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Floristic Patterns and Qualities of Forage Species from Mountainous Rangeland in the Middle Black Sea Region of Turkey

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ABSTRACT

This study was carried out to investigate the floristic features (family, preference by grazers, growth form and response to grazing) and qualities of forage species collected from mountainous rangeland (Akdağ Mountain, Ladik) in the middle Black Sea region of Turkey. Forage samples were collected five times by 15-day intervals from the before-flowering stage to the after-flowering stage in 2015 and 2016. The total number of species was 105 species belonging to 73 genera and related to 26 families. Of the total species, 20 were from Poaceae (19.0%), 30 were from Poaceae (28.6%). Rests of the species belonged to other families (52.4%) dominated by families such as Asteraceae (13/55) and Lamiaceae (6/55), of which 26 species were weeds harmful to animals. While the percentages of decreaser, increaser and invader species were 16.2, 12.4 and 71.4, those of annual, biennial and perennial species were 31.9, 2.9 and 65.2, respectively. The number of species preferred by grazing was 74 (70.5%), while the number of non-preferable species was 31 (29.5%). The ME (MJ kg^{-1}), RFQ and quality category of legumes, grass, and other botanical families were found as 8.88±0.07, 130.9±3.05 and very good, 8.00±0.07, 83.2±1.62 and good, and 8.98±0.07, 141.0±3.62 and premium, respectively. These results can be used as a management tool to improve rangeland quality and sustainability. The evidence from this study is that floristic pattern is not merely a result of invader forage species, but also might be a beneficial result that deserves further study for mountainous rangelands.

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Introduction

Forage species, integral components of rangeland and pasture agro-ecosystem, are plants grown for feeding domestic ruminants (cattle, goat, and sheep) either as grazing pastures and rangelands or as conserved hay, haylage or silage. These crops provide important nutrients to these animals depending on the desired season (dry or wet) of use, the longevity of species, end-use, quality, yield potential (Capstaff and Miller, 2018). Therefore, in grazing-based systems forage availability (quality and quantity) is one of the most important concepts. Rangeland forage species are usually grasses (Poaceae) that increased yield and stability of rangeland, herbaceous legumes (Poaceae) increased both productivity and nutritional value and/or other botanical families be contributed to yield and quality of rangelands (Carlier et al., 2009; Capstaff and Miller, 2018). Although rangeland forage quantity and quality affect the performance of grazing ruminants (Ocak et al., 2006; Uzun and Ocak, 2019), the grazing of rangeland by ruminants provides the cheapest feed source available for these animals (Algan et al., 2018; Uzun and Ocak, 2019). Therefore, grazing-based systems rangelands play a central role in the economic and social life of the nation and are a cornerstone of the economy (Mengistu et al., 2017; Algan et al., 2018).

Recently, Aydin et al. (2019) showed that although the nutritive values of rangeland species during growth stages were different, and forage qualities of species related to Poaceae and other botanical families were higher than those of the family Poaceae. There is a unique function of invasive species such as increasing productivity in overgrazed rangeland compared to native species, depending on grazing intensity and topography such as aspect and elevation (Eviner et al., 2012; Allen et al., 2017; Uzun et al., 2018). As such, in livestock production systems based on the exploitation of rangelands, farmers should be aware of floristic features (FF) of the most basic rangeland forages. Indeed, floristic surveys are important in the assessment process of threatened, declining and/or susceptible forage species in rangelands and identification of the presence of characteristic plant communities

(Abdelaal et al., 2019). Farmers then make choices on which of the forage species are best suited based on quality and animal acceptance criteria (Sayar et al., 2015; Rouquette, 2016). The FF of rangeland forages are sorted as family of forage (Poaceae, Poaceae and other botanical families), preference by grazers (preferred and non-preferred), growth form (annual and perennial) and response (decreasers, increasers and invaders) to grazing (Khojasteh et al., 2013; Uzun and Ocak, 2018). Forages with similar FF have a competitive interaction while species with different FF show a facilitative interaction (Khojasteh et al., 2013; Erkovan et al., 2016).

Existence and type of species belonging to Poaceae, Poaceae and other botanical families, that is, floristic composition in the rangelands are the main determinants in shaping the grazing plan to be applied to the rangelands (Erkovan et al., 2016; Abdelaal et al., 2019). Moreover, assessment of the floristic composition and quality score (QS) based on relative forage quality (RFQ) of rangeland is required to assist farmers with grazing planning and management, benchmarking between seasons and years (Aydin et al., 2019; Uzun and Ocak, 2019). Identification and classification of forage plants are critical components of rangeland management, that is, to maintaining healthy and high-quality of rangelands that provide healthy and nutritious forage for grazing livestock (Abdelaal et al., 2019; Casler and Undersander, 2019).

Forages that stimulated the sensory impulses of grazing animals are preferred and subsequently consumed voluntarily by animals as a feed (Raufirad et al., 2016). Thus, rangeland species preference affects many aspects of sustainable rangeland management, including grazing capacity and grazing behavior. Species diversity refers to variations that exist between the different forms of life (Thakur et al., 2016). Diversity and FF of rangeland species is one of the most important indicators used for assessing the condition of plant communities and are essential for its management and conservation of biodiversity (Thakur et al., 2016). The ultimate purpose of knowing the FF of forage species is to develop rangelands with high and sustainable herbage yield and quality under various management systems (Rauf et al., 2016; Casler and Undersander, 2019). These aims, also, include forages with beneficial impacts on ecosystem functions, animal growth, and health. The most productive rangelands of Turkey are located in high mountains of the Black Sea region due to favorable climate (FAO, 2018). However, there is not enough information on the diversity and FF of species of this area. Therefore, the objective of the present study was to investigate the FF of forage species with respect to their family, preference by grazers, growth form and response to grazing, including a list of forage species in mountainous rangeland (Akdağ Mountain and around). Besides, QS based on the FF of forage species is presented.

Material and Methods

This study conducted at mountainous rangeland (Akdağ Mountain, Ladik) in Samsun province located in the middle Black Sea region of Turkey (40°50′ to 41°51′ N and 37°08′ to 34°25′ E at nearly 1200 m above sea level) is second part of a research carried out by Aydın et al. (2018). As previously reported, in the study area (Figure 1), summers are warm and humid, whereas winters are cool and damp with a mean annual temperature of 10.2°C ranging from 3.1°C in winter to 16.7°C in summer and with a mean annual rainfall of 583.6 mm during the study period (Aydin et al., 2019).

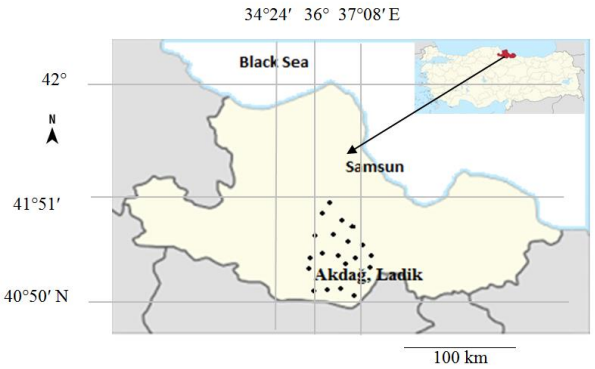

Figure 1. The geographical location (▪) of the study area (Akdağ Mountain and its surroundings)

Table 1 The quality scores (QS) and category (QC) based on relative forage quality (RFQ) ranges of the Poaceae and Poaceae species (Aydin et al., 2019)

QS	QC	RFQ
P	Premium (P)	> 138
1	Very good (V)	125-137
2	Good (G)	115-124
3	Average (A)	99-114
4	Fair (F)	93-98
5	Low/Utility (U)	< 93

The rangeland communities around the Akdağ Mountain have low primary productivity due to its rugged topographic feature and subjected to constant grazing pressure by local farm animals, especially sheep. As such, the different regions of the study area were visited as regular in 2015 and 2016 years and a number of communities, representative of the common plant communities in these rangelands, were selected for sampling forage species in the various habitat types recognized in the study area (Mashaly et al., 2015). After four communities of the experimental rangeland were selected, forage samples were collected in homogeneous units at five different times by 15-day intervals from the before-flowering stage to the after-flowering stage (Aydin et al., 2019). Accordingly, the forage species at various growth stages were collected from each community, identified and recorded. After these species were, each species was sorted according to its belonging family (legume, grass, and other botanical families), preference by grazers (preferred and non-preferred), growth form (annual and perennial) and response to overgrazing (decreasers, increasers, and invaders).

The data related to the metabolizable energy (ME) and RFQ of forage species recorded in this study were obtained from the final report of our research project (Aydın et al., 2018). However, these data are presented on the basis of the FF studied. To present QS of forage species based on the FF were utilized the forage quality categories based on RFQ ranges of Poaceae and Poaceae species (Aydin et al., 2019, Table 1).

Results

In total, 105 forage species belonging to 73 genera recorded in the study were related to 26 taxonomic families. Of the total recorded forage species, 78, 22 and 5 were common to four, three and two communities, respectively. The lowest families were Poaceae (20 species, Table 2), followed by Poaceae (30 species, Table 3), other botanical families (55 species, Table 4). Other botanical families, related to 24 taxonomic families, were dominated by Asteraceae (13 species), Lamiaceae (6 species), Boraginaceae (4 species), Liliaceae (4 species) and Scrophulariaceae (4 species). Other members of other botanical families had 1 to 3 species (Table 3).

Table 2. The growth form (GF), preference by grazing animals (PGA) and response to grazing (RG) of species related to the family Poaceae

Species	GF	PGA	RG
Aegilops sp.	Annual	Preferable	Invader
Agropyron desertorum (Fisch. ex Link)	Perennial	Preferable	Decreaser
Alopecurus myosuroides Huds.	Annual	Preferable	Invader
Avena fatua L.	Annual	Preferable	Invader
Brachypodium sylvaticum (Huds.) Beauv	Perennial	Non-preferable	Increaser
Bromus squarrosus L.	Annual	Preferable	Invader
Bromus tomentellus Boiss.	Perennial	Non-preferable	Increaser
Cynodon dactylon (L.) Pers	Perennial	Preferable	Increaser
Cynosurus cristatus L.	Perennial	Preferable	Increaser
Dactylis glomerata L.	Perennial	Preferable	Decreaser
Festuca arundinacea Schreb.	Perennial	Preferable	Decreaser
Festuca ovina L.	Perennial	Preferable	Increaser
Hordeum bulbosum L.	Perennial	Preferable	Increaser
Hordeum murinum L.	Annual	Preferable	Invader
Lolium perenne L.	Perennial	Preferable	Decreaser
Poa angustifolia L.	Perennial	Preferable	Decreaser
Poa bulbosa L.	Perennial	Preferable	Increaser
Poa pratensis L.	Perennial	Preferable	Decreaser
Poa trivialis L.	Perennial	Preferable	Increaser
Vulpia ciliata Dumort	Annual	Preferable	Invader

Table 3. The growth form (GF), preference by grazing animals (PGA) and response to grazing (RG) of species related to the family Poaceae

Species	GF	PGA	RG
Argyrolobium biebersteinii Ball	Perennial	Non-preferable	Invader
Astragalus sp.	Perennial	Non-preferable	Invader
Bituminaria bituminosa (L.) C.H. Stirt.	Perennial	Preferable	Invader
Chamaecytisus pygmaeus (Willd.) Rothm	Perennial	Preferable	Increaser
Coronilla scorpioides (L.) K.Koch.	Annual	Preferable	Invader
Coronilla varia L. subsp. *varia* L.	Perennial	Preferable	Increaser
Dorycnium graecum (L.) Ser	Perennial	Non-preferable	Increaser
Lathyrus annus L.	Annual	Preferable	Invader
Lathyrus aphaca L. var. *affinis* L.	Annual	Preferable	Invader
Lathyrus ochrus (L.) DC.	Annual	Preferable	Invader
Lotus angustissimus L.	Annual	Preferable	Invader
Lotus corniculatus L.	Perennial	Preferable	Decreaser
Lotus ornithopodioides L.	Annual	Preferable	Invader
Medicago falcata L.	Perennial	Preferable	Decreaser
Medicago lupulina L.	Perennial	Preferable	Invader
Medicago polymorpha L.	Annual	Preferable	Invader
Medicago sativa L.	Perennial	Preferable	Decreaser
Melilotus officinalis (L.) Pall	Biennial	Preferable	Invader
Onobrychis armena Boiss&Huet	Perennial	Preferable	Decreaser
Trifolium alpestre L.	Perennial	Preferable	Decreaser
Trifolium arvense L.	Annual	Preferable	Invader
Trifolium dubium Sibth.	Annual	Preferable	Invader
Trifolium fragiferum L.	Perennial	Preferable	Decreaser
Trifolium hybridum L.	Perennial	Preferable	Decreaser
Trifolium pratense L.	Perennial	Preferable	Decreaser
Trifolium repens L.	Perennial	Preferable	Decreaser
Trifolium resupinatum L.	Annual	Preferable	Invader
Trifolium meneghinianum Clem.	Annual	Preferable	Invader
Vicia cracca L.	Perennial	Preferable	Decreaser
Vicia sativa L.	Annual	Preferable	Invader

Table 4. The Family, growth form (GF), preference by grazing animals (PGA) and response to grazing (RG) of species related to other botanical families

Species	Family	GF	PGA	RG
Ajuga chamaepitys (L.) Schreber	Lamiaceae	Annual	Preferable	Invader
Ajuga orientalis L.	Lamiaceae	Perennial	Non-preferable	Invader
Anacamptis pyramidalis L.	Orchidaceae	Perennial	Non-preferable	Invader
Anchusa azurea Miller	Boraginaceae	Annual	Non-preferable	Invader
Anthemis sp.	Asteraceae	Perennial	Non-preferable	Invader
Anthemis tinctoria L.	Asteraceae	Perennial	Non-preferable	Invader
Bellis perennis L.	Asteraceae	Perennial	Preferable	Invader
Capsella bursa-pastoris (L.) Medik.	Brassicaceae	Biennial	Preferable	Invader
Carex acuta L.	Cyperaceae	Perennial	Non-preferable	Increaser
Carex panicea L.	Cyperaceae	Perennial	Non-preferable	Invader
Centaurea iberica Trevir. & Sprengel	Asteraceae	Annual	Preferable	Invader
Cerinthe minor L.	Boraginaceae	Perennial	Preferable	Invader
Cichorium intybus L.	Asteraceae	Perennial	Preferable	Invader
Convolvulus cantabrica L.	Convolvulaceae	Perennial	Preferable	Invader
Crepis foetida L.	Asteraceae	Annual	Preferable	Invader
Crepis sp.	Asteraceae	Annual	Preferable	Invader
Crepis vesicaria L.	Asteraceae	Annual	Preferable	Invader
Crupina crupinastrum (Moris) Vis.	Asteraceae	Annual	Non-preferable	Invader
Doranicum orientale Hoffm.	Asteraceae	Perennial	Non-preferable	Invader
Echium plantagineum L.	Boraginaceae	Perennial	Non-preferable	Invader
Echium vulgare L.	Boraginaceae	Biennial	Non-preferable	Invader
Fumaria officinalis L.	Fumariaceae	Annual	Preferable	Invader
Galium rotundifolium L.	Rubiaceae	Perennial	Non-preferable	Invader
Geranium sp.	Geraniaceae	Perennial	Preferable	Invader
Globularia trichosantha Fisch	Globulariaceae	Perennial	Preferable	Invader
Hypericum perforatum L.	Hypericaceae	Perennial	Non-preferable	Invader
Juncus sp.	Juncaceae	Perennial	Non-preferable	Invader
Lamium purpureum L.	Lamiaceae	Annual	Preferable	Invader
Linum flavum L. subsp. *flavum* L.	Linaceae	Perennial	Preferable	Invader
Melampyrum arvense L.	Scrophulariaceae	Annual	Non-preferable	Invader
Melissa officinalis L.	Lamiaceae	Perennial	Preferable	Invader
Muscari neglectum Guss. ex Ten.	Liliaceae	Perennial	Non-preferable	Invader
Ophrys apifera Huds.	Orchidaceae	Perennial	Non-preferable	Invader
Ornithogalum armeniacum Baker	Liliaceae	Perennial	Non-preferable	Invader
Ornithogalum narbonense L.	Liliaceae	Perennial	Non-preferable	Invader
Ornithogalum wiedemannii Boiss	Liliaceae	Perennial	Non-preferable	Invader
Parentucellia latifolia (L.) Caruel	Scrophulariaceae	Annual	Non-preferable	Invader
Pilosella hoppeana (Schultes)	Asteraceae	Perennial	Non-preferable	Invader
Species	Family	GF	PGA	RG
Plantago lanceolata L.	Plantaginaceae	Perennial	Preferable	Increaser
Polygala supina Schreb.	Polygalaceae	Perennial	Preferable	Invader
Primula elatior L. Hill.	Primulaceae	Perennial	Non-preferable	Invader
Ranunculus sp.	Ranunculaceae	Perennial	Non-preferable	Invader
Raphanus raphanistrum L.	Brassicaceae	Annual	Preferable	Invader
Rhinanthus angustifolius C.C.Gmel.	Orobanchaceae	Annual	Non-preferable	Invader
Rumex acetosella L.	Polygonaceae	Perennial	Preferable	Invader
Sanguisorba minor Scop.	Rosaceae	Perennial	Preferable	Decreaser
Sinapis arvensis L.	Brassicaceae	Annual	Preferable	Invader
Stachys germenica L	Lamiaceae	Perennial	Non-preferable	Invader
Stellaria holostea L.	Caryophyllaceae	Perennial	Preferable	Invader
Stellaria media (L.) Vill.	Caryophyllaceae	Annual	Preferable	Invader
Taraxacum officinale L.	Asteraceae	Perennial	Preferable	Invader
Thymus praecox Opiz	Lamiaceae	Perennial	Preferable	Invader
Tragopogon reticulatus Boiss	Asteraceae	Perennial	Preferable	Invader
Veronica multifida L.	Scrophulariaceae	Perennial	Preferable	Invader
Veronica orientalis Miller	Scrophulariaceae	Perennial	Preferable	Invader

Table 5. Preference pattern (preferable and non-preferable), metabolizable energy (ME, MJ kg-1), relative forage quality (RFQ) and quality scores (QS) based on family and growth form (GF) of the forage species (Mean±SE)

Family	GF	Preferable			Non-preferable		
		ME	RFQ	QS[1]	ME	RFQ	QS
Poaceae	Perennial	8.73±0.10	125.1±3.59	1 (V)	8.57±0.16	111.7±7.05	3 (A)
	Annual	9.14±0.12	143.3±5.97	P	-	-	
	Biennial	9.23±0.13	138.9±7.43	P	-	-	
Poaceae	Perennial	8.07±0.08	91.2±1.61	5 (U)	7.93±0.16	71.8±2.40	5 (U)
	Annual	7.90±0.13	72.7±2.33	5 (U)	-	-	
	Biennial		-		-	-	
OBF	Perennial	9.08±0.11	146.0±5.49	P	9.10±0.10	143.7±6.24	P
	Annual	8.52±0.26	125.5±11.16	1 (V)	8.67±0.27	127.3±10.13	1 (V)
	Biennial	9.47±0.01	161.4±0.13	P	9.00±0.34	137.4±17.96	1 (V)

P: Premium, V: Very good, A: Average, U: Utility, OBF: other botanical families, [1]The forage quality categories based on RFQ ranges of Poaceae and Poaceae species (Aydin et al., 2019)

Table 6. Preference pattern (preferable and non-preferable), metabolizable energy (ME, MJ kg-1), relative forage quality (RFQ) and quality scores (QS) based on family and response to grazing (RG) of the forage species (Mean±SE)

Family	RG	Preferable			Non-preferable		
		ME	RFQ	QS[1]	ME	RFQ	QS
Poaceae	Decreaser	8.67±0.12	124.1±4.18	2 (G)	-	-	
	Increaser	8.71±0.24	121.6±9.51	2 (G)	8.80±0.21	132.1±8.34	1 (V)
	Invader	9.15±0.10	141.7±4.91	P	8.42±0.22	98.1±5.37	4 (F)
Poaceae	Decreaser	8.04±0.09	91.3±1.90	5 (U)	-	-	
	Increaser	8.11±0.16	90.9±2.81	5 (U)	7.93±0.28	71.8±2.40	5 (U)
	Invader	7.90±0.13	72.7±2.33	5 (U)	-	-	
OBF	Decreaser	9.58±0.59	161.7±24.99	P	-	-	
	Increaser	9.15±0.50	145.0±22.90	1 (V)	8.85±0.19	91.1±3.18	5 (U)
	Invader	8.90±0.11	139.8±5.23	P	9.04±0.10	143.6±5.45	P

P: Premium, V: Very good, F: Fair, U: Utility, OBF: other botanical families, [1]The forage quality categories based on RFQ ranges of Poaceae and Poaceae species (Aydin et al., 2019)

The identified forages species included 69 perennials, 33 annuals and 3 biennials, which they were 65.7%, 31.4% and 2.9% of the total number of species, respectively. The percentages of Poaceae, Poaceae and other botanical families within total perennial species were 24.6% (17/69), 20.3% (14/69) and 55.1% (38/69), respectively, whereas corresponding values within total annual species were 36.4%, 18.1%, and 45.5%, respectively. One of the biennial species was legume (33.3%) while the other two (66.7%) belonged to the other botanical families.

The results on the preference of grazing animals indicated that 70.5% and 29.5% of the total number of species was preferable (74 species) and non-preferable (31 species), respectively. The counts of preferable species within the total number of Poaceae, Poaceae and other botanical families were 27 (36.5%), 18 (24.3%) and 29 (39.2%), respectively. The corresponding values for non-preferable species were 3 (9.7%) 2 (6.5%) and 26 (83.9%), respectively. The perennial, annual and biennial species attained higher contribution to preferable (44/69, 28/33 and 2/3) than non-preferable (25/69, 5/33 and 1/3) species.

The identified forages species included 17 decreasers, 13 increasers, 75 invaders. These results indicated that the invader species attained higher contribution (71.4% of the total number of recorded species) than increaser (12.4%) and decreaser (16.2%) species. The forage species belonging to Poaceae included 13 decreaser (33.3%), 3 increaser (10.0%) and 17 invader (56.7%) species, whereas corresponding values belonging to Poaceae included 6 (30.0%), 8 (40.0%) and 6 (30%), respectively. Other botanical families were 65.7%, 31.4% and 2.9% of the total number of species, respectively. Both entire annual and biennial species were invader species, whereas perennial species composed of decreaser (18/69), increaser (12/69) and invader (39/69) species.

The ME (MJ kg^{-1}) and RFQ of legumes, grass, and other families were 8.88±0.07 and 130.9±3.05, 8.00±0.07 and 83.2±1.62, and 8.98±0.07 and 141.0±3.62, respectively. The ME (MJ kg^{-1}) and RFQ of perennial species belonging to legumes, grass, and other botanical families were found as 8.73 and 125.1, 8.07 and 91.2, and 9.08 and 146.0 (Table 5). The corresponding values for decreaser species of these families were 8.67 and 124.1, 8.04 and 91.3, and 9.58 and 161.7, respectively (Table 6). The QS or quality categorizes of legume and other botanical families of species had higher than those of grass species.

Discussion

There has been increased awareness in determining the plant species distribution as well as variation in vegetation composition in rangelands (Uzun and Ocak, 2019). Although floras, lists of plant species, usually give little information on the botanical composition of rangelands, the present study focused specifically on the forage species distribution as well as variation in floristic composition in mountainous rangeland. According to the results of investigated FF, other botanical families, perennials and invasive species were found in a higher number in the

present rangeland. The dominant of desirable forage families can enhance the production, and simultaneously help to eliminate the dominance of exotic species to increase the productivity of animal feed supply in the studied area (Yulianto et al., 2016). Therefore, the present results suggested that the floristic patterns and qualities of forage species from the studied rangeland can set for management to community structure, taxonomy and functional across plant species.

The identified forage species in the present study coincide with numerous previous studies in various regions of Turkey (Çınar et al., 2014; Sayar et al., 2015; Uzun et al., 2016; Uzun and Ocak, 2018, 2019). However, in different rangelands of the region where the research was conducted, the rates of legumes and other botanical families have found to be higher than the rate of grass (Uzun and Ocak, 2018, 2019). This may be due to the difference in the number of species belonging to each family, as in the present study. To explain the differences between studies is difficult due to the different aims and methods used in livestock grazing managements, grazing time, grazing intensity as well as regional difference (Sayar et al., 2015; Bremm et al., 2016; Uzun and Ocak, 2019).

In the present study, the majority of encountered legumes in the studied rangeland were perennial and annual plant species at about equal ration. In agreement with our results, Tessema et al. (2010) and Sayar et al. (2015) reported that most of the identified herbaceous legumes in rangelands are species of *Trifolium* genome. However, species of *Medicago*, *Lotus* and *Lathyrus* genus those highly palatable to domestic ruminants were dominant in the rangeland studied in the present study. Species belonging to *Trifolium* and *Medicago* genera are highly palatable (Tessema et al., 2010; Khojasteh et al., 2013; Sayar et al., 2015). Unlike the legumes, the majority of grass species encountered in the rangeland of our study were perennial. The floristic composition in rangelands depends on the rage management (fertilization, cutting regime, overseeding), season (white clover develops best in summer, while grass species grow better in springtime), interaction between forage species (competitive or facilitative interaction) and internal and external pressures (Carlier et al., 2009; Khojasteh et al., 2013; Algan et al., 2019). In general, the rangelands are dominated mainly by forage species belonging to the Poaceae and, typically, characterized by low productivity (Knežević et al., 2012; Algan et al., 2019). Carlier et al. (2009) reported that the important grass species in Europe rangelands are *Lolium perenne*, *Lolium multiflorum*, *Festuca arundinacea*, *Festuca pratensis*, *Dactylis glomerata*, *Phleum pratense*, *Poa trivialis*, *Poa pratensis* and *Agrostis* spp., as observed in the present study. While these are perceived as the species of high preference and palatability, the remaining grass species were considered as moderately valuable/palatable species (Khojasteh et al., 2013).

The high number of invader species may risk for rangelands, forage quantity and quality and livestock production, quality and health (Allen et al., 2017; Casler and Undersander, 2019; Uzun and Ocak, 2019). In general, the species richness and diversity in the rangelands decrease depending on the grazing pressure and human activities (Erkovan et al., 2016; Abdelaal et al., 2019; Uzun and Ocak, 2019). The establishment of invader species is facilitated by the augments in disturbance created by grazing livestock (Eviner et al., 2012; Erkovan et al., 2016; Uzun and Ocak, 2019). The result of invader species in the studied rangeland may be related to the fact that overgrazing can increase invasive plant establishment and proliferation. Moreover, the effects of invader species on soil N and P dynamics (Eviner et al., 2012) can greatly alter plant species composition, particularly suppressing desirable native species (Allen et al., 2017). These may explain why the invasive species were relatively high and 5 species were not exclusive for the studied rangeland habitat. If the changes in floristic composition are in favor of low-quality plants that may contain anti-nutritional compounds that may be toxic to grazing livestock (Casler and Undersander, 2019), this invasion (noxious invasive) can be very critical. Our results on the species recorded in the surveyed communities agree with previous findings on the rangelands of Turkey (Çınar et al., 2014; Sayar et al., 2015; Uzun et al., 2016; Uzun and Ocak, 2019).

These observations imply that the preference by grazers is an important factor shaping the intensity of the relationship between plant species (Rouquette, 2016). Indeed, the three preferred species were physically protected from grazing by spatial association with non-preferred plants (Khojasteh et al., 2013, Uzun and Ocak, 2018). Although the studied rangeland species differed in quality, the presence of the other botanical families that are important genetic forage resources may also affect the association between species (Khojasteh et al., 2013). Although there are the detrimental effects of invasive plants in rangelands and other plant communities, these species provide benefits to the rangeland-based livestock system (Hussain and Durrani, 2009; DiTomaso et al., 2017). Uzun and Ocak (2019) noted that annual reseeding clovers provide an abundance of fresh forage with high nutritive value during the spring season and good dry forage during the summer and fall seasons. Therefore, as reported in the previous studies (Hussain and Durrani, 2009; Uzun and Ocak, 2019), all preferable annual species in the studied rangeland are not only important in nutritional contribution but also in diminishing the negative implications of grazing animals on desirable perennial species. Pokorny et al. (2005) reported that an increase in native species richness, including legume species can enhance resistance to invasive plants. The utility of livestock should be expanded to reduce invasive annual grasses and invasive weeds and the improvement of the distribution of livestock grazing across the landscape (DiTomaso et al., 2017).

Forage quality indices such as ME and RFQ varied between both the growth form and response of grazing of the studied families. It has been reported that the forage quality of the legume and the other botanical families were better than that of the grass species (Arzani et al., 2010; Amiri and Shariff, 2012), as reported herein. Moreover, the results of previous studies (Arzani et al., 2010; Amiri and Shariff, 2012; Aydin et al., 2019) and the present study indicate that forage species related to the family Poaceae are typically characterized by low quality due to a shortage of water and nutrients (Arzani et al., 2010; Knežević et al., 2012). The fact that grass species had a lower ME and RFQ compared to the species from legume and the other families could be associated with their cell wall and contents,

because forage species with high fiber and hemicelluloses contents had a relatively low forage values (Arzani et al., 2010; Njidda et al., 2013; Ukanwoko and Ironkwe, 2013). The results on ME and RFQ of grasses were similar to previously reported results on different growth forms of forage species in various environments (Arzani et al., 2006, 2010; Amiri and Shariff, 2012). The lower forage quality of grass species may be attributed to the different leaf forms and structure, and the fiber content of forage plants (Arzani et al., 2010; Amiri and Shariff, 2012; Algan et al., 2019).

The ME and RFQ of forages should be mainly considered among quality features for the evaluation of rangeland species because the variations between the forage species from rangeland resulted from quality indicators (Aydin et al., 2019). Although some forage species recorded in our study were found to be highly nutritious, these species were proved to be worthless as animal forage because of non-preferable. This may result in a selectivity of grazing animals, which is a problematic case due to diminishing the more desirable species and increasing the less desirable ones (Hussain and Durrani, 2009; Khojasteh et al., 2013; Uzun and Ocak, 2019). Consequently, the preferable and the quality indicators such as the ME and RFQ can a major determinant of animal production from rangeland forages. Indeed, Arzani et al. (2006) noted that one of the main objectives of range management is livestock production, which depends on the nutritive value of available forage. As a result, although the forage quality of perennial other botanical families, including weeds, varied among species, they were sometimes equal to or higher to that of leguminous species. Therefore, the other botanical family species recorded in the present study can be grazed by ruminants to improve the nutritional status of animals, as reported by Kemp et al. (2010) and Minneé et al. (2017).

The Akdağ rangelands in the Samsun province in Turkey are dominated by a mixture of patchily distributed grasses, legumes, and other botanical families, with high biodiversity of plants, which severely affects rangeland species palatability. The surveyed rangeland communities are important landscapes in the middle Black Sea region basin in terms of environmental heterogeneity, species diversity, and habitat variability. Also, for predicting of quality of forages from environments like in the present study, the quality score that developed based on relative forage quality may use a better tool. Accordingly, our results on FF of the surveyed rangeland and QS of the studied forages can be considered by managers and farmers to discharge an appropriate conservation plan to preserve and manage the mountain rangelands. The quality of forages varied between the studied FF of forage families from the rangeland communities in Akdağ Mountain. Our forage quality category may be used to achieve sustainable rangeland management. However, due to the diversity of forage species in the study area, the results suggest that the present floristic composition may be enough to provide the daily requirements of grazing animals depending on grazing intensity and grazing animal species. The evidence from the present study is that floristic pattern is not merely a result of invader forage species, but also might be a beneficial result that deserves further study for mountainous rangelands.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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