An assessment of vegetation structure for the rangelands under grazed different seasons in the Eastern Anatolia Region of Turkey

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Abstract

The aim of the study was to determine the effect of different grazing system and environmental variables on plant species distribution in highlands of eastern Anatolia Region of Turkey. Eight range sites, two of which belong to season-long and the others belong to transhumant grazing system, were selected. The vegetation was sampled using the line intercept method. All data were performed Redundancy analysis (RDA) using CANOCO software, version 4.5. Monte Carlo permutation tests were used to determine the significance of environmental variables. Species distribution was located in separate groups depending on grazing season on ordination diagram. Species distribution produced strong correlations with grazing season and bulk density, pH, $CaCO_3$, Ca, P and Na properties of the soil ($p<0.05$). The results indicated that grazing seasons displayed an important role at distribution of species and also soil properties were important at these rangelands. Hence, it will be better if traditional upland-lowland (transhumant) grazing systems improve with respect to grazing time and stocking intensity for sustainable use of semi arid highland rangelands.

Keywords: highland rangelands, ordination analysis, transhumance, species distribution

Introduction

The rangelands have a significant role in animal husbandry in the Eastern Anatolian Region of Turkey. The rangelands in the region have been grazed for centuries, consequently, rangeland vegetations have been progressively shaped in both an ecological and evolutionary sense by this long history of intensive grazing. The different response of range plant community under similar ecological conditions to grazing can be attributed to timing, duration, intensity and system (Price et al. 2011). Grazing systems, by controlling the frequency and duration of grazing, are a management tool to optimize livestock and plant performance (Heitschmidt and Taylor 1991) and botanical composition (Arevalo et al. 2011).

Although grazing has a key role in shaping plant communities, there are other environmental factors such as climate, soil, altitude and aspect are more important than grazing to understand plant species composition and spatial distribution in rangelands (Vermeire et al. 2008, Arevalo et al. 2011). Therefore, grazing can not be evaluated alone as it is one important element shaping plant community as well as other factors.

Understanding the effect of environmental variables such as herbivory, soil, altitude and aspect on vegetation pattern may contribute to apply these findings in management, development and improvement practices. The objective of this study was to determine the role of different grazing system and environmental variables on distribution of plant species on natural rangelands in semi-arid highlands.

Materials and Methods

The study was conducted in 2007 and 2008 at the Kargapazari Mountain in Erzurum, the eastern Anatolia Region of Turkey. Eight range sites, where two different grazing systems, two of them belong to season-long grazing system and the others belong to transhumant grazing system, have been applied traditionally, were selected in the experimental area. The sites can be summarized as follow: (1) Season-long grazed sites; these sites (40^{o} 18$^{'}$ N and 41^{o} 19$^{'}$ E, altitude of 2350 m and 40^{o} 16$^{'}$ N and 41^{o} 23$^{'}$ E, altitude of 2200 m) are grazed from the beginning of spring to the end of autumn. (2) Spring and autumn grazed sites; these sites (40^{o} 23$^{'}$ N and 41^{o} 25$^{'}$ E, altitude of 1950 m and 40^{o} 25$^{'}$ N and 41^{o} 21$^{'}$ E, altitude of 2000 m) are grazed firstly from the beginning of spring to the middle of June and from the middle of the September to the late of November (lowland part of transhumant). (3) Summer grazed sites; these sites (40^{o} 21$^{'}$ N and 41^{o} 24$^{'}$ E, altitude of 2150 m and 40^{o} 26$^{'}$ N and 41^{o} 20$^{'}$ E, altitude of 2450 m) are grazed from the middle of June to the middle of the September (upland, yayla (Turkish), of transhumant) and (4) Winter grazed sites; these sites (40^{o} 18$^{'}$ N and 41^{o} 21$^{'}$ E, altitude of 1900 m and 40^{o} 20$^{'}$ N and 41^{o} 19$^{'}$ E, altitude of 2400 m) are grazed initially in the first half part of growing season and closed to grazing until winter and re-opened to grazing at the beginning of the winter and continues up to snow cover on the ground (winter range of transhumant). Winter range sites are located on the south aspect of the mountain, and grazed mainly by sheep flock, whereas the other areas are grazed by sheep and cattle herds.

The study area is characterized with harsh climatic condition with long and extremely cold winter and cool, short and dry summer. The long-term average annual temperature is 5.7^{o}C, average total annual precipitation is 450 mm and it is generally fall from autumn to the late spring. Soil analysis performed according to Soil Survey Laboratory Staff (1992) procedures revealed that the sites soils textures changed loam, clay-loam, or sandy-loam among the sites, organic matter content ranged from 0.9 to 6.7 %, pH ranged from 5.73 to 7.91. The soils of all sites were poor in lime and phosphorus but rich in potassium.

Vegetation survey of range sites were carried out when common plants reached flowering stage in the both years using the line intercept method developed by Canfield (1941). Measurements were performed using 8-line intercept transects (for 10 m interval over a fixed 80 m long transect) based on the basal area in each site.

The relationships between vegetation and environmental variables (soil properties, altitude and grazing system) were analyzed by ordination techniques. Redundancy analysis (RDA) was used to examine the relationships of floristic composition to the measured environmental variables at different sites (Leps and Smilauer 2003). Species data were transformed because the data contained many zeros using the transformation ln (10 x X + 1), where X= species number in species score (ter Braak and Smilauer 2002). Automatical selection was used to determine the variance explained by individual variables. Monte Carlo permutation tests were used to test the significance of each variable. The relationships between plant distribution and environmental factors were performed using the CANOCO 4.5 software (ter Braak and Smilauer, 1998).

Results

The relationships between plant species distribution and environmental variables were presented in RDA ordination diagram (Figure 1). The Monte Carlo permutation test indicated that all canonical axes were significant ($p<0.05$). The plant species distribution showed clear differences on the ordination diagrams depending on grazing system application. Season-long grazed sites placed in the right site of ordination diagram and soil P, Na and bulk density significantly affected species distribution on these sites ($p<0.05$). Winter grazed sites were placed on the right side of the ordination diagram and there were not any relation between soil properties and species distribution on these sites (Figure 1). Summer grazed sites were placed on the left side of ordination diagram and there was significantly relation between species distribution and some soil properties such as pH, $CaCO_3$, Ca on these sites ($p<0.05$). COVA, CAST, SCAN and ASLA were common and characteristic species of the rangeland sites under season-long grazing system while FEOV, THMI and KOCR were common in the rangeland sites under winter grazing system. ASMA, SASP and FSP were common plants in the rangeland sites under summer grazing system but annual species such as BRTE and XEAN were common in the rangeland sites under spring-autumn grazing system. In general, undesired species were more common in the rangeland sites under season long grazing system that of the other.

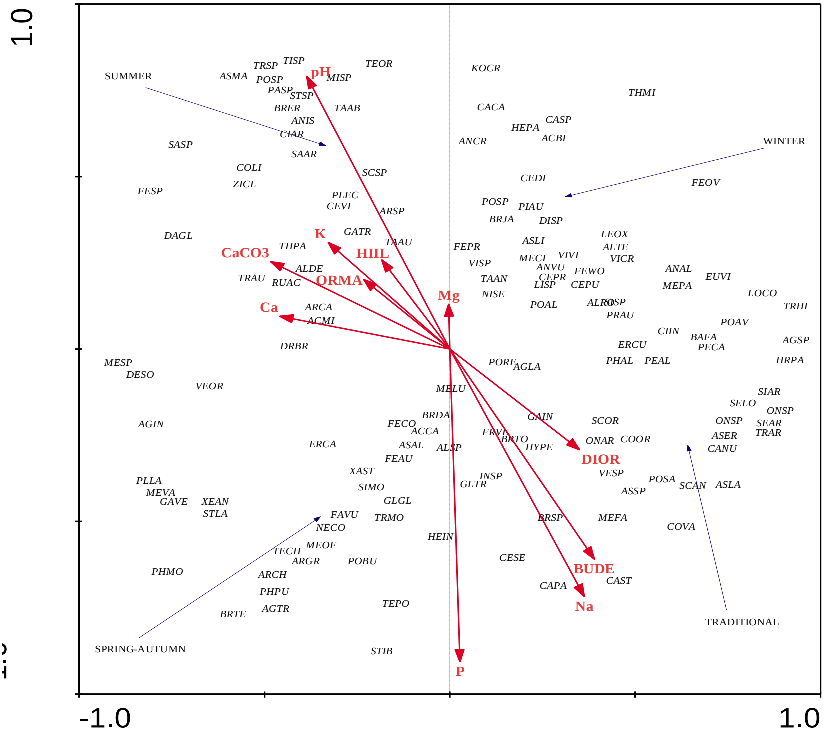

Figure 1 RDA ordination diagram rangeland vegetation composition with environmental variables.

Key to abbreviations: AGCR *Agropyron cristatum*; AGIN *Agropyron intermedium*; AGSP *Agropyron* sp.; AGTR *Agropyron trichophorium*; AGLA *Agrostis lazica*; ALTE *Alopecurus tectilis*; ANIS *Andropogon ischaemum*; BRDA *Bromus danthonia*; BRER *Bromus erectus*; BRJA *Bromus japonicus*; BRSP *Bromus* sp; BRTO *Bromus tomentollus*; BRTE *Bromus tectorum*; CAPA *Catabrollesa parviflora*; DAGL *Dactylis glomerata*; FEOV *Festuca ovina*; FEPR *Festuca prantensis*; FESP *Festuca* sp.; FEWO *Festuca woronowii*; KOCR *Koeleria cristata*; PHAL *Phleum alpinum*; PHMO *Phleum montana*; POAL *Poa alpina*; POBU *Poa bulbosa*; STLA *Stipa lagascea*; ASER *Astragalus ericophalus*; ASLI *Astragalus lineatus*; ASSP *Astragalus* sp.; COOR *Coronilla orientalis*; COVA *Coronilla varia*; LOCO *Lotus cornuculatus*; MEFA *Medicago falcata*; MELU *Medicago lupilina*; MEPA *Medicago papillosa*; MESP *Medicago* sp.; MEVA *Medicago varia*; MEOF *Melilotus officinalis*; ONSP *Onobrychis* sp. TRAR *Trifolium arvense*; TRHI *Trifolium hirtum*; TRMO *Trifolium montanum*; TRSP *Trifolium* sp.; TISP *Trigonella* sp.; VICR *Vicia cracca*; VIVI *Vicia villosa*; ACCA *Acantholimon caryophyllaceum*; ACBI *Achilla biebersteinii*; ACMI *Achilla millefolium*; ALRO *Allium rotundum*; ALDE *Alyssum desertorum*; ALSP *Alysum* sp.; ANAL *Anemone albana*; ANCR *Antemis cretica*; ANVU *Anthllis vulneraria*; ARCA *Arabis caucasica*; ARGR *Arenaria grandiflora*; ARCH *Artemisia chomaemiellifolia*; ARSP *Artemisia spicigera*; ASLA *Asperula laxiflora*; ASMA *Astrantia maxima*; ASAL *Aster alpinus*; BAFA *Bapleurum falcatum*; CAST *Campanula stevenii*; CANU *Carduus nutans*; CASP *Carex* sp.; CACA *Carum carvi*; CESE *Centaurea sessilis*; CEPU *Centaurea pulcherrima*; CEVI *Centaurea virgata*;

CEPR *Cephalaria procera*; CEDI *Cerastium dichotomum*; CIIN *Cichorium intybus*; CIAR *Circium arvense*; COLI *Convolvulus lineatus*; DESO *Descurania sophia*; DISP *Diantus* sp.; DRBR *Draba brunifolia*; ERCU *Erysimum cuspidatum*; ERCA *Eryngium campestre*; EUVİ *Euphorbia virgata*; FAVU *Falcaria vulgaris*; FECO *Ferula communis*; FEAU *Ferulago aucheri*; FRVE *Fragaria vesca*; GAIN *Galium incarnatum*; GAVE *Galium verum*; GATR *Galium tricarnatum*; GLTR *Globularia trichosantha*; GLGL *Glycyrrhiza glabra*; HEPA *Helichyrsum pallasii*; HEPA *Heracleum pastinacifolium*; HEIN *Herniaria incana*; HYPE *Hypericum perfaratum*; INSP *Inula* sp.; LEOX *Leontodon oxylepis*; LISP *Linum* sp.; MECI *Melica ciliata*; MISP *Minuartia* sp; NECO *Nepeta concolor*; NISE *Nigella segetalis*; ONAR *Onosma armenum*; PASP *Papaver* sp.; PECA *Pedicularis caucasica*; *PEAL Petrorhagia alpina;* PHPU *Phlomis pungen*; PIAU *Pimpinella aurea*; PLLA *Plantago lanceolata*; PLEC *Plosella echioides*; POAV *Polygonum aviculare*; POSP *Poligonum* sp; PORE *Potentilla recta*; POSP *Potentilla* sp.; POSA *Poterium sanguisorba*; PRAU *Primula auriculata*; RUAC *Rumex acetosella*; SAAR *Salvia argentea*; SASP *Salvia* sp.; SCAN *Scleranthus annuus*; SCSP *Scobiosa* sp.; SCOR *Scutelleria orientalis*; SEAR *Sempervivum armenum*; SELO *Senecio lorentii*; SIMO *Sideritis montana*; SISP *Silene spergulifolia*; SIAR *Sinapis arvensis*; STSP *Stachys* sp.; STIB *Stachys iberica*; TAAB *Tanacetum abrotanifolium*; TAAU *Tanacetum aucheranum*; TAAN *Taraxacum androssovii*; TECH *Teucrium chamaedrys*; TEOR *Teucrium orientale*; TEPO *Teucrium polium*; THMI *Thalictum minus*; THPA *Thymus parviflorus*; TRAU *Tragopogon aureus*; VESP *Verbascum* sp; VEOR *Veronica orientalis*; XAST *Xanthium strumarium*; XEAN *Xeranthemum annuum*; ZICL *Ziziphora clinopoioides*

Discussion

The results revealed that grazing system and some soil properties affected spatial distribution of plant species at different scale. Plant species distribution showed distinct differences on ordination diagram depending on grazing system application. Grazing plays a key role in shaping plant distribution together the environmental factors (Li et al. 2009, Price et al. 2011). In addition to the differences in soil properties and the other environmental factors, the differences in grazing time and intensity existing from grazing system may contribute to differences in species distribution among the sites. The increases in undesired plant species abundance in season-long grazed sites most probably stemmed from adverse effect of continuous grazing during the active growing season. As it is well known, uncontrolled continuous grazing has seriously detrimental effect on desired range plants (Price et al. 2011).

Soil nutrients and some physical characteristics have significantly role on species distribution on the rangelands in semi-arid ecosystems (He et al. 2007, Zuo et al. 2012). While Na content and soil bulk density were positively related with CAPA, pH was related with ASMA, TRSP, TISP, POSP, PASP, MISP and STSP. Similar results also reported the other studies conducted on different places on the world (Jafari et al. 2004, Rinella and Hileman 2008, Price et al. 2011).

In addition to investigated environmental variables, the other environmental variables such as altitude, slope, aspect etc. have absolutely considerable effect on plant distribution (Vermeire et al. 2008; He et al.

2007) which is main reason for site selection for special grazing season in animal raiser communities in the region.

In conclusion, according to RDA, uncontrolled season-long grazing system had the most adverse effect on rangeland vegetation than the other system in steppe rangelands in high elevation. The grazing systems providing resting for plants during the growing season showed prominent results with respect to species composition in the rangelands. Hence, it will be better if traditional upland-lowland (transhumant) grazing systems improve with respecting to grazing period and stocking intensity for sustainable use of semi arid highland rangelands.

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