PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.3691

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Phytosociological study of a Grassland community of Baripada, Mayurbhanj district of Odisha, India: Conservation strategies for floristic diversity

Ananta Kumar Nayak[1] & Kamal L. Barik[2*]

[1]Department of Botany, Maharaja Purna Chandra Autonomous College, Baripada-757003, India
[2]Department of Botany, Maharaja Sriram Chandra Bhanja Deo University, Baripada-757003, India

*Email: lochannou@gmail.com

OPEN ACCESS

ARTICLE HISTORY
Received: 10 April 2024
Accepted: 16 June 2024
Available online
Version 1.0 : 14 July 2024

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Nayak AK, Barik KL. Phytosociological study of a Grassland community of Baripada, Mayurbhanj district of Odisha, India: Conservation strategies for floristic diversity. Plant Science Today (Early Access). https://doi.org/10.14719/pst.3691

Abstract

A phytosociological study of the grassland community at Maharaja Purna Chandra Autonomous College (21°93'N; 86°76'E) was conducted from July 2022 to July 2023. The study aimed to understand the floristic diversity and propose conservation strategies. A rigorous data collection methodology was implemented using 1 m × 1 m quadrat sampling, and the findings were analyzed and presented using a novel approach. Parameters such as occurrence (+) and non-occurrence (-) of species, frequency, density, abundance, basal area, basal cover, and Important Value Index (IVI) were recorded for 36 species (18 grasses and 18 non-grasses) throughout the research period. The study revealed that certain species, including *Chrysopogon acciculatus* and *Evolvulus nummularius*, exhibited high frequency, density, abundance and IVI throughout the research period. Conversely, *Eragrostis unioloides* and *Sida cordifolia* showed the lowest IVI during the study. Basal area and basal cover data indicated an inverse relationship between grasses and non-grasses. The total Relative Frequency (RF), Relative Density (RD), and Relative Dominance (RDo.) of the community were consistently around 100 for each month, and the total IVI values were approximately 300 each month. These results underscore the need for effective conservation strategies to preserve the unique floristic diversity of this grassland community. The remarkable phytosociological attributes of this experimental grassland community may be attributed to the topography, soil composition, and climatic conditions of the locality.

Keywords

basal cover; important value index; phytosociology; relative dominance; topography

Introduction

Grasslands are one of the major ecosystems in the world, crucial for preserving biodiversity and maintaining ecological functions. Phytosociological parameters are used to access the floristic diversity, community structure, and functions of a grassland community (1). Phytosociology also evaluates species diversity, species richness, species evenness, and dominance within a grassland community (2–11). Phytosociology of a community also changes with the seasons (12). Grasslands are major habitats for grazing animals, insects, and small birds, maintaining a balanced food chain among producers, consumers, and decomposers (13–17). Grasslands play a crucial role in carbon sequestration worldwide (18). However, as population grows, grasslands are increasingly converted to agricultural land for food production. Habitat destruction, overgrazing, industrialization, and other anthropogenic effects disturb grassland communities. Globally, grasslands are under threat from land-use change and urbanization, leading to loss of biodiversity, productivity and biomass (19). The conservation of grassland biodiversity is urgent and can be aided by phytosociological analysis of different grassland communities. National and international research organizations are actively engaged in studying and conserving grasslands across various regions. However, a notable gap exists in research and conservation efforts concerning the grassland community associated with Maharaja Purna Chandra Autonomous College. Considering these facts, the present research was designed to study the Phytosociological of this specific grassland community to aid in the conservation of floristic diversity and promote its sustainable use.

Materials and Methods

Study area

The experimental grassland community (Fig. 1) was selected at Maharaja Purna Chandra Autonomous College (21°93'N; 86°76'E). To avoid grazing and anthropogenic disturbances, the experimental site was fenced with bamboos. The flora of the community was allowed to grow without any biotic interference under natural climatic conditions. The phytosociological attributes of the experimental grassland community were subsequently studied.

Phytosociological study

To determine the phytosociological attributes, systematic sampling was conducted using 1 m × 1 m quadrats, following the methods described by earlier researchers (20, 21). A total of 100 quadrats were randomly placed across various sections of the grassland community each month. In each quadrat, species occurrence was analyzed, recording presence with a "+" signs and absence with a "-" sign. Frequency, expressed as a %, was calculated by determining the proportions of quadrats in which a particular species occurred. Density, representing the number of individuals of a species per unit area, was quantified within each sampled quadrate. Abundance, a measure of overall species abundance, was estimated using appropriate methods. The ink pad and graph sheet method (22) for calculating basal area involved measuring the cross-section of each species by cutting the stem above the ground and pressing the lower transverse section onto an ink pad. The impression of the cross-section was then transferred onto graph paper with a 1 cm interval grid. By counting the number of squares covered by the cross-section on the graph paper, the basal area of the species was determined. This method provided a direct and visual way of calculating basal area and was useful for assessing the relative contribution of different species in a given area. Basal cover, indicating the ground area occupied by a species, was also assessed. The Important Value Index (IVI) was calculated by integrating occurrence, frequency, density, and abundance data, providing insights into the relative importance of each species within the grassland community. The formula for calculating the phytosociological data were used, and the analysis (23, 24) was conducted using Microsoft-Excel 2007 software. Microsoft Excel spread sheets were also used to create graphs, tables, and interpret the data.

$$\text{Frequency} = \frac{\text{Number of quadrates in which the species occurs}}{\text{Total number of quadrates sampled}} \times 100$$

$$\text{Density} = \frac{\text{Total Number of individuals of the species}}{\text{Total area sampled}} \qquad \text{Eqn.02}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}} \qquad \text{Eqn.03}$$

Relative Frequency (RF), Relative Density (RD) and Relative Dominance (RDo.) were also obtained using formula-

$$RF = \frac{\text{Number of individuals observed for a species}}{\text{Total number of individuals of all species observed}} \times 100 \qquad \text{Eqn.04}$$

$$RD = \frac{\text{Number of individuals of that species}}{\text{Total number of individuals of all plant species}} \times 100 \qquad \text{Eqn.05}$$

$$RDo = \frac{\text{Basal area of a species}}{\text{Total basal area of all species}} \times 100 \qquad \text{Eqn.06}$$

The Important Value Index (IVI) is indeed calculated by adding the RF, RD and RDo. of each species within a community

IVI = RF + RD + RDo.

Results and Discussion

The phytosociological analysis of this particular grassland community was conducted by collecting baseline data monthly from July 2022 to July 2023. The floristic diversity study identified a total of 36 species (Supplementary Fig.1) within the grassland community, comprising 18 grasses and 18 non-grasses (25). The occurrence and non-occurrence data are crucial for understanding species composition, population dynamics, and the overall ecological health of the grassland community (Supplementary Table 1).

Several parameters were investigated to assess the species composition and ecological characteristics of the experimental site. These included frequency (%), density, abundance, basal area, basal cover, and Importance Value Index (IVI). Among these grasses, *Chrysopogon acciculatus*, *Cynodon dactylon*, and *Aristida setacea* exhibited high frequency (%) throughout the sampling period. Similarly, among the non-grasses, *Desmodium triflorum*, and *Evolvulus nummularius* showed consistently high frequency (%). This indicates that these species were consistently present and abundant in the grassland community. Conversely, *Eragrostis unioloides* (grass) and *Sida cordifolia* (non-grass) exhibited lower frequency percentages, suggesting they were less frequently encountered during the study period, indicating potential variations in their occurrence or abundance. Furthermore, the study observed that the frequency (%) of both grasses and non-grasses was highest in October and lowest in April, as indicated in the Supplementary Table 2. This variation pattern suggests seasonal dynamics in species occurrence within the grassland community, with higher species frequencies in October and lower frequencies in April throughout the sampling period.

The densities of various species within the grassland community were studied throughout the experimental period. Among the grass species, *C. acciculatus*, *C. dactylon, A. setacea*, and *Eleusine indica* exhibited the highest density values, indicating they were more densely distributed with a greater number of individuals/sq m compared to other grass species. Similarly, among the non -grass species, *E. nummularius*, *D. triflorum*, *Scleria lithosperm*, and *Alternanthera sessilis* showed the highest density values, suggesting a greater number of individuals/ sq m compared to other non-grass species in the grassland community. The peak density of the entire community, reaching 1893.1 individuals/sq m, was observed in September. Within this peak density, grasses contributed 1109 individuals/sq m, while non-grasses contributed 784.1 individuals/sq m. In contrast, the lowest density value of 269.4 individuals/sq m was observed in April, with grasses contributing 152.7 individuals/sq m and non-grasses contributing 116.7 individuals/sq m (Supplementary Table 3). This information underscores the variation in density among different species and highlights the dominance of grasses in the grassland community throughout the study period.

The abundance of species within the community showed seasonal variation, declining gradually from October to May and then increasing from May onwards, peaking in September. The highest abundance recorded was 2809.8 individuals/sq m in September, with grasses contributing 1530.6 individuals/sq m and non-grasses contributing 1279.2 individuals/sq m. Throughout, the study period, *C. acciculatus, C. dactylon*, *A. setacea*, and *E. indica* among the grasses, and *E. nummularius*, *D. triflorum*, *S. lithosperm*, and *A. sessilis* among the non-grasses displayed the highest abundance values. This indicates that these species were more abundant and frequently encountered compared to other species in the grassland community (Supplementary Table 4). This seasonal pattern highlights fluctuations in species abundance and underscores the dominance of certain species within the grassland ecosystem throughout the observational period.

Throughout the study period, the total basal area (measured cm^2/sq m) of all species reached its peak in October and its nadir in April. From November to April, there was a gradual decline in basal area, followed by an increase starting from May onwards, with another peak observed in October. This seasonal pattern indicates fluctuations in the total basal area of the community over time. Additionally, it was observed that the basal area of the grasses was consistently lower than that of non-grasses throughout the study period (Supplementary Table 5). This disparity underscores the varying contributions of different species types to the overall basal area within the grassland community.

The total basal cover (measured cm^2/sq m) of the species exhibited its minimum value during April and its maximum value in September, suggesting a seasonal variation in the basal cover of the community. Additionally, it was found that the basal cover of grasses was more than that of non-grasses throughout the study period. This contrasts with the finding for basal area, where grasses were found to have lower values than non-grasses. Interestingly, the data reveal an inverse relationship between basal area and basal cover in the grassland community (Supplementary Table 6).

The Relative Frequency (RF) of grass species peaked in January and reached its lowest in May, while non-grasses exhibited the highest RF in May and the lowest in January. This seasonal variation indicates fluctuations in the relative abundance of grasses and non-grasses within the grassland community over the course of the study period. It is noteworthy that *C. acciculatus* consistently displayed the highest RF among grass species throughout the study (Supplementary Table 7). Similarly, among non-grasses, *D. triflorum* consistently exhibited the highest RF. These species are particularly significant as they likely play a crucial role in influencing the composition and dynamics of the grassland community.

The Relative Density (RD) of grasses reached its peak in January and October, while it was lowest in July. Conversely, non-grasses exhibited maximum RD in July and minimum in January. This temporal variation in RD reflects fluctuations in the abundance and distribution of both grasses and non-grasses within the grassland community over the study period. Notably, *C. acciculatus* consistently showed the highest RD among grass species throughout the study. Among the non-grasses, *E. nummularius* consistently exhibited the highest RD (Supplementary Table 8).

In this study, the grasses exhibited maximum Relative Dominance (RDo.) in January and minimum in May, while non-grasses showed maximum RDo. in May and minimum in January. This seasonal pattern suggests fluctuations in the dominance of these plant groups within the ecosystem. Moreover, *E. indica* consistently displayed the highest RDo. among grass species throughout the study period. Similarly, *A. sessilis* consistently exhibited the highest RDo. among non-grasses. These species likely play pivotal roles in shaping the structure and composition of the grassland community over time (Supplementary Table 9). Furthermore, the RDo. of non-grasses was consistently higher than that of grasses throughout the study period. This indicates that non-grasses exert greater dominance in terms of their presence and abundance compared to the grass species.

The Importance Value Index (IVI), which integrates Relative Frequency, Relative Density, and Relative Dominance, serves as a comprehensive measure of the ecological significance of plant species within a community. Throughout the study period, the IVI of the community consistently hovered around 300 in each month (Supplementary Table 10), suggesting a balanced distribution and contribution of species within the ecosystem. The IVI of grasses peaked in January and reached its lowest point in May, indicating seasonal fluctuations in the importance and abundance of grass species. In contrast, the IVI of non-grasses showed an opposite trend, with the lowest value in January and the highest value in May, consistently observed throughout the study period. Among grasses, *C. acciculatus* displayed the highest IVI, while among non-grasses, *E. nummularius* exhibited the highest IVI. Conversely, *E. unioloides* among grasses and *S. cordifolia* among non-grasses consistently showed the lowest IVI, suggesting their relatively lesser ecological importance and contribution within the community. The assessment of IVI allows for understanding the relative significance of plant species based on their frequency, density, and dominance within the community. Overall, a comparative analysis and graphical representation of phytosociological data of the collected plant species during the study period are presented in Table 1 and Supplementary Fig. 2, respectively.

Various literature reviews highlight significant findings indicating that anthropogenic activities, agricultural intensification, urbanization, and industrial development profoundly impact grassland communities, particularly their floristic diversity (26, 27). Another study reveals that human activities such as timber cutting, firewood collection, cattle grazing, and surface burning degrade herbaceous vegetation in forests (28). However, the present study identifies that changes in macro and micro climatic fluctuations, competition for resources, niche partitioning, nutrient availability, and soil conditions significantly modify the phytosociological attributes observed. These environmental shifts create favourable conditions for certain species, influencing dominance patterns and community structure. Similar findings across various studies underscore that the modification of phytosociological attributes in grassland communities is a complex process influenced by a range of biotic and abiotic factors (29–35). These findings underscore the importance of implementing conservation strategies to safeguard the rich floristic diversity of the grassland community in Baripada, Odisha, India. Effective conservation efforts may include habitat restoration initiatives, protection of key species, and promotion of sustainable land management practices.

Table 1. A comparative phytosociological data of all species (both Grasses and Non-grasses) during the study period.

Grasses	Frequency	Density	Abundance	Basal area	Basal cover	RF	RD	RDO	IVI=RF+RD +RDO
Aristida setacea	830	553	807.1	2.36	112.9	57.6	60.86	42.14	160.6
Chrysopogon acciculatus	1250	1794.4	1838.6	2.66	389.2	87.86	229.63	48.31	365.8
Cynodon dactylon	1160	1544.8	1700.8	1.37	164.9	79.4	199.46	26.47	305.33
Dactylocteniumaegy ptium	410	68.6	131	1.78	17.2	28.38	9.16	30.43	67.97
Digitaria longiflora	240	135.2	225.3	0.39	14.7	11.29	9.06	4.12	24.47
Eragrostis amabilis	760	231.4	391	0.6	12.3	54.04	27.66	9.92	91.62
Eragrostis unioloides	230	136	233.5	0.21	7.5	10.68	9.44	2.25	22.37
Eleusine indica	610	354.1	509.5	3.68	148	33.02	30.8	49.37	113.19
Heteropogon contortus	500	148.5	251.6	1.24	23.1	34.56	14.97	21.97	71.5
Ischaemum indicum	250	116.4	230.1	0.68	16.4	12.17	8.69	7.65	28.51
Oplismenus burmannii	550	265	485.2	3.12	85	32.28	25.53	45.21	103.02
Oplismenus hirtellus	740	272.9	482.5	1.56	34.1	51.69	33.63	28.93	114.25
Paspalidium flavidum	460	195.5	337.7	2.68	66.3	24.19	16.62	34.37	75.18
Pennisetum pedicellatum	300	137.3	223.9	1.8	52.4	14.69	9.95	20.19	44.83
Perotis indica	280	117.1	206.3	0.23	5.5	14.45	10.64	2.87	27.96
Sacciolepsis indica	540	179	345.4	3.09	58.6	32.24	16.45	43.89	92.58
Sporobolus indicus	490	223.3	354.8	0.95	26.8	25.74	18.47	12.14	56.35
Sporobolus pyramidalis	540	191.4	323.4	0.97	21.1	29.83	17.38	12.98	60.19

Non-grasses									
Alternanthera sessilis	680	236.6	447.4	5.75	110.4	48.71	26.42	107.19	182.32
Desmodium triflorum	1120	1060.5	1198.4	0.18	17.4	76.61	134.18	3.08	213.87
Elephantopus scaber	200	55.6	109.8	1.86	26.4	9.56	4.39	20.46	34.41
Euphorbia hirta	710	173	313.9	5.49	76.4	51.47	19.67	103.35	174.49
Evolvulus nummularius	1020	1159.5	1471	0.4	39.7	69.08	154.1	6.74	229.92
Fimbristylis dichotoma	690	200	384	2.93	48.4	49.17	23.66	53.19	126.02
Hybanthus enneaspermus	630	182.7	365.6	5.54	84.3	44.48	19.31	102.73	166.52
Kyllinga brevifolia	450	173.1	315.2	0.98	21.3	23.84	14.38	12.55	50.77
Mimosa pudica	500	116.6	240.7	4.79	59.4	30.91	11.35	74.81	117.07
Mitracarpus hirtus	460	223.2	387.5	3.55	100.3	24.56	18.67	45.24	88.47
Phyllanthus virgatus	410	176	303.6	1.67	42.7	21.5	13.81	21.21	56.52
Scleria lithosperma	730	331.1	582.5	2.46	68.5	52.22	39.28	44.3	135.8
Sida acuta	270	80.2	184.1	3.03	41.5	14.41	6.75	37.94	59.1
Sida cordifolia	190	42.6	91.4	1.95	21.4	9.11	3.35	21.39	33.85
Spermacoce ramanii	370	103	196.7	2.88	43.3	19.31	7.99	36.7	64
Tridax procumbens	670	143.4	275.6	5.42	63.2	47.22	17.11	100.2	164.53
Vernonia cinerea	700	189.9	341.2	3.31	50.8	49.49	21.2	62.73	133.42
Zornia gibbosa	440	183.6	333.7	0.21	5	23.47	15.77	2.7	41.94

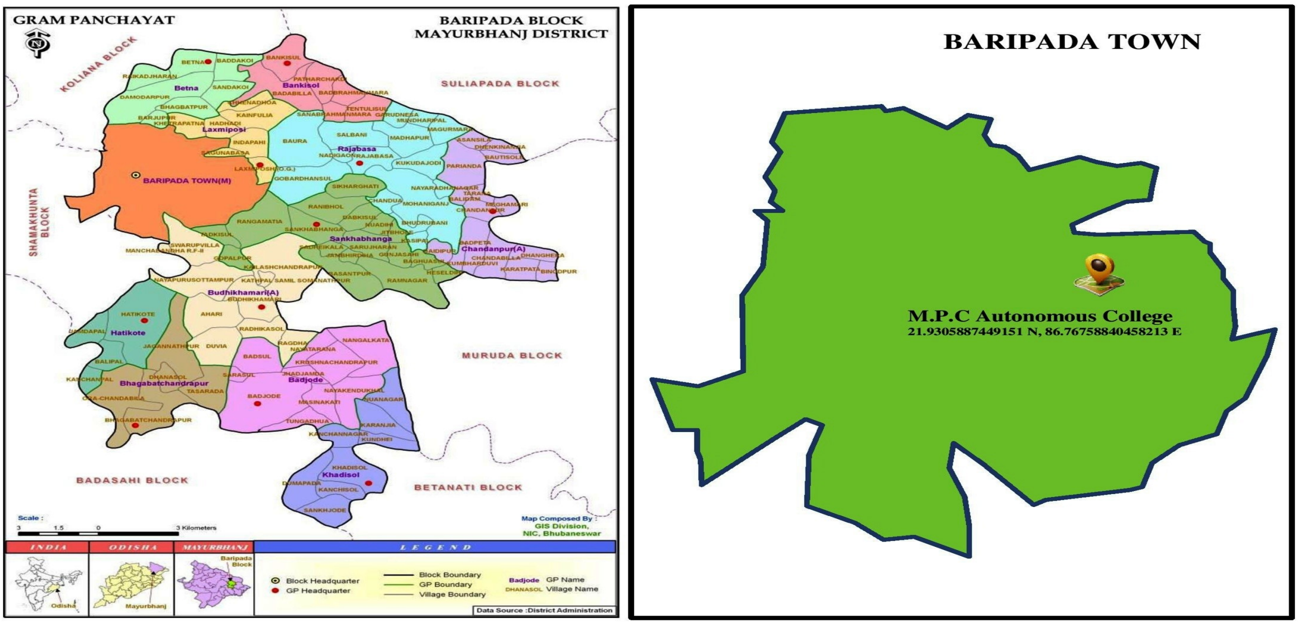

Fig. 1. Experimental grassland community located at Baripada, Odisha, India.

Conclusion

The phytosociological study conducted on the experimental grassland community at Maharaja Purna Chandra Autonomous College, offers valuable insights into the floristic diversity and ecological dynamics of the area. These findings are pivotal in establishing a foundation for conservation efforts aimed at preserving the biodiversity and ecological functions of the community. Conservation strategies are imperative to prevent further degradation and loss of biodiversity in the region. The information gleaned from this phytosociological study serves as a valuable resource for conservationists, policymakers, and decision-makers, enabling them to make informed choices and take necessary actions to safeguard the grassland community at Maharaja Purna Chandra Autonomous College campus. These efforts are crucial for the long-term preservation and sustainable management of the ecosystem, ensuring its ecological balance and continued benefits for future generations.

Acknowledgements

The authors are thankful to the Principal, Maharaja Purna Chandra Autonomous College, Takhatpur, Baripada, for providing the experimental site, Head of the Department of Botany, Maharaja Sriram Chandra Bhanja Deo University for his cooperation and valuable suggestions.

Authors' contributions

AKN has carried out the field work and collected the data throughout the study period. AKN and KLB analyzed the data. AKN drafted the manuscript and KLB has made necessary corrections. AKN and KLB have finalized the manuscript for correspondence.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None.

References

1. Golley FB. Structure and function of an old-field Broom sedge community. Ecol. Monogr. 1965; 35(1):113-137. https://doi.org/10.2307/1942219
2. Misra MK, Misra BN. Species diversity and dominance in a grassland community. Folio Geobot. Et Phytotaxo. 1981; 16:309-316. https://doi.org/10.1007/BF02851900
3. Verma M, Niranjan R, Pal A. Phytosociological attributes of a tropical dry deciduous forest of Bundelkhand region of Uttar Pradesh, India. Environmental science. 2013.
4. Sinha A, Rana RS, Gupta SR. Phytosociological analysis of some natural grassland communities of sodic soils. Tropical Ecology. 1988; 29 (2): 136-145.
5. Rout SD, Panda SK, Panda T. Phytosociological and floristic evaluation of Kuldiha Wildlife Sanctuary, Odisha, India. Tropical Plant Research. 2018; 5(3): 419–430. https://doi.org/10.22271/tpr.2018.v5.i3.051
6. Behera, RK. Community structure, primary production and energetics of a grassland community of Boudh-Khandamals (Dist.-Phulbani) in Orissa, Ph.D. Thesis, Berhampur University, Berhampur, Orissa. 1994.
7. Pandey DD, Pandey K, Kumar SS. Phytosociological studies of grasslands in the vicinity of Pataratu thermal power, Hazaribagh, Jharkhand. Journal of Phytology. 2011; 3(12): 63-66.
8. Ganaie MM, Reshi ZA. Species Diversity and Dominance Pattern in a temperate Grassland of Kashmir Himalaya. Journal of Plant Science and Research. 2021.
9. Symonides E. Floristic richness, diversity, dominance and species evenness in old-field successional ecosystems. Ekologia Polska. 1985; 33(1): 61-79.
10. Priede A. Phytosociological and dynamics of calcareous grasslands in Kemeri National Park, Latvia. Estonian Journal of Ecology. 2011; 60(4):284-304. https://doi.org/10.3176/eco.2011.4.03
11. Yeo MJM, Blackstock TH, Stevens DP. The use of phytosociological data in conservation assessment: a case study of lowland grasslands in mid Wales. Biological Conservation. 1998; 86(2): 125-138. https://doi.org/10.1016/S0006-3207(98)00017-2
12. Barik KL, Misra BN. Seasonal changes in the phytosociological attributes of an upland grassland community. Neo Botanica. 1996; 4 (2): 87-92.
13. S Lavorel. Plant functional effects on ecosystem services. Journal of Ecology. 2013; 101(1): 4–8. https://doi.org/10.1111/1365-2745.12031
14. Grime JP. Competitive exclusion in herbaceous vegetation. Nature. 1973; 242: 344–347. https://doi.org/10.1038/242344a0
15. Tilman D, Downing JA. Biodiversity and stability in grasslands. Nature (London).1994; 367:363-365. https://doi.org/10.1038/367363a0
16. Naeem S, Li S. Biodiversity enhances ecosystem reliability. Nature .1997; 390: 507-509. https://doi.org/10.1038/37348
17. Diaz S, Cabido M. Vive la difference: plant functional diversity matters to ecosystem processes. Trends in Ecology & Evolution. 2001; 16: 646–655. https://doi.org/10.1016/S0169-5347(01)02283-2
18. Bai Y, Cotrufo MF. Grassland soil carbon sequestration: Current understanding,challeneges, and solutions. Science.2022; 377 (6606):603-608. https://doi.org/10.1126/science.abo2380
19. Boval M, Dixon RM. The importance of grasslands for animal production and other functions: a review on management and methodological progress in the tropics. Animal. 2012; 6(5):748-762. https://doi.org/10.1017/S1751731112000304
20. Goodall DW. Quantitative aspects of plant distribution. Biol. Rev. 1952; 27(2): 194-242. https://doi.org/10.1111/j.1469-185X.1952.tb01393.x
21. Oosting HJ. The study of plant communities: an introduction to plant ecology. W.H. Freeman.1956.
22. Misra R. Ecology Work Book. Oxford and IBH Publishing Company, New Delhi, pp. 244. 1968.
23. Curtis JT, McIntosh RP. The interrelations of certain analytic and synthetic phyto sociological characters. Ecology. 1950; 31:434-455. https://doi.org/10.2307/1931497
24. Cottam G, Curtis JT. The use of distance measures in phytosociology sampling. Ecology.1956; 37: 451–460. https://doi.org/10.2307/1930167
25. Nayak AK, Barik KL. Floristic Diversity of a Grassland Community of Baripada, Odisha, India. Eco. Env. & Cons. 2024; 30 (2): 892-896.
26. Sahoo AK, Barik KL. Anthropogenic active grassland communities: Floral diversity and biological spectrum analysis in Odisha, Ecological frontiers. 2024. https://doi.org/10.1016/j.ecofro.2024.03.001
27. Datar MN. Floristic diversity and effect of anthropogenic activities on human-dominated grasslands in subtropical regions of Peninsular India. Tropical Grasslands-Forrajes Tropicales. 2016; 4(1): 8-18. https://doi.org/10.17138/TGFT(4)8-18
28. Behera SK, Mishra MK. Floristic and structure of the herbaceous vegetation of four recovering forest stands in the Eastern Ghats of India. Biodiversity and Conservation. 2006; 15: 2263–2285. https://doi.org/10.1007/s10531-004-8215-7
29. Gupta SR, Misra GP. Relationship between phytosociological attributes and above ground biomass in a grassland community. Geobios. 1978; 5: 105 - 107.
30. Singh UN, Ambasht RS. Floristic composition and phytosociological analysis of three grass stands in Naugarh forest of Varanasi Division. Ind.J. For.1980; 3(2):143 -147.
31. Ambasht RS, Pandey TN. Seasonal changes in the phytosociological and productive structure of two strands of *Aristida cyanantha.* Geo. Ecol.1981; 5 (1): 45 - 56.
32. Naik BK. Phytosociology and primary production of a natural

grassland community of Western Orissa. Ph.D.Thesis, Sambalpur University, Sambalpur, Orissa. 1985

33. Borman MM, Krueger WC, Johnson DE. Growth patterns of perennial grasses in the Annual grassland type of South West Oregon. Agron.J. 1990; 82 (6): 1093 - 1098.

34. Misra BN. Ecological studies on grassland community of South Orissa, Project report, Ministry of Environment, Gov. of India. 1992.

35. Pradhan D. Primary production and phytosociology of a grasslandcommunity of Bhubaneswar. Ph.D. Thesis, Berhampur University, Berhampur, Orissa. 1994.