Life-form and Biological Spectrum of sub-tropical forests and agroecosystems of Manipur in North-east India

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Abstract

The present study was carried out in Community Forest (Sacred grove), Reserve Forest and Agroecosystem (Home Garden) of Imphal West district of Manipur (latitudes 23°50' N to 25°42' N and longitudes 92°58' E to 94°45' E). A total of 159 plant species belonging to 63 families were recorded and categorized in different life forms based on the position of their perennating buds. Percentage of species belonging to each life-form category shows variation from the normal biological spectrum of Raunkiaer (1934) comprising Phanerophytes (53.16 %), Therophyte (24.52 %), Cryptophytes (8.17 %), Hemipterophytes (10.06 %) and Chamaephytes (5.66 %). On the basis of this study the phytoclimate of the study area as per Raunkiaer's terminology, has been described as 7 phenero-therophytic phytoclimate.

Key words: Life-form, Biological spectrum, Phytoclimate, Sacred grove, Manipur

INTRODUCTION

Life-form study is an important part of vegetation description, ranking next to floristic composition (Cain 1950). Plants can be grouped in life form classes based on their similarities in structure and function (Mueller-Dombois & Ellenberg 1974). Humboldt (1806) for the first time formulated the concept of the life forms based on the location of perennating buds or organs. According to Odland (2009) life-forms of plant are functional types that have been used to describe plant adaptation to certain ecological conditions. Plants with a similar life form are expected to exhibit similar responses on the dominant ecosystem processes (Pauses & Austin 2001). In Raunkiaer's (1934) system, there are five major classes, arranged according to increased protection of renewing buds: Phanerophytes, Chamaephytes, Hemipterophytes, Cryptophytes and Therophytes. According to Begon *et al.* (1996) it is the simplest and, in many ways, the most satisfying classification of plant life forms.

Biological spectrum is the percent representation of the number of species belonging to each life form in a given flora. Raunkiaer (1934) constructed a "normal spectrum" which could act as a null model against which different life-form spectra could be compared. Differences in the life form distribution between the normal spectrum and a biological spectrum would point out which life-form characterizes the phytoclimate or the vegetation under study.

METHODOLOGY

Three different sites were selected for the present study namely (i) *Community Forest Sacred grove* [Site I], located at 24°46'50" N latitude and 93°51'83" E longitude at Konthoujam

village, 11 km west of the Imphal city, Manipur at an elevation of 781 m AMSL. (ii) *Reserve forest* [Site II], located at 24°52'45" N latitude and 93°54'51" E longitude at Khonghampat within the Langol Reserve Forest, 12 kms from Imphal city at an elevation of 791 m AMSL and (iii) *Agroecosystem, Home garden* [Site III] located at 24°52'31" N latitude and 93°53'32" E longitude at Khamran village, 14 km from Imphal city at an elevation of 785 m AMSL. The climate of the study area experiences monsoonal climate with warm moist summer and cool dry winter. The mean maximum temperature varied from 22.5° C (January) to 29° C (September) and mean minimum temperature ranged from 4.97° C (January) to 22.94° C (July). The average annual rainfall is 1,467.5 mm.

Intensive survey was conducted during April 2011 to March 2012 for plant collections and observation. All the species were identified and enumerated by matching at ASSAM and CAL herbaria. The voucher specimens are submitted in Life Science Department, Manipur University. The following growth forms were recognized – Trees, Shrubs and Herbs. Biological life form, habit, height and the location of perennating buds of species at three study sites were observed. The species were further placed in various life form classes as per Raunkiaer's system (Raunkiaer 1934). Biological spectrum was worked out representative of the three study sites. For categorization of species in various life forms the following formula was used:

$$\text{Percentage of life-form} = \frac{\text{Number of species in any life-form}}{\text{Total number of species of all life-form}} \times 100$$

RESULT

A total number of 159 species of plants belonging to 63 families were recorded from the study sites and categorized in different life forms based on the position of their perennating buds (Table 1). Families recorded with maximum species were Leguminosae, Asteraceae, Lamiaceae, Poaceae, Malvaceae, Moraceae, Myrtaceae, Lauraceae, Amaryllidaceae, Polygonaceae, Rutaceae, Solanaceae and Zingiberaceae, etc. The life form exhibited by trees and shrubs comprised of phanerophytes whereas herbs were found belonging to five major life forms viz., Phanerophytes (Ph), Chamaephytes (Ch), Hemicryptophytes (Hc), Cryptophytes (Cr) and Therophytes (Th). Biological spectrum of the three study sites is reflected in Table 2. The percentage of species belonging to each life-form category shows variation from the normal biological spectrum of Raunkiaer (1934) comprising Phanerophytes with 53.16% as shown in Figures 1 & 2. Phytoclimate for the study sites as per Raunkiaer's life form classification has been described as 'phanero-therophytic' phytoclimate.

Table 1. Inventory of the floristic composition at study sites.

Scientific name	Family	Life form	Site-I (SG)	Site-II (F)	Site-III (HG)
<i>Abrus precatorius</i> L.	Malvaceae	Ph	-	+	-
<i>Acacia farnesiana</i> (L.) Willd	Leguminosae	Ph	-	-	+
<i>Achyranthes aspera</i> L.	Amaranthaceae	Cr	+	-	-
<i>Acorus calamus</i> L.	Acoraceae	Cr	-	-	+
<i>Adiantum aleuticum</i> (Rupr.) C.A. Paris	Pteridaceae	Hc	-	+	-
<i>Adiantum lunulatum</i> Burm.f.	Pteridaceae	Hc	+	-	-
<i>Aegle marmelos</i> (L.) Correa	Rutaceae	Ph	+	-	-
<i>Ageratum conyzoides</i> (L.) L.	Asteraceae	Th	+	+	-
<i>Albizia chinensis</i> (Osbeck) Merr.	Leguminosae	Ph	+	-	-

Scientific name	Family	Life form	Site-I (SG)	Site-II (F)	Site-III (HG)
<i>Albizia lebbeck</i> (L.) Benth.	Leguminosae	Ph	-	+	-
<i>Allium gomphrenoides</i> Boiss. & Heldr.	Amaryllidaceae	Cr	-	-	+
<i>Allium hookeri</i> Thwaites	Amaryllidaceae	Cr	-	-	+
<i>Allium ramosum</i> L.	Amaryllidaceae	Cr	-	-	+
<i>Alnus nepalensis</i> D. Don	Betulaceae	Ph	-	+	-
<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Th	-	+	-
<i>Amaranthus spinosus</i> L.	Amaranthaceae	Th	-	-	+
<i>Amoora rohituka</i> (Roxb.) Wight & Arn.	Meliaceae	Ph	+	-	-
<i>Antidesma</i> sp.	Phyllanthaceae	Ph	-	+	-
<i>Aquilaria malaccensis</i> Lam.	Thymelaeaceae	Ph	+	+	-
<i>Argemone maxicana</i> L.	Papaveraceae	Th	+	-	-
<i>Argyrea nervosa</i> (Burm.f.) Bojer	Convolvulaceae	Ph	+	-	-
<i>Artabotrys hexapetalus</i> (L.f.) Bhandari	Annonaceae	Ph	+	+	-
<i>Artocarpus integer</i> (Thunb.) Merr.	Moraceae	Ph	-	-	+
<i>Artocarpus lakucha</i> Buch.-Ham.	Moraceae	Ph	-	-	+
<i>Athyrium filix-femina</i> (L.) Roth	Athyriaceae	Hc	-	-	-
<i>Averrhoa carambola</i> L.	Oxalidaceae	Ph	-	-	+
<i>Bambusa nutans</i> Wall. ex Munro	Poaceae	Ph	-	-	+
<i>Bauhinia variegata</i> L.	Leguminosae	Ph	+	-	-
<i>Bixa orellana</i> L.	Bixaceae	Ph	-	+	-
<i>Blumea balsamifera</i> (L.) DC.	Asteraceae	Th	+	-	-
<i>Bombax ceiba</i> L.	Malvaceae	Ph	-	+	-
<i>Brassica oleracea</i> L. [cultivars]	Brassicaceae	Th	-	-	+
<i>Brassica rapa</i> L.	Brassicaceae	Th	-	-	+
<i>Bridelia stipularis</i> (L.) Blume	Phyllanthaceae	Hc	-	+	-
<i>Calotropis gigantea</i> (L.) Dryand.	Apocynaceae	Ph	+	-	-
<i>Carica papaya</i> L.	Caricaceae	Ph	-	-	+
<i>Celtis australis</i> L.	Cannabaceae	Ph	+	+	-
<i>Celtis timorensis</i> Span.	Cannabaceae	Ph	+	-	-
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Hc	-	-	+
<i>Cheilocostus speciosus</i> (J. Koenig) C.D. Specht	Costaceae	Hc	+	+	-
<i>Chenopodium album</i> L.	Amaranthaceae	Th	-	-	+
<i>Chromolaena odorata</i> (L.) R.M. King & H. Rob.	Asteraceae	Ph	-	+	-
<i>Chukrasia tabularis</i> A. Juss.	Meliaceae	Ph	+	-	-
<i>Cinnamomum tamala</i> (Buch.-Ham.) T. Nees & Eberm.	Lauraceae	Ph	-	-	+
<i>Cinnamomum verum</i> J. Presl	Lauraceae	Ph	-	+	-
<i>Citrus limon</i> (L.) Osbeck	Rutaceae	Ph	-	-	+
<i>Citrus maxima</i> (Burm.) Merr.	Rutaceae	Ph	-	-	+
<i>Colocasia antiquorum</i> Schott	Araceae	Cr	-	-	+
<i>Cordia grandis</i> Roxb.	Boraginaceae	Ph	+	-	-
<i>Coriandrum sativum</i> L.	Apiaceae	Th	-	-	+
<i>Corymbia citriodora</i> (Hook.) K.D. Hill & L.A.S. Johnson	Myrtaceae	Ph	-	+	-
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	Hc	-	-	+
<i>Crotalaria saltiana</i> Andrews	Leguminosae	Ph	-	+	-
<i>Curcuma longa</i> L.	Zingiberaceae	Cr	-	-	+

Scientific name	Family	Life form	Site-I (SG)	Site-II (F)	Site-III (HG)
<i>Cyanthillium cinereum</i> (L.) H. Rob.	Asteraceae	Th	+	-	-
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Ch	+	+	-
<i>Cynoglossum zeylanicum</i> (Vahl) Brand	Boraginaceae	Th	+	-	-
<i>Cyperus rotundus</i> L.	Cyperaceae	Cr	+	+	-
<i>Dactyloctenium aegyptium</i> (L.) Wild.	Poaceae	Hc	+	+	-
<i>Datura stramonium</i> L.	Solanaceae	Ph	+	-	-
<i>Delonix regia</i> (Boj. ex Hook.) Raf.	Leguminosae	Ph	+	-	-
<i>Derris robusta</i> (Roxb. ex DC.) Benth.	Leguminosae	Ph	-	+	-
<i>Desmodium laxiflorum</i> DC.	Leguminosae	Th	-	+	-
<i>Digitaria sanguinalis</i> (L.) Scop.	Poaceae	Th	-	+	-
<i>Dipterocarpus turbinatus</i> C.F. Gaertn	Dipterocarpaceae	Ph	-	+	-
<i>Drymaria cordata</i> (L.) Willd. ex Schult.	Caryophyllaceae	Hc	+	-	-
<i>Dryopteris filix-mas</i> (L.) Schott	Dryopteridaceae	Hc	-	+	-
<i>Eclipta prostrata</i> (L.) L.	Asteraceae	Th	+	-	-
<i>Elaeagnus latifolia</i> L.	Elaeagnaceae	Ph	-	-	+
<i>Elaeocarpus floribundus</i> Blume	Elaeocarpaceae	Ph	-	-	+
<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Ch	+	-	+
<i>Elsholtzia griffithii</i> Hook. f.	Lamiaceae	Th	-	-	+
<i>Enydra fluctuans</i> DC.	Asteraceae	Cr	-	+	+
<i>Eryngium foetidum</i> L.	Apiaceae	Th	-	-	+
<i>Erythrina variegata</i> L.	Leguminosae	Ph	-	+	-
<i>Eucalyptus globules</i> Labill	Myrtaceae	Ph	-	-	+
<i>Euphorbia hirta</i> L.	Euphorbiaceae	Th	-	+	-
<i>Euphorbia prostrata</i> Aiton	Euphorbiaceae	Th	-	+	-
<i>Ficus benjamina</i> L.	Moraceae	Ph	+	-	-
<i>Ficus hispida</i> L. f.	Moraceae	Ph	-	+	-
<i>Ficus racemosa</i> L.	Moraceae	Ph	+	-	-
<i>Ficus religiosa</i> L.	Moraceae	Ph	-	+	-
<i>Gmelina arborea</i> Roxb.	Lamiaceae	Ph	+	+	-
<i>Grevillea robusta</i> A. Cunn. ex R. Br.	Proteaceae	Ph	-	+	-
<i>Gynura cusimbua</i> (D. Don) S. Moore	Asteraceae	Th	+	-	-
<i>Hibiscus cannabinus</i> L.	Malvaceae	Ph	-	-	+
<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	Ph	-	-	+
<i>Houttuynia cordata</i> Thunb.	Saururaceae	Hc	-	-	+
<i>Justicia adhatoda</i> L.	Acanthaceae	Ph	+	-	+
<i>Lantana camara</i> L.	Verbenaceae	Ph	+	+	-
<i>Leucas aspera</i> (Willd.) Link	Lamiaceae	Th	-	-	+
<i>Lindernia anagallis</i> (Burm. f.) Pennell	Linderniaceae	Cr	-	+	-
<i>Lithocarpus fenestratus</i> (Roxb.) Rehder	Fagaceae	Ph	-	+	-
<i>Litsea cubeba</i> (Lour.) Pers.	Lauraceae	Ph	+	-	-
<i>Litsea monopetala</i> (Roxb.) Pers.	Lauraceae	Ph	+	+	-
<i>Lolium perenne</i> L.	Poaceae	Ch	-	-	+
<i>Luffa acutangula</i> (L.) Roxb	Cucurbitaceae	Th	-	-	+
<i>Lycopersicon esculentum</i> Mill.	Solanaceae	Th	-	-	+
<i>Magnolia champaca</i> (L.) Baill. ex Pierre	Magnoliaceae	Ph	-	-	+
<i>Mangifera indica</i> L.	Anacardiaceae	Ph	+	+	-

Scientific name	Family	Life form	Site-I (SG)	Site-II (F)	Site-III (HG)
<i>Melia azadirach</i> L.	Meliaceae	Ph	+	+	+
<i>Mentha piperita</i> L.	Lamiaceae	Hc	-	-	+
<i>Meriandra dianthera</i> (Roth ex Roem. &Schult.) Briq.	Lamiaceae	Ph	-	-	+
<i>Meyna laxiflora</i> Robyns	Rubiaceae	Ph	-	+	-
<i>Mimosa pudica</i> L.	Leguminosae	Ph	+	+	-
<i>Musa</i> × <i>paradisical</i> L.	Musaceae	Cr	-	-	+
<i>Mycetia stipulate</i> (Hook.f.) Kuntze.	Rubiaceae	Ph	-	+	-
<i>Neanotis hohenackeri</i> P.Daniel&Vajr.	Rubiaceae	Th	+	-	-
<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	Ph	+	-	-
<i>Ocimum americanum</i> L.	Lamiaceae	Th	-	-	+
<i>Ocimum tenuiflorum</i> L.	Lamiaceae	Th	-	-	+
<i>Oplismenus burmani</i> (Retz.) P.Beauv.	Poaceae	Th	+	-	-
<i>Oroxylum indicum</i> (L.) Kurz	Bignoniaceae	Ph	+	-	-
<i>Osbeckia stellata</i> Buch.-Ham. ex Ker Gawl.	Melastomataceae	Ph	-	+	-
<i>Oxalis corniculata</i> L.	Oxalidaceae	Hc	-	-	+
<i>Parkia timoriana</i> (DC.) Merr.	Leguminosae	Ph	+	+	+
<i>Persicaria barbata</i> (L.) H.Hara	Polygonaceae	Th	-	-	+
<i>Persicaria chinensis</i> (L.) H. Gross	Polygonaceae	Th	-	+	-
<i>Phaseolus lanatus</i> Benth.	Leguminosae	Ch	-	-	+
<i>Phyllanthus emblica</i> L.	Phyllanthaceae	Ph	+	+	+
<i>Phyllanthus urinaria</i> L.	Euphorbiaceae	Th	-	+	-
<i>Pinus kesiya</i> Royle ex Gordon.	Pinaceae	Ph	-	+	-
<i>Pisum sativum</i> L.	Leguminosae	Th	-	-	+
<i>Plantago asiatica</i> subsp. <i>erosa</i> (Wall.) Z.Yu Li	Plantaginaceae	Th	-	+	+
<i>Plumbago zeylanica</i> L.	Plumbaginaceae	Th	-	+	-
<i>Plumeria rubra</i> L.	Apocynaceae	Ph	-	-	+
<i>Polygonum posumbu</i> Buch.-Ham. ex D.Don	Polygonaceae	Th	-	-	+
<i>Portulaca oleracea</i> L.	Portulacaceae	Ch	+	-	-
<i>Psidium gujava</i> L.	Myrtaceae	Ph	-	-	+
<i>Punica granatum</i> L.	Lythraceae	Ph	-	-	+
<i>Quercus griffithii</i> Hook.f.& Thomson ex Miq.	Fagaceae	Ph	+	-	-
<i>Quercus serrata</i> Murray	Fagaceae	Ph	-	+	-
<i>Ranunculus diffusus</i> DC.	Ranunculaceae	Th	-	+	-
<i>Rhus succedanea</i> L.	Anacardiaceae	Ph	-	+	-
<i>Ruellia prostrate</i> Poir.	Acanthaceae	Th	-	+	-
<i>Saccharum officinarum</i> L.	Poaceae	Hc	-	-	+
<i>Schima wallichii</i> Choisy	Theaceae	Ph	-	+	-
<i>Scutellaria discolor</i> Colebr.	Lamiaceae	Ch	-	+	-
<i>Sesbania sesban</i> (L.) Merr.	Leguminosae	Hc	-	-	+
<i>Sida acuta</i> Burm.f.	Malvaceae	Ph	-	+	-
<i>Sida cordifolia</i> L.	Malvaceae	Ph	+	-	-
<i>Smilax calophylla</i> Wall. ex A.DC.	Smilacaceae	Cr	-	+	-
<i>Solanum melongena</i> L.	Solanaceae	Ch	-	-	+
<i>Solanum tuberosum</i> L.	Solanaceae	Th	-	-	+
<i>Spilanthes acmella</i> (L.) L.	Asteraceae	Th	+	-	-
<i>Spondias macrophylla</i> Klotzsch ex Engl.	Anacardiaceae	Ph	-	+	-

Scientific name	Family	Life form	Site-I (SG)	Site-II (F)	Site-III (HG)
<i>Stachytarpheta indica</i> (L.) Vahl	Verbenaceae	Ch	+	-	-
<i>Stellaria media</i> (L.) Vill.	Caryophyllaceae	Ch	-	-	+
<i>Syzygium cymosum</i> (Lam.) DC.	Myrtaceae	Ph	+	-	-
<i>Syzygium jambos</i> (L.) Alston	Myrtaceae	Ph	+	-	-
<i>Taraxacum campylodes</i> G.E.Haglund	Asteraceae	Ph	-	+	-
<i>Tectona grandis</i> L.f.	Lamiaceae	Ph	+	+	-
<i>Terminalia chebula</i> Retz.	Combretaceae	Ph	+	-	-
<i>Toona ciliata</i> M. Roem.	Meliaceae	Ph	+	+	+
<i>Tridax procumbens</i> (L.) L.	Asteraceae	Th	+	-	-
<i>Urena lobata</i> L.	Malvaceae	Ph	-	+	-
<i>Vitex negundo</i> L.	Lamiaceae	Ph	+	+	-
<i>Xylosma longifolia</i> Clos	Salicaceae	Ph	-	+	-
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Cr	-	-	+

Table 2. Comparison of biological spectrum of study sites with Raunkiaer's (1934) Normal Biological Spectrum.

Life-form class	Life form Percentage (%)	
	Normal Spectrum	Present study
PH	46.0	52.83
CH	9.0	5.66
H	26.0	9.43
CR	6.0	8.18
TH	13.0	23.90

Table 3. Comparison of Biological Spectrum of the present study sites with other subtropical climatic types in Manipur.

Location	PH	CH	H	CR	TH	Reference
Normal Biological Spectrum of Raunkiaer	46.0	9.0	26.0	6.0	13.0	Raunkiaer (1934)
Sub-tropical forest Manipur	66.9	8.06	4.03	4.83	16.1	Usharani (2004)
Teak Dipterocarpus forest, Indo-Myanmar border Site I	63.2	8.1	2.04	6.12	20.4	Ranita <i>et al.</i> (2010)
Site II	65.9	8.5	2.12	4.25	19.1	
Hill forest of Manipur	62.76	10.64	1.06	7.45	18.08	Devi <i>et al.</i> (2014)
Amambilok Sacred Grove, Andro, Manipur	55.41	6.36	10.19	8.28	19.74	Imosana & Gupta (2015)
Subtropical Montane forest Site I	53.49	10.46	11.62	8.14	16.28	Easter & Gupta (2016)
Temperate Montane forest, Site II	63.64	9.09	6.81	18.19	2.27	
Subtropical Phytoclimate	52.83	5.66	9.43	8.18	23.90	Present study

DISCUSSION

Biological spectrum not only represents the climatic conditions but the most potent environmental factor representing the ecosystem (Pandeya & Sharma 1950). Similar phyto-

Figure 1. Graphical representation of different Life forms in study sites.

Figure 2. Comparison of biological spectrum of study sites (Average value) with Raunkiaer's Normal Spectrum.

climatic conditions have also been reported by some workers (Lakshmanan 1962; Misra *et al.* 1979; Saxena & Singh 1980; Khatri 2000; Devi *et al.* 2014; Imosana & Devi 2015; Easter & Devi 2016). Biological life forms are reflected by bioclimate of the area (Meher-Homji 1964). Thus, in humid regions, the bioclimate should be phanerophytic, in arid regions and intensively cultivated areas as therophytic and in temperate high altitudinal zones, arctic regions as chamaephytic. According to Subramani *et al.* (2007) higher percentage of Therophytes occurring in the area is the characteristic of subtropics and often related to soil and climatic conditions. It has also been reported that Therophytes and next to Phanerophytes (Thakur 2015). Prevalence of Therophytes is also an indicator of biotic pressure (Bharucha & Dave 1944). The occurrence of Therophytes was much favoured in disturbed areas (Keeley & Albert 1977; Vora & George 1987). Dominance of Phanerophytes reveal the

significance of trees in ameliorating the micro-climate, controlling the regeneration, establishment of herbaceous plants, maintenance of biodiversity and functioning of the ecosystem.

CONCLUSION

The phytoclimate of the present study revealed that the vegetation is predominantly sub-tropical type having a higher percentage of Phanerophytes and Therophytes indicates influence of anthropogenic activities which favors the growth of short lived annuals.

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LITERATURE CITED

- Begon, M.; Harper, J.L. & Townsend, C.R. 1996. *Ecology: Individuals, Populations and Communities*. Blackwell, Oxford.
- Bharucha, F.R. & Dave, R.N. 1944. The biological spectrum of Grassland association. *J. Univ. Bombay*. 13: 15 – 25.
- Cain, S.A. 1950. Life-forms and Phytoclimate. *Bot. Rev.* 16: 1 – 32.
- Devi, K.B.; Singh, H.B. & Gupta, A. 2014. Life form in Hill Forest of Manipur, North-East, India. *J. Agroeco. Nat. Res. Manag.* 1(1): 7 – 13.
- Easter, K.A. & Gupta, A. 2016. Life-forms and biological spectrum along the altitudinal gradient in Montane Forests of Senapati district of Manipur in North-East india. *Pleione* 10(1): 80 – 89.
- Humboldt, A. von 1806. *Ideen zu einer Physiognomik der Gewächse*. Tübingen: Cotta. [Ideas for a physiognomy of plants, pp. 210-352]
- Imosana, R.K. & Gupta, A. 2015. Life-form classification and biological spectrum of Amambiliok Sacred Grove, Andro, Manipur in Northeast India. *Pleione* 9(2): 356 – 364.
- Keeley, S.C. & Albert, W.J. 1977. A comparison of pattern of herb, shrub growth in comparable sites of chili and California. *Am. Midl. Natur.* 97: 120 – 132.
- Khatri, P.K. 2000. *Study on biodiversity in tropical forest ecosystem of Satpura National Park Madhya Pradesh*. Ph.D. Thesis. Forest Research institute, Dehra Dun.
- Lakshmanan, N.K. 1962. The application of Raunkiaer's life-forms. *J. Indian Bot. Soc.* 41: 585 – 589.
- Meher-Homji, V.M. 1964. Life forms and biological spectra as epharmonic criteria of aridity and humidity in tropics. *J. Indian Bot. Soc.* 43(3): 424 – 430.
- Misra, M.P.; Mishra, P.N. & Pandey, B.N. 1979. An ecological account of the vegetation of Brahmyoni Hills (Gaya). *Proc. Indian Sci. Cong.* 3: 108 – 109.
- Mueller-Dombois, D. & Ellenberg, H. 1974. *Aims and methods of vegetation ecology*. John Wiley and Sons, New York.
- Odland, A. 2009. Interpretation of altitudinal gradient in South Central Norway based on vascular plants as environmental indicators. *Ecol. Indicators*. 9: 409 – 421.

- Pandey, S.C. & Sharma, I.K.V. 1950. The biological spectrum of the flora of Makronia Plateau. *Bull. Bot. Soc., Univ. Saugor*: 22.
- Pausas, J.G. & Austin, M.P. 2001. Pattern of plant species richness in relation to different environments. An appraisal. *J. Veg. Sci.* 12: 153 – 166.
- Ranita, N.; Kandya, A.K. & Gupta, A. 2010. 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. 17 – 18.
- Raunkiaer, C. 1934. *The life forms of plants and statistical plant geography*. Claredon Press, Oxford.
- Saxena, A.K. & Singh, J.S. 1980. “Analysis of forest grazing land and vegetation in parts of Kumuan Himalaya land” *J. Range Mange*, 1: 13 – 32.
- Subramani, S.P.; Jishtu, V.; Verma, R.K. & Kapoor, K.S. 2007. Floristic composition, life forms and biological spectrum of Renuka Wild life Sanctuary, Himachal Pradesh. *Indian For.* 133: 79 – 92.
- Thakur, A.S. 2015. Floristic composition, life-forms and biological spectrum of tropical dry deciduous forest in Sagar District, M.P. India. *Trop. Pl. Res.* 2(2): 112 – 119.
- Usharani, L. 2004. *Ecological studies of structure and functioning of certain sacred groves of Manipur, North-East India*. Ph.D. Thesis, Manipur University.
- Vora, A.B. & George, V.C. 1987. The distribution of various life forms in the ground flora under different canopies of Panchamahar forests, Gujarat, *Indian J. For.* 10: 223 – 225.