Change in Grazing Practices Induce Shift in the Ground Vegetation Community in the Western Himalayas

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Abstract

Grazing by livestock is one of the most prevalent and oldest forms of human interventions experienced by most of the terrestrial ecosystems. Several ecosystems are believed to have reshaped by grazing by large ungulates. However, over the last few decades, there is an increasing concern about the detrimental effects of over-grazing by livestock on biodiversity and ecosystem processes. This has resulted in grazing restrictions in many of the protected areas across the world. In most of the cases, such restrictions are based on perceptions and their effectiveness is limited by a lack of knowledge on grazing-vegetation relationships. We investigated the effects of recent restrictions and changes in livestock grazing practices on ground vegetation characteristics in the Western Himalayan landscape, which has a very long history of livestock grazing. We hypothesized that livestock grazing helps fast growing succulent annuals over perennial species of plants. We also examined the role of local climatic and topographic features in determining vegetation characteristics. We carried out interview surveys to identify grazing gradients in the landscape. Ground vegetation was sampled across these grazing gradients and species richness and abundance were compared. The study suggests that the richness and diversity of ground vegetation community at high altitude pastures is determined mainly by elevation. However, at the level of plant functional groups, intensity of livestock grazing

influences the richness and abundance of annual species of plants. Both richness and abundance of annual species was higher in grazed sites compared to non-grazed sites. This suggests a shift in vegetation composition from completely perennial dominated to a system with both annual and perennial plants under grazing. The western Himalayas, with a long history of pastoralism and human use, have very low density of wild herbivores. Under these circumstances, grazing by livestock might play an important role in maintaining the existing diversity and abundance of palatable annual plants in the landscape. We observed a higher percentage of bare ground in grazed sites resulting from overcrowding and subsequent over grazing of available pastures outside protected areas. We conclude that, the future management efforts should be directed towards establishing maximum permissible gazing pressure in each of the pasture based on regular monitoring and experimental studies. This data along with historical records could help in developing better strategies to manage both wildlife and livestock and to conserve existing biodiversity in this landscape.

Introduction

Grazing by livestock is one of the most prevalent and oldest forms of human interventions experienced by most of the terrestrial ecosystems. Several ecosystems are believed to have reshaped by grazing by large ungulates. For example, lawn grass ecosystems in African savannas are mainly maintained through grazing by large ungulates (McNaughton 1984; Archibald 2008). Grazing causes community level changes in an ecosystem (Gibson and Brown 1992; McIntyre et al. 2003) and grazers influence the vegetation community by changing the surface soil nutrient properties (Augustine 2003; Augustine and McNaughton 2006).

In the last few decades, there is an increased concern about the detrimental effects of over grazing by livestock on the biodiversity and ecosystem processes. (Fleischner 1994; Rawat and Sathyakumar 2002). This has resulted in grazing restrictions in many of the protected areas across the world (Kothari et al. 1989). In most of the cases, such restrictions are based on perceptions

and their effectiveness is limited by a lack of knowledge on grazing-vegetation relationships. Landscapes with a long grazing history have shown a decrease in species richness or no changes in the vegetation composition as a response to protection from grazing (Mikhailova et al. 2000; D áz et al. 2007). Thus, such management interventions, though undertaken with good intentions, might end up altering ecosystem functions.

We investigated the effects of recent restrictions and changes in livestock grazing practices on ground vegetation characteristics in the Western Himalayan landscape, which has a very long history of livestock grazing (Pandey and Wells 1997; Tucker 1997). We hypothesized that livestock grazing helps fast growing succulent annuals over perennial species of plants. The role of local climatic and topographic features in determining vegetation characteristics was also examined (McNaughton 1985; Olff and Ritchie 1998; Anderson et al. 2007). We use these results to explore the implications for the management of larger Western Himalayan landscape.

Study area

Great Himalayan National Park Conservation Area (GHNPCA) is a part of the Himalayan biodiversity hotspot, situated in the state of Himachal Pradesh, India. GHNPCA, 1,200 sq. km in area, consists of one National Park, two sanctuaries – Tirthan and Sainj-, and an eco-development zone (Fig. 1). The climate of GHNPCA is sub-tropical to temperate and alpine with the vegetation varying from sub-tropical broad-leaved (1500 m a.s.l) to Himalayan moist temperate forests (3000 m a.s.l) and alpine scrubs and grasslands (>3500 m a.s.l) (Champion & Seth 1968). The area experiences high levels of medicinal plant extraction, livestock grazing and fire (Tucker 1997).

In the year 1999, some parts of GHNPCA were declared as a national park. This has resulted in changes in the traditional grazing regime and reassigning of traditional grazing rights in the region. The National Park is provided with complete protection with no grazing, while grazing and other anthropogenic activities are allowed in the two sanctuaries and eco-development zone. The mosaic of topographical features and legal restrictions at a local-scale (Chhatre and Saberwal

2005) have resulted in gradients in grazing intensity across the landscape providing a unique opportunity to study the vegetation along the grazing gradients.

Methods

We carried out interview surveys to identify grazing gradients in the landscape. Key informants from 25 villages were interviewed between July 2011 and September 2011 to identify traditional grazing grounds, and present intensity of grazing on different pastures. Ground vegetation was sampled across the grazing gradients, at different intensities. We used point intercept method along a line transect of length 5 m to collect information on ground cover features. We followed a systematic random sampling design where the line transects were placed in a grid pattern with a minimum distance of 80 m between two adjacent transects. Along the transect we recorded ground cover features at every 20 cm interval. The number of transects in a pasture ranged from four to 34 (with 100 to 850 points) depending on the area and species accumulation rate in each pasture. We laid 170 transects across 11 pastures.

We used regression models to examine the influence of grazing intensity and other covariates on overall species richness in the landscape. Studies have showed grazing to influence largely the characteristics in plant functional groups. Hence, we examined the effect of grazing on characteristics in plant functional groups, mainly the richness and abundance of annuals and perennials.

Results

Impact of grazing on vegetation characteristics

We recorded 95 species of ground flora across all pastures consisting of herbs (72 species), grasses (11), sedges (3), ferns (3) and shrubs (6). The lowest number of species, 14, was in a medium intensity grazing area (MG) and the highest, 38, was in grazing-restricted area. The landscape was dominated by perennial species, which formed 71% of herb species and 64% of grass species.

Graphs suggested a strong relationship between species richness and elevation compared to species richness and grazing intensity. A comparison of different generalized linear regression models revealed elevation as the most important factor in determining the overall species richness with a positive slope ($b= 0.00113$, $p<0.001$).

In contrast to the overall species richness, richness of annuals showed a strong positive relationship with grazing intensity. Number of annual species increased with grazing intensity. Similarly, annual to perennial species ratio was higher in grazed areas compared to ungrazed pastures. A comparison of different linear regression models revealed grazing intensity as the lone factor in determining annual species richness in the study landscape. Linear regression models suggested a strong positive relationship between grazing intensity and the relative abundance of annual species (multiple $r2= 0.73$, $p<0.01$). We did not find any relationship between the perennial species abundance and any of the covariates considered in the study (null model was the top model).

Influence of grazing on bare ground

Box and whisker plot suggested an increase in amount of bare ground in grazed categories. Linear regression suggested a significant strong correlation between grazing intensity and proportion of bare ground (multiple $r2= 0.54$, $p<0.05$).

Discussion

Grazing by livestock is one of the oldest forms of human interventions experienced by most of the natural landscapes in India. However, there is very little known about the role of livestock grazing in structuring ecosystems in these landscapes. We investigated the effects of different intensities of livestock grazing and protection from grazing on vegetation characteristics in the western Himalayan landscape, which has a very long history of livestock grazing. The study suggests that the richness and diversity of ground vegetation community at high altitude pastures is determined mainly by elevation. However, at the level of plant functional groups, intensity of livestock grazing influences the richness and abundance of annual species of plants. As

hypothesized, we found significantly higher richness and the relative abundance of annual plants in grazed areas as compared to non-grazed areas. A global synthesis of responses of different plant traits to grazing (Díaz et al. 2007) has found richness of annuals as an important ground vegetation trait, which is influenced by grazing. This synthesis, as well as several other studies from different parts of the world, has observed an increase in the richness and abundance of annual plants in intensely grazed areas (Fensham et al. 1999; Dorrough et al. 2004; Papanikolaou et al. 2011).

Ground vegetation composition in the study area suggests that these pastures are primarily dominated by perennial species. Grazing acts at multiple levels in facilitating establishment of annuals in such perennial pastures. Our findings suggest that grazing results in an increased number of bare patches. Short life span and high seed production and dispersal abilities facilitates the establishment of seedlings of annual plants in such bare patches (Dorrough et al. 2004; Best and Arcese 2009; Papanikolaou et al. 2011).

Management implication

In GHNPCA, a distinct vegetation composition was observed in areas subjected to livestock grazing; richness and abundance of annual species of plants was higher in grazed areas compared to non-grazed areas. We found that a few tall perennial plants dominated the sites, where the grazing has been restricted. Such domination by perennials could lead to unavailability of annuals as forage species to wild ungulates. Understanding this recent shift in vegetation community is of immense importance as it can result in a decreased diversity in the landscape. The current restrictions on grazing have resulted in an increase in grazing pressure on remaining large pastures as evident from increase bare-ground patches. Hence, there is a need to halt the occurrence of overgrazing in these pastures and develop alternative strategies to reduce grazing pressure on a single site. The distribution and abundance of palatable species of plants is an important factor that can determine the levels of co-existence between wild and domestic large herbivores (Fritz et al. 1996) and also the diversity and abundance of large herbivores (Olff et al. 2002; Archibald et al. 2005). The western Himalayas, with a long history of pastoralism and

human use, have very low density of wild herbivores. Under these circumstances, grazing by livestock might play an important role in maintaining the existing diversity and abundance of palatable annual plants in the landscape (Nayak et al. 2014). We conclude that, the future management efforts should be directed towards establishing maximum permissible gazing pressure in each of the pastures based on regular monitoring and experimental studies. This data along with historical records could help in developing better strategies to manage wildlife and livestock and to conserve the existing biodiversity.

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References

Anderson TM, Ritchie ME, McNaughton SJ (2007) Rainfall and soils modify plant community response to grazing in Serengeti National Park. Ecology 88:1191–201

Archibald S (2008) African grazing lawns—how fire, rainfall, and grazer numbers interact to affect grass community states. J Wildl Manage 72:492–501. doi: 10.2193/2007-045

Archibald S, Bond WJ, Stock WD, Fairbanks DHK (2005) Shaping the landscape: fire–grazer interactions in an African savanna. Ecol Appl 15:96–109. doi: 10.1890/03-5210

Augustine DJ (2003) Long-term, livestock-mediated redistribution of nitrogen and phosphorus in an East African savanna. J Appl Ecol 40:137 – 149

Augustine DJ, McNaughton SJ (2006) Interactive effects of ungulate herbivores, soil fertility, and variable rainfall on ecosystem processes in a semi-arid savanna. Ecosystems 9:1242–1256. doi: 10.1007/s10021-005-0020-y

Best RJ, Arcese P (2009) Exotic herbivores directly facilitate the exotic grasses they graze: mechanisms for an unexpected positive feedback between invaders. Oecologia 159:139–150. doi: 10.1007/s00442-008-1172-1

Champion HG., Seth SK (1968) A revised survey of the forest types of India. Nataraj Publishers, Dehradun

Chhatre A, Saberwal V (2005) Political incentives for biodiversity conservation. Conserv Biol 19:310–317. doi: 10.1111/j.1523-1739.2005.00012.x

D áz S, Lavorel S, McIntyre S, et al. (2007) Plant trait responses to grazing - a global synthesis. Glob Chang Biol 13:313–341. doi: 10.1111/j.1365-2486.2006.01288.x

Dorrough J, Ash J, McIntyre S (2004) Plant responses to livestock grazing frequency in an Australian temperate grassland. Ecography (Cop) 27:798–810

Fensham RJ, Herbarium Q, Skull SD (1999) Before cattle: a comparative floristic study of eucalyptus savanna grazed by macropods and cattle in North Queensland, Australia. Biotropica 31:37–47

Fleischner TL (1994) Ecological costs of livestock grazing in western North America. Conserv Biol 8:629–644. doi: 10.1046/j.1523-1739.1994.08030629.x

Fritz H, De Garine-Wichatitsky M, Letessier G (1996) Habitat use by sympatric wild and domestic herbivores in African savanna woodland: the influence of cattle spatial behavior. J Appl Ecol 33: 589-598

Gibson CW, Brown VK (1992) Grazing and vegetation change : deflected or modified succession? J Appl Ecol 29:120–131

Kothari A, Pande P, Singh S, Variava D (1989) Management of national parks and sanctuaries in India: a status report. New Delhi

McIntyre S, Heard KM, Martin TG (2003) The relative importance of cattle grazing in subtropical grasslands: does it reduce or enhance plant biodiversity? J Appl Ecol 40:445–457. doi: 10.1046/j.1365-2664.2003.00823.x

McNaughton SJ (1984) Grazing lawns: animals in herds, plant form, and coevolution. Am Nat 124:863–886

McNaughton SJ (1985) Ecology of a grazing system: the Serengeti. Ecol Monogr 55:260–294

Mikhailova E, Bryant R, Cherney DJ, et al. (2000) Botanical composition, soil and forage quality under different management regimes in Russian grasslands. Agric Ecosyst Environ 80:213–226. doi: 10.1016/S0167-8809(00)00148-1

Nayak RR, Vaidyanathan S, Krishnaswamy J (2014) Fire and grazing modify grass community response to environmental determinants in savannas: implications for sustainable use. Agric Ecosyst Environ 185:197–207. doi: http://dx.doi.org/10.1016/j.agee.2014.01.002

Olff H, Ritchie ME (1998) Effects of herbivores on grassland plant diversity. Trends Ecol Evol 13:261–265

Olff H, Ritchie ME, Prins HHT (2002) Global environmental controls of diversity in large herbivores. Nature 415:901–4. doi: 10.1038/415901a

Pandey S, Wells MP (1997) Ecodevelopment planning at India's Great Himalayan National Park for biodiversity conservation and participatory rural development. Biodivers Conserv 6:1277–1292

Papanikolaou AD, Fyllas NM, Mazaris AD, et al. (2011) Grazing effects on plant functional group diversity in Mediterranean shrublands. Biodivers Conserv 20:2831–2843. doi: 10.1007/s10531-011-0112-2

Rawat GS, Sathyakumar S (2002) Conservation issues in the Himalayan region of India. ENVIS Bulletin, Wildl Prot Areas 1:50–56

Tucker R (1997) The historical development of human impacts on Great Himalayan national park. Report, Wildlife Institute of India, Dehradun

Figure 1. The Great Himalayan National Park Conservation Area (GHNPCA). Grazing is restricted inside the national park, whereas, it is allowed in the two sanctuaries and the ecozone surrounding the national park.