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Exploration of species diversity and vegetation pattern in submontane Terai belt forest of North Bengal, Eastern Himalaya

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A B S T R A C T

The current study was done with the aim to investigate the diversity of some selected plants present in the Gorumara National Park of West Bengal, India. In the study, single plant representatives of ten vegetative families (herb, shrubs and small tree) were taken under consideration in ten different plots. Vegetation (tree, shrub and herbaceous species) study was considered with the plot size (20 x 20) m. for small tree species, (5x5) m. and (1x1) m. for shrubs and herbs species. The data revealed that, the selection of dominant plant species had been done including species of one small tree, five shrubs, three herbs and one fern in the experimental side. The most frequently distributed plant species found in the area of study was *Cynodon dectylon* (L.) Persoon(89 %) within 3187 plants of ten families counted by the total quadrates. Density was highest for the plant species *Cynodon dectylon* (L.) Persoon (8.11) followed by *Lantana camara* (L.) (7.86). Relative abundance of ten selected species in the area obtained was 0.314% with evenness 0.837. From the study the indices of species diversity were calculated and the data revealed that the vegetative community of the selected ten plant species of the Gorumara National park was distributed with the Simpson index 0.18 and Shannon index of plant species diversity 1.93 in the pre-monsoon season of this year. The study showed that the dominated plant community of the forest were the tiny plants like *Cynodon dectylon* (L.) followed by terrestrial fern *Dryopteris sparsa* (D. Don) Kuntze and invasive plant *like Lantana camara* (L). The Shannon diversity index (1.93) reflects moderate diversity of selected plant species in the forest community.

Keywords: Vegetative community · Ecological diversity · Plant species · Diversity index · Evenness

1. Introduction

Vegetative community is the assemblage of a species variety of plants in a significant geographical area and are estimated by species richness, relative density, composition of species and relative abundance. A vegetative community is the successive composition of diversified plant species in a dynamic natural system or niche. In a particular geographical region, growth and sustainability of vegetation is controlled by fluctuating climatic conditions and edaphic factors of lithosphere. In the vegetative community, few plant species grows in majority benefited by the prevailing geographical environment. An ecosystem of forests is a naturally occurring woodland unit made up of all the living organisms—plants, animals, and microorganisms—as well as all the inanimate objects (abiotic factors) that make up the environment.

Study of natural ecology bases on calculative knowledge and interpretation of species diversity and composition of species. In ecological succession, more than one species dominate their growth in the given environment factors by ecesis over other species. Positive growth of plant species in a community is influenced by ecological balance rendered by climatic and edaphic factors. A vast number of floral habitat in forest region exposes great ecological diversity.

Investigation of ten dominating plant species from ten different families was done by the researcher in the pre monsoon period at the Gorumara forest ecosystem. The plants were wild or naturally distributed in the buffer zone of the forest. The plants bear different characteristic features with different uses. *Acacia catechu* (L.f.) Wild is a small gregarious deciduous tree and sustains naturally in the elevation of about 1300m or high range from sea level either in the form of pure patches or in close association with *Dalbergia sissoo, Acacia modesta, Pinus roxburghii etc*. [1,2].

India is enriched with three *Acacia catechu* varieties *viz*., Sundra, Catechu and Catechuoides among which Catechuoides is most abundant in terrai regions of Assam, Sikkim and West Bengal. Katha, the filtered concentrated extract of Acacia catechu leads the mountain dwellers for its commercial production beside natural vegetation. In India, the tree is used for multipurpose functions like Katha and Cutch extraction, masticatory or in ayurvedic medicine. This plant fulfils the requirements of building elements, fodder, fuel, medicine *etc*., and meets the cultural, social and economic needs of the dwellers of mountain terrains of West Bengal and India [2]. Perennial plant *Amaranthus viridis has an upright, light green stems that can reach heights of 60 to 80 cm. In the traditional pharmaceutical industry, the herb amaranthus viridis is utilised for medical purposes. By dry weight, green amaranth can have up to 38% protein. Amaranthus viridis* L. is the representative of the plant family Amaranthaceae is a generally available wild herb and is termed as weed for edible crop cultivation. The plant shows the pattern of wide range of distribution in different altitudes and climates. The plant bears anti-pyretic as well as analgesic characters and is traditionally used as medicine for treatment of fever, pain from ulcer, inflammation, asthma, diabetes *etc*. According to research studies, the *Amaranthus viridis* L. exhibits a lot of amino acid compounds *viz*., histidine, arginine, leucine, lysine, cysteine, isoleucine, tyrosine, valine, methionine *etc*.

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According to research studies, the *Amaranthus viridis* L. exhibits a lot of amino acid compounds *viz*., histidine, arginine, leucine, lysine, cysteine, isoleucine, tyrosine, valine, methionine *etc*. It also contains the biologically active phytochemical components like phenols, steroids, tannins, flavonoids, saponins, alkaloids *etc*. The plant possesses potential antimicrobial, inflammatory, antiallergic, anti-pyretic and anti-toxic activity. The traditional use of the plant is in Indian medicine for cure of diseases like venereal disease, rheumatic disease, loss of appetite, asthma *etc*. and leaves are used directly for treatment purpose against rashes, eczema, psoriasis [3-5].

Clerodendrum is a flowering shrub, linan and sub herbaceous perennials from the family Lamiaceae. This plant genus have five hundred species and is distributed widely specially as native of the world's warm temperate and tropical regions [6]. Traditionally, *Clerodendrum infortunatum* L. is popular as hill glory bower and is a type species under the vast 150 species range of *Clerodendrum.* The species is native habitat of tropical Asia dominating in India, Bangladesh, Myanmer, Pakistan, Sri Lanka, Andaman Islands *etc*. [7].

There is a Traditional and ethnomedical claim that *Clerodendrum infortunatum* L. is a popular plant used as natural indigenous medicine in medical system, folklore medicine and siddha medicine to treat life-threatening diseases like asthma, hyperpyrexia, leprosy, leucoderma, dysentery *etc*. throughout the India [8].

The ancient literature reveals that the species associates with biological activities of some chemical ingredients *viz*., sterols, flavonoids, sugars, saponins *etc*. Research on pharmacology reveals that extract of *Clerodendrum* sp. exhibits the properties of biological activities like antimicrobial, anti-inflammatory, anticancer, anti-oxidant, anti-allergic, anti-diarrhral *etc* with some pesticidal properties [9-21]. The *Croton caudatus* Geiseler is naturally widespread in South East Asia including north-eastern India. It has medicinal property ans is used traditionally for medicinal cure of human health diseases like fever, allergy, liver disorders, malaria *etc*. [22].

A representative of perennial and prostrate grass is *Cynodon dactylon* (L.). The species is wild habitat of the World's tropical and sub-tropical regions and propagates through rhizomes and stolons. The species is the example of C4 grass and a representative of the Global Compendium of Weeds [23] and is termed as a serious weed of world's agriculture and environment [24]. The species of *Cynodon dactylon* (L.) is popular as Bermuda grass [25,26] and is considered as a ubiquitous cosmopolitan weed [27]. The species can tolerate a vast range of soil and grows rapidly in clay soil of arid regions [26]. The species is classified as a major noxious weed due to its invasive nature [28]. Contrarily; species of *Cynodon* shows the controlling potential of soil erosion and stabilization of soil due to its soil invasion.

It has been popular as social exposure that *Cynodon dactylon* (L.), found in Malaysia is able to cause allergic symtoms and may become asthmatics [29] and in Brazil also by dispersing its pollens [30]. Dubey *et al*. (2000) has been studied the use of *Cynodon dactylon* (L.) in various religious festivals [31]. The species is also considered as medicinal plant (table 1.) and having antioxidant property and is applied for treatment of neurodegenerative diseases [32]. In many countries, the grass species is applied as pasture grass since it possesses many soil organic and chemical components like minerals, carbohydrates, proteins, phosphorous, calcium, vitamin C, potassium, carotene, palmitic acid, lipids, crude protein, fibre and total ash *etc*. [33].

Dryopteris sparsa (D.Don) Kuntze is a terrestrial fern belongs to the family Dryopteridaceae distributed in the high altitudes of the tropical and sub-tropical regions of Asia and other continents. The fern is a rhizomatous geophyte and grows primarily in the wet tropical biome, native to Asia, India, east Himalayan region *etc.* Recent findings in pharmacology show that the plants in *Dryopteris* genus have not only anti-helminthic activities as the traditional use. The advanced researches on pharmacology revealed that the plants ender the genera of *Dryopteris* bear anti-helminthic responses and so that are considered for traditional uses (table 1.) [34].

One of the 200 species of blooming plants in the taxonomic genus *Ipomoea* is the morning glory. Due to its capacity to self-seed, the annual vine known as Ipomoea is referred regarded as a weed. The Convolvulaceae family includes the therapeutic herb *Ipomoea hederifolia* Linn. Ipagulines, isoipagulins, pyrrolizidine alkaloids, cyanogenic glycosides, calystegines, some ergoline derivatives, and several isoenzymes are among the chemical components that recent research suggests it includes. Indigenous medical systems in India claim that *Ipomoea hederifolia* contains oxytoxic, anticancer, antipsychotic, anti-inflammatory, anti-oxidant, and anti-microbial effects. Indian traditional medical practises claim that *Ipomoea hederifolia* has oxytoxic, anti-cancer, anti-psychotic, anti-inflammatory, anti-oxidant, and anti-microbial qualities. The chemical components of the methanolic extract, such as alkaloids, glycosides, phytosterols, saponins, flavonoids, carbohydrates, proteins, and amino acids, were studied (table 1.). [35, 36].

The Verbenaceae family includes the flowering ornamental shrub *Lantana camara* L. *L. camara* was most likely imported to India before the 19th century. Currently, *L. camara* is found all throughout India. *L. camara* is a well-known medicinal plant in the conventional medical system, and recent research has highlighted the potential application of *L. camara* in contemporary medicine. *L. camara* is a significant plant with numerous medicinal applications in the conventional medical system. In many regions of the world, the plant has been utilised to treat various health issues.

Cuts, rheumatism, ulcers, tetanus, cancer, ulcer, tumour, bilious fever and high blood pressure are treated with leaves. Lantana oil is generally applied as an antiseptic for wounds and to cure skin rashes and itches. External application of decoctions was used for leprosy and scabies [37-39].

Mulberry, the feed for silkworm is an economically important crop cultivated extensively in both tropical and temperate countries. It is believed to be originated in the lower slopes of Himalayas in China [40]. Versatile use of mulberry has made it possible to spread through the world

as an economic commercial plant. A popular commercial plant *Morus alba* Linn of the family Moraceae, has long term traditional use in Ayurvedic and general medicine. The plant shows extensive pharmacological actions [41] including antimicrobial, antidiabetic, antioxidant, antimutagenic, anticancer, anthelmintic, anxiolytic, antistress, hepatoprotective, nephroprotective activities *etc*. (table 1). The representative of malvaceae family shrubs is *Sida acuta* Burm. f. The plant can be found in bushes, farms, and areas close to habitations in the subtropical regions where it is widely dispersed. The plant *Sida acuta* Burm. f. shows pharmaceutical actions [42]. The plant has a wide range of traditional uses that vary by region, according to surveys done among native communities. Fever, headaches, and infectious diseases are the most often mentioned ailments. The treatment may be given orally in case of fever, or externally by directly to the skin, as in the case of skin conditions or snake bites [41].

Table 1 Features of selected plant species

Sl. No.	Identified plant species	Family	Features	Traditional usage	Reference
1	*Acacia catechu* (L.f.) Willd.	Fabaceae	Deciduous, gregarious, small tree	Fodder, fuel, building material and in health care like gastrointestinal and stomach related ailments, and leprosy.	Singh and Lal, 2006[43] Thangavelu, 2020 [44].
2	*Amaranthus viridis* L.	Amaranthaceae	Annual or short-lived perennial herb	Used as medicine for fever, pain from ulcer, inflammation, asthma, diabetes etc.	ELUWA, 1977 [45]
3	*Clerodendrum infortunatum* L.	Lamiaceae	Flowering shrub sub herbaceous perennials	Indigenous and siddha medicine for life-threatening diseases	Khare, 2008 [8]
4	*Croton caudatus* Geiseler	Euphorbiaceae	Scandent deciduous shrub	Treatment of several human health disorders	Cragg and Newman, 2013 [46]
5	*Cynodon dectylon* (L.) Persoon	Poaceae	Prostrate and perennial grass (herb)	Medicinal plant having anti-oxidant property	Auddy *et al*. 2003 [32]
6	*Dryopteris sparsa* (D. Don) Kuntze	Dryopteridaceae	Rhizomatous geophyte (fern)	For traditional uses	Sessa *et al.,* 2015 [34]
7	*Ipomoea hederifolia* L.	Convolvulaceae	Annual, twining vine/ herb, branched,	Indigenous systems of medicine in India	Jenett-Siems *et al*., 1998 [35]
8	*Lantana camara* L.	Verbenaceae	Highly invasive ever green shrub	Medicinal plant in traditional medicinal system	Khare, 2007 [37]
9	*Morus indica* L.	Moraceae	Vigorous shrub	Pharmacological activities	Sang *et al.,* 2002 [41]
10	*Sida acuta* Burm. f.	Malvaceae	Wire weed, shrub	Medicinal activity	Kerharo and Adam, 1974 [42]

2. Materials and Methods

The current study deals with investigation of species diversity of the selected plants in forest ecosystem. The study area selected for the research work was in the Gorumara national park in the Malbazar subdivision of the district Jalpaiguri in the northern region of West Bengal as the Dooars region of the Himalayan foothills, India and it is geographically located at Latitudes 26º 48' 05" to 26º 41' 20" N and Longitudes 88º 45' 19" to 88º 51' 18" E awning an altitude of 100 m to 136 m with forest canopy. The forest extends beside the popular localities like Chalsa, Lataguri, Nagrakata *etc*. Average temperature as per record is approximately 13.4 °C and average annual rainfall is 639 mm of this region.

2.1. Study area

The Gorumara national park is situated in the submontane Terai belt of the Eastern Himalayas' within the water shed between the Brahmaputra and the Ganges river system. It is situated by the combined flood plains of the Raidak and the Murti rivers on the bank of the Jaldhaka river.

The Gorumara national park is famous for the rich population of Indian rhinoceros in the riverine grassland and rolling forest ecosystem and was declared by the Ministry of Environment and Forests as a protected area of India [47]. The Gorumara forest is a part of Indomalayan realm of Terai savannah, tropical and subtropical grasslands, shrublands and broadleaf forest bioms. It is a

floral ecosystem of teaks, rain trees, silk cotton trees, tropical orchids, grasslands, reeds *etc.* Quadrate plots were determined by the area curve method of species [48].Vegetation community (tree, shrub and herbaceous species) study was taken in 10 plots. The plot size were (20 x 20) m. for selected tree species, (5x5) m. for selected shrubs and (1x1)m. for selected herbs respectively.

2.2. Quantitative Analysis

Quantitative data analysis (table 2) was done by density study, frequency estimation, and abundance study of tree, shrub species and species of herbs [49,50]. Quantitative research is regarded as the process of collecting data to address a research topic using statistical approach.

Table 2 Quantitative data analysis by density, frequency and abundance

Sl No.	Parameters	Calculations
1	Density	$Density = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$
2	Frequency	$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which the species occurred} \times 100}{Total\ number\ of\ quadrats\ studied}$
3	Abundance	$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which the species occurred}}$

Species diversity indices (Shannon Wiener Index) of general diversity (H) was computed using the following formula:

Shannon Wiener Diversity Index (H) =

$$\mathrm{H} = -\sum_{j=1}^{S} pi \ln pi$$

Sample calculation:

The Shannon-Wiener Diversity Index, H, is calculated using the following equation [51]:

H = -å Pi(lnPi), where Pi is the proportion of each species in the sample.

The Simpson diversity index- In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species.

$$D = \frac{\mathrm{N}(\mathrm{N}-1)}{\Sigma \mathrm{n}(\mathrm{n}-1)}$$

3. Result and Discussion

Species diversity study was carried out during the premonsoon season in the Gorumara National park in Jalpaiguri. The selected plant species diversity study was done by stratified random sampling among herbs, shrubs and small trees. The selected plant species diversity has been depicted in figure 1 and 2 respectively. The selected plant species density (table 3) was in a range of 0.72 to 8.11 and frequency ranges from 14 to 89 %. Value of IVI of floral species was in a range from 0.14 to 10.81. The result revealed that the values of Simpson diversiy (0.82) was less than Shannon diversity index (1.93) (table 4) [52].

Table 3 Data related to distribution of plant species in the study area

Sl. No.	Dominating plant species	Frequency (%)	Density	IVI
p1	*Acacia catechu* (L.f.) Willd.	26	1.32	0.14
p2	*Amaranthus viridis* L.	42	1.26	0.34
p3	*Clerodendrum infortunatum L.*	24	0.72	0.36
p4	*Croton caudatus* Geiseler	43	3.01	1.29
p5	*Cynodon dactylo*n (L.) Persoon	89	8.11	10.81
p6	*Lantana camara L.*	59	6.28	1.84
p7	*Ipomoea hederifolia* L.	21	1.58	0.89
p8	*Lantana camara* L.	84	7.86	1.84
p9	*Morus indica* L.	14	0.79	0.34
p10	*Sida acuta* Burm.f.	37	0.94	0.72

Table 4 Diversity indices of selected plant species

Parameters	Value
Relative abundance	0.314
Species Richness	31.87
Simpson Diversity index	0.820
Shannon diversity index	1.930
Evenness	0.837

Diversity Indices have correlation with the plant IVI value. Diversity indices of the area indicate the composition of the community. The maximum value of IVI was estimated for grass species. From the research work the conclusion may generate that the shrubs and tree are moderately dominated in the species community in respect to *Cynodon dactylon*, the grass in the study area. Species distribution may shift down word in terms of passive response to fluctuating climate and anthropogenic advancement [53].

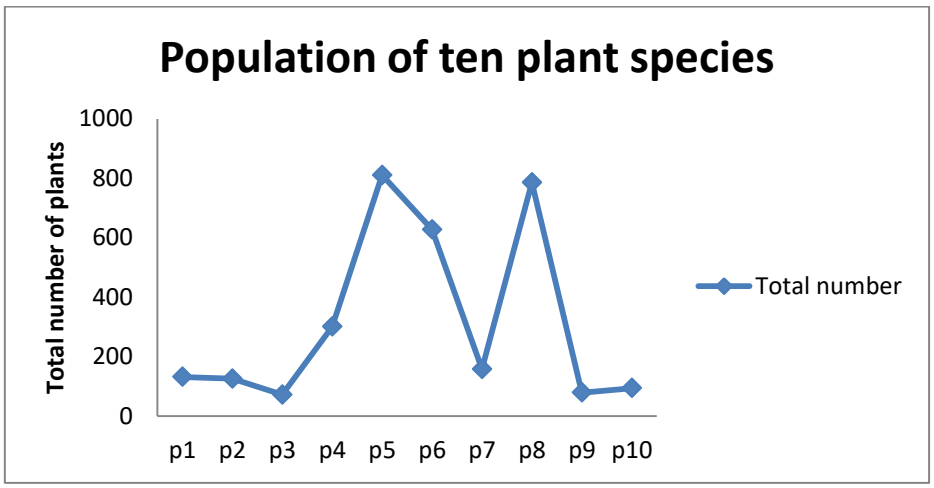

Fig. 1. Population of selected plant species

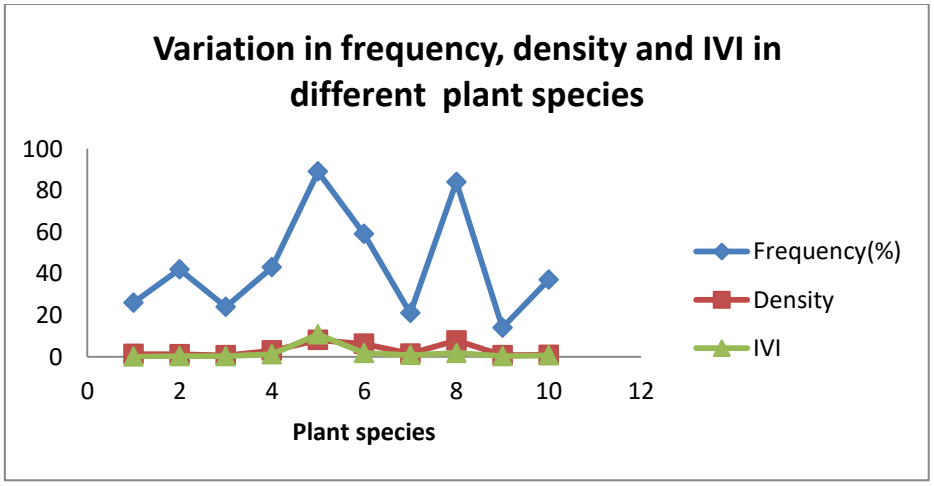

Fig. 2. Variation in frequency, density and IVI in different plant species

4. Conclusion

The data explored the fact that, the selection of dominant plant species had been done including species of one small tree, five shrubs, three herbs and one fern in the experimental side. The most frequently distributed plant species found in the forest region was *Cynodon dectylon* (L.) Persoon(89 %) within 3187 plants of ten families counted by the total quadrates. Species density was highest in case of *Cynodon dectylon* (L.) Persoon (8.11) followed by *Lantana camara* (L.) (7.86). Relative abundance of ten selected species was 0.314% with evenness 0.837. From the study the indices of species diversity were calculated and the data revealed that the vegetative community of the selected ten plant species of the Gorumara National Park was distributed with the Simpson index 0.18 and Shannon index 1.93 in the present pre monsoon season of this year. The study reflected that the forest plant community is dominated by tiny plants like *Cynodon dectylon* (L.) followed by terrestrial fern

Dryopteris sparsa (D. Don) Kuntze and invasive plant like *Lantana camara* (L). The Shannon diversity index (1.93) reflects moderate diversity of selected plant species in the forest community. From the study it is found that the highest IVI among the experimented plants found in *Cynodon dactylon* (L.) Persoon (IVI – 10.81) among the herbaceous grass whereas minimum record of IVI was obtained in case of *Acacia catechu* (L.f.)Willd (IVI = 0.14) and moderate IVI was flourished by the plant species *Lantana camara* L. (IVI- 1.84) which was toward the minimum range like fern species. The research work revealed that among the vegetative community, the abstract community was formed by *Lantana camara* L. (84%) followed by *Lantana camara* L. (59%) rather maximum density was shown by *Cynodon dactylon* (L.) Persoon (8.11). The study revealed that the exotic plant species *Lantana camara* L. was gregariously abundant in the study area.

Conflict of interest

The author declares that there is no conflict of interest in this manuscript.

Data availability

The author confirms that all data collected or analyzed during this study are included in this published article.

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