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Assessment of ecological and phenological traits of *Prangos ferulacea* (case study: Barzok mountains and Naragh, Kashan, Iran)

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Abstract

In order to study ecological and phenological traits of *Prangos ferulacea* as an important medicinal plant, this research was conducted in Barzok Mountains and Naragh in Esfahan province, Iran. Random samples of this plant were taken and their vegetation habitat conditions and their growth characteristics including height of collar leaves, height of the flower stem, flower stem number and forage production were recorded and categorized. Physical and chemical soil characteristics (soil texture, acidity, soil Electrical Conductivity (EC), absorbable phosphorus and potassium, and the percent of organic carbon) were examined by monthly interval at a soil depth of 30 cm from March to September. All characteristics were analyzed using factorial experiment with two factors of sites and months. Results showed that this species grow quite satisfactorily in the foothills elevation of 2750 m to 3540 m above sea level as long as it received more than 200 mm annual precipitation. The soil EC was less than 1 ds/m and acidity ranged from 7.5 to 7.8. Canopy cover in Naragh and Barzok were 15.7% and 6.1%, respectively. Results showed that growth indices as the height of collar leaves and forage production were high at the Barzok sites, while the height of flower stem was important in Naragh. For phenological process, the results indicated that plant germination started from the end of March-April and continued to the end of summer; flowering started from May-June; seeding completed in June-July and dried out completely by the end of summer. Moreover, in winter, the plants were dormant.

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Introduction

In pastoral ecosystems, achieving the specific characteristics of plant species and their vegetation environment condition is needed to increase the possibility of the maintenance of these species. The wide variations in the ecological factors of climate, soil composition, topography, etc., have influenced the formation of a similarly wide variation in vegetation across the country. In order to recognize the various native species and vegetation conditions associated with them, these species can be used in ecosystem improvement and pastoral ecosystems revival. With the study of vegetation conditions associated with the growth of native medicinal species, an effective step can be taken to domesticate and exploit production of these species in the Agro-Ecosystems (Bagheri, 2011).

On the other hand, with the phenology study of this species, the time of livestock entry into rangeland exploitation period, the choice of grazing system, and the formulation of grazing plans etc., can be regulated. Climate change is a direct threat to alpine plants of any area. After climate change in Polar Regions, the alpine areas are sustaining the most damaging effects from climate changes of the earth, (Kullman, 2004). So, the study on vegetation requirements of plant species in alpine area is important. Although a number of studies have reported the vegetation conditions of rangeland species in recent years, only a few of them focused specifically on alpine species. Cansaran *et al.* (2007) studied and observed the autecology, morphological and anatomical characteristics of *Erysimum amasianum* around the Black Sea, reporting that the presence of this species caused an increase in nitrogen, potassium and calcium in the soil. Kaya and Aksakal (2007) studied the autecology of *Salvia rosifolia* Sm. in Turkey. They concluded that the existence of this species in the area was closely linked with the levels of presence of phosphorous, nitrogen and potassium. Sakcali *et al.* (2008) showed that *Capparis spinosa* tolerated drought because its long roots and ecological range permit the species to endure harsh environmental conditions.

Hoveizeh and Shahmoradi (2009) studied the autecology of *Cenchrus ciliaris* in the province of Khuzestan, Iran. They observed that this species settled in the vegetation places with a loamy sandy soil texture and silty sand with stone lyres. Mansoori (2009), studied the autecological characteristics of *Desmostachya bipinnata* species and concluded that this species is present in vegetation places with a loam to sandy loam soil texture that have pH ranged from 8.03 to 8.31, and salinity of 10 to 60 ds/m. Tavili *et al.* (2010) studied *Vicia villosa* in the province of Kohkiloye and Boirahmad, Iran and reported that this species grew on the slopes of 15 to 50% across all geographical directions, and the average rainfall in its vegetation locations was 870 mm. Arya *et al.* (2011) studied the ecological characteristics of *Mentha mozaffarianii* Z. Jamzad in the province of Hormozgan, Ian and reported that this medicinal plant distributed in alpine areas with altitude of 250 m to 2400 m above sea level on the coarse-grained alluvium in the bed of rivers.

Previously, the autecological studies on the alpine species from Apiaceae species involving *Dorema ammoniacum* in the province of Kurdistan, Iran (Hassani and Shahmoradi, 2007), *Ferula ovina* in the province of Tehran (Azhbar and Shahmoradi, 2007) and another type of *Ferula oopoda* species in the province of Esfahan (Sharifi Yazdi *et al.*, 2008) have been done but no research is reported about the ecology of *Prangos ferulacea* as medicinal-forage species from *Apiaceae* growing in the heights of Esfahan, Markazi, Lorestan, Fars, Tehran and Kermanshah provinces, Iran (Rechinger, 1978). About seven species of *Ferula* genus grow exclusively in Iran.

The main compounds of *Feruago angulata* are Alfa-pinen (17.3%), Bournil Asetat (14.45%) and Sis-Asimen (14.4%) from the western vegetation place (Rezazade *et al.*, 2003). This plant is added to meat as

a natural preservative in order to prevent spoilage, for cooling it, and to maintain its delicious sweet taste (Khanamadi and Janfeshan, 2006). The seeping syrup from the stem, obtained after an insect laceration, is used for the treatment of bone fractures and contusions both in man and animal. This alpine species is not only important for water and soil conservation of alpine ecosystems, but also is a favorite of the resident honeybee population. The beauty of the yellow umbrellas of this plant also lends great aesthetic beauty to these alpine areas. Because of the climatological temperature effects observed on the wide variety of this species in the regions along with the variation in ecological characteristics of the soil, we aimed to study of the ecological and phenological characteristics of this species in Barzok and Naragh Mountain, Kashan Iran.

Materials and methods

Two alpine sites of Naragh (location: longitude of 57°32'46″ and latitude of 29°20'55″), and Barzok (location: longitude of 57°17'29″ and latitude of 30°29'43″) were chosen for the study. The vegetation habitat characteristics (topography, climate, and soil) and phenology along with species characteristics were studied in two areas. Forty samples of the subject plants were randomly selected at each site. For each samples the vegetation condition were recorded monthly. In this study, the species characteristics (the height of collar leaves, the height of flower stem, the number of flower stem and the forage production) were recorded and evaluated along with the soil physical-chemical characteristic at depths of 0 to 30 cm (soil texture, acidity, electrical conductivity, absorbable potassium and phosphorous, the percent of organic carbon).

During a period from the beginning of spring to the end of summer, soil samples were sent to the soil Laboratory Research Center for Agriculture and Natural Resources of Kashan for analyzing the following characteristic

- Organic carbon% of the soil, was determined using burning and weighing method.
- Absorbable phosphorous, was determined using Olsen *et al.* (1954) method.
- Absorbable potassium, was determined at pH 7 buffered ammonium acetate solution.
- Acidity was measured by a pH meter.
- EC of the soil, was determined using the Karter method.
- Soil texture measurements, a standard lab hydrometer method was used.

SPSS 16 software was used for the analyses of variance of all the edaphic and species characteristics by focusing on two factors, location and time, covering 5% probability level. For the mean comparisons the Duncan multiple range method was used.

Results

Results showed that the vegetation places of *Prangos ferulacea* were located in the province of Esfahan at altitude of 2730 to 3540 m above sea level. The most prevalent occurrences of this species were within the range of 2900 to 3300 m. The species concentrates on the mountains with a high level of soil erosion. From the geological perspective, Barzok Mountain and Naragh, are generally classified as belonging to the third period of geology. Moreover some parts of it containing more ancient sediment such as Jurassic and Paleozoic fossils have outcrop. The main vegetation cover type of two areas is *Artemisia aucheri* with *Prangos ferulacea* and because of local topography conditions and different slopes, the domination of the above species varies, but *Artemisia aucheri* remained as the main species. *Oryzopsis holciformis* was under the higher forage protection. This species, along with *Artemisia* sp., is the dominant species of vegetation locations in most of the studied sits.

The Prangos ferulacea characteristics

Results obtained from the analysis of variance are shown in Table 1. The effect of site and the sampling time was significant for all characteristics ($P \leq 0.01$). There was also significant interaction between site

with sampling time for height of collar leaves (P≤0.01) and (height of flower stem (P≤0.05) (Table 1). The comparison of the main effects of the studied sites and time of harvesting are shown in (Tables 2 and 3), respectively.

Table 1. Factorial analysis variance for sites, time of sampling and interaction effects between them.

Source of Variation	DF	MS			
		The height of Collar Leaves (cm)	The Height of Flower Stem (cm)	The Number of Flower Stem	Forage Production 10% (g)
Site	1	154.08**	9664**	0.001	86.5*
Replication	3	63.6**	3177.6**	0.61**	132.1**
Error (A)	3	101.6	1520.5	1.03	318.5
Time of sampling	5	3111.6**	15032.2**	3.60**	426.8**
Site by time	3	5.07**	809.86*	047	26.01
Error (B)	30	3.89	143.4	0.084	24.8
CV (%)		4.8	22.4	22.2	26.2

** and * = Significant on probable level of 1%, 5%, respectively.

In comparisons between two sites, the higher and lower collar leaves height with average values of 43 and 39 cm and higher and lower forage production with average values of 203 and 176 g/per plant were obtained for Barzok and Naragh sites, respectively. In contrast, for the flower stem length, the lower and higher values with average values of 53 and 81 cm were obtained in Barzok and Naragh (Table 2).

Table 2. The mean comparisons between sites for plant characteristics.

Sites	The Height of Collar Leaves (cm)	The Height of Flower Stem (cm)	The Number of Flower Stem	Forage Production 10% (g)
Barzok	43 a	53 b	1.31 a	20.3 a
Naragh	39 b	81 a	1.30 a	17.6 b

Means followed by the same letters in each column are not significantly different (P<0.05).

Table 3. The effect of sampling time on the average of the characteristics.

Months	The Height of Collar Leaves (cm)	The Height of Flower Stem (cm)	The Number of Flower Stem	Forage Production 10% (g)
March-April	0.8 c	0.0 c	0.0 c	4.7 c
Apr-May	46 b	24.5 b	1.1 b	24.7 a
May-June	49 a	93 a	1.6 a	18.5 b
June-July	50 a	94 a	1.7 a	22 ab
July-August	50 a	94 a	1.7 a	23 ab
August-Sept	50 a	96 a	1.7 a	21ab

Means followed by the same letters in each column are not significantly different (P<0.05).

The main effects of time of sampling were significant for all traits. The lower values always were obtained in initial growth in March. All traits values were increased by time of growth. For collar leaves height, the lower values of 0.8 cm was obtained in initial growth in March and continued up to 50 cm in June. The length of flower stem was 24.5 cm in April and will increase up to 94 cm in June. Similarly, the stem number in April was 1.1 and increased to 1.7 in June. The lower forage production with average values of 47 g/plant was obtained in March and it was increased up to 247 g/plant in April. In summer, from June to

September, the growth of species was generally constant for all traits (Table 2). The mean comparison between sites by time interaction effects are shown in (Table 4. and Fig. 1). Results indicated the same trend in both sites.

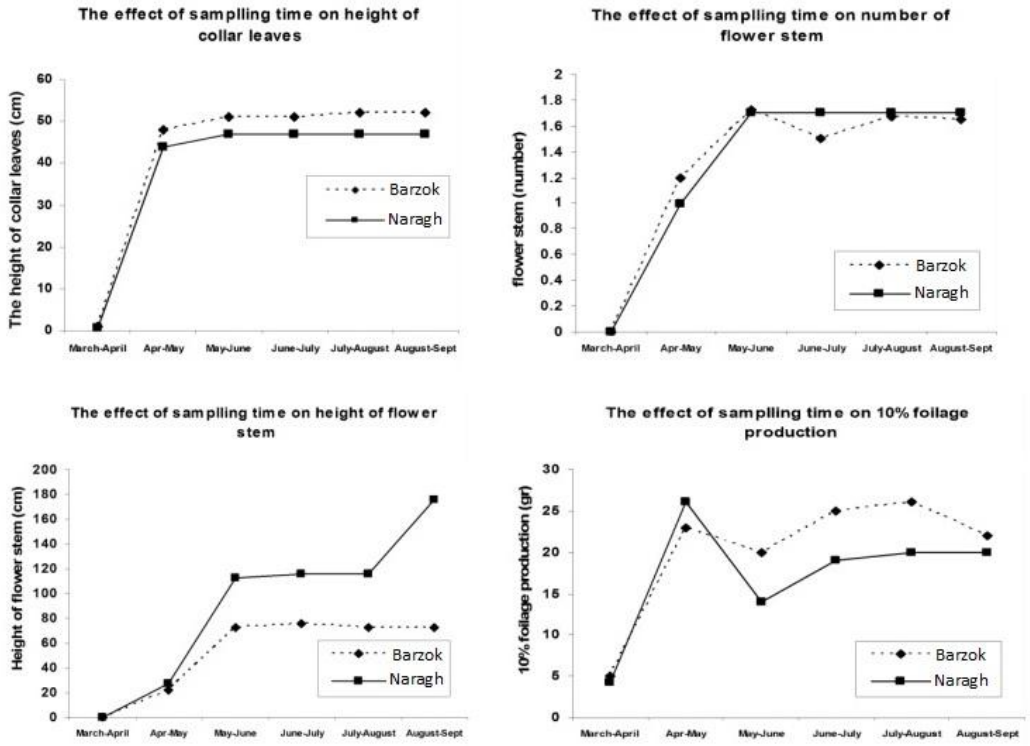

Fig. 1. The trend of studied characters by plant growth over time.

The soil parameters

According to the results obtained from the analysis of soil properties (Table 5), the results showed significant differences between two sites for all traits except pH and EC. The mean values of 1.38 and 0.65% for organic carbon and 68.2 and 63.2 % for sand (%) were obtained on Barzok and Naragh. In contrast, the higher absorbent phosphorous, potassium, silt (%) and clay (%) were obtained in Naragh. Results indicated a good soil quality in Naragh (Table 5).

Table 4. The infraction effects of sampling time and site on the studied characteristics.

Months	Sites	The Height of Collar Leaves (cm)	The Height of Flower Stem (cm)	The Number of Flower Stem	Forage 10% Production (g)
March-April	Barzok	1.05 d	0.0 g	0.00 f	5.1 a
	Naragh	0.73 e	0.0 g	0.00 f	5.1 a
Apr-May	Barzok	48.00 b	22.0 f	1.20 d	23.0 a
	Naragh	44.00 c	27.0 e	1.00 e	26.0 a
May-June	Barzok	51.00 c	73.0 d	1.72 a	20.0 a
	Naragh	47.00 b	113.0 b	1.70 a	14.0 a
June-July	Barzok	51.00 a	76.0 c	1.50 a	25.0 a
	Naragh	47.00 b	116.0 a	1.70 a	19.0 a

Months	Sites	The Height of Collar Leaves (cm)	The Height of Flower Stem (cm)	The Number of Flower Stem	Forage 10% Production (g)
July-August	Barzok	52.00 a	73.0 c	1.67 b	26.0 a
	Naragh	47.50 b	116.0 a	1.70 a	20.0 a
August-Sept	Barzok	52.00 a	73.1 c	1.65 b	22.0 a
	Naragh	47.50 b	176.1 a	1.70 a	20.0 a

Means followed by the same letters in each column are not significantly different (P<0.05).

Table 5. The mean comparisons between sites for soil properties.

Sites	EC (ds/m)	Organic Carbon (%)	Phosphorous (mg/kg)	Potassium (mg/kg)	pH	Sand (%)	Silt (%)	Clay (%)
Barzok	0.78 a	1.38 a	2.6 b	264 b	7.5 a	68.2 a	18.5 b	10.7 b
Naragh	0.78 a	0.65 b	14.8 a	472 a	7.8 a	63.2 b	26.7a	11.1 a

Means followed by the same letters in each column are not significantly different (P<0.05).

Plant phenology

During the plant growth, all phenological processes were recorded and presented at Table 6. The appearance of leave was observed at August-September, which correlated with rise of temperature of air. The emergence of leave begins from the second half of this month, and the manifestation of the flower stem is done at the early of Apr-May. In addition, the appearance of flower cluster was done near the end of Apr-May and flowering was completed near the end of May-June. During a period that the plant arrives at seeding, the collar leave becomes yellow gradually and when the seeds become completely ripe, also the collar leaves become completely yellow and dry.

Table 6. Different processes of phenology of *Ferulago angulata*.

Month	Appearance of Leaves	Appearance Flowers Stem	Appearance Flower Cluster	Flowering	Seeding	Leaves Fall	Complete Dryness
March-April							
Apr-May							
May-June							
June-July							
July-August							
August-Sept							

Discussion

Based on the findings of this research, *Prangos ferulacea* grows at the height range of 2750 to 3540 m above sea level where annual rainfalls average is more than 200 mm, the minimum average annual temperature is less than -16 ºC and a maximum temperature reaching no more than 30 ºC. This range species distributes best in the high, snowy Alpine areas that receive abundant moisture on their northern, northeastern, eastern and a part of their western slopes with grades of 5 to 80 percent.

The highest forage production occurred at Apr-May equaling 247 g/p. The lowest production was obtained at March-April equaling 47 g/p. The higher density per ha was belonging to Naragh with amount of more than 200 bases whereas the higher density over than 60 bases was belonging to Barzok: Also, the canopy cover in Naragh and Barzok were 15.7% and 6.1%, respectively.

The results obtained in this research revealed that the effect of site on the height of collar leaves, height of the flowering stem, and forage production was significant. That the higher values of height of collar

leaves, the production of bush) was related to the area of Barzok and the higher values of generative growth in the height of the flowering stem was obtained in Naragh. Results showed that there was no significant differences of height of collar leaves, the height and number of flowering stems from May to September. These characteristics had no considerable change in spite of additional growth of March-April to May-June. But, the maximum forage production was observed during April and May and reduced from May-June. In fact, the lower growth of these characteristics at summer could be related to soil moisture of these ecosystems. The appearance of the phenological phenomena is under the effect of height, slope, direction and rainfall.

These areas have little differences from this point of view. So, the difference among the emergence time of the phenological phenomena in the different areas was not significant. The results of this study corresponded with those obtained by other researchers. The lack of moisture is an important obstacle for the production of forage and the formation of seed. This corresponds with the research of Koochaki *et al.* (1997). They suggested that the lack of water in the atmosphere was the delaying factor on the flower production of *Sorghum*. Temperature, light, moisture, soil fertility and the growth regulators were all effective factors on the flower production.

In this research, no statistical difference on the estimated characteristics of soil was observed at the different months, and this important issue showed that the chemical characteristics of soil had no much change at short period (data not shown). The higher values of the pH values 7.5 to 7.8, in the areas was related to lower salinity less than 1 ds/m.

On the other hand, other results of edaphic data showed that the soil of two areas had differences with each other for organic carbon (%) and the absorbable phosphorous and potassium and sand (%), that the higher values of organic carbon (equal 1.38%) was related to Barzok and the higher values of absorbable phosphorous and potassium was related to Naragh.

In fact the deeper researches revealed that the maximum vegetation index of *Prangos ferulacea* (the height of collar leaves and forage production) was related to the area of Barzok because soil of this area was rich of organic matter and the presence of soil nitrogen was much in Naragh lead to increasing of height of flower stem because the amount of absorbable potassium and phosphorous was high in this vegetation place. The studies of some researchers such as Eshaghi Rad *et al.* (2009) and Fatahi *et al.* (2009) indicated the effective role of absorbable potassium and phosphorous at the generative parameters. Moreover, the finding of some researchers such as Najafi Tyreh Shabankare *et al.* (1999) and Ghorbanian and Jafari (2007) also showed the effective role of nitrogen at the vegetation parameters of the plant. So, the results of this research are in agreement with their finding. With respect to the role and the importance of soil characteristics in two areas, studies about vegetation and vegetative parameters suggest to use manure and biological fertilizer to improvement of chemical characteristics of poor soil and to increase forage and seed production. With respect to the importance of soil fertility on the improvement of growth indices of this species according to the findings of this research, the necessity of attention to the soil erosion is more felt in the vegetation places of this alpine species. Therefore, the implementation of soil protection and in *Prangos ferulacea* vegetation area is suggested to the department of natural resources because they could conduct the rehabilitation and their productivity.

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