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Animal preference and external plant attributes: application of principle component analysis

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Abstract

To evaluate the relationship between the external plant attributes (EPA) and animal preference (AP), plant composition in the study area and in the diet of sheep and goats, as well as the selection index of species were determined. Then, the most important EPA was selected and evaluated using literature review. Since there were a lot of EPA, plants were ranked based on these attributes using the principle component analysis (PCA). The eigenvalue and eigenvectors of the plant species and EPA were graphed, and the correlation between the species selection index by sheep and goats and the eigenvalue of the PCA axis for each plant species were calculated. Results indicated that while there was no significant difference between grazing time of sheep and rangeland plant composition, a significant relation was found between grazing time of goat and rangeland plant composition. Hence, it can be concluded that goat is not selective as they grazed plants in proportion to their forage yield and canopy cover in the field. Moreover, there is a significant relationship between the species' selection by sheep and goats and EPA. This study showed that the optimum grazing can be achieved by common grazing of goat and sheep as a result of different grazing time of plant life-forms and plant species.

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Introduction

A common denominator of the animal-plant relationships is that every grazing animal selects its food from the wide range of plants in natural vegetation, notwithstanding the fact that some animals eat various kinds of foods. Animal Preference (AP) is reserved for selection by the animal which is essentially behavioral and relative preference indicates proportional choice among two or more foods (Foresters, 1958; Ivins, 1952). AP is a useful term in understanding (1) vegetation changes, (2) formulating better animal management practices, (3) planning vegetation improvement programs, and (4) determining food intakes (Heady, 1964). Indeed, calculating rangeland grazing capacity resulted from multiplying the amount of yield by allowable use and/or AP to obtain the amount of forage available for grazing animals (Ebrahimi *et al.*, 2010; Ebrahimi, 2007). Therefore, if AP is not determined accurately, the figure for grazing capacity will be incorrect. The wrong number of grazing animals on the land will ultimately lead to the pasture destruction or wasting forage resources. There are many factors influencing relative AP such as palatability, associated species, topography climate, soil, animal type and animal physiology. Among these, palatability and animal type are the most important factors influencing AP (Heady, 1964).

Palatability is defined as the plant characteristics or conditions, which stimulate a selective response by animals (Heady, 1964; Cowlishaw and Alder 1960; Young, 1957, 1948). As commonly used, the term implies acceptability but not necessarily desirability. Thus, a food stuff that is palatable may be essentially neutral with regard to preference, being neither attractive nor repellant to the taste. Palatability is extremely difficult to define in terms of the biological processes involved in food selection. It is also important to note that palatability differs from the external plants attributes (EPA) (Ganqa and Scogings, 2007; Scheidel and Bruelheide, 1999; Cronin, 1998; Hay *et al.*, 1994; Frost and Ruyle, 1993; Hendry and Grime 1993; Rumbaugh *et al.,* 1993; Russel *et al.*, 1992). AP is probably related to EPA including presence of awns, spines, hairiness, position of leaves, stickiness, texture (Heady, 1964), thorns (Frost and Ruyle 1993; Russel *et al.*, 1992), tissues, trichome, and toughness (Ganqa and Scogings, 2007; Scheidel and Bruelheide, 1999; Cronin, 1998; Hay *et al.*, 1994; Hendry and Grime, 1993; Rumbaugh *et al.*, 1993). According to Raufirad *et al.*, (2013), and Arzani (1996), it can be concluded that EPA is the most important factor of palatability influencing relative AP as EPA is one of the first characteristics of the plant that animals face with when grazing in rangelands.

Since AP is directly related to the animal's characteristics, animal type is, therefore, considered as the other important factor affecting relative AP. Grazing animals can noticeably reduce the vigor of palatable species. Biomass losses at the grown-up stage can decrease seed production and vegetative extension, and differential grazing can consequently alter the dominance of the different plant species (Gross *et al.*, 2001; Fraser and Grime, 1999; Van *et al.*, 1998; Piper, 1996). It is perhaps not surprising that the most palatable species are generally restricted to habitats with low herbivore pressure (Elger *et al.*, 2002; Fraser and Grime 1999). Furthermore, various kind of animals like sheep or goats significantly differ in their food habits as each species showing innate preferences for certain plants, some parts of plants, or plants within particular growth stages. Interpretation of differences would be most difficult because grazing animals exhibit variations in preferred foods from one location to another (Dasmann, 1949), in different seasons (Heady, and Torell, 1959), over a period of a few days (Nichol, 1938)), within the same day (Van Dyne, 1963) and among individuals (Van Dyne, 1963; Heady Torell, 1959). Since many species of grazing animals inhabit the same area, additional knowledge of food habits, including preferences, is needed so that vegetation may be controlled to provide preferred foods for desirable animals (Heady, 1964).

The most common way in determining AP is to observe whether they eat the plant. In general, the methods utilized for measuring preferences are those employed primarily for other purposes such as determining grazing capacity, effects of grazing on vegetation, forage production, food intake, animal nutrition, and range utilization (Heady, 1964) However, the question of what morphological characteristics precisely appeal to or repel livestock is crucial for effective rangeland management (Heady, 1964). Therefore, there is a need for developing a method that considers external features of the plants in order to evaluate the AP.

The relationship of AP with EPA and animal types is, however, exceptionally complex. Very little research (Scheidel and Bruelheide, 1999; Frost and Ruyle 1993; Rumbaugh *et al*., 1993) has been conducted to correlate the EPA with the acceptability of the plant as a food source for mammalian herbivores (Russel *et al*., 1992). Therefore, little information is available on EPA while it may be an important factor affecting AP. Although there is a large body of research on the food habits of different animals, EPA is not usually investigated (Heady, 1964).The above discussions make it clear that EPA and animal type play an important role in AP. Although the relationship between these factors (i.e., some EPA and animal type) and AP has been previously studied (Arzani, 1996), there is a lack of research on the relationship of AP with all external attributes of the plant and animal type. Thus, the main objective of this study was to understand the relationship between EPA (including leaf position, branch density, leaf trichome, leaf spininess, stem spininess, height, leaf-stem ratio, prehensile resistance, stem trichome, inflorescence spininess, awns and succulence) and animal type with AP.

Materials and methods

Study region

The study area (Karsanak rangelands) is located near the village of Karsanak in Shahrekord city, Chaharmahal-V-Bakhtiari province (32° 30' 30"N, 56° 26´ 4"E), Iran. This area is at an ***altitude*** of about 2250 meters above sea level, which is in semi-steppe ecological zones (Fig. 1). The annual average temperature is 9.9 ◦C and the average annual rainfall is 425 mm which lasts mainly from November to January. The vegetation area is dominated by a mixture of patchily distributed millet (such as *Agropyrum intermedium* and *Bromus tomentellus* (*Poaceae*)), shrubs (mainly as *Astragalus adscendens*, *Astragalus verus* (*Fabaceae*) and herbs (mainly *Prangus acaulis* and *Prangus ferulacea* (*Umbelliferae*)) and the region's soil includes Cambisols, Leptosols, and Regosols. This area was selected due to a long history (centuries) of grazing by domestic livestock under nomadic or semi-nomadic of land use patterns and high level of plants biodiversity, which severely affects rangeland species palatability (Raufirad *et al*., 2013, 2011, 2010; Raufirad, 2009).

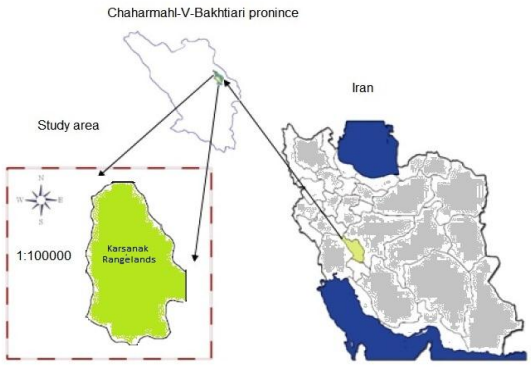

Fig. 1. The location of the Karsanak rangelands, Chaharmahal-V-Bakhtiari province in Iran.

Sampling method

Vegetation and Diet sampling

The vegetation was sampled during June 2008 that is the peak growing period for rangeland plants. Accordingly, the presence of a species in the total plant composition was determined using six transects of 400 meters long that were randomly selected from different patches of each type of sampling grassland . In each transect, 20 plots of 1m ×2m were randomly placed for surveying species numbers, and measuring plant cover and yield. All plots were located within at

least every 20m to avoid the impact of elevation and other related factors. All plant species of each plot were identified and recorded before conducting subsampling. Finally, the plants were identified by botanists who divided them into three functional groups: grasses, shrubs and forbs. Accordingly, the vegetation types were classified and canopy cover and forage yield were calculated for each species.

The presence of a species in the diet of livestock grazing on the rangeland was determined based on the grazing time spent by sheep and goats on each species, using filming method. To this end, according to the Altman's instructions (1974), three sheep and three goats were selected in the study area through a completely random fashion, given that the selected livestock represented the age, size and race of the herd. After ensuring no change in the grazing behavior of the livestock in the vicinity, the sheep and goats grazing time for each plant species was measured using chronometric and filming methods. The duration of observations through chronometric and filming methods was two hours per day (one hour in the morning and one hour in the afternoon) during the maturity stage of plant growth over a ten days period within the spring season (from early to late spring season which is the growth season in this region).

External plant attributes (EPA)

A literature review was conducted to identify the most important EPA including leaf position, branch density, leaf trichome, leaf spininess, stem spininess, height, leaf-stem ratio, prehensile resistance, stem trichome, inflorescence spininess, awns, succulence and shape. Afterwards, these major morphological traits were measured using different references such as the plants database of USA (USDA NRCS, 2009), the biolflor database of Germany (UFZ ISSG, 2009) and Ghahreman colored flora (Ghahreman, 1986). In fact, all morphological traits of plants were determined based on the information available from these resources in which morphological traits of plants have been collected and classified.

Data analysis

The species' grazing time on each plant was utilized to calculate the composition of the species' diet according to formula 1.

$$\%DietComp_{Sp_i} = \frac{t_{Sp_i}}{\sum_{1}^{n} t_{Sp_n}} \times 100$$

Where $\%DietComp_{spi}$ is the ratio of the plant species in the diet composition, t_{spi} is the grazing time of the individual sheep or goat on each species and $\sum t_{spn}$ is the total grazing time on that plant species. Following, a selection index was calculated for each species according to formula 2 in order to avoid the adverse effects of having inappropriate high or low proportion of each plant species in the diet selection (Hosseini Kahnuj *et al.,* 2013; Ngwa *et al.,* 2000; Jacobs, 1974).

$$SI=A/B \qquad (2)$$

In the above formula, *SI* is the selection index of each species, *A* is the average presence of a species in the diet of livestock (sheep or goat) and *B* is the presence of a species in the total plant composition of the rangeland.

Since there was a great number of EPA, and it was not possible to investigate their relationship with AP separately, Plants were ranked based on these external attributes through conducting the principle component analysis (PCA) method on PC-ORD software (McCune and Mefford, 1999). PCA is a method for ranking and abbreviation of effective factors that influence a process without eliminating any of them. This method gives us two groups of data; eigenvalue and eigenvector. The quantitative values for eigenvalue and eigenvectors of the plant species and their attributes were plotted on the main axis of PCA. Afterwards, correlation analysis between the selection index and eigenvalue of the PCA axis was determined for each plant species. Pearson correlation coefficient was applied to find the association between the selection index and physical traits. This latter analysis was performed using SPSS software (version 17).

Results

Vegetation composition

Table 1 shows the list of species within the plant composition of the karsanak rangelands. As shown in the table, the vegetation composition of the study area consists of a mixture of grasses (39.82 %), shrubs (31.41 %), and herbaceous plants or forbs (28.85 %). Although the largest share of species composition (based on both canopy cover and the forage yield) belongs to grasses, these plants are not usually seen in the diet of sheep and goats. Forbs have the highest level of preference both in the diet of sheep and goats. While comparing to the goats, more proportion of forbs were observed in the sheep diet, the figure is generally more than the total plant species composition available at the study field. Moreover, shrubs were more grazed by goats than sheep. However, these plants were relatively less common in the diet species composition of sheep and goats in comparison with their quantity within the plant composition of the study area (Fig. 2)

Table 1. The list of species of the plant composition in the karsanak rangelands.

Row	Scientific name	Canopy cover (%)	Plant composition (%)	Row	Scientific name	Canopy cover (%)	Plant composition (%)
1	*Agropyron intermedium*	□□□□	□□□□□	16	*Phlomis olivieri*	□□□	□□□□
2	*Poa bulbosa*	□□□	□□□□	17	*Achillea santolina*	□□□□	□□□□
3	*Bromus tomentellus*	□□□□	□□□□□	18	*Taraxacum montanum*	□□□□	□□□□
4	*Bromus tectorum*	□□□□	□□□□	19	*Phlomis persica*	□□□□	□□□□
5	*Stipa hohenackeriana*	□□□□	□□□□	20	*Tanacetum polycephalum*	□□□□	□□□□
6	*Melica persica*	□□□□	□□□□	21	*Cousinia bachtirica*	□□□□	□□□□
7	*Heteranthelium piliferum*	□□□□	□□□□	22	*Tragopogon longirostris*	□□□□	□□□□
8	*Astragalus effusus*	□□□□	□□□□	23	*Cardaria deraba*	□□□□	□□□□
9	*Eryngium billradieri*	□□□□	□□□□	24	*Stachys inflata*	□□□□	□□□□
10	*Euphorbia sp*	□□□□	□□□□	25	*Astragalus curvirosteris*	□□□□	□□□□
11	*Scorzonera seidlitzii*	□□□□	□□□□	26	*Cousinia calcitrapa*	□□□	□□□□
12	*Scariola orientalis*	□□□□	□□□□	27	*Medicago stiva*	□□□□	□□□□
13	*Stachys lavandulifolia*	□□□□	□□□□	28	*Astragalus verus*	□□□□	□□□□□
14	*Stachys pilifera*	□□□	□□□□	29	*Astragalus adscendens*	□□□□	□□□□
15	*Centaurea virgata*	□□□□	□□□□	30	*Silene spergulifolia*	□□□	□□□□

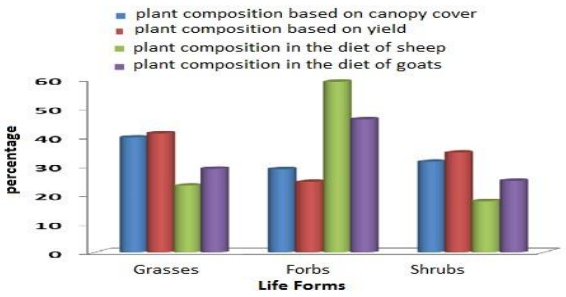

Fig. 2. Plant composition of the study area based on canopy cover and yeild and plant composition of the diet of sheep and goats.

The diet of sheep and goat

Also results indicate while *Agropyron intermedium*, *Bromus tomentellus*, *Poa bulbosa* (especially for sheep), *Eryngium billardieri*, *Scorzonera seidlitzii*, *Achillea santolina*, *Taraxacum montanum*, *Medicago sativa* and *Astragalus verus* have the highest selection index, they contained different ratio in the diet of both sheep and goats considering their total proportion of the plant matter in the study area (Fig. 3). Although the maximum selection index in the diet of sheep and goats was obtained for *Medicago sativa*, its ratio in the diet of sheep was greater than goats. In general, among these studied plants, the grass had the lowest proportion in the diet of sheep and goats. Fig. 3 compares the selection index of *Agropyron intermedium*, *Bromus tomentellus* and *Poa bulbosa* with the figures for other herbaceous species. As it is shown in Fig. 3, grasses were equally grazed by sheep and goats whereas sheep preferred *Bromus tomentellus* and goats preferred *Poa bulbosa*. On the other hand, *Medicago sativa*, *Scorzonera seidlitzii*, *Achillea santolina* and *Taraxacum*

montanum were significantly preferred by goats comparing to the sheep. Meanwhile, the spiny shrubs *Astragalus verus* and *Eryngium billardieri* were preferred more by goats than sheep.

Animal preference and plant composition

According to our results, while there was no significant difference between grazing time of sheep and rangeland plant composition (P≤ 0.05), based on the canopy cover and the forage yield, a significant relation was found between grazing time of goat and rangeland plant composition (P≤ 0.01).

Table 3 shows the results of the PCA applied to 13 external attributes of 30 dominant species of vegetation composition in Karsanak. The first six components accounted for 93.76 percent of variance where the first four ones showed 27.33, 22.76, 14.32 and 11.01 percents of the variation, respectively. Cronbach's alpha coefficient, which determines the amount of validation for each axis, also showed that the values of the axes need to be at least interpreted to the fourth axis.

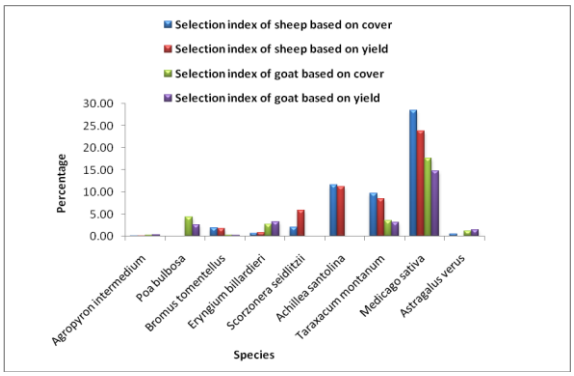

Fig. 3. Selection index of plant species by sheep and goat based on yield and cover of species in the plant composition in Karsanak rangelands.

Accordingly, it can be said that these axes are more important than others (i.e., axes 3, 4, 5 and 6). Although other axes constitute some proportion of the total variance, axes 1 and 2 are the most effective ones in plants selection by animals.

Table 2. Results of correlation test between plant species composition based on canopy cover and yield and plant species composition in the diet of sheep and goats.

		Relative cover of plant species	Relative yeild of plant species	Relative time of sheep grazing	Relative time of goat grazing
Relative cover of plant species	Pearson correlation coefficient	□	□□□□□□□	□□□□□	□□□□□
	Significant level		□□□□□	□□□□□	□□□□□
Relative yeild of plantspecies	Pearson correlation coefficient	□□□□□□	□	□□□□□	□□□□□□□
	Significant level	□□□□□		□□□□□	□□□□□
Relative time of sheep grazing	Pearson correlation coefficients	□□□□□	□□□□□	□	□□□□□
	Significant level	□□□□□	□□□□□		□□□□□
Relative time of goat grazing	Pearson correlation coefficients	□□□□□□	□□□□□□□	□□□□□	□
	Significant level	□□□□□	□□□□□	□□□□□	

* Significant level (P≤ 0.05) - ** Significant level (P ≤0.01)

Table 3. Principle component analysis of external attributes of dominant plant species in Karsanak rangelands.

Axis	Cronbach's alpha coefficient	Variance		
		Eigenvalue	Percentage of variance	Percentage of cumulative variance
1	0,779	3,554	27,335	27,335
2	0,717	2,960	22,768	50,103
3	0,502	1,862	14,326	64,429
4	0,327	1,431	11,011	75.44
5	0,189	1,212	9,326	84,766
6	0,156	1,169	8,989	93,755
total	0.994	12.188	93.755	

Animal preference and external plant attributes

Table 4 shows the result of correlations between the first and fourth explainable axes of PCA (based on the EPA of dominant species in the plant composition)and the sheep and goat selection index of species (based on the yield and canopy cover). According to these results, there is a significant relationship between the selection index of the species by sheep with the axis of the first and second PCA (P≤0.05). Likewise, there is a significant relationship between the selection index of the species by goats with the axis of the second PCA (P ≤0.01).

Tables 5 show the specific amounts of vector (eigenvector) and morphological characteristics of plants on each axis. In addition, the results suggest that leaf spininess, stem spininess, height, prehensile resistance and inflorescence spininess were the five primary elements on the first axis of PCA while succulence, leaf position, leaf-stem ratio, branch density and inflorescence spininess were the most important factors on the second axis.

Table 4. Results of correlation tests between the first and fourth axis (axis is explainable) of plant principle component analysis and the selection index of the plant species by sheep and goats in Karsanak rangelands.

Axis	Statistic index	Selection index of goat based on yield	Selection index of goat based on cover	Selection index of sheep based on yield	Selection index of sheep based on cover
Axis1	Pearson correlation	0.132	0.146	*0.417	*0.408
	Significance level (bilateral)	0.486	0.44	0.022	0.025
	Number	30	30	30	30
Axis2	Pearson correlation	**0.795	**0.835	**0.476	**0.566
	Significance level (bilateral)	0	0	0.008	0.001
	Number	30	30	30	30
Axis3	Pearson correlation	-0.126	-0.095	-0.117	-0.086
	Significance level (bilateral)	0.507	0.617	0.537	0.651
	Number	30	30	30	30
Axis4	Pearson correlation	0.072	0.065	0.136	0.122
	Significance level (bilateral)	0.705	0.732	0.474	0.521
	Number	30	30	30	30

* Significant level (P≤ 0.05) - ** Significant level (P ≤0.01)

Table 5. Eigenvector of Morphological traits of plant on the axes of PCA.

Row	Morphological traits	Axis					
		1	2	3	4	5	6
1	Leaf position	0.252	0.9	0.073	0.145	-0.006	-0.295
2	Branch density	0.512	0.572	0.264	-0.367	0.317	0.103
3	Leaf trichome	-0.234	-0.144	0.887	0.231	-0.244	-0.078
4	Leaf spininess	0.904	-0.314	0.06	-0.086	-0.151	-0.035
5	Stem spininess	0.792	-0.34	-0.106	0.216	-0.288	-0.169
6	Height	0.639	0.26	0.192	0.173	0.45	0.345
7	Leaf-stem ratio	0.156	0.672	-0.087	0.021	-0.647	0.16
8	Prehensile resistance	0.855	-0.284	0.188	-0.216	0.205	0.102
9	Stem trichome	-0.04	-0.198	0.854	-0.294	-0.098	-0.344
10	Inflorescence spininess	0.711	-0.326	-0.191	0.356	-0.243	-0.174
11	Awns	-0.049	0.093	0.372	0.538	-0.134	0.706
12	Succulence	0.213	0.912	0.032	0.088	-0.05	-0.274
13	Shape and orientation	-0.098	-0.045	0.045	0.763	0.441	-0.399

Discussion and conclusion

In general, discussion around AP and factors affecting it is not easy mainly due to the fact that many species of grazing animals inhabit the same area. Therefore, knowledge of food habits including preferences is required to be able to control over the vegetation of

the rangeland to give desirable animals their preferred foods (Heady, 1964). Accordingly, our study, in line with other studies carried out by Raufirad *et al*., (2013), Raufirad (2010), Baghestani Meybodi and Arzani, (2006) and Baghestani Meybodi, (2004), has shown that although grasses, shrubs and forbs were respectively dominant in plant composition of the field, the study livestock (e.g., sheep and goats) showed the highest preference for forbs, the intermediate preference for grasses, and the least preference for shrubs. According to this study, among the numerous factors that may influence AP, only the presence of plants in the overall plant composition cannot be considered as an important factor. In other words, in order to precisely determine AP, considering other plant related characteristics (e.g., EPA) and animal characters (e.g., animal type) are important as well. This finding is confirmed by Borchard *et al*., (2011), and Cowlishaw, (1960) who concluded that considering all plant and animal characteristics significantly influence AP. On the other hand, grazing time of a species by animals was not appeared to be affected by frequency, abundance, and/or amount of herbage (Hurd and Pond, 1958). A plant may constitute a limited quantity in the plant composition of a rangeland but animals may spend a lot of time for grazing that plant and vice versa. Hence, relative grazing time (not grazing time) should be considered as an important factor if the goal is to determine AP in a correct way in order to better management of rangelands (Lewis and Volseky, 1988).

As the results showed, sheep do not graze based on the frequency of plants in the field while goats graze plants in proportion to their forage yield and canopy cover in the rangeland. Therefore, it can be concluded that sheep is selective and goat is not and since sheep and goats noticeably differ in their food habits, the optimum grazing can be achieved by common grazing of goat and sheep given their different grazing time of plant life-forms and plant species preferences. Although these results were not highlighted in some studies (Ebrahimi *et al*., 2010; Ebrahimi, 2007; Baghestani Meybodi and Arzani, 2006; Baghestani Meybodi, 2004; Hay, 1994; Heady, 1964), others confirmed their importance (Raufirad *et al*., 2010, 2011, 2013; Raufi, 2010). However, there is a need for further research on the relationship between the grazing time of sheep and goats and the frequency of plants in the rangeland.

The results of this study show that among many species exist in the study rangeland, 9 species are preferred more by sheep and goat. Since most of these species have suitable morphology for grazing, it can be implied that EPA can be used as an indicator for determining AP which is also confirmed by Heady and Child (1994) and O'Reagain (1993). The EPA is an important factor encouraging livestock to eat the plant or not. Importantly, at the selection moment, the animal is first faced with the morphology characteristics of the plant before perceiving any chemical characteristics (Arzani, 2009). The results from the PCA showed that external attributes are important factors in selecting plants by sheep and goats. Based on these results and the results of study conducted by Arzani (2009), determining AP and plant palatability may not be precise enough without considering EPA. The significant relationship between the first four axes of PCA and the selection index of species by sheep and goats –with knowing the fact that these two axes cover 50.10 percent of variance – strongly suggests that external attributes are among the most important factors in choosing a particular plant species by grazing livestock.

Moreover, according to our study, EPA such as leaf spininess, prehensile resistance, stem spininess, inflorescence spininess and height strongly influence the selection of the plant species by sheep. In contrast, leaf spininess, succulence, leaf position, leaf-stem ratio, branch density and stem spininess strongly affect the selection of the plant species by both sheep and goats. These findings are in line with the results of studies conducted by Borchard *et al*., (2013), Mouissie *et al.,* (2008), Baghestani Meybodi and Arzani (2004), Vallentine (2001), Springfield *et*

al., (1986), Heady (1964), and Springfield (1951) who identified the presence of awns, spines, hairiness, position of leaves (Heady and child, 1994), stickiness (valentine, 2001) as the most important EPA factors affecting AP. Since leaf spininess, stem spininess, inflorescence spininess and branch density (valentine, 2001; Heady and child, 1994; Spalinger *et al.*, 1987; Springfield and Reynoldsm 1951) had the lowest amount of eigenvalue, these EPA have negative effects on AP while height (O'Reagain, 1993), succulence (Vallentine, 2001), leaf position and leaf-stem (Heady and child, 1994) with the highest eigenvalue are the positive factors affecting AP.

In summary, those plant species with suitable EPA are mostly preferred by sheep and goats. As a result, developing species with suitable external attributes like suitable height, succulence, leaf position and leaf-stem ratio should be one of the objectives in the future grass genetics researches in order to improve palatability of species in rangelands. Our study found that EPA is a reliable indicator of AP, although considerable amount of research should be directed towards identification of the most important EPA for different animals in rangelands. Since determining EPA is easier, faster and less expensive than determining chemical characteristics, we suggest using the EPA for determination AP as an effective way for better rangeland management.

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