Infraspecific variations in *Linum album* based on the Determination of Special Stations approach in Iran

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Abstract. In the present study the Determination of Special Stations approach was used for identification of possible infraspecific variations between different populations of *Linum album* in Iran. Different stations of *L. album* were explored and 21 special stations were determined among them. Analysis of the studied special stations on the basis of floristic compositions with ANAPHYTO software has set out twelve main groups. The ANOVA test performed for quantitative morphological characteristics among the studied populations of *L. album* has shown significant difference ($p<0.05$) of some characteristics. The studied populations differed in their qualitative and quantitative morphological characteristics and were separated in the UPGMA tree and Pco plot. Thirteen groups stood out in these diagrams. On the basis of ecological factors, the studied stations differed from each other and were separated in the Pco plot and organized into fourteen groups. The members of some ecological, floristic and morphological groups were absolutely identical with each other. For example, eight floristic and ecological groups were similar, and also seven morphological and ecological groups were identical. Furthermore, the members of floristic groups 2, 3, 4, and 10 were absolutely similar to the respective ecological and morphological groups 2, 3, 4, and 10. The ecological parameters of habitat, floristic composition of the associated taxa and phenotype plasticity of *L. album* significantly converged in the studied special stations. The results of the study have shown that the different populations of *L. album* were adapted to their habitat and the ranges of phenotype plasticity were high between populations which led to creation of ecomorphs.

Key words: ecological groups, floristic groups, *Linum album,* morphological groups

Introduction

Linum is the most important genus in the family Linaceae present across the word with about 230 species (Heywood 1993). Members of this genus grow naturally in Iran. So far 22 species and infraspecific taxa have been reported from Iran classified in five sections. *Linum album* Ky ex Boiss. is one of them and belongs to the section *Syllinum* Griseb. This species is endemic to Iran and is considered an Irano-Turanian element naturally widespread in different regions of the northern, northwestern, western and central parts of the country (Rechinger 1974; Sharifnia & Assadi 2001).

Availability of suitable habitats is considered an important factor in determining the species distribution patterns, and its importance in relation to other factors, such as competition can be often inferred

if, for example, changes in a species distribution pattern coincide with the demonstrable changes in habitat structure (Thomas & Edwards 1986). Two forces, ecogenesis (adaptation to ecological conditions) and phylogenesis (historical events), interact in a complex manner in shaping out the current species distribution (Thorpe & al. 1994).

Creation of intraspecific variation is the main origin and storage of speciation and genetic divergence among populations of a species (Briggs & Walters 1984; West-Eberhard 2005). In this order, emergence of intraspecific variation at different levels of each taxon brings richness to an area. Individuals of a species those are able to response appropriately to a tremendous variety of different conditions have wide distribution in the different stations with various ecological conditions. Genetic diversity is essential both for short-term adaptations to environmental changes and for long-term impact on the species and communities. However, it is genetic variation within species that affords foundation for biodiversity and organic evolution. Such intraspecific variation provides material for long-term evolutionary adaptation and short-term adaptation to seasonal and rapid fluctuations in environmental factors (Claes 1998).

In addition to genetic variation, phenotype plasticity is very important for intraspecific differentiation. Plasticity is a solution to the problem of adaptation to heterogeneous environments. Morphological plasticity enables a plant to change its growth pattern in the process of encountering different stresses (Guo & al. 2007). Many studies have been dedicated to determination of intraspecific diversity (such as Telascrea & al. 2007), but they mostly do not apply any special methods to the data collection process, and engage in time consuming and expensive experiments. On the other hand, in such studies, application of the floristic and ecological markers by use of Determination of Special Station approach (D.S.S.) has led to correct and precise results because this approach is on the basis of existing natural factors. It also avoids further expenses and time consuming experiments. In order to study inter- and intraspecific diversity by the D.S.S. approach, special stations were determined based on the presence of the studied species in it's their localities (Atri & al. 2007).

Floristic composition is a good floristic marker, because any changes in it in a different endogenous milieu testifies to the existence of different ecological factors, thereby leading to inter-and intraspecific diversity. The latter has been established in various studies (Fakhre-Tabatabaei & al. 2000; Sefidkon & al. 2005).

Owing to the wide distribution of *L. album* in Iran, and lack of any intraspecific studies of this species, we have used for the first time in the present work floristic, morphological and ecological markers (with the D.S.S. approach) for identification and distinction of possible interspecific variations between different populations of this species in Iran.

Material and methods

Plant material

On the basis of accessible references such as *Flora Iranica* (Rechinger 1974) and *Flora of Iran* (Sharifnia & Assadi 2001) and of samples collected by the authors (Talebi & al.), different localities of *L. album* were examined, determining a general station for each locality. Among these, 21 different stations were determined in the various parts of Central, Western and North- western Iran during 2010–2011 (e.g. Table 1, Fig. 1) by the use of D.S.S. approach (Atri & al. 2007).

Table 1. Studied populations localities and their vouchers.

Station	Habitat	Voucher No
1	Tehran, Sohanak, 1900 m	2011191 HSBU
2	Qazvin, 1408 m	2011123 HSBU
3	Hamedan to Tehran, 50 km Avaj, 1898 m	2011118 HSBU
4	Hamedan, Saleh Abad, 1789 m	2011106 HSBU
5	Markazi, Saveh, Kharaghan, 1717 m	2011168 HSBU
6	Kurdistan, Sanandaj, Salavat Abad, 1860 m	2011111 HSBU
7	Saveh to Hamedan, Fmenine, 1761 m	2011103 HSBU
8	Kordestan, 140 km Sanandaj to Saghez, 1620 m	2011159 HSBU
9	Markazi, Saveh, Chamran, 1783 m	2011182 HSBU
10	Tehran, Lashkarak	2011192 HSBU
11	Saveh to Hamedan, before Hamedan, 1760 m,	2011105 HSBU
12	Markazi, Zrandiyeh, Vardeh, 1566 m	2011119 HSBU
13	Markazi, Zrandiyeh, Noshveh, 2121 m	2011120 HSBU
14	Kordestan, Sanandaj, Karehsi, 1585 m	2011157 HSBU
15	Kurdistan, Sanandaj to Kamyaran, 1329 m	2011114 HSBU
16	Kordestan, Sanandaj, 1476 m	2011113 HSBU
17	Markazi, Arak, Sefid khani mountain, 2180 m	2011150 HSBU
18	Tehran, Darake, 1710 m	2011190 HSBU
19	Markazi, Saveh, Ghargh Abad, 1464 m	2011101 HSBU
20	Kurdistan, Sanandaj, Abidar mountain 1645 m	2011112 HSBU
21	50 km Abhar to Zanjan, 1805 m	2011131 HSBU

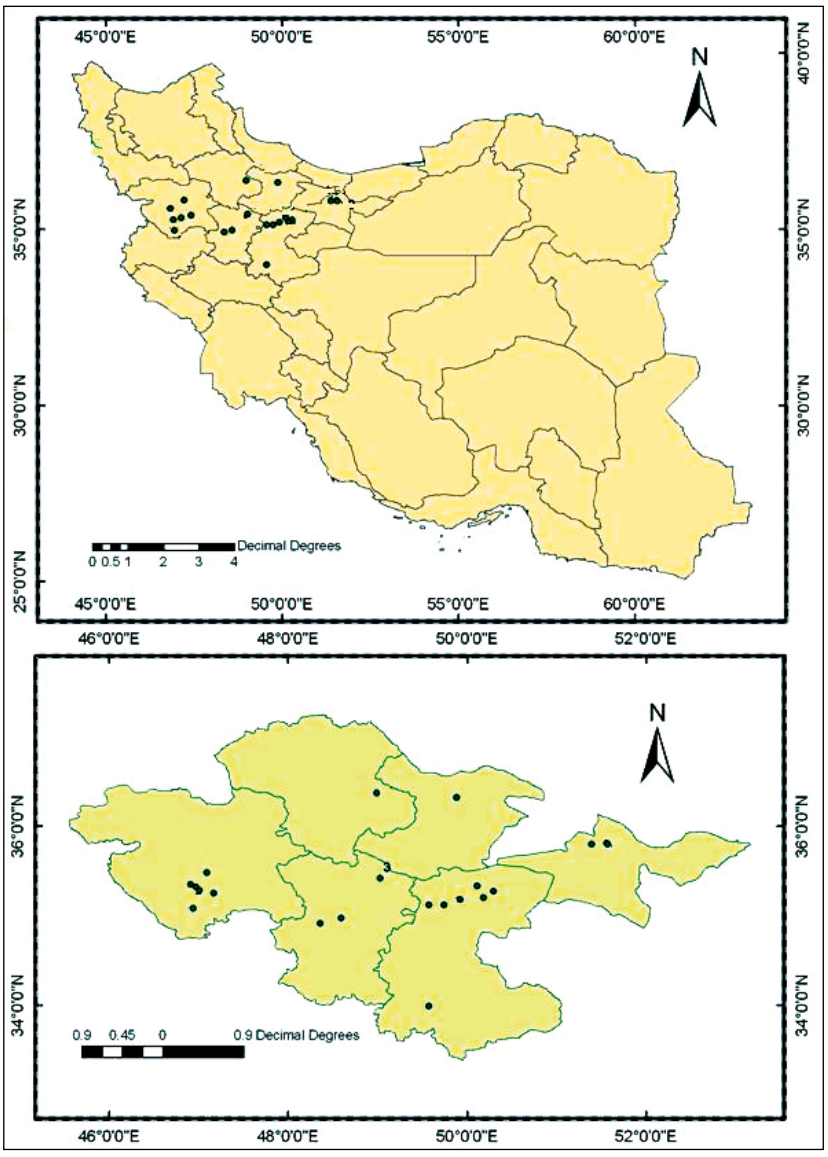

Fig. 1. Distribution map of the studied stations of *L. album* in Iran.

Floristic analysis

A special station was set in for each of the 21 populations of *L. album*. These special stations were set in the basis of presence of the individuals of studied taxa by using the minimum area method. The minimum area was determined by applying the area-species method with the area-species curve and Cain's method (Cain & al. 1959). All floristic data on the studied populations and their associated species as floristic markers were obtained from each special station. Plant specimens were identified and determined by valid Floras (such as *Flora Iranica* and *Flora of Iran*) and deposited in the herbarium of Shahid Beheshti University (HSBU) of Iran.

Plant morphology

Twenty qualitative and quantitative morphological characteristics from the vegetative and reproductive organs of *L. album* were examined. Some of these important morphological characteristics include: stem length and number of stem branches, length and width of basal and floral leaves, dimensions of calyx and corolla and pedicle length.

Ecological factors

In order to compare the effect of different environmental factors on the morphological features of *L. album* populations, ten ecological factors were examined for each special stations, such as: longitude (E°), latitude (N°), altitude (in meters), average annual minimum and maximum temperature (in °C), pH, EC and soil texture, slop exposition and type of habitat. Longitude, latitude and elevation were calculated with Garmin GPS map76CSx, and the average annual minimum and maximum temperature of each locality were taken from the web site of the meteorological organization of Iran.

Statistical analysis

The mean and standard deviation of the studied quantitative morphological characteristics were determined. In order to group the studied taxa on the basis of morphological characteristics, data were standardized (mean = 0, variance = 1) and used for multivariate analyses including UPGMA (Unweighted Paired Group using Average method) and Principal Coordinate Analysis (PcoA) (Podani 2000).

One-way ANOVA test was employed to assess the significant quantitative morphological differences among the studied populations and Pearson's coefficient of correlation was used to determine significant correlations of quantitative morphological characteristics in relation to ecological factors as well as longitude, latitude, altitude, average of annual minimum and maximum temperature, pH and EC of the habitats soil, so as to show possible relationship between

populations, NTSYS ver. 2 (1998) and SPSS ver. 9 (1998) softwares were used for statistical analyses. Data obtained from floristic investigations of each station were analyzed with the help of Anaphyto software (Briane 1991) by C.F.A. method (Correspondence Factorial Analysis).

Results

Floristic composition of the associated taxa

Different populations of *L. album* were selected in different localities of Iran and special stations were identified for each population on the basis of the presence of individual of *L. album.* Twenty-one special stations were set in and a total of 118 associated species or infraspecific taxa were distinguished (Table 2). The number of associated taxa varied between the stations. The highest number of species (18 taxa) was recorded in special station No-11, while the lowest number (5 taxa) occurred in special stations No- 15 and 16. *Senecio vulgaris* was a highly of the greatest number of taxon in the studied stations (about 10 times), while of the greatest number of taxa (nearly 87) were registered in only one station. The most frequent genera were *Trigonella* and *Astragalus* of *Fabaceae* (s.l.) occurring seven times.

Analysis of the studied special stations based on the floristic composition by C.F.A. method distinguished twelve main groups (Fig. 2). Some of the groups were monotypic namely 1, 2, 3, 10 and12; others (4, 5, 7, 8, 9 and 11) consisted of two to four members (6) (for details see Table 3). The groups were separated from each other's on the basis of similarity and dissimilarity of floristic composition of the associated taxa in each population of *L. album*. Among these, group 3 in special station 14 was positioned very far away from the rest and its floristic composition was self-restricted.

Morphology of *Linum album* populations

In order to compare the effect of different environmental factors on the phenotype of these plants, twenty qualitative and quantitative morphological characteristics, both of vegetative and reproductive organs were selected and examined among 21 populations of *L. album*. The means and standard deviations of the studied characteristics are presented in Table 4.

The ANOVA test on the quantitative morphological characteristics among the studied populations of *L. album* showed significant difference ($p<0.05$) in some characteristics, such as: branch number, basal leaf width, floral leaf length and width, sepal, calyx and petal length and width and pedicle length. Some qualitative features such as the shape of basal and floral leaf shape varied between the populations. Most basal leaves were linear-lanceolate, but in some populations they were lanceolate (populations 12 and 13), oblanceolate (population 4), ovate (populations 5, 7 and 8), or linear (population 20). Most floral leaves were lanceolate, but, other shapes, namely linear (populations 3, 7 and 21) and seldom oblanceolate (population 8) and ovate (population 2) occurred too.

Significant positive/negative correlations were found between some morphological characteristics in relation to ecological factors. For example, there was a significant negative correlation ($p<0.05$,

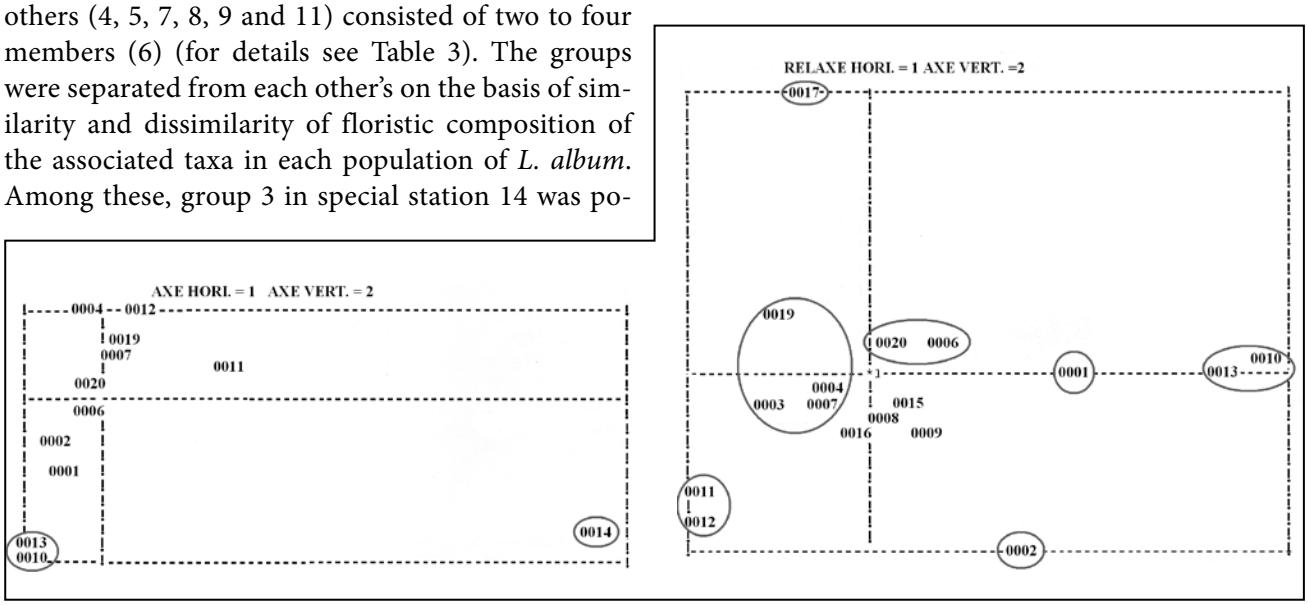

Fig.2. C.F.A diagram of the studied stations based on floristic composition.

r=- 0.50) between stem height and slope exposition. Branch numbers had a significant negative correlation ($p<0.05$, r=- 0.49) with eastern distribution, and a significant positive correlation ($p<0.05$, r=0.47) with soil pH. Basal leaf length and width had a significant negative correlations ($p<0.05$, r=- 0.47) with soil pH. Petal length had significant negative correlation ($p<0.05$, r=- 0.45) with northern distribution and with the average annual minimum temperature.

Changes in morphological characteristics in response to different ecological factors disarranged the plant architecture and affected mechanical performance of the plant organs. In response to this, some phenotypical characters in plant varied between the populations and had negative or positive correlation with the ecologically changed morphological characteristics. For example, floral leaf length and width had significant positive correlation with the basal leaf width. Calyx length had a significant negative correlation ($p<0.05$, r=- 0.52) with petal length. This showed the degree of co-evolution or change between the morphological characteristics of plant.

The studied populations differed in their qualitative and quantitative morphological characteristics and were separated in the UPGMA tree (Fig. 3). Classification of the studied populations based on similarity and dissimilarity of their morphological characteristics set up thirteen groups. Some of these, such as groups 2, 3,5,8,10,11, and 13 were monotypic while others consisted of two (groups 4, 6, 9 and 12) or three (groups 1 and 7) members, (for details see Table 3).

Table 2. Studied stations and their floristic composition (0=absence, 1=presence).

Taxon\ Stations	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Achillea millefolium L. subsp. *elbursensis* Hub.-Mor.	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. talagonica Boiss var. *oxylepis* (Boiss. & Haussk.) Hub.-Mor.	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
Acinos graveolens Link	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Acrobtilon repens (L.) DC. subsp. *repens*	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0
Adonis aestivalis L.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Aegilops columnaris Zhuk.	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
A. crassa Boiss.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. triuncialis L.	0	1	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	1	1
Alcea wilhelminae I. Redl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Alhagi pseudalhagi (M.Bieb.) Desv.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Allium scabriscapum Boiss.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alyssum inflatum Nyarady	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
A. desertorum Stapf. var. *desertorum*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Androsace maxima L.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Anthemis gilanica Bornm. & Gauba.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. haussknechtii Boiss. & Reut. var. *haussknechtii*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Aristolochia bottae Jaub. & Spach.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Astragalus jessenii Bunge	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Astragalus sp. 1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Astragalus sp. 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Astragalus sp. 3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Astragalus sp. 4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Astragalus sp. 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Astragalus sp. 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Avena strigosa Schreb.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Bohsea trinervia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Boissiera squarrosa (Banks & Soland.) Nevski.	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Bromus japonicas (Murray.) Thunb.	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
B. tectorum L.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. danthoniae Trin.	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1
B. madritensis L.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
B. tectorum L.	0	0	0	0	1	0	1	1	1	0	1	1	0	0	0	0	0	1	0	1	0

Table 2. Continuation.

Taxon \ Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Cardaria draba (L.) Desv.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carthamus oxyacntha M. Bieb.	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea depressa M. Bieb.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Centaurea ovina Pall. ex Willd.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cerastium dichotomum L.	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cnicus benedictus L. var. *benedictus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cirsium arvense (L.) Scop.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crupina crupinastrum (Moris) Vis.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Dactylis glomerata L. subsp. *glomerata*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Descurainia sophia (L.) Webb. ex Berth.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Echinophora platyloba DC.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Echinops robustus Bunge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Erodium cicutarium (L.) L'Hér.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Erodium gruinum (L.) L'Hér. ex Aiton.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erodium oxyrrhnchum M. Bieb. subsp. *oxyrhinchum*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Erymopyrum orientale (L.) Jaub. & Spach.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbia aleppica L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
E. chamaesyce L.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. cheirolepioides Rech.f.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
E. helioscopia L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
E. humilis C.A. Mey.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. inderiensis Less. ex Kar. & Kar.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fumaria vaillantii Loisel.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Gallium apparine L.	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Gladiolus atroviolaceus Boiss.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gundelio tourneforti L.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heliotropium kumense Bunge	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Heteranthelium piliferum (Banks & Sol.) Hochst.	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Holesteum glutinosum (M. Bieb.) Fisch. & Mey.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hordeum murinum Boiss.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
H. spontaneum C. Koch.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lamium amplexicaule L. var. *amplexicaule*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lathyrus gorgoni Parl.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Linum album Ky. ex Boiss.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Medicago orbicularis (L.) Bertalini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Medicago spp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Papaver arenarium M. Bieb.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Papaver dobium L.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Paronychia kurdica var. *kurdica*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paronychia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Pisum sativum L. subsp. *sativum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago lanceolata L.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. gentianoides Sibth. & Sm. subsp. *griffithii* (Decne.) Rech.f.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Poa annua L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
P. bulbosa L.	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
Pterocephalus plamosus (L.) Coult.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Reseda alba L. subsp. *alba*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
R. buhseana Mull.-Arg. var. *dshebdli* (Czernjak) Abdallah & De Wit	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. lutea L.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Rosa persica Michx. ex Juss.	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Salvia nemorosa L.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 2. Continuation.

Taxon \ Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Scandix pectin-veneris L.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Scariola orientalis (Boiss.) Sojak subsp. *orientalis*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio vernalis Waldst. & Kit.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
S. vulgaris L.	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	1	1	1	1
Silene conoidea L.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Spartanium juniserum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Stachys inflate Benth.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Tanacetum parthenifolium (Wild.) Schuhz-Bip.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tragopogon buphthalmoides (DC.) Boiss. var. *buphthalmoides*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trigonella monantha C.A.Mey. subsp. *monantha*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
T. monantha subsp. *geminiflora* (Bunge) Rech.f.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
T. monantha subsp. *noeana* (Boiss.) Hub.-Mor.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. persica Boiss.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
T. spruneriana Boiss.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
T. turkmena Popov	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. verae Širj.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triticum spp.	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0
Tulipa wilsoniana Hoog.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turgenia latifolia (L.) Hoffm.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Vaccaria oxyodonta Boiss.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
V. pyramidata Medik.	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Verbascum speciosum Schrad.	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Vicia hirsuta (L.) Gray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
V. latifolia Moench.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
V. michauxii var. *stenophylla* Boiss.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V. tetrasperma (L.) Schreb.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Xeranthemum longepapposum Fisch. & C.A.Mey.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Ziziphora tenuior L.	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 3. Classification of the studied stations based on morphological groups, floristic composition and ecological characteristics.

Morphological groups	Stations	Floristical groups	Stations	Ecological groups	Stations
1	0001, 0003, 0004	1	0001	1	0001
2	0017	2	0017	2	0017
3	0014	3	0014	3	0014
4	0008, 0005	4	0008, 0005	4	0008, 0005
5	0010	5	0013, 0010	5	0010
6	0009, 0007	6	0003, 0004, 0007, 0019	6	0013, 0003
7	0015, 0019, 0021	7	0015, 0016	7	0015, 0016
8	0020	8	0020, 0006	8	0020
9	0018, 0016	9	0018, 0009	9	0018, 0009
10	0002	10	0002	10	0002
11	0011	11	0012, 0011	11	0006
12	0012, 0013	12	0021	12	0021
13	0006			13	0004, 0007, 0011
				14	0019, 0012

Table 4. Morphological characteristics of the studied *L. album* populations.

populations		stem	branch	ba.le.sh.	ba.le.le	ba.le.wi.	ble/wi	fl.le.sh.	fl.le.l	fl.le.wi	fle/wi	cal.wi	cal.le	cle/wi	ped.le	sep.le	sep.wi	sle/wi	pet.le	pet.wi	ple/wi
1	mean	21.62	5.25	lanceolate	1.92	0.41	4.68	lanceolate	1.37	0.23	5.95	0.37	0.90	2.43	0.17	0.57	0.22	2.59	2.40	1.92	1.25
	std.dev.	4.36	2.87		0.60	0.17	3.52		0.27	0.09	3.00	0.05	0.14	2.80	0.09	0.22	0.05	4.40	0.08	0.35	0.22
2	mean	33.45	8.25	lanceolate	1.85	0.5	3.7	ovate	1.55	0.35	4.42	0.34	0.77	2.08	0.25	0.45	0.13	3.46	2.32	1.77	1.31
	std.dev.	6.85	4.03		0.52	0.14	3.71		0.45	0.05	9.00	0.08	0.12	1.5	0.05	0.12	0.19	0.63	0.32	0.28	1.14
3	mean	21.17	7.25	lanceolate	1.6	0.42	3.8	linear	1.50	0.25	6.00	0.38	0.87	2.28	0.17	0.37	0.22	1.68	2.56	2.50	1.02
	std.dev.	2.36	3.59		0.18	0.12	1.5		0.21	0.06	3.5	0.11	0.12	1.09	0.12	0.09	0.04	2.25	0.3	0.6	0.5
4	mean	24.12	3.75	lanceolate	1.9	0.42	4.52	lanceolate	1.41	0.32	4.40	0.37	0.91	2.45	0.10	0.52	0.22	2.36	2.57	2.00	1.28
	std.dev.	1.78	2.87		0.48	0.17	2.82		0.25	0.09	2.77	0.05	0.1	2.00	000	0.09	0.04	2.25	0.2	0.47	0.42
5	mean	28.5	9	oblong	1.2	0.35	3.42	lanceolate	1.55	0.35	4.42	0.35	0.97	2.77	0.27	0.47	0.12	3.91	2.27	1.62	1.40
	std.dev.	2.85	4.69		0.21	0.12	1.75		0.25	0.16	1.56	0.05	0.22	4.4	0.05	0.12	0.02	6.00	0.43	0.58	0.74
6	mean	26.0	5.5	lanceolate	1.77	0.35	5.05	lanceolate	1.57	0.22	7.13	0.37	1.00	2.70	0.10	0.72	0.15	4.80	2.87	1.52	1.88
	std.dev.	3.16	2.51		0.59	0.12	4.91		0.33	0.09	3.66	0.09	0.29	3.22	000	0.26	0.05	5.20	0.18	0.18	1.00
7	mean	22.5	3.5	oblong	1.92	0.75	2.56	linear	1.85	0.45	4.11	0.50	1.05	2.10	0.12	0.67	0.20	3.35	2.90	2.60	1.11
	std.dev.	3.78	0.57		0.35	0.19	1.84		0.26	0.1	2.6	000	0.1	000	0.05	0.05	000	000	0.12	0.43	0.27
8	mean	28.37	8	oblong	1.7	0.47	3.61	oblanceolate	1.97	0.37	5.32	0.50	1.20	2.40	0.23	0.9	0.15	6.00	3.22	1.97	1.63
	std.dev.	4.11	1.41		0.55	0.15	3.66		0.47	0.09	5.22	000	0.21	000	0.05	0.22	0.05	4.40	0.26	0.32	0.81
9	mean	23.75	3.5	oblanceolate	1.62	0.38	4.26	lanceolate	1.62	0.27	6.00	0.41	1.10	2.68	0.18	0.70	0.20	3.50	2.42	2.12	1.14
	std.dev.	2.98	4.04		0.51	0.18	2.83		0.17	0.05	3.4	0.02	0.08	4.00	0.08	0.16	0.04	4.00	0.47	0.15	3.13
10	mean	28.7	2.5	lanceolate	1.82	0.35	5.2	lanceolate	1.62	0.30	5.40	0.42	1.05	2.50	0.22	0.55	0.20	2.75	2.51	1.91	1.31
	std.dev.	0.30	1.00		0.10	0.05	2		0.3	0.05	6.00	0.05	0.1	2.00	0.05	000	0.05	000	0.54	0.16	3.37
11	mean	24.1	7.5	lanceolate	2.37	0.3	7.9	lanceolate	1.47	0.25	3.80	0.37	0.87	2.35	0.09	0.47	0.22	2.13	2.87	1.45	1.97
	std.dev.	2.04	6.24		0.29	0.09	3.22		0.18	0.05	3.6	0.03	0.09	3.00	0.01	0.09	0.05	1.8	0.25	0.07	3.57

Table 4. Continuation.

populations		stem	branch	ba.le.sh.	ba.le.le	ba.le.wi.	ble/wi	fl.le.sh.	fl.le.l	fl.le.wi	fle/wi	cal.wi	cal.le	cle/wi	ped.le	sep.le	sep.wi	sle/wi	pet.le	pet.wi	ple/wi
12	mean	32.50	4	linear	1.8	0.52	3.46	lanceolate	1.50	0.36	4.16	0.30	0.95	3.16	0.10	0.55	0.20	2.75	2.35	1.67	1.40
	std.dev.	13.82	3.74		0.57	0.05	11.4		0.25	0.07	3.57	0.08	0.12	1.50	0.06	0.09	000	000	0.15	0.12	1.25
13	mean	33.67	5	linear	1.57	0.47	3.34	lanceolate	1.60	0.30	5.33	0.33	1.05	3.18	0.11	0.70	0.12	5.83	2.67	1.20	2.22
	std.dev.	9.14	3.16		0.33	0.12	2.75		0.28	0.01	2.8	0.04	0.09	2.25	0.06	0.18	0.02	9.00	0.2	0.68	0.29
14	mean	27.25	11.5	lanceolate	1.67	0.3	5.56	lanceolate	1.17	0.16	7.31	0.47	0.90	1.91	0.20	0.87	0.45	1.93	2.10	1.13	1.85
	std.dev.	2.21	2.64		0.50	0	0		0.26	0.04	6.5	0.05	0.14	2.80	0.08	0.05	000	000	0.27	0.2	1.35
15	mean	29.25	7.5	lanceolate	2.02	0.32	6.31	lanceolate	1.71	0.26	6.57	0.32	0.80	2.50	0.08	0.45	0.17	2.64	2.60	2.11	1.23
	std.dev.	7.49	7.04		0.53	0.09	5.88		0.14	0.04	3.5	0.05	0.08	1.60	0.02	0.05	0.05	1.00	0.55	0.35	1.57
16	mean	29.4	1.25	lanceolate	2.1	0.45	4.66	lanceolate	1.77	0.37	4.78	0.40	0.82	2.05	0.09	0.50	0.17	2.97	2.27	1.82	1.24
	std.dev.	4.31	2.50		0.54	0.12	4.50		0.25	0.09	2.77	000	0.05	000	0.02	000	0.05	000	0.17	0.06	2.83
17	mean	28.25	8	lanceolate	1.3	0.18	7.22	lanceolate	1.60	0.22	7.54	0.40	1.00	2.50	0.25	0.72	0.11	6.54	2.95	1.50	1.96
	std.dev.	1.50	1.82		0.08	0.06	1.33		0.2	0.06	3.33	0.08	0.09	1.25	0.05	0.12	000	000	0.05	0.43	0.11
18	mean	28.80	0	lanceolate	1.42	0.37	3.83	lanceolate	1.42	0.31	4.58	0.32	0.92	2.87	0.10	0.55	0.11	5.00	2.05	2.00	1.02
	std.dev.	2.20	0		0.25	0.09	2.77		0.22	0.05	4.4	0.02	0.14	7.00	000	0.1	0.01	10.0	0.25	0.14	1.78
19	mean	28.47	5.2	lanceolate	1.6	0.31	5.16	lanceolate	1.30	0.20	6.50	0.35	0.82	2.34	0.097	0.5	0.15	3.33	2.57	2.30	1.11
	std.dev.	7.23	3.59		0.42	0.08	5.25		0.23	0.00	000	0.05	0.12	2.40	0.02	0.08	0.05	1.6	0.31	0.36	0.86
20	mean	21.97	11.5	lanceolate-linear	1.32	0.27	4.88	lanceolate	1.30	0.28	4.64	0.32	0.62	1.93	0.10	0.34	0.15	2.26	2.11	1.53	1.37
	std.dev.	1.79	3.10		0.58	0.15	3.86		0.18	0.02	9.00	0.05	0.07	1.40	000	0.06	0.05	1.2	0.39	0.53	0.73
21	mean	19.87	5.25	lanceolate	2.15	0.39	5.51	linear	1.10	0.16	6.87	0.30	1.00	3.33	0.20	0.62	0.25	2.48	2.28	1.25	1.82
	std.dev.	5.53	5.09		0.31	0.15	2.06		0.4	0.09	4.44	0.04	0.09	2.25	0.01	0.09	0.02	4.5	0.22	0.17	1.29

Abbreviations: stem = stem height, ba.le.sh = basal leaf shape, ba.le.le = basal leaf length, ba.le.wi = basal leaf width, ble/wi = basal leaf length/ width ratio, fl.le.sh = floral leaf shape, fl.le.l = floral leaf length, fl.le.wi = floral leaf width, fle/wi = floral leaf length/ width ratio, cal.wi = calyx width, cal.le = calyx length, cle/wi = calyx length/ width ratio, ped.le = pedicle length, sep.le = sepal length, sep.wi = sepal width, sle/wi = sepal length/ width ratio, pet.le = petal length, pet.wi = petal width, ple/wi = petal length/width ratio(all values are in cm).

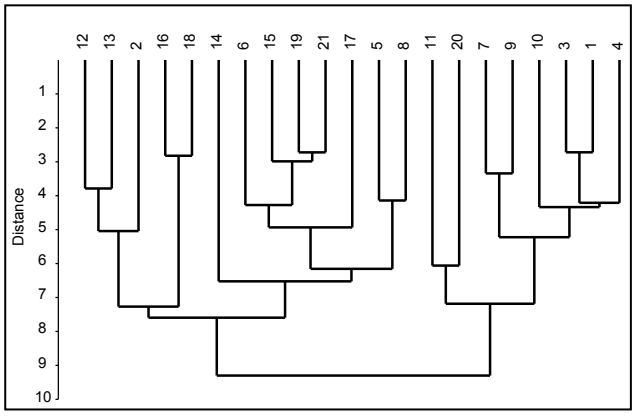

Fig. 3. UPGMA tree of the studied populations of *L. album* on the basis of morphological characteristics.

Ecological investigations

The special stations were selected in different environments confronting various ecological factors, which affected the morphological features of *L. album* populations and the floristic composition of their associated taxa. Ten different ecological factors were examined among the stations (Table 5). Altitude of the stations varied, the maximum altitude being recorded in station No. 17 (at about 2180 m) and the minimum altitude at about 1329 m was recorded in station No.15. The other stations were somewhere in between, but mostly about 1700 m. Not only latitude of the populations distribution varied between N 36.22° to 33.59°, but also longitude of the stations was between E 051.34° to 046.54°. Most populations occurred in the flatlands, but some of them were encountered in different habitats, namely in mountain areas (stations 2 and 18), hill slopes (stations 1, 6, 9, 10 and 20), or valleys (station 14). Exposition of the habitat slopes as was southern, eastern or seldom western.

The soil types of most habitats were clayey, but some habitats were on rocky or sandy soils. The highest soil pH (7.77) was registered in station No. 20, while the lowest (6.12) was found in station No. 16. The electric conductivity of soil was between 1.75 and 0.51. The coldest (2.34 °C) and the hottest (21.79 °C) environments based on the average annual minimum and maximum temperatures were recorded in special stations 6 and 19. The studied stations differed from each other and were separated in the Pco plot (Fig. 4).

On the basis of ecological factors, the special stations were divided into fourteen groups (Table 3). Many groups consisted of one station (groups 1, 2, 3, 5, 8, 10, 11 and 12), but there were some with two(groups 4, 6, 7, 9 and 14) or three (group 13) stations, Details of members of each group are presented in Table 3.

Table 5. Ecological characteristics of the studied station.

Population	Altitude	North	East	Min˚	Max˚	Habitat	Gradient	Soil	pH	Ec
1	1900	35.48	51.33	8.22	18.12	slope	southern	soft-clay	6.97	1.54
2	1408	36.19	49.47	6.06	20.36	mountain	slope	clay	7.10	1.10
3	1898	35.24	49.01	5.48	17.48	flatland	slope	clay	7.65	1.47
4	1789	34.54	48.21	3.04	18.84	flatland	slope	clay	7.49	0.81
5	1717	35.19	50.06	8.35	20.15	flatland	slope	clay	7.61	0.81
6	1860	35.16	47.08	2.34	18.00	slope	eastern	sandy	7.25	1.13
7	1761	35.06	49.34	3.30	19.10	flatland	slope	clay	7.70	0.68
8	1620	35.30	47.04	3.90	19.8	flatland	slope	soft-clay	7.38	0.60
9	1783	35.11	49.54	7.92	19.72	slope	eastern	clay	7.55	0.51
10	2130	35.48	51.34	6.72	16.62	slope	western	sandy	6.98	1.75
11	1760	34.58	48.35	2.65	18.45	flatland	slope	clay	7.20	0.72
12	1566	35.15	50.17	9.33	21.13	flatland	slope	clay	6.84	1.16
13	2121	35.11	50.10	5.72	17.52	flatland	slope	clay	7.47	1.02
14	1585	35.13	46.54	4.13	20.03	valley	eastern	clay	7.66	0.85
15	1329	35.04	46.56	5.78	21.68	flatland	slope	clay	7.37	0.74
16	1476	35.16	47.00	4.84	20.08	flatland	slope	clay	6.12	0.93
17	2180	33.59	49.34	3.94	17.64	flatland	slope	sandy	7.62	1.02
18	1710	35.48	51.23	9.69	19.59	mountain	slope	rocky	7.52	0.74
19	1464	35.07	49.44	9.99	21.79	flatland	slope	clay	7.44	1.60
20	1645	35.19	46.57	3.74	19.64	slope	southern	rocky	7.77	1.15
21	1805	36.22	48.59	4.01	16.91	flatland	slope	clay	7.65	0.96

Abbreviations: Min.: average annual minimum temperature in °C, Max.: average annual maximum temperature in °C.

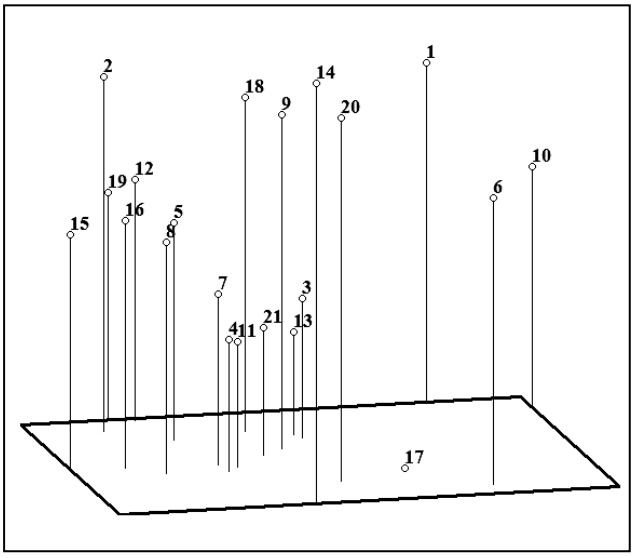

Fig. 4. Pco plot of the studied stations on the basis of ecological characteristic.

Discussion

In the present study, determination of the special station was used for identification of intraspecific variations of *L. album*. For this purpose, twenty-one populations of this species were selected from different geographical regions of Iran and their morphological features as well as their associated taxa and ecological characteristics of the habitat were examined.

Understanding the mechanisms by which plants deal with environmental challenges is of vital importance in plant ecology, forestry, and agriculture (Chapin 1991; Pessarakli 1999). As sessile organisms, plants are constantly exposed to a variety of environmental stresses to which they respond by architectural, morphological, and physiological adjustments (Niklas 1992; Nilsen & Orcutt 1996).

Twenty qualitative and quantitative morphological characteristics of individuals in the *L. album* populations were examined. Typically individuals differ within a species in phenotype; although some of these variations may be random, according to ecological theory, a large proportion of these variations may represent adaptive matching of the phenotypes to variable environment (Clausen & al. 1948).

Quantitative morphological characteristics varied between the populations and the ANOVA test showed significant differences in some quantitative characteristics, as well as significant correlations with the ecological factors for some of these characteristics. In addition to quantitative characteristics, the studied qualitative features showed differences between populations. For example, the shape of leaves varied between the populations, and they were linear-lanceolate, lanceolate, oblanceolate, ovate or linear. Such characteristics as leaf shapes are genetically imprinted, yet they can also be greatly affected by the local environment in which they develop (Thompson 1991; Schlichting & Pigliucci 1998).

In addition to shape, the leaves dimensions varied between the populations and had significant correlations with pH. The ANOVA test confirmed these variations. Some leaf traits, such as the leaf area index, can reflect the status of the whole plant (Tsialtas & Maslaris 2007). Leaves have to be optimally adapted to environmental conditions, for they react most sensitively to the environment. Thus, the causal relationships between various environmental factors and leaf traits can be recognized as effects of the soil moisture and solar radiance (Cescatti & Zorer 2003; Liao & al. 2007).

On the basis of these variations, thirteen morphological groups were identified in the UPGMA tree. Each of these groups had some distinct morphological characteristics which differentiated them from the others. For example, in group No. 3, the number of branches and sepal width were greater, but the calyx length/width ratio was lower than in others. In group 10, floral leaf shape differed from other groups while in group 2 sepal length/width and floral leaf length/width ratio were greater.

In order to classify the special stations on the basis of ecological factors, ten ecological factors were examined and on their basis, fourteen ecological groups were identified. These ecological groups were distinguished on the grounds of dissimilarities and similarities in the ecological characters at each station. Special stations with similar ecological characters were placed in the same ecological group. Each of these ecological groups had some distinct ecological characteristics which set it apart from the others. For example, special station No. 17 was at the highest altitude and was the northern most station: in station No. 14 soil and habitat type were different from the others and that station was also the western most one. On these grounds, these special stations were set apart from the others and placed in distinct groups.

When the results of morphological and ecological grouping were compared, we found that: the members of seven morphological groups (2, 3, 4, 5, 8, 10, and 13) were absolutely identical with the members of ecological groups 2, 3, 4, 5, 8, 10, and11, respectively.

The fact that some members of the morphological groups matched exactly some members of the ecological groups led us to the conclusion that in each population, the individuals of *L. album* had changed their morphological characteristics in order to fit into the surrounding environment, and in their stations, there was significant adaptation between morphological characteristics and ecological features. Phenotypic plasticity is the ability of a single genotype to produce an array of phenotypes, depending on the environmental context (Via & al. 1995). Within species, variation in the expression of phenotypic plasticity has been documented among genotypes from a single population (e.g. Macdonald & Chinnappa 1989) or among populations of the same species (Sultan & Bazzaz 1993).

The effects of naturally occurring variation among the species (interspecific) have driven plant (macro) evolution by natural selection and, this developmental diversity is the basis of plant taxonomy and phylogeny (Cronk 2001). Furthermore, within many species there exists comparable developmental variation (intraspecific), which reflects the adaptation to different natural environments and thus marks the origin of plant species differentiation (Linhart & Grant 1996). Humans have used this intraspecific variation for domestication and genetic improvement of more than 100 plant species (Diamond 2002) by applying directional selection on multiple aspects of plant development.

Morphological variation and geographical separation among populations are also a prerequisite for the formation of subspecies and species (Losos & Glor 2003). Phylogeographical analysis can be used to illuminate the interplay of climate, geographical history, and evolutionary dynamics in generating new taxa (Avise & al. 1987; Arbogast & Kenagy 2001).

Floristic composition of the vegetation is more susceptible to direct study and exact characterization of intraspecific variation. Floristic compositions of the associated taxa of studied populations of *L. album* were distinguished. On the whole 118 associated species, subspecies and varieties were identified belonging to different plant families.

Some taxa, such as *Senecio vulgaris* were recorded in many of the studied stations, and occur along with *L. album*. Therefore, the presence of *Senecio vulgaris* in any natural habitat may be *L. album.* A large number of taxa do not occur in many stations, so when these taxa occur in a special station, they have a diagnostic value for identification of the special stations. Knowledge of the floristic composition of an area is a prerequisite for any ecological and phytogeographical studies and conservation management actions. In order to study a particular type of vegetation from an ecological viewpoint, our first step must be to determine the facts as they exist on the spot e.g., vegetation, habitat, etc. (Nicholes 1930).

As these environmental and biological characteristics change so will the plant community structure as the organism's' distribution shifts to track their climate optimum (Walther & al. 2002). Changes in performance and abundance of the key species can have a profound impact on important ecosystem services, including carbon sequestration, thus providing habitats for commercially important species, and serving as sites for recreation and ecotourism (Vernberg 1993).

On the Basis of the floristic marker, the studied stations of *L. album* were divided into twelve main groups. These groups were classified on the basis of similarity and dissimilarity of the associated taxa of each *L. album* special station. The above-mentioned groups showed high degree of intraspecific variations in *L. album.* Since floristic composition in each environment reflects the ecological conditions that influence plant variation, the special stations with similar floristic composition have similar ecological characteristics.

These floristic groups consist of one to four members. The members of some floristic groups (1, 2, 3, 4, 7, 9, 10 and 12) were absolutely identical to the members of ecological groups1, 2, 3, 4, 7, 9, 10 and 12, respectively. Furthermore, some members of floristic group 6 were identical with those of ecological group 13. These results showed that ecological factors affect strongly the distribution of plant taxa and floristic composition of each region. The obtained data confirmed the theory proposed by Gleason (1926) and others about the species as essential determinant of vegetation structure and composition. This individualistic approach maintains that each species responds in its own way to the physical and biotic environment. Analytical studies of community structure suggest that each species has an optimum environment that does not coincide with the environment of it's a potential competitor (Whittaker 1965).

These observations seemed very attractive when were established that; the members of some ecological, floristic and morphological groups were absolutely identical. For example, the members of floristic groups 2, 3, 4, and 10 were absolutely similar to those of ecological and morphological groups 2, 3, 4, and10. Sig-

nificant convergences occurred between the ecological parameters, floristic composition and phenotype plasticity in some of the studied special stations of *L. album*.

This showed that ecological factors effect strongly the distribution of plant taxa and the composition of regional flora, but that potency of different ecological parameters varied and some of them were stronger than others. For example, on the basis of floristic composition, special stations13 and 10 were closely tougher with each other, but these stations, on the basis of morphological features or all ecological parameters, placed into different groups. While, when ecological groups established on the basis of elevation and average annual minimum temperature, stations13 and 10 placed near each other. On the basis of this observation, it could be concluded that these two ecological characteristics were more effective in the creation of the floristic composition of these stations. Any vegetation in a particular place is influenced by the prevailing environmental factors, including: climate, topography, soil, human activities and other biotic factors (Zahran 1982).

Another example for variation in the potency of different ecological parameters was seen in station No. 14. This station stands quite apart from the others in the C.F.A. diagram based on floristic composition, and also in the Pco plot (based on all studied ecological factors). The separation is not so great, when, in present study, the ecological parameters were examined separately or in both, it found that, station No. 14 was remote from others on the basis of the habitat and soil type. This showed that in station No. 14 the soil type and habitat were more effective than the other ecological characteristics. One of the main components of each rangeland is vegetation; its absence and presence is controlled by environmental variables, such as climate, soil, and topography (Leonard & al. 1988). Among the different environmental factors, soil is of great importance for plant growth, and is a function of climate, organisms, topography, parent material and time (Hoveizeh 1997).

The degree of stress induced by a given factor depends on the intensity and/or frequency of the stress, and therefore, plant responses will vary according to the circumstances. Wind, for instance, is a ubiquitous factor that promotes growth when plants are exposed to slow air flows (Smith & Ennos 2003), but it becomes stressful above certain speed thresholds (Pigliucci 2002). This was especially true for station No. 17 at 2200 m a.s.l. (the highest among the studied stations). At such altitudes the speed of air flows or wind are faster than in lower places and this affected the morphological characteristics of *L. album* and its associated taxa in that special station. For this reason, station No. 17 in the ecological Pco plot, UPGMA tree of morphological characters and C.F.A. diagram of floristic composition was placed in a separate distinct group.

The results of this study have shown that, in many cases, there were significant correlations between the ecological characteristics of the habitat and the phenotypic plasticity of studied populations and their associated taxa. However, there were cases when no adaptation could be traced out between the ecological characteristics of the habitat, morphological features of the studied populations and floristic composition of their associated taxa. For example in station No.13, morphological grouping of the *L. album* population did not match with the ecological characteristics of habitat and its associated taxa. In these cases, the morphological characteristics and associated taxa of the studied populations did not coordinate with the ecological features of habitat and in some stations, morphological classification of the studied species did not match the with floristic and ecological classifications; so these stations were placed each in a separate groups. The reasons of this discoordination are not clear. It may be related to pressures of the contemporary climate changes, or changes in the genome structure of the studied species. Future changes in climate could result in extinction, range shifts, changes in major vegetation types, and alterations in the feedback of vegetation and atmosphere. Indeed, distribution of many plant species has already altered in response to climate changes; some species have registered annually up to 6 km pole-ward migration in the past 16–132 years (Parmesan & Yohe 2003).

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