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Life-forms and biological spectrum along the altitudinal gradient in Montane Forests of Senapati district of Manipur in North-East India

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Abstract

Analysis of life-forms of the vegetation along the altitudinal gradient in Montane forests of Senapati district in Manipur was carried out using quadrat method. The study revealed that the life-form patterns clearly change along altitudinal gradients. While therophytes, chamaephytes and hemicrptophytes showed decreasing trends, the phanerophytes and cryptophytes were recorded with increasing trend along the altitudinal gradient in the area. Temperature, soil moisture and nutrients are the main factors that explain the ecological influences of altitude on life-forms patterns in the montane forests of the area.

***Key words*: Life-form, altitudinal gradient, montane forest, Manipur

INTRODUCTION

Studies on the biological changes along the altitudinal gradients has been proved to be very practical (Kane *et al*. 2003; Zimmermann *et al*. 2009) as altitude is one of the most important factors determining micro-site conditions that impact plant's distribution, morphology, physiology and growth (Chapin *et al*. 1987; Despland & Houle 1997; Parmeson 2006; Li *et al*. 2009). According to Korner (2007), altitudinal gradients are among the most powerful natural experiments for testing ecological and evolutionary responses of biota to environmental changes. The life-forms are classified on the basis of adaptations of their perennating organs to tide over the unfavourable conditions. Plant life-forms are functional types that have been used to describe plant adaptation to certain ecological conditions (Odland 2009). According to Cain (1950), it is the sum of all life processes and evolved directly in response to the environment. Plants with a similar life-form are expected to exhibit similar responses on the dominant ecosystem processes (Pausas & Austin 2001). Therefore, these morpho-ecological types can be used to indicate particular climate properties, biogeographic regions, major biomes of the world and other environmental differences especially in regions with distinguishable seasonal climate (Klimes 2003). Variation in life-forms along the altitudinal gradients has been used commonly for better interpretation of vegetation and species richness patterns in relation to environmental gradient.

Since plant life-forms are associated to the environment, biological spectrum is considered as a sensitive indicator of the prevailing physical and biological factors. The biological spectrum is the percent representation of various life-forms put together. The occurrence of similar biological spectrum in different regions indicates similar climatic conditions. According to Raunkiaer (1934), the bioclimate of the region is characterized by the life forms whose percentage value is much higher than the normal spectrum. Variation in the life form distribution between the normal spectrum and biological spectrum would point out which life-form characterizes the phytoclimate or the vegetation under study. However, the spectrum varies due to high biotic disturbances.

Basic studies on the biological spectrum in different phytoclimatic zones of India have been worked out by different researchers (Meher-Homji 1964~ Pandey & Parmar 1993; Sharma & Dhakre 1993~ Reddy *et al*. 1999, 2002, 2011~ Rana *et al*. 2002; Pattanaik *et al*. 2007). While Usharani (2004), Ranita *et al.* (2010) and Devi *et al.* (2014) worked on different forests of Manipur. Wang *et al*. (2002), Shah *et al*. (2013) and Mahdavi *et al*. (2013) worked on life-form patterns along the altitudinal gradient, however they remarked about lesser availability of literature on the subject. Therefore, the present study aims to (i) investigate the floristic composition, (ii) classify vegetation into life-forms, and (iii) study the distribution of plant life-forms along the altitudinal gradients.

Study area

The present study was carried out along the altitudinal gradient in Montane forests of Senapati district, Manipur in NE India (Latitude: 25°14’52.7" – 25°22’57" N and Longitude: 94°00’ 10.0" – 94°13’41.7" E) with an elevation ranging from 1160 – 1810 m above the mean sea level. Two study sites have been selected viz. Tahou (*site I*) and Purul (*site II*). *Site I* occurs at lower elevation located about 60 km away from Imphal City. The site hosts the characteristic subtropical elements dominated by tree species like *Schima wallichii* with the associated species as *Albizia procera, Quercus serrata, Litsea monopetala* etc. while *site II* occurs at the higher elevation and is located 120 km away from Imphal. It is characterised by temperate tree species as *Castanopsis hystrix* associated with *Engelhardtia spicata, Lithocarpus fenestratus, Prunus nepalensis* etc.

The site enjoys humid subtropical to temperate climate and as per the nearest meteorological station, it gets an average annual rainfall of 1450 mm. The temperature ranges from a minimum of –3p C in winter to a maximum of 34.14p C in summer. Geologically, the area falls in two types, the Disang and the Barail groups of rocks and is characterised by red soil and brownish loam in the hills and alluvial soil in the foothills.

METHDOLOGY

Survey for plant collections and observations were carried out from June 2011 to May 2013 using quadrats of three sizes, 10 x 10 m² for trees, 5 x 5 m² for shrubs and 1 x 1 m² for herbs. Ten samples of trees, twenty five samples of shrubs and 50 samples of herbs were studied in each site in different elevation bands to facilitate biogeographical comparison of species richness. Thus, floristic data were obtained from a total of 170 samples. The following growth forms were recognized-Trees, Shrubs and Herbs. In each forest the biological life form, habit, height and the location of perennating buds of species were observed. The species were further placed in various life-form classes as per Raunkiaer system (Raunkiaer 1934). The number of species in each life-form was calculated. The percentages of species belonging to each life-form were determined using following formula.

$$\text{Percentage of life-form} = \frac{\text{Number of species of a given lifeform}}{\text{Total number of species of all lifeform in a given altitudinal belt}} \times 100.$$

RESULTS

In the present study, altogether 111species belonging to 54 families and103 genera were recorded from the two study sites (Table 1). While *Site I* harbours 86 species representing 50 families and 82 genera, and, on the other hand, 44 species belonging to 30 families and 41 genera were recorded from the *site II*. Families recorded with maximum species were Asteraceae, Fagaceae, Verbenaceae and Apiaceae at lower elevation while Liliaceae, Lauraceae and Rosaceae were observed as dominant families at higher elevation areas.

The biological spectrum of the study area reveals the predominance of phanerophytes (57.66 %) followed by therophytes (12.61 %), chamaephytes (10.81 %), cryptophytes (9.91 %) and hemicryptophytes (9.01 %) based on analysis of the two study sites. The study also revealed that phanerophytes and cryptophytes showed an increasing trend towards high altitude when therophytes, chamaephytes and hemicryptophytes showed a decreasing trend. The percentage of species belonging to each life-form category relative to the total number of species in each altitude is presented in Figs. 1 and 2. Phanerophytes were the dominant life-form and together with cryptophytes showed an increasing trend with altitude. Therophytes comprising annuals with 12.61 % on overall average showed a sharp decreasing trend with altitude reaching from 16.28 % at lower elevation to 2.27 % at higher elevation.

Table 1. An inventory of the floristic composition in Montane Forest of Senapati.

Scientific Name	**Family**	**Life-form**	**Lower elevation, Site-I**	**Higher elevation, Site II**
Ageratina adenophora (Sprengel) R.M. King & H. Robinson	Asteraceae	Ph	+	+
Ageratum conyzoides Linnaeus	Asteraceae	Th	+	-
Ainsliaea pteropoda DC.	Asteraceae	Th	+	+
Ajuga macrosperma Wallich ex Bentham	Lamiaceae	Ph	+	-
Alangium chinense (Loureiro) Harms	Alangiaceae	Ph	+	-
Albizia lebbeck (Linnaeus) Bentham	Leguminosae	Ph	-	+
Albizia procera (Roxburgh) Bentham	Leguminosae	Ph	+	-
Alnus nepalensis D.Don	Betulaceae	Ph	+	+
Alpinia galanga (Linnaeus) Willdenow	Zingiberaceae	Cr	+	-
Alternanthera philoxeroides (Martius) Grisebach	Amaranthaceae	Th	+	-
Antidesma bunius (Linnaeus) Sprengel	Euphorbiaceae	Ph	+	-
Ardisia polysticta Miquel	Myrsinaceae	Ph	-	+
Arisaema tortuosum (Wallich) Schott	Araceae	Cr	+	+
Artemisia nilagirica (C.B. Clarke) Pampan	Asteraceae	Th	+	-
Asparagus filicinus Buch.- Hamilton ex D. Don	Liliaceae	Cr	+	+
Bauhinia variegata Linnaeus	Leguminosae	Ph	+	-
Bidens pilosa Linnaeus	Asteraceae	Th	+	-
Blumea hieracifolia Hayata	Asteraceae	Th	+	-
Bombax ceiba Linnaeus	Bombacaceae	Ph	+	-
Cassia fistula Linnaeus	Leguminosae	Ph	+	-
Castanopsis hystrix Hooker f. & Thomson ex A.DC.	Fagaceae	Ph	-	+
Celtis australis Linnaeus	Ulmaceae	Ph	+	-
Centella asiatica (Linnaeus) Urban	Apiaceae	H	+	-
Cinnamomum verum J. Presl	Lauraceae	Ph	-	+
Clerodendrum infortunatum Linnaeus	Verbenaceae	Ph	+	-
Commelina benghalensis Linnaeus	Commelinaceae	Ch	+	-

Scientific Name	Family	Life-form	Lower elevation, Site-I	Higher elevation, Site II
Cordia grandis Roxburgh	Boraginaceae	Ph	+	-
Curculigo orchioides Gaertner	Hypoxidaceae	Cr	+	-
Cyanthillium cinereum (Linnaeus) H. Robinson	Asteraceae	Th	+	-
Cyperus diffusus Vahl	Cyperaceae	Cr	-	+
Cyperus rotundus Linnaeus	Cyperaceae	Cr	+	+
Dactyloctenium aegypticum (Linnaeus) Willdenow	Poaceae	H	+	+
Datura stramonium Linnaeus	Solanaceae	Ph	-	+
Dichrocephala integrifolia (Linnaeus f.) Kuntze	Asteraceae	Th	+	-
Dillenia pentagyna Roxburgh	Dilleniaceae	Ph	+	-
Diospyros glandulosa Lace	Ebenaceae	Ph	+	+
Disporum cantoniense (Loureiro) Merril	Liliaceae	Cr	-	+
Drymaria cordata (Linnaeus) Willdenow ex Schultes	Caryophyllaceae	H	+	-
Dryopteris blanfordii (C. Hope) C. Christensen	Pteridaceae	H	+	+
Duranta erecta Linnaeus	Verbenaceae	Ph	+	-
Eclipta prostrata (Linnaeus) Linnaeus	Asteraceae	Th	+	-
Elaeagnus parvifolia Wallich ex Royle	Elaeagnaceae	Ph	-	+
Elaeocarpus lanceifolius Roxburgh	Elaeocarpaceae	Ph	-	+
Emilia sonchifolia (Linnaeus) DC. ex DC.	Asteraceae	Th	+	-
Engelhardtia spicata Lechen ex Blume	Juglandaceae	Ph	+	+
Fagopyrum esculentum Moench	Polygonaceae	Th	+	-
Ficus hispida Linnaeus	Moraceae	Ph	+	-
Ficus semicordata Buch.-Hamilton ex J.E. Smith	Moraceae	Ph	+	-
Flacourtia janggomas (Loureiro) Raeuschel	Flacourtiaceae	Ph	+	-
Fragaria nubicola Lindley ex Lacaita	Rosaceae	Ch	+	-
Girardinia diversifolia (Link) Friis	Urticaceae	Ch	+	-
Gmelina arborea Roxburgh	Verbenaceae	Ph	+	-
Hedychium coccineum Buch.-Hamilton ex Smith	Zingiberaceae	Cr	+	-
Heracleum sprengelianum Wight & Arnott	Apiaceae	Ch	+	-
Hippochaete debilis (Roxburgh ex Vaucher) Ching	Equisetaceae	H	+	-
Houttuynia cordata Thunberg	Saururaceae	H	+	-
Hydrocotyle javanica Thunberg	Apiaceae	H	+	+
Impatiens arguta Hooker f. & Thomson	Balsaminaceae	Ch	+	-
Impatiens leavigata Wallich	Balsaminaceae	Ch	-	+
Ixora coccinea Linnaeus	Rubiaceae	Ph	+	-
Juglans regia Linnaeus	Juglandaceae	Ph	-	+
Lantana camara Linnaeus	Verbenaceae	Ph	+	-
Lepidagathis incurva Buch.-Hamilton ex D.Don	Acanthaceae	Ch	-	+
Lindera pulcherrima (Nees) Hooker f.	Lauraceae	Ph	-	+
Lithocarpus fenestratus (Roxburgh) Rehder	Fagaceae	Ph	+	+
Litsea monopetala (Roxburgh) Persoon	Lauraceae	Ph	+	-
Lobelia nummularia Lamarck	Campanulaceae	H	+	-
Lyonia ovalifolia (Wallich) Drude	Ericaceae	Ph	-	+
Maesa indica (Roxburgh) A. DC.	Myrsinaceae	Ph	+	-
Magnolia campbellii Hooker f. & Thomson	Magnoliaceae	Ph	-	+

Scientific Name	**Family**	**Life-form**	**Lower elevation, Site-I**	**Higher elevation, Site II**
Magnolia hodgsonii (Hooker f. & Thomson) H. Keng	Magnoliaceae	Ph	+	-
Magnolia montana (Blume) Figlar	Magnoliaceae	Ph	-	+
Malus baccata (Linnaeus) Borkhausen	Rosaceae	Ph	-	+
Meizotropis buteiformis Voigt	Leguminosae	Ph	+	-
Melia azedirach Linnaeus	Meliaceae	Ph	+	+
Mikania micrantha Kunth	Asteraceae	Ph	+	-
Mimosa pudica Linnaeus	Leguminosae	Ph	+	-
Morus australis Poiret	Moraceae	Ph	+	+
Mussaenda frondosa Linnaeus	Rubiaceae	Ph	+	+
Oenanthe javanica (BIume) DC.	Apiaceae	Ch	-	+
Oldenlandia pinifolia (Wallich ex G.Don) Kuntze	Rubiaceae	Ch	+	-
Ophiopogon intermedius D. Don	Liliaceae	Cr	-	+
Osbeckia chinensis Linnaeus	Melastomataceae	Ph	+	-
Oxalis corniculata Linnaeus	Oxalidaceae	H	+	-
Panax pseudoginseng Wallich	Araliaceae	Cr	-	+
Paris polyphylla J.E. Smith	Liliaceae	Cr	+	+
Persicaria chinensis (Linnaeus) H. Gross	Polygonaceae	Ph	+	-
Phoebe hainesiana Brandis	Lauraceae	Ph	-	+
Phyllanthus emblica Linnaeus	Phyllanthaceae	Ph	+	-
Pilea glaberrima (Blume) Blume	Urticaceae	Ch	+	+
Pinus kesiya Royle ex Gordon	Pinaceae	Ph	-	+
Plantago erosa Wallich	Plantaginaceae	Th	+	-
Pogostemon elsholtzioides Bentham	Lamiaceae	Ch	+	-
Prunus nepalensis Linnaeus	Rosaceae	Ph	-	+
Prunus rufa Wallich ex Hooker f.	Rosaceae	Ph	-	+
Pteris ensiformis Burman f.	Pteridaceae	H	+	-
Quercus griffithii Hooker f. & Thomson ex Miquel	Fagaceae	Ph	+	-
Quercus serrata Murray	Fagaceae	Ph	+	-
Rhododendron arboreum J.E. Smith	Ericaceae	Ph	-	+
Rhus chinensis P. Miller	Anacardiaceae	Ph	+	-
Rubus ellipticus J.K. Smith	Rosaceae	Ph	+	-
Rubus niveus Thunberg	Rosaceae	Ph	+	-
Schima wallichii Choisy	Theaceae	Ph	+	+
Scutellaria discolor Colebrook	Lamiaceae	Ch	+	-
Sida rhombifolia Linnaeus	Malvaceae	Ph	+	-
Solanum indicum Linnaeus	Solanaceae	Ph	+	-
Toona ciliata M. Roemer	Meliaceae	Ph	+	-
Urena lobata Linnaeus	Malvaceae	Th	+	-
Wendlandia glabrata DC.	Rubiaceae	Ph	+	-
Youngia japonica (Linnaeus) DC.	Asteraceae	Th	+	-
Ziziphus oenopolia (Linnaeus) P.Miller	Rhamnaceae	Ph	+	+

DISCUSSION

Altitude is a complex environmental gradient associated with variation in several ecological factors (Odland 2009). However, severe environmental conditions simplify this complexity to some extent and reduce the number of factors that control species diversity. As altitude

Table 2. Comparison of biological spectrum of Montane forest of Senapati district with spectra of other climatic types.

Regions	Ph	Th	Cr	Ch	H	References
Normal Biological spectrum	46.0	13.0	6.0	9.0	26.0	Raunkiaer 1934
Matheran	65.3	10.5	4.8	17.2	2.2	Bharucha & Ferreira 1941
North Kanara	48.3	22.0	10.9	14.8	4.0	Arora 1966
Yusmarg (J&K)	10.40	6.20	10.20	46.40	25.40	Gupta & Kachroo 1981
Sub-tropical forest Manipur	66.9	16.1	4.83	8.06	4.03	Usharani 2004
Bhitarkanika	47.31	19.89	13.44	12.37	6.99	Pattanaik *et al.* 2007
Lal Dhang forest range	42.1	37	7.4	11.6	1.9	Ghildiyal & Juyal 2010
Teak Dipterocarpus forest, Indo-Myanmar border						Ranita *et al.* 2010
Site I	63.2	20.4	6.12	8.1	2.04	
Site II	65.9	19.1	4.25	8.5	2.12	
Temperate forest, Chakesar valley	21.43	54.23	11.6	10.34	2.5	Shah *et al.* 2013
Hill forest of Manipur	62.76	18.08	7.45	10.64	1.06	Devi *et al.* 2014
Subtropical Montane forest, *Site I*	53.49	16.28	8.14	10.46	11.62	Present study
Temperate Montane forest, *Site II*	63.64	2.27	18.19	9.09	6.81	Present study

was determined as the major ecological gradient, the life-form pattern clearly changes along altitudinal gradient. The study indicates that altitude is the main factor influencing both biodiversity and vegetation structure.

Factors influencing the number of functional types were thought to be very different from those influencing the number of species within a functional type (Moore & Keddy 1989; Cody 1991 and Huston 1994). However, relative species richness within different life-form groups varied differently along the altitudinal gradient.

The life-form composition of the community is the manifestation of the adaptation of its component species to the climatic condition and contributes to the community architecture (Jamir *et al.* 2006). In the present study, a good percentage of phanerophytes in both the study sites were the characteristics of humid bioclimate and its predominance along the altitudinal gradient reflected a significant role of canopy in ameliorating the climate, controlling the regeneration, establishment of herbaceous plants, maintenance of biodiversity and functioning of the ecosystem. The co-dominance of cryptophytes at higher elevation reflected the best performance of species belonging to these life-forms. Cryptophytes have underground perennating organs like rhizomes, bulbs etc. that draw their energy during unfavourable conditions from these perenating organs. Thus, cryptophytes become the next dominant life form at higher

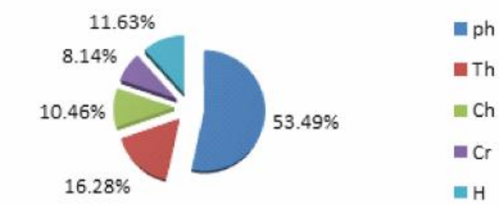

Figure 1. Graphical representation of different Life-Forms at lower elevation in montane forest of Senapati district

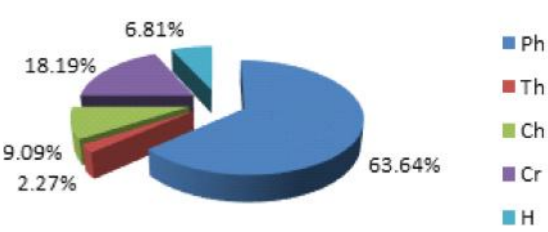

Figure 2. Graphical representation of different Life-Forms at higher elevation in montane forest of Senapati district

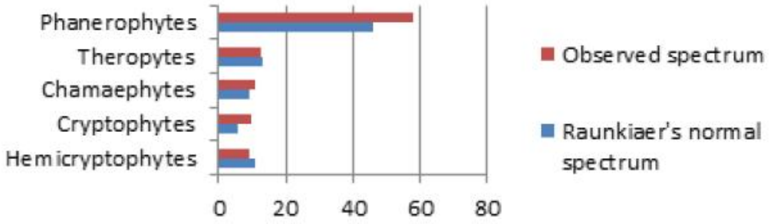

Figure 3. Comparison of biological spectrum of montane forest of Senapati district with Raunkiaer’s normal spectrum

elevation in the Montane forest of Senapati district. The co-dominance of annuals at lower altitude partly can be explained by soil disturbance, which makes a suitable place for ruderals. Generally, temperature show a decreasing trend of 0.5 - 0.6 p C per 100 m rise in altitude**.** Gould *et al*. (2006) and Barone *et al.* (2008) reported increasing moisture across the gradient. Therefore, at lower elevation in the study area, temperatures and length of growing-seasons are adequate but soil moisture is not readily available, which may be responsible for well-developed annual species. The number of annuals showed a decreasing trend towards higher altitude and drastically drops in the subnival zone. Also, the higher percentage of chamaephytes and hemicryptophytes in the lower elevation can be attributed to the impact of anthropogenic activities as the site at lower altitude has been subjected to anthropogenic stress. According to Qadir & Shetvy (1986), chamaephytes and therophytes are considered as indicator of unfavourable environment. Moreover, performances of chamaephytes affect other associated species through the competitive ability. Hence, the site facing anthropogenic stress show majority of chamaephytes. Thus the biological spectra at lower and higher elevations along altitudinal gradient reveals distinct biological spectrum which have evolved according to the climatic factors operating in the area.

CONCLUSION

The phytoclimate of the study site varies along altitudinal gradient and has been designated as phanero-therophytic in lower elevation and phanero-cryptophytic in higher elevation. In lower altitude the forests are highly disturbed due to anthropogenic activities. While in the higher altitude due to less anthropogenic activities the phanero-cryptophytic are higher which is more favourable in the undisturbed area. Thus, altitude and anthropogenic activities play important roles in determining the species diversity, life-form and biological spectrum of a habitat.

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