Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 6, p. 18-23, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Using GIS, ordination and discriminant analysis for study inghabitat characteristics of medicinal plants from Compositae family; case study: Boushehr province, Iran

R. Khalifehzadeh*, M. Farahnak Ghazani

Rangeland Research Division, Research Institute of Forests and Rangelands, Tehran, Iran

Article published on December 06, 2014

Key words: Medicinal plants, Compositae, CCA, discriminant analysis, Boushehr province.

Abstract

Medicinal plants are among the most important byproducts of Rangelands. The Compositae family, with 10 medicinal plants, is one of the richest plant families in the Boushehr province. Habitat conditions of medicinal plants from Compositae family, were determined by crossing of homogeneous unites map of the study area and distribution map of each species using ArcGIS 9.3. Then, the averages of the studied parameters including the annual mean of temperature(T), precipitation(P), potential evapotranspiration (Eva), elevation(H) and Slope (S) were calculated by using Excel software. Based on habitat environmental conditions, all studied species were compared each other and classified by CCA ordination method using CANOCO 4.5 software. The classified species accuracy was tested by Discriminant Analysis in SPSS 17. The results showed that, the studied species were classified in 3 groups with accuracy of 69.3%. The first group is consists of the three species of *Achillea eriophora*, *Artemisia scoparia* and *Gundelia tournefortii*, have a positive relation with (T) and (Eva) and their relation with (H), (S) and (P) is negative. The second group is consists of the four species of *Centaurea depressa*, *Carthamus oxyacantha, Carthamus tinctorius* and *Anthemis altissima* have a positive relation with (T), (Eva) and (P). However their relation with (H) and (S) is negative. The third group is consists of the three species of *Centaurea persica Boiss, Centaurea brugueriana* and *Centaurea intricata Boiss,* have a positive relation with (H), (P) and (S) but their relation with (T) and (Eva) is negative.

***Corresponding Author:** R. Khalifehzadeh ✉ Khalifehzadeh@ymail.com

Introduction

Human strategies for survival have long depended on an ability to identify and utilize plants (Swanson, 2007).It seems that up to 80% of the world's population rely chiefly on so-called 'traditional' medicine for primary health care (Prescott-Allen and Prescott-Allen,1982). Interest in traditional systems of medicine and, in particular, herbal medicines, has increased substantially in both developed and developing countries over the past two decades. Global and national markets for medicinal herbs have been growing rapidly, and significant economic gains are being realized. According to the Secretariat of the Convention on Biological Diversity, global sales of herbal products totaled an estimated US$ 60,000 million in 2000. As a consequence, the safety and quality of herbal medicines have become increasingly important concerns for health authorities and the public alike(The WHO, 2002). The WHO(World Health Organization) has published guidelines for GACPs (good agricultural and collection practices) for medicinal plants. The national governments are required to develop country-specific guidelines for sustainable production of raw material of quality and standardized ingredients. The development of WHO guidelines on GACPs for medicinal plants is an important step to ensure quality of herbal medicines and ecologically sound cultivation practices. The GACPs cover a wide spectrum of cultivation and collection activities, including site selection, climate and soil considerations, identification of seed, main post-harvest operations, and legal aspects. It is necessary to concentrate on standardizing the cultivation practices, collection practices, and post-harvest technologies for these plants adhering to GACPs (Anita Das, 2008).

Analysis of plants species and ecological classification of plants is a method for determining of the relationship between vegetation and environment factors (Grabherr *et al.,* 2003). There are many researches about the relationship between habitat characteristics and plant species in overall world; (Zhang *et al.,* 2005), (Comin, 2005), (Baruch, 2005), (Barret, 2006), (Yibing, 2008), (Taghipoor, 2008), (Wei-Qiang *et al.,* 2008), (Heydari *et al.,* 2009), (Tatian, 2010), (Zare Chahouki, 2012) and the others.

The ecological system is one of the most common vegetation classification systems. In this system the species having similar ecological relations with environmental factors, classified in a group as Ecological species group. These palnt species often have a similar distribution in natural areas. So, the vegetation unites are recognized on the basis of ecological species groups instead of indicator species. In this research the relationship between frequency of the medicinal plants from Compositae family and habitat characteristics have been studied. The purpose of the study was to determine the ecological groups of above mentioned species that have similar relationships with environmental factors. These species cover a widespread area of southern part of Iran (Bushehr provice) and separating them into ecological species groups can be a good guideline to determine suitable cultivation areas.

Material and methods

Study area

Boushehr with an area of 22000 km², is one of the southern provinces of Iran which is located within the geographical coordinates of 27.29 to 30.28 degree of north latitude and 50.11 to 52.94 degree of east longitude. Minimum and maximum elevation of the study area are zero and 1900 m respectively. The minimum and maximum precipitation of the study area are 50 and 551 mm respectively. The mean of annual temperature is 22.5 ˚C. The average potential evapotranspiration in the study area, using Thornthwaite method, is 3100 mm. Bushehr province has five distinct climatic classes as follows:

1. Very hot and dry 2. Dry temperate desert 3. Semiarid temperate 4. Hot semiarid 5. Very dry temperate.

Fig. 1 shows the location of Boushehr province in Iran.

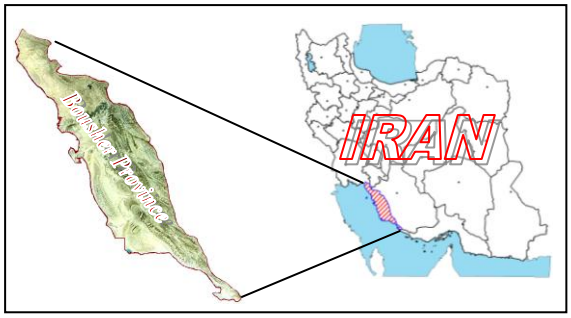

Fig. 1. Location of the study area in Iran.

Research method

The vegetation studies have been done on the basis of topographic map with a scale of 1:250000 from 2002 to 2012 by Hoveizeh (2012), Khoda gholi (2010) and Rashidi (2004). By using the vegetation map, the spatial distribution maps of plants species from compositae family including *Achillea eriophora*, *Artemisia scoparia*, *Gundelia tournefortii*, *Centaurea depressa*, *Carthamus oxyacantha*, *Carthamus tinctorius*, *Anthemis altissima*, *Centaurea persica Boiss*, *Centaurea brugueriana* and *Centaurea intricata Boiss*. were created in ArcGIS 9.3 software. For creating the homogenous map of the study area, five layers of hypsometric, slope, the annual mean of precipitation, the annual mean of temperature and the annual mean of evapotranspiration were crossed using ArcGIS 9.3. In order to create the habitat condition map of each plant species, the spatial distribution maps of plant species were crossed with the homogenous map separately. The attribute tables of the created maps transported into the Excel software. Because of the environmental variables have not a uniform scale, all of them were standardized to unit variance firstly and transformed using equation 1.

$$A' = \log (A+1) \quad \text{.....(Eq. 1)}$$

The multivariate statistical analysis of data including Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) ordination methods were done by CANOCO 4.5 software. In order to select the linear or unimodal method, length of the data set gradients on the ordination axes was evaluated using DCA. In DCA with detrending by segments and Hill's scaling, the length of the longest axis was equaled to 9.1. This suggests that the unimodal ordination methods for vegetation frequency of the studied data is appropriate (Leps, J. and Smilauer, P., 2003). Then on the basis of the habitat environmental conditions, all studied species were compared each other and classified by CCA ordination method. Additionally, to determine the accuracy of the classified species, the Discriminant Analysis (D.A) was used in SPSS 17 software.

Results and discussion

The homogenous map of the study area is shown in Fig. 2.

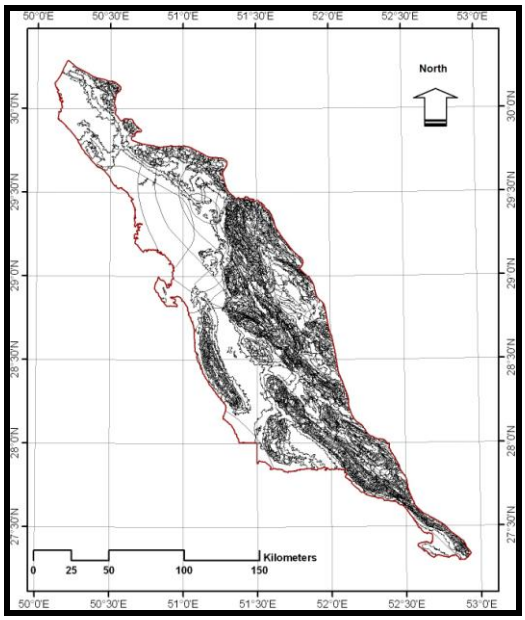

Fig. 2. The homogenous map of the study area.

The results show that the highest VIF(Variance Inflation Factor) of environment variables in CCA ordination is equal to 4.03. This value is smaller than 10. In other words, the degree of interaction between the variables used in the model is negligible (Bihamta, M. R. and Zare Chahouki, M. A., 2011). Table 1 shows the Eigenvalues and species – environment correlations on the ordination axes. The CCA ordination results indicate that the environment variables can explain the 80% of data set variance. The explained variance in the first and second axes is

more than the third and fourth axes as well as. As a result, in order to explain the species respond to changes in environmental factors, the CCA biplot was drawn on the first and second ordination axes. The review of biplot revealed that the studied species on the basis of relations to environmental factors, are distinctable in the three groups (Fig. 3).

Table 1. The results of the CCA constrained ordination.

Ordination axes	1	2	3	4
Eigenvalues	0.563	0.127	0.078	0.017
Species – environment correlations	0.751	0.357	0.279	0.132
Cumulative percentage variance of species – environment relation	70.8	86.8	96.6	98.8

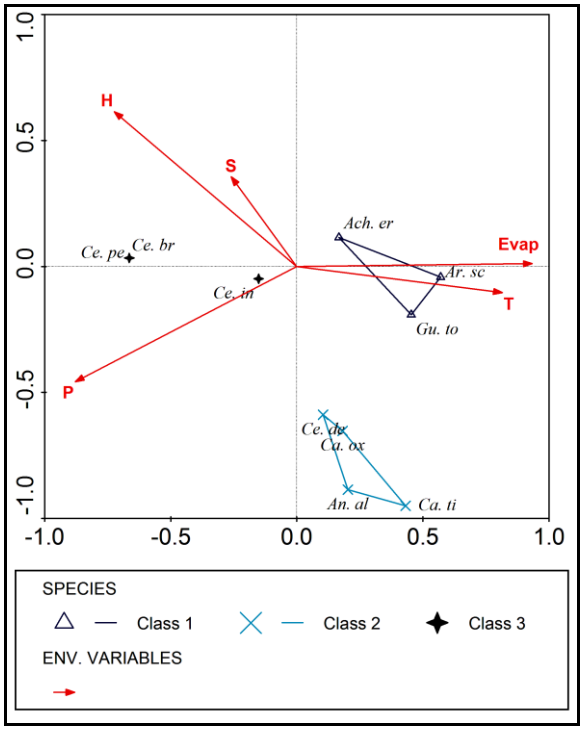

Fig. 3. The biplot of CCA constrained ordination on the first and second axes.

Table 2 shows the result of the functions test of discriminant analysis on the grouped species data, As can be seen the Wilks' lambda in both the first and second function is significant (P<0.01).

Table 2. Results of functions test of Discriminant Analysis.

Test of Function(s)	Wilks' Lambda	Chi-square	df	P-value
1 through 2	.578	8434.202	10	0.0
2	.927	1127.355	4	0.0

In order to specify the name of each function, the correlation between predictive variables and discriminant functions within-groups was determined (table 3). Based on the standardized coefficient, the mean of precipitation and potential evapotranspiration have the strongest association with the first and the second function respectively. As a result, the first function was named as; "The mean of precipitation" and the second function was named as; "The averege potential evapotranspiration". Fig. 4 shows the canonical discriminant functions of plant species groups.

Table 3. The correlation and standardized coefficient of D.A functions with predictive variables.

Predictive variables	Correlation coefficients on the discriminant functions		Standardized coefficients for discriminant functions	
	1	2	1	2
Pricipitation	0.92	0.37	**0.68**	0.88
Evapotranspiration	-0.84	0.25	-0.33	**0.90**
Tempurature	-0.7	0.07	0.07	-0.51
Height	0.54	-0.63	0.19	-0.7
Slope	0.21	-0.34	0.15	-0.1

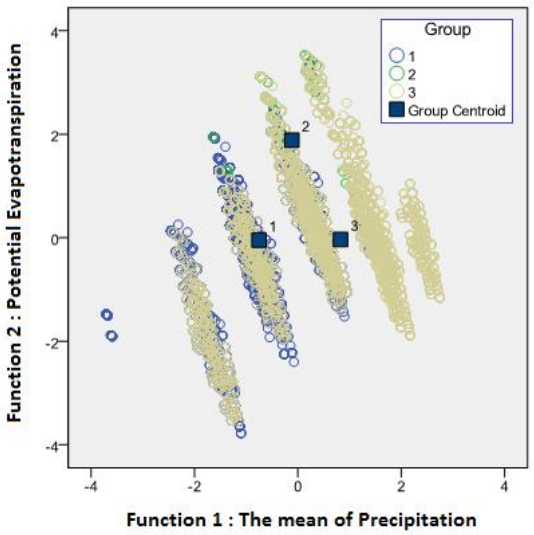

Fig. 4. Canonical Discriminant functions of plant species groups.

According to the classification results of plant species using D.A method, the accuracy of classification in groups 1, 2 and 3 are 64.1%, 73.2% and 75.2% respectively. Totally 69.3% of groups memberships were correctly classified (Table 4).

Table 4. The classification results of plant species by D.A method.

	Group	Predicted Group Membership			Total
		1	**2**	**3**	
Count	1	**5050**	844	1983	7877
	2	10	**235**	76	321
	3	908	757	**5053**	6718
%	1	**64.1**	10.7	25.2	100
	2	3.1	**73.2**	23.7	100
	3	13.5	11.3	**75.2**	100

The first group is consists of the three species of *Achillea eriophora*, *Artemisia scoparia* and *Gundelia tournefortii*. The species frequency of this group has a positive relation with temporature (T) and potential evapotranspiration (Eva) and their relation with elevation from the see level (H), slope(S) and precipitation(P) is negative.The second group is consists of the four species of *Centaurea depressa*, *Carthamus oxyacantha*, *Carthamus tinctorius* and *Anthemis altissima*. The species frequency of this group has a positive relation with T, Eva and P. However their relation with H and S is negative. The third group is consists of the three species of *Centaurea persica Boiss*, *Centaurea bruguerіana* and *Centaurea intricata Boiss*. The species frequency of this group has a positive relation with H, P and S but their relation with (T) and (Eva) is negative.

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