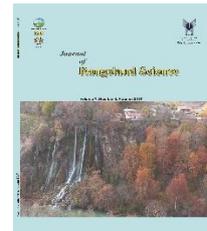


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Research and Full Length Article:

Forage Quality of Endangered Species of *Astragalus fridae* Rech. F. in Semnan Province, Iran

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Abstract. *Astragalus fridae* Rech. F. is a native and endemic species in Iran. Considering the circumstances of this species in the country and the world and the importance of conservation of genetic resources, the awareness of *A. fridae* forage quality seems necessary. For this purpose, forage samples of *A. fridae* were taken at four phenological stages including vegetative growth, flowering, seed setting and maturity over three years (2012- 2014) in Semnan province, Iran. Forage quality factors such as DMD, CP, WSC, ADF, Ash, CF, NDF and ME were measured by NIR. Their overall means over phenological stages were 67.38%, 7.58%, 17.43%, 27.79%, 5.89%, 39.87%, 47.47% and 9.46mj/kg, respectively. Result of analysis of variance showed significant differences ($P < 5\%$) between phenological stages for all of traits. The lowest values of DMD, CP, WSC, Ash and ME were obtained at the vegetative stage, but there were no significant differences between three other phenological stages. The highest values of latter traits were obtained in seed setting stage and could be attributed to higher nutritional values of seeds. The means of ADF, NDF and CF were increased by the development of plant growth. But their increases did not have significant effects on reducing forage quality. DMD, CP, WSC, Ash and ME had a positive and significant correlation with each other and all of them were negatively correlated with ADF, NDF and CF.

Key words: *A. fridae*, Nutritional value, Phenological stage, Semnan

Introduction

Iran with wide climate variations and abundant plant genetic resources is considered as one of the rich countries in terms of facilities and natural resources. It is also one of the main origins of *Astragalus* genus having 804 species that 65% out of them are endemic to Iran (Masoumi, 2005). Due to diversity in species, *Astragalus* has different applications in pharmaceutical and industrial uses and also in the soil stabilization and forage production (Hoseini, 2012). *Astragalus fridae* Rech. F. is classified in hardwood category and it is a subcategory of the dicotyledons, dialypetale and calciflore (Masoumi, 2005). It is a perennial species belonging to Fabaceae family, *Astragalus* genus and Rosales order. Geographical distribution of this species is mainly in the North East of Iran, Sorkheh, Semnan (Masoumi, 2005). This is a native and endemic species in Iran that is classified as an endangered species according to International Union for Conservation of Nature (IUCN) (Jalili & Jamzad, 1999).

Forage species have different nutritional values and qualities. Nutritional value and food quality are directly related to the growth and development of plants. Thus, knowing these changes can help to adjust the livestock entry and exit time of the rangeland that not only carries out an optimal utilization of forage by livestock grazing, but also maintains the plant survival and lessens the damages to growth and regeneration of these species (Arzani, 2004). Arzani *et al.* (2006) reported Crude Protein (CP), Dry Matter Digestibility (DMD) and Metabolizable Energy (ME) as the most important indicators of forage quality. According to Linn and Martin (1991), plant species, stage of maturity and environmental conditions are the most important factors of forage quality.

Uniyal *et al.* (2005) reported lignin, cellulose and fiber as the reducing factors

while CP and ME are the increasing factors of forage nutritional values. Thus, by changing the growing season and some changes made in the above elements, digestibility, palatability and consequently forage quality are altered. Ritchie *et al.* (2006) suggested that lower values of ADF and NDF and higher values of DMD and CP increased the yield of plant nutritional value and consequently, animal production. Jafari *et al.* (2008) reported the forage requirement of an animal unit (in Iran, an adult and non-lactating sheep weighing 50 kg) grazing in the rangeland that should be able to produce at least 7.5 to 8.5 MJ ME per day from 7 to 10 % CP and a balanced and adequate level of minerals and vitamins. Arzani (2004) reported that digestibility between 50 and 85% is the most important factor determining plant consumption by livestock. Majidi and Shahmoradi (2003) in their studies on *Smirnovia turkestanica* species in rangelands of Isfahan (Iran) found that CP and Crude Fibers (CF) were lessened and increased with plant maturity, respectively. Malan and Rethman (2003) reported that differences in forage palatability depends on such factors as protein, chemical composition, fiber content, morphology, growth form and stage of phenology. Among the factors affecting forage quality, plant phenology and habitat are very important. Holechek *et al.* (2004) indicated that the nutritional value of forage in rangeland changes between different seasons. Ghanbari and Sahraei (2012) estimated the nutrient value of *Festuca ovina*, *Trifolium montanum* and *Alopecurus textileis* in Sabalan Mountain, Iran. Their results showed that *Trifolium montanum* as a legume had higher values for CP, Ash, OMD, ME and lower values for ADF and NDF. Variation of quality traits in *Trifolium montanum* was lower than two other species. Dehghani Bidgoli *et al.* (2012) evaluated nutritive values of some range species including grasses

(*Secale montanum* and *Festuca ovina*), forbs (*Lotus corniculatus* and *Sanguisorba minor*) and shrubs (*Kochia prostrata* and *Salsola rigida*). Their results showed that forbs contained more WSC as compared to grasses and shrubs. For other forage quality traits (CP, DMD and ME), higher and lower forage qualities were obtained for forbs and shrub, respectively. For WSC, *Sanguisorba minor* and *Lotus corniculatus* had the highest values while *Secale montanum* and *Salsola rigida* had the lowest WSC content. Ahmadi Beni *et al.* (2014) indicated that as the age of *Vetiveria zizanioides* increased, the quality values including CP, DMD, ME, Ash, DE and TDN were decreased while ADF was increased. Shadnoush (2015) studied the forage quality of *Vicia variabilis*, *Astragalus spp.*, *Medicago sativa*, *Prangos uloptera* and *Sanguisorba minor* and reported that higher and lower values of CP were obtained in vegetative stage of *Medicago sativa* and seed ripening stage of *Prangos uloptera*, respectively. The highest and lowest values of CF% were obtained in the vegetative stage of *Prangos uloptera* and ripening stage of *Medicago sativa*, respectively. For NDF and ADF, lower values were found in the vegetative stage

of *Prangos uloptera* and *Sanguisorba minor*, respectively and higher values were observed in the seed ripening stage of *Astragalus spp.* and *Prangos uloptera*.

Therefore, for scientific range management, knowledge of forage quality is important. Arzani (2004) reported that knowledge of forage quality as one of the primary challenges of managing rangelands which could benefit from the protection of endangered species. The aim of this research was to obtain comprehensive information on the most important indicators of *A. fridae* forage quality as an endangered species during different stages of phenological to make decisions on its protection.

Materials and Methods

Study area

Project location is in 36 km west of Semnan city, and in right side of Semnan to Firouzkouh road, Iran (52°52' eastern longitude and 35°29' northern latitude) near Aftar village (Fig. 1) which is the natural habitat of *A. fridae*. The mean rainfall and temperature are 192.1 mm and 11.3°C, respectively. The number of frost days is 90 days a year (based on the nearest weather station, Aftar).

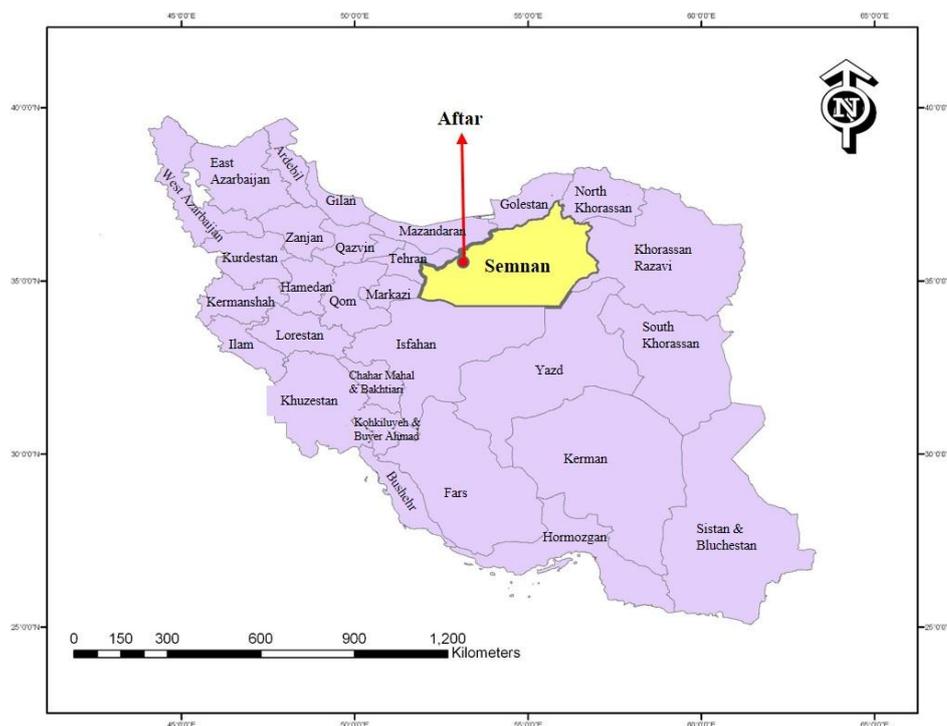


Fig. 1. The map of site location in Semnan province, Iran

Data collection

To study the phenology of plant species, 30 individual plants of *A. fridae* were selected and marked. Dates of phenological stages (vegetative, flowering, seed formation, maturity, re-growth and winter dormancy) were recorded at specified intervals over three years starting from 2012. In order to determine the forage quality, samples were randomly taken from an elevation of 1800 to 2000 m above sea level and collected from four phenological stages with five replications at each phenological stage in 2014. In sampling method to prevent from the damages to the plant, 50% of the stands were cut so that the plant could continue its normal growth without any problems (Fig. 2).

The samples were dried in open air and then, were placed for 24 h at 70°C in an Oven. Then, the samples were ground to pass through a 1.0 mm screen for laboratory analysis. Samples were analyzed for Dry Matter Digestibility (DMD), Water Soluble Carbohydrates (WSC), Crude Protein (CP), Acid Detergent Fiber (ADF), total ash, Crude

Fiber (CF) and Neutral Detergent Fiber (NDF) measured using Near-Infrared spectroscopy (NIR) (INFRAMATIC8620 model) in the laboratory of Research Institute of Forests and Rangelands according to the method of Jafari (2001) and Jafari *et al.* (2008) and The Metabolisable Energy (ME) was calculated using the equation provided by the Australian Agricultural Council, Standing Committee on Agriculture (1990) as follows (Equation 1):

$$ME = 0.17DMD - 2 \quad (1)$$

Where:

ME= mj/kg

DMD= Dry Matter Digestibility

Data were analyzed using one-way analysis of variance for each quality traits. Means comparisons were made between phenological traits using Duncan method. Simple correlations between quality traits were also estimated. The SAS9 software was used for statistical analysis.

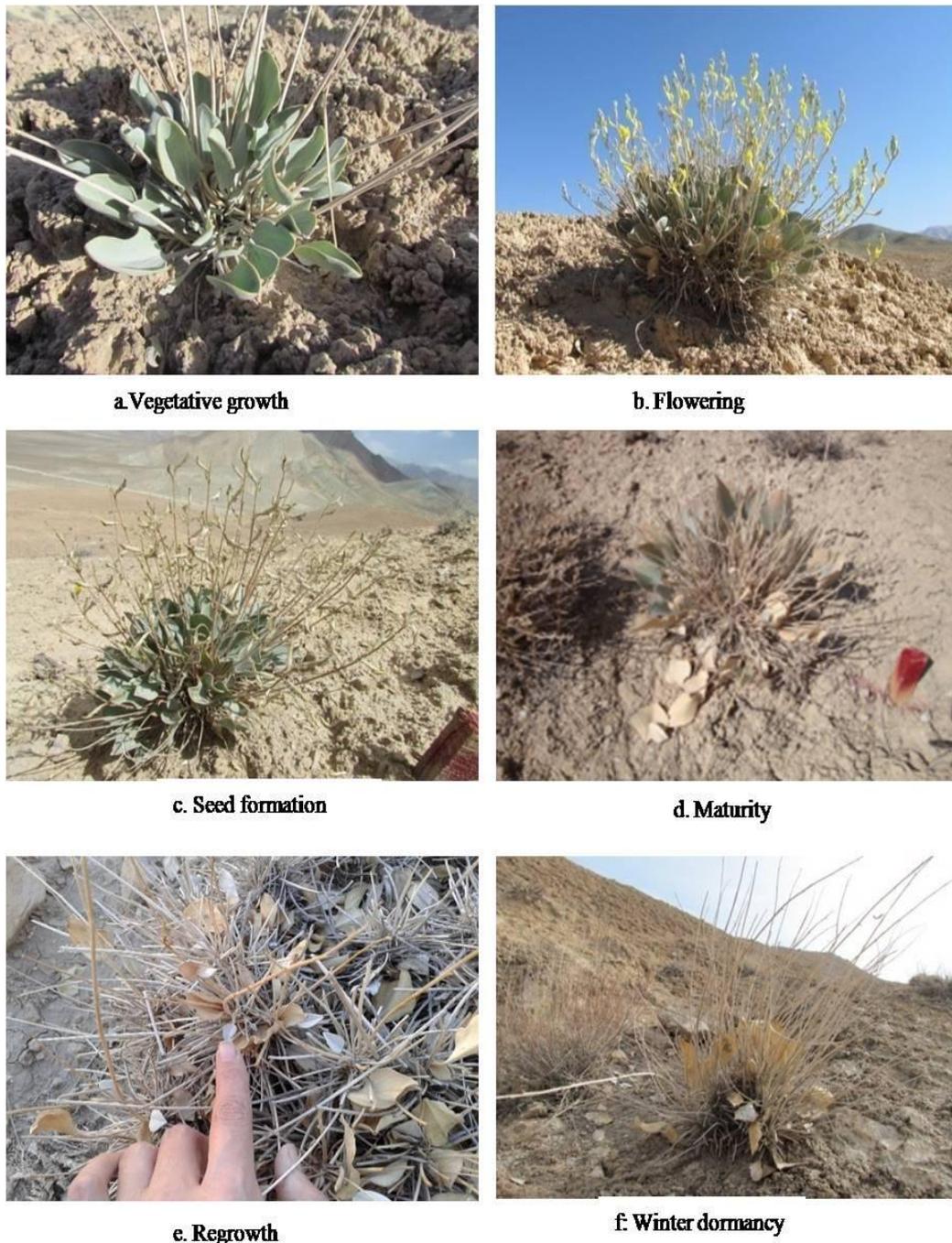


Fig. 2. Phenological stages of *A. fridae* (a: Vegetative, b: Flowering, c: Seed setting, d: Maturity, e: Regrowth, f: Winter dormancy)

Results

Plant phenology

The Results of plant phenology showed that the vegetative growth of the plant started with the advent of the first leaves from the first ten days of March to mid-May. Then, the plant entered into flowering stage. Flowering continued until early June and gradually, seeds formed and matured. Since early July, the

seed dispersion started and lateral and longitudinal growth of plant was very slow after flowering and seed setting; thus, there was no significant change. In September, a number of leaves fell and the petioles were still attached to the plant; in October, regrowth was seen in bottom leaves of plants due to rainfall and growth recession that occurred by winter dormancy (Fig. 3).

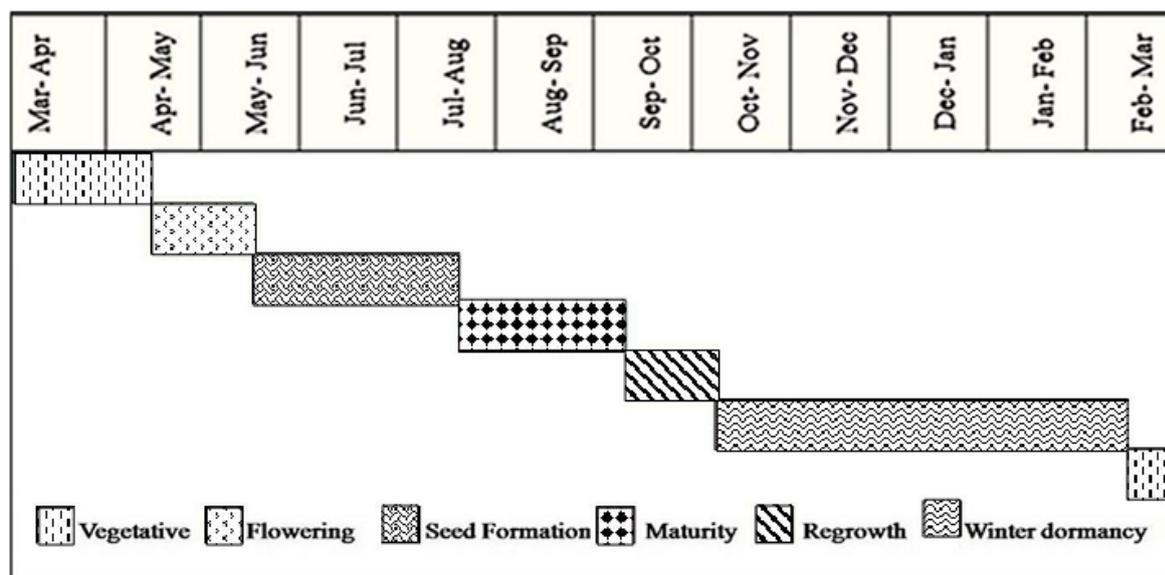


Fig. 3. Different phenological stages of *A. fridae* during the year

Forage quality

Dry Matter Digestibility (DMD) significantly increased with the advancing stages of plant growth from 61.81 to 72.25%. CP was significantly different at phenological stages ($P < 5\%$). The lowest (4.58%) and highest (9.1%) values of CP were obtained at initial phase of growth period and maturity, respectively. There was no significant difference for CP among the flowering, seed setting and maturity stages, but the trend was significantly increased from vegetative to stage maturity stages (Table 1). ME values were also increased with advancing maturity with the highest [10.28 (mj/kg)] and lowest [(8.51 (mj/kg)] values at maturity and vegetative stage, respectively. There were significant differences between

phenological stages for WSC contents. The lowest (14.38%) and highest (20.33%) WSC values were achieved at the beginning and mature stages with no significant difference between the flowering and seed setting stages. However, WSC content was significantly lower in the vegetative than reproductive stages (Table 1).

The lowest ash content (4.3%) was obtained at vegetative stage with significant differences with other stages (Table 1). However, no significant difference was found at other phenological stages. The phenological stages of the plant differed for ADF and NDF contents and these parameters were increased with advancing phenological stages (Table 1).

Table 1. Comparison of *A. fridae* forage quality parameters at different stages of phenological

Quality traits	Phenological stage			
	Vegetative	Flowering	Seed setting	Maturity
DMD (%)	61.81 ^b ± 4.88	66.08 ^{ab} ± 6.32	68.24 ^{ab} ± 4.27	72.25 ^a ± 6.18
CP (%)	4.58 ^b ± 0.84	7.58 ^a ± 2.68	8.18 ^a ± 2.03	9.10 ^a ± 2.01
ME (mj/kg)	8.51 ^b ± 0.83	9.23 ^{ab} ± 1.07	9.60 ^{ab} ± 0.72	10.28 ^a ± 1.05
WSC (%)	14.38 ^c ± 0.61	17.41 ^b ± 1.39	16.99 ^b ± 1.78	20.33 ^a ± 2.61
ASH (%)	4.30 ^b ± 0.58	6.39 ^a ± 1.14	6.14 ^a ± 1.38	6.39 ^a ± 0.88
CF (%)	36.83 ^a ± 2.30	39.86 ^a ± 2.15	41.11 ^a ± 4.80	41.67 ^a ± 3.58
ADF (%)	25.10 ^a ± 3.37	26.98 ^a ± 4.70	28.85 ^a ± 2.80	30.62 ^a ± 4.43
NDF (%)	45.09 ^a ± 7.90	45.20 ^a ± 7.89	48.02 ^a ± 7.80	52.62 ^a ± 5.10

Means ± Standard error, Means of each rows with various letters are significantly different (Duncan 5%)

Comparing the forage quality of *A. fridae* with 16 other rangeland species in Semnan province that was investigated by Arzani (2009) showed that the lowest ADF content (27.79%) occurred in *A. fridae*. In addition, it had the highest

DMD (67.38%). Changes in ME were similar to DMD. *A. fridae*'s CP with an average of 7.58% with a medium rank between other species in Semnan province (Table 2).

Table 2. The means of quality traits in *Astragalus fridae* and other plant species in Semnan province according to Arzani (2009)

Plant species	Grazing season	CP (%)	ADF (%)	DMD (%)	ME (mj/kg)
<i>Salsola rigida</i>	Winter	14.00	30.00	64.00	9.00
<i>Artemisia aucheri</i>	Summer	8.38	46.79	48.54	6.25
<i>Artemisia sieberi</i>	Winter	9.25	41.37	53.38	7.07
<i>Aeluropus littoralis</i>	Winter	5.56	32.65	59.02	8.03
<i>Agropyron pectiniforme</i>	Summer	7.94	38.42	55.27	7.4
<i>Agropyron tauri</i>	Summer	6.56	52.38	43.18	5.35
<i>Dactylis glomerata</i>	Summer	7.56	41.25	52.78	5.97
<i>Festuca ovina</i>	Summer	6.25	44.94	49.2	6.36
<i>Melica persica</i>	Summer	8.75	40.00	54.00	7.20
<i>Phragmites communis</i>	Winter	5.81	41.48	51.83	6.81
<i>Cyperus rotundus</i>	Winter	5.63	53.01	42.28	5.19
<i>Medicago sativa</i>	Summer	13.81	28.54	65.89	9.20
<i>Stachys inflata</i>	Summer	10.56	44.89	51.00	6.68
<i>Alhagi camelorum</i>	Winter	11.5	38.27	56.89	7.67
<i>Verbascum thapsus</i>	Summer	6.94	52.9	42.90	5.29
<i>Tamarix stricta</i>	Winter	8.44	37.62	56.12	7.54
<i>Astragalus fridae</i>	Summer	7.58	27.79	67.38	9.46

Pearson correlation coefficients between forage quality traits of *A. fridae* are shown in Table 3. ME was positively correlated with DMD, CP, WSC and total ash and negatively correlated with ADF and NDF ($P < 0.01$). The same trend was observed for DMD. It was positively correlated with CP, WSC and total ash and negatively correlated with ADF and NDF ($P < 0.01$). CP was positively

correlated with WSC and total ash ($P < 0.01$) and negatively correlated with ADF and NDF ($P < 0.05$). WSC had a positive correlation with total ash and negative correlation with ADF and NDF. Both ADF and NDF had a positive correlation with each other and a negative correlation with ME, DMD, and WSC contents (Table 3).

Table 3. Pearson correlation coefficients between forage quality variables of *A. fridae*

Quality traits	ME	DMD	CP	WSC	ADF	Ash	CF
DMD (%)	0.99**						
CP (%)	0.79**	0.79**					
WSC (%)	0.78**	0.78**	0.79**				
ADF (%)	-0.87**	-0.87**	-0.46*	-0.63**			
ASH (%)	0.74**	0.74**	0.85**	0.85**	-0.54*		
CF (%)	-0.21 ^{ns}	-0.21 ^{ns}	-0.23 ^{ns}	-0.20 ^{ns}	0.20 ^{ns}	-0.45*	
NDF (%)	-0.70**	-0.7**	-0.52*	-0.66**	0.72**	-0.68**	0.62**

** Significant at 1%, * significant at 5%, ns: non-significant

Discussion

Understanding forage quality for supplying CP and ME requirements of livestock is the basic principle of range management (Arzani, 2009). The results of this study showed that phenological stages had a significant effect on forage

quality: CP, DMD and ME increased up to seed setting. In vegetative stage, only leaves are present, but in heading stages, the accumulated protein is increased in the organs and gently by seed setting, CP will be increased. This justifies the increased CP content in the

later stages of *A. fridae* growth. But it should be noted that there was no significant difference in CP content between flowering to maturity stages and it showed only less increases. Jafari (1993) reported that there were differences among ratios of plant parts during various phenological stages. In the present study, these differences resulted in the addition of CP after vegetative phase. Cheniani and Hamidipour (2014) studied the CP content in different organs of *Colchicum kotschy* and found that seed setting stage had higher CP storage than that for vegetative growth. Harden and Zolfaghari (1988) with a research on *Prosopis glandulosa* stated that seed contained about 82% of the total pod protein. Ball *et al.* (2001) found that many rangeland legumes had an ability to preserve their CP up to maturity stage. They stated that this ability may be due to the coexistence between rhizobium and legumes to biological nitrogen fixation. Legumes use sufficient nitrogen in their different growth stages and store it in the plant tissues. Asaadi and Khoshnood Yazdi (2011) in a study of some legume species (*Sanguisorba minor*, *Onobrychis transcaspica*, *Onobrychis radiata* and *Astragalus brevidens*) found double potential of maintaining of their CP content as compared to grasses.

Abarsaji *et al.* (2008) reported that the highest DMD in *Hedysarum coronarium* occurred in seed ripening stage. Ether extract and gross energy in the flowering stage were higher than others. Ash and CF in seed ripening were the highest. In vegetative and flowering stages, the leaves and stems are green and they have less dry matter but with the development of growth and maturity, the structural carbohydrate increases and leads to rise the dry matter.

Comparing the forage quality of *A. fridae* with 16 other rangeland species in Semnan province (Table 2) showed that *A. fridae* had the highest DMD (67.38%), ME (9.46 mj/kg), lowest ADF (27.79%)

and CP (7.58%) among the other species (Arzani, 2009). So, based on Table 2 and comparisons between the plant species in the province, it is clear that *A. fridae* had the highest DMD and ME, the least amount of ADF and moderate level of CP. Arzani (2004) and Vallentine (2001) reported that CP and CF contents are the most important factors affecting the forage quality of rangeland plants. In general, forage quality with 7% CP, 50% DMD and 8 MJ ME are recommended as critical indices for the daily maintenance of grazing livestock unit in rangelands of Iran (Arzani *et al.*, 2013b). There was a positive correlation between CP and DMD of forage that is consistent with the results of Arzani and Naseri (2009). These authors believed that increasing CP content increased forage DMD. Nitrogen is important in food digestion of ruminants, but when they are fed by forage with less than 7% CP, the issue becomes critical. This level is far less than the rumen bacteria nitrogen demand. *A. fridae* species has an average of 4.5% CP that does not meet the livestock nitrogen requirement at vegetative stage. However, plant CP content increased to higher than 7.5 % at flowering and continued to maturity stage.

Information on nutritional value of each organ at each growing stage may be of great importance. In the present study, because branches with flowers and seeds remained on the plant, CP content showed an increase during flowering and seed setting. ME was between 8.5 MJ/kg at vegetative to 10.28 at maturity stages which is consistent with the results of Hosseini (2012) who studied quality of some of *Astragalus* species (including *A. podolobus*, *A. lilacinus*, *A. sumbari*, *A. rawlinsianus* and *A. jolderensis*) in Golestan natural park and found that forage ME ranged between 5.9 to 8.6 MJ/kg with *A. jolderensis* as the highest and *A. sumbari* as the lowest. Based on our findings, *A. fridae* ME increased with plant growth. Allen and Segarra (2001),

Arzani (2004), and Arzani *et al.* (2006) also reported that the forage quality depended on higher CP, DMD and ME, and lower ADF.

Ghadaki *et al.* (1974) found that cell wall became thicker and wooden along plant growth and NDF and ADF contents are augmented. Forage with lower NDF or ADF had comparatively improved forage quality than those with higher NDF or ADF. If forage ADF is high, the digestibility will be lower (Chen *et al.*, 2001; Garza & Fulbright, 1988); this negative correlation is evident between these factors. Arzani and Naseri (2009) suggested that ADF included cellulose and lignin. Digestibility decreased with increasing lignin. In case of the *A. fridae*, no significant difference was found for ADF during various stages of plant growth; however, it gradually increased with advancing plant growth. NDF acts as a benchmark for predicting the voluntary intake of food. In other words, forage with lower NDF contents has higher potential to be consumed by livestock (Arzani, 2009). In this study, various growth stages did not have significant differences for NDF. The *A. fridae* with higher values of ME, DMD, CP and WSC and lower values of ADF and NDF was recognized as a palatable plant and also based on the observations of sheep grazing of this species, *A. fridae* could be classified as class I for sheep preference. It was found that *A. fridae* had the lowest ADF as compared with other species in Semnan province. Although it increased by advancing plant growth, this increment was not significant. As mentioned earlier, this species had the highest DMD and ME even at late stage of growth as compared to other species that have been studied by Arzani (2009) in Semnan province. Uniyal *et al.* (2005) showed that ash, lignin, fiber and cellulose are the reducing factors of forage quality while CP is the enhancing factor. Therefore, digestibility, palatability and forage

quality decreased by changing the growing season and the alteration of these parameters. In the current study along with the developmental stages of plant phenological, ash and fiber contents increased and were higher than vegetative stage.

The lowest WSC was found in the early growth stages and gradually increased during growth period. Other researches indicated that the highest and lowest WSC occurred in the late and early stages of plant development, respectively if the growth of plants (in perennials) took its normal trend. Knowledge of WSC content is useful in the assessment of plant response to grazing. Stored WSC begins to decline to support new plant growth with the onset of spring and will continue until sufficient leaf surface formation to carry out photosynthesis, produce WSC and restore the consumed WSC which agrees with the findings of this study (Arzani, 2009). This study showed that the early spring grazing damaged *A. fridae*. Grazing in the early stages of plant growth can cause the disruption of physiological activities and plant weakening which will intensify the risk of extinction due to the reduced carbohydrate reserves.

Arzani *et al.* (2013a) in their research on 18 Rangeland species in Golestan province found that the best time for grazing would be at the end of the first phase of vegetative and flowering stages because the plants were not ready for grazing in the early phenological stages and were woody at the end of the growing season with low nutritional values. At this time, plants are quantitatively (production) and qualitatively palatable, and also have reached the stage of development protecting them from grazing. Asaadi and Khoshnood Yazdi (2011) reported that vegetative, flowering and seed setting stages have a suitable quality for livestock grazing, but for the health of the

plants, flowering and seed setting stages were considered as the most suitable ones for grazing. Abarsaji *et al.* (2008) considered flowering stage as the best time for harvesting forage. However, grazing of *A. fridae* at the flowering stage eliminated flowering branches and reduced its seed production posing a threat on plant reproduction. What is certain is that this species is endangered and any grazing plan should be done to maintain and strengthen this species. Generally, when the total CP contents reach a satisfactory level in the late growth stage, DMD and ME during the developmental growth are also higher than vegetative growth stage and with respect to this factor, there was no significant difference between three stages of flowering, seed setting and maturity. In addition, the highest WSC occurred during the late stages of plant growth. In spite of the fact that the reducing factors of forage quality including cellulose, lignin, NDF and CF had no significant difference during different growth stages and considering that plant reproduction must be preserved, it is most preferable to graze this species when its growth is completed to not only have the highest forage quality but also to pose the lowest damages to the plant. It should be noted that animal entrance time to rangeland can not be determined solely upon one species, and it must be set on the basis of forage quality changes of particular species (Arzani *et al.*, 2013a).

Conclusion

With respect to the fact that various plant species grow simultaneously in a given rangeland, grazing is distributed among many species and plant nutritional value changes over time, grazing must be carried out during the active stages of plant growth, in order to prevent from the decline of rangeland-based livestock productivity and to concomitantly maintain plant reproduction. To prevent

from the damages to *A. fridae*, a suitable grazing plan must be set each year to provide forage with sufficient quality for livestock and augment the animal production. Based on the findings of this study, the main factor threatening this species of interest is overgrazing. Therefore, conservation and then suitable grazing system have been recommended for this species in this region.

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کیفیت علوفه گونه در حال انقراض گچی (*Astragalus fridae* Rech. F.) در سمنان، ایران

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چکیده. گونه در معرض خطر انقراض گچی (*Astragalus fridae* Rech. F.) از جنس گون، بومی و انحصاری ایران است. با توجه به شرایط خاص این گونه در کشور و جهان و اهمیت حفظ ذخایر ژنتیکی در کشور، انجام مطالعات مختلف از جمله آگاهی از کیفیت علوفه گونه گچی ضروری بنظر می‌رسد. به این منظور نمونه برداری از مراحل مختلف فنولوژیکی گون گچی شامل رشد رویشی، گلدهی، بذردهی و رسیدگی گیاه طی سه سال (۱۳۹۱-۱۳۹۳) در روستای افتر استان سمنان، انجام شد. فاکتورهای کیفیت علوفه از جمله ME, NDF, CF, Ash, ADF, WSC, CP, DMD در گیاه با استفاده از دستگاه NIR اندازه گیری شدند. مقدار آنها به صورت میانگین به ترتیب ۶۷/۳۸، ۷/۵۸، ۱۷/۴۳، ۲۷/۷۹، ۵/۸۹، ۳۹/۸۷، ۴۷/۴۷ (درصد) و ۹/۴۶ مگا ژول بر کیلوگرم بود. مقایسه میانگین صفات در مراحل فنولوژیکی نشان داد که مرحله رشد بر کیفیت علوفه اثر معنی‌دار دارد ($P < 5\%$). کمترین میانگین صفات DMD, CP, WSC خاکستر و انرژی در مرحله رشد رویشی بدست آمد ولی از لحاظ آماری تفاوت معنی‌داری بین سه مرحله دیگر مشاهده نشد، اگرچه میانگین صفات مذکور در مرحله بذردهی حداکثر بود و می‌توان آن را با ارزش غذایی محتوی بذر مرتبط دانست. بر خلاف صفات فوق، میانگین ADF و NDF و CF با پیشرفت رشد گیاه افزایش یافت ولی این افزایش تاثیر چندانی در کاهش کیفیت علوفه نداشت. صفات DMD, CP, WSC خاکستر و انرژی باهم دیگر همبستگی مثبت و معنی‌دار داشتند و همه آنها با صفات فیبری ADF و NDF و CF رابطه معکوس داشتند.

کلمات کلیدی: *A. fridae*، ارزش غذایی، مرحله رشد، سمنان