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Some vegetation characteristics of rangelands subjected to different grazing pressures with single- or multi-species of animals for a long time (A case of Zonguldak province, Turkey)

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ABSTRACT
Two studies were carried out to evaluate the rangelands subjected to grazing pressures (GP) at different levels with single (SSG, cattle) - or multi (MSG, cattle, sheep and goats)-grazing animals species (GAS) for a long time in Zonguldak province, Turkey. These studies were done in 2015 and 2016 years. The GP treatment was classified as <0.30 (very low, VL), 0.31 to 0.60 (low, L), 0.61 to 0.90 (high, H) and 0.91< (very high, VH) livestock unit (LU) ha^{-1}. The percentages of decreaser, increaser and invader range plant species, including shrub and herbaceous species and rangeland condition score interacted among the GP and GAS treatments. The percentages of decreaser species in the MSG communities under the L level and in the SSG communities under the VH level were higher compared to other treatments. The rate of shrub species in the VL rangeland subjected to SSG was higher than that in the VH rangeland. The rate of shrub species in VH range subjected to MSG was higher than that in other ranges subjected to MSG and in VH range subjected to SSG. The frequencies of decreaser and invader species of SSG were higher than that of MSG, but the frequency of increaser species was lower than that of MSG. The range condition class for the SSG and MSG rangelands were “poor” and “fair”, respectively. These results indicate that increasing GP prevents animals from grazing selectively and the MSG system can contribute to the control of weeds.

Keywords:
Grazing livestock
Overgrazing
Rangeland condition
Response to grazing
Stocking rate
Weed control

Uzun süre bir veya birden fazla hayvan türü ile farklı otlatma baskılarına maruz kalan meraların bazı vejetasyon özellikleri (Zonguldak ili örneği, Türkiye)

ÖZET
Zonguldak ilinde uzun süre bir (BTO; sığır) veya birden fazla (karışık) hayvan türü (KTO; sığır, koyun ve keçi) ile farklı seviyelerde otlatma baskısına maruz kalan meraların değerlendirilmesi için 2015 ve 2016 yıllarında iki çalışma yapılmıştır. Otlatma baskısı muameleleri şu şekilde oluşturulmuştur: büyük baş hayvan birimi (BBHB) ha^{-1}<0.30 (çok düşük, ÇD), 0.31-0.60 (düşük, D), 0.61-0.90 (yüksek, Y) ve 0.91< (çok yüksek, ÇY). Çalı ve otsu türler de dâhil azalıcı, çoğalıcı ve istilacı bitki türleri ve mera durum skorları üzerine otlatma baskısı ve hayvan türü arasındaki etkileşimin etkisi önemli bulunmuştur. Çalı ve otsu türler de dâhil azalıcı, çoğalıcı ve istilacı bitki türleri ve mera durum skorları üzerine otlatma baskısı ve hayvan türü arasındaki etkileşimin etkisi önemli bulunmuştur. Azalıcı türlerin oranı bakımından, D otlatma basınçlı KTO sistemine ve ÇY otlatma basınçlı BTO sistemine ait meralar, diğer otlatma basınçlı sistemlere ait meralardan daha yüksek bir değere sahip olmuştur. BTO sistemine ait meralardaki çalı türlerinin yüzdesi, ÇD otlatma basıncında, ÇY otlatma basıncı ile karşılaştırıldığında daha yüksek bulunmuştur. ÇY otlatma basınçlı KTO sistemine ait meralardaki çalı türlerinin oranı, diğer otlatma basınçlı KTO sistemine ve ÇY otlatma basınçlı BTO sistemine ait meralardakinden daha yüksek bulunmuştur. BTO sistemine ait meralardaki azalıcı ve istilacı türlerin frekansı, KTO sistemindekilerden daha yüksek, çoğalıcı türlerin frekansı ise daha düşük olmuştur. BTO ve KTO sistemlerine ait meralarının mera durum sınıfı sırasıyla “zayıf” ve “orta” olarak belirlenmiştir. Bu sonuçlar, artan otlatma baskısının hayvanların seçici otlamasını önlediğini ve karışık hayvan türleri ile otlatma sisteminin yabancı otların kontrolü açısından daha etkili olabileceğini göstermiştir.

Anahtar Sözcükler:
Aşırı otlatma
Mera durumu
Mera hayvancılığı
Otlatmaya tepki
Hayvan yoğunluğu
Yabancı ot kontrolü

1. Introduction

One of integral components of agricultural systems is utilization of rangeland forages by grazing domestic ruminants (cattle, goat and sheep), because grazed herbage is the cheapest feed source available for these animals (Ahmed et al., 2017; Asmare, 2018). Although rangeland forage quantity and quality affect the performance of grazing ruminants (Ocak et al., 2006; Alay et al., 2016; Pullanagari et al., 2018), the traits of rangelands is often less than desirable for sustainable and productive agriculture in the Mediterranean countries (Uzun et al., 2016; Reis and Şen, 2017; Asmare, 2018). To protect and maintain both species diversity and optimum rangeland health by controlling invader plants in rangelands should be understand perfectly the interactions between forage and grazing animal species (Foroughbakhch et al., 2013). The way animals graze a rangeland is influenced by the state of the plant development, the time they are on the rangeland, the time the rangeland is rested between grazing, the ability of the animals to choose forage species and grazing pressures (GP) with a single- (SSG) and multi-species grazing (MSG). Therefore, the GP and grazing animal species (GAS) affects the distribution of plant species based on response to grazing and can have the major impact on plant choice of animals (Erkovan et al., 2016), because grazing can either promote or reduce invader species abundance at a specific rangeland (Tallowin et al., 2005; Alay et al., 2016; Bremm et al., 2016). Reis and Şen (2017) noted that unplanned grazing practices which led to much greater GP resulted in non-uniform grazing.

Livestock grazing strategies (continuous grazing vs. no grazing) and intensities (heavy to light grazing) can influence plant composition (Koc and Kadioglu, 2012; Alay et al., 2016; Koç and İleri, 2016; Bremm et al., 2016) which is vital for the sustainable use of rangelands over the years (Tallowin et al., 2005; Allred et al., 2012). This situation is depending on that the GAS is proficient of consuming all plant species, including alien species in rangelands (Erkovan et al., 2016). Grazing can affect ecosystems in many ways such as woody plant encroachment and livestock productivity as well as plant communities (Allred et al., 2012; Erkovan et al., 2016). The botanical composition (BC) and especially the rates of desirable plant species depend on the GP and GAS as well as plant species diversity (Tallowin et al., 2005; Alay et al., 2016; Bremm et al., 2016; Erkovan et al., 2016). However, the long-term effects of different grazing systems such as the SSG and MSG remain poorly understood.

Existence and type of grass and/or legume in the rangelands, that is, rangeland quality are the main determinant in shaping the grazing plan to be applied to the rangelands. Moreover, assessment of rangeland quality is required to assist farmers with grazing planning and management, benchmarking between seasons and years (Erkovan et al., 2016; Pullanagari et al., 2018). Overgrazing for long periods can reduce canopy cover, alter BC and decrease range condition score (RCS). Therefore, to investigate long-term consequences of grazing on vegetation structure of a rangeland is important not only to understand range forage species, but also to be able to deal with the primary factors that can threaten livestock productivity. Indeed, degradation of rangelands subjected to the SSG and MSG for a long time is a fundamental problem (Ouédraogo-Koné et al., 2006; Koç and İleri, 2016; Ahmed et al., 2017; Asmare, 2018) in the countries like Turkey, since nutrition of domestic ruminants in Turkey is mainly based on the exploitation of rangelands (Uzun et al., 2015; Alay et al., 2016; Koç and İleri, 2016). Therefore, invasion of rangelands by weed species is a threat to animal production in Turkey. There are numerous effects of grazing on rangelands, and these effects have been the subject of much study in pastoral systems, because plant and animal species composition can be dramatically altered with the presence of single-species or multiple-species (Read et al., 2011; Erkovan et al., 2016). Indeed, it has been reported that the proportion of land desirable for grazing plant species and the density of plant or richness of species decreased as a result of the elimination of the less grazing-tolerant species (Allred et al., 2012; Uzun et al., 2016). The presence of goats or cattle among multiple-species due to the intensity of their browsing is critical for woody plant suppression and generally vegetation efficacy (Benavides et al., 2009; Read et al., 2011; Allred et al., 2012; Uzun et al., 2015; Alay et al., 2016). In Turkey, the effects of long-term early, irregular and heavy grazing on rangelands in different regions of Turkey have been the subject of extensive studies (Yavuz et al., 2012; Çınar ve ark. 2014; Ünal et al., 2014; Uzun et al., 2015; Alay et al., 2016; Erkovan et al., 2016; Koç and İleri, 2016; Reis and Şen, 2017; Seydoşoğlu ve ark. 2018). However, there is limited information about the vegetation structure, especially the rates of desirable forages species for grazing in rangelands subjected to different livestock grazing for a long time. Accordingly, the objectives of studies reported herein were to determine the changes in the BC, canopy cover, condition score and health class of rangelands subjected to the GP at different levels with SSG or MSG for a long time and thus to evaluate the applicability of SSG or MSG as a rangeland management strategy.

2. Material and Methods

In this study, two experiments were conducted in rangelands of Zonguldak province (41°27′ N and 31°49′ E, with an elevation of 40 to 86 m a.s.l) located in the Western Black Sea Region of Turkey. Data on the number of grazing animals as livestock unit (LU) and the properties of the rangeland communities were collected in the years of 2015 and 2016. Based on these data, 21 and 23 rangeland communities for Experiment 1 and Experiment 2, respectively, were selected by considering their suitability to quantify the balance between rangeland feed supply and the demand of these animals (Shakhane et al., 2013) and to test the hypothesis of each experiment. In the region, summers are warm and humid, while winters are cool and damp with a mean annual temperature of 13.7 °C ranging from 7.0 °C in winter to 21.2 °C in summer, and annual rainfall of 1233 mm (TSMS, 2017). In the rangeland communities (approximately 2.2% of the province) of the province, there was a pastoral system which has been grazing by cattle or a mix of sheep, goats and cattle.

2.1. Experiment I

A total of 21 rangeland communities grazed *ad libitum* with different GP levels and grazing systems throughout the year for a long time were evaluated. The vegetation cover and the BC in all communities were estimated using the step-point method as previously described (Evans and Love, 1957; Mganga et al., 2013; Alay et al., 2016). Plant species were characterized as decreaser (higher-yield species, more palatable plants and more desirable for grazing lands), increaser (lower-yielding and tasteless species) and invader (native or introduced plants that invaded the rangeland after the decreasers and increaser are reduced by grazing) corresponding to response to grazing (Dyksterhuis, 1949; Koç et al., 2003; Holechek et al., 2011; Koc and Kadioglu, 2012). To determine the canopy cover, RCS and health classes of each rangeland community, the rate of decreaser, increaser and invader species were used as described by Koç et al. (2003) and Holechek et al. (2011). The RCS were calculated considering the lowest amount of each of decreaser and increaser species, irrespective of invaders (Dyksterhuis, 1949).

The GAS treatments was SSG (100% cattle) and MSG composed of sheep (41.7%), goats (15.2%) and cattle (43.1%). The levels of the GP treatment were composed as livestock units (LU) managed for long time per unit experimental area (ha) and designated as very low (VL, <0.30 LU ha^{-1}), low (L, 0.31 to 0.60 LU ha^{-1}), high (H, 0.61 to 0.90 LU ha^{-1}) and very high (VH, 0.90< LU ha^{-1}). The impacts of the GAS and GP treatments on decreaser, increaser, invader species and RCS were evaluated in a 2 grazing GAS (SSG and MSG) × 4 GP (VL, L, H and VH) factorial design. In this study, ungrazed rangeland was not evaluated, since these areas were open to public grazing. The standard deviation (mean ± 1 or 2 SD) of mean LU managed per unit experimental area were used as the criteria of grouping GP into the different classes. As known, GP is the demand to supply ratio between dry matter requirements of LU and the quantity of forage available in a rangeland at a specific time. After the amount of forage yield and utilization rate were determined using a scale developed for rangelands in different regions of Turkey (Gökkuş et al., 2000), the carrying capacity were calculated, which can be used to determine either the total forage available and/or the LU forage requirements. As such, the GP levels in the rangeland communities were determined according to carrying capacity was calculated as following (Carter, 2008; Holechek et al., 2011); Carrying capacity = forage supply [useable forage production (kg ha^{-1}) × area (ha)] ÷ forage demand [daily forage requirement (kg LU^{-1}) × number of grazing days (180 days)]. The usable forage production was calculated by adjusting for allowable use on the rangeland which is accessible for grazing in this zone and daily forage requirement (as dry matter basis) was considered to be 2.5% of body weight. On the other hand, to standardize the forage demand and the forage available in the public rangelands, livestock unit month (LUM) was used as unit of carrying capacity. The LUM is an estimate of how many acres are required to support the kind and class of livestock grazing for a period of one month (Carter, 2008). As such, the current and desired carrying capacities of the studied rangelands were expressed as the LUM ha^{-1}.

2.2. Experiment II

A total of 23 rangeland communities evaluated in Experiment 2 were separated to two rangeland classes subjected to SSG (100% cattle) or MSG (11.40% sheep, 4.06% goats and 84.58% cattle) system throughout the year for a long time. The frequency of each species was calculated as described by Khojasteh et al. (2013) and Uzun and Ocak (2018). The BC of the rangelands is classified according to families (grass, legume and the others) and responses to grazing (decreaser, increaser and invader) of plant species (Koc and Kadioglu, 2012). Then, the shrubs and herbaceous species were articulated as percentage of invader species.

2.3. Statistical analysis

The optimal sample sizes (number and size of the community) for the experiments in this study were determined to assure adequate power to detect statistical significance. Based on experimental design, factors GAS and GP both fixed $Y_{ijk} = \mu + GAS_i + GP_j + (GASGP)_{ij} + \varepsilon_{ijk}$ in the mixed effects model. Where: Y_{ijk} is the kth observation at the ith level of factor GAS and the jth level of factor GP, μ is the population (grand) mean, GAS_i is the fixed effect for the ith level of factor GAS, GP_j is the fixed effect for the jth level of factor GP, $(GASGP)_{ij}$ is the interaction effect between factors GAS and GP, and ε_{ijk} is the random error effect. The “t test” was used to identify significant differences between SSG and MSG treatments. Data expressed as percentages or proportions of the total sample were arcsine or angular transformed to meet analysis of variance assumptions as to correct deficiencies in normality and homogeneity of variance. Treatment means which showed significant differences were associated using Tukey's pairwise comparison procedures. Differences were deemed significant at

P<0.05. All statistical analyses were carried out using IBM SPSS Statistics software package (SPSS, 2012).

3. Results and Discussion

3.1. Experiment I

The vegetation of rangeland communities studied in Experiment I had mixture of 49 plant families, and the BC of these rangelands was dominated by *Fabaceae* (22.6%), *Gramineae* (16.0%), *Astraceae* (14.6%) and *Rosaceae* (7.1%) families. Both GAS and GP affected the rates of invasive shrub and herbaceous species and only the GP influenced the percentage of the decreasers (P<0.05, Table 1). The percentage of decreaser, increaser (P<0.05) and invader (P<0.01) species, including shrub and herbaceous species and the RCS (P<0.05) interacted among GAS and GP treatments (Figure 1, Figure 2 and Figure 3).

Table 1. Level of significance and standard error of the mean (SEM) for effects of grazing animal species (GAS), grazing pressure (GP) and the interaction between these factors (GAS × GP) on the percentages of forage species based response to grazing, the invader species and rangeland condition score

Items	Significance level			SEM
	GAS	GP	GAS × GP	
Response to grazing				
Decreaser	NS	*	*	1.208
Increaser	NS	NS	*	0.909
Invader	NS	*	**	3.057
Invader species				
Shrub	*	*	*	1.658
Herbaceous	*	NS	*	1.547
Rangeland condition score	NS	NS	*	2.057

*P < 0.05; **P < 0.01; NS: not significant (P > 0.05).

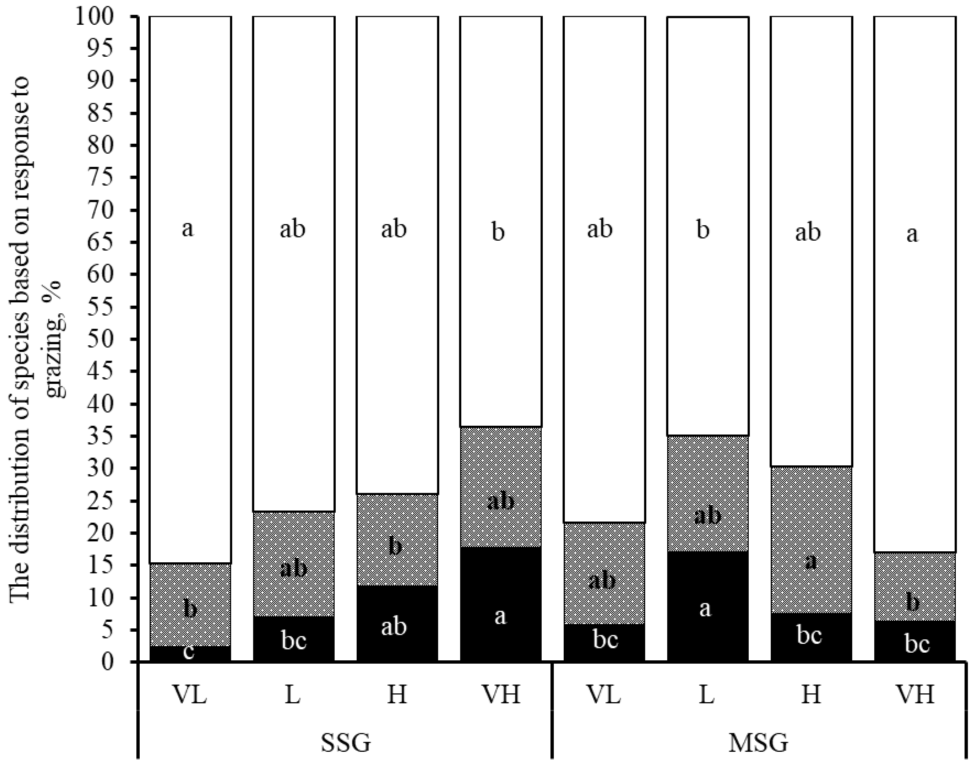

Figure 1. The percentage distribution of decreaser (■), increaser (▒), invader (□) species based on response to grazing in the rangeland communities grazing by different animal species and subjected different grazing pressure (grazing animal species × grazing pressure interaction). SSG, single species grazing (cattle only), MSG: multi species grazing (like sheep or goats into a cattle system); VL: very low (>0.30 LU ha^{-1}), L: low (0.30–0.60 LU ha^{-1}), H: high (0.61–0.90 LU ha^{-1}) and VH: very high (0.90< LU ha^{-1}). [a,b,c] Different superscripts within a bar with different colour indicate significant differences (P < 0.05).

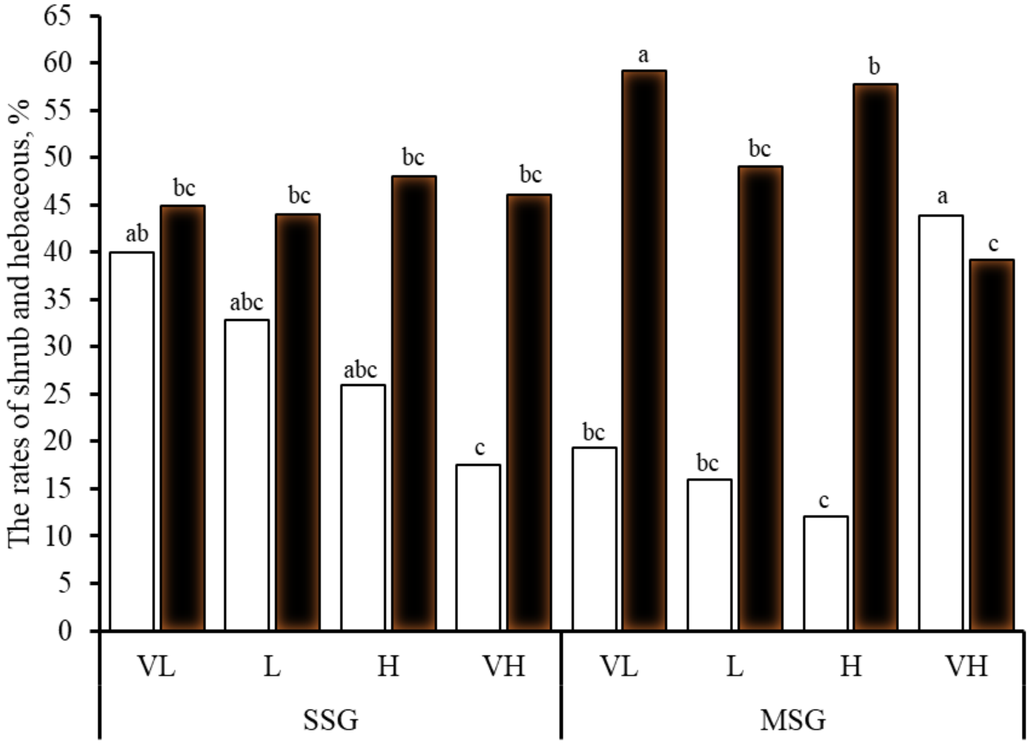

Figure 2. The rates of shrub (□) and herbaceous (■) species as percentage of the invader species in the rangeland communities grazing by different animal species and subjected different grazing pressure (grazing animal species × grazing pressure interaction). [a,b,c] Different letters on top of bars for each species indicate difference (P<0.05). The abbreviations of the treatments are as in Figure 1.

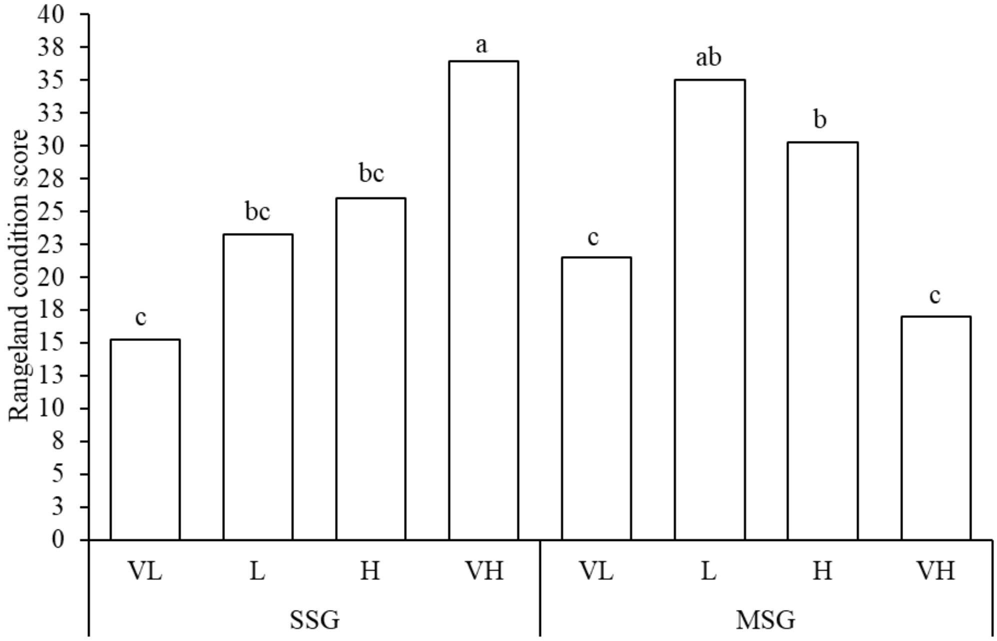

Figure 3. Rangeland condition score of the rangeland communities grazing by different animal species and subjected different grazing pressure (grazing animal species × grazing pressure interaction). [a,b,c] Different letters on top of bars indicate difference (P<0.05). The abbreviations of the treatments are as in Figure 1.

The decreaser species of the VH level (17.65%) of GP in the SSG communities had higher percentage ($P<0.05$) compared to that of the VL (2.47%) and L (6.92%) levels in the SSG and the H (7.43%), VH (6.28%) and VL (5.74%) levels in the MSG (Figure 1). The VL and L of SSG and the VL, H and VH of MSG had same effect on the percentage of decreaser in the studied rangelands. In addition, the H (11.73%) and VH (17.65%) of SSG and the L (17.01%) of MSG had a similar effect on the percentage of decreaser species. The increasers in the VH (10.75%) level of MSG communities and in the VL (12.77%) and H (14.29%) levels of SSG communities of GP had lower values than that in the H (22.84%) level of MSG communities. The other levels of SSG (16.36 and 18.84% for L and VH levels, respectively) and MSG (15.80, 18.05 and 22.84% for VL, L and H levels, respectively) communities had similar values in terms of the percentage of increaser species. Regarding of the rate of invaders, the VL level (84.77%) of SSG and the VH level (82.98%) of MSG rangelands of GP were higher than the VH (63.51%) of SSG and the L (64.85%) of MSG rangelands ($P<0.05$). The other levels of SSG (84.77, 76.72 and 73.98% for VL, L and H levels, respectively) and MSG (78.46, 69.73 and 82.98% for VL, H and VH levels, respectively) communities had similar values in terms of the percentage of invader species.

The VH level (43.80%) in the MSG treatment increased ($P<0.05$) the rate of shrub species compared to the VL (19.32%), L (15.99%) and H (12.00%) levels in the MSG treatment and the VH level (17.50%) in the SSG treatment. The rate of shrub species in the SSG range decreased ($P<0.05$) at VH level (17.50%) compared to that at VL level (39.92%). However, there was no significant difference among the other GP levels in the SSG and MSG rangelands. The rate of shrub in the SSG range were 32.82 and 25.95% for the L and H levels ($p>0.05$). The rate of herbaceous in the MSG range increased ($P<0.05$) at VL level (59.14%) compared to that at the other GP levels in the SSG (44.85, 43.92, 48.03 and 46.01% for VL, L, H and VH levels, respectively) and in the MSG (49.02, 57.73 and 39.18% for L, H and VH levels, respectively) rangelands. However, there was significant difference between H and VH levels in the MSG range ($P<0.05$). The RCS of the SSG rangeland was higher ($P<0.05$) at VH level (36.49) than that at the other GP levels in the SSG (15.23, 23.28 and 26.03 for VL, L and H levels, respectively) and in the MSG (21.54, 30.27 and 17.03 for VL, H and VH levels, respectively) rangelands (Figure 3). Also, the RCS at L (35.06) and H (30.27) levels of GP in the MSG range was higher ($P<0.05$) than that at VL and VH levels in the MSG and that at VL level in the SSG rangelands.

The results of Experiment I indicate that the SSG and MSG systems had an unstable impact on the BC based on the percentage of decreaser, increaser and invader species and the RCS of rangelands and that the differences in GP of the present study did not create dramatically a selective grazing. In general, the species richness and diversity in the rangelands decreased depending on the GP due to augments in disturbance created by grazing livestock that facilitated establishment of invader species, as reported by Alexander et al. (2016). Also, it has been reported similar findings on rangelands in different regions of Turkey (Ünal et al., 2014; Yavuz et al., 2012; Çınar et al., 2014; Uzun et al., 2015; Seydoşoğlu et al., 2018). These results may be related to the fact that goats habitually spend more time grazing, including rangelands with high shrub species (Benavides et al., 2009; Ferreira et al., 2013; Nampanzira et al., 2015) and/or that the presence of cattle at different numbers can dramatically altered plant species composition (Read et al., 2011; Erkovan et al., 2016). Indeed, goats spent more daily time grazing on shrubland compared to sheep and cattle, which spent most of the time on the improved rangelands (Benavides et al., 2009; Ferreira et al., 2013; Nampanzira et al., 2015). Because animals in goat-mixed herds might spent a greater portion of their grazing time on shrub species compared those in monospecific groups (Benavides et al., 2009; Nampanzira et al., 2015; Uzun et al., 2015), the impact of the GP treatments on the studied parameters may be altered depending on the presence of goats in the MSG system. Goats graze primarily on shrubs compared to sheep which exhibit no particular preferences among grasses and invasive species like shrubs and herbaceous (Benavides et al., 2009; Uzun et al., 2015).

In the present study, there was a beneficial effect of MSG on the percentages of shrubs, because herbaceous species in cattle (95%) and sheep (89%) diets is higher rates than in goat (28%) diets (Benavides et al., 2009). Therefore, the MSG systems can be used as an effective management tool to control undesirable vegetation (Animut et al., 2005; Benavides et al., 2009). As reported herein, Animut et al. (2005) and Benavides et al. (2009) noted that the SSG system can influence negatively the BC, despite it provides benefits (or facilitate) to other GAS. Thus, this may explain why cover of shrubs reduced in the MSG system. Unlike studies carried out at a range of GP with different grazing system (Benavides et al., 2009), in our study, the effects of the GP × GAS interactions on plant species diversity or other aspects of rangeland community structure and dynamics were observed. Hence, the long-term ecological consequences of the various livestock grazing systems implementation were relatively understood. Indeed, these results indicated that changes in the rangeland structure and dynamics due to the GP × GAS interactions may result in changes in rangeland supply and carrying capacity over the longer term. In terms of BC, the results support idea that the presence of sheep and goats in grazing systems could, also, have highly beneficial consequence or that rangelands grazed by mixtures of goats, sheep and cattle can have more invader herbaceous species than rangelands grazed by cattle alone (Benavides et al., 2009; Utsumi et al., 2010; Erkovan et al., 2016). A dramatically decrease in invader species such as *Dryopteris filix-mas* L. and Schott and *Galega officinalis* L. in the MSG rangelands compared to those of the SSG rangelands (data not shown) support ideas that the utilization of heterogeneous plant resources can be enhanced due to the complementary grazing of goats (Benavides et al., 2009). Thus, the presence of goats in MSG may be a more proficient way for productive as well as ecological goals (Benavides et al., 2009) or increase the sustainability of the pastoral system by maintaining more desirable species in rangelands compared to SSG system with cattle or sheep alone (Uzun et al., 2015; Erkovan et al., 2016).

The problem related to invader species in the present study may, therefore, be a result of diminishing in sheep and particularly goat numbers during the past 20-30 years (TUIK, 2017). If GP is too low, competitive plants may dominate. Conversely, at moderate GP, animals can increase plant diversity while heavy GP can selectivity and thus, results in overgrazing of desirable grasses (Tallowin et al., 2005; Batchelor et al., 2015; Erkovan et al., 2016). It is not necessarily always true, as reported herein. The selectivity of grazing animals is usually problematic over the long term because of diminishing the more desirable species and increasing the less desirable ones as increased the GP (Baumont et al., 2005). The results with respect to the effect of GP indicate that moderate and/or high GP has no adverse effect on invader plants and the RCS. This may be ascribed to the helpful impacts (their faeces and urine as well as their role in endozoochorus or exozoochorous seed dispersal) of the grazing animals on the range ecosystem relative to plant diversity and ecological succession (Read et al., 2011; Batchelor et al., 2015; Alexander et al., 2016). As noted in a review (Asmare, 2018), in the present study, the alien species or weeds did not make the rangeland unhealthy; these species appeared because rangelands subjected to different GP with SSG or MSG system for a long time were unhealthy.

3.2.. Experiment II

In Experiment II, a total of 228 species consisting of 39 grasses, 49 legumes and 140 the other families in the SSG rangelands and 128 species consisting of 26 grasses, 28 legumes and 74 the other families in the MSG rangelands were recorded (Table 2). The other families contributed 56.49% and 58.78% in the SSG and MSG rangelands, respectively. The difference between the two rangeland groups in terms of the number of the plant families was found to be significant (t=11.118, P<0.01). There were significant differences among the studied rangelands in terms of the distribution of species based on response to grazing. The cover rate of decreaser, increaser and invader species in the BC were affected by the SSG and MSG systems (t=12.536, P<0.01). The frequencies of decreaser and invader species of SSG were higher than that of MSG, but the frequency of increaser species was lower than that of MSG. Similarly, the SSG and MSG systems influenced the percentages of tree, shrub and herbaceous in the invasive species (t=11.245, P<0.01). Accordingly, in the rangelands of both grazing system, the most common groups among the plant family, species based on response to grazing and invader species were the other families, invaders and herbaceous, respectively. Similarly, grass family, species of decreaser and tree were also the rare groups in the BC of the studied rangelands. These results indicate that MSG decreased both the number of families and species in terms of response to grazing compared to SSG. Also, the influences of grazing systems on species composition differed in communities with tree and shrub in comparison to communities with decreaser and increaser (Table 2), due to differing competitive relationships between species, conditions for regrowth, and patterns of grazing system which differed between communities (Batchelor et al., 2015). The potential for forage competition between cattle and sheep is higher for grasses compared to legumes and other families. This may be resulted from the fact that the diets of cattle and small ruminants contained herbs and grasses as well as trees and shrubs throughout the year (Nampanzira et al., 2015).

The BC of the SSG and MSG rangelands consisted of a mixture of 54 and 36 plant families, respectively, dominated by *Fabaceae, Poaceae, Asteraceae and Rosacea* based on the frequencies of families (Table 3). As reported by Koç and İleri (2016), species composition was different at rangeland vegetation depend on the GAS. In the previous studies in Turkey (Yavuz et al., 2012; Çınar et al., 2014; Ünal et al., 2014; Uzun et al., 2015; İspirli et al., 2016; Seydoşoğlu et al., 2018), it has been noted that the abundance of invasive species in the BC of rangelands is high due to both regional conditions and utilization methods (Seydoşoğlu et al., 2018), which is an indicator of overgrazing. Therefore, the high abundance of both the other families and invader species in the studied rangelands may be

Table 2. The botanical composition of rangelands subjected to single- and multi-species grazing for a long time

Traits	Species in the SSG rangelands		Species in the MSG rangelands		t-value
	Number	Percentage	Number	Percentage	
Plant families					11.118**
Grass	39	19.04	26	21.19	
Legume	49	24.47	28	20.03	
The others	140	56.49	74	58.78	
Response to grazing					12.536**
Decreaser	27	9.09	16	8.00	
Increaser	14	14.02	12	17.85	
Invader	187	76.89	100	74.15	
Invaders					11.245**
Tree	10	4.80	4	2.32	
Shrub	20	27.77	12	24.10	
Herbaceous	157	44.32	84	47.73	

**P<0.01.

Table 3. Dominant plant families, range condition, health class and carrying capacity of the rangelands subjected to single- and multi-species grazing for a long time

	The rangelands grazed by single-species	The rangelands grazed by multi-species
Dominant families (%)[1]		
Fabaceae	21.5	21.9
Poaceae	17.1	20.3
Astraceae	14.9	12.5
Rosaceae	6.1	6.3
Range condition		
Score	23.11	25.85
Class	Poor	Fair
Health class	Healthy	Healthy
Carrying capacity (LUM ha^{-1})[2]		
Current	2.34	3.90
Desired	0.20	0.40

[1]More than 5% of the number of families (54 for single-species grazing and 36 for multi-species grazing).
[2]LUM: livestock unit month.

related to the GP as well as the GAS, as reported in the previously studies (Batchelor et al., 2015; Uzun et al., 2016). Under overgrazing conditions, these plants benefit over desired range plant species (Kemp et al., 2010; Ouédraogo-Koné et al., 2006). Indeed, it has been found (Kemp et al., 2010) that body weight gain in lambs grazed on chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) based pastures is 70% greater than those on perennial ryegrass (*Lolium perenne*).According to our findings, the significant variations observed in the botanical composition in terms of decreases in perennial species regarded as highly desirable or decreaser species may be due to increased pressures from livestock grazing. In spite of a distinct BC may be generated depending on utilization of less palatable plants by goats (Utsumi et al., 2010), the MSG system in the present study did not create similar floristic composition and species diversity. The difference in the BC generated by goat browsing is likely attributed to the initial consumption of the weed, woody and shrub plants (Allred et al., 2012).

As reported in Experiment I, results of Experiment II indicate that cattle, sheep and goats preferred grass to other species, forbs to grass and shrubs and then broad-leaved weeds to other species, respectively. Indeed, invasive plant families such as *Amaranthaceae, Berberidaceae, Caryophyllaceae, Cornaceae, Crassulaceae, Ericaceae, Gentianaceae, Globulariaceae, Iridaceae, Juncaceae, Juglandaceae, Lamiaceae, Malvaceae, Pinaceae, Plumbaginaceae, Polygalaceae, Rubiaceae, Rosaceae, Scrophulariaceae* and *Solanaceae* were not found in the MSG rangelands (data not shown). This situation may be related to the fruits, leaves and young stems of these families are consumed by goats during the growing season of plants (Nampanzira et al., 2015; Uzun et al., 2015).

The RCS and carrying capacity for the SSG and MSG rangelands were classified as poor and fair, and calculated as 2.34 and 3.90 LUM ha^{-1}, respectively (Table 3). Rangeland health class was healthy for both rangeland communities, as a consequence of the high canopy coverage (Koç and İleri, 2016). Cheng et al. (2011) reported that RCS, health class and species diversity in a rangeland were strongly associated with rainfall availability and that precipitation would be more important than GP on the BC changes in rangelands with high rainfall variability. The frequency of forbs and annual species affecting the canopy coverage of rangelands are strictly a function of rainfall (Ahmed et al., 2017). The present study conducted in a region with 1233 mm of mean annual precipitation during the experimental years.

The MSG system used in the present study may be touted to maximize both livestock and rangeland production (Animut et al., 2005; Benavides et al., 2009) because of better managed invasive or undesirable species compared to the SSG system (Erkovan et al., 2016). This situation may be related to that the MSG system allow recover of the desirable species by spreading the GP more equitably among plant species in the studied rangelands (Uzun et al., 2015). Erkovan et al. (2016) stated that uncontrolled grazing with sheep gives more damage to vegetation and related resources than uncontrolled grazing with cattle in rangelands where short grasses are dominated. The rangeland condition class is crucial for sustainable forage production. The lower rangeland condition class (poor for SSG and fair for MSG) of rangelands in the present study may be related to the high animal density of these areas, since there is a relationship between the rangeland condition class and animal density (Koç et al., 2003; Koc and Kadioglu, 2012).

Erkovan et al. (2016) found that unlike our results the rangelands grazed with cattle had excellent rangeland condition class, whereas the rangelands grazed as mixture with sheep and cattle herds had poor rangeland condition class. This difference between two studies can be related to the structural difference between the studied rangelands (semi-mountainous and lowland rangelands vs. highland or upland rangelands) and the GAS (goat, sheep and cattle herds vs. sheep and cattle herds) in MSG system. The rangeland condition and canopy data in the present study indicate that the SSG and MSG rangelands were overgrazed, as reported by Koç and İleri (2016). As noted by Animut et al. (2005) and in Experiment I, overgrazing suppresses the desirable pasture species, which can allow undesirable species like shrub and weeds to establish while high stocking rates limits forage selectivity and forces the animals to consume all species present. This argument may be explained why the number of species reduced and the rangeland condition class improved in the MSG rangelands compared to the SSG. Therefore, it can be said that utilizations of the MSG system and the GP possible without exceeding the carrying capacity could be valuable in more effectively renovating the rangelands (Animut et al., 2005; Uzun et al., 2015).

Most dominant species of *Poaceae* in the studied communities are almost highly palatable and nutritious forages for animals during the spring season (Hussain and Durrani, 2009; Aydın and Ocak, 2018). Moreover, annual reseeding clovers provide an abundance of nutritious fresh forage during the spring season and good dry forage during the summer and fall seasons (Aydın et al., 2015; Aydın and Ocak, 2018). Therefore, the annual grasses and legumes in public grazing rangelands are not only important in nutritional contribution but also in diminishing the negative implications of GP on desirable perennial species (Hussain and Durrani, 2009). However, to maintain their ecological success, these species disappear from rangeland vegetation after late spring and during early summer season, due to the proverbial characteristics of life cycle (rapid growth in early spring and then clovers bloom, set seed and die after late spring). Therefore, disappearance of these grasses and legume species during sampling of the floristic composition may explain why the studied rangeland has such RCS and rangeland condition class as well as health class. On the other hand, annual invader legume and grass species associated with GP is an indicator of the rangeland degradation (Gemedo-Dalle et al., 2006; Haftay et al., 2013). In the present study, a total of 20 (80.0%) and 13 (84.6%) invader type grass species were identified for SSG and MSG rangelands, respectively. Our studies indicated that there was a complexity of the relationships between the floristic composition of rangelands and climatic conditions or certain factors inherent to the animal nature, such as the species in question, nutrient requirements and feed selectivity in addition to management practices (Hussein and Durrani, 2009).

4. Conclusion

The results of the present study indicated that increasing GP may prevent animals from grazing selectively and that MSG system in which goat included can be contributed to the control of undesirable plants species. In addition, the studied rangelands can be classified as healthy due to enough plant density although their healthy class, RCS and carrying capacity were undesirable. It can be recommended that to maintain or improve the rangelands, carrying capacity should be allowed at most 0.20 to 0.40 LUM per ha for both grazing systems. Furthermore, goats may be used as an operative management tool to maintain and improve heavily encroached-rangelands, because goats were shown to control *Rubus, Rosa, Genista, Prunus, Crataegus species* and many other troublesome plants in the present study. As a result, the complementary grazing of goats in the mixed stocking can enhance the utilization of heterogeneous plant resources, providing a more efficient way for both productive and environmental goals than single cattle. Therefore, future research is warranted in a more controlled setting to determine the benefits of multi-species grazing, is needed to determine optimum stocking densities and to detect thresholds at which goats successfully regulate. The effect of selective or non-selective grazing in the present study was difficult to ascertain, because the floristic composition in each rangeland group included the other families or invasive species. Also, to explain the relationships between the floristic composition of rangelands and climatic conditions or certain factors inherent to the animal nature (nutrient requirements and feed selectivity) besides rangeland management practices further studies should be conducted.

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