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***Research Article***

# *Astragalus ovinus* Boiss. Responses Along the Gradient of Environmental Factors in Oak Forests of Yasouj, Iran

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## Abstract
Environmental factors have a major impact on the distribution and yield of plant species. For this purpose, considering the importance of *Astragalus ovinus* (L.) Boiss. in forage production and the possibility of using it in improvement and reclamation of forest ecosystem. In the present study, the responses of *A. ovinus* were evaluated to some environmental factors in one of its habitats of southwest of IRAN (Kohgiluyeh and Boyer-Ahmad province) in 2018- 2020. Redundancy Analysis (RDA) and Generalized Additive Models (GAM) were used to determine the ecological factors affecting vegetation changes and to evaluate the response of *A. ovinus* along the gradients of ecological factors, respectively. Data analysis was performed using SPSS17 and CANOC4.5 software. According to the results, the response pattern of *A. ovinus* along the gradient of soil surface litter, percentage of bare soil, percentage of land slope, and altitude, followed the unimodal model and the optimum growth levels for these factors were 20%, 20%, 30%, and 2220 m, respectively. Also, the response of this species to aspects has followed the unimodal model, so that in the eastern and western slopes, the presence of the species increased and the northern, southern slopes of the species decreased. The reaction of this species to changes in soil sand content followed the bimodal model indicatinga competitive constraint along the environmental gradient. The results of the *A. ovinus* phenology study showed that the best time for livestock to use of this species is mid-May and the best time to collect seeds of this species is late June to the first half of July. Percentage of canopy cover in forest it has not affected the performance and frequency of this species. Regarding the response of this plant to the gradient of studied environmental factors, it is recommended to pay attention to its habitat characteristics and ecological requirements in improvement programs on oak forests understorey vegetation.

**Keywords:** Ecological factors, Generalized Additive Model, Ordination, Species response curve.

## 1. Introduction
The presence and distribution of plant communities in forest ecosystems are not accidental, rather, climatic, soil, topographic factors, and human activities play an important role in their distribution (Leonard et al., 1984). Vegetation plays an important role in providing various ecosystem services. Analysis of the relationship between plants and environmental factors has always been considered as a fundamental issue in ecological studies (Guisan & Zimmermann, 2000).

The authors Wang et al. (2016) assert that employing statistical regression methods to

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accurately quantify the distribution of species is imperative for gaining a comprehensive understanding of their realized niche, as well as for promoting species conservation in the face of global environmental changes.Initially, these models were used as tools in autecology studies, but in recent decades, they are used in many cases such as land use impact assessment, various hypotheses in biogeography, mapping, as well as conservation issues (Gogina, 2010).

Jankju et al. (2010) by investigating the autecology of winter milkvetch (*Astragalus arpilobus Kar. & Kir*) in the rangelands of northeastern Iran (winter rangelands of North Khorasan province) reported that the distribution of this species is in the altitude range of 500-600 meters above sea level, slopes of 20 to 100% and the average annual rainfall of 236.85 mm. Nosrati et al. (2018) by studying the individual ecology of *Astragalus fasciculifolius* Boiss. in natural habitats in the south of Sistan and Baluchestan province with an average annual rainfall of 52 mm and an average annual temperature of 25 ◦C, reported that this species is distributed in areas with an acidity of 8.23-6.73, the electrical conductivity of 1.2-1.06 ds/m and at an altitude of 1300-1500 meters above sea level.

The effectiveness of the Generalized Linear Model (GLM) and the Generalized Additive Model (GAM) in determining the relationships between vegetation and environmental factors in the Pleur tourist area was investigated. Accordingly, it was reported that the highest $R^2$ in the GLM model was related to the presence of *Agropyron* sp. species at 0.98. The lowest RMSE and AIC were 0.29 and 12 for *Astragalus ochrodeucus*, respectively. In the GAM model, the highest $R^2$ belonged to *Thymus kotschyanus* Boiss. (0.88). Also, the lowest RMSE and AIC related to *Astragalus ochrodeucus* and *Ferula gumosa* Boiss. were 0.22 and 18.12, respectively (Jafarian & Kargar, 2017).

Modeling the potential habitat of yellow milkvetch (*Astragalus verus* Oliver.) using the ecological nest factor analysis method in the rangelands of Faraydunshahr area of Isfahan province showed that the most important environmental factors affecting the distribution of this species are soil electrical conductivity, calcium carbonate content, soil acidity, land slope and average monthly temperature (Safaei et al., 2013).

*Astragalus ovinus* Boiss, is a perennial and herbaceous plant with a height of 30 to 35 cm from the Fabaceae family, which is one of the important species in steppe and semi-steppe rangelands of Iran due to its suitable forage production, high palatability and high distribution level in the Iran and Kohgiluyeh and Boyer-Ahmad province (south-west of Iran) (Mozafarian, 2017). Due to the fact that the expression of the response of the studied species to the gradient of environmental changes has mainly remained descriptive and also the lack of information about the response of the *A. ovinus* to environmental factors, it appears imperative to address the ecological characteristics and study the presence of this valuable species in the growing areas for better management and reproduction.

The aim of the study was threefold: 1) to examine the ecological requirements of A. ovinus, 2) to investigate how this species responds to soil and topographical changes, and 3) to conduct a phenological analysis of A. ovinus. To achieve these goals, a Generalized Additive Model (GAM) was employed to model the species' habitat in the Kohgiluyeh and Boyer-Ahmad province of Iran.

## 2. Materials and methods

### *2.1. Study area*

The study site with the local name of Vezg Pass is located in forest ecosystem an area of 1200 hectares, It is situated 25 km southeast of Yasouj city in Kohgiluyeh and Boyer-Ahmad province (south-west of Iran), with a geographical position of 30˚34' 27" N to 30˚35' 12" N and 51˚38' 34" E to 51˚39' 15" E. (Figure 1). Oak trees in study area exhibit two vegetative forms: High-forest trees and coppice trees (or sprout clumps), each with its own set of functions.

The average annual rainfall of the study area based on Yasouj synoptic station located 15 km from the area with an altitude of 1820 meters asl.is 836.5 mm. The average annual temperature is 15.06˚ C. The minimum and maximum absolute temperatures in this region are 5 and 39.2˚ C, respectively, and are among the cold semi-arid regions.

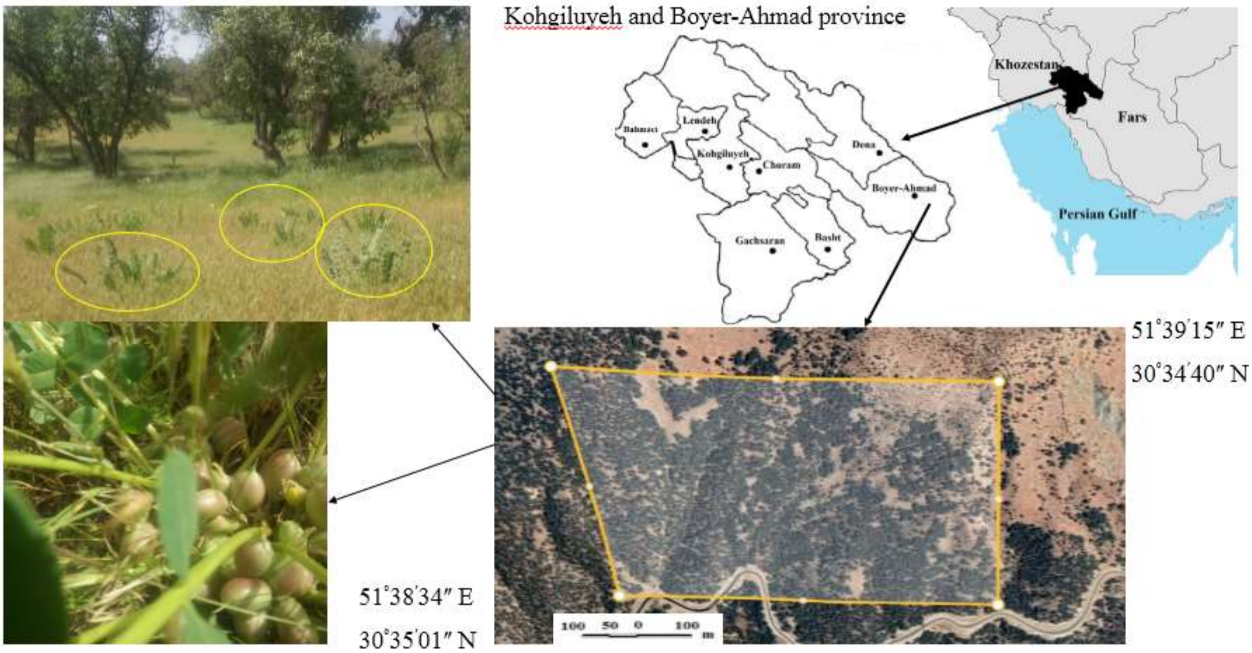


**Figure 1.** Location of the study area in the country and the province of Kohgiluyeh and Boyer-Ahmad and photographs of *A. ovinus* in the forest ecosystem

### *2.2. Experimental design and soil sampling*

Vegetation sampling was performed usingsystematic-random method (Arzani & Abedi, 2015), inside plots located along linear transects in 2018. In the study habitat (distribution site), five transects with the same distance from each other were selected, and on each one of them, six plots with equal distances were established (totally 30 plots). The length of of transects were 660 meters and their distance was 250 meters. While the distance of plots on each transect relative to each other was considered 110 meters. The size of the plot in each ecological unit was determined by the species-area curve (Asri, 2005) whose dimensions were considered 4×4 meters. After the sampling network in each ecological plot was established, the plant density and the percentage of canopy cover of each plant species in the plots and the annual production of *A. ovinus* were measured. Plants density was determined by counting and their canopy cover percentage theoretically estimated (ocular estimate). The current year production of *A. ovinus* was also measured by clipping and weighing method. Similarly, in each plot, the percentage of total canopy cover, percentage of ston & gravel, percentage of bare soil and percentage of litter were also calculated. For the purpose of investigating the effect of environmental factors on the dispersal of *A. ovinus*, a composite soil sample was gathered from each plot to the rooting depth of the plant (0-30 cm). The soil physical and chemical properties including texture, pH, Electrical Conductivity (EC), Total Neutralizing Value (TNV%), Organic Carbon Content (OC%), total nitrogen and Saturated Moisture percentage (SP) were measured (Robertson et al., 2003). The aspect variable was recorded based on four main directions (90, 180, 270, 360 degrees) and analyzed using Beers et al. (1966) as the equation (1):

$$A' = Cos(45 - A) + 1 \qquad (1)$$

Where A; The amount of direction azimuth and A`; The value converted is directional.

At data preparation stage, initially the nominal and sequential variables such as soil texture and the relative data in the column related to each of the factors were identified. The outcome of this division was 26 environmental variables that for easier interpretation were classed in five groups of soil (texture, pH, EC, TNV%, S.P.%, Oc%, N%, bare soil%, litter%, gravel%); topography (altitude, slope percentage and aspect); rock outcrop (rock percentage as a measure of rock habitats), overstory% (percentage of canopy cover of upper forest floors) and spatial correlation between sample plots (Borcard et al., 1992) were evaluated.

Plant phenology was studied with the aim of managing livestock in rangelands, specially by detrmining the time of entry of livestock into the habitat of the studied specis as well as the seed collection time. For this purpose, the plant growth calendar was recorded for three years (2018-2020) from the beginning of the growing season (early March) and for a total of 10 random plants (marked inside the plots) every two weeks at studied habitats. Finally, the phenological diagram was drawn.

### *2.3. Data analysis*

For investigation of the relationship between effective and significant environmental variables and plant vegetation and to select the appropriate linear and nonlinear method, Detrended Correspondence Analysis (DCA) was performed on vegetation data (response data), and the gradient length was determined. Given the length of the first axis gradient (which was lesser than 4), the Redundancy Analysis (RDA) method was used. For the analysis of the data in this section, Canoco software version 4.5 was used (ter Braak & Smilauer, 2002).

For plotting the response curve of *A. ovinus* to environmental factors, the GAM was applied (Bakkenes et al., 2002; Traore et al., 2012; Godefroid & Koedam, 2004). As for ranking the variables affecting the performance of the species, the Akaike Information Criterion (AIC) was used as a measure of good fit (Akaike, 1974). Thus, the smaller the AIC value, show that the variable has more effect on species performance (percentage of canopy coverage) or the proposed model is the most appropriate model for fitting the species response curve (Dawson et al., 2007). In this study, the percentage of canopy cover of *A. ovinus* was used to explore the relationship between species and the environment, and the ecological range was calculated as a function of the Gaussian response (Ardekani, 2009).

## 3. Results

### *3.1. Study plants*

The study of plants in the studied area showed the existence of 46 species of vascular plants belonging to 39 genera and 15 plant families (Table 1).

**Table 1.** Scientific name, Life form, and Chorotype of some plants registered in the site

| Family | Species | Life form | Chorotype |
|---|---|---|---|
| Anacardiaceae | *Pistacia atlantica* Desf | Tree | IT |
| Apiaceae | *Dorema aucheri* Boiss | Perennial forb | IT |
| | *Eryngium billardieri* F. Delaroche | " | IT-ES-M |
| | *Ferula ovina* Boiss | " | IT |
| | *Ferulago angulata* Boiss | " | IT |
| | *Prangos ferulacea* Lindl | " | IT-M |
| | *Smyrnium cordifolium* Boiss | " | IT |
| Asteraceae | *Achillea wilhelmsii* C. Koch | Annual forb | IT-ES |
| | *Centaurea virgata* Lam | Perennial forb | IT |
| | *Cousinia bachtiarica* Boiss | " | IT |
| | *Echinops ceratophorus* Boiss | " | IT |
| | *Gundelia tournefortii* L | " | IT-M |
| | *Tanacetum polycephalum* Schultz | " | IT-ES |
| | *Tragopogon caricifolius* Boiss | " | IT- ES |
| Brassicaceae | *Fibigia macrocarpa* Boiss | " | IT |
| Caprifoliaceae | *Lonicera nummulariifolia* Jaub | Bushy tree | IT-M |
| Colchicacear | *Colchicum persicum* Baker | Perennial forb | IT |
| Euphorbiaceae | *Euphorbia helioscopia* L | " | IT-M |
| | *Euphorbia macrostegia* Boiss | " | IT |
| Fagacceae | *Quercus brantii* Lindl | Tree | IT |
| Lamiaceae | *Nepeta glomerulosa* Boiss | Perennial forb | IT |
| | *Teucrium polium* L | " | IT-M |
| | *Thymus daenensis* Celak | " | IT |

| | | | |
|---|---|---|---|
| | *Salvia reuterana* Boiss | " | IT-ES-SS |
| Malvaceae | *Althaea officinalis* L. | " | PI |

**Table 1.** Continued

| Family | Species | Life form | Chorotype |
|---|---|---|---|
| Papilionaceae | *Astragalus adscendens* Boiss | Shrub | IT |
| | *Astragalus effusus* Bunge. | Perennial forb | IT |
| | *Astragalus ovinus* Boiss. | Perennial forb | IT |
| | *Astragalus verus* Olivier. | Shrub | IT |
| | *Glycyrrhiza glabra* L. | Perennial forb | IT |
| | *Vicia villosa* Roth | Annual forb | IT-ES |
| Plantaginaceae | *Plantago lanceolata* L. | Perennial forb | Cosm |
| Poaceae | *Aegilops triuncialis* L. | Annual grass | IT-ES-M |
| | *Avena sativa* L. | " | IT |
| | *Boissiera squarrosa* (Banks et Sol.) Nevsky | " | IT |
| | *Bromus tectorum* L. | " | IT-ES |
| | *Bromus tomentellus* Boiss. | Perennial grass | IT |
| | *Heteranthelium piliferum* Hoechst | Annual grass | IT-SS-M |
| | *Hordeum bulbosum* L | Perennial grass | IT-ES-M |
| | *Hordeum glaucum* Steud | Annual grass | IT-M |
| | *Poa bulbosa* L. | Perennial grass | IT-ES-M |
| | *Taeniatherum crinitum* (Banks et Sol.) Nevsky. | Annual grass | IT |
| Rosaceae | *Amygdalus haussknechtii* Bornm | Bushy tree | IT |
| | *Amygdalus lycioides* Spach | " | IT |
| | *Cerasus brachypetala* Boiss | " | IT |
| Thymelaeaceae | *Daphne mucronata* Royle | " | IT |

Chorotype: ES: Europe-Siberia, IT: Iranian-Turanian, M: Mediterranean, Pl: Polyregional, SS: Saharo-Sindian

Among the plants of this region, perennial forbs with a frequency of 54.34% have formed the dominant vegetative form. After that, annual grasses, trees and shrubs, perennial grasses, bush, and annual forbs are with frequencies of 15.2, 15.2, 6.5, 4.34, and 4.34%, respectively (Figure 2).

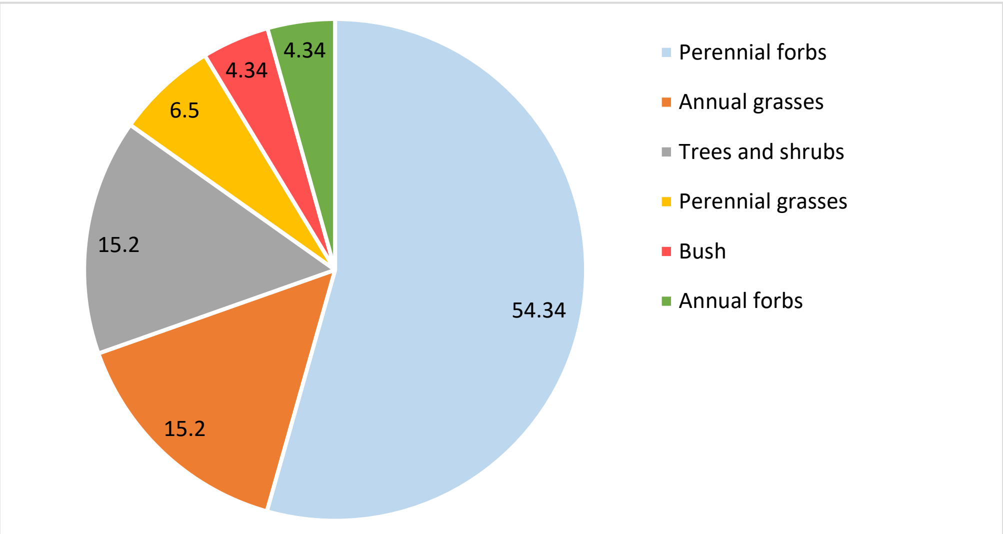


**Figure 2**. Percentage of Vegetation forms of plants in the study area

### *3.2. The Reduction Analysis Ordination (RDA)*

Investigating the effect of a set of environmental factors on vegetation changes in the study area, using the forward selection method in canonical ordination, led to the selection of five variables from among the 25 primary variables. The selected variables are aspect, percentage of ston and gravel, percentage of bare soil, percentage of litter and percentage of canopy cover in forest (see Table 2).

The total amount of variance in the vegetation, expressed using canonical ordination, is 4.036. Considering all the selected variables as constraining variables and considering spatial correlation as covariates and eliminating the effect of this variable on vegetation changes, the above model demonstrated 37.8% of the total variance. The first axis with an eigenvalue of 0.168 and the second axis with an eigenvalue of 0.124 explain 16.8% and 12.39% of the total vegetation changes, respectively.

**Table 2.** Important variables affecting vegetation changes in the habitat of *A. ovinus*

| Selected variables | variance | F* | *P** |
|---|---|---|---|
| Percentage of canopy cover in forest | 15.2 | 10.5 | 0.002 ** |
| Percentage of bare soil | 9.7 | 7.4 | 0.002 ** |
| Percentage of litter | 6.5 | 4.9 | 0.002 ** |
| Aspect | 4.5 | 3.6 | 0.008 ** |
| Percentage of stones and gravel | 2.7 | 2.2 | 0.024 * |

F is the test statistic calculated for the significance of the focal axes. P is the value of the probability level obtained from the Monte Carlo permutation test (with 999 random permutations). ** and * are significant at the level of one percent and five percent, respectively.

The results of the Reduction Analysis Ordination (RDA) based on the first and second axes and the important factors identified in the forward selection method are presented in Figure 3. The distance of points from the coordinate axes shows the strength or weakness of the relationship. The larger the length of vector and the smaller their angle with the axis, the stronger the correlation between the factors and plant species wirh the axis, indicating its relationship with the features of the axis.

As can be seen in Fig. 3, plant species that were mostly present in the plots with *A. ovinus* are *Pistacia atlantica*, *Astragalus verus*, *Eryngium billardieri*, *Smyrnium cordifolium.*

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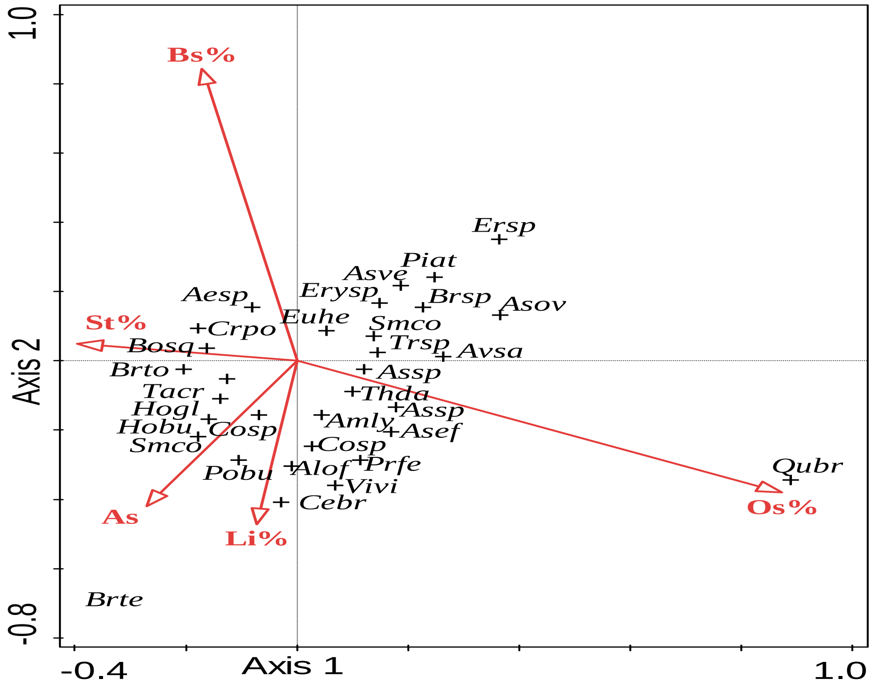


**Figure 3.** Distribution of plant species in relation to. Bs percentage of bare soil, Li percentage of litter, Os% percentage of canopy cover of upper ecological factors forest floors , As geographical direction, St percentage of rock

***3.3. A. ovinus species response curve to environmental factors***

Applying the Generalized Additive Model with Poisson error distribution for each of the environmental variables showed that some of the studied variables such as altitude at 0.05% and soil sand percentage, slope percentage, aspect, litter percentage, and bare soil percentage at 0.01% level had a significant effect on the cover percentage of *A. ovinus*. Ranking of variables affecting the cover percentage of *A. ovinus*using Akaike information criterion showed that factors such as litter percentage, slope percentage, and aspect are the most important variables, and altitude, percentage of bare soil, and percentage of soil sand were less important in the cover percentage of of *A. ovinus* (Table 3).

**Table 3.** The results of fitting the GAM to each of the significant explanatory variables

| Environmental variable | F* | P* | Akaike Information Criterion |
|---|---|---|---|
| Percentage of soil sand | 4.6 | 0.00614 | 772.2 |
| Altitude | 3.6 | 0.02045 | 812.2 |
| Slope percentage | 4.5 | 0.00666 | 763.6 |
| Aspect | 4.4 | 0.00773 | 764.7 |
| Percentage of litter | 8.2 | 0.00014 | 664.4 |
| Percentage of bare soil | 4.5 | 0.00742 | 778.7 |

F is the test statistic calculated for the significance of the focal axes. P is the value of the probability level obtained from the model fit test.

Considering the significant respnse of *A.ovinus* to thethe above-mentioned factors in the study area, the response curve of this species to each of the influential environmental variables was investigated (Figure 4). With increasing altitude up to 2220 m, the species response was increasing and since then, with increasing altitude, the presence of the species decreases (the species response has

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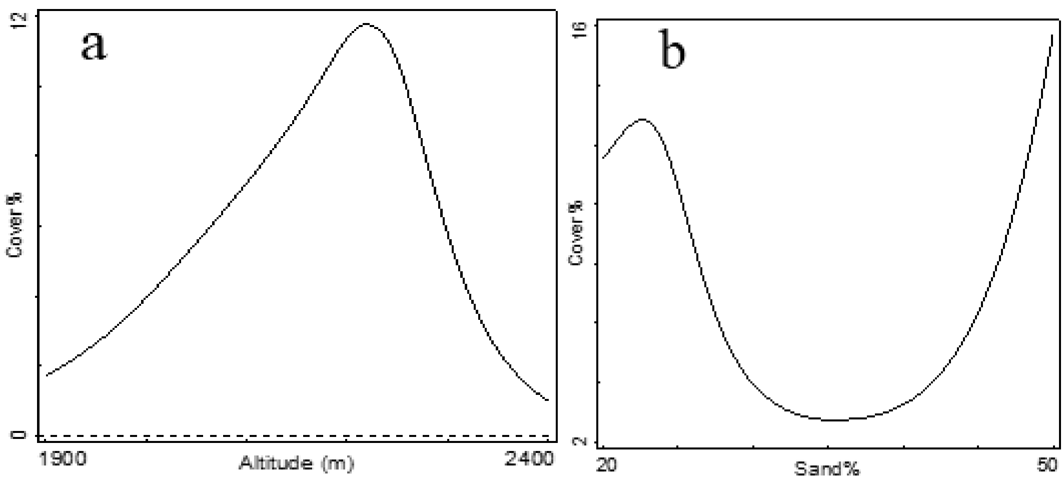
followed the unimodal model). In the study area, the presence of this species started from an altitude of 1900 meters and continued up to an altitude of 2400 meters above sea level, and was not present outside this altitude range. Its optimum growth limit for this factor was 2220 m (Figure 4a). However, with further increases in soil sand to 35%, the presence of the species decreased. Subsequently, with further increases in soil sand, the presence and cover percentage of the studied species increased, indicating a bimodal distribution in the response of this species to the amount of soil sand." (Figure 4 b).

As the slope percentage increased from 10% to 30%,the species response also increased. However, as the land slope percentage increased further, the cover percentage of *A.ovinus* decreased, and its response pattern followed a unimodal model (Figure 4c). (Figure 4c). Also, the response of the studied species was increasing in the southeastern and western aspects, and in the northern, southern aspects, the cover percentage of the species decreases (the species response has followed the unimodal model) (Figure 4d). With increasing litter percentage to 20%, the species response is increasing and after that, with increasing litter, the cover percentage of *A.ovinus* decreases (its response pattern has followed the unimodal model) (Figure 4e). With increasing the percentage of bare soil up to 20%, the species response is increasing, and then with increasing soil percentage, the cover percentage of this speciesdecreases (the species response has followed the unimodal model) (Figure 4f).

### *3.4. Phenology of A.ovinus*

The life form of *A.ovinus* is hemicryptophyte, therefore, the findings of three years of phenological investigations of *A.ovinus* in studied habitats revealed that the regrowth of plants restarts with the onset of rainfall throughout September and early autumn from the vegetative buds of the soil surface at the collar. With the rise in temperature from the first half of March, the vegetative growth of plants started from the crown and with the increase of light intensity, the vegetative growth of leaves and stems is accomplished quickly until the second half of April. Flowering started in mid-May and continued until late May. The seeds were in the milky state from the second half of May and with the increase of temperature in early June, they had doughy state and by the end of June, the seeds were fully ripe and began to fall. The phenology diagram was shown in Figure 5.



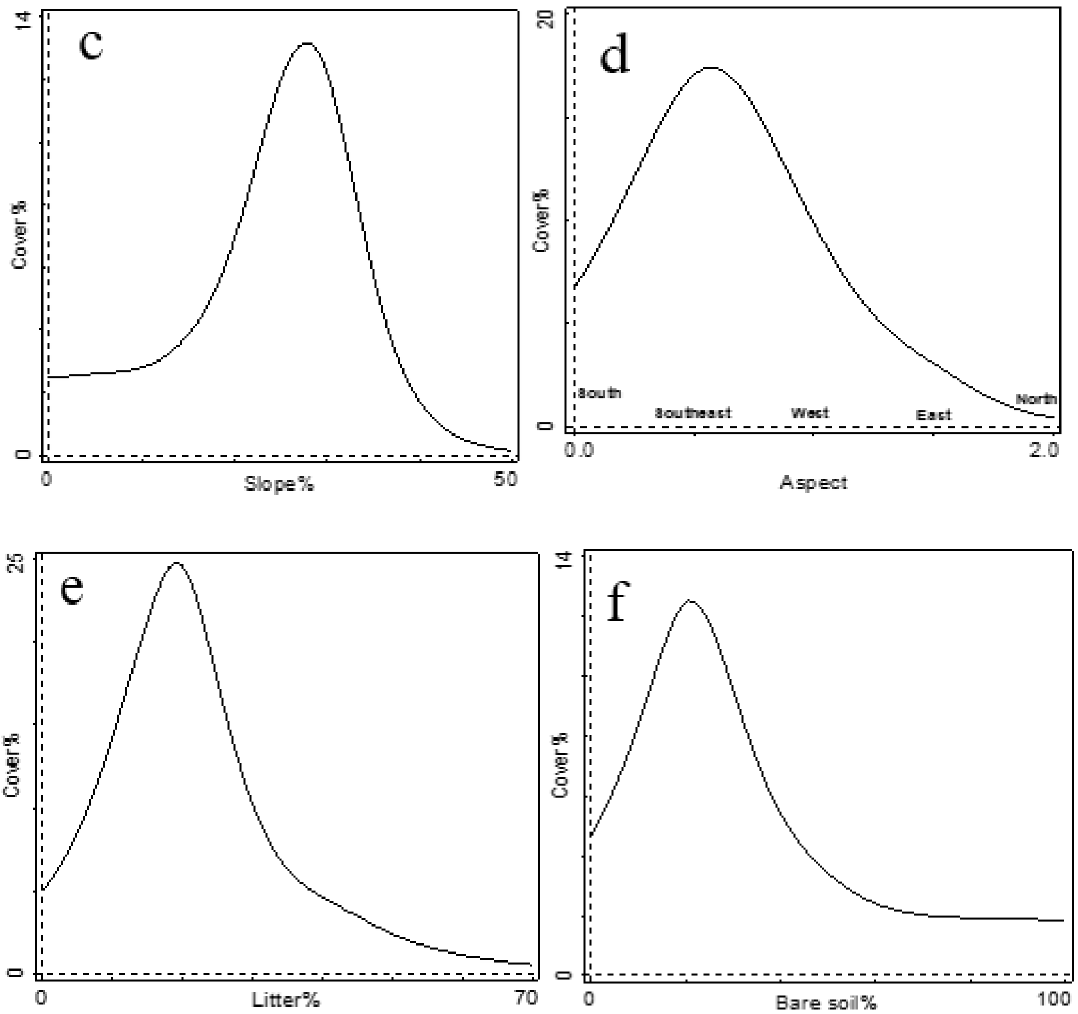



**Figure 4**. *A.ovinus* species response curve to each of the significant explanatory variables

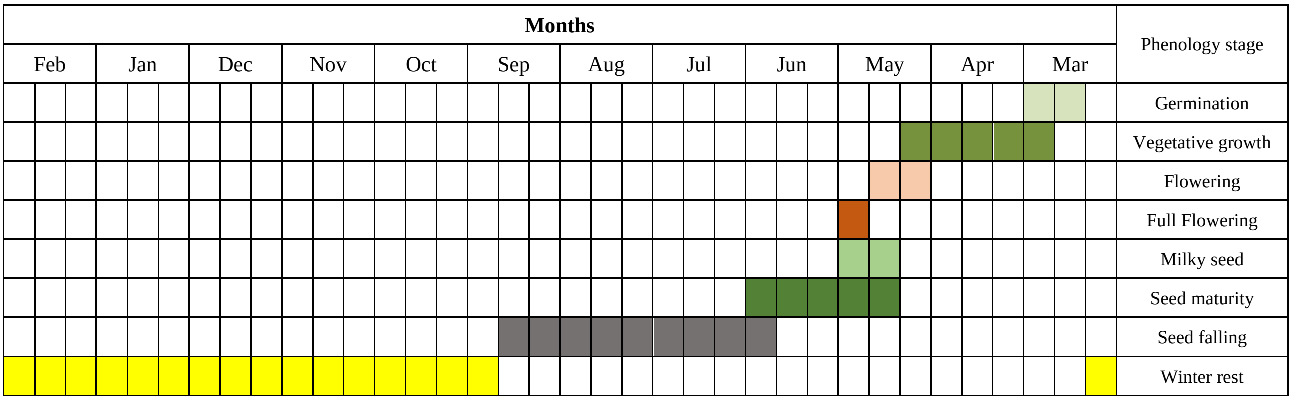



**Figure 5.** Phenological diagram of *A.ovinus* in studied habitat

## 4. Discussion

with regards to the significance of *Astragalus ovinus*, appealing palatability and also its importance in soil conservation (Askari & Mirdavodi, 2020), the ecological requirements of this species and its response to some environmental factors have been studied. The findings of RDA indicated that the percentage of Overstory, Percentage of bare soil, Percentage of litter, Aspect and Percentage of stones and gravel, by expressing 15.2, 9.7, 6.5, 4.5 and 2.7% of the variance, respectively, played a significant role in variations of the plant composition within the habitat (Table 2). This study, furthermore, revealed that *Quercus brantii*, *Bromus tectorum*, *Astragalus verus*, *Astragalus adscendens*, *Astragalus effusus* along with *A.ovinus* were significant plant types in the region.

The study revealedthat of the 26 environmental variables, 5 variables (soil sand percentage, slope percentage, aspect, bare soil%, and litter%) were effective on the yield of *A.ovinus* The results of fitting the GAM to determine its growth range under the influence of the studied variables, showed that *A.ovinus* is more dispersed on clay to clay loam soils. It has the highest yield in moderate amounts of clay (about 33 to 45%) and loam (about 27 to 40%). With increasing the percentage of soil sand to 24%, the species response is increasing and since then with increasing the amount of soil sand to 35% the presence of species has decreased, and again with increasing soil sand the presence and growth of the studied species have increased. The response of this species to the amount of sand in the state follows a bimodal distribution. This model indicates a competitive constraint along the slope of this environmental factor. This result is consistent with previous studies by Mirdavoodi et al. (2015), Kolahi & Atri (2014).

Generally, soil texture has primary effect on the movement of water in the soil and is an important factor in nutrient availability and a factor in soil erosion potential (Alavi et al., 2013).

This plant was observed in the range of 1900 to 2400 m in the studied habitat. The results showed that altitude parameters and related factors such as rainfall and temperature are the main factors in the distribution of this species. Therefore, it can be said that altitude in mountain rangelands is an effective factor in the distribution of species. Other studies (Ghorbani et al., 2015; Khademolhosseini & Habibian, 2007; Schimel et al., 1985) have also mentioned altitude as an important and influential factor in the distribution of plant species. The response pattern of *A.ovinus* species follows the unimodal model along the gradient of altitude changes. The tolerance range of this species was in the range of 2100 to 2300 meters and its optimal growth level in this habitat was 2220 meters above sea level. The greater presence of this species in this altitude range can be considered due to the existence of a combination of suitable biological factors (soil humidity, soil texture, litter and etc) in this altitude range, which indicates the balance of society with its environment. This issue has been addressed by other researchers (Wang et al., 2002; Balent & Stafford Smith, 1991).

Another important and influential factor in the distribution of *A.ovinus* was the slope percentage of the study area so that with increasing the slope percentage from 10% to 30%, the species response is increasing and after that, with increasing the land slope, the presence of the species decreases. The cheek response followed the bell model. As mentioned, *A.ovinus* in the study area is distributed in lands with low to relatively high slope, but in gentle slopes (about 20%), has a higher yield. This finding is consistent with the results of Feizi et al. (2003).

In lands with high slopes, precipitation moves as runoff and has less opportunity to penetrate the soil and in the long run, soil formation is slower and therefore the conditions for the establishment of this species are not provided. Some researchers have also pointed to the effect of slope on the yield of some species (Alavi et al., 2013).

The reaction of *A.ovinus* to geographical direction followed the Unimodal model. Hence, the conditions for growth and presence of the species along the western and southeastern aspects are more desirable. Declined presence and yield of this species on the southern aspect, partly may be due to the ecophysiological constraints such as reduced soil moisture, high temperature and low ecosystem production capacity in these geographical aspect. Previous research (Fahimipour et al., 2010; Cimalova & Lososova, 2009; Zare Chahouki & Abasi, 2016) have also reported the effect of geographical directions as one of the most important factors in the distribution and distribution of plant species.

The results also showed that the most important environmental factors affecting the distribution of *Astragalus ovinus* are the percentage of stone and gravel, percentage of litter and the percentage of bare soil, so that by increasing the percentage of litter to 20%, the response of the species is increasing and after that, with the increase of litter, the presence of the species decreases. Percentage of canopy cover in forest did not affectthe performance and frequency of this species. Also, with increasing the percentage of bare soil up to 20%, the response of the species is increasing and after that, with increasing the percentage of soil, the presence of the species decreases. The amount of litter on the soil surface are the main factors of soil fertility and the main source of soil humus production. Other studies, such as (Ghorbani et al., 2015; Gavili Kilaneh & Vahabi, 2012) have also identified litter as one of the factors affecting the distribution of plant species, which is consistent with the results of the present study. The increase in the frequency and yield of the plant in areas with higher litter percentages can be attributed to the fact that the high percentage of litter has created a suitable substrate for seeds and also provided the necessary moisture to increase germination and establishment. Conversely, the decrease in the presence of this species in areas with uncovered soil was consistent with the results of research by Vandenberghe et al. (2007) on other plants, so that *A.ovinus* yield decreased with an increasing percentage of uncovered soil from 20% upwards. Decreased presence and yield of this species in areas of habitat where the percentage of uncovered soil is high, can be partly due to reduced permeability (reduced soil moisture storage), increased runoff, and soil erosion. Which plays a very important role in the lack of germination and establishment of vegetation. The results of the present study are consistent with the findings of Carcey Hincz & Irma (2011), Wassie et al. (2009).

Since the flowering stage is the most suitable time for livestock grazing (Arzani et al., 2009), according to the results of *Astragalus ovinus* phenology study, the most suitable time for livestock grazing of this species is mid-May and the best time to collect seeds of this species is late June to the first half of July. Therefore, more consideration should be given to the amount of exploitation of this plant at the beginning of the growing season. Overall, the results showed that the proposed models for this species are validated only within the habitat conditions of the studied area, and in case any attempt of generalization to other areas, it should be tested in other habitats. Although multivariate regressions such as the GAM can play a role in the expression of ecological nests of a particular species, that can be considered by natural resource managers in vegetation management and rangeland improvement operations in similar areas.This ecological range can include the interaction of biotic and abiotic factors, however, the relative role of living factors such as species competition, compared to non-living factors are not transparent and the issues of this nature needs further research and clarification.

## 5. Conclusion

*Astragalus ovinus* is a palatablespecies and also its importance in soil conservation (Askari & Mirdavodi, 2020). RDA ordination, indicated that the overstory gradient is more important factor determining their floristic composition at small scale. GAM highlighted resource gradients that determine the occurrence of *A. ovinus*. *A. ovinus* most often occurred in soils with moderate amounts of clay (about 33 to 45%).

This species has undergone a small range of changes in relation to the aspect factor, and the geographical directions of east and west have been suitable for the distribution of this species.

Such ecological responses are useful for rangelands management and improvement operations in similar areas. The response pattern of *A. ovinus* along the gradient of soil surface litter, percentage of bare soil, percentage of land slope, and altitude, followed the unimodal model and the optimum growth levels for these factors were 20%, 20%, 30%, and 2220 m, respectively.

## Reference

Akaike, H. (1974). A new look at the statistical model identification, *IEEE Transactions on Automatic Contorol*, 19(6), 716-723. https://doi.org/10.1109/TAC.1974.1100705

Alavi, S.J., Zahedi Amiri, G., Rahmani, R., Marvi Mohajer, M.R., Muys, B., & Nouri, Z. (2013). Investigation on the response of Fagus orientalis Lipsky to some environmental variables using beta function and its comparison with Gaussian function (Case study: Kheyrud forest research station). *Iranian Journal of Forest*, *5*(2), 161-171. (In persian)

Ardekani, M.R. (2009). *Ecology*, Tehran University Publication, 340p. (In persian)

Arzani, H., Sadeghi manesh, M., Azarnivand, H., Asadian, Q., & Shahriari, E. (2009). Effect of phenological stage on forage quality of twelve rangeland species in Hamedan province. *Journal of Rangeland and Desert Research of Iran*, *15*(1), 42 -50. (In persian)

Arzani, H., & Abedi, M. (2015). *Rangeland Assessment: The Vegetation Measurement*. Tehran University Publication, pp 295. (In persian)

Askari, Y., & Mirdavodi, H. (2020). Floristic study and chorology of plants species in Kohgiluyeh and boyerahmad province (Case study: Vezg Pass), 6th International Conference on Agriculture Sciences, Environment, Urban and Rural Development, 12 pp. (In persian)

Asri, Y. (2005). *Vegetation Ecology*, Payam Nour University Press, pp 214. (In persian)

Austin, M.P., & Smith, T.M. (1989). A new model for the continuum concept. *Vegetatio*, *83*, 35–47. https://doi.org/10.1007/BF00031679

Bakkenes, M., Alkemade, J.R.M., Ihle, F., Leemans, R., & Latour, B. (2002). Assessing the effects of forecasted climate change on the diversity and distribution of European higher plants for 2050. *Global Change Biology*, *8*, 390–407. https://doi.org/10.1046/j.1354-1013.2001.00467.x

Balent, G., & Stafford Smith, D.M. (1991). Conceptual model for evaluating the consequences of management practices on the use of pastoral resources. In: Proceedings of the fourth International Rangeland Congress. Montpellier, France, 1158–1164.

Beers, T.W., Dress, P.E., & Wensel, L.C. (1966). Aspect trans-formation in site productivity research. *Journal of Forestry*, *64*(10), 691–692.

Borcard, D., Legendre, P., & Drapeau, P. (1992). Partialling out the spatial component of ecological variation. *Ecology*, *73*, 1045-1055. https://doi.org/10.2307/1940179

Carcey Hincz, P.A., & Aguilar, I.D. (2011). Impact of grazing on soil mesofauna diversity and community composition in deciduous forested rangelands of northwest Alberta. 23 pp.

Cimalova, S., & Lososova, Z. (2009). Arable weed vegetation of the northeastern part of the Czech Republic: effects of environmental factors on species composition. *Plant Ecology*, *203*, 45–57. . https://doi.org/10.1007/s11258-008-9503-1

Dawson, CW., Abrahart, R.J., & See, L.M. (2007). HydroTest: a web-based toolbox of evaluation metrics for the standardized assessment of hydrological forecasts, Environmental Modelling and Software, *22*(7), 1034-1052. https://doi.org/10.1016/j.envsoft.2006.06.008

Fahimipour, E., Chahuki, M.A.Z., & Tavili, A. (2010). Investigation on some environmental factors influencing distribution of plant species (Case study: Taleghan rangeland). *Iranian Journal of Rangeland*, *13*(1), 23-32. (In persian)

Feizi, M.T., Khodagholi, M., Saeedfar, M., & Shahmoradi, A. (2003). Autecology of *Eurotia ceratoides* L. in Esfahan province, *Iranian journal of Range and Desert Research*, *10*(4), 387-408. (In persian) https://doi.org/10.22092/ijrdr.2019.119686

Gavili Kilaneh, E., & Vahabi, M.R. (2012). The effect of some soil characteristics on range vegetation distribution in central Zagros. *Iranian Journal of Science and Technology*, *16*(59), 245- 258. (In persian)

Ghorbani, A., Abbasi Khalaki, M., Asghari, A., Omidi, A., & Zare Hesari, B. (2015). Comparison of some effective environmental factors on the distribution of *Artemisia fragrans* willd. and *Artemisia austriaca* Jacq. in southeast faced slopes of Sabalan. *Iranian Journal of Rangeland*, *9*(2), 129-141. (In persian)

Godefroid, S., & Koedam, N. (2004). Interspecific variation in Soil compaction sensitivity among forest floor species. *Biological Conservation*, *119*, 207- 217. https://doi.org/10.1016/j.biocon.2003.11.009

Gogina, M. (2010). Investigation of interrelations between sediment and near-bottom environmental parameters and macrozoobenthic distribution patterns for the Baltic Sea. A doctoral thesis at the Ernst Moritz Arndt University of Greifswald, Germany.

Guisan, A., & Zimmermann, N.E. (2000). Predictive habitat distribution models in ecology. *Ecological Modelling*, *135*, 147-186. https://doi.org/10.1016/S0304-3800(00)00354-9

Jankju, M., Melati, F., Noedoost, F., & Bozorgmehr, A. (2010). Autecology of (*Astragalus arpilobus* Kar. & Kir.) a promised species for restoration of the winter rangelands in the northeast of Iran. *Journal of Agroecology*, *2*(4), 648-657. (In persian) https://doi.org/10.22067/JAG.V2I4.8803

Jafarian, Z., & Kargar, M. (2017). The effectiveness of the Generalized Linear Model (GLM) and the Generalized Additive Model (GAM) in determining the relationships between vegetation and environmental factors in the Pleur tourist area. *Journal of Geography and Development*, *15*(46), 117-132. (In persian)

Khademolhosseini, Z., Shokri, M., & Habibian, Sh. (2007). Effects of topographic and climatic factors on vegetation distribution in Arsanjan shrublands (case study: Bonab watershed). *Iranian Journal of Rangeland*, *3*(1), 222-236. (In persian)

Kolahi, M., & Atri, M. (2014). The Effect of Ecological Factors on Vegetation in Hamedan Alvand Region (Iran). *International Journal of Farming and Allied Sciences*, *5*(3), 489-496. (In persian)

Leonard, S.G., Miles, R.L., & Burkhartdt, J.W. (1984). Comparison of soil properties associated with basin wildrye and black greaswood in the Great Basin region.

Mirdavoodi, H., Marvie Mohadjer, M., Davis, M., Zahedi Amiri, G., Etemad, V., & Zandi Esfahan, E. (2015). Are disturbances altering the species composition of Iranian oak woodland?. *Journal of Biodiversity and Environmental Sciences*, *6*(1), 499-510. (In persian)

Mozafarian, V.A. (2017). Iranian Trees and Shrubs. Tehran Publication, Contemporary Culture, pp 991. (In persian)

Nosrati, F., Fakheri, B., Solouki, M., Mahdi Nezhad, N., & Valizadeh, M. (2018). Autecology of *Astragalus fasciculifolius* Boiss. in some natural habitats of south Sistan and Baluchestan province. *Iranian Journal of Medicinal and Aromatic Plants*, *34*(4), 62-671. (In persian) https://doi.org/10.22092/ijmapr.2018.120924.2273

Robertson, M.P., Peter, C.I., Villet, M.H., & Ripley, B.S. (2003). Comparing models for predicting species' potential distributions: a case study using correlative and mechanistic predictive modeling techniques, *Ecological Modelling*, *164*, 153–167. https://doi.org/10.1016/S0304-3800(03)00028-0

Safaei, M., Tarkesh, M., Bassiri, M., & Boshri, H. (2013). Modeling the potential habitat of yellow milkvetch (*Astragalus verus* Oliver) using the ecological nest factor analysis method. *Journal of Rangeland*, *7*(1), 40-51p. (In persian)

Schimel, D.S., Stillwell, M.A., & Woodmansee, R.G. (1985). Biogeochemistry of C, N and P in a soil catena of the short grass steppe. *Ecology*, *66*, 276-282. https://doi.org/10.2307/1941328

ter Braak, C.J.F., & Smilauer, P. (2002). Canoco, reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (vers ion 4.5). Microcomputer Power, Ithaca.

Traore, S., Zerbo, L., Schmidt, M., & Thiombiano, L. ( 2012). Acacia communities and species responses to soil and climate gradients in the Sudano-Sahelian zone of West Africa. *Journal of Arid Environments*, *87*, 144-152. https://doi.org/10.1016/j.jaridenv.2012.07.010

Vandenberghe, C., Franc¸ois F., Moravie, M.A., Gadallah, F., & Buttler, A. (2007). Shortterm effects of cattle browsing on tree sapling growth in mountain wooded pastures. *Plant Ecology*, *188*, 253–264.

Wang, G., Zhou, G., Yang, L., & Li, Z. (2002). Distribution, species diversity and life-form spectra of plant communities along an altitudinal gradient in the northern slopes of Qilianshan Mountains, Gansu, China. *Plant Ecology*, *165*, 169–181. https://doi.org/10.1023/A:1022236115186

Wang, J., Wang, H., Cao, Y., Bai, Z., Qin, Q. (2016). Effects of soil and topographic factors on vegetation restoration in opencast coal mine dumps located in a loess area. *Scientific Reports*,*6*, 22058. https://doi.org/10.1038/srep22058

Wassie, A., Sterck, F.J., Teketay, D., & Bongers, F. (2009). Effect of livestock exclusion on tree regeneration in church forests of Ethiopia. *Forest Ecology and Management*, *257*, 765- 772. https://doi.org/10.1016/j.foreco.2008.07.032

Whittaker, R.H. (1973). Direct gradient analysis: In Whittaker, R.H., editor, Handbook of vegetation science 5: ordination and classification of communities. The Hague: Junk publishers, 19-50. https://doi.org/10.1007/978-94-009-7989-5_2

Zare Chahouki, M.A., & Abasi, M. (2016). Habitat suitability modeling for *Thymus kotschyanus* Boiss. & Hohen. Using ecological-niche factor analysis (case study: rangeland of middle Taleghan). *Iranian Journal of Medicinal and Aromatic Plants*, *32*(4), 561-573. (In persian) https://doi.org/10.22092/ijmapr.2016.107129

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# پاسخ گونه *Astragalus ovinus* Boiss. به برخی از عوامل محیطی در جنگل‌های بلوط یاسوج

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## چکیده

عوامل محیطی غیر زنده تأثیر عمده‌ای در پراکنش و عملکرد گونه‌های گیاهی دارند. به همین منظور و با توجه به اهمیت گونه گون گوسفندی (*Astragalus ovinus* (L.) Boiss.) در تولید علوفه و امکان استفاده از آن در اصلاح و احیای مرتع نیمه استپی، در پژوهش حاضر، به مطالعه برخی از نیازهای اکولوژیک این گونه در شهرستان بویراحمد از استان کهگیلویه و بویراحمد پرداخته شد. برای تعیین عوامل اکولوژیک مؤثر بر تغییرات پوشش‌گیاهی و بررسی پاسخ گون گوسفندی به تغییرات عوامل اکولوژیک، به ترتیب از روش آنالیز تحلیل کاهشی (RedundancyAnalysis, RDA) و مدل‌جمعی تعمیم‌یافته (GAM؛ Generalized Additive Models) استفاده شد. تجزیه و تحلیل داده‌ها با استفاده از نرم‌افزارهای $SPSS_{17}$ و $CANOC_{4.5}$ انجام شد. طبق نتایج بدست آمده الگوی پاسخ گونه *A. ovinus* در امتداد شیب میزان لاشبرگ سطح خاک، درصد خاک بدون پوشش، درصد شیب زمین، و ارتفاع از سطح دریا، از مدل زنگوله‌ای (Unimodal)، پیروی کرده و حد بهینه رشد آن برای این عوامل، به‌ترتیب ۲۰ درصد، ۲۰ درصد، ۳۰ درصد، و ۲۲۲۰ متر بود. همچنین پاسخ این گونه به جهات جغرافیایی نیز از مدل تک نمایی پیروی کرده به طوریکه در شیب‌های شرقی و غربی حضور گونه افزایشی و شیب‌های شمالی، جنوب حضور گونه کاهش یافته است. عکس‌العمل این گیاه به تغییرات میزان شن خاک، از مدل دونمایی (Bimodal)، پیروی کرد. این مدل، نشان‌دهنده وجود یک محدودیت رقابتی در طول شیب محیطی است. نتایج حاصل از بررسی فنولوژی گون گوسفندی نشان داد که مناسب‌ترین زمان ورود دام به رویشگاه این گونه، اواسط اردیبهشت‌ماه و بهترین زمان جمع‌آوری بذر این گونه اواخر خرداد تا نیمه اول تیرماه است. بررسی پاسخ گونه *A. ovinus* در شیب عوامل توپوگرافی و خاک، اطلاعات ارزشمندی برای تعیین نیازهای اکولوژیکی این گونه ارائه داد که می‌تواند در مدیریت پوشش‌گیاهی و عملیات اصلاح مراتع در مناطق مشابه، مورد توجه قرار گیرد.

**واژه‌های کلیدی**: رسته‌بندی، عوامل اکولوژیک، گون گوسفندی، مدل‌جمعی تعمیم‌یافته، منحنی‌پاسخ گونه

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