Phytosociological Studies of the Flora of Dhanamanjuri University Campus in Imphal West District (Manipur), India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors DT and NR carried out the field, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author ARD designed the study and managed the literature searches. Author HMS give the finishing touches to the manuscript besides managed the analyses of the study. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Aims: To study the life forms and biological spectrum of the vegetation of Dhanamanjuri University Campus, Manipur to determine its phytoclimate and species diversity.
Study Design: The vegetation of the whole university campus was studied and the site selection was made randomly.
Place and Duration of Study: Dhanamanjuri University Campus is located at the intersection of 24.82ºN Latitude and 93.94ºE Longitude. The study was carried out from March to September, 2023.
Methodology: Life forms were determined in the study area after detailed floristic studies. Vegetation classification on a physiognomic basis as per Raunkiaer's system as modified by Ellenberg and Mueller-Dombois. Frequency, density, abundance and basal area were calculated for

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quantitative analysis. Both Shannon- Weiner Index and Simpson index were calculated for diversity studies. The degree of association between two randomly selected species was studied with a simple index of association IASM.

Results: The biological spectrum of Dhanamanjuri University Campus consists of 183 plant species belonging to 163 genera distributed over 74 families. Due to predominance of Phanerophytes (54.1%) and Therophytes (22.4 %) over the other life-forms, the study site was assigned to the "Phanero-Therophytic" Phytoclimate. The values of the Shannon- Weiner Index and Simpson Index were found to be 1.5202 and 3.101 respectively. For the degree of association between two randomly selected species χ^2 value was calculated to be 0.101 inferring that the two species are not associated with each other, rather they are independently distributed in the site.

Conclusion: The current study has described the vegetation of the Dhanamanjuri University Campus, as per Raunkiaer's terminology as "Phanero-Therophytic" phytoclimate. The study also shed light on various phytosociological attributes of plants growing on the campus, thus shedding more light on the diversity and distribution patterns of the plants growing there.

1. INTRODUCTION

Vegetation can be defined as an assemblage of plants growing together in a particular location. The vegetation covering an area has a definite structure and composition closely associated with that particular area's biotic and abiotic factors. Due to changes in habitat, certain species or whole group of plants may disappear or get replaced by others. Such changes can be studied by doing vegetation analysis. For vegetation study, Raunkiaer [1], for the first time, put forward the idea of life-forms and biological spectrum. A community's life form is generally defined as the sum of plant adaptations to certain ecological conditions and is an important part of vegetation analysis. Over the years many different systems of classification of plant life-forms have been revised by many ecologists [2,3]. However, Raunkiaer's [1] life-form system and its further extension by Braun-Blanquet [4] have found the widest application worldwide, making the system of Raunkiaer the most accepted one. According to this system, plant species are grouped into 5 broad life-forms categories based on the position of perennating buds on plants and the degree of their protection during adverse conditions. The five categories are Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes and Therophytes. A biological spectrum is formed when all species of higher plants of a community are classified into life-forms, and their ratio expressed in numbers of percentage [5]. According to Raunkiaer [1], the bioclimate of a region is characterized by the life-forms whose percentage value is much higher than the normal spectrum [6]. The dominant life-forms would reflect the probable climatic condition to which the plants try to adapt to prevailing climatic stress. The dominant life-form is called as phytoclimate [7].

The critical role of species composition in the dynamics and functioning of an ecosystem has been recognised in various scientific studies in the past few decades [8] (Hobbie 1996). Community structure, composition and vegetative function which are the most important attributes of an ecosystem shows variations in response to environmental as well as anthropogenic variables [9,10,11]. Therefore taxonomic diversity within an ecosystem and its compositional change over time constitute the most important biodiversity parameters, with wide applications such environmental monitoring and conservation evaluation (Magurran 1988) [12].

1.1 Study Site

The study site, Dhanamanjuri University Campus is located at the heart of Imphal city, the capital of Manipur, North-east India. It comes under the Imphal west district extending within the geographical coordination of 24.82°N latitude and 93.94° E longitude, at 780 meters above mean sea level. It is bounded by National Highway No. 2 in the east, Thangmeiband Road in the west and north, and the Naga Turel (river) in the south. The study was carried out from February to September, 2023 and during the study period, the temperature ranged between 27.67°C (maximum) and 18.55°C (minimum) with an average precipitation of 170.65mm and average relative humidity of 88.21%.

2. MATERIALS AND METHODS

Life-forms were determined in the study area after detailed floristic studies. For each plant species, the form, habit and nature of perennating bud were critically examined in the field. The vegetation classification on physiognomic basis has been done as per Raunkiaer's system modified by Ellenberg and Mueller-Dombois [13]. Accordingly, life-form was assigned to all the plants. After having assigned a life-form to all the plants, the percentage of each life-form class was determined using the formula:

> Percentage of life-form = (no.of species falling in particular life form/ total no.of species in all life forms) ×100

Then, the biological spectrum for the study site was prepared and has been compared with the Raunkiaer's normal spectrum and the spectra available for other locations of the world. Specimens of all plants were identified with relevant floras and available revisions.

Phytosociological attributes of plants growing in a site within the University campus were estimated by taking 30 quadrates of 50cm x 50cm, distributed randomly. The size and the number of quadrats have been determined using the "-Species Area Curve Analysis-" [14] (Oosting, 1958). For quantitative analysis, frequency, density, abundance and basal area were calculated. Using the ratio of abundance to frequency, the distribution pattern of the different species present in the site was studied [15]. To have an overall picture of the ecological importance of species for the community structure, IVI (Importance Value Index) of individual species present in the site was calculated by adding the percentage values of the relative density, relative frequency and relative dominance [16].

Using the Shannon-Wiener Information Function [17,18,19], the species diversity was calculated as:

$$H^- = -S \sum_{i=1}^{S}\left[\left(\frac{Ni}{N}\right)\log\left(\frac{Ni}{N}\right)\right]$$

Where:

H - = Shannon index of general diversity.
Ni= Importance value or biomass or total number of individuals of each species.
N= Total importance value or biomass or total number of individuals of all species.

With the Simpson index, the Concentration of dominance (Cd) was measured [20].

$$Cd = \sum_{i=1}^{S}\left(\frac{Ni}{N}\right)^2$$

Where:

Cd = Concentration of dominance.
Ni= Importance value or biomass or total number of individuals of each species.
N= Total importance value or biomass or total number of individuals of all species.

With 50 random quadrats of 50cm x 50cm for studying the degree of association between two species (Sp. 1 and Sp. 2), several indices of association (I.A.) have been suggested to study whether species are associated in their distribution or not [13]. The simplest to apply is 'Jaccards' Index [21] based on presence (*I Ap*) data:

$$IAp = \frac{c}{a+b+c} \times 100\%$$

a= no. of the quadrat in which Sp. 1 occurs alone
b=no. of the quadrat in which Sp. 2 occurs alone
c= no. of the quadrat in which both the species occur together

In another formula which is also based on species presence, an additional parameter, d which represents the joint absence of the two species (the number of quadrats in which both the species are absent together) is also put under consideration, as it is necessary for statistical evaluations [22]. A 2 x 2 contingency table is prepared which has four cells a, b, c and d, as follows:

Table 1. Quadrats wise species distribution

Species 1	Species 2		
	+	-	
+	a	b	a+b
-	c	d	c+d
	a+c	b+d	n= a+b+c+d

A simple index of association $IA_{SM} = \frac{a+d}{n}$

Then the χ² value is calculated using the formula:

$$X^2 = \sum \frac{(ad-bc)^2}{(a+b)(c+d)(a+c)(b+d)}$$

The χ² value is looked up in Chi- square table for one degree of freedom and compared the value at P< 0.001 and P < 0.05.

For the index of association:

Jaccard index, IAp= c/(a+b+c) ×100% = 16/(3+25+16)×100%

(Where a=3, b=25 and c= 16) =36.30%

A simple index of association

IASM = (a+d)/n (where a= 16; b= 25; c= 3; d= 6 and n = 50)
IASM = 0.44

3. RESULTS AND DISCUSSION

The biological spectrum of Dhanamanjuri University Campus situated in Imphal West District (Manipur) consists of 183 plant species belonging to 163 genera that are distributed over 74 families. With 21 species, the family Fabaceae is the dominant family followed by Poaceae with 11 species, Asteraceae with 9 species and Moraceae with 7 species respectively. Many economically important plant species namely *Bixa orellana* L. (Bixaceae), *Nyctanthes arbor-tristis* L. (Oleaceae), *Terminalia citrina* (Gaertn.) Roxb. (Combretaceae), *Tectona grandis* L.f. (Lamiaceae), *Ficus elastica* Roxb. ex Hornem. (Moraceae), *Saraca asoca* (Roxb.) W.J. de Wilde (Fabaceae), *Neolamarckia cadamba* (Roxb.) Bossers (Rubiaceae) etc. are found in the study site.

Table 2. Distribution of different life-forms in the study area

Sl. No.	Botanical name	Family	Habit	Life-form
1	*Barleria cristata* L.	Acanthaceae	H	Ch
2	*Justicia adhatoda* L.	Acanthaceae	S	Ch
3	*Phlogacanthus thyrsiformis* (Roxb. ex Hardw.) Mabb.	Acanthaceae	S	Ch
4	*Thunbergia coccinea* Wall. ex D. Don	Acanthaceae	CL	Ph
5	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	H	G
6	*Amaranthus viridis* L.	Amaranthaceae	H	Th
7	*Spinacia oleracea* L.	Amaranthaceae	H	Th
8	*Amaryllis belladonna* L.	Amaryllidaceae	H	G
9	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	T	Ph
10	*Mangifera indica* L.	Anacardiaceae	T	Ph
11	*Annona squamosa* L.	Annonaceae	S/T	Ph
12	*Allamanda cathartica* L.	Apocynaceae	S/T	Ph
13	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	T	Ph
14	*Asclepias curassavica* L.	Apocynaceae	SS	Ch
15	*Catharanthus roseus* (L.) G. Don	Apocynaceae	SS	Ch
16	*Nerium oleander* L.	Apocynaceae	S	Ph
17	*Plumeria rubra* L.	Apocynaceae	T	Ph
18	*Alocasia cucullata* (Lour.) G. Don	Araceae	SS	G
19	*Alocasia macrorrhizos* (L.) G. Don	Araceae	SS	G
20	*Colocasia esculenta* (L.) Schott	Araceae	H	G
21	*Syngonium podophyllum* Schott	Araceae	CL	Ch
22	*Araucaria bidwillii* Hook.	Araucariaceae	T	Ph
23	*Araucaria columnaris* (G. Forst.) Hook.	Araucariaceae	T	Ph
24	*Areca catechu* L.	Arecaceae	T	Ph
25	*Chrysalidocarpus lutescens* H.Wendl.	Arecaceae	T	Ph
26	*Diplazium esculentum* (Retz.) Sw.	Aspleniaceae	H	Ch
27	*Agave americana* L.	Asparagaceae	H	H
28	*Dracaena reflexa* Lam.	Asparagaceae	H	H
29	*Dracaena trifasciata* (Prain) Mabb.	Asparagaceae	H	H
30	*Acmella oleracea* (L.) R.K. Jansen	Asteraceae	H	Th
31	*Ageratum conyzoides* L.	Asteraceae	H	Th
32	*Bidens pilosa* L.	Asteraceae	H	Th
33	*Gynura cusimbua* (D.Don) S. Moore	Asteraceae	H	Th
34	*Mikania micrantha* Kunth	Asteraceae	SS	H
35	*Parthenium hysterophorus* L.	Asteraceae	H	Th
36	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	H	Th
37	*Tagetes erecta* L.	Asteraceae	H	Th

Sl. No.	Botanical name	Family	Habit	Life-form
38	*Xanthium strumarium* L.	Asteraceae	H	Th
39	*Impatiens balsamina* L.	Balsaminaceae	H	Th
40	*Jacaranda mimosifolia* D. Don	Bignoniaceae	T	Ph
41	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	T	Ph
42	*Millingtonia hortensis* L.f.	Bignoniaceae	T	Ph
43	*Spathodea campanulata* P. Beauv.	Bignoniaceae	T	Ph
44	*Bixa orellana* L.	Bixaceae	S	Ph
45	*Cardamine hirsuta* L.	Brassicaceae	H	Th
46	*Mesua ferrea* L.	Calophyllaceae	T	Ph
47	*Trachelium caeruleum* L.	Campanulaceae	SS	Ch
48	*Cannabis sativa* L.	Cannabaceae	H	Th
49	*Trema orientale* (L.) Blume	Cannabaceae	T	Ph
50	*Lonicera japonica* Thunb.	Caprifoliaceae	S/CL	Ph
51	*Carica papaya* L.	Caricaceae	T	Ph
52	*Garcinia xanthochymus* Hook.f. ex T. Anderson	Clusiaceae	T	Ph
53	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	T	Ph
54	*Terminalia citrina* (Gaertn.) Roxb.	Combretaceae	T	Ph
55	*Ipomoea aquatica* Forsk.	Convolvulaceae	H	Ch
56	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	H	G
57	*Ipomoea triloba* L.	Convolvulaceae	H	Ch
58	*Alangium chinense* (Lour.) Harms	Cornaceae	S	Ph
59	*Kalanchoe pinnata* (Lam.) Pers.	Crassulaceae	H	Th
60	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae	H	Th
61	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	CL	G
62	*Cucumis melo* L.	Cucurbitaceae	H	Th
63	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	H	Th
64	*Momordica charantia* L.	Cucurbitaceae	CL	Th
65	*Hesperocyparis arizonica* (Greene) Bartel	Cupressaceae	T	Ph
66	*Cycas rumphii* Miq.	Cycadaceae	S/T	Ph
67	*Cyperus esculentus* L.	Cyperaceae	H	G
68	*Pteridium aquilinum* (L.) Kuhn	Dennstaedtiaceae	H	G
69	*Dillenia indica* L.	Dilleniaceae	T	Ph
70	*Elaeagnus umbellata* Thunb.	Elaeagnaceae	S	Ph
71	*Equisetum arvense* L.	Equisetaceae	H	G
72	*Jatropha curcas* L.	Euphorbiaceae	S	Ph
73	*Mallotus philippensis* (Lam.) Müll. Arg.	Euphorbiaceae	S/T	Ph
74	*Ricinus communis* L.	Euphorbiaceae	S/T	Ph
75	*Acacia acoma* Maslin	Fabaceae	S	Ph
76	*Acacia auriculiformis* A. Cunn. ex Benth.	Fabaceae	T	Ph
77	*Bauhinia variegata* L.	Fabaceae	S/T	Ph
78	*Calliandra haematocephala* Hassk.	Fabaceae		Ph
79	*Cassia fistula* L	Fabaceae	T	Ph
80	*Cassia javanica* L.	Fabaceae	T	Ph
81	*Chamaecrista fasciculata* (Michx.) Greene	Fabaceae	H	Th
82	*Crotalaria pallida* Aiton	Fabaceae	H	Th
83	*Delonix regia* (Bojer ex Hook.) Raf.	Fabaceae	T	Ph
84	*Enterolobium contortisiliquum* (Vell.) Morong	Fabaceae	T	Ph
85	*Erythrina stricta* Roxb.	Fabaceae	T	Ph
86	*Mimosa pudica* L.	Fabaceae	S	Ch
87	*Mucuna monosperma* Roxb. ex Wight	Fabaceae	CL	Th
88	*Parkia timoriana* (DC.) Merr.	Fabaceae	T	Ph
89	*Phaseolus vulgaris* L.	Fabaceae	H	Th
90	*Psophocarpus tetragonolobus* (L.) DC.	Fabaceae	CL	G
91	*Samanea saman* (Jacq.) Merr.	Fabaceae	T	Ph

Sl. No.	Botanical name	Family	Habit	Life-form
92	*Saraca asoca* (Roxb.) W.J. de Wilde	Fabaceae	T	Ph
93	*Senna sulfurea* (DC. ex Collad.) H.S. Irwin & Barneby	Fabaceae	T	Ph
94	*Senna tora* (L.) Roxb.	Fabaceae	H	Th
95	*Sesbania sesban* (L.) Merr.	Fabaceae	S	Ph
96	*Lithocarpus pachyphyllus* (Kurz) Rehder	Fagaceae	T	Ph
97	*Iris foetidissima* L.	Iridaceae	H	G
98	*Anisomeles indica* (L.) Kuntze	Lamiaceae	H	Th
99	*Gmelina arborea* Roxb. ex Sm.	Lamiaceae	T	Ph
100	*Premna mollissima* Roth	Lamiaceae	S/T	Ph
101	*Premna serratifolia* L.	Lamiaceae	S/T	Ph
102	*Tectona grandis* L.f.	Lamiaceae	T	Ph
103	*Vitex trifolia* L.	Lamiaceae	S/T	Ph
104	*Cinnamomum camphora* (L.) J. Presl	Lauraceae	T	Ph
105	*Litsea cubeba* (Lour.) Pers. var. *cubeba*	Lauraceae	T	Ph
106	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	T	Ph
107	*Cuphea carthagenensis* (Jacq.) J.F. Macbr	Lythraceae	H	H
108	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	T	Ph
109	*Phoebe bootanica* (Meisn.) M. Gangop.	Lythraceae	T	Ph
110	*Punica granatum* L.	Lythraceae	T	Ph
111	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	T	Ph
112	*Hibiscus cannabinus* L.	Malvaceae	H	Th
113	*Hibiscus* x *rosa-sinensis* L.	Malvaceae	S	Ch
114	*Sida rhombifolia* L.	Malvaceae	S	Th
115	*Urena lobata* L.	Malvaceae	S	Th
116	*Azadirachta indica* A. Juss.	Meliaceae	T	Ph
117	*Toona ciliata* M. Roem.	Meliaceae	T	Ph
118	*Artocarpus heterophyllus* Lam.	Moraceae	T	Ph
119	*Artocarpus lacucha* Buch.-Ham.	Moraceae	T	Ph
120	*Ficus benghalensis* L.	Moraceae	T	Ph
121	*Ficus elastica* Roxb. ex Hornem.	Moraceae	T	Ph
122	*Ficus racemosa* L.	Moraceae	T	Ph
123	*Ficus rumphii* Blume	Moraceae	T	Ph
124	*Morus alba* L.	Moraceae	T	Ph
125	*Musa sp.* L.	Musaceae	H	Ph
126	*Eucalyptus globulus* Labill.	Myrtaceae	T	Ph
127	*Melaleuca citrina* (Curtis) Dum. Cours.	Myrtaceae	S/T	Ph
128	*Psidium guajava* L.	Myrtaceae	T	Ph
129	*Syzygium cumini* (L.) Skeels	Myrtaceae	T	Ph
130	*Syzygium jambos* (L.) Alston	Myrtaceae	T	Ph
131	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	H	G
132	*Bougainvillea spectabilis* Willd.	Nyctaginaceae	CL	Ph
133	*Mirabilis jalapa* L.	Nyctaginaceae	H	Th
134	*Jasminum sambac* (L.) Aiton	Oleaceae	S	Ph
135	*Nyctanthes arbor-tristis* L.	Oleaceae	S/T	Ph
136	*Ludwigia octovalvis* (Jacq.) P.H. Raven	Onagraceae	SS	Th
137	*Papilionanthe teres* (Roxb.) Schltr.	Orchidaceae	SS	G
138	*Passiflora edulis* Sims	Passifloraceae	CL	Ph
139	*Eurya japonica* Thunb.	Pentaphylacaceae	T	Ph
140	*Phyllanthus emblica* L.	Phyllanthaceae	T	Ph
141	*Peperomia pellucida* (L.) Kunth	Piperaceae	H	Th
142	*Plantago major* L.	Plantaginaceae	H	Th
143	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae	H	G
144	*Bambusa bambos* (L.) Voss	Poaceae	H	H
145	*Cynodon dactylon* (L.) Pers.	Poaceae	H	G

Sl. No.	Botanical name	Family	Habit	Life-form
146	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	H	Th
147	*Digitaria sanguinalis* (L.) Scop.	Poaceae	H	Th
148	*Eleusine indica* (L.) Gaertn.	Poaceae	H	Th
149	*Panicum trichoides* Sw.	Poaceae	H	Th
150	*Paspalum conjugatum* P.J. Bergius	Poaceae	H	Ch
151	*Paspalum scrobiculatum* L.	Poaceae	H	H
152	*Puccinellia distans* (Jacq.) Parl.	Poaceae	H	H7
153	*Setaria viridis* (L.) P. Beauv.	Poaceae	H	Th
154	*Podocarpus neriifolius* D. Don	Podocarpaceae	T	Ph
155	*Fallopia dumetorum* (L.) Holub	Polygonaceae	CL	Th
156	*Persicaria lapathifolia* (L.) Delarbre	Polygonaceae	H	Th
157	*Polygonum sp.* L.	Polygonaceae	H	Th
158	*Pontederia hastata* L.	Pontederiaceae	H	G
159	*Ardisia colorata* G. Lodd.	Primulaceae	S	Ph
160	*Adiantum raddianum* C. Presl	Pteridaceae	H	G
161	*Ziziphus mauritiana* Lam.	Rhamnaceae	T	Ph
162	*Fragaria vesca* L.	Rosaceae	H	Th
163	*Rosa alba* P. Gaertn. B. Mey. & Scherb.	Rosaceae	S	Ch
164	*Rosa indica* L.	Rosaceae	S	Ch
165	*Ixora chinensis* Lam.	Rubiaceae	S	Ph
166	*Meyna spinosa* Roxb. ex Link	Rubiaceae	S/T	Ph
167	*Mussaenda glabra* Vahl	Rubiaceae	S	Ph
168	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	T	Ph
169	*Aegle marmelos* (L.) Corrêa	Rutaceae	T	Ph
170	*Bergera koenigii* L.	Rutaceae	S	Ph
171	*Citrus maxima* (Burm.) Merr.	Rutaceae	T	Ph
172	*Flacourtia jangomas* (Lour.) Raeusch.	Salicaceae	T	Ph
173	*Xylosma longifolia* Clos	Salicaceae	T	Ph
174	*Datura stramonium* L.	Solanaceae	H	Ch
175	*Petunia × atkinsiana* (Sweet) D. Don ex W.H. Baxter	Solanaceae	H	Th
176	*Solanum nigrum* L.	Solanaceae	H	Th
177	*Solanum torvum* Sw.	Solanaceae	H	Ph
178	*Symplocos paniculata* (Thunb.) Miq.	Symplocaceae		Ph
179	*Duranta erecta* L.	Verbenaceae	S	Ph
180	*Lantana camara* L.	Verbenaceae	S	Ph
181	*Stachytarpheta cayennensis* (Rich.) Vahl	Verbenaceae	H	Ch
182	*Sambucus canadensis* L.	Viburnaceae	S	Ph
183	*Hedychium coronarium* J. Koenig	Zingiberaceae	H	G

(H= Herb, S= Shrub, SS-Sub-shrub, Cl=Climber, T= Tree, Ph = Phanerophytes, G=Geophytes, Ch= Chamaephytes, Th= Therophytes, H= Hemicryptophytes)

Table 3. Comparative account of the Biological Spectrum of the present study site with those of Normal Biological Spectrum

Life-form	Normal spectrum of the world (%)	Biological spectrum of the present study site (%)
Phanerophytes	46	54.1
Chamaephytes	9	9.3
Hemicryptophytes	26	3.8
Geophytes	6	10.4
Therophytes	13	22.4
TOTAL	100	100

Table 4. Life- form (%) of some studied sites of the world

Study Site	Life-form (%)					Source
	Ph	Ch	H	G	Th	
Normal spectrum of the world	46	9	26	6	13	Raunkiaer (1934) [1]
Canchipur Grassland (Manipur), India	0	9.26	11.11	14.81	64.81	Devi et al. (2000) [23]
Emas National Park, Brazil	31.6	12.8	49.9	2.0	3.7	Batalha and Martins (2002) [24]
Tons Valley, Garhwal Himalaya (Uttaranchal)	29.06	22.19	2.11	2.64	17.83	Rana et al. (2002) [5]
Sub-tropical forest (Manipur), India	66.9	8.06	4.03	4.83	16.1	Usharani (2004) [25]
Thoubal Grassland (Manipur), India	0	4.84	11.29	14.52	69.35	Devi et al. (2004) [7]
Sarsawa Hills Forest (Pakistan)	67.88	0.0	22.87	0.97	8.25	Nazir and Malik (2006) [26]
Teak Dipterocarpus forest, Indo-Myanmar border	63.2	8.1	2.04	6.12	20.4	Ranita et al. (2010) [27]
Dry Deciduous Forest Karnataka (India)	29	12	13	1	45	Sidanand and Kotresha (2012) [28]
Lamberi Forest Rajouri, J&K (India)	40.09	13.51	11.26	2.25	27.03	Sharma et al. (2014)
Hill forest of Manipur (India)	62.76	10.64	1.06	7.45	18.08	Devi et al. (2014) [29]
Amambilok Sacred Grove, Andro, Manipur (India)	55.41	6.36	10.19	8.28	19.74	Imosana and Gupta (2015) [30]
Tropical dry deciduous forest Madhya Pradesh (India)	55.0	6.25	1.25	3.75	32.5	Thakur (2015) [31]
Subtropical Montane Forest, Manipur (India)	53.49	10.46	11.62	8.14	16.28	Easter and Gupta(2016) [32]
Grassland community of Odisha (India)	3.7	14.8	11.1	7.4	63.0	Barik (2018) [33]
Subtropical forest Manipur (India)	52.83	5.66	9.43	8.18	23.90	Sophia et al. (2019) [34]
Riyadh region, Central Saudi Arabia	9.0	30.0	8.0	0.0	52.0	Al Shaye et al. (2020) [35]
Kankupura, North Gujarat (India)	42.55	46.81	2.13	0	8.51	Patel (2021) [36]
D.M. University Campus (Manipur), India	54.1	9.3	3.8	10.4	22.4	Present study

Table 5. Phytosociological attributes estimation: Relative frequency, relative density, relative dominance, abundance, A/F ratio and IVI (Important Value Index) values of different species present in the selected study site within the campus

| Name of the species	Relative frequency	Relative density	Relative dominance	Abundance	A/F ratio	IVI
1. *Acmella oleracea* (L.) R.K. Jansen	7.42	2.24	3.51	3.46	0.46	13.4
2. *Alternanthera philoxeroides* (Mart.) Griseb.	17.25	15.69	22.51	9.53	0.55	55.45
3. *Digitaria sanguinalis* (L.) Scop.	13.80	11.03	10.05	8.37	0.60	34.88
4. *Cynodon dactylon* (L.) Pers.	17.25	52.86	16.88	3.21	1.86	86.99
5. *Ageratum conyzoides* L.	10.35	4.05	3.71	4.11	0.39	18.11
6. *Mikania micrantha* Kunth	2.29	0.49	0.45	2.25	0.98	3.23
7. *Colocasia esculenta* (L.) Schott	6.90	1.41	26.53	2.16	0.31	34.84
8. *Commelina benghalensis* L.	5.17	1.25	0.402	2.55	0.49	6.82
9. *Ipomoea aquatica* Forsk	7.42	2.56	11.91	3.16	0.48	21.89
10. *Diplazium esculentum* (Retz.) Sw.	0.56	0.16	0.30	3.00	5.35	1.02
11. *Persicaria lapathifolia* (L.) Delarbre	0.56	0.10	0.15	2.0	3.57	0.81
12. *Ludwigia octovalvis* (Jacq.) P.H. Raven	2.86	0.37	0.72	1.40	0.48	3.95
13. *Urena lobata* L.	0.56	0.054	0.60	1.00	1.78	1.214
14. *Sesbania sesban* (Linn.) Merr.	5.17	6.521	2.01	2.11	0.40	13.70
15. *Cuphea carthagenesis* (Jacq.) J.F. Macbr.	2.29	0.92	0.29	4.25	1.85	3.5
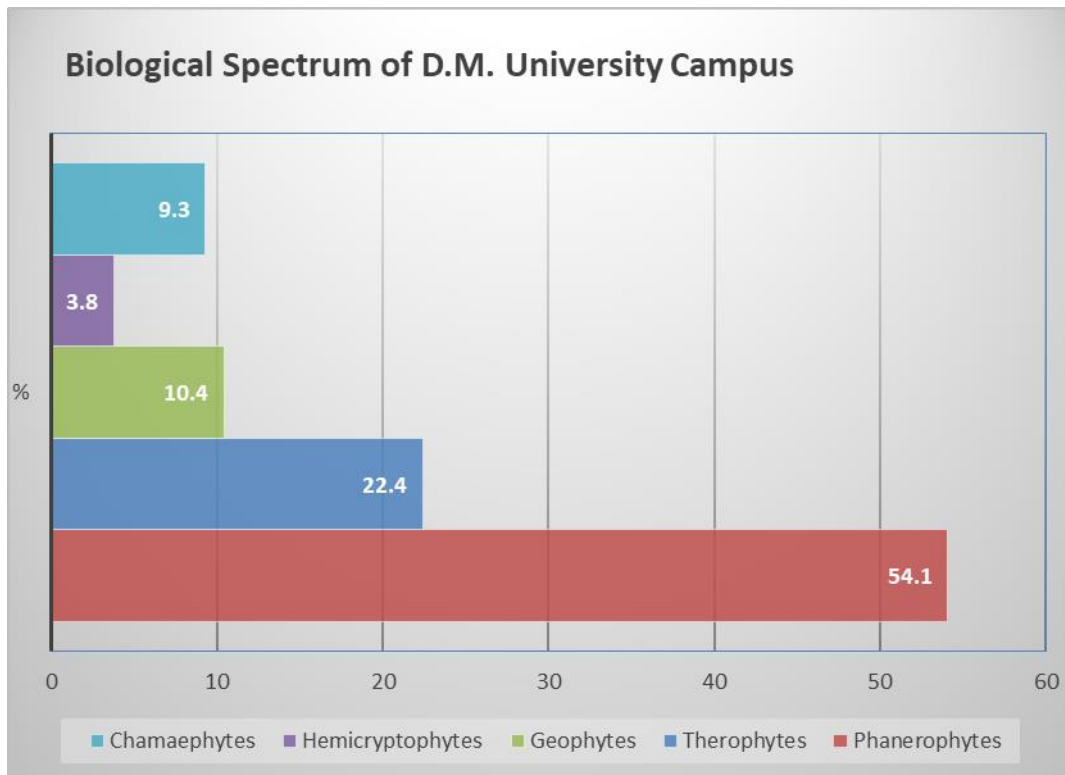
Fig. 1. Biological Spectrum of D.M University Campus

The highest percentage to the Biological Spectrum of the present study site was contributed by Phanerophytes (54.1%) which was higher than the percentage value of Phanerophytes (46%) in the Normal Spectrum of Raunkiaer (1934). Therophytes (22.4%) contributed the second largest followed successively by Geophytes (10.4%), Chamaephytes (9.3%) and Hemicryptophytes (3.8%). (Table 2) Hemicryptophytes shows the maximum departure from the Normal percentage value of Hemicryptophytes (26%).

The predominance of Phanerophytes in the present study site is a characteristic of sub-tropical climate with anthropogenic disturbance. The presence of Geophytes (10.4%) which is more than the Normal Spectrum (6%) could be attributed to the moist soil conditions as has been suggested by Raunkiaer [1]. The percentage of Chamaephytes (10.4%) was very close to the Normal Spectrum (9%). The percentage of Hemicryptophytes (3.8%) was much lower than the Normal Spectrum (26%) and this could be due to not so-cold and non-arid condition in the area as Hemicryptophytes are usually dominant in cold and arid regions as they reserve water by losing their leaves or reducing the sizes of leaves, reducing vegetative growth

and have overwintering buds located on the soil surface. This feature is an effective strategy for their survival. Due to the predominance of Phanerophytes (54.1%) and Therophytes (22.4%) over the other life-forms, the present study site could be assigned to the "Phanero-Therophytic" Phytoclimate. The Biological Spectrum of the present study is comparable with the Biological Spectrum reported from different ecosystems of India [37-51].

At the site, during our study of 30 random quadrats of 50cm x 50cm, 15 plant species belonging to 12 families were encountered. Asteraceae was the dominant family with 2 species. The highest IVI value was that of *Cynodon dactylon* (L.) Pers. followed by *Alternanthera philoxeroides* (Mart.) Griseb. and the least value was that of *Persicaria lapathifolia* (L.) Delarbre (Table 4). Among the 15 species, 8 plant species show IVI value greater than 10 (IVI > 10). The IVI value of a species signifies its dominance and ecological success, and potential and ecological amplitude in the area, thus helping to identify the richly and poorly established plant species in the study area. Accordingly, *Cynodon dactylon* (L.) Pers. with an IVI value of 86.99 is the highly established plant species in the study area. Using A/F (Abundance

to frequency ratio), the distribution pattern of the species in the site was assessed. Depending on the ratios, distribution may be regular (ratio < 0.025), random (ratio = 0.025 -0.05) and contagious (ratio > 0.05). Since all the A/F ratio values are > 0.05 in our study site (Table 4), the distribution pattern of species in the study site is stated to be contagious. This result aligns with several other findings which reported that most species exhibit a contagious distribution pattern in natural vegetation [52]. The General index of diversity (Shannon-Weiner Index) value was 1.5202, and the Concentration of Dominance (Simpson Index) value was 3.101.

For χ^2 test, the calculated value is 0.101. Checking the Chi-square table for one degree of freedom at $P < 0.001$, equal to 10.82, and at $P < 0.05$, equal to 3.84, the calculated value of 0.101 was lower than both values. Therefore, it is concluded that the two species, *Eleusine indica* (L.) Gaertn and *Paspalum conjugatum* P.J. Bergius are not associated with each other; rather they are independently distributed in the site.

4. CONCLUSION

In conclusion, the current study has described the vegetation of the Dhanamanjuri University Campus, as per 'Raunkiaer's terminology' as "Phanero-Therophytic" phytoclimate. The study has also gathered information on various selected phytosociological attributes of plants growing in a site within the campus, thus shedding more light on the diversity and distribution patterns of the plants growing there. The study findings hold significant importance from a conservative and management standpoint as it could be suggested that species with lower IVIs should be prioritized for conservation, and those with higher IVIs should be tracked to maintain diversity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raunkiaer C. The life-form of plant and statistical plant geography. Oxford: Clarendon Press, England; 1934.
2. Dansereau P. Biogeography: An Ecological Perspective. Ronald Press, New York, USA; 1957.
3. Ellenberg H, Mueller-Dombois D. A key to Raunkiaer plant, life-forms with revised sub-division Ber. Geobot. Inst. ETH. Stiftg. Rubel, Zuric. 1967;37:56 -73.
4. Braun-Blanquet J. Pflanzensoziologie. 3 Aufl, Springer Wien; 1951.
5. Rana TS, Datt B, Rao RR. Life forms and biological spectrum of flora of tons valley, Garhwal Himalaya (Uttaranchal), India. Taiwania. 2002;47(2):164 -169.
6. Arila K, Easter, Gupta A. Life forms and biological spectrum of the grassland communities in the Thoubal district of Manipur in North- East India. Pleione. 2016;10(1):80 -89.
7. Devi AR, Sharma BM, Sharma HM. Analysis of life-forms and biological spectrum of the grassland communities in the Thoubal District, Manipur. Indian J. Environ and Ecoplan. 2004;8(1):97-101.
8. Power ME. Floods, food chains and ecosystem processes in rivers. In: Jones CG, Lawton JH, editors. Linking Species and Ecosystems. Chapman and Hall, New York, USA. 1995;52-60.
9. Gairola S, Rawal RS, Todaira NP. Forest vegetation patterns along an altitudinal gradient in Sub-alpine zone of West Himalaya, India. African Journal of Plant Science. 2008;2(6):42-48.
10. Timilisina N, Ross MS, Heiner JT. A community analysis of Sal (*Shorea robusta*) forest in the Western Terai of Nepal. Forest Ecology and Management. 2007;241(1-3):223 -234.
11. Shaheen, Ullah Z, Khan SM, Harper DM. Species composition and community structure of Western Himalayan moist temperate forests in Kashmir. Forest Ecology and Management. 2012;278:138 -145.
12. Pressey RL, Johanson IR, Wilson PD. Shades of irreplaceability: Towards a measure of the contribution of sites to a preservation goal. Biodiversity and Conservation. 1994;3:242 -262.
13. Mueller-Dombois D, Ellenberg H. Aims and methods of vegetation ecology. John Wiley and Sons Inc., New York., USA; 1974.
14. Cain SA. Life forms and phytoclimates. Bot. Rev. 1950;16:1-32.
15. Whitford PB. Distribution of Woodland plants in relation to succession and colonial growth. Ecology. 1949;30:199 -208.

16. Misra R. Ecology Work Book. Oxford and IBH Pub. Co., New Delhi (India); 1968.

17. Shannon CC, Weaver W. The mathematical theory of communication. University of Illinois Press, Urbana, Illinois, USA; 1963.

18. Shannon CE. A mathematical theory of communication. The Bell System Technical Journal. 1948;27:379–423 and 27: 623–656.

19. Sharma PD. Ecology and environment. 11th revised ed. Meerut, Rastogi Publications. 2012;135- 136.

20. Simpson EH. Measurement of diversity. Nature. 1949;163:688.

21. Jaccard P. Étude comparative de la distribution florale dans une portion des Alpes et des Jura. Bulletin de la Société Vaudoise des Sciences Naturelles. 1901;375:47-579.

22. Dice LR. Measures of the amounts of ecological association between species. Ecology. 1945;26;3:297-302.

23. Devi AR, Sharma BM, Sharma HM. Biological spectrum of the grasslands at Canchipur, Manipur. Geobios. 2000;27:65 -68.

24. Batalha MA, Martins FR. The vascular flora of the cerrado in Emas National Park (Goiás, central Brazil). Sida. 2002;20:295 -312.

25. Usharani L. Ecological studies of structure and functioning of certain sacred groves of Manipur, North-East India. Thesis, Manipur University; 2004.

26. Nazir A, Malik ZH. Life form and index of similarity of plant communities recorded at Sarsawa hills district Kotli. J. Research (Science), Bahauddin Zakariya University, Multan, Pakistan. 2006;17(1):27 -33.

27. Ranita N, Kandya AK, Gupta A. Composition, diversity and distribution trends in human impacted indo-myanmar border forest. Proceedings on National Conference on Current Scenario on Global Challenges in Germplasm Conservation and Biodiversity, Nagpur University. 2010;17 – 18.

28. Sidanand VK, Kotresha K. Life-forms and biological spectrum of a dry deciduous forest in gadag District, Karnataka, India. Research and Reviews: A Journal of Botany. 2012;1(1):1- 28.

29. Devi KB, Singh HB, Gupta A. Life form in hill forest of Manipur, North-East, India. J. Agroeco. Nat. Res. Manag. 2014;1(1):7 -13.

30. Imosana RK, Gupta A. Life-form classification and biological spectrum of Amambiliok Sacred Grove, Andro, Manipur in Northeast India. Pleione. 2015;9(2):356 -364.

31. Thakur AS. Floristic composition, life-forms and biological spectrum of tropical dry deciduous forest in Sagar District, MP. India. Trop. Pl. Res. 2015;2(2):112 -119.

32. Easter KA, Gupta A. Life-forms and biological spectrum along the altitudinal gradient in Montane Forests of Senapati district of Manipur in North-East India. Pleione. 2016;10(1):80 -89.

33. Barik S, Barik KL. Biological spectrum of a grassland community of Balasore District in Odisha. International Journal of Scientific Research and Review. 2018;7(7):478 -485.

34. Sophia M, Behera N, Gupta A. Life-form and biological spectrum of sub-tropical forests and agroecosystems of Manipur in North-east India Pleione. 2019;13(2):346 -354.

35. Al Shaye NA, Mizrahi YS, Thomas J. Ecological significance of floristic composition and life forms of Riyadh region, Central Saudi Arabia. Saudi Journal of Biological Sciences. 2020;27:35 -40.

36. Patel AK. Study of biological spectrum and life form of kankupura area of visnagar taluka, Dist. Mehsana (North Gujarat). International Journal of Creative Research Thoughts. 2021;9(10):511 -516.

37. Bhatt RP. Vegetation analysis and differences in local environment variables in Indrawati hydropower project areas in Nepal. International Research Journal of Plant Science. 2010;1(4):083-094.

38. Gupta VC, Kachroo P. Life-form classification and biological spectrum of the flora of Yusmarg, Kashmir. Tropical Ecology. 1983;24:22 -28.

39. Katewa SS, Sharma R. Species composition, life-forms and biological spectrum of the shed areas of south Rajasthan. Indian Forester. 1999;125:713 -718.

40. Kaul V, Sarin YK. Life form classification and biological spectrum of flora of Bharderwah. Tropical Ecology. 1976;17(2):132 -138.

41. Jadhav DG. Biological spectrum with some other attributes of the flora and vegetation of the Salher Fort of Maharashtra, India.

Int. J. Adv. Res. Biol. Sci. 2020;7(4):146-155.

42. Niirou NG, Gupta A. Life forms classification and biological spectrum in natural and human impacted ecosystems of Senapati district, Manipur, India. Eco. Env. and Cons. 2020;26:S307 -S313.

43. Pandey N, Nautiyal BP, Bhatt AB. Growth form and biological spectrum in an alpine region in northwest Himalaya. Tropical Ecology. 1999;40:319 -322.

44. Raina AK, Kumar R. Floristic composition, life form classification and biological spectrum of the catchment of Rattle H.E. project, District Kishtwar- J and K. Environ. Conserv. J. 2011;12(3):1-6.

45. Saxena A, Pandey P, Singh JS. Biological spectrum and other structural-functional attributes of the vegetation of Kumaun Himalaya. Vegetatio 1982;49(2):111 -119.

46. Singh BP, Arora A. Biological spectrum of the vegetation of Ganganagar District of Rajasthan. *Rheedea.* 1994;4:74-78.

47. Singh JS, Yadava PS. Seasonal variation in composition, plant biomass and net primary productivity of a tropical grassland at Kurukshetra, India. Ecol. Monogr. 1974;44: 351-376.

48. Singh UN, Ambasht RS. Biotic stress and in variability in structure and organic (net primary) production of grassland communities at Varanasi, India. Tropical Ecology. 1975;16:86 -95.

49. Subramani SP, Jishtu V, Verma RK, Kapoor KS. Floristic composition, life-forms and Biological spectrum of Renuka Wild life Sanctuary, Himachal Pradesh. Indian Forester. 2007;133:79 -92.

50. Varma R, Das RR. A new approach towards the use of Raunkiaer's biological spectrum. Tropical Ecology. 1980;21:9 -15.

51. Vora AB, George VC. The distribution of various life forms in the ground flora under different canopies of Panchamahal forests, Gujarat. Indian J. For. 1987;10:223 -225.

52. Sharma J, Raina AK, Sharma S. Life form classification and biological spectrum of Lamberi Forest Range, Rajouri, J&K, India. Int. J. Curr. Microbiol. App. Sci. 2018;3(11):234-239.

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