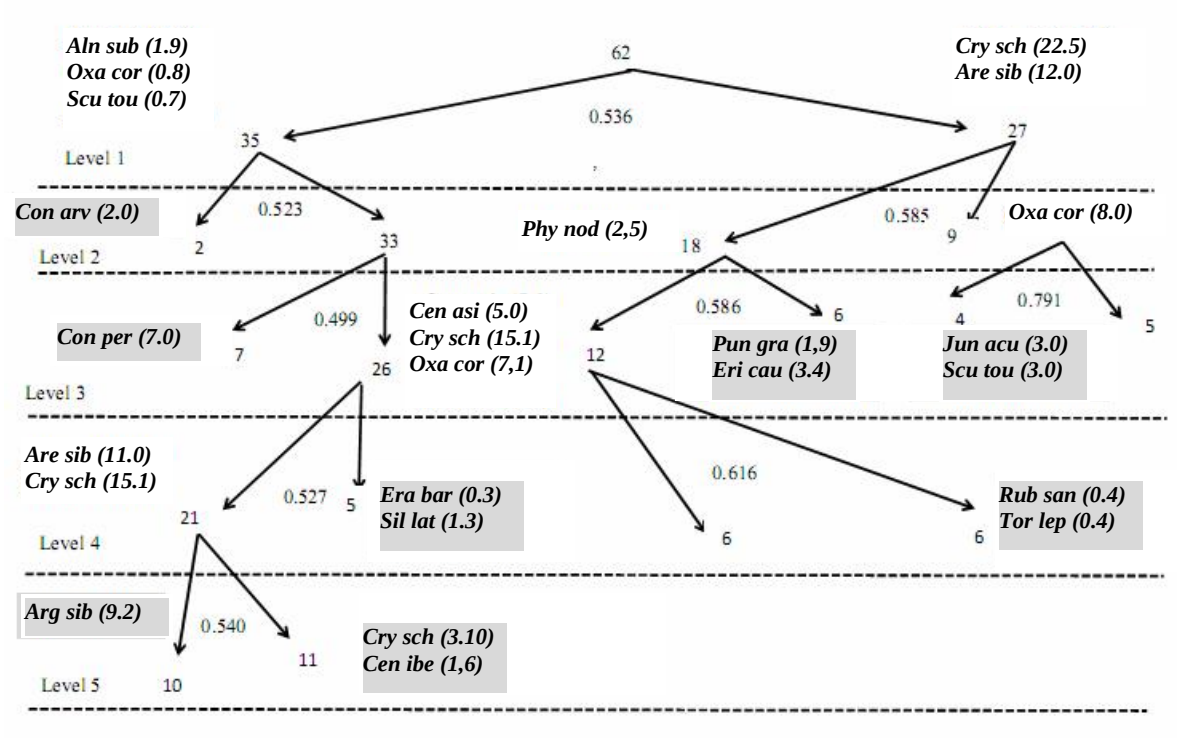

Figure 2. Classification of ecological species groups by using TWINSPAN analysis.
Note: Aln sub = *Alnus subcordata*, Oxa cor = *Oxalis corniculata*, Scu tou = *Scutellaria tournefortii*, Cry sch = *Crypsis schoenoides*, Arg sib = *Argusia sibirica*, Con arv = *Convolvulus arvensis* , Phy nod = *Phyla nodiflora*, Con per = *Convolvulus persicus*, Cen asi = *Centella asiatica*, Pun gra = *Punica granatum*, Ery cau = *Eryngium caucasicum*, Jun acu = *Juncus acutus*, Era bra = *Eragrostis barrelieri*, Sil lat = *Silene latifolia*, Rub san = *Rubus sanctus*, Tor lep = *Torilis leptophylla*, Cen ibe = *Centaurea iberica*.

Table1 1. ANOVA results of diversity indices among groups and mean and standard error of diversity indices.

Diversity index	F	P	Mean square	df	Mean and standard error
Shanon diversity index	3.756	.003*	.606	7	1.491±0.662
Simpson diversity index	3.074	.010*	.068	7	0.6572±0.236
Margalef richness index	2.769	.018*	1.872	7	2.070±0.285
Pielou 's evenness index	2.679	.021*	.051	7	0.6572±0.236

the second level, 35 sampling plots were divided into two groups (Eigenvalue = 0.523) with *Convolvulus arvensis* (group 1) on the left side as indicator species. Also, on the right side, there was not any indicator species. In this level, 27 sampling plots were divided into two groups (Eigenvalue = 0.585) with *Phyla nodiflora* and *Oxalis corniculata* on the left and right side, respectively, as indicator species.

In the third level, 33 sampling plots were divided into two groups (Eigenvalue = 0.499); the indicator species on the left side was *Convolvulus persicus* (group 2) and there was not any indicator species on the right side. In this level, 18 sampling plots were divided into two groups (Eigenvalue = 0.586). The indicator species on the left side included: *Centella asiatica*, *Crypsis schoenoides* and *Oxalis corniculata.* The indicator species on the left side were *Punica granatum* and *Eryngium caucasicum* (group 3). Also, in this level, 9 sampling plots were divided into two groups (Eigenvalue = 0.791). The indicator species on the left side were *Juncus acutus* and *Scutellaria tournefortii* (group 4) while on the right side, there was not any indicator species.

In the fourth level, 26 sampling plots were divided into two groups (Eigenvalue = 0.527); the indicator species on the left side were *Argusia sibirica* and *Crypsis schoenoides* and those on the right side included: *Eragrostis barrelieri, Silene latifolia* (group 5). In this level, 12 sampling plots were divided into two groups (Eigenvalue = 0.616); the indicator species were *Rubus sanctus* × *hyrcanus* and *Torilis leptophylla* (group 6) on the right side while there was not any indicator species on the left side. In the fifth level, 21 sampling plots were divided into two groups (Eigenvalue = 0.540) that those indicator species on the left and right side were *Argusia sibirica* (group7), and *Crypsis schoenoides* and *Centaurea iberica* (group8), respectively.

Species diversity among groups

First of all, based on Kolmogorov-Smirnov test it should be approved that the data are normal. .For analyzing the diversity among the groups, one-way Analysis of variance (ANOVA) was used. ANOVA results of diversity indices among groups and mean and standard error of diversity indices were listed in Table 1. ANOVA showed that there were significant differences among groups in terms of biodiversity indices ($P<0.05$).

Duncan's test of groups showed in figure of 3- 6. Figure 3 shows the changes of Shannon-Wiener's diversity index among ecological groups. Maximum of Shannon-Wiener's diversity index is in group 6. While there were not significant differences among groups of 5 and 6. The lowest value of Shannon-Wiener's diversity index is in group 3. There were not significant differences among groups of 1, 2, 3, 7 also between groups of 4 and 8. Figure 4 shows the changes of Simpson's diversity index among ecological groups. Group 6 had the highest value of Simpson's diversity index. The lowest value of Simpson's diversity index was in group 3.In this index there were not significant differences among groups of 1, 2, and 7 also between groups of 4 and 8.

Figure 5 shows the changes of Margalef's richness index among groups. The highest value of Margalef's richness was in group 5.and group 1 had the lowest value of Margalef 's richness index. Figure 6 shows the changes of Pielou's evenness index among ecological groups. The highest value of Pielou's evenness index was in group 5.and group 3 had the lowest value of this richness index. Altogether Duncan's tests showed that among the eight ecological groups, Group 5 and 6 had the highest and Group 1 and 3 had the lowest values in groups.

Discussion

In the present study, TWINSPAN analysis was performed to identify plant species groups. Results showed that eight ecological species groups were found in the southwestern coastal sand dune of the Caspian Sea. The vegetation groups in the Caspian coastal regions have been analyzed by different methods such as physiognomic, Braun-Blanquet and multivariate methods led to the identification of these communities and types: *Juncus, Rubus,* sand dune, halophyte, hydrophyte (Shokri et al. 2004); *Plantago indica-Carex nutans,* pure *Punica, Punica-Rubus, Punica-Juncus, Juncus-Rubus, Frankenia hirsuta-Plantago coronopus* (Ejtehadi et al. 2005); *Convolvulus persicus-Cakile maritima, Juncus acutus, Trifolium repens-Centaurea iberica, Tamarix ramosissima, Ruppia maritima, Typha latifolia-Phragmites australis, Schoenoplectus litoralis, Nelumbium caspicum, Ceratophyllum demersum-Myriophyllum spicatum* (Naqinezhad 2012a), *Potamogeton pectinatus, Ceratophyllum demersum-Azolla filiculoides, Nymphaea alba, Nelumbium nuciferum, Phragmites australis, Hydrocotyle ranunculoides, Typha latifolia, Cladium mariscus, Sparganium neglectum, Cyperus* sp., *Paspalum distichum, Cerastium dichotomum* (Asri and Moradi 2006); *Frankenia hirsuta, Juncus acutus, Juncus maritimus, Juncus littoralis, Juncus littoralis-Tamarix*

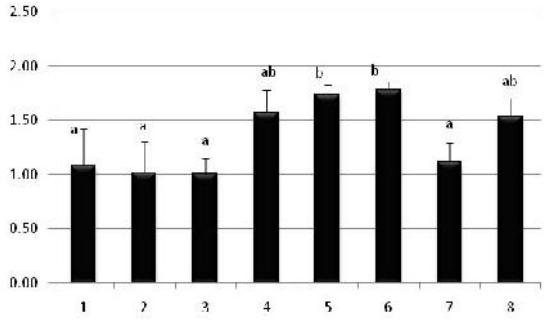

Figure 3. Changes in Shannon-Wiener's diversity index among ecological groups.

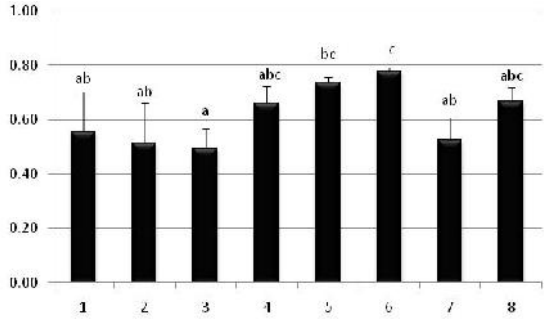

Figure 4. Changes in Simpson's diversity index among ecological groups.

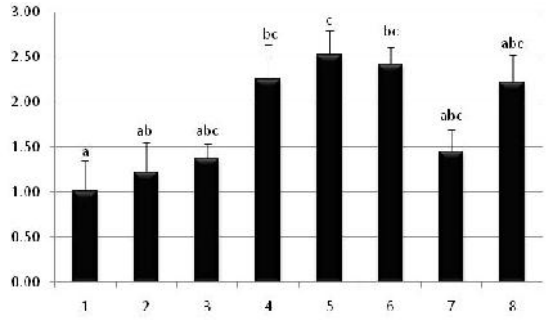

Figure 5. Changes in Margalef's richness index among ecological groups.

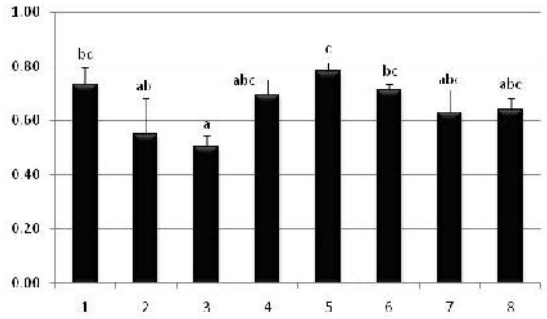

Figure 6. Changes in Pielou's evenness index among ecological groups.

arceuthoides, Salicornia europaea, Tamarix ramosissima, Artemisia tschernieviana, Convolvulus persicus, Tournefortia sibirica, Filaginella sp., *Juncus maritimus-Rubus sanctus, Juncus littoralis-Punica granatum, Juncus littoralis-Rubus sanctus, Mespilus germanica-Punica granatum, Punica granatum, Rhamnus pallasii-Punica granatum, Rubus sanctus-Punica granatum, Saccharum griffithii, Saccharum kajkaiense, Sambucus ebulus, Phragmites australis, Phragmites australis-Juncus acutus, Scirpus lacustris, Typha laxmannii, Typha laxmannii-Phragmites australis* (Asri et al. 2007).

These groups, types and communities indicated that some of them belong to Freshwater or marginal freshwater ecosystems those were plentifully found in the wetlands and southern coastal area of the Caspian Sea. Our study showed that the vegetation types included: *Convolvulus persicus, Juncus acutus, Punica granatum* and *Rubus sanctus* have been reported in the other studies (Shokri et al. 2004; Ejtehadi et al. 2005; Asri et al. 2007; Naqinezhad 2012a). The following ecological species groups were reported firstly from Iran containing: *Convolvulus arvensis, Eragrostis barrelieri-Silene latifolia, Argusia sibirica* and *Crypsis schoenoides-Centaurea iberica.*

As was mentioned in the results, the goal of this research was to investigate diversity indices among ecological groups. The results of the ANOVA and the Duncan's tests showed that the groups differed significantly in terms of biodiversity indices. Checking of the 3-6 Figures indicated that groups 5 and 6, and 1, 2, 3 and 7 had the highest and lowest level of the indices, respectively. The reason of high diversity in groups 5 and 6 can be interpreted that these groups belong to coastal pasture grass including helliophyta species. Also, the group 6 was a marginal sea shrub cover consisting of some sciophyta species in the under layer of canopy cover and helliophyta species in the open space between shrubs. Also, these two groups were grown on the stabilized soil with appropriate distance from the sea. In contrast, the reasons of the low species diversity in the groups 1, 2 and 7 were perhaps growing in don't fixed sand dunes and being closely to the sea.

In conclusion, diversity is one of the main factors of sustainable management. Identifying plants species of a region and their biodiversity is very effective way to identify disturbance factors and develop recovery plans. It is also essential to maintain a high proportion of native species, create protection programs and preserve the area against human and livestock disturbances. Our knowledge about plant biodiversity of the southern Caspian coast is fragmentary and requires in-depth studies to reveal all of its components. The southern Caspian coast and their sand dune went through extensive man-made changes during the past decades. The growth of population followed by the land usage changing for agriculture and urban utilizing, has affected on the biodiversity. The loss of genetic and species diversity by the destruction of natural habitats would need to restore many years. It is necessary to establish certain laws and regulations in order to protect all plants species and ecosystems.

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