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# Life form composition and stratification of montane humid forests in Meghalaya, northeast India

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**Abstract**: Life form composition and stratification was studied in five protected patches of humid montane forest in Jaintia hills of Meghalaya, northeast India. A total of 546 vascular plants recorded from the five stands were distributed in five major life-forms, exhibited dominance of phanerophytes (44-51%) in the community followed by chamaephytes (11-17%), epiphytes (11-16%), lianas (7-16%), geophytes (4-12%) and therophytes (2-9%). The presence of different life forms resulted into a five-layered distribution of plant species in the community. Out of the five layers, the woody species were distributed in three distinct layers, i.e., canopy, sub-canopy, and under canopy layer which was followed by shrub and herb layers in the community, making it similar to those of humid broad-leaved and subtropical forest found in China. These forests are also similar to the humid tropical forests in stratification, except the absence of emergent trees and shorter tree height in the canopy.

**Resumen:** La composición de formas de vida y la estratificación fueron estudiadas en cinco rodales protegidos de bosque montano húmedo en las colinas Jaintia de Meghalaya, nordeste de la India. Un total de 546 plantas vasculares registradas en las cinco áreas estuvieron distribuidas en cinco formas de vida principales, mostrando una dominancia de fanerófitas (44-51%) en la comunidad, seguidas por las caméfitas (11-17%), epífitas (11-16%), lianas (7-16%), geófitas (4-12%) y terófitas (2-9%). La presencia de diferentes formas de vida resultó en una distribución de cinco estratos de especies de plantas en la comunidad. De los cinco estratos, las especies leñosas estuvieron distribuidas en tres distintos, a saber dosel, subdosel y sotobosque; este último estuvo seguido por los estratos de arbustos y de hierbas en la comunidad, lo que la hace similar a las comunidades de bosque húmedo latifoliado y bosque subtropical de China. Estos bosques también son similares a los bosques tropicales húmedos en su estratificación, excepto por la ausencia de árboles emergentes y la altura menor de los árboles del dosel.

**Resumo:** A composição das formas de vida e a estratificação em cinco manchas protegidas na floresta húmida montana nas Colinas de Jaintia em Meghalaya, no nordeste da Índia foram estudadas. Das cinco parcelas foram registadas um total de 546 plantas vasculares distribuídas por cinco grandes formas de vida, com uma dominância para a comunidade das fanerófitas (44-51%) seguindo-se a das caméfitas (11-17%), epífetas (11-16%), lianas (7-16%), geófitas (4-12%) e terófitas (2-9%). A presença de diferentes formas de vida na comunidade pode ser representada em cinco estratos de distribuição de espécies. Dos cinco estratos, as espécies lenhosas encontravam-se distribuídas por três estratos distintos, i.e., o estrato do copado, o do sub-copado, e o abaixo do copado aos quais se seguem o dos arbustos e das ervas, tornando-o similar ao das florestas de folhosas húmidas e subtropicais encontradas na China. Estas florestas são

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também similares às florestas húmidas tropicais quanto à estratificação, excepto no que se refere à ausência de árvores emergentes e menor altura das árvores no copado.

**Key words**: Life form, Meghalaya, montane forests, northeast India, sacred grove, stratification.

## Introduction

The natural vegetation of Khasi and Jaintia hills of Meghalaya is often mistaken for the stretches of mono dominant secondary pine forests or meadows. In fact the vanishing pristine forests of Meghalaya are now mostly confined to Biosphere Reserve, Wild Life Sanctuaries, National Parks, and Sacred groves. Out of these, the sacred groves have gained importance because of their high species richness (Jamir & Pandey 2002, 2003; Upadhaya *et al*. 2003) and relatively large area as compared to their counterparts elsewhere in the world. Another unique feature of the groves is that the indigenous tribes have protected them since time immemorial due to their various religious beliefs attached to them. Besides acting as a gene pool and providing refuge to a large number of endemic, endangered and threatened species (Jamir & Pandey 2002, 2003), they render ecological services such as source of perennial water, maintain local micro environmental conditions and help in biogeochemical cycles (Upadhaya 2002).

Several quantitative measures are employed to describe the structure of plant communities with much ecological precision, qualitative characters such as species richness, life-form spectrum and vertical disposition of species are some of the important parameters to describe community structure. Raunkiaer (1934) described communities of different climatic zones or phytoclimatic zones of the earth on the basis of life-form spectrum or Biological spectrum. Any change in the life-form composition away from its phytoclimatic zone is considered as an indicator of alteration in vegetation either due to biotic or edaphic factors or both. However, in recent years man has abused the natural vegetation so much so that often plant communities do not show their natural structural complexities. Excessive utilization of forest resources and overgrazing has resulted in change in the life form composition of plant communities (Reddy *et al*. 2002; Verma & Shukla 1993).

Vegetation profile of the component species indicates the phytoclimatic condition of the area and is employed commonly in community structural description through profile diagrams (Ashton & Hall 1992; Chen Wei-Lie 1995; Pignatti 1995; Sahunalu & Dhanmanonda 1995; Unwin 1989; Visalakshi 1995). Similar studies have not been undertaken in the montane humid forests of northeast India though several ecological studies have been carried out in the sacred groves of Meghalaya (Barik *et al*. 1992, 1996a, 1996b; Jamir & Pandey 2002, 2003; Rao 1992; Rao *et al*. 1990, 1997; Upadhaya *et al*. 2003). In the present paper life form composition and stratification in montane humid forests have been described on the basis of a study conducted in five sacred groves located in Jaintia hills of Meghalaya, northeast India.

## Materials and methods

### *Study area and climate*

The study was conducted in *Khloo Paiu Ram Pyrthai* (Sg-1), *Khloo Langdoh* (Sg-2), *Urkhla* (Sg-3), *Khloo Blai* (Sg-4) and *Khloo Poh Lyngdoh* (Sg-5) sacred groves within a radius of 28 km of Jowai town, in Jaintia hills of Meghalaya. The groves are situated at an altitudinal range between 1200 and 1300 m asl. The climate of the area is monsoonic with warm-wet and cold-dry seasons. The wet period extends from April to October followed by a dry period from November to March. The annual rainfall was about 5500 mm during the study period (1997-2001). The mean monthly temperature varied from a maximum of 26°C in June - July to a minimum of 5°C in January. Physiographically the groves are located on gentle (10-20°) to steep (20-60°) hill slopes. The soil reaction was acidic, and texture varied from loamy to sandy loam (Jamir 2000; Upadhaya *et al*. 2003).

### *Methodology*

A detailed floristic survey was carried out in all the five groves during 1997-2001. Plant species from each forest were collected at monthly intervals and identified with the help of local flora (Balakrishnan 1981-1983; Haridasan & Rao 1985-1987; Hooker 1872-1879; Kanjilal *et al.* 1934-1940). The herbaria at Botanical Survey of India, North-Eastern Circle, and North-Eastern Hill University, Shillong were also consulted for correct identification of the plants. All the plant species collected from each forest were grouped into different life forms based on criteria outlined by Raunkiaer (1934) and Mueller-Dombois & Ellenberg (1974).

Profile diagrams of the vegetation were drawn along belt transects having a width of 7.5 m of 80 to 120 m length. All plant individuals ≥5 cm dbh were considered for the profile diagram. Tree height was measured with the help of a Clinometer (Suunto pm - 5/1520).

## Results

### *Life-form composition*

A total of 546 vascular plants were recorded from the five sacred groves. In all the five groves phanerophytes were dominant life forms. The percentage of therophytes was minimum (2-4%) in Sg-1, Sg-2 and Sg-3, whereas in Sg-4 and Sg-5 it constituted about 12% of the vegetation. Epiphytes contributed 11-16% of the total species in all stands. The lianas and climbers, which together constituted about 7% to 18% of the species, were conspicuous component of the forest (Fig. 1).

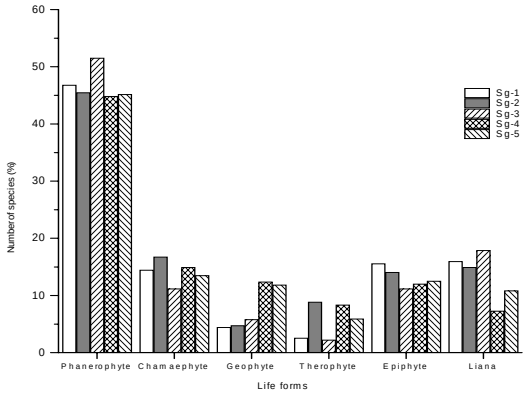


**Fig. 1.** Life form composition of the sacred groves of Jaintia Hills (Sg-1= Khloo Paiu Ram Pyrthai, Sg-2= Urkhla, Sg-3= Khloo Langdoh, Sg-4 = Khloo Blai, Sg-5= Khloo Poh-Lyngdoh).

### *Stratification*

The vegetation profiles of Sg-1, Sg-2, Sg-3, Sg-4 and Sg-5 are depicted in Fig. 2a, 2b, 2c, 2d, and 2e respectively. In Sg-1 (Fig. 2a) there were 45 individuals distributed in three distinct layers viz., canopy, sub-canopy and under canopy layers. The discontinuous canopy layer having a height of ≥20 m was composed of *Schima khasiana*, *Cinnamomum glanduliferum, Castanopsis tribuloides*, *Persea odoratissima* and *Fraxinus floribunda*. The canopy layer was interrupted at places by gaps that were filled by trees of the sub-canopy layer. The common species in this layer were *Helicia nilagerica*, *Symplocos cochinchinensis*, *Xantolis assamica*, *Turpina nepalensis* and *Vaccinium sprengelii*. Young trees of the canopy layer such as *Schima khasiana*, and *Rhus acuminata* were also found in this layer. Below the sub-canopy, there was a dense layer in which *Coffea khasiana*, *Styrax serrulatum* and *Camellia caudata* were conspicuous.

In the profile diagram of *Urkhla* (Sg-2) forest (Fig. 2b) the uppermost stratum was composed of *Cinnamomum glanduliferum*, *Castanopsis*


**Fig. 2a.** Profile diagram of Sg-1= Khloo Paiu Ram Pyrthai: *Schfellera hypoleuca*- 1, *Schima khasiana*- 2,5, *Vaccinium speringelii*-3,40, *Persea odoratissima*- 4,10,38, *Castanopsis tribuloides*- 6, 7, 9, 18, *Saurauia nepalensis*- 8, *Styrax cerrulatum*- 11, *Pithecellobium monodelphum*- 12, 16, 28, *Camellia caudata*- 17, *Helicia nilagirica*- 13, 32, 37, *Coffea khasiana*- 14, 13, 39, 42, *Cinnamomum glanduliferum*- 29, 31, 44, *Rhus acuminate*- 23, 34, *Symplocos cochinchinensis*- 15, 19, 36, *Ficus hirta*- 21, *Xantholis assamica*- 27, 35, *Engelhardtia spicata*- 22, 25, 26, *Myrsine semiserrata*- 24, *Microtropis discolor*- 33, *Lithocarpus fenestrate*- 41, *Turpina nepalensis*- 43, *Fraxinus floribunda*-45.

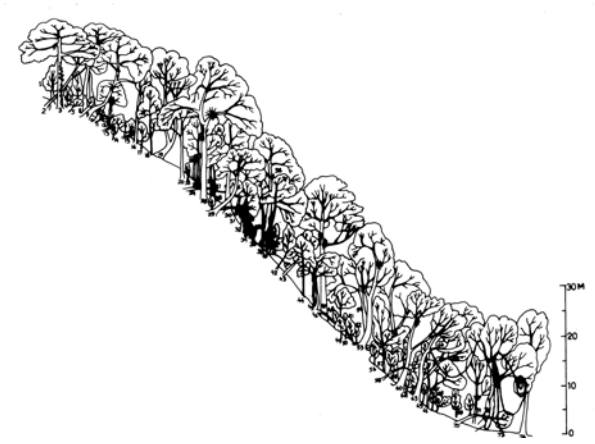

**Fig. 2b.** Profile diagram of Sg-2= Urkhla: *Persea parviflora*- 1, 4, 52, *Pithecellobium monodelphum*- 2, 42, 66, *Castanopsis tribuloides*- 3, 13, 27, 38, 51, 57, *Coffea khasiana*- 5, 11, 68, *Persea globularia*- 7, 10,31, *Camellia caudate*- 6, 8, 45, 46, 49, 50, *Quercus kamroopii*- 9, 19, 29, 63, *Helicia nilagirica*- 12, 14, 16, 17, 20, 41, 56, *Syzygium tetragonum*- 15, 18, 23, 37, 43, 55, 60, 72, *Cinnamomum glanduliferum*- 25, 26, 53, 62, *Myrsine semiserrata*- 21, 22, 36, 44, 71, *Styrax serrulatum* -24, 32, 40, 58, 70, *Erythroxylon kunthianum*- 28, 33, 48, *Quercus kamropii*- 30, *Symplocos cochinchinensis*- 34, 35, *Croton oblongus*- 39, *Betula alnoides*- 47, *Lithocarpus elagans*- 54, 64, 69, 74, *Cnamomum parviflorum*- 61, *Daphne involucrate*- 65, 67, *Tetrastigma leucostaphyllum*- 73.

*tribulioides*, *Betula alnoides* and *Syzygium tetragonum*. *Betula alnoides* was the tallest tree (average height ≈ 33 m) of this layer. The subcanopy was composed of *Quercus kamroopii*, *Helicia nilagirica*, *Lithocarpus elegans*, *Croton oblongus*, *Pithecellobium monadelphum*, and *Myrsine semiserrata*. *Erythroxylum kunthianum*, *Daphne involucrata*, *Camellia caudata* were the common undercanopy species.

In the *Khloo Langdoh* (Sg-3) the canopy and sub-canopy layers were indistinct; both formed a single undulating layer in which height was about 20 m (Fig. 2c). The species encountered in this layer are *Drimycarpus racemosus*, *Acer laevigatum*, *Cinnamomum bejholghota*, *Garcinia anomala*, and *Glochidion lanceolarium*. The under canopy was composed of *Coffea khasiana*, *Microtropis discolor* and *Acronychia pedunculata* etc.

The *Khloo Blai* (Sg-4) forest had uninterrupted canopy cover (Fig. 2d). The forest near hill top had two distinct layers of trees, while that on the slope had three distinct layers of trees. The canopy layer growing to a height of 25 m was composed of *Castanopsis tribuloides*, *Castanopsis purpurella*, *Betula alnoides*, *Cinnamomum glanduliferum* and *Alseodaphne petiolaris*. Young individuals of top canopy species such as *Castanopsis purpurella*, *Alseodaphne petiolaris*, *Schima wallichii*, *Rhus acuminata*, *Alangium chinense*, *Ficus cocinna* etc. were present in the subcanopy. The undercanopy layer was quite dense. The common species in this

**Fig. 2c.** Profile diagram of Sg-3= Khloo Langdoh: *Pithecellobium monadelphum*- 1, 7, 13, *Xantholis assamica*- 2,16, 17, *Acer laevigatum*- 3,8,24, *Cinnamomum bejolghota*- 4, 36, *Ficus concinna*- 5, *Drimycarpus racemosus*- 6, 31, 43, *Glochidin lanceolarium*- 9, 22, 30, 39, *Styrax serrulatum*- 10, 32, *Castanopsis tribuloides*- 11, 14, 19, *Coffea khasiana*- 12, 15, 25, 26, 44, *Camellia caudata*- 18, *Persea odoratissima*- 20, 37, 47, *Garcinia anomala*- 21, 29, 46, *Lindera latifolia*- 35, 41, *Evodia trichotoma*- 23, *Castanopsis purpurella*- 28, 42, *Microtropis discolor*- 27, 33, *Acronychia pedunculata*-34, 38, *Helicia nilagirica*- 40, 45.

**Fig. 2d.** Profile diagram of Sg-4= Khloo Blai: *Castanopsis tribuloides*- 1, 3, 38, *Schima wallichii*- 2, 4, *Rhus acuminate*- 5, 12, 19, *Ficus nerifolia*- 6, 10, *Betula alnoides*- 7, *Eurya acuminate*- 8, 24, *Alangium chinense*- 9, 13, *Camellia caudata*- 14, 15, 26, 27, 31, 33, 34, 35, 39, 43, 46, *Engelhadtia spicata*- 17, *Castanopsis purpurella*- 11, 16, 18, 25, 36, 40, *Pyrularia edulies*- 20, 29, *Alseodaphnae petiolaris*- 21, 22, 23, *Ficus concinna*- 28, *Cinnamomum glanduliferum*- 30, 32, *Eurya cerasifolia*- 37, *Symplocos spicata*- 41, *Coffea khasiana*- 42, *Phobe lanceolata*- 44, *Itea macrophylla*- 45, 48, *Meyna spinosa*- 47.

layer were *Camellia caudata*, *Eurya acuminata*, *Ficus nerifolia*, *Itea macrophylla* etc.

*Khloo Poh Lyngdoh* (=Raliang) sacred grove (Sg-5) showed three distinct layers (Fig. 2e). The canopy layer was composed of *Engelhardtia spicata*, *Castanopsis purpurella*, *Sarcosperma griffithii*, *Acer laevigatum* etc.; the sub canopy layer was constituted by *Prunus jenkensii*, *Sarcosperma griffithii*, *Knema angustifolia*, *Pithecellobium monadelphum* etc. Some scandent plants like *Fissistigma verrucosum* grew to a height of canopy layer. The under canopy layer was dominated by *Capparis acutifolia*, *Lindera latifolia*, *Citrus latipes* etc.

## Discussion

The most conspicuous feature of the primary tropical and subtropical humid forests such as species richness, community architecture and structure are greatly influenced by rainfall pattern and temperature. These are further modified, by edaphic, orographic, biotic and historical influences (UNESCO/UNEP/FAO 1978).

The life form composition (Raunkiaer 1934) of the community, which is the manifestation of the adaptations of its component species to the climatic condition, contributes to community architecture and species richness of the forest (Jamir & Pandey 2003). Dominance of phanerophytes (44-51%) in the sacred groves brings them closer to the tropical forests at Mexico (Vazquezg *et al*. 1998) and Costa Rica (Lieberman *et al*. 1996). High concentrations of lianas and climbers, another important characteristic feature of the tropical moist and humid forests (Daniels *et al*.1995; Vazquezg *et al*. 1998) was also observed in the sacred forests. High percentage of epiphytes (11-16%) in the sacred groves is attributed to the year round precipitation and high atmospheric humidity (Benzing 1983; Sugden & Robins 1979). Since the forests under investigation are exposed to mild intensity of human disturbance, its effect was noticed by presence of a good number of chamaephytes and therophytes at the forest fringes. In the tropical belt, places with increase in aridity; deforestation and other anthropogenic activities have therophytic or thero–chaemaephytic conditions (Reddy *et al*. 2002; Verma & Shukla 1993).

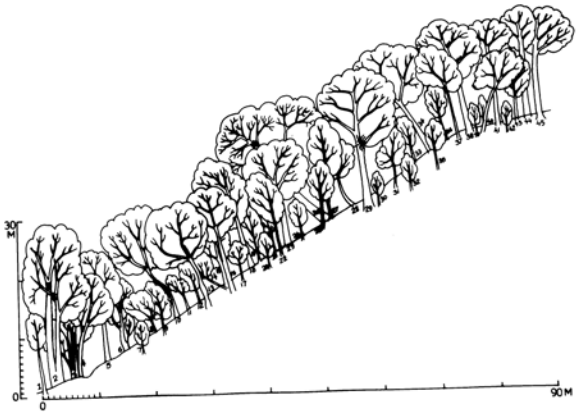


**Fig. 2e.** Profile diagram of Sg-5= Khloo Poh-Lyngdoh: *Engelhardtia spicata*-1, *Macropanax dispermus*- 2, 9, *Sarcosperma griffithii*- 3, 5, 7, 16, 18, 24, 33, 40, *Castanopsis purpurella*- 4, 8, 12, *Actinodaphne obovata*- 6, 15, *Capparis acutifoli*a- 10,22, 25, *Prunus jenkensii*- 11, 23, 30, 31, 35, 36, *Fissistigma verrucosum*- 13, 17, *Garcinia tinctoria*- 14, 38, *Acer laevigatum*- 19, 29, *Tupidanthus calyptratus*- 20, *Dysoxylon gobara*- 21, 27, *Neolitsea cassia*- 26, *Spondias axillaries*- 28, *Citrus latipes*- 32, *Lindera latifolia*- 34, *Pithecellobium monadelphum*- 37, *Acer oblongum*- 39, *Knema angustifolia*-41, 42, Unidentified species -43, *Ficus* sp.- 44.

The vegetation of sacred groves of Meghalaya showed similarity with the evergreen broad leaved and subtropical forest of southern China in the preponderance of Fagaceae, Lauraceae, and Theaceae members, over storey tree height and stratification (Box 1995; Cao & Rob 1997; Song 1995). This could be attributed to a number of factors such as climatic condition, location of the two sites at similar latitude, their geographical proximity, and closeness to the species rich eastern Himalayas, Myanmar and Malaya (Table 1).

The tropical rain forest, which is considered to be the most complex and highly organized terrestrial community in the world, has five or six distinct strata (Richards 1996). In most of them, the emergent trees constitute the top layer or A stratum and the B and C strata form a continuous canopy layer; often with indistinct boundary between the two (Ashton & Hall 1992; Pascal 1992; Richards 1996; Unwin 1989). The emergent trees were absent in the studied forests and the average tree height in the canopy layer is comparable to the height of the B stratum of the tropical forest at Moraballi Creek and Sarawak (Richards 1996). Ashton & Hall (1992) and Thompson *et al*. (1992) have reported similar tree

**Table 1.** Salient features of vegetation of sacred groves of Meghalaya, and evergreen broad-leaved and subtropical rain forests of China.

| Parameters | *Evergreen broad-leaved forest | *Subtropical rain forest | Sacred groves of Meghalaya |
|---|---|---|---|
| Climate | Developed under the monsoon climate with hot and moist summers and fairly cold winters. | Climate is much hotter and moist in whole year round. | Monsoon climate with hot and moist summer. |
| Species composition | *Quercus*, *Castanopsis*, *Lithocarpus*, *Michilus*, *Neolitsea*, *Schima* etc. | Tropical species, palms and woody ferns. | *Quercus*, *Castanopsis*, *Lithocarpus*, *Michilus*, *Neolitsea*, *Schima*, *Camellia* etc. |
| Stratification | Stratification is quite distinct, commonly divided into 4-5 layers. | Stratification is not quite distinct; structure is much more complex, similar to tropical rainforest. | Stratification is quite distinct, commonly divided into 4-5 layers. |
| | Overstorey is 15-25 m high, rarely over 30 m. | Overstorey taller >25 m high. | Overstorey is 15-25 m high, rarely over 30 m. |
| Buttress | Commonly trees have no plank uttress; occasionally some smaller buttresses are seen. | Trees of upper layer are taller and always have plank-buttress. | Some trees exhibits small plank buttress. |
| Lianas and epiphytes. | Abundant, epiphytic ferns and phanerogams are rare or absent. | Abundant, thick lianas, epiphytic ferns and phanerogams, epiphylls and strangle plants also present. | Lianas less abundant; epiphytic ferns and phanerogams, epiphylls and strangle plants also present. |
| Understorey | The understorey is sparse, mainly consists of species of fern, Cyperaceae and Liliaceae. | The understorey is well developed in which woody ferns are seen. | The understorey is sparse, mainly consists of species of fern, Cyperaceae and Zingiberaceae. |

*Source: Box 1995; Cao & Rob 1997; Song 1995

height distribution in the tropical forest at Brunei and in Brazil respectively. Dry climate and unproductive soil also result in the shorter canopy height (Sahunalu & Dhanmanonda 1995; Visalakshi 1995; Whitmore 1975). But in the present case neither the climate is dry nor does the soil fertility low. Therefore, it may be presumed that shorter tree height may be related to the altitude (Aiba & Kitayama 1999; Grubb 1977; Lieberman *et al*. 1996; Whitmore 1975). However, the low canopy height and indistinct canopy and sub-canopy strata found in *Khloo Langdoh* and upper ridges of *Khloo Blai* sacred grove could also be attributed to the selective extraction of tree species for the annual '*Beh dein Khlam*' festival, and other anthropogenic disturbances.

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