

## Floristic diversity assessment and vegetation analysis of Upper Siang district of eastern Himalaya in North East India

Ritesh Kumar Choudhary, Ramesh Chandra Srivastava<sup>1</sup>, Arup Kumar Das<sup>2</sup> and Joongku Lee\*

*International Biological Material Research Center, Korea Research Institute of Bioscience & Biotechnology, Daejeon 305-806, Korea*

<sup>1</sup>*Botanical Survey of India, Kolkata 700 064, India*

<sup>2</sup>*Department of Botany, Rajiv Gandhi University, Itanagar 791 111, India*

(Received 29 August 2012; Revised 10 September 2012; Accepted 18 September 2012)

## 인도 북동부의 동히말라야 상부 Siang 지역의 식물다양성 및 식생 조사

Ritesh Kumar Choudhary · Ramesh Chandra Srivastava<sup>1</sup> · Arup Kumar Das<sup>2</sup> · 이종구\*

한국생명공학연구원 해외생물소재허브센터

<sup>1</sup>Botanical Survey of India, Kolkata 700 064, India

<sup>2</sup>Department of Botany, Rajiv Gandhi University, Itanagar 791 111, India

**ABSTRACT:** Present paper is an outcome of a four-year floristic survey work carried out in Upper Siang district of eastern Himalayan region in India which is also recognized as one of the 39 known 'Biodiversity Hot-Spots' of the world. We present here with a vegetation analysis of this area along with a checklist of 1,003 taxa belonging to 110 families, 529 genera, 994 species, 1 subspecies and 8 varieties of the angiosperms. Besides, one new species, 3 new records to India and 82 endemic species were also recorded. The diversity of herbs and shrubs were found higher than the tree species. Orchidaceae was found the most dominant family followed by Poaceae and Fabaceae. Many threatened plants have also been reported from the area. However, rapid urbanization and Jhum cultivation are imposing direct threat to the natural vegetation. We suggest some conservation measures that could help protecting this natural heritage.

**Keywords:** eastern Himalaya, Upper Siang district, floristic diversity, vegetation analysis

**적 요:** 이 연구는 세계 39개 생물다양성 hot spot중에 하나인 인도 동부 히말라야 상부 Siang 지역의 식물상을 4년 동안 조사한 결과물이다. 이 지역의 식생에 대한 분석결과와 함께 조사된 총 1,003분류군, 110과, 529속, 994종, 1아종 그리고 8변종의 피자식물 목록을 첨부하였으며 1신종, 3미기록종 및 82특산종을 포함하고 있다. 초본과 관목의 다양성이 교목보다는 높게 나타났으며 과별로는 벼과, 콩과 그리고 난과 순으로 다양성이 우세한 것으로 조사되었다. 이 지역의 절멸위기에 처한 종들을 보고함과 동시에 급속한 도시화와 화전은 자연식생의 직접적인 절멸을 가속화하고 있어 이 지역의 자연유산을 보호하고 보존하는 방법을 찾는 데 도움이 되기를 제안한다.

**주요어:** 동히말라야, Siang 지역 상부, 식물다양성, 식생분석

Eastern Himalaya is considered as one of the 39 Biodiversity hot-spots of the world because of its diverse and luxuriant vegetation in addition to a high degree of endemism and occurrence of rare and threatened taxa (Hara, 1966; Rao et al.,

2003). Further, the presence of a large number of primitive flowering species truly signifies the region to be called as 'The Cradle of Flowering Plants' (Takhtajan, 1969; Baishya, 2001). The state of Arunachal Pradesh is divided into 16 districts, among which Upper Siang District is of immense significance from the botanical point of view. The district is located between

\*Author for correspondence: joongku@kribb.re.kr

28°09'09"N-29°19'10"N Lat. and 94°17'36"E-95°25'35"E Long. and bounded by China in north, East Siang district in south, Upper and lower Dibang valley in east and by West Siang district in west, covering an area of 6,188 km<sup>2</sup>. It is endowed with rich and fascinating vegetation holding a large number of rare, endemic, endangered and economic plants. The geography, location, climate and varying topography with lofty hill ridges and deep valley accompanied by wide variation in climate and soil have resulted into the formation of varied ecological diversity; and hence, the area is a huge repository of plants of botanical importance being a reservoir of genetic variability, ecosystem diversity and species diversity. Because of the floristic richness, a major part of the area has been protected by the government establishing a national park and a biosphere reserve namely Mouling National park and Dehang-Dibang Biosphere Reserve.

**Previous works:** A perusal of the literature and scrutiny of herbarium materials at ARUN, ASSAM, CAL and APFH has revealed that significant contributions were made towards the botanisation of the state of Arunachal Pradesh prior to the reorganization of Botanical Survey of India (in 1954). Lieutenant R. Wilcox and Captain Bedford were the first who visited the Mishmi hills in view of geographic discoveries on the North East Frontier (1825-1828). But the pioneer floristic work in Arunachal Pradesh was carried out by Griffith (1836), who published "Flora of Mishmi Hills" based on the collection made by him during October-December, following more or less the route of Wilcox and Bedford. The account deals with 900 species of flowering plants and 22 species of ferns and fern allies. Thomas J. Booth undertook horticulture explorations during 1840-1850, from Bisnath (Assam) into the hills of *Daphlas* (present day *Nyishis*), situated at the south-eastern corner of Bhutan and described some *Rhododendrons* from this area. In 1848, J.D. Hooker came to India and explored the forests of Eastern Nepal, Sikkim and Assam. His travels in the Eastern Himalayas are described in the 2-volume "Himalayan Journals" (1854). With the advent of 20<sup>th</sup> century, more plant explorations have been carried out resulting in the publication of "On the Botany of Abor Expedition" by Burkill (1924-1925); "Botanical Expedition in the Mishmi Hills" and "Lohit valley" by Kingdon Ward (1929); "A sketch of the vegetation of Aka Hills" by Bor (1938) etc. However, the Abor expedition of Burkill (1924-1925) was confined mostly to the areas surrounding Pasighat (E. Siang) and to the ranges of the outer Syom valley upto Kempang. In his detailed analysis of the flora of Abor land, he indicated the Abor land as a variable node in phytogeography. Later, K.P. Biswas published 'The

Flora of Aka Hills' based on the collections of Bor (1931-1939) which includes 1549 species of flowering plants (Angiosperms), 9 species of Gymnosperms and 58 species of Ferns and Fern allies. Huge collections were also made by U.N. Kanjilal, the Chief Commissioner of Assam, which came into light with the publication of "Flora of Assam" in five volumes (Kanjilal et al., 1934-1940). With the inception of the Eastern Circle of Botanical Survey of India in December, 1955, expeditions in various parts of the districts of Kameng, Subansiri, Lohit, Tirap and Siang were carried out. However, this included only a few areas of Upper Siang (Rao, 1972).

All these works are quite significant from the botanical point of view but gives a meager idea about the floristic richness of the district Upper Siang. Rao and Joseph (1965) were the pioneer workers in this area who collected a total of 319 species of Angiosperms, out of which 119 new to the *Abor* land (Siang) and ten species new to Himalayan region. They also reported *Beccarinda cordifolia*, *Coelogyne radicata* and *Dioscorea scortechinii* for the first time from India. It was found that the flora of the district shares affinities with the flora of Sikkim and Bhutan with regard to endemism and floristic composition (Rao and Joseph, 1965).

As the district also harbors good number of orchids, the contributions made by Rao and Haridasan (2005) and Hegde (1984) of the Forest Department, Arunachal Pradesh are worth mentioning. Hegde (1993) reported a new species namely *Eria jengingensis* for the first time from the Jengging locality of Upper Siang. Rao (2005) reported *Dendrobium vexabile* for the first time from India occurring in the Tuting locality of the district. Later, two new species namely *Arisaema setosum* and *Camellia siangensis* were also described from Sirang and Minguing-Takekpong locality of the area respectively. In addition, some significant ethno-botanical works have also been carried out revealing the traditional knowledge system of the aborigines inhabiting the area (Das, 1986; Gajurel et al., 2006). After the establishment of Mouling National Park and Dehang Dibang Biosphere Reserve which covers a major area of Upper Siang district, the district gained much attention of the botanists. Kumar et al. (2004) reported 110 species of flowering plants occurring in the Mouling National Park area. Agrawala et al. (2005) have also made significant contributions by reporting a considerable number of orchids from the area. But except for these sporadic collections and a few publications (Rao and Joseph, 1965; Das, 1986; Kumar et al., 2004; Agrawala et al., 2005 etc.) no significant publication came out on Upper Siang district. In spite of being an area of great botanic importance, it was hitherto underexplored and the knowledge about the floristic wealth was rudimentary. The

present work was undertaken to fill this lacuna and to prepare a flora that could serve as a good reference source for future researchers.

## Materials and Methods

**Study site:** The district Upper Siang is a rugged mountainous terrain covering a range of hills. The mighty river Siang originating from Tibet flows through the district to East Siang district and joins the Brahmaputra in the plains of Assam. The altitude varies from  $ca350 \rightarrow 2,000$  m. The region is endowed with an intricate labyrinth of precipitous rocky high hills and mountains with beautiful green valleys. The mighty river Siang bifurcates the district into two halves and cascades down from the upper elevation and criss-crossed by innumerable rivulets. Moreover, the rivers Yamne, Nyigong and their tributaries also provide life sustenance to the inhabitants besides being a hydro-electric potential to the state. The district is divided into 10 administrative circles under three subdivisions namely Yingkyong, Mariyang and Tuting. Yingkyong is also the district headquarter with two circles viz. Yingkyong and Jengging. On the western part of the district lies the subdivision Mariyang consisting of three circles viz. Geku, Katan and Mariyang. The easternmost part of the district is occupied by the subdivision Tuting consisting of five circles viz. Tuting, Gelling, Singa,

Palling and Migging (Fig. 1).

This typical nature of geography also poses severe problem of transport and communication. The human habitation is scattered and geographically isolated from one another. The day to day human life is hard and economic pursuits are difficult.

The district lies mainly in the catchment area of the river Siang and is mostly mountainous. Deep and narrow valleys run generally north to south in the mountains. Due to this characteristic geographical feature, the climate varies significantly from place to place, depending mostly on elevation and hence, no generalization is possible with regard to the climate of the whole district. However, the general climatic feature of the district may be divided into four seasons in a year i.e. spring, summer, monsoon and winter.

**Data Collection:** Regular survey and exploration works were conducted to cover the entire area during different seasons. Observations on the habit/habitat, flower color, fruiting, seeds, including other features of interest recorded and photographed at the spot. All the field data were recorded in the standard field book maintained by Botanical Survey of India. The route followed for the survey work is presented herewith in Fig. 2.

Information regarding local names of plants and other noteworthy characters were obtained from the local inhabitants.

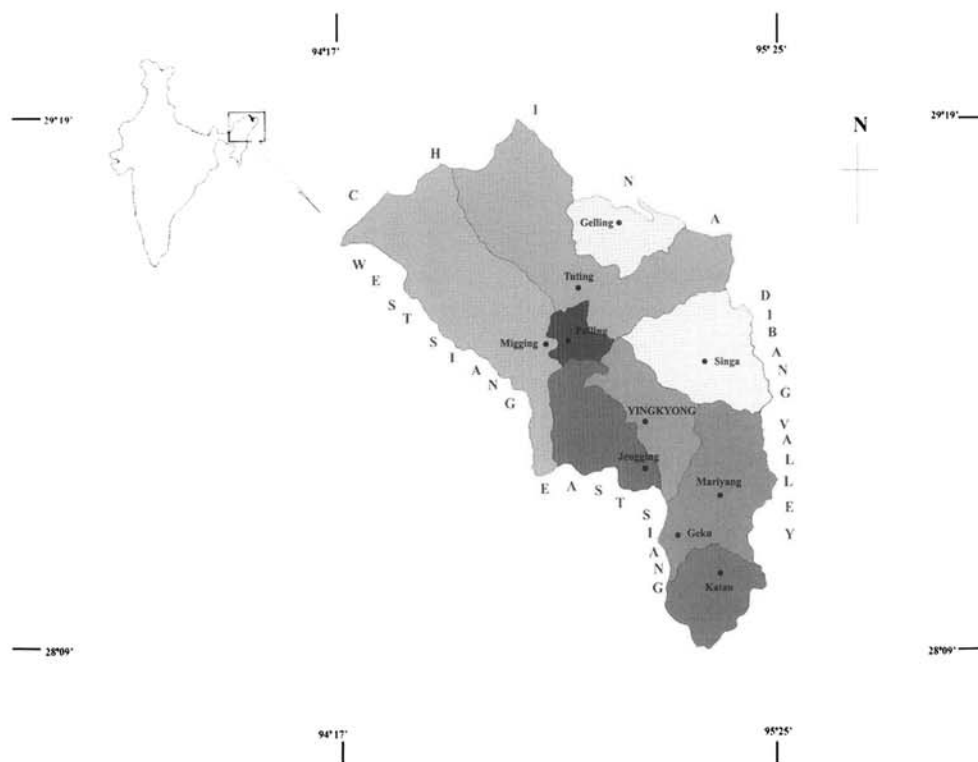


Fig. 1. Map of Upper Siang district showing different circles.

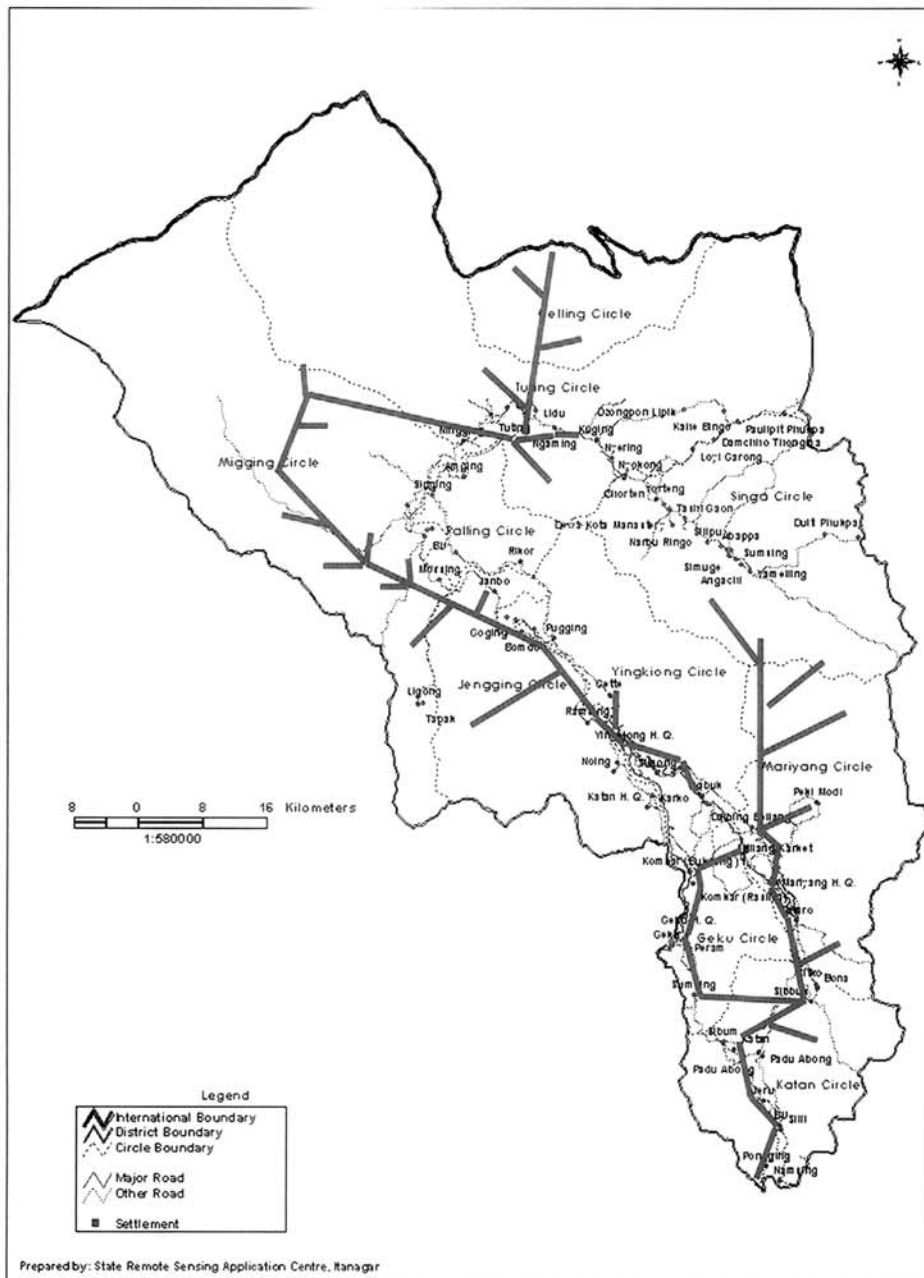


Fig. 2. Map showing the route followed during the floristic investigation in Upper Siang district.

The community structure, composition etc. were also noted. Complete specimens were collected.

The collected plants were carried in polyethylene bags and pressed in wooden frames provided with folded sheets of blotting papers. Folded sheets of newspaper were also used for changing of blotting materials depending on the nature of the plant specimen (retaining more or less water) and humidity. (Jain and Rao, 1976).

All the specimens were properly mounted, labeled and deposited in the herbarium of Botanical Survey of India, Arunachal Pradesh Regional Center, Itanagar, India (ARUN).

The aim of the present study was to prepare comprehensive taxonomic account of the flowering plants; to inventorize rare, endemic and threatened plants of the region, preventing their unscrupulous exploitation and to chalk out a future plan for conservation. Therefore, the study was carried out with a year wise plan of work.

*First Year:* Review of literature, preparation of reference card and field surveys in month of March and September.

*Second Year:* Critical study of the herbarium specimens housed in APFH, ASSAM and CAL herbaria along with identification of the collected specimens, field surveys in

months of February, May and October.

*Third Year:* Field surveys in January, July and December. Identification of the collected specimens consulting ARUN and ASSAM herbaria.

*Fourth Year:* Identification of critical specimens at CAL herbarium.

Angiosperm Phylogeny Group III classification (APG, 2009) system for the circumscription of families has been followed. They have been sorted alphabetically and genera are sorted alphabetically within families. Accepted names of the taxa, their habit and the place of collection have been provided. Herbarium acronyms used in the appendix follow *Index herbariorum* (Holmgren et al., 1990; <http://sweetgum.nybg.org/ih/>).

## Results and Discussion

Vegetation and topography together make up the basic ecological template defining the distribution and abundance of the species in the area. The type of vegetation met within a region depends solely upon the topography, soil and climate of that area. Following the structural and compositional characteristics the vegetation (Fig. 3), classification patterns earlier proposed by Champion and Seth (1968) and Kaul & Haridasan (1987); the vegetation of the district can be broadly

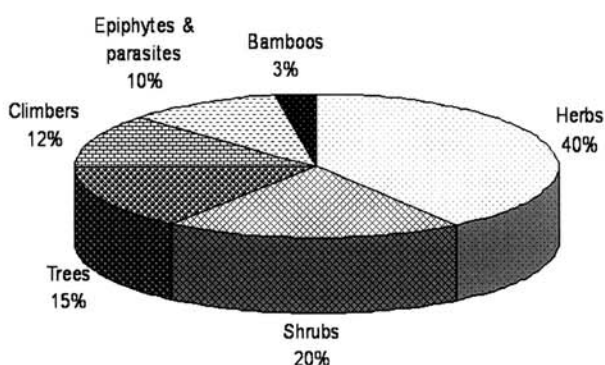


Fig. 3. Diagrammatic representation of the vegetation components and their percentage in Upper Siang district.

Table 1. Major vegetation types of Upper Siang district.

Climatic zone	Altitude (in mtrs.)	Vegetation zones
1. Tropical	300-900	a. Tropical Deciduous Forests
		b. Tropical Semi evergreen Forests
		c. Tropical Evergreen Forests
2. Subtropical	900-1,500	Subtropical Evergreen
3. Sub temperate	> 1,500	Sub temperate mixed

classified under three major types (Table 1; Figs. 4, 5).

### 1. Tropical forests

This kind of vegetation mainly occurs in the southern and southeastern slopes of the district, starting from Ditedime, Geku, Sumsing, Sibum, Katan, Geku, Yingkyong and upto Ramsing and Jengging area, upto an altitude of ca 900 m. This zone receives a heavy rainfall during the months of June to September. Winter is mild, followed by a comparatively dry season from February to April. This forest is composed of tall trees with dense, close canopy and a large variety of smaller trees, lianas, epiphytes, shrubs, ferns and other ground flora. This is further divided into three types viz.

#### Tropical deciduous forests:

This forest can be seen at the lower elevations in the study area like Ditedime, Geku, Komkar and Gette etc. Species in this forest are mixed so that no particular species dominates the vegetation. The important species are *Callicarpa arborea*, *Dillenia indica*, *Macaranga denticulata*, *Macaranga peltata*, *Albizia julibrissin* subsp. *mollis*, *Sterculia hamiltonii*, *Terminalia myriocarpa*, *Bauhinia purpurea*, *B. variegata*, *Prunus cerasoides*, *Melastoma malabathricum*, *Casearia vareca*, *Osbeckia nutans*, *Grewia serrulata*, *Poikilospermum suaveolens*, *Pterospermum acerifolium*, *Styrax serrulatus* etc. The most commonly practiced Jhum cultivation has highly degraded this kind of forest. Many native species have been replaced by jhum re-growth of various intensities. Bamboos like *Dendrocalamus hamiltonii*, *Bambusa tulda*, *B. pallida* and other plants like *Cuscuta reflexa*, *Ageratum conyzoides*, *Mikania micrantha*, *Chromolaena odorata* and *Cuphea carthagensis* dominate the vegetation cover.

#### Tropical semi evergreen forests:

The areas of Yingkyong, Ramsing, Moying, Katan, Sibum, Sumsing etc. falls under this category of forests. The dominant trees in such forests are mostly deciduous species. The other associate trees include evergreen species. Major elements of this forest are *Castanopsis indica*, *C. armata*, *Firmiana colorata*, *Syzygium aborense*, *Terminalia catappa*, *T. alata*, *Maesa indica*, *M. chisia*, *M. rugosa*, *Ficus semicordata*, *Chisocheton cumingianus*, *Combretum wallichii*, *Anogeissus acuminata*, *Duabanga grandiflora*, *Neolamarckia cadamba*, *Artocarpus heterophyllus* etc.

In the next storey small trees and shrubs are growing. Some of the important ones are *Abroma augusta*, *Pandanus tectorius*, *Embelia ribes*, *Maesa indica*, *Mussaenda roxburghii*, *Elatostema platyphyllum*, *Boehmaria macrophylla*, *Melastoma malabathricum*, *Polygonum chinense*, *Clerodendrum*

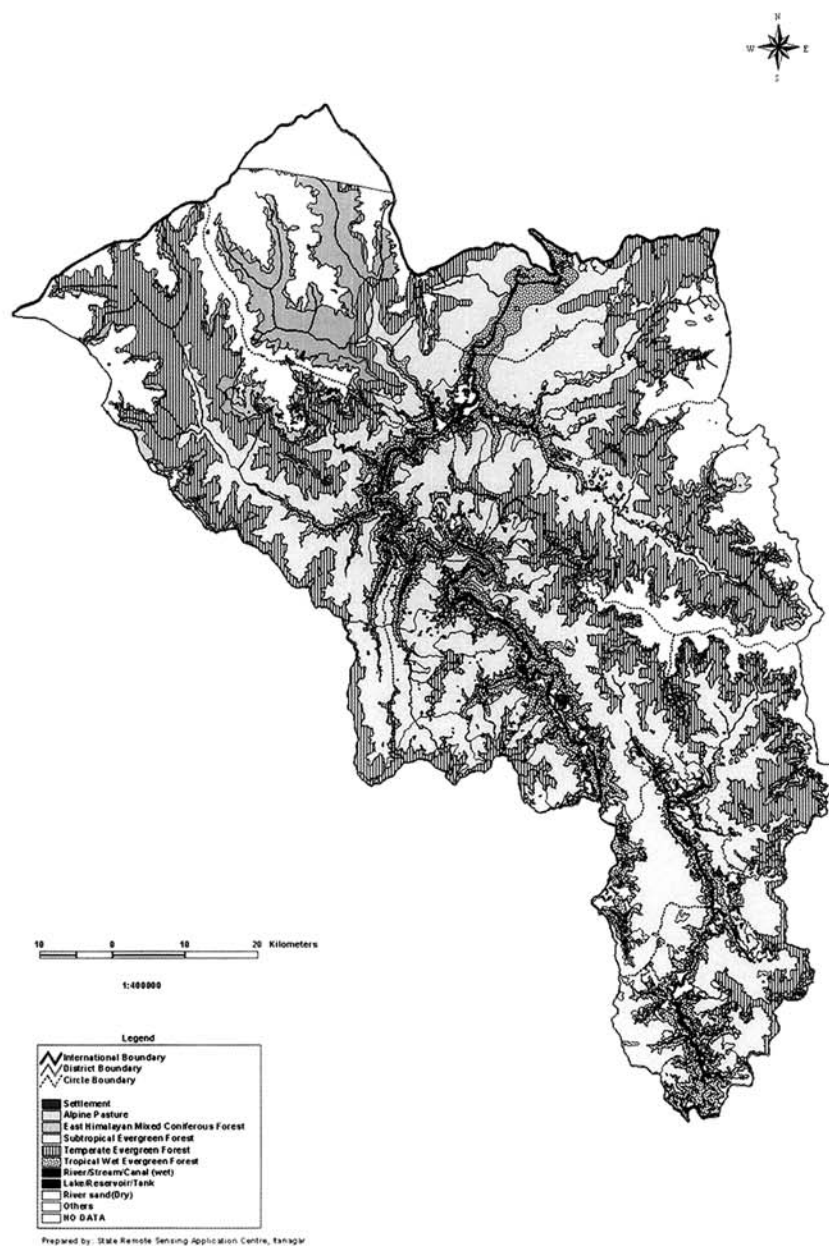


Fig. 4. Map showing different forest types of Upper Siang district.

*bracteatum*, *C. serratum*, *C. griffithianum*, *C. colebrookianum*, *Phlogacanthus tubiflorus*, *Casearia vareca*, *Eurya acuminata*, *E. japonica*, *E. nitida*, *Neyraudia reynaudiana*, *Scleria terrestris*, *Phrynium pubinerve*, *Alpinia malaccensis* etc.

The ground flora is predominantly composed of dense herbaceous layer with *Lobelia montana*, *Ageratum conyzoides*, *Bidens biternata*, *Cuphea carthagensis*, *Stellaria media*, *Acmella paniculata*, *Osbeckia stellata*, *Urena lobata*, *Sida rhombifolia*, *Triumfetta pilosa*, *Mazus pumilus*, *Lindernia antipoda*, *L. ciliata*, *L. crustacea* etc.

#### Tropical evergreen forests:

This canopy of forest is confined to upper reaches of hill ranges beginning from Yingkyong and Jengging and extending upto Mariyang and Tuting area. Within this kind of forest, a few deciduous elements are also found. The forest is also not completely free from the human interferences. Nevertheless, it has luxuriant growth of tropical flora under warm and humid conditions. The chief components of the forest are *Terminalia myriocarpa*, *T. catappa*, *Altingia excelsa*, *Magnolia hodgsonii*, *Elaeocarpus sikkimensis*, *E. aristatus*, *Castanopsis armata*, *C.*

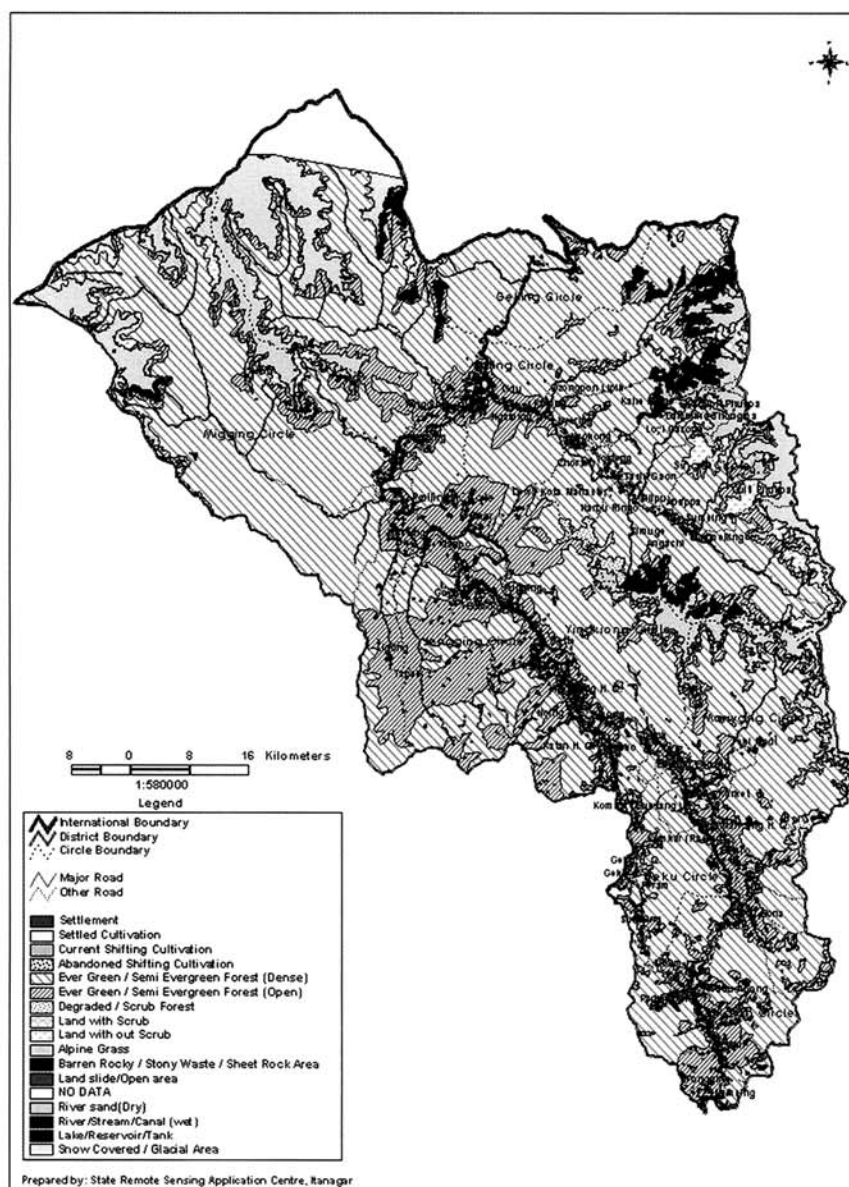


Fig. 5. Land use/Land cover map of Upper Siang district.

*indica*, *Chisocheton cumingianus*, *Combretum wallichii*, *Anogeissus acuminata*, *Duabanga grandiflora*, *Neolamarckia cadamba*, *Artocarpus heterophyllus*, *Ficus cyrtophylla*, *F. hirta*, *Actinodaphne obovata*, *Cinnamomum bejolghota*, *C. glanduliferum*, *C. tamala* etc. The next lower storey is composed of the trees of 10–20 m height. The common species of this layer are *Ficus semicordata*, *Sapium eugeniaefolium*, *Sterculia hamiltonii*, *Pterospermum acerifolium*, *Schefflera venulosa*, *Brassaiopsis hispida*, *Vernonia talaumifolia*, *Solanum erianthum*, *Saurauia armata*, *Baccaurea ramiflora*, *Bischofia javanica*, *Callicarpa arborea*, *Macaranga peltata*, *M. denticulata*, *Ostodes paniculata*, *Erythrina stricta*, *Litsea cubeba*, *Persea odoratissima*, *Phoebe goalparnesis*, *P.*

*lanceolata*, *Morus macroura*, *Wendlandia puberula*, *W. wallichii*, *W. tinctoria* etc. The trees of the lowest storey are 5–10 m high. Some of them are *Premna barbata*, *Saurauia punduana*, *S. roxburghii*, *Vernonia volkameriifolia*, *Trevesia palmata*, *Styrax serrulatus*, *S. hookeri*, *Actephila excelsa*, *Miliusa globosa*, *Friesoldiella fornicata*, *Pinanga gracilis*, *Oreocnide integrifolia*, *O. frutescens* etc.

The ground flora is predominantly composed of dense herbaceous layer with *Polygonum pubescens*, *P. hydropiper*, *Chirita pumila*, *Elatostema sikkimense*, *E. rupestre*, *Pilea insolens*, *P. glaberrima*, *Impatiens laevigata*, *I. porrecta*, *I. drepanophora*, *Begonia annulata*, *B. griffithiana*, *B. palmata*, *Ophiorrhiza mungos*, *O. repens*, *Globba multiflora*, *Drymaria*

*cordata*, *Achyropermum densiflorum*, *Mosla dianthera*, *Anisomeles indica*, *Clinopodium gracile*, *Chromolaena odorata*, *Carex cruciata* etc.

A number of large lianas like *Cayratia pedata*, *Leea macrophylla*, *L. compactiflora*, *Entada phaseoloides*, *Mucuna pruriens*, *Mastersia assamica*, *Poikilospermum suaveolens* etc. can be seen spread throughout the area. Many climbers also form a major component of the vegetation viz. *Medinilla assamica*, *Oxyspora paniculata*, *Millettia pachycarpa*, *Calamus floribundus*, *Thunbergia coccinia*, *T. grandiflora*, *Dioscorea bulbifera*, *D. hamiltonii*, *D. alata*, *D. pentaphylla*, *Piper rhytidocarpum*, *P. sylvaticum* etc. Besides, *Mikania micrantha* is also growing widely throughout the area particularly in the cleared and burnt secondary forests. *Cuscuta reflexa* has not invaded the upper reaches of the district but seen sporadically growing in the lower reaches viz. Jengging and Ditedime.

The epiphytic flora is also considerably rich particularly in the occurrence of orchids. The most common orchids growing in the region are *Dendrobium nobile*, *D. hookerianum*, *Cymbidium aloifolium*, *Rhynchostylis retusa*, *Bulbophyllum odoratissimum*, *Goodyera procera*, *Spiranthes sinensis*, *Vanda stangeana*, *Luisia zeylanica*, *Eria pannea* etc. Among other epiphytes, mention may be made of *Aeschynanthus novogracilis*, *A. acuminatus*, *Lysionotus serratus* etc.

## 2. Subtropical evergreen forest

The subtropical evergreen forest covers mostly the eastern and northern parts of the district starting from Mariyang, Migging, Paling, Kugging, Singa and ranging upto Kopoh and Gelling. Most of the area lies on the altitude of ca 900 m or above. The influence of altitude is distinctly visible on the floristic components which make the vegetation a characteristic one. Most of the area is cloudy for most of the times. This zone also receives a high rainfall during the months of May-September and the relative humidity is also very high providing an ideal environment for the growth of a luxuriant vegetation cover and orchids in particular.

The commonest trees of the uppermost storey are *Castanopsis indica*, *C. armata*, *C. kurzii*, *Lithocarpus listeri*, *L. dealbatus*, *Alnus nepalensis*, *Cyclobalanopsis lamellosa*, *Engelhardia spicata*, *Albizia julibrissin* var. *mollis*, *Saurauia napaulensis*, *Exbucklandia populnea* etc. This tree storey is however, not uniformly spread throughout the area and is generally merged with those of second storey. The second storey is chiefly composed of *Helicia nilagirica*, *Michelia doltsopa*, *Vernonia volkameriifolia*, *Edgeworthia gardneri*, *Syrax serrulatus*, *Debregeasia longifolia*, *Acer oblongum*, *Persea odoratissima* etc.

In addition to these, lianas like *Tetrastigma leucostaphylum*, *Cayratia pedata*, *Entada phaseoloides*, *Beaumontia grandiflora*, *Leea macrophylla* etc. climb over the trees to the uppermost layer. Some other climbers and scandent shrubs like *Aspidopterys indica*, *A. glabriuscula*, *Kadsura heteroclita*, *Tetrastigma serrulatum*, *T. dubium*, *Vitis heyneana*, *Cissus adnata*, *Ipomoea kingii*, *Argyrea sikkimensis*, *A. elliptica*, *Rivea ornata*, *Aeschynanthus superbus* etc. form a major component of the forest cover.

The ground layer represents perhaps the richest diversity of species including many herbs and shrubs viz. *Baliospermum calycinum*, *Grewia serrulata*, *Mycetia logifolia*, *Begonia thomsonii*, *B. inflata*, *Loxostigma griffithii*, *Clerodendrum lasiocephalum*, *C. serratum*, *Strobilanthes elongata*, *Garcinia lanceifolia*, *Polygala mariesii*, *Chloranthus erectus*, *Silvianthus bracteatus*, *Stellaria vestita*, *S. media*, *Pollia hasskarlii*, *Peliosanthes teta*, *Polygonum runcinatum*, *P. nepalensis*, *P. barbatum*, *Psychotria denticulata*, *P. monticola*, *P. silhetensis* subsp. *tomentosa*, *Pilea umbrosa*, *Gonostegia hirta*, *Pouzolzia frondosa*, *Elatostema sikkimense*, *Glochidion heyneanum*, *Hitchenia careyana*, *Cheilocostus speciosus*, *Hedychium gardnerianum*, *Arisaema cosanguineum*, *A. jacquimontii*, *A. concinuum*, *Limnophila sessiliflora*, *Desmodium laxiflorum*, *D. multiflorum*, *D. gyroides*, *Commelina diffusa*, *C. paludosa* etc. The occurrence of root parasites like *Balanophora dioica* and *B. involucrata* is quite common in Tuting and Gelling circles.

Many climbing species occupy a dominating position deep in the forest like *Clematis gouriana*, *C. acuminata*, *Smilax ferox*, *S. aspericaulis*, *S. minutiflora*, *Dioscorea pentaphylla*, *Stephania japonica*, *Solena amplexicaulis*, *Trichosanthes himalensis* and occasionally *Indofevillea khasiana* in Tuting-Gelling area. A thick mass of *Paederia foetida*, *Rubia cordifolia*, *R. sikkimensis*, *Argyria sikkimensis*, *A. elliptica* can be seen along the forest borders.

Many epiphytes, parasites, mosses and ferns also hold position on the branches of so many trees. The orchid flora in these areas is richest with a great diversity and good population (Hegde, 1984; Chowdhery, 1998). Some of the common orchids are *Coelogyne barbata*, *C. flaccida*, *C. fuscescens*, *Dendrobium nobile*, *D. hookerianum*, *D. acinaciforme*, *D. chrysanthum*, *D. aphyllum*, *Eria ferruginea*, *E. pannea*, *Bulbophyllum elatum*, *Liparis longipes*, *Calanthe alismifolia*, *Vanda cristata* etc. Some other epiphytic species like *Aeschynanthus acuminatus*, *A. novogracilis*, *Hoya retusa*, *Dischidia nummularia*, *Agapetes variegata* are commonly seen. Some Loranthaceous hemiparasites like *Helixanthera ligustrina*, *H. parasitica*, *Elytranthe psilantha*, *Scurulla parasitica* are also sporadically found.



The hydrophilic species includes *Eichhornia crassipes*, *Juncus prismatocarpus*, *J. ochraceus*, *Polygonum hydropiper*, *P. pubescens*, *Alternanthera sessilis*, *Oenanthe thomsonii*, *Ranunculus sceleratus*, *Ludwigia octovalvis*, *L. prostrata*, *Ficus squamosa*, *Murdannia nudiflora*, *M. simplex*, *Salomonina cantoniensis*, *Floscopa scandens*, *Pilea insolens*, *Hydrocotyle javanica* and many species of Cyperaceae.

A large chunk of the area comes under bamboo forests which are best developed not only in this zone but throughout the district. The most common species are *Denrocalamus giganteus*,

*D. hamiltonii*, *D. hookeri*, *Bambusa tuda*, *B. pallida* etc.

### 3. Sub-temperate mixed forest

This type of forest gradually emerges from the sub-tropical type, covering the upper slopes of the district viz. Garsing to Kepang La, areas of Bomdo-Janbo, Sebsiang area of Mariyang circle, Singa and adjacent areas. Most of these areas are extremely difficult to access and foot tracks are poorly developed. The altitude of these areas varies between 1200–2200 m. Along the track from Takekpong to Sirang, a distinct



**Fig. 6.** Some remarkable dicots of Upper Siang district. A. *Clerodendrum lasiocephalum* C.B.Clarke; B. *Clerodendrum serratum* Spr.; C. *Clerodendrum wallichii* Merr.; D. *Clerodendrum bracteatum* Walp.; E. *Clerodendrum colebrookianum* Walp.; F. *Clerodendrum griffithianum* C.B.Clarke; G. *Aeschynanthus superbus* C.B.Clarke; H. *Aeschynanthus parasiticus* (Roxb.) Wall.; I. *Aeschynanthus novogracilis* W.T.Wang; J. *Abroma augusta* (L.) L.f.; K. *Sterculia hamiltonii* (Kuntze) Adelb.; L. *Achyrospermum densiflorum* Blume; M. *Leucosceptrum canum* Smith; N. *Casearia vareca* Roxb.

temperate type of forest with *Quercus-Castanopsis*, *Michelia*, *Rhododendron-Cephalostachyum* association can be seen growing luxuriantly. A population of *Abies pindrow* is also visible in the area along with the population of *Rhododendrons*. The commonest species occurring in this kind of forest is *Rhododendron arboreum*, *R. johnstoneanum*, *R. ciliatum*, *R. grande*, *R. dalhousiae*, *Agapetes variegata*, *A. nutans*, *Vaccinium serratum*, *V. griffithianum*, *Gaultheria fragrantissima*, *G. dumicola*, *Castanopsis indica*, *C. armata*, *Cyclobalanopsis lamellosa* etc. The most celebrated medicinal plant of this area i.e. *Coptis teeta* also occurs in this forest. The occurrence of a highly poisonous plant i.e. *Aconitum lethale* is also reported from these areas. However it is difficult to differentiate this type of forest under a separate category as so many species characteristic of tropical or sub-tropical areas continue to grow

merging with the temperate species along the lower slopes of the Nyiggong, Siang, Siyom and Yamne rivers.

During the months of November to March, the region periodically comes under the influence of western disturbances causing precipitation, mostly as snowfall, particularly over the mountains of Janbo, Sebsiang, Singa and adjacent areas. The vegetation of these area although could not be properly assessed due to the inaccessibility caused by the geographical constraints but the occurrence of *Aconitum*, *Coptis*, *Abies*, *Gaultheria*, *Rhododendrons* etc. in these areas is evident.

The main agricultural products of the district are paddy, maize and millets (*Eleusine coracana*, *E. indica* etc.) whereas the chief horticultural produce are orange, pineapple, guava, banana, pear etc. The main domestic animals are Mithun, Pig, Goat, Dog and cattle.



**Fig. 7.** Some remarkable orchids of Upper Siang district. A. *Anoectochilus sikkimensis* King & Pantl.; B. *Uncifera obtusifolia* Lindl.; C. *Cymbidium aloifolium* (L.) Sw.; D. *Dendrobium chrysanthum* Lindl.; E. *Dendrobium aphyllum* (Roxb.) C.E.C.Fischer; F. *Eria lasiopetala* (Willd.) Ormerod; G. *Zeuxine nervosa* (Wall. ex Lindl.) Trimen; H. *Spiranthes sinensis* (Pers.) Ames.; I. *Phaius flavus* (Blume) Lindl.; J. *Liparis longipes* Lindl.; K. *Vanda stangeana* Reichb.f.; L. *Vanda cristata* Lindl.

Study of the area suggests that the district harbors a number of important plants which yield medicine, dye, fiber, timber, essential oil, gum, resin and tannin yielding plants, food and edible plants, spices and condiments etc. in addition to many other minor products about which we have practically no knowledge. Moreover, the area also holds key for the evolution of many important plant species that could offer valuable genes

and biodynamic compounds of great economic importance. The area under study is inhabited by some of the most fascinating traditional communities of India, who are living here for thousands of years and have developed a precious knowledge about the use of the bioresources of the region. The traditional uses of wild plants for edible, medicinal and miscellaneous purposes, is still well preserved and practiced



**Fig. 8.** Some remarkable monocots of Upper Siang district. A. *Arisaema consanguineum* Schott; B. *Arisaema concinuum* Schott; C. *Cheilcostus speciosus* (J.Koenig) C.D.Specht; D. *Amorphophallus nepalensis* Bogner & Mayo; E. *Amorphophallus bulbifer* (Roxb.) Blume; F. *Paris polyphylla* Sm.; G. *Musa velutina* H.Wendl. ex Drude; H. *Musa sikkimensis* Kurz; I. *Globba multiflora* Wall. ex Baker; J. *Amischotolype mollissima* (Blume) Hassk.; K. *Commelina paludosa* Blume; L. *Dioscorea pentaphylla* L.

by local communities of this area.

During present study, a wide range of diversity in terms of taxa, habit and life forms have been recorded (Figs. 6, 7 and 8). A total of 1003 taxa of angiospermic plants belonging to 110 families, 529 genera, 994 species, 1 subspecies and 8 varieties have been recorded. Out of these, 728 species with 398 genera under 95 families belong to dicotyledons and 266 species with 131 genera under 16 families to monocotyledons.

A new species of *Embelia* was also found from the Gelling area of the district and described as *Embelia arunachalensis*. Besides, the occurrence of *Ranunculus trigonus* var. *strigosus*, *Polygonum huananense* and *P. taquetii* has been reported as the first distributional record to India (Choudhary et al., 2007; Choudhary, 2008). The occurrence of *Buddleja yunnanensis* in India has also confirmed by the collection from Mariyang area during the present survey work (Choudhary, 2008). The taxon was hitherto poorly known from India.

The ten most dominant families are: Orchidaceae (88 species), Poaceae (69 species), Fabaceae (52 species), Asteraceae (49 species), Rubiaceae (47 species), Lamiaceae (36 species), Urticaceae (32 species), Cyperaceae (24 species), Euphorbiaceae (20 species) and Araceae (20 species). 42.2% species diversity is restricted to the above ten dominant families. The remaining species belong to the rest of the families out of which 25 families are represented by single species.

*Polygonum* is the most dominant genus with 14 species followed by *Ficus* (13 species), *Begonia*, *Elatostema* and *Dendrobium* (each with 11 species), *Piper* (10 species), *Desmodium*, *Impatiens*, *Eria*, *Bulbophyllum*, *Coelogyne* and *Bambusa* (each with 9 species.), *Dioscorea* and *Liparis* (8 species), *Cyperus*, *Schizostachyum*, *Rhododendron*, *Vernonia*, *Rubus* and *Solanum* (each with 7 species), *Carex*, *Arisaema*, *Smilax* and *Pilea* (each with 6 species), and *Citrus*, *Lindernia*, *Ophiorrhiza*, *Hedyotis*, *Aeschynanthus*, *Chirita*, *Pueraria*, *Embelia*, *Boehmeria*, *Calanthe* and *Fimbristylis* each with 5 species. All these dominant genera represent ca 26% of the total species.

Some of the genera which are represented by single species are *Acer*, *Asystasia*, *Justicia*, *Perilepta*, *Peristrophe*, *Pseuderanthemum*, *Pteracanthus*, *Holigarna*, *Pegia*, *Friesodielsia*, *Trivalvaria*, *Pimpinella*, *Stuednera*, *Heteropanax*, *Trevesia*, *Arenga*, *Caryota*, *Wallichia*, *Dillenia*, *Dischidia*, *Tylophora*, *Cleome*, *Stixis*, *Garcinia*, *Combretum*, *Cyanotis*, *Merremia*, *Rivea*, *Dipterocarpus*, *Antidesma*, *Sapium*, *Crawfordia*, *Swertia*, *Passiflora*, *Engelhardia*, *Paris*, *Sarcopyramis*, *Cyclea*, *Acampe*, *Luisia*, *Oberonia*, *Paphiopedilum*, *Pleione*, *Anoetochilus*, *Sacciolepis*, *Acroceras* etc.

The families which are represented by single species are

Betulaceae, Bignoniaceae, Cannabaceae, Caricaceae, Chloranthaceae, Connaraceae, Coriariaceae, Costaceae, Dilleniaceae, Dipterocarpaceae, Hypericaceae, Juglandaceae, Nyctaginaceae, Opiliaceae, Passifloraceae, Pedaliaceae, Plantaginaceae, Plumbaginaceae, Pontederiaceae, Proteaceae, Salicaceae, Saururaceae, Schisandraceae, Thymelaeaceae & Ulmaceae.

Out of the 1,003 taxa reported here, 402 are herbs, 200 shrubs, 152 trees, 119 climbers and 101 epiphytes & parasites and 29 bamboos (arborescent herbs).

A comparative data of dicots and monocots are given in Table 2 and dominant families and genera are presented in Table 3. A comparative account of ten dominant families in Upper Siang district, Arunachal Pradesh, E. Himalaya and India is presented in Table 4. An appendix has also been provided listing all the plants along with their habit and localities (Appendix 1).

#### Endemic taxa

The 'Abor' hill is considered an important 'micro-center' of endemism in Arunachal Pradesh (Burkill, 1924). The high mountains of Upper Siang district ranging from ca350 → 2,000 m and the deep gorges in between the mountains have created a number of ecological niches and isolated geographic islands. Some of the plants which are confined only to the Eastern Himalayan region and found in Upper Siang district are presented in the table below along with their distribution range (Appendix 2).

**Table 2.** Comparative data of Dicot and Monocot species.

Groups	Family	Genera	Species
Dicotyledons	94 (85.6%)	398 (75.2%)	728 (73.2%)
Monocotyledons	16 (14.4%)	131 (24.8%)	266 (26.8%)
Total	110	529	994

**Table 3.** Ten dominant families of Upper Siang district.

Sl. No.	Family	No. of genera	No. of species
1	Orchidaceae	32	88
2	Poaceae	46	69
3	Fabaceae	29	52
4	Asteraceae	30	49
5	Rubiaceae	25	47
6	Lamiaceae	24	36
7	Urticaceae	13	32
8	Cyperaceae	6	24
9	Euphorbiaceae	15	20
10	Araceae	7	20
	Total	227	447

**Table 4.** Comparative account of ten dominant families in Upper Siang district, Arunachal Pradesh, E. Himalaya (N-E region) and India.

Sl.No.	Upper Siang dist. (Present study)	Arunachal Pradesh (Chowdhery et al., 1996)	N.E. Region (Hooker, 1872-1897)	British India (Rao and Murti, 1990)
1	Orchidaceae	Orchidaceae	Poaceae	Orchidaceae
2	Poaceae	Leguminosae	Orchidaceae	Leguminosae
3	Fabaceae	Asteraceae	Leguminosae	Gramineae
4	Asteraceae	Rubiaceae	Asteraceae	Rubiaceae
5	Rubiaceae	Ericaceae	Cyperaceae	Euphorbiaceae
6	Lamiaceae	Poaceae	Lamiaceae	Acanthaceae
7	Urticaceae	Urticaceae	Scrophulariaceae	Compositae
8	Cyperaceae	Rosaceae	Acanthaceae	Cyperaceae
9	Euphorbiaceae	Cyperaceae	Euphorbiaceae	Labiatae
10	Araceae	Euphorbiaceae	Rubiaceae	Urticaceae

#### Rare, endangered and threatened taxa

The district Upper Siang provides shelter to many plants which are known to be rare, endangered, threatened and endemic. As a consequence of deforestation and over-exploitation, many of them have become seriously threatened and are in the focus of conservation concerns. Deforestation and shifting cultivation have been observed as the main causes of forest fragmentation. This may lead to a decline in natural populations of species and a loss of genetic diversity, and even extinction. A list of such plants is given below:

(1) *Aconitum lethale* Griff. (Ranunculaceae)

Distribution: Endemic to Arunachal Pradesh (Chauhan et al., 1996).

*Notes:* Reported so far from Upper Siang and Lohit districts only. This plant had been collected by T.S. Deory (1960) from Komdi (Miripadmi) area of Upper Siang district. Thereafter, no collection has been made.

(2) *Begonia aborensis* Dunn (Begoniaceae)

Distribution: Endemic to Arunachal Pradesh & Assam.

*Notes:* This species has been included in the Red Data Book of threatened vascular plants of India (Rao et al., 2003). It was found very scarcely distributed in Mariyang area of Upper Siang district.

(3) *Beilschmiedia pseudomicropora* (Purkay.) Kosterm. (Lauraceae)

Distribution: Endemic to Arunachal Pradesh and Assam.

*Notes:* Vulnerable; known only by its type collection from Assam until Naithani and Bahadur (1983) collected it from the Kameng district of Arunachal Pradesh after a gap of 41 years. During the present survey work, it was collected from Moying area of Upper Siang.

(4) *Buddleja yunnanensis* L.F.Gagnep. (Scrophulariaceae)

Distribution: India (Arunachal Pradesh), China

*Notes:* A rare taxon. Distributed in some difficult terrains of Mariyang circle of Upper Siang.

(5) *Camellia siangensis* T. K.Paul & M.P.Nayar (Theaceae)

Distribution: Endemic to Arunachal Pradesh. Known so far from the 'type locality'.

*Notes:* Vulnerable (Chowdhery, 1999). The species was first described by Pal and Nayar (1987) based on the collection made by R.S.Rao (1958). Thereafter, no collection has been made. During the present study, it was not encountered.

(6) *Clerodendrum lasiocephalum* C.B.Clarke (Lamiaceae)

Distribution: India (North East region), Myanmar.

*Notes:* Vulnerable, Rajendran and Daniel (2002) quote this species as 'Rare in India'. This beautiful plant has been seen sporadically distributed near Kopoh area of Tuting circle and some locations of Migging circle.

(7) *Coelogyne barbata* Lindl. ex Griff. (Orchidaceae)

Distribution: India (North East India), Bhutan, Myanmar.

*Notes:* Indeterminate; included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(8) *Coelogyne flaccida* Lindl. (Orchidaceae)

Distribution: India (North East India, Uttarakhand), Nepal, Myanmar, Thailand, Laos.

*Notes:* Indeterminate; included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(9) *Coelogyne nitida* (Wall. ex D.Don) Lindl. (Orchidaceae)

Distribution: India (Arunachal Pradesh, Sikkim, Uttarakhand, West Bengal), Bangladesh, Bhutan, Nepal, Myanmar, Thailand, Laos.

*Notes:* Rare; included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(10) *Coelogyne prolifera* Lindl. (Orchidaceae)

Distribution: India (North East India), Bhutan, Myanmar,

Nepal.

*Notes:* Indeterminate; included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(11) *Coptis teeta* Wall. (Ranunculaceae)

Distribution: India (Arunachal Pradesh).

*Notes:* Vulnerable due to its overexploitation and habitat loss. Nevertheless, it has been observed under cultivation at Mariyang and Tuting area. Scarcely distributed in some difficult locations of the district being traditionally utilized by the local people as a medicine for stomachache. Included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(12) *Dioscorea deltoidea* Wall. ex Griseb. (Dioscoreaceae)

Distribution: India (Kashmir to Assam), Afghanistan, Indo-China, W. China. Rather sporadic.

*Notes:* Vulnerable due to over-exploitation. High in demand for its medicinal tubers.

(13) *Dioscorea scortechinii* Prain & Burkill (Dioscoreaceae)

Distribution: India (Arunachal Pradesh), Malaysia.

*Notes:* This species was so far known from Malaysia till it was collected from the Minguing area of Upper Siang district as a new record to India. (Rao and Joseph, 1958). Thereafter, no collection has been made.

(14) *Eria jenggingensis* S.N.Hegde (Orchidaceae)

Distribution: India (Arunachal Pradesh).

*Notes:* Known so far only from its type locality i.e. Jengging, in Upper Siang district.

(15) *Goodyera recurva* Lindl. (Orchidaceae)

Distribution: India (North East region).

*Notes:* Indeterminate; included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003).

(16) *Indofevillea khasiana* Chatterjee (Cucurbitaceae)

Distribution: India (Arunachal Pradesh, Assam, Meghalaya), Bhutan. (Naithani and Bahadur, 1983)

*Notes:* This species was previously considered an endemic to Assam and Arunachal Pradesh. But, later it was reported to occur in Bhutan also. In Upper Siang district, it was found scarcely growing in some remote localities of the Gelling circle.

(17) *Livistona jenkinsiana* Griff. (Arecaceae)

Distribution: India (North East region) (Chauhan et al., 1996).

*Notes:* Used for thatching purpose by the local people of the study area.

(18) *Musa velutina* H.Wendl. & Drude (Musaceae)

Distribution: India (North East region) (Chauhan et al., 1996).

*Notes:* Though the plant was seen growing well in many areas of Upper Siang viz. Mariyang, Jengging, Tuting, Gelling etc. But the ongoing practice of jhum cultivation has caused

a threat to its population at many places. Therefore, proper attention of the scientific community is needed to protect the germplasm.

(19) *Neonauclea gageana* (King) Merr. (Rubiaceae)

Distribution: India (Arunachal Pradesh, Andaman, Nicobar Islands).

*Notes:* Endemic. Only reported from Upper Siang district and the Andaman & Nicobar Islands of India.

(20) *Pilea insolens* Wedd. (Urticaceae)

Distribution: India (North East region), Bhutan, China, Nepal.

*Notes:* Confined only to the North-Eastern mid-sector of Arunachal Pradesh (Mandal, 1983). Though, the plant was seen growing well at many places of Upper Siang district.

(21) *Ranunculus trigonus* Hand.-Mazz. var. *strigosus* W.T.Wang (Ranunculaceae)

Distribution: India: Arunachal Pradesh, China.

*Notes:* This species has been collected for the first time from India. Previously known only from China. During the present study, it was collected from the Yingkyong area occurring in a very small population of around 15 individuals. Evidently, the existence of this species in India is under threat.

(22) *Rhododendron johnstoneanum* Watt ex Hutch. (Ericaceae)

Distribution: India (Arunachal Pradesh, Manipur, Mizoram), Myanmar.

*Notes:* Endemic, Endangered. (Sastry and Hajra, 1983)

(23) *Solanum kurzii* Prain (Solanaceae)

Distribution: India (North East India), Myanmar.

*Notes:* Indeterminate. Included under the Red Data Book of threatened vascular plants of India (Rao et al., 2003). This species was observed growing well at many places in the study area.

(24) *Syzygium aborense* (Dunn) Rathakr. & N.C.Nair (Myrtaceae)

Distribution: Endemic to Arunachal Pradesh (Hajra et al., 1996). Scarcely distributed in the study area.

Besides the above list, the district also harbours a number of plants which are so far known only from the eastern Himalayan region. Some of them are *Didymosperma nanum*, *Globba multiflora*, *Glycosmis cyanocarpa* var. *simplicifolia*, *Loxostigma griffithii*, *Luculia pinceana*, *Ophiorrhiza repens*, *Spiradiclis bifida*, *Spiradiclis cylindrica*, *Vitis planicaulis* etc.

## Conservation

The conservation and proper management of biodiversity is the priority area of any biologist which can be achieved only through the consistent exploration and systematic recording of

various biotic entities. In this context the flora of Eastern Himalayas represents one of the most important mega-centers of biodiversity because of its diverse and luxuriant vegetation, a high degree of endemism and occurrence of rare and threatened taxa.

Present study is an attempt towards our understanding of the diversity of the flowering plants growing in Upper Siang which holds a large number of rare, curious, economically important, endangered and endemic plants.

As is now understood from the floristic exploration and survey work, Upper Siang district represents a vast repository of rich gene-pool. Many of the plants are recorded to be very rare with thin frequency of occurrence and their population is also rapidly declining. The study also revealed that the floristic resources of the area are of great economic value as numerous species are medicinal, wild edibles, potential ornamentals, fodders and high priced timbers. Many of them may prove to be important land races for future use. The huge bamboo resource of the area can also prove beneficial if utilized in a sustainable manner. The occurrence of a number of orchids can also prove helpful to the local people if they are trained to cultivate them with proper marketing facility.

Lately, the increasing pressure of development such as expansion of roads, establishments of communication setups, dams etc. have drastically changed the harmony between biological and cultural diversity that existed in the past. This has also led to the depletion of vast natural resources. Fortunately, a major portion of the district still enjoys the primary vegetation. But the increasing destruction of habitats particularly due to 'Jhuming' and indiscriminate exploitation have resulted a major threat to orchids and other important plants like *Aconitum lethale*, *Coptis teeta*, *Balanophora dioica*, *Polyura geminata*, *Buddleja yunnanensis*, *Ranunculus trigonus* var. *strigosus* etc.

Some of the common threats posed to the flora as a result of biotic interferences are:

- (1) Rapid urbanization
- (2) Clearing of vegetation for agriculture, including *Jhum* Cultivation.
- (3) Ruthless exploitation of the forest for timber and fuel wood.
- (4) Construction of roads.
- (5) Landslides
- (6) Fires.
- (7) Narrow habitat preference and highly patchy distribution of some species.
- (8) Human settlements inside the protected areas, and

- (9) Natural calamities like flash flood etc.

To save, what still remains of our vegetation, the exploitation of forest resources and extraction of major and minor forest products has to be strategically regulated. *In situ* conservation is the best and most effective means to conserve species diversity in its natural habitats. *Jhum* cultivation needs to be tackled effectively and scientifically since it is an integral part of the local inhabitants. Public awareness is required to be created. Agro forestry system with new technologies should be introduced as an alternative means of *Jhuming* system. There should be a coordinated effort of all departments concerned with the development to evolve policies which are beneficial and suitable in local conditions. Proper rules should be framed out for tree felling and extraction of NTFPs. Bamboo-based industries can be established to improve the living standard of the local people. Plantations of cash crops, poultry farming, dairy farming, and other forest based small industries etc. need to be encouraged among *jhumias*. Definitely, these steps would ensure a safe and bright future of the coming generations.

## Acknowledgements

Authors are thankful to the Director, Botanical Survey of India for facilities and allotting research fellowship to the first author under 'Flora of India' project. Support received from IBMRC, KRIBB vide-2011-00402 funded by Ministry of Education Science and Technology of Korean government is also duly acknowledged.

## Literature Cited

- Agrawala, D. K., C. M. Sabapathy and B. Tam. 2005. The Orchidaceae of Mouling National Park, Arunachal Pradesh. *In* Plant Taxonomy: Advances and Relevance. Pandey, A. K., J. Wen and J. V. V. Dogra (eds.), CBS Publishers & Distributors, New Delhi, India. Pp. 251-266.
- Angiosperm Phylogeny Group. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 161: 105-121.
- Baishya, A. K., S. Haque, P. J. Bora and N. Kalita. 2001. Flora of Arunachal Pradesh-An overview. *Arunachal Forest News* 19 (1&2): 1-25.
- Bor, N. L. 1960. The Grasses of Burma, Ceylon, India and Pakistan (excluding Bambuseae). Pergamon, NewYork.
- Burkill, I. H. 1924. The botany of the Abor expedition. *Records of*

- Botanical Survey of India 10 (1): 376-381.
- Champion, H. G. and S. K. Seth. 1968. A Revised Survey of Forest Types of India. Manager of Publications, Govt. of India Press, New Delhi, India.
- Chauhan, A. S., K. P. Singh, D. K. Singh and P. K. Hajra. 1996. A contribution to the flora of Namdapha, Arunachal Pradesh. Govt. of India, Botanical Survey of India, Calcutta, India.
- Choudhary, R. K., R. C. Srivastava and A. K. Das. 2007. *Ranunculus trigonus* var. *strigosus* W.T. Wang: A new record for India from Arunachal Pradesh. *Rheedea* 18 (1): 37-38.
- Choudhary, R. K. 2008. Floristic diversity of Upper Siang district, Arunachal Pradesh, India. Ph.D. dissertation, Rajiv Gandhi University, Arunachal Pradesh, India.
- Choudhary, R. K., R. C. Srivastava and A. K. Das. 2009. A new species of *Embelia* Burm.f. from Arunachal Pradesh (India). *Journal of Japanese Botany* 84 (6): 338-341.
- Hajra, P. K., D. K. Verma and G. S. Giri. 1996. Materials for the flora of Arunachal Pradesh, Vol.1. Govt. of India, Botanical Survey of India, Calcutta, India.
- Chowdhery, H. J. 1998. Orchid Flora of Arunachal Pradesh. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
- Chowdhery, H. J. 1999. Floristic diversity and conservation strategies in India. Govt. Of India, Botanical Survey of India, Calcutta, India.
- Das, A. K. 1986. Ethnobotany of East Siang District, Arunachal Pradesh, India. Ph. D. dissertation, Gauhati University, Guwahati, India.
- Gajurel, P. R., P. Rethy, B. Singh and A. Angami. 2006. Ethnobotanical studies of Adi tribes in Dihang Debang Biosphere Reserve in Arunachal Pradesh, Eastern Himalaya. *Ethnobotany* 18: 114-118.
- Hara, H. 1966. The Flora of Eastern Himalaya: results of botanical expedition of Eastern Himalaya. University of Tokyo, Tokyo, Japan.
- Hegde, S. N. 1984. Orchids of Arunachal Pradesh. State forest department, Arunachal Pradesh, Itanagar, India.
- Hegde, S. N. 1993. *Eria jengingensis* Hegde: a new species of orchid from Arunachal Pradesh. *The Journal of the Orchid Society of India* 7(1-2): 13-16.
- Holmgren, P. K., N. H. Holmgren and L. C. Barnett. 1990. Index Herbariorum, Part I: the Herbaria of the World. New York Botanical Garden, New York, U.S.A. (also on-line at <http://sweetgun.nybg.org.ih/>).
- Hooker, J. D. 1872-97. Flora of British India, Vol. I-VII. Reeve & Co. London.
- Jain, S. K. and R. R. Rao. 1976. A hand book of field and herbarium methods. Today & Tomorrow's Printers & Publishers. New Delhi-5, India.
- Kanjilal, P. C., A. Das, C. S. Purkayastha, R. N. De and N. L. Bor. 1934-40. Flora of Assam, Vol. I-V. Offset Press, Delhi, India.
- Kaul, R. N. and K. Haridasan. 1987. Forest types of Arunachal Pradesh: A Preliminary Study. *Journal of Economic and Taxonomic Botany* 9(2): 379-389.
- Kingdon-Ward, F. 1929. Botanical exploration in the Mishimi Hills. *Himalayan Journals* 1:51-59.
- Kumar, A., H. Medhi, R. Choudhary, B. Tam, and A. K. Baishya. 2004. Note on the floristic diversity and vegetation types of the Mouling National Park, Arunachal Pradesh. *Himalayan Biosphere Reserves* 6 (1&2): 65-71.
- Naithani, H. B. and K. N. Bahadur. 1983. Observation on extended distribution of new and rare taxa of North eastern India with special reference to Arunachal Pradesh. *In An assessment of the threatened plants of India*. Jain, S. K. and R. R. Rao (eds.), Botanical Survey of India, Howrah, India.
- Paul, T. K. and M. P. Nayar. 1985. A new species of *Camellia* (Theaceae) from Arunachal Pradesh, India. *Bullin of Botanical Survey of India* 27(1-4): 92-93.
- Rajendran, P. and P. Daniel. 2002. The Indian Verbenaceae. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
- Rao, R. S. 1972. Botanical Survey work in Arunachal Pradesh. *In Arunachal Research Bulletin*. Shastri, B. (ed.), Independence Silver Jubilee Volume. Director of Information and Public relations, Arunachal Pradesh administration, Shillong, India.
- Rao, A. N. and K. Haridasan. 2005. *Dendrobium vexabile* Rchb.f. (Orchidaceae): A new record to India from Arunachal Pradesh. *Arunachal Forest News* 21 (1&2): 14-16.
- Rao, A. S. and P. K. Hajra. 1971. *Arisaema setosum*: a new sps. of Araceae from Siang distt., N.E.F.A. *Bulletin of Botanical Survey of India* 11: 196-197.
- Rao, R. S. and J. Joseph. 1965. Observations on the flora of Siang Frontier Division, North Eastern Frontier Agency (NEFA). *Bulletin of Botanical Survey of India* 12 (1-4): 261-263.
- Rao, R. R. and S. K. Murti. 1990. North-East India: A major centre for plant diversity in India. *Indian Journal of Forestry* 13 (3): 214-222.
- Rao, C. K., B. L. Geetha and G. Suresh. 2003. Red list of threatened vascular plant species in India. ENVIS, Botanical Survey of India, Kolkata, India.
- Sastry, A. R. K. and P. K. Hajra. 1983. Rare and Endemic species of *Rhododendrons* in India-A preliminary study. *In An assessment of the threatened plants of India*. Jain, S. K. and R. R. Rao (eds.), Botanical Survey of India, Calcutta, India. Pp. 222-231.
- Takhtajan, A. 1969. Flowering plants: Origin and Dispersal. Oliver and Boyd, Edinburgh.