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Original Research Article

Does Altitude Effect on Species Composition and Diversity on Himalayan Rangeland?

Dilkumar Limbu[1], *Madan Koirala*[2] *and Zhanhuan Shang*[3]

[1]Central Campus of Technology, Dharan, Tribhuvan University, Nepal

[2]Central Department of Environmental Science, Kirtipur, Tribhuvan University, Nepal

[3]International Centre for Tibetan Plateau Ecosystem Management, Lanzhou University,China

Corresponding Author: Dil Kumar Limbu, Department of Biology, Central Campus of Technology, Dharan, Nepal

E-mail:dilklimbu@yahoo.com

Abstract

Himalayan rangelands have diverse floristic composition and important ecological services. The floristic diversity and composition play an important role in grassland ecosystem regulation. It is different in altitudinal gradient due to grazing intensity, climatic condition and topography. To reveal the vegetation composition values, this work was conducted on August and September 2011 in Tinjure-Milke mountain ridge, Guphapokhari, Nepal. In the present study we have described the impact of altitude on the species richness, species diversity and dispersion behavior of different plants (grasses) in Himalayan rangeland. The values of community indices were observed to be: RD (0.09 to 49.57), RF (3.57 to 14.71), RA (0.23 to 47.59), IVI (3.89 to 111.87), Shannan-Wiener diversity index (1.09 to 2.23) and species diversity evenness (0.12 to 0.19) at the study area, MilkeJaljale, eastern Nepal. Similarly, Species richness (R) value of 8.87 to 11.86 and Simpson dominant index value of 0.12 to 0.42 were observed. All diversity indices were reversed to altitudinal gradient higher the altitudes lower the values. Species richness of all plants showed a unimodal relationship with altitude. Similarly, negative correlation of density and species richness with altitude and slope was recorded.

Key words: rangeland, himalaya, diversity index, grazing and elevation

Introduction

High altitude rangelands are home to a unique assemblage of flora and fauna (Yonzon and Heinen, 1997). It is considered as a unique and important ecosystem in nature as well as subsistence of Himalayan herdsmen. Cattle, yaks, dzos, sheep, goats, horses and mules are the livestock reared by the local people. Himalayan rangeland spreads over 2500 – 4500 m asl mountain region covering 22.6% of total land of Nepal (Government of Nepal, 2012). These play an important role in the country's farming systems and are the major feed resource for livestock and the wild life.

Species richness is an easily interpretable indicator of biological diversity (Peet, 1974) and ecological condition of the area. Ellu and Obua (2005) have pointed out that different altitudes and slopes influence the species richness and dispersion behavior of plant species. Some scholars have revealed that altitude and climate variables viz. temperature and rainfall are the determinants of species richness. Within one altitude, the co-factors like topography, aspect, inclination of slope and soil type further effect the vegetation composition (Holland and Steyn, 1975). Measures of species richness are by nature scale dependent, as are relationships between species richness and environmental variables (Whittaker et al., 2001).

Variation in species richness with elevation has been known over a century (Wallace, 1878; Pianka, 1966; Brown & Davidson, 1977; Lomolino, 2001). Several studies have found a decreasing trend in species richness with increasing elevation (Hamilton, 1975; Wolda, 1987; Gentry, 1988; Stevens, 1992; Patterson et al., 1998), whereas others have found a hump shaped relationship between species richness and elevation (e.g. Janzen, 1973; Whittaker and Niering, 1975; Rahbek, 1995; Lieberman et al., 1996; Gutierrez, 1997; Odl and and Birks, 1999; Grytnes and Vetaas, 2002). Korner (2003) argues that elevation gradients can contribute important insights into developing a general theory of species diversity. The elevation gradient in the species richness pattern is commonly explained by similar factors to the latitudinal gradient, such as climatic factors, productivity, and other energy-related factors (Richerson and Lum, 1980; Turner et al., 1987; Grytnes et al., 1999). Lomolino (2001) pointed out that many components of climate and local environment (e.g. temperature, precipitation, seasonality and disturbance regime) vary along the elevation gradients and ultimately create the variation in species richness.

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Similarly, grazing is often considered as an important form of disturbance (Grime, 2006) on species richness. Species richness is regulated by edaphic factor (Tompkins et al., 2010). This study, therefore, makes an attempt to address the question how the oristic composition, diversity, richness and density of plant communities differ among three altitudinal gradient on Himalayan rangeland.

Materials and Methods

Study Area

The research work was conducted in the Milke-Jaljale Mountain ridge - political border of the three districts viz. Taplejung, Tehrathum and Sankhuwasabha, (27° 03' 30.5" N to 27° 22' 15" N and 87° 26' 09" E to 87° 34'14" E) of eastern Nepal (Figure. 1) on September 2012. The Tinjure-Milke-Jaljale (TMJ) mountain ridge starts from Tinjure Mountain (3030m) to Jaljale Mountain (4600 m). The altitude of the study site ranges from 3000 m asl to 4500 m asl and the average temperature is 10-15 °C and the average annual rainfall is 2250 mm. In fact, the area is the grazing ground of livestock (Yak, sheep, cow and buffaloes). Tree-line lies at 3800 m asl in the study area. The study area has two distinct areas i. e. cold, harsh climate and rocky mountain, which is above 3500 m asl and accessible and moderate climate below 3500 m asl. Usually, buffaloes and cows graze in lower belt on summer season in the meantime yaks and sheep are taken to rocky mountain, upper region. Dominant vegetation is *Agrotis micrantha*, *Agrotis pilosula*, *Carex* sp. The Tinjure-Jaljale ridge serves as a habitat corridor between Makalu-Barun Conservation Area, Nepal and Kanchenjunga Conservation Area, Nepal. Both of the conservation areas touch the Qomolongma Biosphere Reserve, Tibet (Koirala et al., 2011).

Research Design

After the reconnaissance survey, three altitudinal gradients having different species composition, altitudes slope and aspects were identied. We used a transect line method to enumerate the plant community in each sampling plot. Within each plot, we randomly selected a point to begin vegetation sampling (without any prior knowledge of plant community at that point) and marked it. From the central sampling point, we established 40 m transect and placed 90 cm^2 (30 cm x 2 cm) quadrats at every 10 m intervals along this transect. A total of 45 sample quadrats, 15 quadrats from each plot, were sampled at the study area.

Data analysis

The Shannon-Wiener Diversity Index, H, was calculated using the following equation:

H =*Pi*(lnP*i*), where P*i* is the proportion of each species in the sample. The Shannon-Wiener index values (H) can range from 0 to ~4.6 using the natural log (ln). Simpson's index is calculated with following equation:

$$D = \sum_{i=1}^{s} n(n-1)/N(N-1)$$

where n*i* - No. of individuals in the *i*th species; N - Total no. of individuals for all species. The Simpson's Index (D) can range from 0 to 1. Lower the values higher the diversity. Total species richness was simply taken as a count of number of species present in that study area. Species richness (number of species per unit area) was calculated as; R= S-1/ln (N); where R- Species richness, S-Number of species and N-T total number of individuals. Evenness expresses how evenly the individuals in the community are distributed over the different species.

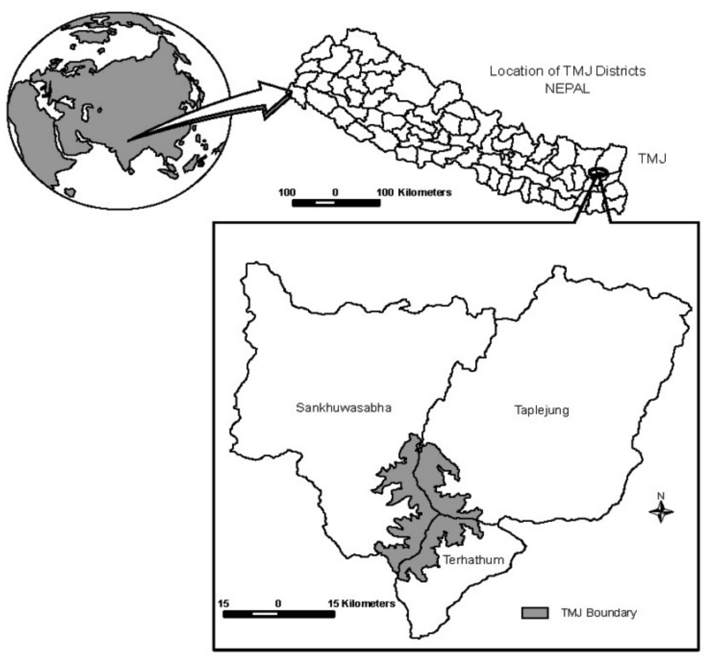

Figure 1: Tinjure Milke Jajale (TMJ) study area

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Results and Discussion

The plant community and diversity showed that 11 families comprised 14 genuses and 7 unidentified genuses in the study area. *Agrostis micrantha* (111.9) had the highest IVI value, *Poa* sp. (94.4) followed the second position and *Bistorta macrophylla*(9.56) had the least value in Jaljale area at 4000 m asl. Similarly *Prunella vulgaris* had the highest IVI value(81.38), an unidentified species followed the second position(51.84) and another unidentified species had the least value(3.89) in Gorujure area at 3500 m asl, *Swertia pedicellata* had the highest IVI value (50.05) and *Galium* sp. followed the second position(42.09) and *Poa annua* had the least value (3.89) in Milke area at 3000 m asl (Table 1). Evenness of plant community diversity was high in 4000 m asl. The difference between the highest and the lowest IVI values was 11 times the least IVI value in 4000 m asl. It was very low among the plant communities. Similarly, the difference between the highest and the least IVI values was 21 times the least IVI value in 3500 m asl. All diversity indices, viz. species richness, species evenness, Shannon-Wiener diversity index and Simpson's dominant index were highest at the lowest altitude and lowest value at highest altitude (Table 2). Species richness and species evenness were not sharply different among the study area, whereas Shannon-Wiener diversity and Simpson dominant indices were 2.0 and 3.4 times more in 3000 m asl than in 4000 m asl respectively.

Table 1. Relative frequency and IVI of the species in the various study area

Jaljale (4000 m)	**Total**	**RD**	**RF**	**RA**	**IVI**
Agrostis micrantha	1221	49.57	14.71	47.59	111.87
Agrotis pilosula	1008	40.93	14.71	39.29	94.92
Bistorta macrophylla	7	0.28	8.82	0.45	9.56
Cortiella sp.	12	0.49	11.76	0.58	12.84
Eupatorium adenophorum	56	2.27	11.76	2.73	16.77
Gentiana phyllocalyx	16	0.65	8.82	1.04	10.51
Poa sp.	11	0.45	8.82	0.71	9.98
Potentilla lineata	60	2.44	11.76	2.92	17.12
Ranunculus adoxifolius	72	2.92	8.82	4.68	16.42
Gorujure (3500 m)					
Agrotis micrantha	245	21.68	14.29	14.29	50.26
Carex nubigena	32	2.83	17.86	1.49	22.18
Carex sp.	470	41.59	17.86	21.93	81.38
Gentiana pedeallata	3	0.27	7.14	0.35	7.76
Persicaria alata	155	13.72	7.14	18.08	38.94
Potentialla lineata	37	3.27	7.14	4.32	14.73
Prunella vulgaris	22	1.95	7.14	2.57	11.66
Ranunculus adoxifolius	8	0.71	7.14	0.93	8.78
Unidentified species1	1	0.09	3.57	0.23	3.89
Unidentified species2	7	0.62	7.14	0.82	8.58
Unidentified species3	150	13.27	3.57	34.99	51.84
Milke (3000 m)					
Swertia pedicellata	113	8.00	12.20	4.45	24.64
Agrostis sp.	115	8.14	4.88	11.32	24.33
Carex nubigena	77	5.45	12.20	3.03	20.68
Carex sp.	214	15.15	12.20	8.42	35.76
Galium sp.	220	15.57	4.88	21.65	42.09
Hemiphragma heterophylla	29	2.05	9.76	1.43	13.24
Poa annua	22	1.56	4.88	2.16	8.60
Prunella vulgaris	34	2.41	12.20	1.34	15.94
Unidentified species4	199	14.08	12.20	7.83	34.11
Unidentified species5	30	2.12	4.88	2.95	9.95
Unidentified species6	93	6.58	4.88	9.15	20.61
Unidentified species7	267	18.90	4.88	26.27	50.05

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The ecosystems are organized to support high species diversity and richness in the setting where they evolved (Hamilton 1984; Hamilton and Bensted, 1990; Chapin et al., 1996; Newmark, 2002). It is found that higher the altitude, lower the plant diversity indices. Due to topographic condition, climatic harshness and edaphic factors, high altitude regions are nott for plant growth. In the region of the mountain ora, species number decreased with altitude, which suggests a relationship between species diversity and productivity (Brown and Gibson, 1983; Currie, 1991; Cox and Moore, 1993).

In this study, species richness, species evenness, Shannon-Wiener index and Simpson index showed a negative relationship with elevation.

The low elevation sites were relatively dense populated than those of high elevation sites, because human interference in these areas facilitates the introduction and establishment of non-native species (Rawal and Pangtey, 1994). A high altitude (4000 m asl) receives very low grazing pressure as it is covered with snow for three months in a year and is hardly accessible for cattle. Grazing is considered as one of the most important types of disturbances altering natural processes, affecting species persistence and in uencing the structure and composition of plant communities (Olff and Ritchie 1998). Grazing has been considered to be a complex disturbance affecting plant communities directly and indirectly (Hay and Kicklighter, 2001) by altering establishment, growth and survival rates of different species (Facelli and Springbett, 2009). Consequently, signi cant changes in plant species richness and composition are induced by grazing (Landsberg et al., 1999; Bergmeier and Dimopoulos, 2003). Many studies have attempted to nde the consequences of grazing on plant communities and have highlighted different responses of species with different functional traits (Landsberg et al., 1999).

A number of plant species found in the Himalaya exhibit varying patterns of distribution. This study revealed that plant diversity decreased with increasing elevation. Austin et al. (1996) have found that the total species richness was greatest at lower elevation and warmer sites. The extension of climatic gradient enabled several species to realize their fullest range of elevation adaptability. Pausas and Austin (2001) suggested that over any large region, the distribution of species richness is likely to be governed by two or more environmental factors and not by a single factor. High Himalayan regions have a thin soil layer, a low precipitation and low temperature resulting in a very harsh climate. These environmental factors are not good for plant growth. Temperature decreases with increasing elevation (Barry, 2008). If temperature were the main determinant for species richness with elevation, the pattern predicted decreasing diversity with increasing elevation (Heaney 2001; McCain, 2007).

Overgrazing, deforestation, temperature and erosion may be some of the factors responsible for the observed low species diversity (Malik and Malik, 2012). Species diversity was low due to less number of species in higher altitude and high diversity due to high number of species in lower altitude.

Table 2. Diversity value of study area

Diversity indices	Range value	Jaljale (4000 m asl)	Gorujure (3500 m asl)	Milke (3000 m asl)
Shannon- Wiener Index (H)	0 - 4.6	1.09	1.61	2.23
Species Evenness (E)	0 -1	0.12	0.15	0.19
Species Richness (S)		8.87	10.86	11.86
Simpson Index (D)	Reverse (0 -1)	0.42	0.26	0.12

Conclusions

It is concluded that because of edaphic factors, climatic factors and topographic position, the various diversity indices of plant community in the Himalayan rangeland was negatively correlated with elevation.

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