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A Survey of Plant Species Diversity and Ecological Species Group from the Coastal Zone Of Boujagh National Park, Guilan, Iran

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Abstract. The aim of this study was to identify the ecological species groups and investigate the diversity among them. The research area comprises in a coastal system of Boujagh National Park, in Northern of Guilan Province, Iran. Vegetation sampling was carried out along 6 shore perpendicular transects, ween minimum 153 m and maximum 5562 m long. A total of 52 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). Classification of plots showed four vegetation groups: *Convolvulus persicus - Crepis foetida, Argusia sibirica, Eryngium caucasicum - Juncus acutus, Rubus sanctus.* Plant diversity in these vegetation groups have been evaluated. The comparison of diversity indices among groups were performed with ANOVA test. 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 group 3 had the highest and group 2 had the lowest Shannon-Wiener's, Simpson's and Fisher's diversity indices respectively. In Menhinink's and Margalef's richness indices group 2 and 3 had the highest and group 1 had the lowest measure. In Sheldon's evenness index group 2 had the highest and group 3 had the lowest measure. Finally, the overall survey of indices showed that groups 1 and 2 had less diversity but had more evenness than groups 3 and 4.This shows that despite suitable living conditions for the growth and development of vegetation in the groups 3 and 4, the abundance of species has declined Because of the destruction done in this section.

Key words: Boujagh National Park, Plant species diversity, Caspian Sea, Iran.

Introduction

Progression in natural resources sciences and the need to conserve biodiversity and manage resources of life, the survey of biological diversity by using different indicators to describe and compare the ecological diversity in natural resource management is highly regarded (KOLONGO *et al.,* 2006). Phytosociological surveys are important tools of ecologists to assess and evaluate the vegetation types of given ecosystem. These surveys ultimately help in planning, management and exploitation of natural resources since important components of food chain viz., human, livestock, wildlife and soil fauna are closely associated with specific plant assemblages of the area (MASHWANI *et al.,* 2011). Species diversity and richness or biodiversity are good indicators which

determine the health of an ecosystem. Diversity and richness of plants are reduced by abiotic (slope, feature, altitude, latitude, soil properties, etc.) and biotic (animal and human) factors along the time (JOURI *et al.*, 2011).

Coastal vegetation is interface region between land and sea, including habitat sand and plain is constantly affected by natural permanent changes and human interference (BEATLEY, 2002). 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 (RAVANBAKHSH *et al.*, 2015). Boujagh National Park (BNP) is the first founded land-marine National Park and one of nineteen National Parks in Iran located in Caspian coastline (NAQINEZHAD *et al.*, 2006). BNP is very important ecosystem complex because of the fact that this area serves as a very valuable resting, nesting and wintering place for a wide variety of waterfowls particularly Siberian Crane, an endangered migratory bird (NAQINEZHAD, 2012b). Some studies were conducted on the Flora and identification of species groups of this national park. The floristic study of this unique ecosystem investigated for the first time by NAQINEZHAD *et al.* (2006). They identified 248 vascular plants and 10 bryophytes out of which six taxa are endemic for the flora of Iran. Then in 2007 they recorded 4 species for Iran and Flora Iranica from these collected species. *Melilotus polonicus* L. (Fabaceae), as psammophyte plant on the Caspian coast is reported as new noteworthy record for the flora of Iran. *Apium leptophyllum* (Apiaceae), *Sisyrinchium exile* (Iridaceae) and *Tagetes minuta* (Asteraceae) are recorded for the first time from Iran/Flora Iranica area. NAQINEZHAD (2012a) recognized nine vegetation types in the area based with physiognomic-ecologic approach. This study was carried out to identify ecological species groups of the coastal zone of Boujagh National Park by phytosociological analysis of existing vegetation and inventory plant species diversity in this part of BNP.

Materials and Methods

Study area. Boujagh National Park located on the coast of Caspian Sea. This national park is located in Guilan Province, about 2 km away from north of Kiashahr city, and 35 km from northwest of Rasht city. It is 21 m below sea level and has an area of 3177 ha. Its geographical coordinates are 49° 51′ 40″- 49° 59′ 50″E and 37° 25′ 00″-37° 28′ 50″N. Boujagh and Kiashahr Lagoons are located within this national park (Fig. 1) (NAQINEZHAD, 2012b; REIHANIAN *et al.*, 2015).

Sampling methods. Prior to the commencement of fieldwork a short reconnaissance survey was undertaken to get an overview of the area (MASHWANI *et al.*, 2011). Vegetation sampling was carried out along 6 shore perpendicular transects between minimum 153 m and maximum 5562 m long (Fig. 2). 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 & ELLENBERG, 1974) A total of 52 plot of 25 square meters 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 & ELLENBERG, 1974).

Vegetation analysis. The phytosociological data were collected during 2014-2015, and using the cover-abundance scales. A divisive classification of 52 relevés was carried out, using the modified TWINSPAN embedded in a JUICE program (TICHÝ, 2002). Pseudospecies cut levels were set to seven and the values of cut levels to 1, 2, 3, 4, 5, 6, 7. Five relevés were selected as a minimum group size for division. The

fidelity of species to clusters and diagnostic species for particular vegetation units was calculated with the help of presence/ absence data using the phi-coefficient. Threshold value of phi = 0.25 was selected (TICHÝ & CHYTRÝ, 2006).

Measuring plant diversity. To quantify the diversity of the plant species, The Shannon-Wiener diversity index (H'), Simpson diversity index (1-D), Fisher's alpha - a diversity index (a), Menhinink richness index (DMn), Margalef richness index (DMg) and sheldon (Buzas and Gibson) eveness index (E3) were used. The formulas are shown in Table 1.

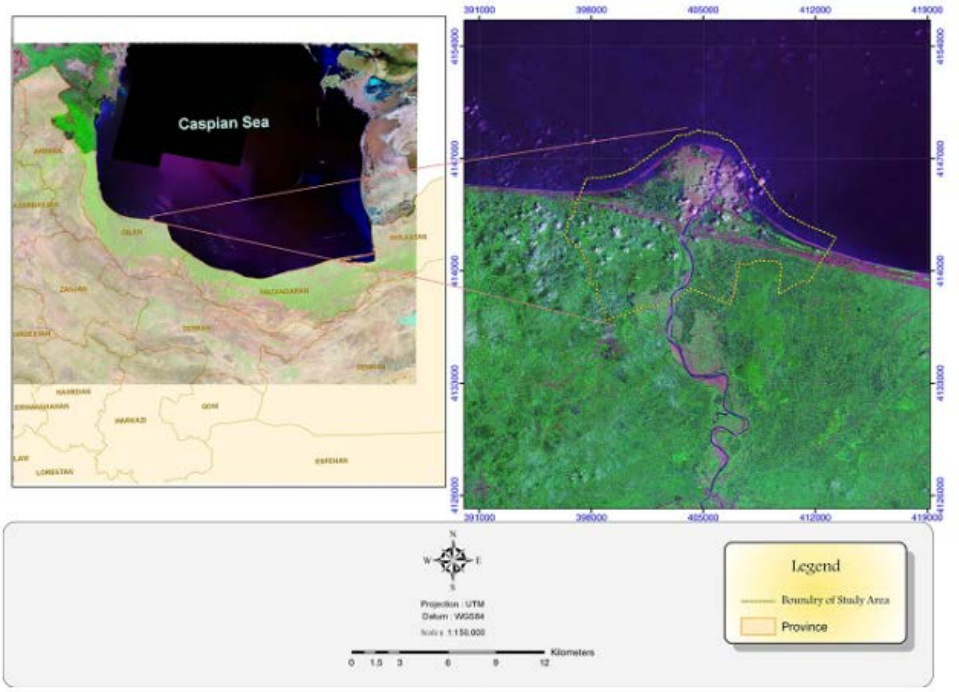

Fig. 1. Location of Boujagh National Park

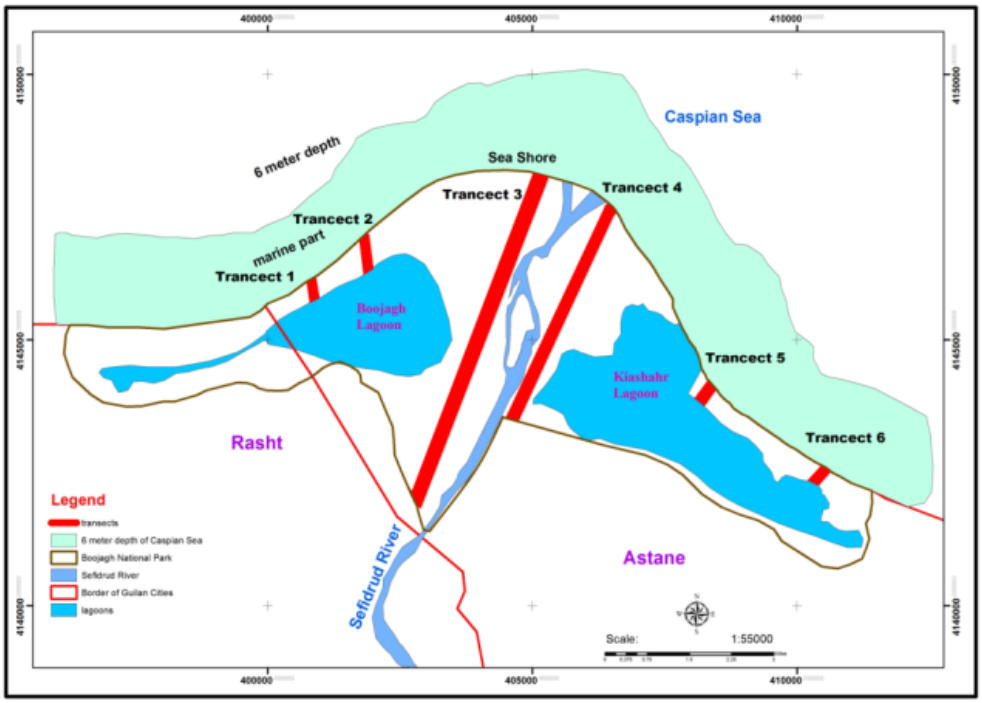

Fig. 2. Location of vegetation sampling in study area

Table 1. Richness, diversity and evenness indices used in this study (after EJTEHADI *et al.*, 2009). *Legend:* Pi = relative frequency of ith species, S = number of species (taxa), n is number of individuals, N = Total individual of species.

Diversity index	Richness index	Eveness index
$H' = -\sum_{i=1}^{s} Pi \ln Pi = -\sum_{i=1}^{s} (Pi)(\log pi)$	$D_{Mg} = \frac{S-1}{LnN}$	$E_3 = \frac{e^H}{S}$
$1 - D = \sum_{i=1}^{s} P_i^2 \qquad Pi = \frac{ni}{N}$	$D_{Mn} = \frac{S}{\sqrt{n}}$	
$S = a^* \ln(1 + {}^{n}/_{a})$		

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 analysis (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

Modified TWINSPAN analysis based on 52 plots were classified coastal area of Boujagh National Park. Four distinct groups of species were identified (Fig. 3, Table 2). Details of each group are as follows:

Group I (*Convolvulus persicus - Crepis foetida* subsp. *foetida*): This group with 12 plots, including annual plants which mostly formed a variable width strip in sand dune. Plants adapted to periodically disorder, heterogeneous and intolerable conditions such as strong winds, Waves, Waterlogging, severe storms and sand movement and can grows by seed and underground stems. Most plants of this group are obligatory psamophytes. The diagnostic species include *Convolvulus persicus, Crepis foetida* subsp. *foetida, Xanthium spinosum, Medicago minima.*

Group II (*Argusia sibirica*): This group with 5 plots including plants growing in dunes along the coastline of the Caspian Sea. Plants are resistant to high acidity and some of the species able to build colonies in this harsh environment by producing abundant seed or strong root. This plant species is resistant to low nutrients, high temperature, erosion and burying in the sand. Indicator species are *Argusia sibirica, Senecio vernalis, Cynodon dactylon*.

Group III (*Eryngium caucasicum - Juncus acutus*): This group of 16 plots were established in established sand around Sefidrood River and humid coastal areas. The most plants are ruderal, perennial and don't sensitive to soil acidity. Mostly have hemicryptophyte life form and help to soil stabilization. This group had most richness. Indicator species are *Eryngium caucasicum, Juncus acutus, Anagalis arvensis, Plantago lanceolata, Lolium perrene, Briza minor, Cerastium semidecandrum.*

Group IV (*Rubus sanctus*): this group with 19 plots has distance from the coastal line, therefore water salinity is lowed sand structure is relatively stable and soil is almost plainly. This group is suitable habitat for phanerophyte life form. Indicator species are *Rubus sanctus, Lotus krylovii, Medicago lupulina, Poa trivialis.*

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 2. ANOVA showed that there were significant differences among groups in terms of biodiversity indices ($P<0.05$).

Duncan's test of groups showed in fig. of 4-9. Figure 4, 5 and 6 shows the changes of diversity indices (Shannon-Wiener, Simpson and Fisher). Group 3 and group 2 had maximum and minimum of these indices respectively. The measurement of these indices indicated that Groups 3 and 4 also Groups 1 and 2 had closer value to each other. In Simpson index is not significant difference between groups 3 and 4.

Fig. 7 and 8 shows the changes Menhinink and Margalef's richness indices among ecological groups. Group 1 had the lowest value of these indices and the highest value belong to Group 2 and Group 3 in these indices. Figure 9 shows the changes of Sheldon's evenness index evenness index among ecological groups. The highest value of Sheldon's evenness index was in group 2 and group 3 had the lowest value of this richness index. In this index is not significant difference between groups 3 and 4 also, the value of group 1 and 2 are close together. In total the indices showed group 1 and 2 had more evenness but lower richness and diversity in compared to group 3 and 4.

Discussion

Conversation of plant species diversity is one of the goals of ecosystems management. Plant species diversity is used in vegetation studies and environmental assessments as one of the important and rapid indices of determining ecosystem status (SHARAFATMANDRAD *et al.*, 2014).

Coastal sand dune habitat as an ecological niche between onshore and offshore basins is used to create a major natural conservation sites. However, these habitats have been severely affected by natural and human activities resulting in its fauna and flora have been destroyed (SAYE & PYE, 2007). The coastal parts of the South Caspian Sea are severely degraded because of intensive human activities. Nearly all parts of the area are occupied by villas, hotels, industry or are under cultivation. Some fragmented dunes can be seen in the eastern parts between Anzali and Astara, which they are invaded by many ruderal plants (AKHANI, 2003).

Seventeen vegetation types respectively from the coast to the mountains in the Caspian area identified. In the first was Sand dune vegetation. Large parts of sandy dunes along the coast have been degraded and fragmented due to intensive urbanization, transforming into agricultural lands and industry (AKHANI *et al.*, 2010). NAQINEZHAD (2012b) introduced least three vegetation bands (zones) around the south Caspian coastline. first band is related to sand dune habitats covered by psammophytes. The second band covered by wet sandy soils, has a higher water table and possesses many plant species. The most important species dominated often in these habitats are *Juncus* species. The third belt is characterized with many depressions, big holes, wetlands or lagoons.

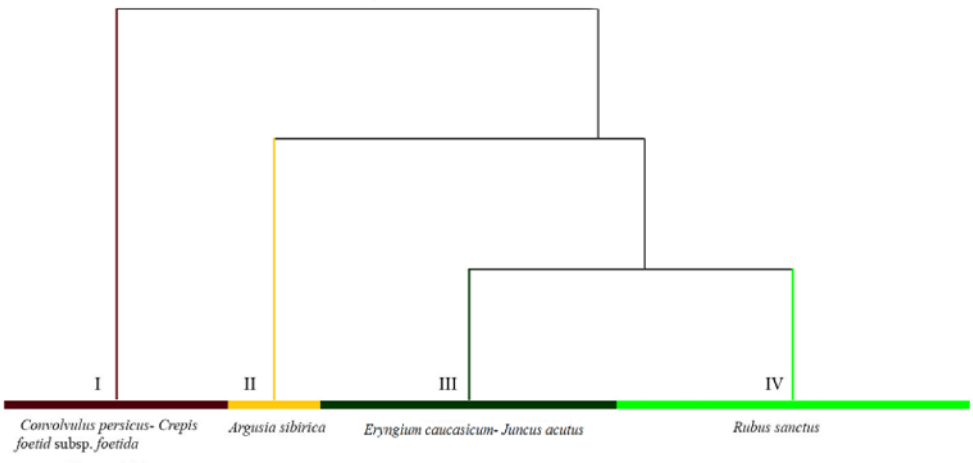

Fig. 3. The cluster analysis to classify samples by Modified TWINSPANS.

Table 2. Synoptic table with the frequency of each species in each group by Modified TWINSPANT analysis.

Group	**1**	**2**	**3**	**4**
Number of plots	**12**	**5**	**16**	**19**
Crepis foetida subsp. *foetida*	83	.	6	5
Convolvulus persicus	67	.	.	5
Xanthium spinosum	58	.	31	16
Poa annua	42	.	25	32
Medicago minima	42	.	25	11
Argusia sibirica	25	80	.	11
Senecio vernalis	.	40	6	11
Xanthium brasilicum	8	40	13	.
Eryngium caucasicum	.	.	69	26
Anagalis arvensis	17	20	56	21
Plantago lanceolata	.	.	50	5
Lolium perrene	.	20	50	26
Briza minor	.	.	44	26
Cerastium semidecandrum	17	.	44	32
Cerastium glomeratum	8	.	44	11
Equisetum ramosissimum	.	.	31	47
Juncus acutus	17	.	63	68
Rubus sanctus	17	.	63	89
Lotus krylovii	8	.	13	37
Medicago lupulina	17	20	6	37
Poa trivialis	.	.	.	32
Cynodon dactylon	25	80	75	42
Geranium dissectum	.	.	31	26
Alopecurus myosuroides	8	.	6	26
Euphorbia helioscopia	.	.	31	26
Plantago major	.	.	38	26
Veronica persica	.	.	31	21
Torilis leptophylla	.	.	6	21
Galium gilanicum	.	.	38	21
Geranium molle	.	.	6	16
Mentha aquatica	.	.	.	16
Conyzanthus squamatus	.	20	13	16
Parentucellia viscosa	.	.	.	16
Lophochloa phleoides	.	.	19	16
Tamarix ramosissima	.	.	.	16
Setaria glauca	8	.	25	16
Sisymbrium officinale	.	.	38	16
Echinochloa crus-galli	.	.	.	16
Rumex sanguineus	.	.	6	11
Hydrocotyle vulgaris	.	.	.	11
Trifolium resupinatum	.	.	38	11
Vulpia myuros	8	.	6	11
Geranium purpureum	.	.	25	11
Alnus glutinosa subsp. *barbata*	.	.	.	11

Lotus corniculatus	8	.	13	11
Myosotis palustris	.	.	.	11
Digitaria sanguinalis subsp. *pectiniformis*	.	.	.	11
Conyza canadensis	.	.	38	11
Sonchus oleraceus	.	20	.	11
Ranunculus scleratus	.	.	25	11
Veronica arvensis	.	.	.	11
Vicia tetrasperma	.	.	19	11
Cirsium vulgare	.	.	19	11
Alnus subcordata	.	.	.	11
Eleusine indica	.	.	19	11
Galium elongatum	.	.	25	11
Lolium loliaceum	33	.	6	11
Potentilla reptans	.	20	25	11
Medicago polymorpha	.	.	6	11
Conyza bonariensis	25	.	6	11
Spergularia marina	.	.	.	11
Calamagrostis pseudophragmites	.	20	.	5
Daucus carrota	.	.	.	5
Polypogon fugax	.	.	6	5
Lathyrus aphaca		.	.	5
Stellaria media	.	.	.	5
Juncus gerardii	.	.	.	5
Iris pseudacorus	.	.	.	5
Paspalum paspaloides	.	.	.	5
Vicia sativa	.	.	.	5
Phragmites australis	17	.	.	5
Minuartia hybrida subsp. *hybrida*	.	.	6	5
Centaurium pulchellum	.	.	6	5
Lythrum hyssopifolia	.	.	6	5
Amaranthus viridis	.	.	6	5
Urtica urens	.	.	.	5
Salicornia europaea	.	.	6	5
Plantago psyllium	.	.	6	5
Arenaria leptoclados	25	20	19	5
Samolus valerandi	.	.	19	5
Artemisia annua	8	.	19	5
Polygonum patulum	.	.	19	5
Daucus litoralis subsp. *hyrcanus*	33	.	.	5
Catapodium rigidum	8	20	13	5
Eclipta prostrata	.	.	.	5
Chondrilla juncea	.	.	.	5
Phytolacca americana	.	.	.	5
Ranunculus marginatus	8	.	25	5
Trifolium repens	8	.	38	5
Capsella bursa-pastoris	.	.	.	5
Agriophyllum squarrosum	.	.	.	5
Punica granatum	.	.	.	5
Trachomitum venetum	.	.	.	5

Lolium persicum	.	.	25	5
Parapholis incurva	8	20	13	5
Maresia nana	.	.	.	5
Trifolium micranthum	.	.	13	5
Sonchus asper subsp. *glaucescens*	17	.	6	5
Silene conica	.	.	.	5
Melilotus indicus	8	.	.	5
Polycarpon tetraphyllum	17	.	.	5
Trifolium scabrum	.	.	6	5
Juncus bufonius	.	.	13	5
Potentilla supina	8	.	6	5
Silybum marianum	.	.	13	5
Lycopus europaeus	.	.	13	5
Silene gallica	8	.	.	.
Cakile maritima	8	.	.	.
Mulgedium tataricum	25	.	.	.
Salsola kali	.	20	.	.
Typha caspica	25	.	.	.
Rorippa islandica	.	.	13	.
Epilobium hirsutum	.	.	13	.
Ranunculus muricatus	.	.	13	.
Veronica polita	.	20	13	.
Bidens tripartita	.	.	6	.
Veronica anagaloides	17	.	13	.
Paspalum dilatatum	.	.	13	.
Carex divisa	.	.	19	.
Verbena officinalis	.	.	25	.
Trifolium campestre	.	.	25	.
Mentha pulegium	.	.	38	.
Hypericum perforatum	.	.	19	.
Ranunculus ophioglossifolius	.	.	19	.
Phyla nodiflora	.	.	19	.
Prunella vulgaris	.	.	19	.
Calystegia sepium	.	.	6	.
Crypsis schoenoides	.	.	6	.
Erodium cicutarium	.	.	6	.
Aster tripolium	.	.	6	.
Solanum nigrum	.	.	6	.
Sambucus ebulus	.	.	6	.
Nasturtium officinale	.	.	6	.
Bromus brachystachys	.	.	6	.
Rumex pulcher	.	.	6	.
Raphanus raphanistrum subsp. *raphanistrum*	.	.	6	.
Lolium rigidum	25	.	6	.
Linum bienne	.	.	6	.
Centaurea iberica	.	.	6	.
Trifolium striatum	.	.	6	.
Atriplex sp.	.	.	6	.

Table 2. 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
Diversity index	Shanon diversity index	7.534	0.000*	1.242	3	1.532 ±0.654
	Simpson diversity index	4.752	0.05*	0.101	3	0.688 ±0.221
	Fisher's diversity index	3.793	0.016*	25.391	3	3.707 ±0.382
Richness index	Menhinink 's richness	3.056	0.037*	0.980	3	1.104 ±0.822
	Margalef richness index	7.702	0.000*	8.628	3	2.481 ±0.171
Evenness index	sheldon's evenness index	4.248	0.010*	0.121	3	0.443 ±0.252

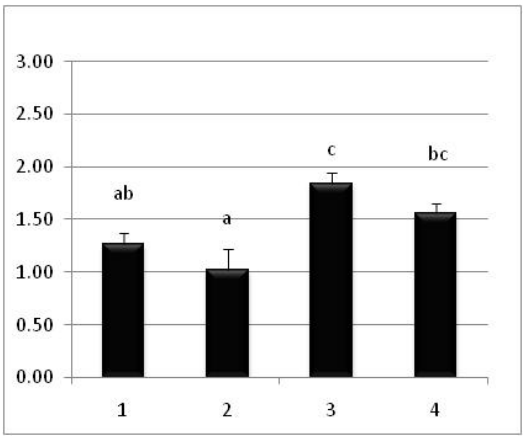

Fig. 4. Changes in in Shannon-Wiener's diversity index among ecological groups.

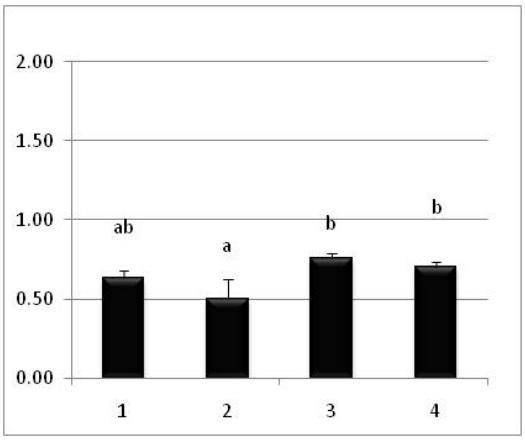

Fig. 5. Changes in in Simpson's diversity index among ecological groups.

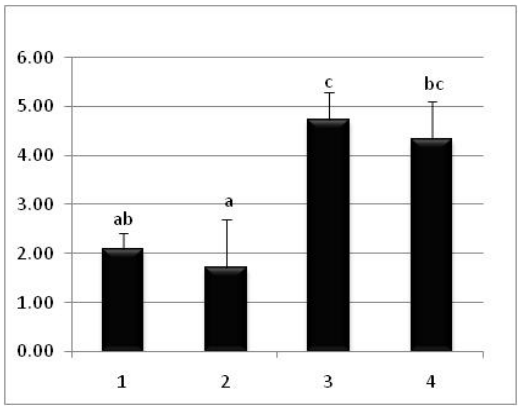

Fig. 6. Changes in Fisher's diversity index among ecological groups**.**

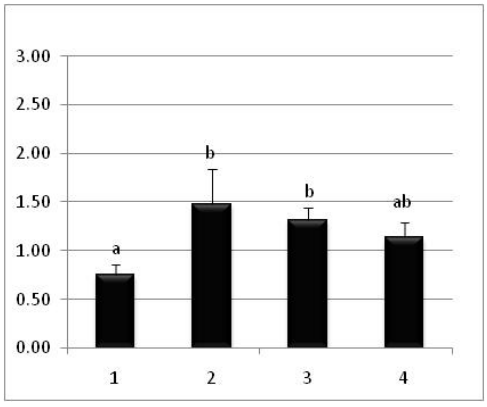

Fig. 7. Changes in Menhinink 's richness index among ecological groups.

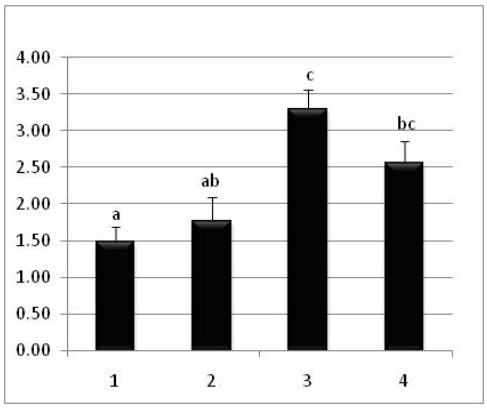

Fig. 8. Changes in in Margalef 's richness index among ecological groups.

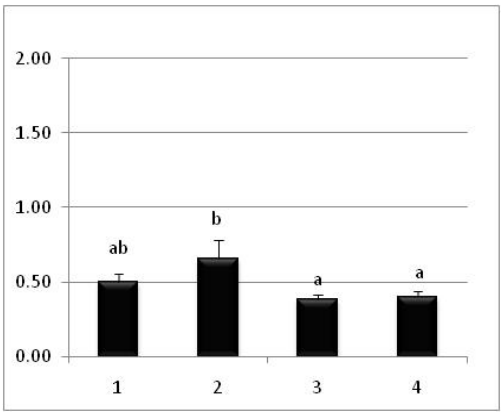

Fig. 9. Changes in in sheldon's evvennes index among ecological groups.

This study for the first time introduced ecological species group in coastal zone of Boujagh national park (BNP) by floristic method and multivariate analysis. Modified TWINSPAN analysis was identified four species groups. Other studies presented vegetation type and species group in coastal area of southern Caspian Sea are belong to SHOKRI *et al*. (2004), EJTEHADI *et al*. (2009), ASRI *et al*. (2007) and RAVNABAKHSH *et al*. (2015).

NAQINEZHAD (2012a) introduced four vegetation unites in coastal area of BNP Based on the field observations and physiognomic-ecologic method. Comparing our study results to this investigation showed that two groups *Convolvulus persicus* and *Juncus acutus* are similar and groups *Rubus sanctus* and *Argusia sibirica* as new groups of study area are introduced. Anova analysis results indicated that groups 1 and 2 (*Convolvulus persicus* - *Crepis foetida* and *Argusia sibirica*) had less diversity but had more evenness than groups 3 and 4. The survey of geographical location in these groups showed them located in unstable sand dunes. In more distance from the coastline is situated wet and stabilized sand dunes where is located groups 3 and 4 (*Eryngium caucasicum* - *Juncus acutus* and *Rubus sanctus*). In this habitat, ecological species groups with more diversity and richness and less evenness occupant. This shows that despite suitable living conditions for the growth and development of vegetation, the abundance of species has declined Because of the destruction done. The most important destruction reason in this habitat are grazing, recreation, the release of waste, commercial port construction, harvesting sand from the beaches and Sefidrud River. RAVNABAKHSH *et al*. (2015) surveyed plant diversity in ecological species group in Caspian Sea coastal sand dune. Checking of the group's position with high diversity in comparison with other groups indicated the group settled on the coastal land with stabilized soil and proper distance from the sea had higher diversity indices.

Conclusion

This study assessed coastal area of BNP by using diversity indices as an indicator for evaluating vegetation. Coastal area of BNP remain as fragmented strips lying parallel to the Caspian Sea coastline and are largely occupied by anthropogenic impacts including grazing, deposition of solid wastes, Construction and development of commercial port, Fishing, tourism and agriculture that result in drastic changes in plant species diversity. Strict enforcement of rules and monitoring of their implementation can be an effective step in reducing the damage caused by unsustainable development activities implemented in the study area.

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