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Species Diversity and Dominance Pattern in a Temperate Grassland of Kashmir Himalaya

Research Article

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Abstract

Species richness, evenness, species diversity and concentration of dominance, computed on the basis of density of constituent species during months and seasons, were used to study the community organization of protected temperate grassland in Kashmir Himalaya. The vegetation showed a strong seasonal pattern reflected by high species richness and diversity during favourable seasons and low during unfavourable season. The species diversity revealed an inverse relationship with concentration of dominance. The relative species, abundance pattern confirmed to log-normal pattern indicative of a heterogeneous assemblage of species with relative abundance distribution governed by many independent factors.

Keywords: Species richness; Evenness; Species diversity; Relative abundance distribution; Dominance

Introduction

Species diversity is an important structural attribute of a natural community and there is increasing evidence from experimental studies that plant diversity can influence a variety of ecosystem functions [1,2] particularly productivity [3] and stability[4-10]. Although species diversity in strict sense is the number of species (richness) in a community, it also includes relative abundance pattern of the species which also has been shown to have marked influence on the structure and function of the community [11] and as such a number of attempts have been made to explain the species abundance and distribution pattern of both real and idealized communities [12-14]. For plants the most common view is that both abundance and distribution reflect species' relationships to resource availability (Mitchley and Grubb, 1986 and Mitchley, 1988)[15,16] but lately it has been shown that the 'mobile' dispersal phase also plays a role in determining species abundance pattern [17].

In view of the importance of such studies, a number of investigations have been conducted particularly on central Himalaya grasslands [18-22]to quantitatively analyse their community structure and function, but the temperate grasslands of Kashmir Himalaya are yet to be investigated hence the present study.

Study Area

The present studies were carried out on a grassland with flat topography located in Srinagar district, lying at an altitude of 1576 m, above mean sea level and protected from any biotic disturbance for last five years. The climate of the study area was temperate with four distinct seasons viz. spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). During the study period (March to next March) maximum temperature of about 30.1o C was recorded during summer while a minimum of about -3.6o C was recorded during winter (Figure 1). Annual precipitation of 345.9 mm during the study period was less than the annual average precipitation of 6.14.75 mm.

Materials and Methods

Twenty quadrats of 0.5 m2 size were randomly laid each month

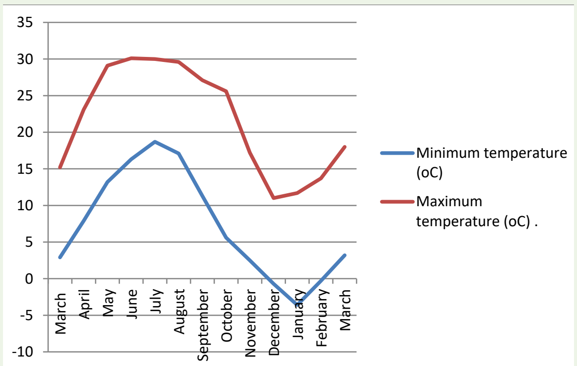

Figure 1: Minimum and maximum temperature in (oC) during study period in the study area.

during the study period to record the number of individuals of each species and the density of constituent species was calculated after Curtis and Cottom (1965). In case of runners each node was taken equivalent to an individual and in respect of other rhizomatous species each upright shoot was considered as an individual [23]. The diversity indices, evenness, concentration of dominance and species abundance pattern was determined on the basis of density using following formulae:

a) Diversity indices after [24]

N0 = Total number of species present

N1 = exp(Ĥ)

N2 = Reciprocal of Simpson's index

N0 = Total number of species present

b) Shannon-Wiener's index of general diversity after Shannon and Wiener (1949)[25]

Ĥ = -Σpilnpi

where pi is the proportion of the total number of individuals belonging to ith species

Ĥmax = log2S

where S is the total number of species

c)Equitibility or evenness indices

E1 = Ĥ/Ĥmax

E2 = (N2 -1)/(N1-1)/[26]

d) Concentration of dominance was by Simpson's (1949)[27] formula

C = Σ(Pi)2

where Ĥ, Ĥmax, N1, N2 and pi are same as defined earlier.

Relationship between various attributes was studied through correlation and regression analysis.

Observations

The effective number of species (N0) revealed a very characteristic pattern of high species richness in month of March with consistent decline in intervening months. Lowest number of species [12] was recorded during January. The species richness, computed on the basis of abundant species (N1), was highest during March 2020 but also recorded increase during June and November (Table 1). Richness on the basis of very abundant species (N2) exhibited bimodal pattern with one peak in June and other in March 2021. Irrespective of index of species richness, lowest value was recorded in January.

Evenness or Equitability

The evenness index (E1) revealed three peaks in months of March 2019, June and November (Table 1). Evenness revealed an entirely different pattern (E2) when worked after [26]. Data reveals a low evenness value during March 2020 followed by an increase till October but during November it recorded a sharp decline and in the succeeding months a more or less regular pattern of increase and decrease was observed with highest value observed during February.

Species diversity

Ĥmax (Table 1) shows a more or less a uniform trend up to November followed by a decline with lowest value recorded in January. A sharp increase, however, was recorded after January with Ĥmaxregistering a peak value in March 2021. Species diversity computed on the basis of Shannon-Weiner information (Ĥ) also reveals a similar pattern of lowest value during January and highest during March.

Concentration dominance

The dominance index (C) revealed a more or less uniform pattern up to December followed by a sharp increase attaining a peak value in January, though marginal decrease was recorded during June. A consistent decline, however, was recorded after January.

Discussion

The species richness in the present grassland reflects a seasonal pattern of maximum species richness during spring and minimum during winter. Such a seasonal pattern is indicative of the involvement of climatic variables chiefly precipitation and temperature pattern. The maximum species occurrence during spring could be attributed

Table 1: Species richness, evenness, diversity and concentration of dominance of the grassland during the study period.

Months	Species richness			Evenness		Species diversity		Concentration of dominance
	N_0	N_1	N_2	E_1	E_2	Ĥ	$Ĥ_{max}$	C
March	40	21.54	5.20	0.57	0.20	3.07	5.32	0.192
April	42	11.35	6.25	0.45	0.50	2.43	5.39	0.160
May	38	12.42	6.62	0.48	0.49	2.52	5.24	0.151
June	29	14.15	9.43	0.54	0.64	2.65	4.85	0.106
July	25	6.75	4.20	0.41	0.55	1.91	4.64	0.238
August	24	6.23	4.08	0.39	0.58	1.83	4.58	0.245
September	24	7.24	4.27	0.43	0.52	1.98	4.58	0.234
October	25	6.61	4.52	0.40	0.62	1.89	4.64	0.221
November	24	10.17	3.02	0.50	0.22	2.32	4.58	0.331
December	16	4.90	3.70	0.39	0.69	1.59	4.00	0.270
January	12	3.35	1.92	0.33	0.39	1.21	3.58	0.520
February	19	3.59	3.09	0.30	0.80	1.28	4.24	0.323
Mach	44	6.95	4.71	0.35	0.62	1.94	5.45	0.212

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to the prevalence of favourable climatic conditions while the very cold climatic conditions during winter may be responsible for low species richness. Analysis of the relationship between species richness (N0) and the climatic variables revealed that precipitation pattern had a significant influence on it explaining about 37% variability in species variability in species richness and the two were related according to the following equation:

$$Y = 0.3261X + 17.441 \ (r = +0.61, P<0.05)$$

However, temperature and species richness (N0) showed an insignificant positive correlation (r = +0.27). In addition to climatic variables, changes in species composition have been attributed to plant phenology [28], germination attributes [29-31]cycling and availability of mineral nutrients, especially nitrogen [32-36] photosynthetic strategy [37] and edaphic conditions [38]. Thus, the seasonality in the species richness observed in the grassland during the present study could be attributed to intrinsic species-specific characteristics and a variety of biotic factors, besides climatic factors particularly precipitation pattern.

Evenness, a measure of how similar are the abundances of different species [39,40], has been related to a number of factors like strong current completion [41], soil fertility [42] and succession [43-46]. A low value of evenness indicates that one or a few species are highly dominant, while as a high value of evenness indicates that all the species in the community have rather similar abundance. In the present study, indices of evenness, in general, reveal high values during favourable seasons of spring, summer and autumn but low during unfavourable winter season suggestive of dominance of cold tolerant species during winter while a more or less similar abundance of constituent species during other seasons.

Diversity index, based on Shannon-Wienner information, further strengthens our earlier conclusion of strong seasonal influence on the community organization as the grassland under study was more diverse when favourable climatic conditions prevailed and least diverse during winter when climatic conditions were unfavourable. Furthermore, diversity index showed a negative relationship with concentration of dominance (Figure 2). The negative relationship is presumably due to richness in species composition of the community leading to distribution of importance value among many species, rather than in few species. Such negative relationship has been reported by [46-49] Increase in plant species richness has shown to

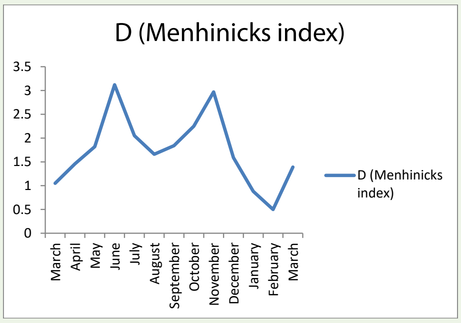

Figure 2: Spectrum of species richness (Menhinicks index, D) in the grassland during the study period.

increase above-ground biomass production [50-54]in experimental assemblages of grassland species, where species richness and functional composition were controlled through such a trend has not been observed in semi-natural grasslands [55,56]. In the present study also species diversity (log2S) and aboveground productivity did not reveal any significant positive relationship (r = +0.429) and species diversity explained only 18.44% of the variation in aboveground biomass.

The relative abundance pattern of species was used to interpret the nature and organization of the grassland community has been by [57,58,59]. The species – abundance curve (Figure 2) approached by the grassland under study, drawn by plotting log abundance (measured as density) and ranked from the most to the least abundant species, conforms neither to broken stick model nor to niche pre- emption model but conforms to log-normal relationship that indicates large and heterogeneous assemblage of species where abundance distribution pattern is governed by,many more or less independent factors [60] has further suggested that log-normal species abundance curve is reflective of communities in stable environments[61-64] and thus similar conclusions can be drawn for the grassland under study.

Climatic condition particularly temperature and precipitation have a positive effect on the species richness as indicated in the present study. High values of species richness during favourable seasons (with good temperature conditions) and low ones in unfavourable winter period indicates dominance of cold tolerant species during winter while a similar abundance of constituent species during other seasons. In the present study no significant relationship was found between species diversity and aboveground productivity. Shannon-Wienner diversity index in the present study showed a negative relationship with concentration of dominance. This seems due to richness in species composition of the community leading to distribution of importance value among many species, rather than in few species. The relative abundance pattern values of species in the present study indicates large and heterogeneous assemblage of species where abundance distribution pattern is governed bymany more or less independent factors. The values also indicate stability of the plant community under study.

References

1. Grime JP (1998) Benefits of plant diversity to ecosystems: Immediate, filter and founder effects. Journal of Ecology 86: 902-910.
2. Wiegand T, Snymann HA, Kellner K, Paruelo JM (2004) Do grasslands have a memory: Modeling phytomassofsemiaridSouth African grassland. Ecosystems 7: 243-258.
3. Hector A (1998) The effect of diversity on productivity: Detecting the role of species complementarity. Oikos. 82: 597-599.
4. Tilman D, Downing JA (1994) Biodiversity and stability in grasslands. Nature (London) 367: 363-365.
5. Wedin DA, Tilman D (1996) Influence of nitrogen loading and species composition on the carbon balance of grasslands. Science 274: 1720-1723.
6. McGrady-Steed J, Harris PM, Morin PJ (1997) Biodiversity regulates ecosystem periodicity. Nature 390: 162-165.
7. Naeem S, Shibin Li (1997). Biodiversity enhances ecosystem reliability. Nature 390: 507-509.

Citation: Ganaie MM, Reshi ZA. Species Diversity and Dominance Pattern in a Temperate Grassland of Kashmir Himalaya. J Plant Sci Res. 2021;8(2): 211

8. Peterson G, Allen CR, Holling CS (1998). Ecological resilience, biodiversity and scale. Ecosystems 1: 6-18.

9. Schlapfer F, Schmid B (1999) Ecosystem effects of biodiversity- A classification of hypothesis and cross-system exploration of empirical results. Ecological Applications 9: 893-912.

10. Spenhn EM, Joshi J, Schmid B, Diener M, Korner C (2000) Aboveground resource use increases with plant species richness in experimental grassland ecosystem. Journal of Ecology. 14: 326-337.

11. Putman RJ, Wratten SD (1984) Principles of Ecology University of California Press, Berkeley, USA.

12. May RM (1975) Patterns of species abundance and diversity. In: R. M. May (Ed.). Theoretical Ecology-Principles and Applications. Blackwell, Oxford 197-227.

13. Crawley MJ (1997) The structure of plant communities. In: M. J. Crawley (Ed.). Plant Ecology. pp. 475-531. Blackwell. Oxford.

14. Gaston KJ and Kunin WE (1997). Rare- common differences: An overview. In: W. E. Kunin and K. J. Gaston (Eds.). The Biology of Rarity: Chapman and Hall, London. 12-29.

15. Mitchley J, Grubb PJ (1986) Control of relative abundance of perennials in chalk grassland in southern England. I. Constancy of rank order results of pot- and field-experiments on the role of interference. Journal of Ecology. 74: 1139-1166.

16. Mitchley J (1988) Control of relative abundance of perrenials in chalk grassland in southern England. II. Verical canopy structure. Journal of Ecology 76: 341-350.

17. Eriksson O, Jakobsson A (1998) Abundance, distribution and life histories of grassland plants: A comparative study of 81 species. Journal of Ecology 86: 922-933.

18. Semwal JK, Gaur RD, Purohit AN (1981) Floristic pattern of Tungnath alpine zone in Garhwal Himalaya. Acta Botanica Indica 9: 110-114.

19. Ram J (1988) Phytosociology and primary productivity of an alpine grassland in Garhwal Himalaya. Ph.D. Thesis, Kaumaun University, Nainital.

20. Rawat DS, Dangwal LR, Gaur RD (1994) Plant communities in alpine habitat with special reference to Garhwal Himalaya. In: Y. P. S. Pangtey and R. S. Rawal (Eds.) High Altitude of the Himalaya.GyanodyaPrakashan, Nainital 65-75.

21. Nautiyal B, Pandey PN Bhatt AB (1997) Analysis of vegetation pattern in an alpine zone in northwest Himalaya: A case study of Garhwal Himalaya with reference to diversity and distribution patterns. International Journal of Ecology and Environment 23: 49-65.

22. Raizada A, Joshi SP, Srivastava MM (1998) Composition and vegetational diversity in an alpine grassland in the Garhwal Himalayas. Tropical Ecology 39: 133-141.

23. Singh JS (1969) Influence of biotic disturbance on the preponderance and interspecific association of two common forbs in the grassland at Varanasi. Tropical Ecology 10: 59-71.

24. Hill MO (1973) Diversity and evenness: Aunifying notations and its consequences. Ecology 54: 427-432.

25. Shannon CE, Weaner W (1949) The Mathematical Theory of Communications. University of Illinois Press, Urbana, USA.

26. Alatalo RV(1981). Problems in the measurement of evenness in ecology. Oikos 37: 199-204.

27. Pielou EC (1969) An Introduction to Mathematical Ecology. John Wiley& Sons Inc., New York. 286

28. Day TA, Delting JK (1990) Grassland patch dynamics and herbivore grazing preference following urine deposition. Ecology 71: 180-188.

29. Gulmon SL (1992) Patterns of seed germination in Californian serpentine grassland species.Oecologia(Heidelb) 89: 27-31.

30. Morris CD, Tainton NM (1993) The effect of defoliation and competition on the regrowth of ThemedatriandraandAristidajunciformis subsp. junciformis. African Journal of Range and Forage Science 10: 124-128.

31. Szente K, Nagy Z, Tuba Z, Fekete G (1996) Photosynthesis of Festucarupicola and Both riocholaischaemum under degradation and cutting pressure in a semi-arid loess grassland. Photosynthetica(Prague) 32: 399-407.

32. Hoyle G. L., S. E. Venn, K. J. S R B G E J MA E R W A B N

33. Tilman D (1987) Secondary succession and patterns of plant dominance along experimental nitrogen gradients.Ecological Monograph. 57: 189-214.

34. Gibson DJ, Seastedt TR, Briggs JM (1993) Management practices in tallgrass prairie: large-and small- Scale experimental effects on species composition. Journal of Applied Ecology 30: 247-255.

35. Wedin DA, Tilman D (1993) Competition among grasses along a nitrogen gradient: Initial conditions and mechanism of competition. Ecological Monographs 63: 199-229.

36. Blair JM, Seastedt TR, Rice W, Ramundo RA (1998) Terrestrial nutrient cycling in tallgrass prairie [In: A. K. Knapp, J. M. Briggs, D. C. Hartnett. Grassland Dynamics- Long-Term Ecological Research. Oxford University Press, New York 222-243

37. Fekete G, Tuba Z, Precsenyi I 1995. Application of three approaches to evaluate abundance and rarety in a sand grassland community. Coenoses 10: 29-38.

38. Keubach W, Virch G, Bach F (1994) Changes in botanical composition of intensively used grassland during a process of denitrification. Wirtschaftseigne Futter 40: 101-110.

39. Pielou EC (1977). Mathematical Ecology. John Wiley and Sons, New York.

40. Bulla L (1994) An index of evenness and its associated diversity measure. Oikos 70: 167-171.

41. Cotgreave P, Harvey P (1994). Evenness of abundance in bird communities. Journal of Animal Ecology 63: 365-374.

42. Wilson JB, Wells TCE, Trueman IC, Jones G, Atkinson MD, (1996) Are there assembly rules for plant species abundance? An investigation in relation to soil resources and successional trends.Journal of Ecology 84: 527-538.

43. Odum EP (1969) The strategy of ecosystem development. Science 164: 262-270.

44. Nicholson SA, Monk CD (1974). Plant species diversity in old-field succession on the Georgia Piedmont.Ecology 55: 1075-1085.

45. Symonides E (1985) Floristic richness, diversity, dominance and species evenness in old-field successional ecosystems. Ekologia Polska 33: 61-79.

46. McNaughton S J (1967). Relationships among functional properties of Californian grasslands. Nature. 216: 168-169.

47. Precsenyi I (1973) Relationship between structure and function characteris in steppe-meadows in Hungary.Acta Bot. Acad. Sci. Hung (Budapest) 18: 155-162.

48. Singh UN, Ambasht RS (1975) Relationship among diversity, dominance stability and net production in an Indian grassland. Indian Journal of Ecology 2: 110-114.

49. Singh JS, Misra R (1969) Diversity, dominance, stability and net production in grasslands at Varanasi. Canadian Journal of Botany 47: 425-427.

50. Hector A (1998) The effect of diversity on productivity: Detecting the role of species complementarity. Oikos. 82: 597-599.

51. Hooper DU, Vitousek PM (1997) The effects of plant composition and diversity on ecosystem processes. Science 277: 1302-1305.

52. Naeem S, Hakansson K, Lawton JH, Crawley MJ, Thompson LJ (1996). Biodiversity and plant productivity in a model assemblage of plant species. Oikos 76: 259-264.

Citation: Ganaie MM, Reshi ZA. Species Diversity and Dominance Pattern in a Temperate Grassland of Kashmir Himalaya. J Plant Sci Res. 2021;8(2): 211

53. Tilman D (1992) Biodiversity: Population versus ecosystem stability. Ecology 77: 350-363

54. Czarnieka-Wiera M, Kacki Z, Chytry M, Palpurina S (2019) Diversity loss in grasslands due to the increasing dominance of alien and native competitive herbs. Biodervity and Conservation. 28: 2781-2796.

55. Gough L, Grace J, Taylor K (1994) The relationship between species richness and community biomass: The importance of environmental variables. Oikos. 70: 271-279.

56. Grime JP (1973) Control of species density in herbaceous vegetation. Journal of Environmental Management 1: 151-167.

57. Whittaker RH (1965) Dominance and diversity in land plant communities. Science 147: 250-260.

58. Whittaker RH, Woodwell GM (1969) Structure, production and diversity of the oak pine forest at Brookhaven, New York. Journal of Ecology 57: 155-174.

59. Sinha A, Rana RS,Gupta SR(1988). Phytosociological analysis of some natural grassland communities of sodic soils. Tropical Ecology 29: 136-145.

60. Stenseth NC (1979) Where have species gon? On the nature of extinction and the Red Queen Hypothesis. Oikos 33: 61-79.

61. Gibson DJ (2009) Grasses and Grassland Ecology.Oxford University Press, Oxford, UK.

62. Simpson EH (1949) Measurement of diversity. Nature163: 688.

63. Odum EP (1971) Fundamentals of Ecology (3rdedn.)- Philadephia 1-574.

64. Olff H, Pagtel DM, Van Groendael JM, Bakker JP (1994) Germination strategies during grassland succession. Journal of Ecology 82: 69-77.

Citation: Ganaie MM, Reshi ZA. Species Diversity and Dominance Pattern in a Temperate Grassland of Kashmir Himalaya. J Plant Sci Res. 2021;8(2): 211