Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

DIFFERENCES IN VEGETATION AND SOIL PROPERTIES OF THE HIGHLAND RANGELANDS GRAZED WITH SINGLE CATTLE HERD AND CATTLE+SHEEP HERDS

Mehmet Kerim GULLAP[1], Halil İbrahim ERKOVAN[2], Ali KOC[2]

[1]Ataturk University, Faculty of Agriculture, Erzurum, Turkey
[2]Eskisehir Osmangazi University, Faculty of Agriculture, Eskisehir, Turkey

Corresponding author email: erkovan@ogu.edu.tr

Abstract

The effect of grazers on vegetation and soil properties changes depending on their foraging behaviour and hoof pressure. In general, cattle prefer grasses while sheep prefer considerably forbs and goat skilfully browse during feeding. These differences in feeding preferences herbivore effects species composition and consequently alter vegetation structure on the area. The aim of this study was to determine the effects of single cattle herd and cattle+sheep herds grazing on vegetation composition and soil properties in highlands rangelands. For this aim, four rangeland sites in two locations were selected two site in each location grazed with single cattle herds and the other sites have been grazed with cattle + sheep mixing herds for least 20 years. To compare the effect of grazer differences on vegetation and soil properties, redundancy analysis (RDA) was chosen as the most appropriate constrained ordination technique. Species data were transformed to provide have normality of data. Statistical tests of the significance of the relationship soil properties used Monte Carlo permutation test within CANOCO. Species distribution in the vegetation and some soil properties such clay, silt, sand, organic matter, pH, P, CaCO3, showed a significant correlation related to herd type. These results indicated that animal types have an important role on distribution of plant species and soil properties in the highland short grass steppe rangelands. It can be suggested that cattle and sheep are grazed together to enhance biological diversity and sustainable use of highland short grass steppe rangelands.

Key words*: cattle, mixed grazing, rangeland, soil properties.*

INTRODUCTION

Rangelands have been an important component of farming systems in the Eastern Anatolia region of Turkey for centuries. Both big and small ruminants obtains significant part of their feeds from rangelands, hence, rangeland depended animal husbandry has crucial role in the Eastern Anatolia agricultural production (Koc et al., 2014). Grazing by livestock is a widely used management tool in rangeland, and is known to preserve and enhance plant diversity particularly in wetlands (Gordon et al., 1990), but has a great impact on plant species in low productive rangelands because of foraging selectivity and food quality requirements depend on herbivore size (Bakker and Olff, 2003). Plants species can decrease or increase abundance on the rangelands depends on grazing behaviour of animals especially selective grazing. Because cattle tend to graze grasses, sheep prefer forbs especially legume forb whereas goat willing to consume shrubs (Lemus, 2012; Rose et al., 2012). As a result of differences in grazing behaviour of animal types, dispersal and recruitment of plant species are affected. Consequently, vegetation structure and composition alters depending on changing competition condition (Tilman, 1982). Furthermore, the effect of animal type on seed dispersal may depend on animal size. Big animal has a strong effect on seed dispersal because of consume large amounts of seeds and move over long distances (Haskell et al., 2002). Grazing animals impact vegetation and soil properties direct or indirect. Direct effects of grazing are trampling, treading and excretal, while indirect effects are mediated by changes vegetation (Greenwood and McKenzie, 2001). Disintegration forces of soil are due to animal treading and trampling, and their impact depends on animal type, soil bearing capacity, vegetation, and grazing system. The mechanical impact of animal hooves on soil surface can be a severe disturbance on topsoil structure by treading and trampling (Greenwood and McKenzie, 2001). This mechanical impact changes the form and

stability of soil aggregates, bulk density, pore size distribution, and other soil properties. The pressure exerted by grazing animals on soil is a function of the animal's size for example the pressures exerted by a standing sheep and cattle are average 66 kPa and 138 kPa, respectively (Li et al., 2008; Taboada et al., 2011). While trampling causes compaction in wet soils, it causes structural degradation in aggregate and finally crushing occurs in this condition.

The aim of this study was to determine the effects of single cattle or cattle+sheep mixed grazing on species composition and soil properties in highlands rangelands. For this aim, four rangeland sites in two locations were selected two sites; in each location grazed with single cattle herds and the other sites have been grazed with cattle and sheep mixed herds for least 20 years.

MATERIALS AND METHODS

The study was conducted in the year of 2010 at the Muratgeldi, Kirmizitas, Kosk and Umudum villages in Erzurum, the eastern Anatolia Region of Turkey. Four range sites were selected while two of them have been grazed by single cattle herd (Muratgeldi and Kirmizitas) and the others have been grazed by cattle and sheep mixed herds (Kosk and Umudum) for more two decades.

The study area is characterized by 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. The precipitation 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 sandy-loam among the sites, organic matter content ranged from 0.5 to 2.5 %, pH ranged from 5.73 to 7.91. The soils of all sites were poor in lime and phosphorus but rich in potassium.

Botanical composition and canopy coverage were measured when common species reach the flowering (late June) stage using modified wheel point method (Koc and Cakal, 2004) on ten transects lines. Every line had 20 m interval and 100 m length (100 point with 1 m interval were recorded).

The relationships between vegetation and environmental variables (soil properties and grazed animal type) were analysed by ordination techniques. Redundancy analysis (RDA) was chosen as the most appropriate constrained ordination technique. Rare species are represented lower than 1% in the botanical composition was removed from the dataset before analysis. Redundancy analysis (RDA) was used to examine the relationships of floristic composition to the measured environmental variables at sites grazed by different animal type. Species data were transformed because the data contained many zeros using the transformation ln (10 x X + 1), where X= species number in species record in transect (ter Braak and Smilauer, 2002). Automatically 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, 2002).

RESULTS AND DISCUSSIONS

The correlations of soil variables with the four RDA vegetation axes are given Figure 1 and Table 1. The Monte Carlo permutation test results indicated that all canonical axes were significant ($p<0.05$). The plant species distribution showed clear differences on the ordination diagrams depending on grazing animal type. There was significantly relation between species distribution and some soil properties such as pH, lime and clay on the rangeland site grazed by only cattle herd. Although the effects of herd types were significant, botanical composition and species distribution was mostly controlled by environmental factors. The effects of selected variables on plant composition defined. The RDA correlation variance of botanical composition showed distinct separation with species environment correlations 0.999, 0.906, 0.716 and 0.475 and cumulative percentage variance of species-environment relation are 47.6, 72.0, 84.2 and 89.7. Eigen values changed between 0.023 and 0.196, and sum of canonical eigenvalues determined is as 0.411 (Table 1).

In general, soil of site grazed by mixed herd had higher lime, pH and clay content but soil of site grazed by cattle had higher P and silt (Figure 1). LOTCOR *Lotus cornuculatus,* SCUORI *Scutelleria orientalis,* FESOVI *Festuca ovina,* AGRINT *Agropyron intermedium* and THYPAR *Thymus parviflorus* were found to significantly higher in the sites grazed by single cattle herd than the other site. Whereas, BROTOM *Bromus tomentollus,* GALVER *Galium verum,* CREARM *Crepis armena,* KOECRI *Koeleria cristata* and SIDMON *Sideritis montana* were significantly higher in the site grazed by mixed herd. Some plant species such as ERYCAM *Eryngium campestre* and VERSPP *Verbascum* sp. where not affected by distinctively by herd type.

Table 1. The results of RDA of species and soil properties

Axes	1	2	3	4
Eigenvalues	0.196	0.100	0.050	0.023
Species-environment correlations	0.909	0.906	0.716	0.475
Cumulative percentage variance of species data	19.6	29.6	34.6	36.9
Cumulative percentage variance of Species-environment relation	47.6	72.0	84.2	89.7
Sum of canonical eigenvalues	0.411			

The results revealed that herd type and some soil properties affected deeply spatial distribution of plant species. Plant species distribution showed distinct differences on ordination diagram depending on grazing animal type application. Grazer type plays a key role in shaping plant distribution together the environmental factors (Lemus, 2012; Rose et al., 2012). Single species grazing can affect botanical composition due to animal grazing behaviour. As it well known, mixed herd grazing could be an alternative to reducing undesired plant populations. If done right, studies have shown that mixed grazing, not only make good use of land and forage resources, but also results in higher animal production per unit area. Mixture grazing can improve utilization of rangeland, increase forage quality, and carrying capacity also it can control weeds (Erkovan et al., 2016).

There is a positive relation between grazing animal type and plant species distribution in the experiment results. While soil properties such as organic matter, sand, phosphorus, silt were positively related with plant species (ASTSPP *Astragalus* sp.; LOTCOR *Lotus cornuculatus*; SCUORI *Scutelleria orientalis*; TANABR *Tanacetum abrotanifolium*; VERSPP *Verbascum* sp.) in the plot grazed by mixed herd, there were relation between clay, pH, lime and BRMTOM *Bromus tomentollus*; KOECRI *Koeleria cristata*; CREARM *Crepis armena*; FALVUR *Falcaria vulgaris*; GLOTRI *Globularia trichosantha*; SIDMON *Sideritis montana* in the plots grazed by single cattle in experiment. Forb plant species in the botanical composition have higher cattle grazed area compared to mixed herd grazed area. These decreases in forb abundance in the site grazed with mixed herd must be related to sheep grazing preferences because sheep prefer to graze forbs. It is well known that forbs never resist to grazing as much as grasses (Holechek et al., 2004). Also similar research showed that plant species and soil properties are affected by grazing animal type (Bakker and Olff, 2003; Yunusbaev et al., 2003; Li et al., 2008; Taboada et al., 2011).

Some soil characteristics have significantly role on species distribution on the rangelands in semi-arid ecosystems, also grazing animal type have an important role soil properties (Tessema et al., 2011; Haftay, 2017). Animals have important mechanical effect on soil properties depending on size. The sheep decreases stubble height due to grazing ability and on the other hand, drags its back foot during the grazing, which break soil aggregates. These factors encourage erosion. Consequently silt move easily by erosive power.

This mechanical impact changes the form and stability of soil aggregates, bulk density, pore size distribution, and soil other properties. As a result of this effect soil properties can change grazing due to animal type.

While clay, pH, lime were positively related with mixed herd grazing, organic matter, sand, phosphorus, silt were related with mixed herd

grazing. Similar results also reported the other studies conducted on different places on the world (Greenwood and McKenzie, 2001; Haskell et al., 2002; Li et al., 2008; Taboada et al., 2011).

In conclusion, according to RDA, cattle grazing had the most adverse effect on grasses species in the botanical composition than mixed grazing on in high altitude rangelands. It is important to use correct animal herd that efficiently using land and forage type for sustainable use of grazing lands.

Mixed herd grazing can improve grazed area increasing quality and carrying capacity decreasing or controlling weed invasion.

Mixed animal grazing management has a harmony with soil properties and plant species, enabling grasses and legumes to proliferate can increase carrying capacity and decreasing detrimental effect of grazing.

But correct grazing capacity performing has crucial importance to obtain this positive effect of mixed grazing.

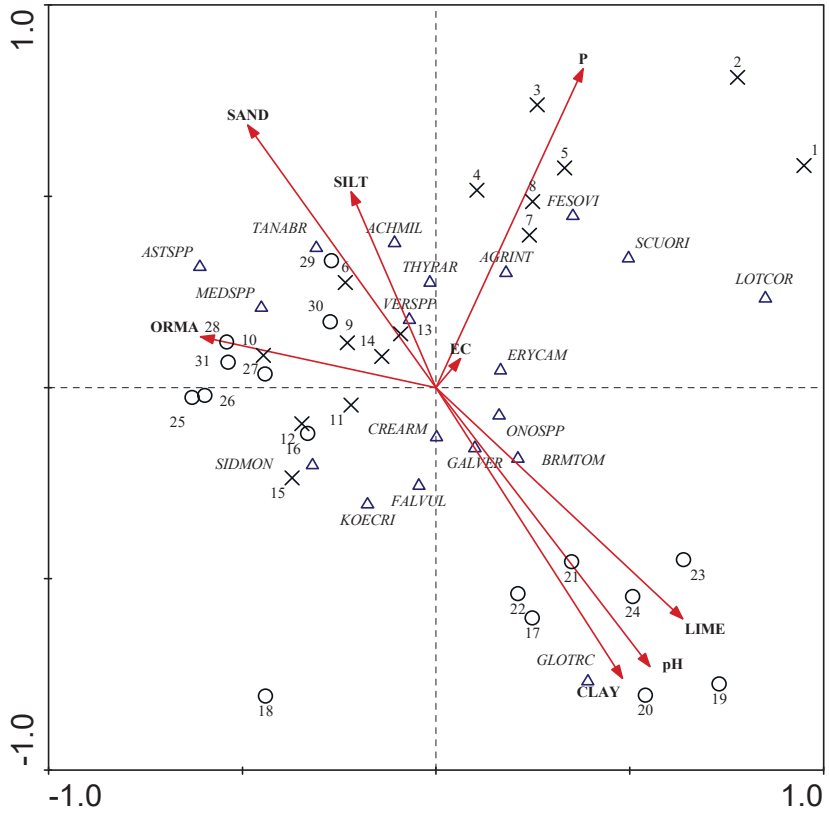

Figure 1. Triplot RDA ordination diagram rangeland vegetation composition with environmental variables

Key to abbreviations: x-mark represent grazed by single cattle samples and non-filled circle represent grazed by cattle and sheep mixed herds. pH, ORMA organic matter, LIME, P phosphorus, SUND, SILT, CLAY. AGRINT *Agropyron intermedium*; BRMTOM *Bromus tomentollus*; FESOVI *Festuca ovina*; KOECRI *Koeleria cristata*; ASTSPP *Astragalus* sp.; LOTCOR *Lotus cornuculatus*; MEDSPP *Medicago* sp.; ONOSPP *Onobrychis* sp.; ACHMIL *Achilla millefolium*; CREARM *Crepis armena*; ERYCAM *Eryngium campestre*; FALVUR *Falcaria vulgaris*; GALVER *Galium verum*; GLOTRI *Globularia trichosantha*; SCUORI *Scutelleria orientalis*; SIDMON *Sideritis montana*; TANABR *Tanacetum abrotanifolium*; THYPAR *Thymus parviflorus*; VERSPP *Verbascum* sp.

REFERENCES

Bakker E., Olff H., 2003. Impact of different-sized herbivores on recruitment opportunities for subordinate herbs in grasslands. Journal of Vegetation Science, 14: 465-474.

Erkovan S., Gullap M.K., Erkovan H.I., Koc A., 2016. Rangeland health and ecological site classification of the rangeland with grazed different type animals. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 25(Özel sayı-2):174-178.

Gordon I.J., Duncan P., Grillas P., Lecomte T., 1990. The use of domestic herbivores in the conservation of the biological richness of European wetlands. Bulletin d'Ecologie, 21: 49-60.

Greenwood K.L., McKenzie B.M., 2001. Grazing effects on soil physical properties and the consequences for pastures: A review. Aust. J. Exp. Agric., 41:1231–1250.

Haftay H., 2017. Analysis of vegetation phytosociological characteristics and soil physico-chemical conditions in harishin rangelands of eastern Ethiopia. Land, 6(4): 5-17.

Haskell J.P., Ritchie M.E., Olff H., 2002. Fractal geometry predicts varying body size scaling relationships for mam- mal and bird home ranges. Nature, 418: 527-530.

Holechek J.L., Pieper R.D., Herbel C.H., 2004. Range management: principles and practices. Prentice Hall, New Jersey, USA.

Koc A., Cakal S., 2004. Comparison of some rangeland canopy coverage methods. Int. Soil Cong on Natural Resource Manage. For Sust. Develp.7-10 June 2004, Erzurum, Turkey: pp. 41-45.

Koc A., Kaya A., Gullap M.K., Erkovan H.I., Macit M., Karaoglu M., 2014. The effect of supplemental concentrate feed on live weight gain of yearling heifers over grazing season in subirrigated rangelands of East Anatolia. Turkish Journal of Veterinary and Animal Sciences, 38(4): 278-284.

Lemus R., 2012. Target multispecies grazing: Should you try it?. Mississippi State University Extension Service, Vol: 5(12): 1-3.

Li C., Hao X., Zhao M., Han G., Willms W.D., 2008. Influence of historic sheep grazing on vegetation and soil properties of a desert steppe in Inner Mongolia. Agric. Ecosyst. Environ., 28: 109–116.

Rose, L., Hertel D., Leuschner C., 2012. Livestock-type effects on biomass and nitrogen partitioning in temperate pastures with different functional-group abundance. Grass and Forage Science, 68: 386-394.

Soil Survey Laboratory Staff (1992). Soil survey laboratory methods manual. USDA-SCS. Soil Survey Investigations Report No: 42.

Taboada A.M., Rubio G., Chaneton E.J., 2011. Grazing impacts on soil physical, chemical, and ecological properties in forage production systems. In: Jerry L.H.E., Thomas J.S., (Eds.), Soil Management: Building a Stable Base for Agriculture. American Society of Agronomy and Soil Science Society of America, 5585 Guilford Road, Madison, WI 53711, USA, 301-320.

Ter Braak C.J.F., Smilauer P., 2002. Canoco reference manual and canodraw for windows user's guide: software for canonical community ordination (Version 4.5). Wageningen University and Research Centre, Wageningen.

Tessema Z.K., de Boer W.F., Baars R.M.T., Prins H.H.T., 2011. Changes in soil nutrients, vegetation structure and herbaceous biomass in response to grazing in a semiarid savanna in Ethiopia. J. Arid Environment, *75*: 662–670.

Tilman D, 1982. Plant strategies and the dynamics and structure of plant communities. Princeton University Press. Princeton, USA.

Yunusbaev U.B., Musina L.B., Suyundukov Ya.T., 2003. Dynamics of steppe vegetation under the effect of grazing by different farm animals. Russian Journal of Ecology, 34(1): 46-50.