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The survey of macrophytes diversity in wetlanl 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 wetland system of Boujagh National Park, in Northern of Guilan Province, Iran. Vegetation sampling was carried out by 44 sample plots were placed within the different zones in a stratified random manner. 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: "*Ceratophyllum demersum-Nelumbo nucifera, Juncus acutus-Rubus sanctus, Mentha aquatica-Phragmites australis, Hydrocotyle vulgaris-Phragmites australis*". 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 some biodiversity indices. The survey of variation in the groups showed that group 3 had the highest and group 1 had the lowest in Fisher's diversity indices and Menhinink's and Margalef's richness indices respectively. In Sheldon's evenness index group1 had the highest and group 2 had the lowest measure. Finally, the overall survey of indices showed that despite the high richness and diversity in groups of 3 and 2, evenness of these group less than group 1 with lowest richness and diversity.

Key words: Boujagh National Park, macrophytes, Caspian Sea, Iran

INTRODUCTION

Wetland macrophytes are defined as aquatic emergent, submergent or floating plants growing in or near water (USEPA, 1998). There are however some noted shortcomings of using macrophytes as biological indicators. These include the potential delay in response time for perennial vegetation, difficulty identifying taxa to the species level in certain seasons and for some genera,different herbivory patterns and varied pest-management practices (Cronk & Fennessy, 2001). Despite these limitations, macrophytes have provided strong signals of anthropogenic influence (USEPA, 2003).Knowledge of the plant communities enables us to forecast the likely changes in floristic composition afterchanges of site factors (Grevilliot & Muller, 2002). Description of patterns in species assemblages and diversity is an essential step before generating hypotheses in functional ecology (Jonsson and moen, 1998).

Vegetation studies on Water and surrounding area in wetland habitats along the southern Caspian shore has been done by Asri & Aftekhari, 1992, Riazi, 1996, Ghahreman & Attar, 2003, Shokri *et al.,* 2004, Asri & Moradi, 2006, Jalili *et al.,* 2009, Zahed *et al.,* 2013 and Naqinezhad e*t al.,* 2014.

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, 2012). 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. Naqinezhad (2012) recognized nine vegetation types in the area based with physiognomic-ecologic approach. This study was carried out to identify ecological species groups of the wtland 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

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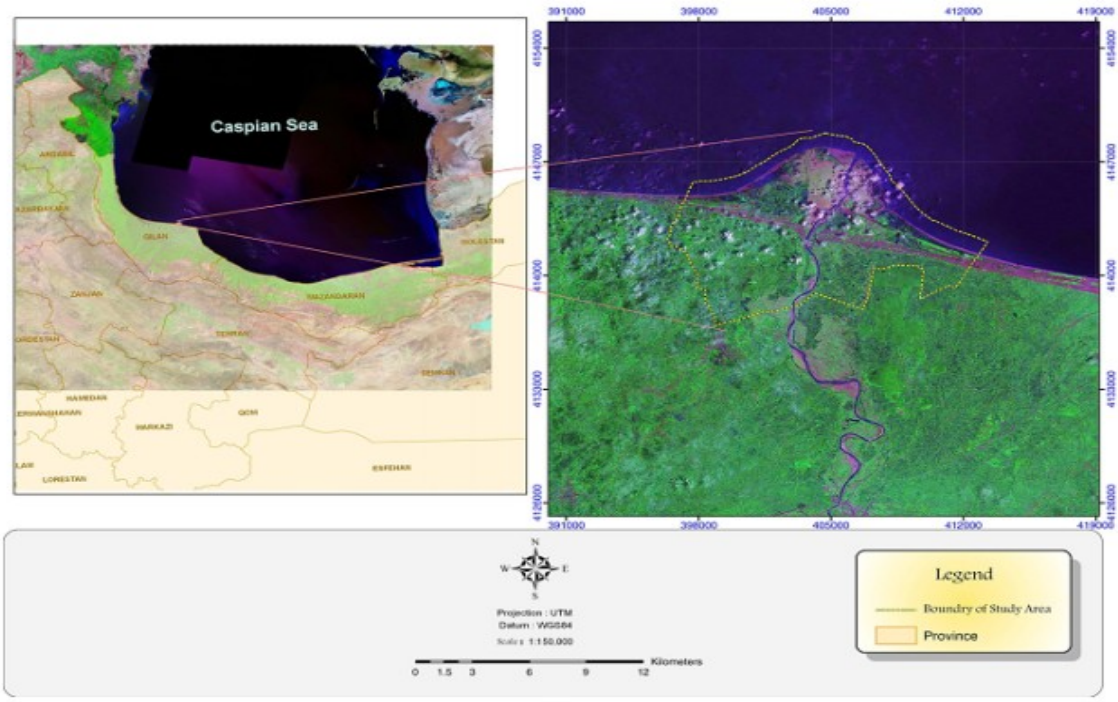

Figure 1. Location of Boujagh National Park

located within this national park (Fig. 1) (Reihanian *et al.,* 2012; Naqinezhad, 2012).

Sampling methods

Vegetation surveys were conducted within the period of 2013 to 2014. A total of 44 sample plots (2 m x 2 m) were placed within the different zones in a stratified random manner. In each sampled plot, the cover percentage value of each species was estimated using Braun-Blanquet scale (Braun-Blaunquet, 1964; Muller-Dombois & Ellenberg, 1974).

Data analysis

Vegetation analysis method

The phytosociological data were collected during 2014-2015, and using the cover-abundance scales. A divisive classification of 44 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.

Table 1. Richness, diversity and evenness indices used in this study

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

(Ejtehadi *et al*., 2009)

Pi = relative frequency of i^{th} species, S = number of species(taxa), n is number of individuals, N = Total individual of species

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 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 44 plots were classified coastal area of Boujagh National Park. Four distinct groups of species were identified (Fig. 2.) Details of each group are as follows.

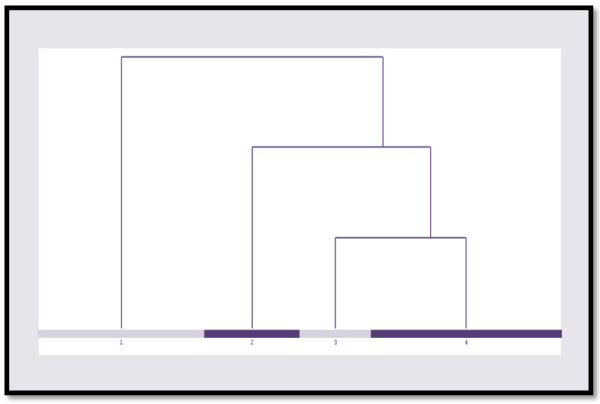

Figure 2. The cluster analysis to classify samples by Modified TWINSPANS

Group I (Ceratophyllum demersum- Nelumbo nucifera): This plant group with 13 plot situated in the middle of Boujagh and Kiashahr Lagoons where the depth is more.*Ceratophyllum demersum* and *Nelumbo nucifera are dominant species.* This group was seen in Boujagh Lagoon with *Nelumbo nucifera but this species didn't seen in* Kiashahr Lagoon. Most improtant indicator species include *Myriophyllum spicatum, Potamogeton crispus, Potamogeton pectinatus, Potamogeton pusillus* and *Zannichellia palustris*.

Group IV(*Hydrocotyle vulgaris-Phragmites australis*):. This group that includes 17 plots situated in the wet marginal area of northeastern and eastern Kiashahr lagoon. *This group make* border between marginal and open water. *Hydrocotyle vulgaris, Phragmites australis, Poa annua and Sambacus ebulus* are Diagnostic species.

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 sheldon's evenness index and Menhinink 's richness index ($P<0.05$).

Group II (*Juncus acutus-Rubus sanctus*):

This group with 8 plots growe in wet marginal area of the lagoons where soil consist of sand and clay. This group formated a narrow strip in eastern and western parts of Kiashahr Lagoon and northern and southern parts of Boujagh Lagoon. *Juncus acutus*, *Rubus sanctus, Equisetum ramosimum* and *Geraniumn molle are diagnostic* species.

Group ш (*Mentha aquatica-Phragmites australis*) :

This group with 6 plot situated in wet marginal area of lagoons where soil in wet and swamapy. *Phragmites australis* consistad a narrow strip around the lagoons.This species is a invasive-helophyte species and reduces frequency of hydrophyte in open water. *Also Mentha aquatica* is indicator species can be seen in the most wet area particularly in parts of eastern Kiashahr Lagoon and southern Boujagh Lagoon.

Group IV(*Hydrocotyle vulgaris-Phragmites australis*):

This group that includes 17 plots situated in the wet marginal area of northeastern and eastern Kiashahr lagoon. *This group make* border between marginal and open water. *Hydrocotyle vulgaris, Phragmites australis, Poa annua and Sambacus ebulus* are Diagnostic species.

Tablel 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	0.828	0.48	0.188	3	1.440 ±0.071
	Simpson diversity index	0.210	0.88	0.006	3	0.677 ±0.024
	Fisher's diversity index	2.227	010	3.867	3	2.022 ±0.209
Richness index	Menhinink 's richness index	2.730	0.05*	0.265	3	0.644 ±0.049
	Margalef richness index	7.2.617	0.06	1.800	3	1.485 ±0.131
Evenness index	sheldon's evenness index	3.856	0.01*	0.087	3	0.563 ±0.024

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 sheldon's evenness index and Menhinink 's richness index ($P<0.05$).

Duncan's test of groups showed in fig. of 3- 6. Figure 3 shows the changes of Fisher diversity indices. group 3 and group 1 Maximum and minimum of these indices respectively. The measurement of these indices indicated that is not significant difference between groups 2 and 4.

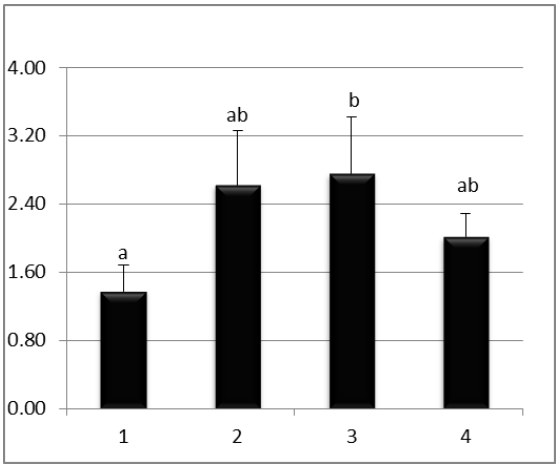

Figure 3. Changes in Fisher's diversity index among ecological groups

Fig. 4 & 5 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 3.The measurement of these indices indicated that is not significant difference between groups 2 and 3 in Menhinink index and2 and 3 Margalef index.

Figure 6 shows the changes of sheldon's evenness index evenness index among ecological groups. The highest value of sheldon's evenness index was in group1 and group 2 had the lowest value of this richness index. In this index is not significant difference between groups 3 and 4. Finally, the overall survey of indices showed that despite the high richness and diversity in groups of 3 and 2, evenness of these group less than group 1 with lowest richness and diversity.

DISCUSSION

This study for the first time introduced ecological species group in wetland zone of Boujagh national park (BNP) by floristic method and multivariate analysis. Modified TWINSPAN analysis was identified four species groups.

The vegetation groups in the Caspian Sea coastal wetlands have been analyzed by different methods such as physiognomic, Braun-Blanquet and

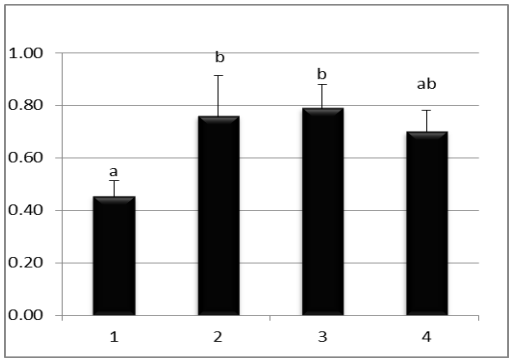

Figure 4. Changes in Menhinink 's richness index among ecological groups.

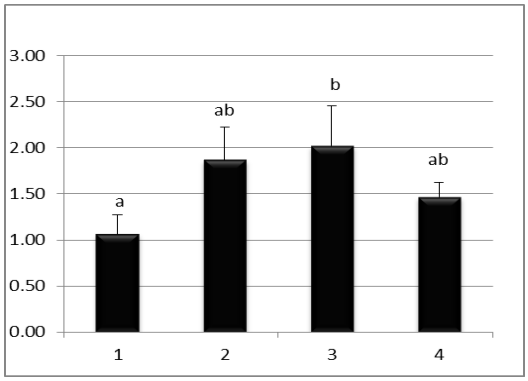

Figure 5. Changes in in Margalef 's richness index among ecological groups.

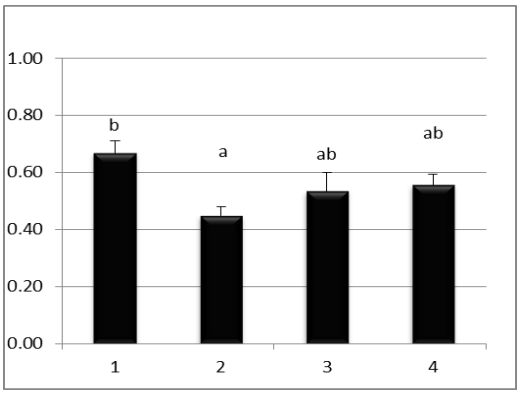

Figure 6. Changes in in sheldon's evvennes index among ecological groups.

multivariate methods led to the identification of these groups, communities and types: *Juncus, Rubus, Sand dune, Halophyte, Hydrophyte* (Shokri *et al.,* 2004); *Juncus acutus, Ruppia maritima, Typha latifolia-Phragmites australis, Schoenoplectus litoralis, Nelumbium caspicum, Ceratophyllum demersum-Myriophyllum spicatum* (Naqinezhad 2012), *potamogeton pectinatus, Ceratophylletum demersum-Azolla filiculoides, Nymphaea alba, Nelumbium nuciferum, Phragmites australis, Hydrocotyle ranunculoides, Typha latifolia, Cladium mariscus, Sparganium neglectum, Cyperus transitourius, paspalum distichum, Cerastium dichotomum* (Asri & Moradi, 2006); *Lemno minoris-Azolletum filiculoidis,Lemno minoris- Spirodeletum polyrrhizae, lemnetum minori-*

trisulcae, salvinietum natantis, Hydrocharitetum morsus-ranae,Utricularietum australis,Trapo- potametum crispi, Trapo-Potametum pectinati, Potametum pectinati,Ceratophylletum demersi, Hydrilletum verticillatae, Myriophylletum verticillati, Nelumbietum nucifei, Batrachietum trichophylli, Marsileo-Callirichetum brutiae, Potametum nodosi, Phragmitetum australis, Schoenoplectetum lacustris, Hydrocotyletum ranunculoidis, Iridetum pseudacori, Typhetum latifoliae,Sparganietum neglecti, Nasturietum officinalis, Paspaletum distichi, Rorippetum islandicae, Cyperetum serotini, Alismo- Sagittarietum sagittifoliae, Caricetum ripariae, Juncetum effusi, Cyperetum longi, Bidentetum cernuae, Bidento tripartitae-Polygonetum hydropiperis (Asri & eftekhari1992).

Comparing our research to referred to above studies showed that groups of *Mentha aquatica-Phragmites australis* and *Hydrocotyle vulgaris- Phragmites australis* as new groups in wetland of southern of Caspian Sea. Naqinezhad *et al.* (2013) in survay of biomass in Babol wetlands (cosatal wetlands of southen of Caspian Sea) mention that lack of socialization and growth in different depths, Ceratophyllum demersum and Nelumbium nuciferum rarely obseved together. The co-existence of the two species in the Boojagh wetland Conflict With above results. Due to the overlap depth ranges between two groups of floating and submerged plants 10-140 cm for floating species and 40-160 Cm for submerged species (Jalili *et al.,* 2009) justifies presence of these two species in one group.

Anova analysis results indicated that group1 (Ceratophyllum demersum- Nelumbo nucifera) had less diversity and richness but had more evenness than others groups. The survey of geographical location in these groups showed group 1 located in the deep But other groups exsist on the sidelines and shallow area. Low diversity and richness of this group compared to other groups could be due to the reducing the area of the deep section and increase of sidelines and shallow area also euhydrophytic plant species has less diversity than terrestrial andmarginal because of More uniformity in Aquatic ecosystems. Depth gradient can show floristic differences in wetlands(Seabloom *et al.,* 1998).

Compareing of measuement of diversity indices changes in the other groups showed groups 2 and 3 had more diversity and richness than group 4. Evaluation of functional types of species in each of these groups showed groups 2 and 3 consist of emergent indicator species but groups 4 combined of emergent and floating species. This feature showed among marginal groups, those settele in Less depth, Low humidity and more away from the center of the lagoon indicated more richness and diversity.

Boujagh National Park is the first founded landmarine national park and one of 19th National Parks in Iran as well as the first one in Guilan Province. Habitat variation in the study area makes it possible to provide diversity of plant taxa as well as the development of ecologically specialized plant communities (Naqinezhad *et al.,* 2006). but this unique ecosystem dosent have suitable environmental condition. The main reasons for the destruction of this wetland ecosystem consist of : pollution Transmission of agricultural land, Urban and rural settlements, agricultural land and industries, Implementation of development projects and infrastructure such as roads, power transmission lines, kiashahr port development of fisheries to Commercial port, creating fish ponds, illegal hunting, waste accumulation on the eastern part of the wetland, presence of non-native Azolla species, harvesting of wetland margins and widespread and uncontrolled presence of tourists. Comprehensive management plan within the framework of the ecosystem approach can help to coservation of species diversity in this park.

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