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Research article

Similarity and difference of species among various plant communities across grassland vegetation of north-eastern Uttar Pradesh

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Abstract: The grassy landscape as a mosaic of grassland patches presented 287 species in the sampled quadrats which represented 177 genera under 53 families. The species composition of different sites varied significantly and the species richness increased with the heterogeneity of communities. Some communities were found to be homogenous possibly due to similar ecological conditions. The highly disturbed communities showed reduced dominance and sprouting of many exclusive species in the communities. A few species, common to most of the concrete communities were *Aneilema nudiflora, Cynodon dactylon, Evolvulus nummularis, Desmodium triflorum, Lindernia decussata, L. ciliata* and *Rungia repens*. These species also showed high presence and constance values indicating their wide ecological amplitude to cover various microhabitats. The cluster analysis also showed distinct patterns of presence for various grassland communities. Few communities showed more similarity among themselves, suggesting quite similar structural and floristic patterns, probably due to better survival of common species. The heterogeneity of communities may be created by habitat degradation, climate and soil conditions, overgrazing, trampling and soil erosion in an area. Few species, which could not survive the severity of these factors, added heterogeneity to the grassy landscape.

Keywords: Grassland communities - Habitat factors - Synthetic characters - Fidelity - Similarity indices.

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INTRODUCTION

Plant community is a dynamic entity of vegetation (Cowles 1901). A community may also be defined as aggregation of living organism having mutual relationship among themselves and to their environment (Oosting 1948). The structure of any plant community has been conventionally assessed through various phytosociological attributes (Braun-Blanquet 1932, Mueller-Dombois & Ellenberg 1974). The structure and composition of plant community can be described on the basis of several quantitative and qualitative characteristics. Synthetic characters provide a picture of organization and characteristics of an abstract community or landscape.

Braun-Blanquet & Pavillard (1922–1928) recognized five fidelity classes. For the understanding of the degree of association between species and of similarity between stands, some mathematical treatments in the form of similarity indices were given by Sorenson (1948). Further summarization of data was made possible through ordination (Bray & Curtis 1957, Whittaker 1975) and vegetation mapping (Kuchler & McCormick 1965). In comparing species composition of two or more assemblages or communities, similarity or dissimilarity indices provide quantitative bases of assessment (Magurran 2004). The degree of similarity or dissimilarity between any two concrete communities may be shown by cluster analysis (Chahouki 2012). The present study focuses on the synthetic characters like presence, constance and fidelity status of species and on the degree of similarity among various communities. The multilateral relationship of plants and environmental variables within different concrete communities has also been analyzed.

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MATERIALS AND METHOD

Study area

The *Terai* region is a belt of marshy grasslands, savannahs, and forests located south of the Siwalik foothills and north of the Indo-Gangetic Plain. The region is sandwitched between the Bhabhar tract of the sub-Himalayas and the main Gangetic Plain. The plains of north-eastern Uttar Pradesh cover 14 districts and occupy 45,760 km^2 areas. The climax vegetation is forest which now remains only in patches (Bajpai *et al.* 2012). Most of the area has been cleared for agriculture and the abandoned and vacant lands are subjected to recurrent disturbances in the form of grazing, trampling, fire. The grassland vegetation characterises the vegetational landscape which is traversed by many rivers, rivulets and nullahs and also possess a number of lakes and ponds. The regional plain slopes gently from northwest to southeast. The landscape presents a mosaic of plant communities with varying amount of grasses and forbs of contrasting life-forms. The grassland presents a stage of arrested succession under the influence of recurrent biotic disturbances. The composition of various grassland communities appears to vary in relation to the types of disturbance, soil types and soil moisture regimes.

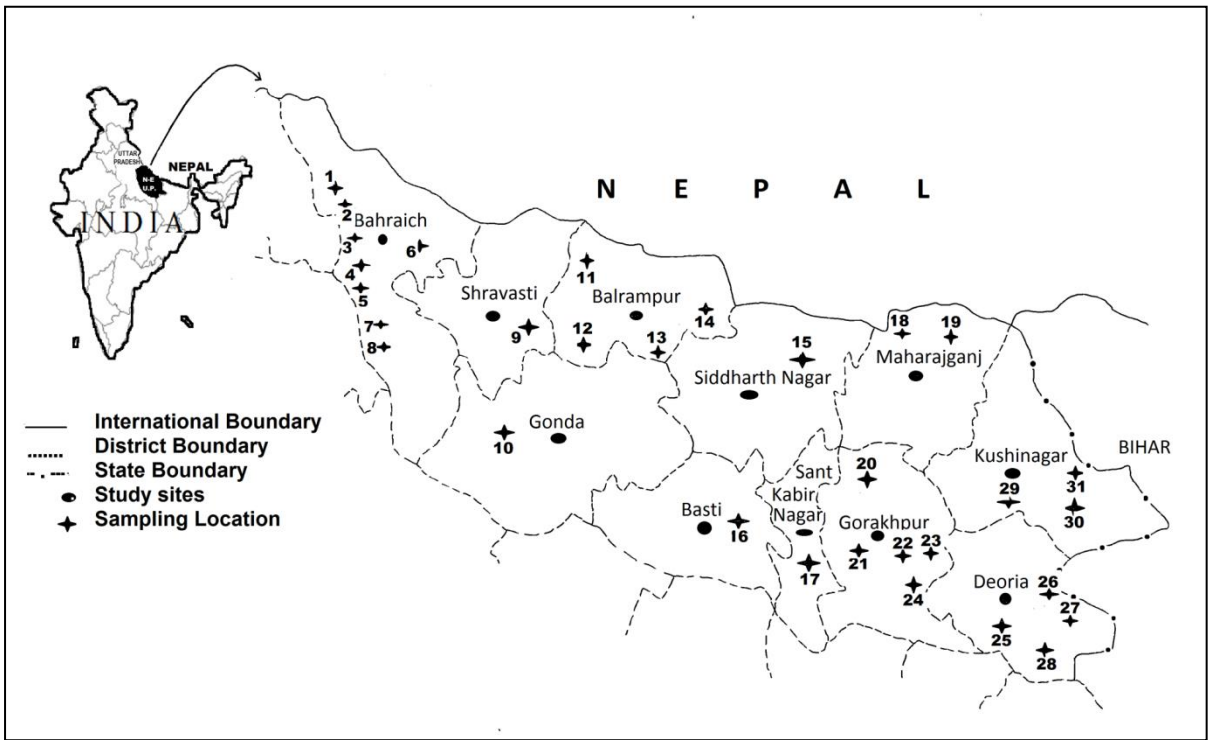


Figure 1. Map showing the study sites and sampling locations (1–31).

Climate and *Soil*

The climate of the region is typically tropical monsoonal with 3 distinct seasons, *viz.* summer (March to mid-June), monsoon (mid-June to mid-October) and winter (mid-October to February). Average annual rainfall is about 1704mm for the entire study region, with 91% occurring during the wet summer. The numbers of rainy days per annum is 51±3.2 and mean relative humidity is about 87% in the morning and 74% in the evening. The eastern *Terai* plains receive more rainfall over a longer period and possess much richer plant biodiversity as compared to the western and southern districts of the state. Mean maximum temperatures during wet summer, winter and dry summer seasons are 23.3, 23.71 and 36.23^{o}C and mean minimum temperatures are 23.9, 10.34 and 21.28^{o}C, respectively (Indian Metrological Department 2012–2014). The soil of the region is part of the trans-Sarju Plains and comprises Gangetic alluvium brought down by rivers like Ghaghara, Rapti, Rohin and Gandak from the Himalayas in the north. The texture is sandy loam and pH is near neutral. In the northern area, there are a few elevated mounds, locally called *dhus*, which have brown sandy soil and range in sizes from a few hundred to five thousand square meters.

Vegetation

The growing season spans from mid-June to mid-September, when most species flower and set seeds. The general grassland vegetation of *Terai* of north-eastern Uttar Pradesh is interspersed with patches of forest, old

fields, open pasture, upland mounds (*dhus*), lowlands, orchards, playgrounds and human settlements. The important tall grasses include the species of *Saccharum, Phragmites, Arundo, Themeda* and *Erianthus* etc. Some short grasses like the species of *Imperata, Andropogon* and *Aristida* are also there. Several upland areas are covered with forests dominated by sal (*Shorea robusta*). The belt also contains riverside tropical deciduous forest commonly comprising the species of *Mallotus, Syzygium, Bombax, Trewia* and *Garuga*.

Methods

We started this study in June 2011 with a general survey of the vegetation and habitat conditions over a vast stretch of grassy landscape of *Terai* of north-eastern Uttar Pradesh, encompassing more than 11 districts and covering about 128,076 ha of a total 36,015 km^2 geographical area (Fig.1). Finally, 31 locations, showing marked differences in habitat conditions, were selected and sampled during August 2011 to March 2014. Twenty quadrats each of 50 cm × 50 cm size were randomly laid down at each locations. Thus, a total of 620 quadrats were sampled across the regional grassy landscape. The locations with quite similar species composition and habitat conditions were pooled into 22 distinct communities or habitat types (Srivastava *et al.* 2015). The synthetic characters were derived treating each sub-community as concrete community and the composite community as an abstract community.

The number of concrete communities in which a particular species occurred was expressed as percentage of total concrete communities to derive the presence value of that species. Since 20 quadrats each of 50 cm × 50 cm were sampled per concrete community, a total sampled area per concrete community was $5m^2$ based on which the constance of different species was determined. The species were grouped into five different fidelity classes as per their faithfulness or restriction of occurrences to various communities. Thus the presence, constance and fidelity classes of species were derived and the similarity indices between any two concrete communities were determined (Oosting 1956).

The degree of similarity between any two communities has been expressed mathematically on the basis of quantitative characters i.e. frequency. The index of similarity (Is) between any two communities was estimated by Sorenson's (1948).

$$\mathrm{Is} = \frac{2C}{A + B} \times 100; \qquad \mathrm{Id} = 100 - \mathrm{Is}$$

Where,

C = sum of common species between any two communities
A = Sum of all the species of community A.
B = Sum of all the species of community B.

Data analysis

The data was analyzed by using PAST (Paleontological Statistics software) Version 2.17 (Hammer *et al.* 2001, Bajpai *et al.* 2015). The presence/absence values were used to calculate the degree of similarity among various communities using cluster analysis in PAST following the Bray–Curtis method.

RESULT

Presence, Constance and Fidelity:

Distribution of number of species falling under five different presence classes are shown in figure 2A. The highest number of species (175) was noticed in presence class A and least number in class E. 199 of the total species, fell under constance class A followed by 48 species in class B, 21 species in class C and 14 species in class D and 5 species in class E. The most dominant species namely *Desmodium triflorum, Evolvulus nummularis, Lindernia deccusata, Oldenlandia corymbosa* and *Rungia repens* represented constance class E across the grassy landscape community (Fig. 2B). The grouping of species according to the degree to which a species is restricted to a particular concrete community has been represented in the form of five fidelity classes (Fig. 2C). It is evident from the figure that the maximum number of species generally found in fidelity class 2 that represent generalist species and approximately similar number of species observed within fidelity classes 1 and 4. The least number of species were observed in fidelity class 5 which explain their exclusives status and indicator value.

Cluster analysis:

The commonness of species that exist within various plant communities are represented in figure 3. The highest similarity was (70%) between community O and R followed by communities F and H (67%), E and V

(63%), R and U (61%) and Q and T (61.5%). The least similarity (0.22%) was observed between community J and C.

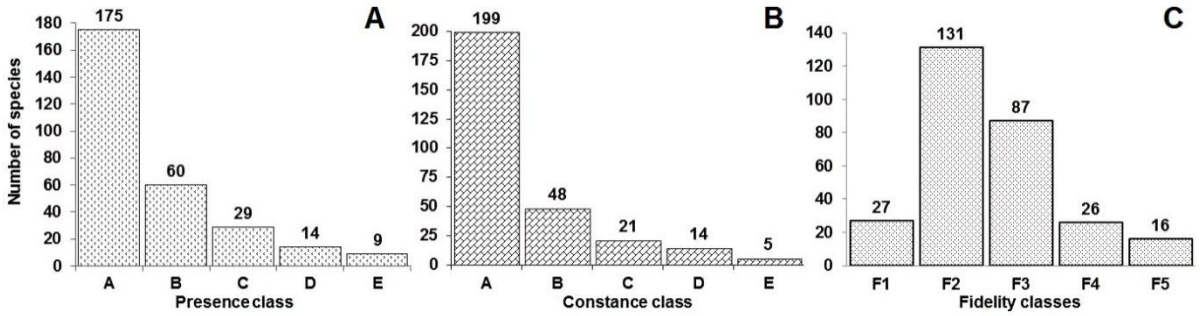
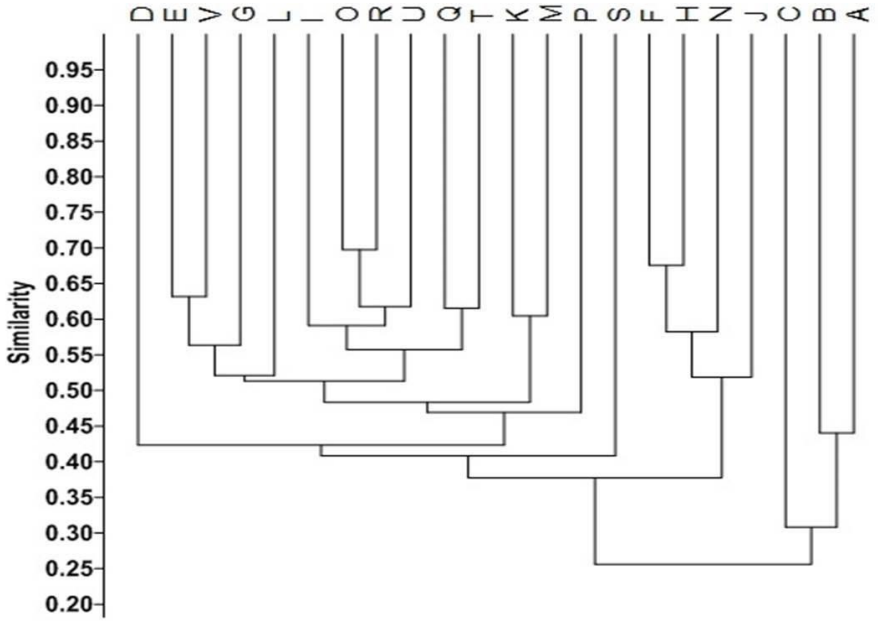


Figure 2: Number of species of grassland community: **A,** Presence classes; **B,** Constance classes; **C,** Fidelity classes.



Community	Ecological Factors
A	Lo, Mh, C, Dh
B	Lo, Mh, C, Dm
C	Lo, Mh, C, Dl
D	Lo, Ma C, Dm
E	Lo, Ma, CL, Dm,
F	Lo, Ma, SL, Dm
G	Lo, Ml, L, Dh
H	Lo, Ml, SL, Dh,
I	Lo, Ml, CL, Dm
J	Lo, Ml, S, Dm
K	Lo, Ml, SL, Dl
L	Lo, Ml, C, Dl
M	Lo, Ml, SL, Dl
N	Lps, Mh, SL, Dh
O	Lps, Mh, CL, Dh
P	Lps, Mh, CL, Dm
Q	Lps, Ma CL, Dh
R	Lps, Ma, SL, Dh
S	Lps, Ma, CL, Dm
T	Lps, Ma, G, Dl
U	Lps, Ml, SL, Dm
V	Lps, Ml, SL, Dl

Figure 3. A bray-Curtis presence/absence based similarity indices between any two of the 22 communities occurring under different ecological set ups as determined by 2 ***light regimes*** (O= open; PS= partial shade), 3 ***moisture regimes*** (LM= low moisture; AM= average moisture; HM= high moisture), 3 ***disturbance regimes*** (HD= high disturbance; MD= moderate disturbance; LD= low disturbance) and 6 ***textures of soil*** (SS= sandy soil; LS= loamy soil; CS= clayey soil; CLS= clayey loam soil; SLS= sandy loam soil; GS= gravelly soil).

DISCUSSION

The relatively low number of shared species among the communities is not surprising because of the irregular and heterogeneous nature of the environment (Swaine 1996) within the communities due to natural as well as anthropogenic disturbance (Mwavu 2007). Some communities were found to be homogenous possibly due to similar ecological conditions. These ecologically similar communities created habitats for similar composition of herbaceous plants (Durrani 2010). A few species, common to most of the concrete communities were *Aneilema nudiflora*, *Cynodon dactylon*, *Evolvulus nummularis*, *Desmodium triflorum*, *Lindernia decussata*, *L. ciliata* and *Rungia repens*. These species also showed high presence and constance values indicating their wide ecological amplitude to cover various microhabitats (Oosting 1956). A maximum number of species falling under constance classes A and B, indicates considerable floristic heterogeneity and presence of ephemeral adventives in the landscape.

The characteristic species is an important concept of community classification (Whittaker 1962, Westhoff & van der Maarel 1973). They include species which preferably occur in a single community (character species) or in a few communities (differential species). The concept of characteristic species has been associated with fidelity, which is a measure of species concentration in a community (Szafer & Pawłowski 1927). The much greater number of exclusive species may be attributed to conditions in terms of disturbance and resource. Most of the exclusive species had erect habit with foliage crown which may be related to low level of disturbances in

the form of grazing, clipping and trampling. Regular clipping inhibited them to grow at various site. The highly disturbed communities showed reduced dominance and sprouting of many exclusive species in the communities. Few communities had more exclusive species, possibly due to the removal of disturbance-vulnerable species. Similar observation was made by Overbeck et *al.* (2005). Few exclusive species like *Alternanthera pungens, Baccopa monnieri, Basella alba, Chrysanthellum indicum, Crotolaria calycina, Cyperus niveus, Evolvulus alsinoides, Heliotropium ovalifolium, Indigofera linnaei, Ipomea aquatica, Ludwigia adscendens, Oxystelma secamone, Perotis indica, Spermacoce pusilla* and *Tribulus terrestris* fell under fidelity class 5. These species are site-specific and encountered in the habitat conditioned by certain level of a few ecological factors. Ecological amplitude of a species is the capacity of growing and reproducing within a definite range of environmental conditions (Good 1974). Few other species- *Alysicarpus bupleurifolius, Astercantha longifolia, Cynoglossum lanceolatum, Elaphantopus scaber, Ficus heterophylla, Hemarthria compressa, Ionidium suffruticosum, Lindernia antipoda, Ludwigia octovalis, Sphenoclea zeylanica* and *Zephyranthes citrina* were habitat specific and were found in only one community. They occurred very rarely in any other communities.

Although cluster analysis showed a distinct pattern for grassland communities, patterns among each clustering group were not uniform. Few communities showed more similarity among themselves both in cluster as well as in ordination analysis, suggesting a structural and floristic pattern, probably due to the survival of common species (Müller *et al.* 2007). Degree of similarity between plant communities allows combining them into an association of plant species. According to Muller- Dumbois & Ellenberg (1974) and Chao *et al*. (2006; 2008), communities having less than 65% similarities are regarded as dissimilar. The highest index of similarity was reported in four communities (O & R and F & H). These communities showed more than 65% of similarity. The lowest similarity occurred in two communities (C and J). These communities which have low similarity value were also composed of a large number of annuals. These results were in accordance with those of Shah *et al*. (1991).

CONCLUSION

A few species, common to most of the concrete communities showed high *presence* and *constance* values indicating their wide ecological amplitude to cover various microhabitats. Most of the exclusive species had erect habit which indicated low level of disturbance in the form of grazing, clipping and trampling. Several exclusive species showed efficient sprouting. Only few communities showed significant number of exclusive species. Few exclusive species were habitat specific and were found in only one community. Although cluster analysis showed distinct patterns for grassland communities, patterns among each clustering group were not uniform. Few communities also showed high similarity among themselves.

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