

**ASSESSMENT OF ENDEMISM, RARITY AND
CONSERVATION STATUS OF A FEW MEDICINAL
PLANT SPECIES OF MEGHALAYA**

ABSTRACT

BY
NIGYAL JOHN LAKADONG



THESIS
SUBMITTED IN FULFILMENT
OF THE DEGREE OF
DOCTOR OF PHILOSOPHY IN BOTANY

NORTH-EASTERN HILL UNIVERSITY
SHILLONG – 793 022, INDIA
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The present study was conducted in Meghalaya to assess the threat status of three selected medicinal plant species viz., *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*. The other objectives of the study were, to determine the concentration of endemism in different parts of Meghalaya, to assess the endemism of selected medicinal plant species based on their distribution mapping; and to prioritize the areas for conservation for the selected species. Besides achieving the above objectives, the study has been able to establish a workable protocol with selected population parameters for classifying the plant species from threat perspective based on a short term (4 years) research work. The empirical population data were collected through extensive field study and were analyzed using spatial and mathematical models to achieve the above objectives.

Three possible causative factors for rarity viz., over-exploitation, narrow species niche and regeneration constraint were evaluated in respect of each species. Rarity assessment was done by monitoring the populations, studying the fluctuations in the number of individuals within the population, and change in the geographic range-sizes of the species. Two protocols were consulted and adapted for rarity assessment, viz., Atlantic Canada Conservation Data Centre (CDC, 2003) protocol, and IUCN Categories and criteria (IUCN 2001) protocol. The IUCN criterion of Geographic range size was derived using ArcView 3.3 script “cats.avx” to delineate the AOO and EOO of the selected species (Moat 2007).

A detail inventory of medicinal plant species present in the state of Meghalaya was prepared both through primary and secondary data. The distribution pattern of threatened and endemic medicinal plant species was studied with the help of extensive field visits and presented. Field visits were made during the peak growing season of the

species. A Geographical Positioning System (GPS) was used to pinpoint the exact location of endemic species restricted to Meghalaya. Further, based on the GPS readings, distribution of the species was mapped on a scaled-map of Meghalaya to determine the areas of concentration of the endemic medicinal plant species.

The technique of ecological niche modeling was used to delineate the potential distributional areas of the species. The modeling approach used genetic algorithm as a tool to model the ecological niche of the plant species. The ecological niche modeling was carried out using a desktop version of GARP (Genetic Algorithm for Rule-set Prediction). The independent validation of the model was done by overlaying the occurrence points with the model projections. To visualize the ecological niche of the selected medicinal plant species in a two-dimensional environmental space, the geographic projection of the ecological niche models was related to the original environmental data layers to reconstruct the overall ecological variation across the landscape and the conditions under which the species was predicted to occur. To accomplish this task, all the layers were combined in Arc View 3.3. For *Monotropa uniflora* twentytwo environmental parameters were used. They were GIS raster layers summarizing the bioclimatic variables with a spatial resolution of 30 arc seconds ($\approx 1\text{km}$). GIS layers used from the USGS Hydro-1K dataset (USGS 2001) were also used in the predictive distributional modeling. For modeling the distribution of *Osbeckia capitata* and *Panax pseudoginseng*, twenty three environmental parameters were used. Areas for conservation were prioritized based on the potential distribution areas of the respective species in the state. The global potential distribution of the species was modeled using GARP to confirm the endemism of the species.

PVA was performed based on the demography of the populations and the size of the seed bank. Transition matrices and deterministic projections of population growth and size class distribution were then performed with stage-based matrix models (Lefkovich Matrix). Matrices were calculated as the standard deviation of the four corresponding estimates. The finite rate of increase (λ) and elasticity analysis were calculated from the matrix projections. Incorporation of stochasticity into the model yielded simulations used to analyse the effect of environmental and demographic stochasticity on the persistence of the populations of the selected species. These simulations allowed us to estimate a minimum viable population size from the Time to extinction curve (Time step corresponding to $\leq 5\%$) and Population trajectory curve (population size corresponding to this time step) generated through the simulations. A stage-based matrix model was constructed for all known populations of the selected species. The matrix construction, manipulation and projection were done using RAMAS Metapop (Ackakaya 2000).

In total, 834 medicinal plant species distributed in different elevational gradient of Meghalaya were listed. Of the total 239 endemic plant species of the state, 37 endemic medicinal plant species are found in Meghalaya, which are endemic to Himalayas, Indo-Burma region and Peninsular India. At least 12 medicinal plants are endemic to Meghalaya only

The mean population size of *Monotropa uniflora* (110 ± 14.1) was greatest among the three species at the beginning of the study, followed by *Osbeckia capitata* (87 ± 2.9) and *Panax pseudoginseng* (72 ± 9.9). The mean population sizes declined over a period of four years for all the three species. However, the decline was highest in case of *Monotropa uniflora*, where the population size declined to 57 ± 15.0 in the year 2007.

Based on Rarity assessment (IUCN Category and Criteria 2001), *Panax pseudoginseng* and *Monotropa uniflora* belonged to the Critically Endangered (CR) category, whereas, *Osbeckia capitata* was assigned the status of Endangered (EN). Based on the CDC Category and Criteria *Monotropa uniflora* and *Panax pseudoginseng* were both placed under the S-Rank “S-1”. *Osbeckia capitata* was placed under the S-Rank “S-3”. According to the conservation assessment tools “cats.avx”, the EOO rating for all three species was Endangered (EN). However, the AOO rating for *Monotropa uniflora* shifted from Vulnerable (VU) to Endangered (EN). Similarly, The AOO rating for *Panax pseudoginseng* was Endangered (EN). However, the AOO rating for *Osbeckia capitata* was Near Threatened (NT).

Overall, the extraction of plants, regeneration constraints, decline in metapopulation size and narrow ecological niche are the causes of rarity for *Osbeckia capitata* and *Panax pseudoginseng*. In case *Monotropa uniflora*, narrow ecological niche, regeneration constraints due to shrinking safe sites, decline in metapopulation size and poor germination are the causes of rarity.

Monotropa uniflora had the highest population at the beginning of the study followed by *Osbeckia capitata* and *Panax pseudoginseng*. The populations of all the three species declined over the study period and the declining was maximum in *Monotropa uniflora* leaving only a mean population size of 54 from the initial mean population size of 154.

Decadal change in population sizes for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* revealed that 100% extinction probability was projected in 140, 190 and 260 years, respectively. Elasticity analysis revealed that Fecundity

contributed the most to population growth in the case of *Monotropa uniflora*, whereas, matrix transitions representing growth from one stage to another contributed the most to population growth of *Osbeckia capitata* and *Panax pseudoginseng*. From the metapopulation occupancy, it was inferred that the number of time steps that each population of *Monotropa uniflora* will remain extant is 97 years. Similarly, that for *Osbeckia capitata* and *Panax pseudoginseng* is 128 and 192 years respectively. In case of *Monotropa uniflora* there is a 50% risk that the metapopulation abundance will fall below the threshold in 69.2 years. Similarly, in the case of *Osbeckia capitata* and *Panax pseudoginseng* there is a 50% risk that the metapopulation abundance will fall below the Threshold in 98.8 and 119.2 years respectively. The minimum viable population size (MVP), including the seeds for *Monotropa uniflora* is 2019 and that for *Osbeckia capitata* and *Panax pseudoginseng* is 19,104 and 2429, respectively. The major areas of concentration of endemic species in Meghalaya are confined to undisturbed habitats and protected areas like Nokrek Biosphere Reserve (37.8%) and sacred groves at Jowai (35.1%) and Raliang (32.4%).

The common important factors, highlighted by the ecologic niche models that were responsible for the distribution of the three species were temperature, precipitation and altitude. However, other factors regulating the distribution of the three species were topography in case of *Osbeckia capitata*, diurnal range in case of *Panax pseudoginseng* and vegetation cover in case of *Monotropa uniflora*. Ecological niche modeling served as a useful tool to assess the endemism of a species as evident from the present study of *Osbeckia capitata*. The species was found to be endemic to Meghalaya in the Indó-

Burma hotspot. The model also confirmed the political or biogeographic endemism of the species.

An area of 5821 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District were identified as the priority areas for the conservation of *Osbeckia capitata*, 1993 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District for *Monotropa uniflora* and 2086 km² in East Khasi Hills District for *Panax pseudoginseng*. The major areas of concentration of endemic species in Meghalaya were also identified as the priority areas for the conservation.

Overall, it is recommended that the identified areas of concentration of endemics would require immediate conservation efforts to protect these species from extinction. The methods followed in this study and the protocols developed for the study would be extremely useful for studying and classifying the populations of threatened and endemic species. Assessment of endemism and rarity following these methods would help in taking appropriate and effective measures for conservation of the species.

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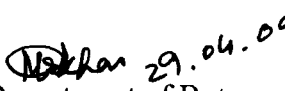
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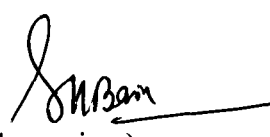
I, Mr. Nigyal John Lakadong, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis entitled "*Assessment of endemism, rarity and conservation status of a few medicinal plant species of Meghalaya*" did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any University/ Institute.

This is being submitted to the North-Eastern Hill University for the degree of Doctor of Philosophy in Botany.


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(Nigyal John Lakadong)

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CHAPTER I

INTRODUCTION

Biodiversity represents the variability in nature and relates to the differences within and between species and their surroundings *i.e.* ecosystems. The UN Convention on Biological Diversity (CBD 1992) defines biodiversity as “The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.” Essentially, there are three levels of biodiversity that come from the definition of CBD *viz.* 1) diversity between and within ecosystems and habitats; 2) diversity of species and 3) genetic variation within individual species.

The diversity of species within a habitat is measured and expressed as α -diversity. While β -diversity measures the rate of replacement of species along a gradient of habitats or communities, γ -diversity measures the diversity of the habitats over the total landscape or geographical area. It can be demonstrated that changing conditions within a habitat will often change the diversity of species within the habitat, and vice versa. So, by monitoring the numbers and types of species present, it is possible to determine whether any adverse changes, beyond those of natural variability, are occurring. Human induced environmental changes are occurring at a rapidly increasing pace and have severely impacted species diversity and composition. The conservation of rare species is guided by the biological attributes of the taxon. However, lack of basic biological data for many species in India as well as well as abroad has led to the failure of many recovery plans, especially for plants (Pavlik 1994; Schemske *et al.* 1994; Schultz and Gerber 2002).

About 1.4 million different species of living organisms have so far been scientifically described of which 270,000 are plant species. IUCN has listed 33,798 species as threatened vascular plants species (IUCN 1998). At least 3.5 billion people in the developing world depend on an estimated 70,000 medicinal plants as part of their primary health care (Balick and Cox 1996). Globally, about 70-80% of the traditional medicines used for primary health care are derived from plants (Farnsworth and Soejarto 1991; Pei Shengji 2001).

The use of different plant parts to cure specific ailments by different ethnic groups around the world is in vogue since time immemorial. Traditional Medicine may be defined as “the sum total of all the knowledge and practical, whether explicable or not, used in the diagnosis, prevention and elimination of physical, mental and social imbalance and relying exclusively on practical experience and observation handed down from generation to generation, whether verbally or in writing” (WHO 2002-2005). Traditional medicine can also be defined as the knowledge, skills and practices of holistic health care, recognized and accepted for its role in the maintenance of health and the treatment of diseases. It is based on indigenous theories, beliefs and experiences that are handed down from generation to generation. It is an ancient practice that existed in human societies before the application of modern science to health. It has evolved to reflect different philosophical backgrounds and cultural origins. Although modern medicine is widespread, traditional medicine still exists in all countries and areas in the Western Pacific Region. Interest in traditional medicine has increased over the last decade. People in many countries are now more prepared to look for alternative approaches to maintain their health. Demands for traditional medicine from the people

and the growing economic importance of traditional medicine have led to increased interest on the part of both governments and academic communities (WHO 2002-2005).

In many developing countries the majority of the population depends on traditional remedies. This is partly due to poverty, but also because traditional systems are more culturally acceptable, and are able to meet psychological needs in a way western medicine does not (Prescott-Allen and Prescott-Allen 1982). Traditional medicinal treatments often provide culturally familiar techniques that treat both the physical and spiritual conditions of an individual (Bodeker 1994; Pachter 1994; O'Conner 1998). Among the traditional community, the tribal people have always lived in harmony with nature and had maintained a close link with the environment (Sajem and Gosai 2006). The Indian sub-continent is unique in its plant wealth. Over 17,500 species of higher plants are found in the country of which 6,000 are believed to have therapeutic properties (FRLHT 2007). The north-eastern India alone harbors about 8,000 plant species of which about 2,500 have various medicinal properties. Meghalaya is home to 3,126 plant species (Khan *et al.* 1997) of which 834 are pharmaceutically or locally used in health care (Barik *et al.* 2007).

Meghalaya is inhabited by numerous tribes *viz.*, the Khasis, Jaintias and Garos that have a live tradition of practicing indigenous traditional medicine for curing various ailments. The practitioners harvest the species in a restricted manner ensuring the conservation of medicinal plant genetic resources. These ethnic groups have provided several "Miracle plants" of immense medicinal values to modern civilization. With the increasing demand of raw material for pharmaceutical industries, commercial establishments have come up for trading such plants. Most of these plants are being

collected from the wild without giving adequate attention to its sustainability. Due to such high level of exploitation and faulty harvesting techniques, many of the endemic species have been rendered rare (Haridasan *et al.* 1995).

A species is rare either because it lives in a very limited habitat (Natural Rarity), or, because its habitat has been converted by humans to other uses (Anthropogenic Rarity). Essentially, using the word “Rare” is a statement about the geographic distribution and population size of a particular species. Rarity, in fact, describes at least three different biological possibilities. A rare taxon may have (i) broad distribution but never abundant where found, (ii) narrow distribution, but abundant where found, and, (iii) narrow distribution or clumped, and not abundant where found (Fiedler 2001). Narrow geographic range is one of the key factors that characterize rare species (Rabinowitz 1981; Fiedler and Ahouse 1992; Fiedler 1995; Gaston 1997) and often indicates increased vulnerability to extinction.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between Governments to save plants and animals from extinction. It ensures that international trade in specimens of wild animals and plants does not threaten their survival. Not one species protected by CITES has become extinct as a result of trade since the Convention entered into force and, for many years, CITES has been among the largest conservation agreements in existence, with now 160 Parties. India is one of the signatories to the Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES 1973). The Botanical Survey of India (BSI) initiated work on rare and endangered species way back in the 1980s and published lists of these species. Jain and Rao (1983) brought to light several hundreds

rare species from different parts of the country. The Red Data Book of Indian Plants (RDB), published by the Botanical Survey of India (Nayar and Sastry 1987, 1988, 1990), focuses exclusively on the Indian flora, more precisely on threatened angiosperms, gymnosperms and pteridophytes. Scientists studying rarity use it as an analytical tool and the accuracy of their results depends on the accuracy of the RDB. The most recent edition of the RDB is based on the criteria of Lucas and Synge (1978). Since then, the criteria used to define the categories of threatened species have been refined considerably (IUCN 2001). It has been shown that about 1236 (7%) of the 17500 plants recorded for the Indian subcontinent are threatened globally (Walter and Gillett 1998). The RDB however, contains only 814 species (5.4%) (Nayar and Sastry 1987).

There is an international effort to identify species that face extinction in order to make conservation efforts more efficient. Since its creation, the International Union for the Conservation of Nature and Natural Resources (IUCN) has attempted to list species that are threatened with extinction globally. The criteria used to define the categories of threatened species change with new information (IUCN 2001) and the lists of threatened species are accordingly upgraded. The Red List of Threatened Plants (Walter and Gillett 1998) is the most recent attempt to inventory the threatened plant species of the World.

Conservation biologists and others concerned with management of rare species use many tools, but perhaps the most synthetic and powerful of these tools is population viability analysis (Beissinger and McCullough 2002). In PVA, computer simulations are used to describe population demographic processes by incorporating ecological and life history information into a formal mathematical model. Such a quantitative model in effect represents a set of hypotheses about factors that influence the abundance of various

life stages of the organism through time. PVA can theoretically be used to predict the fate of a population in absolute terms, but is better used to weigh the relative importance of different factors and management scenarios in determining the ability of a population to persist through time. As in any computer simulation procedure, the validity of PVA depends to a great extent on the quantity and quality of the ecological and life history information that goes into model construction.

Most currently existing PVAs have been constructed for animals, especially vertebrates (Beissinger and McCullough 2002). A fundamental difference between quantitative population models for vertebrates and those for plants is the need to consider seed demographic rates. Because the seed bank is largely invisible and difficult to measure, plant population models that include explicit consideration of seed bank dynamics are relatively rare (Menges 2000). This is particularly true for species with persistent seed banks, for which the field experiments needed to obtain age-specific vital rates for seed viability loss and seed germination must necessarily be long term (Doak *et al.* 2002). In addition, most studies that include quantitative analysis of seed demographic rates are for weedy species. Very few such studies have been carried out for non weedy species, and almost none has been carried out for plants of conservation concern.

The importance of PVA is increasing as the pressures from anthropogenic activities are driving the extinction rates of populations to newer scales of magnitude (Ehrlich and Ehrlich 1981; Leakey and Lewin 1995; Woodruff 2001; Ellner and Fieberg 2003). Better understanding of local population demography of rare species is a critical step towards the incorporation of demographic features into management decisions and practices (Sckhmeske *et al.* 1994). Incorporating variations in demographic parameters

into projection matrices may be critical to developing realistic models of populations and species viability (Krishnayya *et al.* 2004). Therefore, matrix population models are a standard method used to assess the viability of structured populations (Morris and Doak 2002). Repeated iterations of the matrix model result in the projection of a population equilibrium growth rate and extinction risk, providing a measure of the overall performance of populations. Moreover, sensitivity and elasticity analyses of matrix models can identify the life-history stages most critical for the persistence of the species. The results of the matrix model analyses and simulation are often used to assess the vulnerability of a population to extinction (Freckleton *et al.* 2003; Beverley and Martell 2004; Garcia 2004; van Mantgem *et al.* 2004).

Population viability analyses often use models that simulate the future of the species based on parameters on the ecology and demography of its population(s). In demographically structured (also called frequency based) models, the individuals in a population are grouped into distinct classes, based on their demographic characteristics, or their location, or both (Lacy 2000; Sjögren-Gulve and Hanski 2000).

Some plants and other species have life history stages that are invisible or otherwise difficult to detect. In plants, the seed bank is often modeled as one or more separate stages. Estimating parameters related to these stages often presents difficulties. In addition, time-dependent contingencies and rules of transition (from seed to seedling following fire) make the application of a simple matrix structure difficult (Drechsler *et al.* 1999; Menges 2000).

Metapopulation dynamics and the applicability of metapopulation models to specific problems in conservation have contributed significant insights into conservation

and have inspired field studies focused on collecting key data on demography and movement. Moreover, metapopulation concepts have had positive effects in conservation research, especially, as interest in metapopulation dynamics has prompted renewed research concerning dispersal capacities that is extremely valuable in understanding population structure (Yuttham *et al.* 2003). The term metapopulation was first introduced by Levins (1969). Studies using metapopulation generally subdivide the general population into a series of local populations with a balance between extinctions and recolonisations of local populations that facilitates long-term persistence of the metapopulation. The key process is the interpatch connection functions by migration (Hanski and Gilpin 1997). Metapopulation models have been widely used in the biological field including in population ecology, conservation biology, and pest control (Harrison 1994; Wu 1994; Hanski and Gilpin 1997; Takagi 1999; Fagan *et al.* 2002).

Typically, extinction and metapopulation theories emphasize that stochastic fluctuations in local populations cause extinction and that local extinctions generate empty habitat patches that are then available for re-colonization. Metapopulation persistence depends on the balance of extinction and colonization in a static environment. For many rare and declining species, Thomas (1994) argues (1) that extinction is usually the deterministic consequence of the local environment becoming unsuitable (through habitat loss or modification, introduction of a predator, etc.); (2) that the local environment usually remains unsuitable following local extinction, so extinctions only rarely generate empty patches of suitable habitat; and (3) that colonization usually follows improvement of the local environment for a particular species (or long-distance transfer by humans). Thus, persistence depends predominantly on whether organisms are

able to track the shifting spatial mosaic of suitable environmental conditions or on maintenance of good conditions locally.

Modelling has become an important tool in population and conservation biology (Cappuccino and Price 1995; Haefner 1996; Hanski and Gilpin 1997; Hilborn and Mangel 1997; Roughgarden 1998; Shugart 1998). Model can be categorised into two classes: qualitative (expressed in words or diagrams) and quantitative (expressed in mathematical equations) (Wu 1994). Many ecological theories today are represented in largely mathematical terms because mathematics provide the most precise language to describe complex ecological systems and is also an ideal tool for prediction in ecological systems (Tilman *et al.* 1994; Jansen 1995; Gyllenberg and Hanski 1997; Hanski and Ovaskainen 2000; Keymer *et al.* 2000; Casagrandi and Gatto 2002). However, mathematical formulations have limitation in that they usually force ecologists to make clear and unambiguous assumptions. Metapopulation models are useful and are always represented as analytical or simulation models.

There are three types of modeling approaches used in metapopulation studies assuming many habitat patches and local population (Hanski and Gilpin 1997): (1) spatially implicit approaches, often based on a critical simplification of what at first appears as a complex problem, in which the habitat patches and local populations are discrete (and are generally assumed to have independent dynamics) but are assumed to be all equally connected to each other, (2) spatially explicit approaches in which it is assumed that local populations are arranged as cells on a regular grid (lattice), with population sizes modeled as either discrete or continuous variables and where local populations are assumed to interact only with local populations in the nearby cells, and

(3) spatially realistic approaches in which the models allow one to include in the model the specific geometry of particular patch networks, such as how many patches there are in the network, how large they are, and where exactly they are located.

With the recent development of metapopulation theory (Hanski 1989), it has been recognized that regional-scale processes are also important for long-term survival of species in the landscape (Carroll *et al.* 2003; du Toit *et al.* 2004). In such cases population viability analysis has to be performed at regional scale and should take into account both the present distribution of the species in the landscape and the number and distribution of patches that are potentially available for recolonization. Management of threatened populations will be necessary to guarantee long-term survival of endangered species and ecosystems (Beissinger and Westphal 1998; Reed *et al.* 2002). Population viability analysis (PVA) is becoming an ever more central tool in conservation biology (Beissinger and McCullough 2002; Morris and Doak 2002). In a PVA, biological and landscape data are used to parameterize a population model which projects the dynamics, abundance and (meta)population structure of a focal threatened species into the future. From these projections, viability is estimated and compared under different scenarios of landscape or population management to design effective conservation guidelines.

A thorough evaluation of the rare plants in a flora requires sound information as to which species are rare, combined with knowledge of their distributions, threats and ecology (Kaye *et al.* 1997). Rare plants cannot be managed as though they represent any one type of distribution, rarity or life history, instead, their conservation must be approached individually, with careful attention to the biology of each species (Massey and Whitson 1980).

Confronted by current threats to biodiversity and the difficulty of obtaining detailed, repeated species inventories for much of the world, biologists rely increasingly on distribution models to inform conservation strategies. Distribution models predict species richness (Jetz and Rahbeck 2002), centers of endemism (Johnson *et al.* 1998), the occurrence of particular species assemblages (Neave *et al.* 1996) or individual species (Gibson *et al.* 2004), and the breeding habitat (Osborne *et al.* 2001), breeding success (Paradis *et al.* 2000), abundance (Jarvis & Robertson 1999) and genetic variability (Scribner *et al.* 2001) of species.

Such models do more than fill gaps in distribution maps. By delineating favourable habitats, distribution models can help target field surveys (Engler *et al.* 2004), aid in the design of reserves (Li *et al.* 1999), inform wildlife management outside protected areas (Milsom *et al.* 2000) and guide mediatory actions in human–wildlife conflicts (Sitati *et al.* 2003). Distribution models can be used to monitor declining species (Osborne *et al.* 2001), predict range expansions of recovering species (Corsi *et al.* 1999), estimate the likelihood of species' long-term persistence in areas considered for protection (Cabeza *et al.* 2004) and identify locations suitable for reintroductions (Joachim *et al.* 1998). They allow biologists to identify sites vulnerable to local extinction (Gates and Donald 2000) or species invasion (Kriticos *et al.* 2003), and to explore the potential consequences of climate change (Peterson *et al.* 2002).

Distribution models will always perform better for some taxa than for others (Venier *et al.* 1999). To maximize their utility, we need to understand whether the variation in performance reveals inherent ecological differences in a species' predictability or whether it reflects statistical artefacts. Range size is one ecological

characteristic, likely to differ from species to species, that might influence the success of distribution models (Venier *et al.* 1999; Manel *et al.* 2001; Stockwell and Peterson 2002). Such influence could have ecological roots. Species with large ranges or disjunctive distributions, for example, may exhibit subspecific variation in habitat associations because of local adaptation (Stockwell and Peterson 2002).

The concept of diversity and endemism is critical to the understanding of overall biological diversity. Large environmental variation within a small geographical area makes altitudinal gradients ideal for investigating several ecological and biogeographical hypotheses (Korner 2000). The majority of elevational studies world over have focused on species richness (Lieberman *et al.* 1996; Vazquez and Givnish 1998) and elevational zonation of vegetation types (Fram and Gradstein 1991) both in the tropics and other parts of the world. This relationship of species richness to elevation has been linked to the random elevational association between the extent and the position of elevational ranges of species along the geographical ranges (Cowell and Hurtt 1994). Numerous hypotheses have been proposed to explain this relationship (Brown and Lomolino 1998; Brown 2001; Lomolino 2001) of which, area (MacArthur 1972; Rahbek 1997; Odland and Birks 1999), climate (Odland and Birks 1999), and mass effect (Shmida and Wilson 1985; Kessler 2000) are commonly discussed. Areas with high species richness may also have a high number of endemic species, but not necessarily in a coherent pattern (Huston 1994; Whittaker *et al.* 2001).

Endemic species are those species, which are restricted to a particular geographical region or ecological unit. Endemism, therefore, signifies unique biodiversity. Endemics are categorized according to their (i) Spatial (Williams *et al.*

1993) distribution, (ii) inferred evolutionary age and affinities, and (iii) abundance. Engler (1882) provided one of the first classifications of endemics according to their evolutionary age and recognized Neoendemics and Paleoendemics. Latter on, Favreger and Constandriopoulos (1961) provided a more rigorous basis for assessing the relative age and affinities of plant endemics based on cytological data. Four categories were recognized according to Taxonomic rank and Ploidy level, viz., (i) Paleoendemics – ancient isolated taxa with a high ploidy level, whose diploid ancestors are extinct or unknown, (ii) Shizoendemics – vicariant species of equal ploidy level, resulting from either gradual or rapid divergence, (iii) Patroendemics – restricted diploid species that have spawned younger, widespread polyploid species, and (iv) Apoendemics – polyploid endemics that are derived from widespread species of a lower ploidy level. Shizoendemics, Patroendemics and Apoendemics are further sub-divisions of Neoendemics.

Of the 17,500 species of plants present in the country, around 5725 are broadly considered as endemics. These represent 32.7% of the country's flora. A good degree of endemism is found at all the altitudinal zones of the Indo-Burma vegetation. About 7000 species of plants are found to be restricted to the Indo-Burma hotspot. The Indo-Burma hotspot encompasses 2,373,000 km² of tropical Asia east of the Ganga-Brahmaputra lowlands (Mittermeier *et al.* 2004). The biodiversity of Northeast India is of global significance as it has high endemism, which is related to a number of physical and biological factors.

The special significance of medicinal plants in conservation stems from the major cultural, livelihood or economic roles that they play in many people's lives (Bodeker

2002). Probably, the single most important role for medicinal plants in biological and ecological conservation stems from the foundation that can be provided involving people in conservation of natural habitats (Schopp-Guth and Fremath 2001).

In Meghalaya, very few studies are available on endemic and threatened plant species. Kumar (1988-89) recorded 111 rare plants from Balphakram Wildlife Sanctuary, of which 55 are endemic. Rao and Haridasan (1982) provided the distribution of 70 rare, endangered and endemic plants of Meghalaya. Hooker (1854) stated that Orchidaceae are, perhaps, the largest natural order in the Khasi Hills. Of the approximately 1000 orchid species found in India, 550 species, 85 are endemic to Northeastern India and of these 18 are endemic to Meghalaya (Das and Deori 1983).

The IUCN Red List categories and criteria Version 3.1 (2000) classifies species based on the Population reduction, Geographic range, Population size, Matured individuals and Probability of extinction in the wild. The main categories for classification are Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concerned and Data Deficient.

For conservation, prioritization of species is fundamental, which is based on assessment and categorization of species into different threat categories (rare) and endemics. The categorization of threatened species based on their population size and distribution has not been attempted. Most studies emphasize presence/absence based on herbarium records rather than population size. Population size, metapopulation dynamics, regeneration rate, rate of decline, environmental stochasticity, external perturbations including their intensity and frequency are important determinants of species perpetuation. Hence, these parameters need to be quantified in respect of a species for

correct threat categorization. However, no such attempt has been made in India while developing strategies for conservation. Even at global level, the information and prediction are “tallied” at the scale of entire countries, and little information is available at local scales. No standard baseline data is also available for validating the predictions. For effective conservation strategy, there is a need to categorize endemics and threatened species more carefully using the data on their population abundance. Since population size has important conservation implications, the population data is more important for threatened and endemic species.

Main shortcomings for effective classification are i) meager availability of population data and ii) categorization restricted to herbarium. The major problems of data because of inaccessibility of an area, inhospitable climate, and limited survey. Moreover, Research data on population status, distribution and ecology are nonexistent.

The main objectives of the proposed research are as follows:

1. to assess the threat status of selected medicinal plants species based on empirical population data collected through extensive field study;
2. to determine the endemic type of selected medicinal plant species and to assess the endemism in different parts of Meghalaya;
3. to investigate the genesis of rarity and to determine possible reasons for rarity; and
4. to prioritize the areas for conservation for the selected species.



The inventory of many pharmaceutically important drugs gather clue from the traditional medicine systems. For instance, in the 1990's, the National Cancer Institute (NCI) of USA recognised that the Leaves of *Aneistrocladus korupensis* used by the indigenous people of Cameroon forest contained an extract "Michellamine B" which had the capacity to inhibit the HIV (AIDS) Virus. The tranquilizers, Resinamine and Reserpine, were obtained from the roots of *Rauwolfia serpentina* used in India for more than a thousand years in folk medicine for snakebite, insanity, epilepsy and high blood pressure (Trivedi 2002). During the last few decades, a series of "Wonder drugs" were discovered from the plants having high medicinal values used by the traditional societies.

Medicinal and aromatic plants (MAPs) play an important role in the healthcare of people around the world, especially in developing countries. Until the advent of modern medicine, man depended on plants for treating human and livestock diseases. Over centuries, human societies throughout the world have accumulated a vast body of indigenous knowledge on medicinal uses of plants, poisoning for fishing and hunting, purifying water, and for controlling pests and diseases of crops and livestock (de Silva 1997).

Of the 4,22,000 plant species documented worldwide, about 52,750 (12.5%) have been reported to have medicinal value; the proportion of medicinal plants to the total documented species in different countries varies from 4.4% to 20% (Schippmann *et al.* 2002). About 25% of drugs in modern pharmacopoeia are derived from plants (phytomedicines) and many others are synthetic analogues built on prototype compounds

isolated from plants. Up to 60% of the drugs prescribed in Eastern Europe consist of unmodified or slightly altered plant products (Lancet 1994).

Traditional medicine has been an important component of health care systems in Asian countries and includes Ayurveda, Yunani, Siddha, Homeopathy and folk medicine systems. These systems in particular have been in practice in India since time immemorial and were not significantly disrupted by the colonial era. Even today, hundreds of millions of people, mostly in developing countries, derive a significant part of their subsistence needs and income from medicinal plant and animal products gathered from the wild (Iqbal 1993; Walter 2001).

Demand for a wide variety of wild species is increasing with growth in human population needs and commercial trade. With the increased realization that some wild species are being over-exploited, a number of agencies are recommending that wild species be brought into cultivation systems (WHO, IUCN and WWF 1993; Lambert *et al.* 1997; BAH 2002). Cultivation can also have conservation impacts, which need to be better understood. Medicinal plant production through cultivation, for example, can reduce the extent to which wild populations are harvested, but it also may lead to environmental degradation and loss of genetic diversity as well as loss of incentives to conserve wild populations (Anon 2002).

It is estimated that 25% of total life forms could become extinct during the next twenty to thirty years, the causes for loss of species or rendering them as rare are numerous, most importantly, the fragmentation of natural habitats (Singh 1998). Kruckeberg and Rabinowitz (1985) considered three distribution factors in plant rarity *viz.* geographic area, ecological breadth, and isolation. On the other hand, Fiedler (1986)

listed nine factors causing plant rarity. These are: (i) evolutionary age, (ii) genotypic heterogeneity of the species or populations, (iii) evolutionary history, (iv) taxonomic position, (v) ecology, habitat and present environmental conditions, (vi) population biology, (vii) reproductive success, (viii) land-use history and (ix) recent human land uses. The first seven factors are aspects of the natural environment, while the last two are human induced causes of rarity. Thus, many plants are naturally rare while others have become rare and endangered through human activities. Each rare plant is the idiosyncratic product of a unique combination of these factors and must be understood individually (Fiedler 1986).

Effective management of rare plant species requires an understanding of their ecological niche and areas of occurrence. The fundamental issue with such species is to determine the habitat parameters that accurately predict the occurrence of the species, and the likelihood that the species will occur in a given specific site conditions (Simberloff 1988; Brussard 1991; Falk and Olwell 1992).

Finding a universally acceptable definition and measure of rarity is not so straightforward. Some of the many possible measures that have been used include the breadth of geographic range size, degree of habitat specificity, local frequency, endemism, ephemerality, relative abundance, area of occurrence, and absolute population numbers (Harper 1981; Rabinowitz 1981; Gaston 1994a, b; Quinn *et al.* 1996). Three of the most commonly applied and easily quantified measures are extent of occurrence (EEO), area of occupancy (AOO), and numbers of individuals. These three measures can be arranged on an axis of increasing spatial resolution.

Although precise quantitative and qualitative criteria are used to assign a particular status to a species (IUCN 2001), such decisions depend on the way the target species populations are monitored and the sampling design used for data collection. A range of sampling schemes can be used to estimate the state of the population and its rate of change, the most efficient of which is a constitution of repeated random samples among existing sites with additional independent random samples at unvisited locations (Yoccoz *et al.* 2001; Stauffer *et al.* 2002).

The information on threatened species have been utilized to: (i) influence conservation policies and legislation at national and international levels; (ii) stimulate research and monitoring programs for species and/or habitats; (iii) monitor the status of biodiversity and report on the state of the environment; (iv) regulate development and exploitation; (v) target geographical areas for conservation planning; (vi) increase public awareness on human impacts on biodiversity; and (vii) set priorities for the allocation of limited conservation resources (Maes and van Swaay 1997; Bennun *et al.* 2000; Rodriguez *et al.* 2004; Miller *et al.* 2006).

The late twentieth century has witnessed exceptional concern for conservation of rare organisms and at the same time has seen many rare plants and animals brought close to extinction (Engler 1882). Understanding the processes determining the abundance or rarity of plant species can provide information necessary for effective conservation of rare species (Magurran and Henderson 2003; Bevill and Louda 1999; Pachepsky *et al.* 2001; Murray *et al.* 2002). Given the same environmental requirements and human influence, species rarity can be influenced by species demography, colonization ability,

and ability to adapt to changing environments (Cole 2003; Kwit *et al.* 2004; Yates and Ladd 2004).

Incorporating a large number of species in red lists even though they are not vulnerable or endangered is not useful for conservation, and can even be harmful. In recent years the credibility of conservationists has suffered a lot; partially due to exaggerated warnings and negative scenarios (Mannion 1991) that have not become true. The IUCN system for classifying and categorizing endangered species is rather complete and allows for a good evaluation when exact data are available. In the case of tropical species most specialists are basing their results exclusively on the restricted distribution (often referring only to the known collecting points) while assigning a threat category.

To the conservationist, rare species are of interest because of the risk of extinction, which would result in the loss of their potential economic or medicinal use, as well as their ecosystem function, often with unknown environmental effects. One of the basic challenges involved in the conservation of rare species is that the group to be protected is heterogeneous, comprising many causes and expressions of rarity. There is no single conservation measure that will sustain all species (Rabinowitz *et al.* 1986; Gaston 1994a, b).

Nautiyal *et al.* (2002) studied the population of three *Aconitum* species in the Garhwal Himalayas for monitoring their status of rarity. The alpine and sub-alpine regions were surveyed and the Population data of the three *Aconitum* sp. viz., *Aconitum balfourii*, *Aconitum heterophyllum*, *Aconitum violaceum* revealed that they were restricted to specific pockets and had very low density. Population density and

occurrence were used to assign threat categories and they inferred that all the three species were endangered.

A series of Conservation Assessment and Management Plan (CAMP 1998) workshops were conducted for selected medicinal plants of northern, northeastern and central India to assess their status in the wild. In total, 75 taxa of medicinal plants were assessed, 37 being from northern India, 18 from northeastern India, 18 from central India and two taxa being distributed both in northern and northeastern India. Of these, 33 medicinal plants were assessed as Critically Endangered, 17 as Endangered, 16 as Vulnerable, seven as Lower Risk near threatened and two as Data Deficient. A similar CAMP workshop for Medicinal Plants of Meghalaya, Sikkim, Arunachal Pradesh and Assam was held in 2003, where 51 species were worked out for conservation prioritization. Of these, 46 species are used in one or more systems of medicine, while five are traded or having potential for trade as medicinal plants. Forty-eight of the assessed species were red listed in one or more states, while six were red listed at a global scale.

The concept of 'endemism', on the other hand, has attracted much less attention in comparison to the concept of 'rarity' by the ecologists, conservation biologists and biogeographers of the world. The categorization of endemics taking into account their population size and distribution has never been attempted. Most studies on endemics emphasize biotope specificity rather than population size (Given and Norton 1992). There is an urgent need to categorize endemics more carefully in relation to their population abundance, since population size has important conservation implications (Mace *et al.*

1992; Mace 1993; IUCN 1995). It is especially relevant when an endemic species is also a rare species.

The effect of human activity on endemism is a little-studied and complex topic related to the particular taxon and to the spatial and temporal scales under consideration. Worldwide, endemic species on oceanic islands are disproportionately represented among the biotic extinctions of the last few centuries, mostly as a result of human influence (Johnson and Stattersfield 1990). In particular, endemic species seem to be susceptible to exotic invasions (Rebelo 1992; Samways 1994), suggesting that endemics may be competitively inferior to widespread taxa. Huston (1994) concluded that the evolution and maintenance of endemic plant species is favored by low rates of competitive displacement and a low frequency of major disturbances.

Endemic species are frequently given high priority in conservation strategies (Bibby *et al.* 1992; Williams *et al.* 1996; Davis *et al.* 1997) because their small ranges render them particularly vulnerable to habitat loss (Balmford and Long 1994) and because they are assumed more susceptible to anthropogenic habitat disturbance than widespread taxa (Moolman and Cowling 1994; Samways 1994; Andersen *et al.* 1997).

Narrow endemic taxa are those that occur in one or a few small populations (Drury 1980) and hence are confined to a single domain or to a few localities. Three primary factors *viz.*, geographic area, ecological breadth, and isolation (Carlquist 1974) determine the distribution of endemics. Endemics are found on all landmasses of the world, both continents and islands, and in all major biomes. Systematic studies of endemics help to address questions of their origins and radiations, that is, of their evolutionary history and phylogeny (Richardson 1978).

The spatial scale of the area where a species is found is an important determinant for ascertaining the endemism of the species (Major 1988). Almost inevitably, larger centers of endemism have within them smaller centers, as observed by Gentry (1992) for the plants of New Caledonia. Range-sizes for defining local endemism are often arbitrarily set. For example, Terborgh and Winter (1982); Gentry (1986) and ICBP (1992) defined local endemics (birds and plants) to be those with geographical ranges <math><50,000 \text{ km}^2</math>. In contrast, Cowling and Holmes (1992) set the geographical range limit for endemic plants in the Cape Floristic region of South Africa as

The endemic taxa of different regions can be evaluated on a continuous scale of Range-size when calculated as the sum of the inverse range-sizes of all taxa in each grid cell or map unit (Howard 1991; Williams 1993; Williams *et al.* 1994). The sizes of the

geographic ranges of species vary. A number of methods have been used to quantify this variation. These include, measures of the latitudinal extent of occurrences, the area of the minimum convex polygon enclosing all occurrences, the numbers of grid squares containing occurrences, and the number of sites occupied (Reaka 1980; Rapoport 1982; Juliano 1983; McAllister *et al.* 1986; Anderson and Marcus 1992; Gaston 1994 a, b). Kessler *et al.* (2001) studied the patterns of species richness and range-size rarity among pteridophytes, bromeliads and birds along two gradients of elevation, humidity and human land-use in a forested Andean valley. Human impact was correlated with species richness and found to be high in the zones of high endemism. Suzan *et al.* (2002) determined species richness, endemism and rarity patterns in Turkey. The results indicated that species endemism or rarity hot spots could not be explained by only a few geographic or climatic variables, although higher rainfall, lower latitude, diverse habitats and higher altitudes generally meant more species, both total and endemic. Laffan and Crisp (2003) aimed to develop an approach for assessing the spatial scale for centers of endemism using species level data in Australia. They used the Corrected Weighted Endemism (CWE) Index (Crisp *et al.* 2001) to account for species samples in local neighborhoods as the spatial CWE Index. This allowed the analysis of how the degree of endemism of a location (cell) changes with spatial scale.

Janson (2003) proposed that global patterns in number of range-restricted endemic species are caused by variation in the amplitude of climatic change occurring on time-scales (*e.g.*, Milankovitch's oscillations). The smaller the climatic shifts, the more probable is that Paleoendemics survive and that diverging gene pool persists without going extinct or merging, favoring the evolution of Neoendemics. It was shown that the

higher the temperature in an area, the fewer endemic species it harbours. Past climatic change was a better predictor of endemism than annual temperature range suggesting that “Rapaport’s Rule” (*i.e.*, species range size increases with latitude) is best explained by the increase in amplitude of climate oscillations towards the poles.

Endemism is a relative concept, dependent on the spatial scale employed in a particular analysis. Taxa endemic to a biogeographic region, average area ranging between 10^3 - 10^6 km², occupy relatively restricted range sizes. As such, they are often used for identifying genetically rich and unique areas for biodiversity conservation (Terborgh and Winter 1983; Ackery and Vane-Wright 1984; Myers 1990; Davis and Heywood 1994). The study of species richness and endemism in Western Australian Flora revealed that the Southwestern Province retained very high rates of endemism (Beard *et al.* 2000). Such regions termed as “Phytochoria” are distinguished by a high concentration of endemic plant taxa (Van Wyk and Smith 2001). Such centers of plant diversity have been identified in many parts of the World. For example, seven centers have been identified in South Africa (Davis *et al.* 1994) of which four centers and two regions were described within Mpumalanga (Lotter *et al.* 2002).

Over the past decades there has been renewed emphasis on locating centres of species richness or endemism, in attempts to optimize conservation strategies (Beentje *et al.* 1994; Ceballos and Brown 1994). The development of modern computing hardware and software, such as GIS and World Map, has led to more rigorous numerical analyses of distributional data. These analyses have been directed at locating biogeographical regions (Oliver *et al.* 1983; Linder 1998; Williams *et al.* 1999), centres of richness (Williams *et al.* 1999) and centres of endemism (Linder 1998). In the northern

hemisphere there is a rapid increase from the southern margin of the Sahara to the equator, with species richness more than doubling for every 10° of latitude (Linder 2001a, b).

Many endemic distributions can be related to particular habitat types, including localized habitat conditions such as serpentine, or unique disturbance regimes such as periodic flooding (Kruckerberg 1984; Kruckerberg and Rabinowitz 1985; Baskin and Baskin 1988; Menges 1990; Hickman 1993; Jensen *et al.* 1993). Although the highly endemic distributions and habitat affinities of many plants are well known, the proximal factors that maintain plant endemism have not been investigated for most species. However, knowledge of the ecological factors limiting rare species is important for a clear understanding of both the forces leading to current distributions and the management regimes needed to preserve these species in the future (Kluse and Doak 1999).

Some years ago, a worldwide red data book for plants was prepared by the World Conservation Monitoring Centre (WCMC) (Walter and Gillett 1998). This species list had been based mainly on endemism data. Recently, the first plant red data book of a tropical country has been prepared for Ecuador (Valencia *et al.* 2000) where the first comprehensive plant inventory has been completed. This book provides a complete list of all endemic species of the country. In most cases, the conservation status of the species has been concluded from the number and age of the collection records. Of the more than 4,000 endemic species 83% are believed to belong to some of the IUCN threat categories.

Gupta (1996) described a method to study the patterns of rarity and endemism in flowering plants for conservation planning. An attempt was made to find out potential

sites for rare and endemic plants based on available data. A relationship was drawn between broad distribution and frequency of collection to assess possible rarity value of each taxon. Mandal *et al.* (2000) worked on rare and endangered flowering plants of Andaman and Nicobar Islands with special reference to endemics and extra Indian taxa. They described 223 endemics, 110 rare-threatened plants, and their status with special reference to the distribution patterns of the species in the island. Shevock (1996) studied the status of rare and endemic species in Sierra Nevada, USA and described 405 taxa of plants to be endemic to the region of which 218 were considered rare. Parameters considered for each rare and/or endemic taxon includes, habitat type and distribution by county, river basin and topographic quadrangle.

Floristic exploration is quite deficient and mainly restricted to areas with road access. Naturally, here, the conservation status of habitats in these areas tends to be problematic. Many species are simply not well sampled, especially at intact and inaccessible habitats. On the other hand, many tropical, locally or regionally endemic species are not as sensitive to anthropogenic habitat conversion as is generally assumed. For example, in the Neotropics, a high percentage of endemic bromeliads is confined to open and rocky habitats; many of them are benefited by deforestation rather than endangered (Ibisch 1998; Ibisch *et al.* 2001), which appear as vulnerable or threatened in the worldwide red data book (Walter and Gillett 1998).

Many plant population studies are presented as sets of deterministic models developed from data for specific years (Bierzychudek 1982; Kalisz and McPeck 1992). Efforts to introduce stochasticity into these models have often taken the form of choosing a sequence of matrices obtained for different years according to a random sampling

scheme or a scheme designed to address theoretical questions (Bierzychudek 1982; Kalisz and McPeck 1993).

Matrix population models are used to assess the viability of structured populations (Morris and Doak 2002). Repeated iterations of the matrix model result in the projection of a population's equilibrium growth rate and extinction risk, providing a measure of the overall performance of populations. Moreover, sensitivity and elasticity analyses of matrix models can identify the life-history stages most critical for the persistence of a species. The results of matrix model analysis and simulation are often used to assess the vulnerability of a population to extinction and to evaluate different management options (Freckleton *et al.* 2003; Beverly and Martell 2004; Garcia 2004; van Mantgem *et al.* 2004).

The earliest plant PVA was calculated for age-structured data derived from a *Pinus sylvestris* forest (Usher 1969). The classic study of *Ranunculus* sp. brought matrix methods to the attention of plant ecologists (Sarukhán and Gadgil 1974). Some other notable plant PVAs are those of Werner and Caswell 1977, Bierzychudek 1982, Fiedler 1987, van Groenendael and Slim 1988, Menges 1990, Burgman and Lamont 1992, Cochrane and Ellner 1992, Kalisz and McPeck 1992, Alvarez-Buylla 1994, Bullock *et al.* 1994, Eriksson 1994, Ehrlén 1995, Nantel *et al.* 1996, Valverde and Silvertown 1997, Bradstock *et al.* 1998, Damman and Cain 1998, Enright *et al.* 1998, Gross *et al.* 1998, Menges and Dolan 1998, Pascarella and Horvitz 1998 and Oostermeijer 1999.

Recent analytical methods allow the estimation of age-based parameters from stage-based matrices (Cochrane and Ellner 1992), which is likely to lead to more plant studies integrating stage and age approaches (Morris and Doak 1998). Simulations of

stage-based populations can also be used to estimate age-related parameters, such as life span (Damman and Cain 1998). Most plant PVAs have been carried out based on short duration data, have been performed on a single species and have considered only a few populations. The mean, median and modal length of a PVA is about four years; it is an open question whether such short periods of study can result in PVAs that genuinely represent a species' population dynamics (Fiedler 1998). Most studies also consider very few populations (mean 3.4, median 2.0 and mode 1.0), but because populations within species vary widely in demographic parameters, studies based on only a few populations would seem incomplete. Demographic variation over time (environmental stochasticity) is only weakly correlated among populations (Horvitz and Schemkse 1995; Crone and Gehring 1998), which argues that multiple populations need to be followed for several years.

Most assessments of plant PVAs have used deterministic approaches and have calculated (Shaffer 1981) population size and population structure. Few have calculated a stochastic population growth rate (Caswell 1989; Nakaoka 1996). Many other deterministic parameters have been calculated, with elasticities (Benton and Grant 1999) among the most common. However, because elasticities within species vary across space and time (Horvitz and Schemkse 1995; Silvertown *et al.* 1996; Oostermeijer *et al.* 1996) interpretations of elasticities need to be made with caution.

In particular, elasticities of declining populations differ from those of increasing populations. Stochastic modeling and other complex approaches have been less commonly used in plant PVAs. Demographic stochasticity (Damman and Cain 1998;

Menges 1998) is not considered as great a threat to population viability as systematic factors (such as continuing habitat loss) or other stochastic factors.

More commonly, environmental stochasticity or various types of disturbance or catastrophe have been considered in PVAs. Of the 21 studies using stochastic modeling to predict extinction, 19 reported extinction probabilities; others reported times to extinction or both. The time periods used for projecting extinction risk vary from 25 to 1000 years (many authors used several different periods), with 50, 100 and 200 years being the most frequently used time periods; thus, comparisons of extinction risk are difficult. Few studies presented risk analyses with full distribution of times to extinction; these full-time distributions are recommended because they are less misleading than single results (Beissinger and Westphal 1998).

Doak *et al.* (2002) showed that, in the absence of good information on seed demographic rates, model predictions based on assumptions about a persistent seed bank can vary widely depending on the amount of variation in vital rates for the reproductive phases of the plant life cycle. This points to the need for realistic assessment of environmental variation and its impact at all life history stages. Extinction of populations is of prime evolutionary and conservation interest and stochasticity is a decisive factor in the survival or extinction of populations (Goel and Richter-Dyn 1974; Goodman 1987 a and b). Not surprisingly, theoretical research on stochastic extinction of populations and the application of stochastic models for population viability analysis (PVA) have become very popular within the last two decades (Leigh 1981; Soulé 1987; Lande and Orzack 1988; Hanski and Gilpin 1991; Mace and Lande 1991; Burgman *et al.* 1993; Wissel *et al.* 1994; Settele *et al.* 1996; Drechsler *et al.* 1998; Amler *et al.* 1999). The popularity of the

PVA approach in conservation biology is reflected in the availability of several software packages and reviews (Goel and Richter-Dyn 1974; Akçakaya and Ferson 1990; Boyce 1992; Lacy 1993; Lindenmayer *et al.* 1995; Oostermeijer *et al.* 1996; Reich and Grimm 1996; Groom and Pascual 1997; Beissinger and Westphal 1998).

Alternatively, measured among-year variation in vital rates can be examined statistically to generate means, variances, and correlation structures that can be incorporated into the modeling procedure (Morris and Doak 2002). This allows vital rates to vary randomly within the constraints of defined statistical distributions, resulting in greater realism than that obtained by selecting entire matrices randomly from an array of matrices.

A third approach for incorporating stochastic variation into a population model is to use documented long-term variation in environmental variables as drivers of among-year variation in demographic rates. This approach starts with regression of measured vital rates for a series of years on measured value for environmental driver variables for those years. These equations are then used to parameterize the model, so that the variance structure of the driver variables controls the variance structure of corresponding vital rates. This results in a correlation structure among vital rates that is mediated by their dependence upon common driver variables. This approach has the important advantage of incorporating realistic levels of environmental variation into the model and can be helpful in extrapolating demographic data collected over relatively short time spans (Fieberg and Ellner 2001). It may be most appropriate in environments where abiotic factors such as precipitation are the main determinants of demographic performance.

PVAs can be used to define, given an assumption of the maximum risk to be tolerated (e.g. less than 5% risk of extinction in 100 years), a MVP that will forestall extinction. Deterministic and stochastic analyses, which incorporated harvesting pressure on wild ginseng (*Panax quinquefolium*) and wild leek (*Allium tricoccum*) in Quebec, Canada, were used to formulate MVPs (Nantel *et al.* 1996). While there are a large number of both short-term and long-term studies focusing on almost all aspects of plant population biology in the temperate zone (Tamm 1972; Whigham 1984; Calvo 1990; Leeson *et al.* 1991; Primack and Stacey 1998; Brzosko and Wroblewska 2003; Wotavova' *et al.* 2004), the plant demography of the much more species-rich tropical zone been little studied. Such demographic studies are essential for a better understanding of the relationship between these plant communities.

Disturbance is not only a factor that has important effects on the demography of plants, but also one that can often be manipulated to increase population growth rates and population sizes. For example, increased rates of canopy disturbance promoted population growth of the understory shrub *Lindera benzoin* (Cipollini *et al.* 1994). Population growth rates for an annual grass *Andropogon brevifolius* were fourfold higher in burned than in unburned savanna, particularly owing to higher fecundity in burned areas (Canales *et al.* 1994). Many plant species exist in environments that do not vary randomly, but instead vary cyclically. The effects of periodic disturbance and of subsequent recovery can be modeled by a combination of information about the disturbance cycle, the frequency and intensity of disturbance, and the demographic response to disturbance. These can be handled by a megamatrix approach. Megamatrices have been used to show that open, post-hurricane environments supported the highest

population growth rates for the tropical understorey shrub *Ardisia escallonioides* (Pascarella and Horvitz 1998) and to model dynamics of the tropical forest gap specialist *Cecropia obtusifolia* in a shifting mosaic of canopy gaps in tropical rainforest (Alvarez-Buylla 1994). In *Primula vulgaris*, complex matrices were used to examine the impact of increased forest disturbance rates on metapopulation growth rates (Valverde and Silvertown 1997). Simulations were carried out on varying disturbance frequency and plant demography in relation to the time since the last disturbance, to predict optimal sod-cutting intervals for *Gentiana pneumonanthe* (Oostermeijer *et al.* 1996) and to predict optimal fire return intervals for *Banksia attenuata* (Enright *et al.* 1998). Population viability models were used for *B. cuneata* considering fire frequency effects, environmental stochasticity and potential inbreeding (Burgman and Lamont 1992). The fire frequency that maximizes population size does not minimize extinction, because it exposes vulnerable seedlings to the risk of catastrophic mortality during droughts. Minimizing extinction and maximizing population size do not always require the same conditions.

Spatial structure refers to the location of individuals, which are grouped into sub- or local populations. Different subpopulations may have different demographic characteristics, such as population size (abundance), carrying capacity, and vital rates.

Natural variability in population dynamics is compounded by uncertainty in the population parameters due to lack of perfect information (*i.e.* ignorance). The consequent difficulty of making precise predictions has shaped the language of population viability analysis (Shaffer 1990). The conservation-related problems and questions that PVA addresses are usually phrased in terms of probabilities; for example, we may want to

assess the probability of extinction or the chance of recovery from a population bottleneck.

Many structured models concentrate on a single sex *i.e.*, usually only the females are modeled. In species where one male can mate with several females, the number of males may not affect the total fecundity very much, and only females should be modeled. For other species, it is possible to develop models that include both sexes, but this requires additional information about reproduction. In particular, the contribution of males to fecundity (which is likely to be frequency-dependent) must be known. In models of monogamous species with only one breeding stage, fecundity can be expressed simply as number of offspring per breeding pair, multiplied by the minimum of the number of males and the number of females in the breeding stage. If more than one age class is reproductive, or if breeding is not monogamous, the frequency dependence will be more complicated.

Often, habitat loss or degradation results in deterministic changes (such as temporal trends) in population characteristics that are different from random environmental fluctuations. Such changes can be incorporated by trends in model parameters such as carrying capacities or vital rates (Akçakaya and Raphael 1998).

Demographic properties like births and deaths interact with both population size and life history in their effect on population persistence time and extinction risk. Stochastic demographic variability increases the risk of extinction of small populations (Shaffer 1987). Further, Kokko and Ebenhard (1996) showed that life history characteristics and the demographic effective population size were more important than total population size determining the strength of demographic stochasticity. Variation in

life history characters like seed bank and clonal propagation may also affect the risk of population extinction due to environmental stochasticity (Eriksson 1996). In a theoretical study, Lande (1993) showed that the average life time of a population subjected to environmental stochasticity or random catastrophes is more dependent on its long run population growth rate than on initial population size.

Variation in model performance with species' range sizes might equally, however, reflect biases inherent in the modeling process. Range size can measure a species' extent of occurrence or its area of occupancy. Where range size measures area of occupancy, it will affect either sampling prevalence (the proportion of data points representing a species' presence) or sample size (the total number of data points, presence plus absence) in the data sets used to train (parameterize) and/or evaluate models. Both sampling prevalence (Fielding and Haworth 1995; Manel *et al.* 1999; Cumming 2000; Olden, *et al.* 2002) and sample size (Hendrickx 1999; Cumming 2000; Pearce and Ferrier 2000; Stockwell and Peterson 2002) have been shown to influence the performance of distribution models independently of range size.

Nonetheless, range size and prevalence are often confounded because sampling prevalence is allowed to vary with a species' 'natural' prevalence, *i.e.* local range size or the proportion of study sites occupied by the species (Manel *et al.* 2001; Pearce *et al.* 2001; Kadmon *et al.* 2003). Consequently, it is difficult to distinguish real ecological phenomenon from statistical artefact. Furthermore, it remains unclear whether within the modeling procedure sample size and sampling prevalence exert their artefactual effects, and whether these effects could be avoided (McPherson *et al.* 2004). In Britain, species distributions are often summarized as presences and absences recorded on a regular grid

of 100km² square cells, these squares being used as the sample unit with which to calculate AOO (Stewart *et al.* 1998; Wigginton 1999).

Therefore, development of models in population studies have become an integral part for better and clear understanding of the population behaviour. Besides, the predictive capacities of the models help in species conservation. The models can be used to identify endemic-rich areas at different spatial scales. Few such models exist (Samways 1994; McDonald and Cowling 1995), possibly because the causes of endemism are complex and numerous, including historical processes, contemporary ecological factors, inherent biological properties of taxa, and combinations of these (Nelson and Platnick 1981; Kruckeberg and Rabinowitz 1985; Major 1988). Nevertheless, there is much to be gained from developing models based on explanatory variables which reflect primary, ecological determinants of endemism and which can be easily and inexpensively tested and applied (Peters 1992).

Recently several theoretical models have been developed to assess species survival probabilities at the landscape level (Lahaye *et al.* 1994; Gustafson and Gardner 1996; With *et al.* 1997; Hanski and Ovaskainen 2000; Casagrandi and Gatto 2002; Dreschler *et al.* 2003). Most of these models assume that the current distribution of species in habitat patches is the result of equilibrium between colonization and extinctions (Lahaye *et al.* 1994).

Metapopulation approaches might be particularly relevant to understanding persistence in plants because many plant species have patchy distributions and occur on specialized, identifiable sites that can be censused for occupancy. Some additional patchiness is created by disturbances and by disturbance-specialized or disturbance

avoiding species. The dispersal of many species is limited so that suitable patches can remain unoccupied. The concepts of minimum viable metapopulation and minimum available suitable habitat (Hanski *et al.* 1996) are likely to be applicable to many plant species. Data on species presence or absence in suitable habitat patches have been used to infer metapopulation dynamics in 80 species of Florida scrub plants. For 25 species, with occupancy related to patch size, isolation or fire regime, an incidence-based metapopulation model was used to infer colonization and extinction rates (Quintana-Ascencio and Menges 1996). This work suggests that, as patch size decreases, herbs are more sensitive than woody plants to increased extinction risks.

Metapopulation viability is also drastically and negatively affected by the strength of the environmental stochasticity; temporal variation in population growth rate may lead several local populations and even the whole metapopulation to extinction. Hanski (1997) outlined four conditions that, if satisfied, suggest that a Levins style metapopulation approach will help explain regional persistence of a species: (1) suitable habitat occurs in discrete patches; (2) all local populations have a substantial risk of extinction; (3) habitat patches must not be too isolated to prevent recolonization; and (4) local populations do not have completely synchronous dynamics. These were offered as general criteria, not necessarily tailored to plant systems. Eriksson (1996) had argued the need to conceptually extend the metapopulation approach for plants due to the difficulties outlined above. Rather than extending the metapopulation concept, Freckleton and Watkinson (2002), in their review of plant metapopulation studies, classified large-scale spatial dynamics in plants to restrict the definition of metapopulation to more closely match Hanski's criteria. They then identified additional categories, distinct from

metapopulations, based on the relative dominance of regional versus local processes. But defining “regional” and “local” scales in plant systems is problematic without some knowledge of population dynamics and seed and pollen dispersal ability. As dispersal characteristics vary widely among plant species, the ecologically appropriate scale to study metapopulation dynamics also varies greatly.

Plant species adapted to particular disturbance regimes that impose frequent population turnover fit metapopulation approaches. For example, many prairie plants are adapted to frequent small-scale soil disturbance created by gophers (Thomson *et al.* 1996; Wolfe-Bellin and Moloney 2000). Similarly, Gawler *et al.* (1988) found that populations of the riverbank endemic *Pedicularis furbishiae* were often destroyed in the short term by ice scouring and flooding, but relied on these disturbances to create suitable habitat for long-term persistence. In the xeric scrublands of central Florida, plant species are adapted to fire, the dominant type of disturbance. While some species persist in the landscape via resprouting, others rely on seed dispersal and recruitment to recover from fire and are most likely to show measurable metapopulation dynamics. These differing responses to fire, combined with microhabitat diversity and differences in between-fire competitive abilities interact to structure the heterogeneous plant communities in Florida scrub (Menges and Hawkes 1998).

There are various ways of adding spatial structure to a model to account for the spatial factors discussed above. At one extreme are simple occupancy models that are based on the number of occupied and unoccupied habitat patches, ignoring their location (Sjögren-Gulve and Hanski 2000). At the other extreme are individual-based models that describe the spatial structure with the location of each individual in the population, or the

location of territories or home ranges. Between these are spatially explicit metapopulation models that describe the dynamics of each population with structured demographic models, and incorporate spatial dynamics by modeling dispersal and temporal correlation among populations. Both dispersal and correlation between each pair of populations depend on the location of the populations, making these models spatially explicit. One type of spatially explicit metapopulation model is based on a regular grid, each cell of which is modeled as a subpopulation of a metapopulation (Price and Gilpin 1996).

Another approach expands spatially explicit metapopulation models by incorporating information about habitat relationships of the species and the characteristics of the landscape in which the metapopulation exists (Akçakaya and Atwood 1997). This method uses a habitat suitability map to determine the spatial structure of the metapopulation (number and location of habitat patches in which subpopulations of the metapopulation live) and population-specific parameters.

The habitat suitability map can be calculated in a number of different ways, including statistical analyses (such as logistic regression) that find the relationship between the occurrence or density of the species and independent variables that describe its habitat requirements. The relationship can be statistically validated by estimating the function from half of the available data, and predicting the habitat suitability of known locations in the other half (Akçakaya and Atwood 1997).

The habitat suitability map is then used to calculate the spatial structure of the metapopulation. This is done by identifying cluster of cells in a raster map that are suitable (e.g., above a threshold value of habitat suitability), and that are close to other suitable locations. This patch recognition is based on species-specific characteristics such

as the home range size, dispersal distance and minimum habitat suitability for reproduction. The demographic parameters (such as carrying capacity and average vital rates) of the population inhabiting each habitat patch can be determined as functions of patch-specific characteristics, such as the total habitat suitability in the patch (Akçakaya 1998). This provides a link between the spatial and demographic components of the model, and makes it easier to parameterize models with large number of populations, based on limited data.

Inferential procedures that provide robust and reliable predictions of species' geographic and ecological distribution are thus critical to biodiversity analyses. This approach has recently been explored under the domain of "ecological niche modeling" (ENM) (Soberon and Peterson 2005), and refers to reconstruction of ecological requirements of species that are analogous to the Grinnellian ecological niche (Grinnell 1917). ENM can provide diverse insights into the ecological and geographic extents of species' distributions (Soberon and Peterson 2004).

Predictions from niche-based models of species distribution (Guisan and Zimmermann 2000) are promising tools in this respect (Cote and Reynolds 2002; Edwards *et al.* 2005) as a way to improve the sampling of species of conservation interest. Although population viability analyses have long been used in rare species management (Brook *et al.* 2000), spatially explicit, predictive, habitat distribution models have only recently been used in conservation biology (Vaughan and Ormerod 2003; Rushton *et al.* 2004).

The majority of predictive models published in the literature were developed for common plant and animal species or for biodiversity. To date, relatively few successful

applications of this approach have been published for rare and endangered plant species (Miller 1986; Elith and Burgman 2002; Engler *et al.* 2004), although reliable spatial predictions are essential for species of great conservation interest. Paucity of data, spatial inaccuracy, and lack of valid absences are the main reasons identified for this shortcoming (Engler *et al.* 2004).

Conservation strategies have largely focused on patterns of diversity, specifically how to maximize the number of species that can be protected within a particular geographic region. Species inventory data are fundamental to the development of conservation plans or “portfolios,” which represent the full array and diversity of native species, communities and ecosystems within an area (TNC 2004). Conservation of rare species must be guided by the biological attributes of the taxon, yet the lack of basic biological data has been implicated in the failure of many recovery plans, especially for plants (Pavlik 1994; Schemske *et al.* 1994; Schultz and Gerber 2002).

By combining reliable locational data with technological and analytical tools, however, we can learn more about species distribution. The development of high-speed computers and geographic mapping software now allows us to model the distribution of a particular species by analyzing the environmental characteristics of its known localities (Guisan and Zimmermann 2000; Elith and Burgman 2003; Guisan and Thuiller 2005). These mathematically defined models can then be combined with known constraints based on the species’ life history to predict where else on the landscape the species might occur. A variety of environmental data are used as the basis for these mathematical models, some of which have only recently become widely available. These include digital elevation models (and other descriptions of topography such as terrain, slope, and aspect

that can be derived from these data); current vegetation cover based on analysis of satellite imagery, and digital data layers providing estimates of precipitation, temperature, and other climatic conditions.

Species distribution models generated in this quantitative fashion are much more detailed than the familiar polygon depictions of species' ranges found in field guides. Another benefit is that they control somewhat for the bias that most collectors work near cities or along roads and rivers (Nelson *et al.* 1990). If one simply examined localities where a particular plant has been collected, you might believe that it is restricted to roadsides (where collectors have easy access). Species distribution models identify remote natural areas where a species is likely to occur because of shared characteristics with sites where collectors have worked. Through the use of these models, we hope to improve our knowledge of the distributions of plant and animal species endemic to our study area. Analyses of these data help pinpoint areas of endemism for different kinds of organisms as well as identify concentrations of endemic species that occur outside of the existing protected areas system (Young 2007).

Most of the conservation planning literature on threats to biodiversity has focused on identifying threats at the species level (Master 1991; Rebelo 1992; Sisk *et al.* 1994; Flather *et al.* 1998). Threats were categorised according to the Red Data Book species status or by estimating potential impacts following human development (Abbit *et al.* 2000). Fewer studies have assessed threat levels for plant communities or habitat types (Pressey *et al.* 1996; Margules and Pressey 2000).

Assessments at a global scale can provide an indication of the relative conservation priority of broad regions of the world (Bibby *et al.* 1992; Olson and

Dinerstein 1998; Myers *et al.* 2000). However, most decisions about the actual location of new conservation areas are made at finer spatial scales (Cooper and du Plessis 1998; da Fonseca *et al.* 2000; Mace *et al.* 2000; Soberon *et al.* 2000). Global assessments help to focus attention on regions of particular conservation concern, but a more detailed assessment is required within each of these regions to prioritize areas for protective management (Margules and Redhead 1995; Dinerstein *et al.* 2000; Groves *et al.* 2000): a process referred to here as regional conservation planning. The region of interest can be variously defined as a natural region or ecoregion, or as an administrative region such as a province, state, or country (Ferrier 2002).

At the global scale, several schemes have been employed for identifying areas that may be particularly important for the long-term maintenance of biodiversity. As decision criteria, these schemes have variously used data on patterns of species richness, endemism, threat or taxonomic uniqueness of species, as well as habitat features (Kapos *et al.* 2001). They have led to the recognition of, for example, biodiversity hotspots (Mittermeier *et al.* 1998; Myers *et al.* 2000), centres of plant diversity (Davis and Heywood 1994), endemic bird areas (Bibby *et al.* 1992; Balmford and Long 1994; Stattersfield *et al.* 1998), and the most valuable ecoregions (Olson and Dinerstein 1998).

In prioritizing areas for conservation at the national scale, the focus on threatened and endemic species has commonly been retained (Smith and Theberge 1986). Thus, schemes based on these criteria have been explored for, e.g. the United States (Dobson *et al.* 1997; Abbitt *et al.* 2000), Greece (Troumbis and Panayotis 1998), India (Daniels *et al.* 1991), the Nicobar islands (Sankaran 1997), Namibia (Barnard *et al.* 1998) and South Africa (Drinkrow and Cherry 1995).

Recent methodological progress (Guisan and Thuiller 2005), such as improved predictive algorithms and more causal environmental predictors at a better spatial resolution, has made predictive models more reliable and applicable to the sampling of rare and endangered species (Ferrier 2002).

Monitoring populations of rare and endangered species has become a priority for most conservation agencies. It provides the major source of data for updating World Conservation Union and national red lists (Lamoreux *et al.* 2003), the main use of which is setting the long-term goals of conservation programs, such as helping identify biotopes or areas particularly in need of protection (Prendergast *et al.* 1993). When species are rare, standard-sampling methods such as simple or stratified random sampling, based on a simple combination of the main environmental gradients, can be highly inefficient (Rushton *et al.* 2004).

The accelerating and widespread loss of species is unprecedented (Thomas *et al.* 2004) and the task of conserving biodiversity is considered to be one of the most important global environmental challenges today. The scale of loss is daunting and most conservationists have recognized the need for prioritizing areas for conservation to make recovery and protection efforts more efficient and effective, often before all relevant data is collected.

The emphasis in conservation planning worldwide has been on identifying salient features of biodiversity (Franklin 1993). Loss of habitat through land use practices has been recognised as the major threat to biodiversity (Wilcove *et al.* 1998). One strategy for implementing conservation decisions is to select areas on the basis of irreplaceability (contribution of the area in terms of conservation goal) and vulnerability (risk of the area

being transformed, Pressey *et al.* 1996; Pressey and Taffs 2001). A conceptually similar approach has been suggested for identifying hotspots of biodiversity at a global scale whereby hotspots are defined as “areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat” (Myers *et al.* 2000).

Relatively pristine habitats around the world are being lost at unprecedented rates (Melillo *et al.* 1985; Skole and Tucker 1993) as an expanding human population converts them to agriculture, forestry, and urban centers (Hall 1978; Vitousek *et al.* 1986). As these habitats are altered, untold numbers of species are disappearing before they have been recognized, much less studied (Wilson 1989), and the functioning of entire ecosystems is threatened. This loss of biodiversity, at the very time when the value of biotic resources is becoming widely recognized (Malone 1992), has made it strikingly clear that current strategies for conservation are failing dismally (Ehrlich and Wilson 1991; Ehrlich 1992).

The Biodiversity Conservation Prioritization Project (BCPP) was the first exercise of its kind that attempted to identify priority sites and species on the basis of their biological and socio-economic values and to develop strategies for their conservation at a national scale. A significant outcome of the exercise was to bring out locations of biodiversity significance beyond the protected area network. Many important locations which were earlier not known widely were identified. BCPP attempted assigning IUCN conservation categories to groups of species like invertebrates, fish, medicinal plants and reptiles using CAMP (Conservation Assessment and Management Planning) approach that relies on both published and unpublished information (Singh *et al.* 2000).

The lists of endemic and rare categories of plant species have been published by various authors from time to time. Most of these studies are based on inadequate field studies and hence, speculative in nature. Therefore, there is a need to assess the rarity and endemism among the plants based on empirical data generated through extensive field studies. Considering the conservation importance of threatened and endemic medicinal plant species of Meghalaya, the present research work aims to analyze rarity and endemism of three important medicinal plants of Meghalaya. The rarity and endemism have been assessed based on empirical population data and taking modeling approach. Attempts have been made to suggest strategies for their conservation. The present research would also provide guidance to the future researchers selecting appropriate and quantifiable parameters for classifying the species under different endemic and rare categories.

The study was conducted in the state of Meghalaya which lies between 25°02' and 26°07' N latitude and 89°49' and 92°50' E longitude with an area of 22, 429 km² (Fig 3.1). Being a part of the northeastern Indian bio-geographic zone (Rodgers and Panwar 1988), it constitutes the meeting place of paleo-arctic, Indo-Malayan and Indo-Chinese bio-geographic realms. The topography of the state is variable and the elevation ranges from 50 m to 2040 m a.s.l. The state has high concentration of plant species and harbours at least 239 endemic flowering plants (Lakadong and Barik 2006).

Geology

Meghalaya represents the remnant of the ancient plateau of Pre-Cambrian Indian peninsula and forms a prominent geomorphic unit stretching across the Garo, Khasi and Jaintia hills in east-west direction. The central and northern part of Meghalaya plateau is made essentially of highly metamorphosed crystalline rocks of Pre-Cambrian origin, which are often referred to as “Archaean Gnessic Complex”. It is made up of gneisses (biotite gneiss, biotite granulite, quartz-sillimanite gneiss, cordierite, garnet and chondrodite) and Schistose (mica schist, quartz-sillimanite schist and metabasite) members of varying composition (Anon 1974; Murthy *et al.* 1976).

Physiography

Based on the physiography, the state may be divided into (i) western region, (ii) central and eastern region, (iii) northern undulating hills, and (iv) southern precipitous zone. The western region includes Garo hills and western parts of west Khasi hills. The central and eastern region includes Khasi hills, Ri-Bhoi and Jaintia hills. The northern region is

characterized by undulating hills towards the north with altitude ranging between 300 m and 1600 m a.s.l., while the southern part is a high precipitous zone. The central upland zone constitutes the highest elevation zone of the Shillong plateau.

Soil

The soils of Meghalaya are derived from the underlying gneisses, schists and granites. They have been grouped under latosols (Oxisol) type (Pascoe 1950). In general, soils are highly leached, acidic and deficient in phosphorus and potassium. The soils are acidic (pH 3 - 6.5) in nature. Acidity is attributed to the leaching of cations like calcium, magnesium and potassium from the soil due to high rainfall and undulating topography. Total Kjeldahl nitrogen content is low (*ca.* 0.15%) at degraded sites and fairly high (*ca.* 0.94%) in the undisturbed forests. Soils are deficient in available phosphorus ($15 \mu\text{g g}^{-1}$) and medium in available potassium ($13 \mu\text{g g}^{-1}$), and rich in organic carbon (1.62%). Soils are not suitable for intensive cultivation due to their poor base (35%) saturation (Singh 1996).

Climate

The climate of the state is monsoonic and is directly influenced by the southwest monsoon originating from the Bay of Bengal. The climatic variables like temperature, rainfall and humidity vary widely from place to place in the state due to wide variation in topography. Based on the climatic conditions, the year may be divided into summer, rainy, autumn and winter seasons. The summer (May to September) is characterized by relatively high temperature, occasional thunderstorms and high wind velocity. The rainy season commences with the onset of southwest monsoon in May and continues up to September. Three fourth of the total annual rainfall is received during this season.

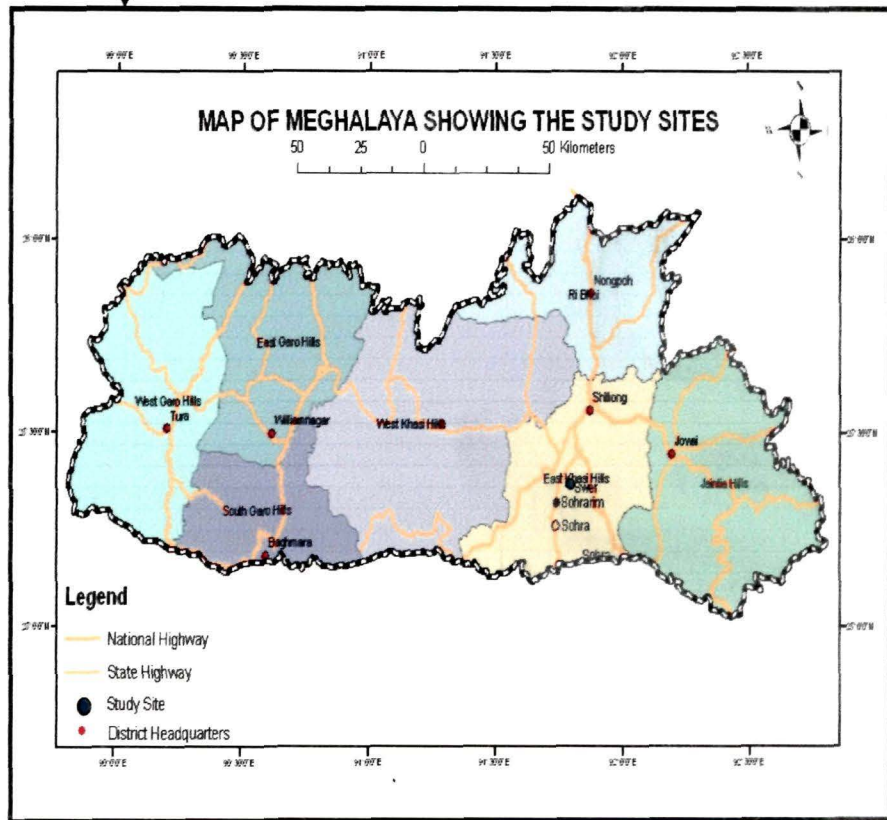
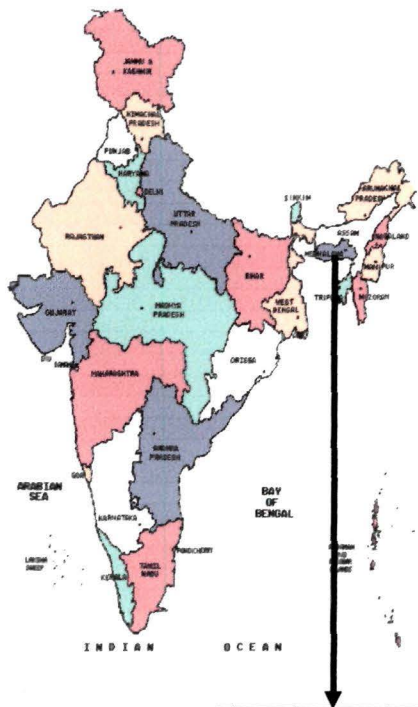


Fig 3.1: Map of the study area

The rainy season is followed by a brief autumn during October and November. Rainfall and temperature sharply decline during this period. The winter season extends from December to February. Morning fog and frost, and dry weather are the characteristic features of this season.

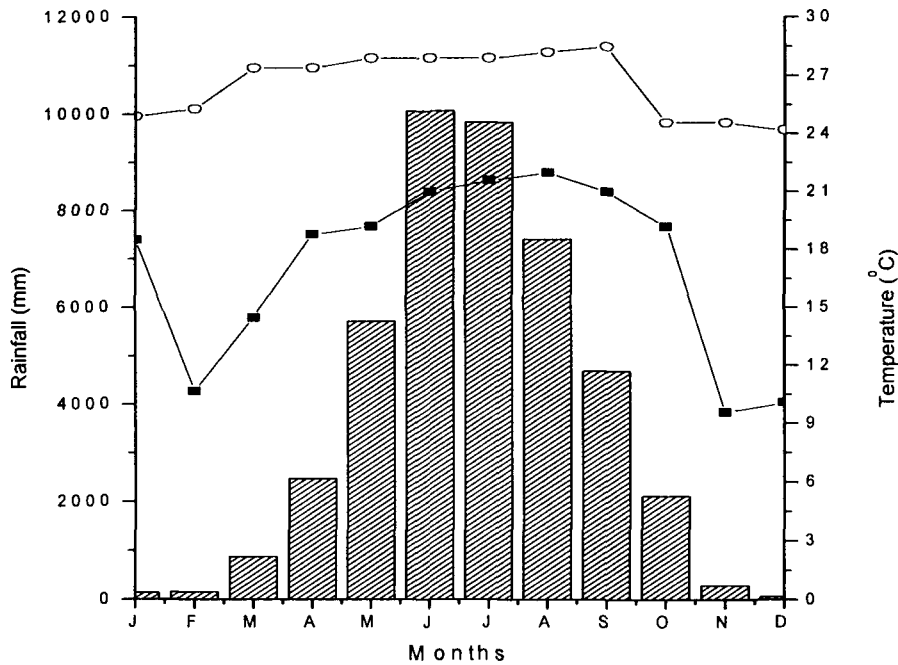


Fig 3.2: Mean annual rainfall and temperature of Meghalaya recorded at Upper Shillong meteorological station for the period from 2004 – 2007.

The annual rainfall varies widely in the state ranging from about 60 mm in the month of December to over 10,070 mm in the month of June. Highest amount of rainfall is received during May to September. Cherrapunjee and Mawsynram, located in the southern part, are the highest rainfall spots of the world. The annual mean minimum temperature is 10°C and mean maximum temperature is 24°C and mean maximum temperature does not exceed 29°C (Fig. 3.2).

Forests

The forests of Meghalaya were classified by Kanjilal *et al.* (1934); Champion and Seth (1968); Balakrishnan (1981); Haridasan and Rao (1985); Rao and Hajara (1986) and Chauhan and Singh (1992). The forest cover of the state in 2005 was 16,988 km², or 75.7% of the total geographical area of the state (FSI 2005).

The tropical forest occurring below 1000 m may be either evergreen or semi-evergreen type depending on the dominance of evergreen and deciduous trees in the canopy. The subtropical forest found above 1000 m is either broad-Leaved or needle-Leaved. Small pockets of subtropical evergreen broad-Leaved forest are found where rainfall is relatively high and soil moisture condition remains favourable for most part of the year, while those areas which receive relatively low annual rainfall support semi-evergreen forest. Pine forests have developed as a stable secondary community on the disturbed evergreen and semi-evergreen subtropical broad-Leaved forest sites, which are seasonally dry and nutrient-poor.

The primary tropical and subtropical forests of the state have been destroyed to a great extent by age-old tradition of shifting agriculture, which is extensively practiced in the state even today. As a result of this and other human activities, extensive degradation of the forest has taken place in the state. The degraded forestlands support a variety of successional communities ranging from weed-dominated communities on recently abandoned Jhum fields to pine forest and grassland on frequently burnt and nutrient-deficient sites.

The major forest types of Meghalaya are tropical moist deciduous, subtropical evergreen, subtropical semi-evergreen and subtropical pine forests.

Tropical moist deciduous forest

This forest type is represented by sal-bearing forest at low elevational areas of Garo hills, where annual rainfall is less than 150 cm. Along with *Shorea robusta*, other tree species found in the forest are *Tectona grandis*, *Terminalia myriocarpa*, *Sterculia villosa*, *Calliandra* sp., *Styrax serrulatum*, *Cordia grandis*, *Picrasma javanica*, *Embelia floribunda*, *Callicarpa arborea*, *Bauhinia variegata*, *Dysoxylum binectariferum*, *Lagerstroemia parviflora*, *Schima wallichii*, *Dillenia scabrella* and *Mallotus philippensis*. The under storey is composed of *Clerodendrum viscosum*, *Eupatorium adenophorum*, *Psychotria monticola*, *Melastoma malabathricum*, *Pongamia* sp., *Sabia purpurea*, *Ardisia neriifolia*, *Digitaria* sp., *Desmodium* sp., *Gleichenia* sp., and *Vandelia* sp.

Subtropical evergreen forest

It generally occurs above 1200 m a.s.l., where average annual rainfall ranges between 300 and 500 cm and temperature shows a noticeable difference between summer and winter season. The ground frost is common in December and January. The trees are generally short statured not exceeding >25 m height. Buttressed trunks and lianas are rare. Stratification is indistinct in the valleys, but it is clear at hilltops. The shrubby and herbaceous layers are clearly seen in the forest. Epiphytes, mosses and liverworts are abundant. The forest floor is spongy due to presence of thick litter layers and a dense network of fine roots.

Tall scattered trees of *Castanopsis* sp., *Lithocarpus elegans*, *Engelhardtia spicata*, *Ficus elastica*, *Mangleitia insignis*, *Prunus nepalensis*, *Exbuklandia populnea* and *Betula* sp., constitute the canopy layer of the forest. Occasionally, *Schima wallichii* is also seen. *Viburnum foetidum*, *V. simonsii*, *Quercus glauca*, *Helicia nilagirica*, *Michelia punduana*,

Vernonia volkamerifolia, *Daphne involucrata*, *Symplocos racemosa* and *Ligustrum robustum* are common in the sub-canopy layer. Tree ferns are commonly found in the forest.

The common shrub species found in the forest include, *Goniothalamus sesquiopedalis*, *Sarcococca saligna*, *Sarcandra glabra*, *Baliospermum micranthum*, *Neillia thorsiflora*, *Ixora subsessilis*, *Clerodendrum* sp., *Eurya japonica*, *Psychotria* sp., *Ardisia* sp., *Camellia caudata*, *Saurauria* sp, and members of Acanthaceae and Araliaceae.

The forest floor is covered with mosses, *Selaginella* and angiosperm species such as *Begonia palmata*, *Senecio griffithii*, *Sonerilla* sp., *Impatiens* sp., *Didymocarpus punduana*, *Elatostema rupestre*, *Begonia rubro-venia*, *Disporum* sp., and members of Zingiberaceae, Araceae and Commelianaceae. *Clematis* sp., *Smilax* sp., *Dioscorea* sp., *Melodinus* sp. and species of Menispermaceae and Cucurbitaceae are common climbers in the forest.

Subtropical semi-evergreen forest

The altitudinal limits of distribution and climatic conditions prevailing in the subtropical semi-evergreen forest area are similar to those of evergreen forest. A transitional zone between tropical and subtropical forests is distinguishable at certain places between 1000-1400 m.

The common canopy (25 m height) species are *Engelhardtia spicata*, *Castanopsis indica*, *Sapindus rarak*, *Paramichelia baillionii*, *Elaeocarpus floribundus*, *Meliosma wallichii*, *Diospyros undulata*, *Ficus altissima* and *Vitex glabrata*. The sub-canopy in the forest is composed of small trees of *Vitex vestita*, *Quercus semicarpifolia*, *Casearia*

vareca, *Micromelum integrimum*, *Photinia arguta*, *Symplocos cochinchinensis* and *Xylosma controversum*.

Lianas are less frequent and they are represented by *Mucuna macrocarpa*, *Tetrastigma obovatum* and *Celastrus campionii*. The shrub layer has fewer species. The common shrubs are *Crotalaria assamica*, *Boehmeria platyphylla*, *Capparis acutifolia*, *Lyonia ovalifolia*, *Randia griffithii*, *Mussaenda glabra*, *Desmodium* sp., *Maesa tetrandra* and *Clerodendrum* sp. The herbaceous layer is sparse. The common flowering plants of this layer are *Pilea umbrosa*, *Galinsoga parviflora*, *Anisadenia khasiana*, *Curcuma* sp., *Polygalla* sp., *Acanthus leucostachys*, *Pouzolzia hirta*, *Hedychium* sp., and many plants of Asteraceae.

Subtropical pine forest

The forest is confined to the central upland of Shillong plateau between *ca.*, 1000-2000 m a.s.l. The climatic conditions are similar to those of evergreen and semi-evergreen forests. It occurs in Khasi and Jaintia hills above 800 m (either as pure or mixed stands) on nutrient-poor soil. The forest is exposed to annual winter fire when ground vegetation is almost completely dry. Besides annual fire, other biotic disturbances such as fuelwood collection, timber extraction and grazing are common in the forest. As a result of these activities, the forest has been fragmented into small patches.

The average height of pine trees ranges between 20 and 35 m, however, on degraded sites the height may be less. Few scattered trees of broad-leaved species are often associated with pine. A few small trees or large shrubs are found scattered in the forest forming the sub-canopy layer. Annual fire prevents establishment of shrubs and

other woody elements. However, weeds and perennial grasses form dense undergrowth during monsoon.

Pine forest is very poor in tree species content. At places it forms a mixed stand with *Schima wallichii*, *Prunus undulata*, *Prunus cerasoides*, *Rhus javanica*, *Quercus dealbata*, *Q. glauca*, *Q. griffithii*, *Lyonia ovalifolia*, *Rhododendron arboreum*, *Alnus nepalensis* and *Exbucklandia populnea*. The shrubby undergrowth includes *Rubus ellipticus*, *R. khasianus*, *R. rugosus*, *Myrsine semiserrata*, *Osbeckia crinita*, *Desmodium* sp., *Eupatorium* sp., *Lantana camara* and *Bidens pilosa*.

Grassland

In Meghalaya grasslands have developed on degraded sites after the destruction of natural forests. The species of flowering plants encountered in such grasslands are *Setaria glauca*, *Arundinella nepalensis*, *Imperata cylindrica*, *Arundinella bengalensis* and *Arundinella khasiana*. Dabadghao and Shankarnarayan (1973) have given an account of the grassland communities found on the hills of Meghalaya. According to them, the principal species in the grasslands at 1200-1600m a.s.l. are *Arundinella khasiana*, *Dimeria fuscescens*, *Ischaemum barbatum* and *Eragrostiella leioptera*, while those found at 800-1200m a.s.l. have a mixture of species from the plains and hills. *Arundinella bengalensis* is the dominant species here. Above 1800m a.s.l. the grassland developed on an abandoned jhum field is dominated by *Eragrostiella leioptera* and the community is similar to that occurring at 1200-1600m a.s.l. They have grouped all these grassland communities under *Themeda-Arundinella* type grass cover distributed in the entire northern and northeastern montane tract of the country.

Introduction

Three Threatened and Endemic plant species of medicinal importance were selected for detailed study. For selection of species the flora of Meghalaya and Northeastern India, and the Red Data Books (Kanjilal *et al.* 1934-40; Joseph 1968; Balakrishnan 1981-83; Haridasan and Rao 1985-87; Nayar and Shastry 1988-90) were extensively consulted. *Monotropa uniflora* L. (Monotropaceae), *Panax pseudoginseng* Wall. (Araliaceae) and *Osbeckia capitata* Benth. (Melastomataceae) were finally selected.

Taxonomic description*Monotropa uniflora*

The species belongs to Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Ericales and Family: Monotropaceae.

A white, thick and translucent stem covered with scaly bracts and terminated by a single nodding flower is the identifying characteristic of the plant. Inflorescence always with solitary flowers, whitish, 20-30 cm high (from root connection), 2-5 mm diameter. Stamens 8-14, of two series of alternating lengths, 7-15 mm long, anthers short, 2 mm diameter. Ovary 6-12 mm long, 5-9 mm diameter, locules 5-6; stigma broadly funnel form, 2-6 mm diameter, style stout, tapering to ovary, 2-7 x 2-5 mm. Capsule 7-11 x 5-12 mm, perianth may persist in fruit, capsular segments stout, persistent. Seeds ranged from 0.6 – 0.8 mm in length and 0.012 – 0.15 mm in width (Figure 4.1, Plate 1).

Distribution: The species is found in Northern California, British Columbia, Southern Canada, Eastern United States, Eastern Texas, Southern Mexico, Northwestern Colombia

and Asian countries such as Japan, Southeastern China, Nepal and India. In India the species is found in Darjeeling, Sikkim, Bhutan and Meghalaya (Wallace 1975). In Meghalaya the species is restricted to East Khasi Hills, West Khasi Hills and Jaintia Hills.

Panax pseudoginseng

The species belongs to Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Apiales and Family: Araliaceae.

Herbs, perennial, ca. 50 cm tall. Rootstock short, with 2-5 fleshy roots, fusiform, 2-4 cm, ca. 1 cm in diam. Leaves usually 4, verticillate at apex of stem, palmately compound; bases of petiole and petiolules with numerous lanceolate, stipule-like appendages; leaflets 3 or 4, obovate-elliptic to obovate-oblong, 9-10 × 3.5-4 cm (lateral ones smaller), membranous, abaxially glabrous, adaxially setose on veins (trichomes 1.5-2 mm), base attenuate, margin biserrate, apex long caudate-acuminate. Inflorescence a solitary, terminal umbel 20-50-flowered; peduncle ca. 12 cm; pedicels ca. 1 cm, glabrous. Ovary 2-carpellate; styles 2 divided, reflexed (Fig 4.2, Plate 2).

Distribution: The species is found in Southeast Asian countries such as China, Japan and India. The species has been reported from north-eastern states, although the correct identity of the species is yet to be established (Wu *et al.* 2007). In Meghalaya the species is restricted to East Khasi Hills only.

Osbeckia capitata

The species belongs to Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Myrtales and Family: Melastomaceae.

Herbs or shrublets, 8-25 cm tall, erect. Stems 4-sided, sparsely appressed strigose. Petiole very short, strigose; leaf blade ovate, 1.7-2.5 × 0.9-1.3 cm, stiffly papery, both surfaces strigose, secondary veins 2 on each side of mid vein, tertiary veins inconspicuous, base rounded to subcordate, margin entire, apex acute. Inflorescences terminal, capitate, 2- or 3-flowered, with 2-4 bracteal leaves at base; bracts sessile, ovate, both surfaces glabrous or sparsely strigose only on midvein. Hypanthium often reddish, ca. 1.5 cm, glabrous. Calyx lobes 4, ovate, ca. 1.5 cm, setiform tuberculate among lobes, margin ciliate. Petals 4, purple to pale purple, obovate, ca. 1.5 cm, margin ciliate. Stamens 8, inclined to one side; filaments of equal lengths; anthers narrowly lanceolate, long beaked; connective abaxially with a short basal spur, adaxially slightly inflated tuberculate. Ovary ovoid, 4-celled, apex with 16-20 setae. Capsule purplish red, ovoid, ca. 7 × 7 mm, glabrous (Fig 4.3, Plate 3).

Distribution: The species is found in Khasi and Jaintia Hills of Meghalaya only (Balakrishnan 1981-83).



Plate 2: Habit and habitat of *Panax pseudoginseng*



Plate 1: Habit and habitat of *Monotropa uniflora*.



Plate 3: Habit and habitat of *Osbeckia capitata*.

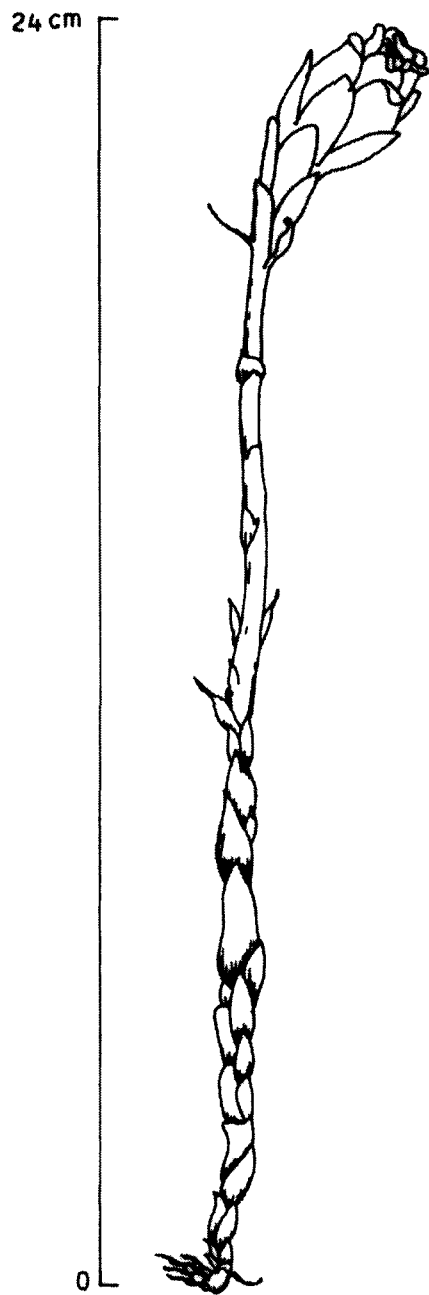


Fig 4.1. Diagrammatic representation of *Monotropa uniflora*.



Fig 4.2. Diagrammatic representation of whole plant and rhizome of *Panax pseudoginseng*

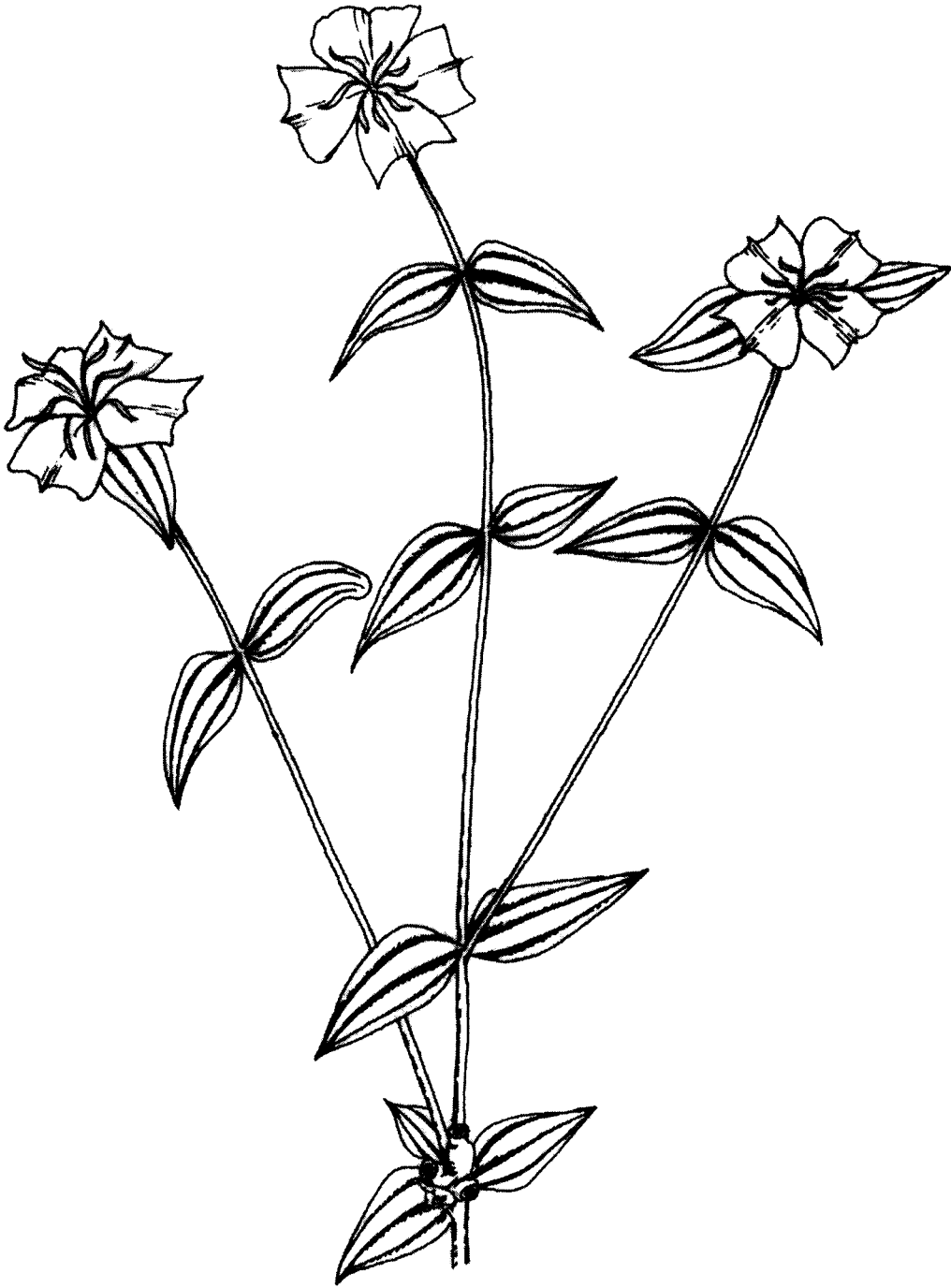


Fig 4.3. Diagrammatic representation of *Osbeckia capitata*

Autecology of species

The autecology of the species was studied by analyzing morphological features, uses, phenology and association.

Methods

Twenty five matured individuals of each of the three species were randomly selected at three sites. Different morphological parameters were measured during the peak flowering and fruiting season. The parameters are individuals per clump, plant height, leaf number, number of flowers per plant, flower length and diameter, number of fruits produced per plant and number of seeds produced per plant. Medicinal uses of the selected species were also investigated through available literature and interviewing the local people. Phenological cycles from emergence from the soil to death of the species were closely observed over a period of one annual cycle from January 2005 to December 2005. Species association was analyzed using the Community Analysis Package (CAPS4). Positively significant χ^2 values at 0.05 significance level so obtained were tabulated. These highly significant χ^2 values helped to ascertain the species those are closely associated with the study species.

Results

Species morphology

Osbeckia capitata had 2-15 Individuals per clump. *Monotropa uniflora* had 1-15 Individuals per clump. Only 1-2 individuals were representing a clump of *Panax pseudoginseng*. Plant height in the case of *Panax pseudoginseng* ranged between 50-150 cm. In the case of *Monotropa uniflora* and *Osbeckia capitata*, the plant height ranged between 20-35 cm and 10-35 cm, respectively. Number of leaves in matured individuals

of *Panax pseudoginseng* varied between 4 and 6. In *Osbeckia capitata* the number of leaves in matured individuals ranged from 25-112. Number of flowers and fruits produced per plant by *Panax pseudoginseng* ranged between 26-40 and 24-40, respectively. In *Osbeckia capitata* the number of flowers and fruits produced per plant ranged between 1-15. However, in *Monotropa uniflora* only one flower and one fruit are produced per plant. Flower length and diameter in *Panax pseudoginseng* ranged between 0.4-0.6 cm and 0.2-0.4 cm, respectively. In *Osbeckia capitata* flower length and diameter ranged between 0.5-0.7 cm and 2-3 cm, respectively. In *Monotropa uniflora*, however, flower length and diameter ranged between 3-4 cm and 1-2 cm, respectively. Number of seeds produced per plant in *Panax pseudoginseng* ranged from 48-78 and that in case of *Osbeckia capitata* ranged between 125-1548. In *Monotropa uniflora*, number of seeds produced per plant ranged between 173-219 (Table 4.1).

Table 4.1: Range of morphological parameters of the study species (Mean±SE) during the peak flowering season.

Species	<i>Panax pseudoginseng</i>	<i>Osbeckia capitata</i>	<i>Monotropa uniflora</i>
Individuals per clump	1-2	2-15	1-15
Plant height (cm)	50-150 (130.8 ± 4.0)	10-35 (16.5 ± 1.1)	20-35 (25.6 ± 0.7)
Leaf number (no.)	4-6 (4 ± 0.3)	25-112 (59 ± 5.2)	-
Number of flowers per plant (no.)	26-40 (35 ± 0.8)	1-15 (8 ± 0.8)	1 (1 ± 0.0)
Flower length (cm)	0.4-0.6 (0.5 ± 0.1)	0.5-0.7 (0.6 ± 0.1)	3-4 (3.7 ± 0.1)
Flower diameter (cm)	0.2-0.4 (0.3 ± 0.1)	2-3 (2.6 ± 0.1)	1-2 (1.5 ± 0.1)
Number of fruits produced per plant (no.)	24-40 (33 ± 0.9)	1-15 (7 ± 0.8)	1 (1 ± 0.0)
Number of seeds produced per plant (no.)	48-78 (67 ± 1.7)	125-1548 (889 ± 97.8)	173-219 (196 ± 3.5)

Species uses

All the three species are of medicinal importance. Many ailments are cured by the use of these species either alone or in combination with other herbs (Table 4.2).

Table 4.2: Medicinal uses of *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*.

Species	Common names	Parts used	Ailments treated
<i>Monotropa uniflora</i>	Indian Pipe [E]	Whole plant, Roots	Eye ailments, Nervous conditions, Inflamed Eyes, Bunions, Warts, Spasms, Convulsions, Fits, Fever, Epilepsy, Antispasmodic, Cold, Bactericidal, Restlessness, Pains.
<i>Osbeckia capitata</i>	Soh Pythem [K]	Whole plant	Snakebite, Muscle Swellings.
<i>Panax pseudoginseng</i>	Jynseng [K]	Roots	Amnesia, Headache, Convulsions, Dysentery, Cancer, Neurasthenia, Dyspepsia, Palpitation.

Traditionally, *Monotropa uniflora* has been used in the indigenous medicine systems such as the “*Ani Yvwiya (Cherokee) Nvwoti*” and the “*Eclectic System of Medicine*” (1825-1939), U.S.A. as Anodyne, antispasmodic, sedative, diaphoretic, fevers with pain, convulsions (Winston 2005), eye inflammations (Ames 1999). However, no modern usage of the species has been reported for the species.

Panax pseudoginseng is widely used in traditional Chinese medicine (Himi *et al.* 1989, Wen *et al.* 1996). Ginsenosides or ginseng saponins are the active ingredients in *Panax pseudoginseng* and more than thirty different ginsenosides have been identified (Liu and Xiao 1992, Back *et al.* 1996). Another active ingredient, Trilinolein, a triacylglycerol purified from *Panax pseudoginseng*, which is commonly used in Chinese traditional medicine, has been found to have pharmacological effects, including antioxidant activity that may explain the benefits in treating circulatory disorders perceived from the use of the herb over the centuries (Chan and Tomlinson 2000).

Osbeckia capitata, on the other hand, has been used traditionally in Meghalaya only (Lakadong and Barik 2006). No modern usage of the species has been reported for the species so far.

Species phenology

Monotropa uniflora had the shortest phenological cycle compared to *Panax pseudoginseng* and *Osbeckia capitata*. *Osbeckia capitata* had the longest phenological cycle (Table 4.3).

In case of *Monotropa uniflora*, emergence from the soil takes place during the month from mid May to Early July, soon after which initiation of flowering takes place from mid July to early August. The peak flowering season starts from mid August to mid September which is immediately followed by the fruiting season from late September to early October. Seed set followed by death of adult individuals soon takes place after fruit maturity during mid October to early November.

In *Panax pseudoginseng*, however, emergence from the soil starts from mid April and continues to early June after which initiation of flowering takes place. The peak flowering season starts from early to late August followed by fruiting from early to mid September. Seed set takes place during the period late September to mid October after which the plant dies off.

Osbeckia capitata starts emerging from the soil during the month of April to July followed by the initiation of flowering from early August to early September. Mid September to mid October is the peak flowering season of the species followed by fruiting during late October, shortly after which seed set takes place during the period early November to mid November followed by death of the adult individuals.

Species association

The species associated with *Monotropa uniflora* are, *Balanophora dioica* ($\chi^2=5.65725$), *Globba clarkei* ($\chi^2=1.42665$) and *Impatiens chinensis* ($\chi^2=1.37423$).

In case of *Osbeckia capitata*, the species associated are, *Cyperus distans* ($\chi^2=4.32561$), *Mazus pumillus* ($\chi^2=3.15156$), *Eragrostiella leioptera* ($\chi^2=2.97855$), *Gnaphalium luteoalbum* ($\chi^2=2.88871$), *Gentiana quadrifaria* ($\chi^2=2.19412$) and *Anaphalis timmua* ($\chi^2=2.19011$). The other associated species are, *Crassocephalum crepidioides*, *Isachne albens*, *Dicranopteris linearis*, *Hedyotis uncinella* and *Eriocaulon cristatum*.

Panax pseudoginseng was associated with *Impatiens radicans* ($\chi^2=11.00070$), *Houtuynia cordata* ($\chi^2=8.06496$), *Eupatorium odoratum* ($\chi^2=6.80120$), *Cassia mimmosoides* ($\chi^2=3.08393$), *Begonia rubrovenia* ($\chi^2=3.00417$), *Ophiorrhiza mungos* ($\chi^2=2.59517$) and *Colocasia esculenta* ($\chi^2=2.10641$). The other associated species are *Ophiopogon intermedius*, *Balanophora dioica* and *Globba clarkei* (Table 4.4).

Table 4.4: Dominant species associated with the selected species along with their χ^2 values ($p<0.05$).

Species	Associated species	χ^2
<i>Monotropa uniflora</i>	<i>Balanophora dioica</i>	5.65725
	<i>Globba clarkei</i>	1.42665
	<i>Impatiens chinensis</i>	1.37423
<i>Osbeckia capitata</i>	<i>Cyperus distans</i>	4.32561
	<i>Mazus pumillus</i>	3.15156
	<i>Eragrostiella leioptera</i>	2.97855
	<i>Gnaphalium luteoalbum</i>	2.88871
	<i>Gentiana quadrifaria</i>	2.19412
	<i>Anaphalis timmua</i>	2.19011
	<i>Crassocephalum crepidioides</i>	1.93681
	<i>Isachne albens</i>	1.91402
	<i>Dicranopteris linearis</i>	1.60344
	<i>Hedyotis uncinella</i>	1.55046
	<i>Eriocaulon cristatum</i>	1.52454
<i>Panax pseudoginseng</i>	<i>Impatiens radicans</i>	11.00070
	<i>Houtuynia cordata</i>	8.06496
	<i>Eupatorium odoratum</i>	6.80120
	<i>Cassia mimmosoides</i>	3.08393
	<i>Begonia rubrovenia</i>	3.00417
	<i>Ophiorrhiza mungos</i>	2.59517
	<i>Colocasia esculenta</i>	2.10641
	<i>Ophiopogon intermedius</i>	1.75625
	<i>Balanophora dioica</i>	1.07332
	<i>Globba clarkei</i>	1.06899

Discussion

Species description

Wu *et al.* (2007) recorded the height of *Panax pseudoginseng* as ca. 50 cm. In the present study the height ranged between 50-150 cm. In *Monotropa uniflora* the height ranged between 20-35 cm. In *Osbeckia capitata* the plant height range was recorded as 8-25 cm in the "Flora of Jowai" (Balakrishnan 1983). In the present study the height ranged between 10-35 cm. This large difference could be due to varietal difference or it can be a new species. As such, *Panax* poses severe identity challenge. It needs to be confirmed if it belonged to the same species.

Species phenology

Phenological patterns in *Monotropa uniflora* and *Panax pseudoginseng* varied along the altitudinal gradient. All phenological phenomena occurred earlier in higher altitude areas (>1600m a.s.l.) than the lower elevation areas. The peak flowering occurred during rainy season for all the three selected species.

In *Monotropa uniflora*, the time interval between fruiting and seed set was very short which was <1 month. Although the species produces many seeds per capsule, the emergence of seedlings was very less. Similar observations were also made by Wallace (1975).

Species association

Two species are said to be positively associated if they are found together more often than expected by chance. The most common reason for such positive associations can be expected if the species share similar microhabitats. It is clear that the species associated with *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* are highly

significant at <0.05 probability level, which means that these are the species that are associated with one another.

Significant pair wise associations can be beneficial, and may be well differentiated by the coefficients of association. These coefficients will indicate respectively greater or smaller chances of finding one given species in a field and may also indicate similarity or disparity in relation to other environmental conditions (Rodrigues *et al.* 1996).

Introduction

There are numerous factors that contribute to a species being rare and endangered. Species can be rare in either space or time, or both (Rabinowitz 1981; Kruckeberg and Rabinowitz 1985; Fiedler and Ahouse 1992). Rare species can be geographically widespread but infrequent throughout their distribution, or the species can be locally abundant in a very narrow geographic range. Furthermore, abundance may vary temporally such as relictual species that were once widespread and are now limited in distribution, or incipient species that are recent in origin and have yet to reach their potential to colonize large areas, to become geographically widespread, and to be ecologically successful (Stebbins and Major 1965; Harper 1977; Rabinowitz 1981; Fiedler and Ahouse 1992). If adequate potential habitat is available, individuals of an incipient species may become abundant, and the species may never become endangered. Alternatively, populations of incipient species may never become very abundant and may always remain rare, continually threatened by extinction. Relictual species whose populations have become isolated and fragmented may also become threatened or endangered, as is the case with numerous contemporary species (Falk 1991).

The likelihood of extinction of a species depends not only on the cause of rarity, but also on the consequence of rarity (Soule 1983; Barrett and Kohn 1991; Fiedler and Ahouse 1992). For example, species that are rare and have a small population size are subject to inbreeding depression and reduced fitness resulting from homozygosity (Schaal and Levin 1976; Soule 1980; Frankel and Soule 1981; Levin 1983; Ledig 1986; Lacy

1992). Because of being genetically homogeneous, the species becomes more susceptible to local extinction due to demographic and environmental stochasticity (Clegg and Brown 1983; Mitton and Grant 1984; Guerrant 1992).

For effective conservation of rare and endangered species, it is important to distinguish between cause and consequence of rarity. This includes proximate and ultimate causes of rarity, including evolutionary and historical events that resulted in the present-day distributions, and current ecological and genetic factors limiting colonizing and evolutionary success (Fiedler and Ahouse 1992).

In the present study, the causes of rarity were assessed and identified for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*. The threats so identified can be mitigated through proper protective measures. These causes would also help provide a baseline for the species conservation starting from local to regional scales.

Methods

Three approaches were followed to assess the causative factors of rarity.

⬇ *Over-exploitation as a factor for rarity.*

Rates of extraction from the wild for each species were assessed over a period of four years from 2004-2008 during the active growth period of the particular species. This was done by interviewing local medicine men. The data on the annual harvest from the wild as well as from other sources were collected. From the interviews an estimate of the annual extraction of the species from the wild was made.

✦ *Narrow species niche as a factor for rarity.*

The micro environmental conditions of the habitats, where the species occur were characterized by measuring climatic factors such as air temperature, light intensity and relative humidity on the forest floor or habitat. Edaphic factors such as soil pH, temperature, moisture content, texture, C, N, P and K were also estimated for the soil samples collected from the habitat of natural occurrence to quantify the species niche. The niche breadth (B) was calculated for each parameter following Levins (1968):

$$B = 1/\sum_{i=1}^R p_i^2$$

where, p_i is the proportion of resource i used and R is the total number of the resource states.

✦ *Regeneration constraint as a factor for rarity*

Annual seed production and seedling recruitment rate were estimated for each species. The metapopulation size and population dynamics of juveniles were studied for each species, to ascertain the regeneration constraints during the establishment phase.

Results

Over-exploitation

The average annual recruitment rate was 25 individuals per population for *Monotropa uniflora* with no record of extraction from the wild. In *Osbeckia capitata* average annual recruitment rate was 10 individuals per population, of which average annual extraction was recorded as 4 individuals per population. *Panax pseudoginseng* recorded an average annual recruitment of 12 individuals per population of which average annual extraction

was recorded as 3 individuals per population (Table 5.1). Thus, the average annual extraction by traditional healers in the case of *Panax pseudoginseng* was 6.3%. Annually, the average harvest rate of *Osbeckia capitata* was 11.1%.

The rates of extraction in all the three species varied significantly ($p < 0.05$) among the population/sites (Table 5.2) indicating the role of site protection and disturbance history in determining the level of extraction. The rates of extraction also varied significantly among the year of study in *Monotropa uniflora* and *Osbeckia capitata*.

Table 5.1: Rate of extraction of *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata* from the wild.

Species	Year	Total number of populations/sites	Mean number of individuals per population		% Extraction
			Recruitment	Extraction	
<i>Monotropa uniflora</i>	2004	7	30	0	0.0
	2005		25	0	0.0
	2006		31	0	0.0
	2007		15	0	0.0
	Mean (\pmSE)		25 \pm 3.7	0	0.0
<i>Panax pseudoginseng</i>	2004	6	14	3	21.4
	2005		12	3	25.0
	2006		10	3	30.0
	2007		11	2	18.2
	Mean (\pmSE)		12 \pm 0.9	3 \pm 0.3	25.0
<i>Osbeckia capitata</i>	2004	54	13	5	38.5
	2005		11	3	27.3
	2006		9	4	44.4
	2007		7	4	57.1
	Mean (\pmSE)		10 \pm 1.3	4 \pm 0.4	40.0

Table 5.2: Result of two-way ANOVA performed to assess the variation due to populations/sites and years in *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Species	df	F-value	p-value
<i>Monotropa uniflora</i>	Sites	3.48	0.02
	Year	5.61	0.01
<i>Panax pseudoginseng</i>	Sites	3.22	0.03
	Year	0.14	0.94
<i>Osbeckia capitata</i>	Sites	9.79	0.01
	Year	10.55	0.01

Niche characterization

Microenvironment

Panax pseudoginseng

The relative humidity in *Panax* occurring areas ranged between 75% - 89%, light intensity ranged between 500 Lux – 37500 Lux. The soil temperature range was between 17.8°C – 22.0°C and air temperature range was between 19.8°C – 22.8°C (Table 5.3).

Monotropa uniflora

The relative humidity at the different locations where *Monotropa* was encountered ranged between 85% - 97%, light intensity ranged between 2000 Lux – 7500 Lux. The soil temperature range was between 17.8°C – 23.3°C and air temperature range was between 19.8°C – 23.7°C (Table 5.3).

Osbeckia capitata

The relative humidity at the different locations where *Osbeckia* was encountered ranged between 27% - 95%, light intensity ranged between 1400 Lux – 4000 Lux. The soil temperature range was between 7.2°C – 24.6°C and air temperature range was between 11.2°C – 27.3°C (Table 5.3).

Table 5.3: Microenvironmental conditions in *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Locations	Relative Humidity (%)	Light Intensity (Lux)	Air Temperature (°C)	Soil Temperature (°C)
<i>Monotropa uniflora</i>				
Laitkor	86	2000	19.80	17.80
Mawphlang	87	7500	20.10	18.90
Sutnga	70	5800	23.00	21.60
Sohra-rim	97	2500	22.10	21.40
Khathynniewmer	89	4400	23.70	23.30
Lum Shillong	85	5900	22.4	19.31
Laitkseh	88	5400	24.10	22.44
Mean (±SE)	86 ± 3.1	4771 ± 740	22.2 ± 0.6	20.7 ± 0.8

<i>Panax pseudoginseng</i>				
Laitkor	86	2000	19.80	17.80
Mawphlang	75	4500	22.50	20.00
Nongkrem	87	7500	20.10	18.90
Laitryngew	82	500	22.00	18.90
Hynniew mer	82	3200	22.00	19.00
Lum Shillong	85	5900	22.40	19.31
Mean (\pmSE)	84 \pm 2.3	3933.3 \pm 1048.4	21.7 \pm 0.5	19.1 \pm 0.3
<i>Osbeckia capitata</i>				
Amlarem	91	5300	24.1	22.3
Bapung	58	36800	23.5	22.1
Domiasiat	43	60200	25.5	24.1
Jakrem	48	59600	22.9	18.2
Jaraiñ	78	44500	27.3	21.8
Jatah Lakadong	27	85600	19.0	14.0
Jongsha	42	69900	16.2	12.5
Jowai	86	45800	24.9	22.9
Kdohule	60	35400	20.3	18.5
Khathynniew mer	54	65300	19.8	16.3
Khliehriat	60	23600	22.9	21.8
Kynroh	62	69400	18.0	7.2
Kynshi	70	38200	20.6	20.0
Laitkor	95	22000	18.5	16.9
Lynniong	45	55600	23.9	20.8
Mawdiangdiang	55	2000	17.8	16.5
Mawiong (EKH)	51	3800	18.6	15.5
Mawlangkhar	43	66700	17.7	8.6
Mawlieh	32	11800	21.5	15.4
Mawliehpoh	58	90300	22.0	20.7
Mawlyndep	63	20500	15.5	8.1
Mawlyngot	45	35800	23.5	21.9
Mawmaram	75	36000	18.9	18.1
Mawphlang	89	56900	19.1	16.9
Mawryngkneng	75	103500	25.8	24.6
Mawsmmai	88	25000	22.5	20.8
Mawsynram	58	7600	25.3	18.0
Mih-myntdu	64	32100	24.1	22.6
Muswang	55	36500	19.6	18.2
Mynsang	39	65900	22.2	18.7
Mynsyngat	27	75300	24.4	19.1
Nongkrem	88	6500	21.0	16.5
Nongriat	40	20700	25.5	13.6
Nongrim Sadew	56	35800	21.6	19.5
Nongstoin	81	32100	22.0	21.1

Pambriew	45	63600	24.2	15.1
Pariong	48	58100	22.8	18.2
Phlangwanbroi	59	1400	25.3	22.7
Pongtung	61	45000	26.2	23.5
Pynursla	68	44000	22.9	21.8
Raliang	52	42100	22.6	21.5
Rambrai	43	4400	14.8	12.8
Rangblang				
Sohsynniang	27	87000	22.7	16.7
Risiang	69	32600	11.2	8.0
Shillong	65	38900	25.0	20.4
Sohra-rim	79	39800	21.8	20.2
Sohryngkham	51	23600	22.6	21.0
Sutnga	93	3500	20.5	18.8
Swer	86	60300	21.7	19.9
Ummulong	41	22400	22.7	16.6
Umsaw (EKH)	39	79000	20.3	17.8
Umsaw (WKH)	44	62600	21.4	11.2
Wahkaji	27	104000	25.4	24.2
Weiloi	49	31900	24.8	21.1
Mean (\pmSE)	58 \pm 2.5	43078 \pm 3630	21.8 \pm 0.4	18.3 \pm 0.6

Soil Physical properties

Panax pseudoginseng

The Soil Moisture Content (SMC) in the areas of occurrences of *Panax* ranged between 39.0% - 62.8%. Soil texture also showed a considerable variation in amount of sand (75.7% - 94.6%), silt (4.3% - 16.9%), and clay (1.1% - 12.4%), indicating that *Panax* was growing well in loamy sand soil (Table 5.4).

Monotropa uniflora

The Soil Moisture Content ranged between 41.8% - 62.8% in the locations where *Osbeckia* was encountered. Soil texture also showed a considerable variation in the amount of sand (75.6% - 94.6%), silt (4.3% - 16.8%), and clay (1.1% - 12.0%) %, indicating that *Monotropa* was growing well in the soil textural class of loamy sand (Table 5.4).

Osbeckia capitata

The locations where *Osbeckia* was growing showed a significant variation in the Soil Moisture Content that ranged between 4.4% - 52.9%. Soil texture also showed a considerable variation in amount of sand (63.4% - 97.0%), silt (2.0% - 32.7%), and clay (1.0% - 13.5%), indicating the species preference towards sandy to loamy sand (Table 5.4).

Table 5.4: Soil physical characteristics in *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Locations	Sand (%)	Silt (%)	Clay (%)	Textural class	SMC (%)
<i>Monotropa uniflora</i>					
Laitkor	77.90	16.74	5.28	Loamy Sand	44.50
Mawphlang	74.60	14.27	11.13	Loamy Sand	62.80
Sutnga	75.60	16.80	7.45	Loamy Sand	52.90
Sohra-rim	82.50	8.98	7.45	Loamy Sand	52.90
Khathynniew mer	81.35	10.05	8.60	Loamy Sand	57.10
Lum Shillong	80.88	7.99	11.13	Loamy Sand	41.80
Laitkseh	80.44	7.45	12.11	Loamy Sand	48.94
Mean (±SE)	81.9 ± 2.3	10.4 ± 1.8	7.8 ± 1.4	Loamy Sand	51.6 ± 2.7
<i>Panax pseudoginseng</i>					
Laitkor	77.98	16.74	5.28	Loamy Sand	44.50
Mawphlang	74.60	14.27	11.13	Loamy Sand	62.80
Nongkrem	75.66	16.89	7.45	Loamy Sand	52.90
Laitryngew	82.56	8.98	8.46	Loamy Sand	39.40
Hynniew mer	81.40	9.06	9.00	Loamy Sand	43.60
Lum Shillong	80.88	7.99	11.13	Loamy Sand	41.80
Mean (±SE)	82.0 ± 2.3	10.1 ± 1.9	7.9 ± 1.4	Loamy Sand	46.3 ± 3.3
<i>Osbeckia capitata</i>					
Amlarem	86.75	12.21	1.04	Sandy	17.60
Bapung	92.86	4.07	3.07	Sandy	17.70
Domiasiat	88.88	4.10	7.02	Sandy	10.30
Jakrem	78.05	18.20	3.75	Loamy sand	17.70
Jaraiñ	88.69	10.31	1.06	Sandy	30.30
Jatah Lakadong	72.58	18.27	9.05	Sandy loam	14.90
Jongsha	64.21	32.70	3.02	Sandy loam	21.60
Jowai	76.59	20.34	3.07	Loamy Sand	16.90
Kdohule	78.53	12.26	9.21	Loamy Sand	20.80
Khathynniew mer	69.45	23.57	6.98	Loamy Sand	21.16
Khliehriat	86.87	8.08	5.05	Loamy Sand	8.90

Kynroh	84.43	8.28	7.29	Loamy Sand	34.60
Kynshi	75.34	14.39	9.27	Sandy loam	26.60
Laitkor	71.90	17.70	10.40	Loamy Sand	32.50
Lynniiong	86.70	4.09	9.21	Loamy Sand	20.70
Mawdiangdiang	82.68	14.35	3.07	Loamy Sand	17.80
Mawiong (EKH)	72.59	22.33	5.08	Loamy Sand	13.60
Mawlangkhar	72.19	26.75	1.06	Loamy Sand	28.20
Mawlieh	80.49	10.26	9.25	Loamy Sand	24.70
Mawliehpoh	74.49	20.39	5.12	Loamy Sand	19.30
Mawlyndep	84.68	8.16	7.16	Loamy Sand	19.40
Mawlyngot	63.38	24.47	7.15	Sandy loam	18.90
Mawmaram	65.88	24.79	9.33	Sandy loam	32.00
Mawphlang	82.62	15.25	12.13	Sandy loam	34.50
Mawryngkneng	86.80	12.17	1.03	Sandy	14.10
Mawsmi	69.90	16.60	13.50	Sandy loam	5.60
Mawsynram	78.86	18.11	3.03	Loamy Sand	7.60
Mih-myntdu	94.97	2.01	3.02	Sandy	5.20
Muswang	82.92	6.16	11.32	Loamy sand	25.80
Mysang	74.06	14.51	11.43	Sandy loam	34.80
Mysyngat	77.55	19.14	3.31	Loamy sand	19.15
Nongkrem	87.60	7.20	5.20	Loamy Sand	52.90
Nongriat	68.47	28.46	3.07	Sandy loam	16.20
Nongrim Sadew	90.22	6.58	3.20	Sandy	34.50
Nongstoin	84.58	14.37	1.05	Loamy Sand	25.80
Pambriew	88.68	4.11	7.21	Sandy	25.70
Pariong	78.63	17.61	3.75	Loamy sand	17.90
Phlangwanbroi	96.98	2.01	1.01	Sandy	5.70
Pongtung	88.99	10.01	1.00	Loamy Sand	10.00
Pynursla	92.96	6.03	1.01	Sandy	4.40
Raliang	81.19	12.74	6.07	Loamy Sand	31.00
Rambrai	78.54	12.25	9.21	Loamy Sand	20.60
Rangblang Sohsynniang	86.77	10.16	3.07	Sandy	16.30
Risiang	93.93	3.03	3.04	Sandy	11.00
Shillong	76.33	18.50	5.17	Loamy Sand	17.50
Sohra-rim	77.95	10.05	12.00	Loamy Sand	30.20
Sohryngkham	88.64	8.24	3.12	Sandy	29.10
Sutnga	88.63	10.31	1.06	Sandy	30.00
Swer	78.05	20.86	1.08	Loamy Sand	41.60
Ummulong	80.64	12.22	7.14	Loamy Sand	17.50
Umsaw (EKH)	78.74	18.21	3.05	Loamy Sand	11.50
Umsaw (WKH)	96.94	2.03	1.03	Sandy	14.90
Wahkaji	74.60	22.34	3.06	Loamy Sand	15.00
Weiloi	72.77	24.20	3.03	Loamy Sand	8.20
Mean (\pmSE)	81.2 \pm 1.2	13.6 \pm 1.0	5.2 \pm 0.5	Loamy Sand	20.8\pm1.4

Soil chemical characteristics

Panax pseudoginseng

In the areas where *Panax* was growing the Soil pH ranged between 4.5 – 4.8, Soil Organic Carbon ranged between 5.5% - 5.7%. Total Kjeldahl Nitrogen ranged between 0.10% – 0.43%. Available Phosphorus ranged between 7.3µg/g – 12.9µg/g and Potassium between 11.0ppm – 19.5ppm (Table 8.5).

Monotropa uniflora

In the areas where *Monotropa* was growing the Soil pH ranged between 4.37 – 4.69, Soil Organic Carbon ranged between 5.5% - 5.7% Total Kjeldahl Nitrogen ranged between 0.1% – 0.4%, available Phosphorus between 1.2µg/g – 12.0µg/g and Potassium between 3.7ppm – 19.5ppm (Table 5.5).

Osbeckia capitata

In the areas where *Osbeckia* was growing the Soil pH ranged between 2.5 – 5.9, Soil Organic Carbon ranged between 0.1% - 5.7%. Total Kjeldahl Nitrogen ranged between 0.02% – 0.3%, available Phosphorus between 0.9µg/g – 21.0µg/g and Potassium ranged between 1.0ppm – 110.7ppm (Table 5.5).

Table 5.5: Soil chemical characteristics in (a) *Panax pseudoginseng*, (b) *Monotropa uniflora* and (c) *Osbeckia capitata*.

Locations	pH	SOC (%)	TKN (%)	P (µg/g)	K (ppm)
<i>Monotropa uniflora</i>					
Laitkor	4.69	5.66	0.15	7.25	19.48
Mawphlang	4.51	5.65	0.43	10.50	10.95
Sutnga	4.55	5.54	0.13	1.20	3.68
Sohra-rim	4.44	5.61	0.08	6.00	17.60
13th mile	4.37	5.55	0.07	2.98	9.70
Lum Shillong	4.67	5.53	0.25	12.01	12.85
Laitkseh	4.48	5.50	0.12	7.26	10.08
Mean (±SE)	4.5 ± 0.1	5.6 ± 0.1	0.2 ± 0.1	6.7 ± 1.5	12.1 ± 2.0

<i>Panax pseudoginseng</i>					
Laitkor	4.69	5.66	0.15	7.25	19.48
Mawphlang	4.55	5.54	0.13	8.20	13.68
Nongkrem	4.51	5.65	0.43	10.50	10.95
Laitryngew	4.61	5.57	0.10	9.50	17.83
7th Mile	4.50	5.57	0.24	11.10	13.60
Lum Shillong	4.67	5.53	0.25	12.01	12.85
Mean (±SE)	4.6 ± 0.1	5.6 ± 0.1	0.2 ± 0.1	10.2 ± 0.8	14.4 ± 1.2
<i>Osbeckia capitata</i>					
Amlarem	4.79	1.27	0.08	2.50	18.80
Bapung	3.99	1.18	0.16	4.25	39.58
Domiasiat	5.17	1.19	0.25	1.75	12.95
Jakrem	5.11	1.82	0.11	0.96	31.99
Jarait	4.66	5.60	0.19	3.25	10.00
Jatah Lakadong	4.94	0.11	0.03	4.25	0.98
Jongsha	4.74	0.32	0.04	4.50	27.58
Jowai	4.92	5.61	0.11	1.75	90.15
Kdohule	3.20	0.24	0.08	5.25	13.33
Khathynniew mer	4.23	2.40	0.06	4.19	37.94
Khliehriat	5.05	0.48	0.04	3.75	26.15
Kynroh	5.93	1.19	0.15	10.00	19.50
Kynshi	3.91	1.11	0.13	4.75	14.68
Laitkor	5.01	1.85	0.12	6.85	15.62
Lynniong	5.27	1.14	0.10	9.50	4.25
Mawdiangdiang	5.44	1.19	0.11	3.25	11.75
Mawiong (EKH)	5.42	0.30	0.04	2.50	110.70
Mawlangkhar	5.38	1.16	0.03	19.75	7.83
Mawlieh	5.27	1.19	0.10	2.00	27.33
Mawliehpoh	5.54	1.16	0.17	4.25	6.60
Mawlyndep	5.19	1.11	0.10	6.00	7.50
Mawlyngot	5.50	0.41	0.06	1.75	3.68
Mawmaram	3.46	0.35	0.08	6.50	13.88
Mawphlang	3.85	1.25	0.11	8.56	8.36
Mawryngkneng	5.70	0.89	0.09	1.00	8.15
Mawsmai	5.90	0.87	0.13	9.84	1.90
Mawsynram	4.79	0.84	0.10	2.75	3.20
Mih-myntdu	5.02	0.81	0.02	1.00	1.80
Muswang	5.21	1.19	0.14	4.75	57.00
Mynsang	3.27	1.27	0.10	9.00	14.05
Mynsyngat	5.12	0.85	0.11	1.46	28.72
Nongkrem	3.68	1.25	0.12	6.00	11.25
Nongriat	5.64	1.00	0.17	2.00	7.13
Nongrim Sadew	4.22	1.05	0.12	7.21	7.46
Nongstoin	3.63	1.14	0.08	6.00	10.70
Pambriew	5.52	1.11	0.12	2.75	1.20

Pariong	5.09	1.85	0.11	1.29	31.01
Phlangwanbroi	5.23	0.16	0.02	21.00	3.83
Pongtung	5.16	5.49	0.04	0.88	67.70
Pynursla	5.28	5.60	0.17	9.25	10.43
Raliang	2.49	2.21	0.19	7.05	23.04
Rambrai	5.56	0.78	0.10	3.25	16.83
Rangblang Sohsynniang	5.38	1.03	0.11	2.75	12.60
Risiang	5.80	0.32	0.02	7.50	10.45
Shillong	4.69	5.66	0.05	1.75	6.75
Sohra-rim	4.85	4.14	0.17	1.45	12.04
Sohryngkham	4.41	1.03	0.10	5.50	11.48
Sutnga	3.46	4.01	0.15	1.10	13.65
Swer	4.61	5.64	0.24	1.05	22.83
Ummulong	5.09	1.02	0.07	1.75	40.93
Umsaw (EKH)	4.67	0.70	0.05	1.75	109.60
Umsaw (WKH)	5.62	0.43	0.12	5.50	12.95
Wahkaji	5.52	0.89	0.09	4.75	12.20
Weiloi	5.09	0.51	0.10	2.00	7.80
Mean (±SE)	4.9 ± 0.1	1.6 ± 0.2	0.1 ± 0.1	4.7 ± 0.6	21.1 ± 3.3

Levins niche breadth

The relative utilization of four micro-environmental parameters by the three species revealed that *Monotropa uniflora* had the narrowest niche breadth for Relative humidity (1.29), Light intensity (1.00), Air temperature (1.29) and Soil temperature (1.00). *Panax pseudoginseng*, on the other hand, had an intermediate niche breadth for Relative humidity (1.41), Light intensity (1.00), Air temperature (1.41) and Soil temperature (2.00). *Osbeckia capitata* had the broadest niche breadth for all the environmental parameters (Table 5.6).

The relative utilization of four soil physical properties by the three species revealed that *Monotropa uniflora* had the narrowest niche breadth for Sand (2.1), Silt (2.1) and SMC (2.9). On the other hand, *Osbeckia capitata*, had the broadest niche breadth. *Panax pseudoginseng* occupied an intermediate niche breadth (Table 5.7).

The relative utilization of five soil chemical properties by the three species revealed that *Monotropa uniflora* had the narrowest niche breadth. *Panax pseudoginseng*, on the other hand, occupied an intermediate niche breadth while, *Osbeckia capitata* had the broadest niche breadth (Table 5.8).

Metapopulation size

The Metapopulation size was highest in the month of September in the case of all three species *i.e.*, during rainy season. The graph depicts the growth in the size of the Metapopulation from recruitment of new individuals into the subpopulation to death of all individuals. The Metapopulation size at first increases and peaks at one point (July to October), after which there is a decline as the individuals start to die (Figure 5.1).

Regeneration constraint

Seed production and Seedling recruitment

The average annual seed production in *Osbeckia capitata* was 4289 per population with an annual average number of 36 adult individuals. An annual average of 69 adult individuals in the case of *Monotropa uniflora* produced an average 17,011 seeds per population. In *Panax pseudoginseng*, the average annual seed production was 3308 per population with an annual average number of 50 adult individuals (Table 5.9).

The average annual seedling recruitment was very low in all the three species. In *Panax pseudoginseng*, the average annual seedling recruitment was 12 (0.36%) per population. In case of *Monotropa uniflora* and *Osbeckia capitata*, the average annual seedling recruitment was 25 (0.15%) and 10 (0.22%) respectively (Table 5.9).

Table 5.6: Resource matrix for different micro-environmental parameter.

Air temperature (°C)	<i>Monotropa uniflora</i>	<i>Panax pseudoginseng</i>	<i>Osbeckia capitata</i>
0-5	0.0	0.0	0.0
5-10	0.0	0.0	0.0
10-15	0.0	0.0	3.0
15-20	12.0	11.9	25.8
20-25	88.0	88.1	57.0
25-30	0.0	0.0	14.3
Levins Niche Breadth	1.3	1.4	5.7
Relative Humidity (%)			
10-20	0.0	0.0	9.0
20-30	0.0	0.0	9.0
30-40	0.0	0.0	41.0
40-50	0.0	0.0	41.0
50-60	0.0	0.0	29.4
60-70	17.0	0.0	15.4
70-80	0.0	13.0	7.8
80-90	83.0	87.0	10.8
90-100	0.0	0.0	5.7
Levins Niche Breadth	1.3	1.4	5.7
Light intensity (Lux)			
0-10	100.0	100.0	15.4
10-20	0.0	0.0	2.2
20-30	0.0	0.0	12.1
30-40	0.0	0.0	23.5
40-50	0.0	0.0	16.0
50-60	0.0	0.0	5.1
60-70	0.0	0.0	15.3
70-80	0.0	0.0	1.1
80-90	0.0	0.0	3.7
90-100	0.0	0.0	2.4
100-110	0.0	0.0	3.3
Levins Niche Breadth	1.0	1.0	6.7
Soil temperature (°C)			
0-5	0.0	0.0	0.0
0-10	0.0	0.0	9.0
10-15	0.0	0.0	9.0
15-20	48.0	100.0	41.0
20-25	52.0	0.0	41.0
Levins Niche Breadth	1.0	2.0	2.8

Table 5.7: Resource matrix for different soil physical characteristics.

Sand (%)	<i>Monotropa uniflora</i>	<i>Panax pseudoginseng</i>	<i>Osbeckia capitata</i>
0-10	0	0	0
10-20	0	0	0
20-30	0	0	0
30-40	0	0	0
40-50	0	0	0
50-60	0	0	0
60-70	0	0	9
70-80	29	24	31
80-90	58	63	45
90-100	13	13	14
Levins Niche Breadth	2.1	2.28	3.01
Silt (%)			
0-5	13	13	15
5-10	44	63	18
10-15	14	0	35
15-20	29	24	10
20-25	0	0	16
25-30	0	0	4
30-35	0	0	2
Levins Niche Breadth	2.1	3.15	4.62
Clay (%)			
0-3	13	13	22
3-6	12	12	41
6-9	39	37	14
9-12	23	39	21
12-15	13	0	2
Levins Niche Breadth	3.18	3.96	3.52
SMC (%)			
0-10	0	0	14
10-20	0	0	36
20-30	0	0	29
30-40	0	25	18
40-50	49	51	1
50-60	39	12	2
60-70	13	13	0
Levins Niche Breadth	2.88	2.48	3.78

Table 5.8: Resource matrix for different soil chemical characteristics.

pH	<i>Monotropa uniflora</i>	<i>Panax pseudoginseng</i>	<i>Osbeckia capitata</i>
0-1	0.0	0.0	0.0
1-2	0.0	0.0	0.0
2-3	0.0	0.0	2.0
3-4	0.0	0.0	17.0
4-5	100.0	100.0	28.0
5-6	0.0	0.0	53.0
Levins Niche Breadth	1.0	1.0	2.6
TKN (%)			
0.0-0.5	100.0	100.0	20.0
0.5-0.10	0.0	0.0	36.0
0.10-0.15	0.0	0.0	27.0
0.15-0.20	0.0	0.0	13.0
0.20-0.25	0.0	0.0	4.0
Levins Niche Breadth	1.0	1.0	3.8
SOC (%)			
0-1	0.0	0.0	33.0
1-2	0.0	0.0	45.0
2-3	0.0	0.0	8.0
3-4	0.0	0.0	0.0
4-5	0.0	0.0	4.0
5-6	100.0	100.0	10.0
Levins Niche Breadth	1.0	1.0	3.0
P (µg/g)			
0-5	31.0	0.0	64.0
5-10	33.0	32.0	32.0
10-15	36.0	68.0	0.0
15-20	0.0	0.0	2.0
20-25	0.0	0.0	2.0
Levins Niche Breadth	1.8	3.0	2.0
K (ppm)			
0-10	31.0	0.0	35.0
10-20	69.0	100.0	43.0
20-30	0.0	0.0	9.0
30-40	0.0	0.0	2.0
40-50	0.0	0.0	2.0
50-60	0.0	0.0	2.0
60-70	0.0	0.0	2.0
70-80	0.0	0.0	0.0
80-90	0.0	0.0	0.0
90-100	0.0	0.0	2.0
100-110	0.0	0.0	1.0
110-120	0.0	0.0	2.0
Levins Niche Breadth	1.0	1.8	3.1

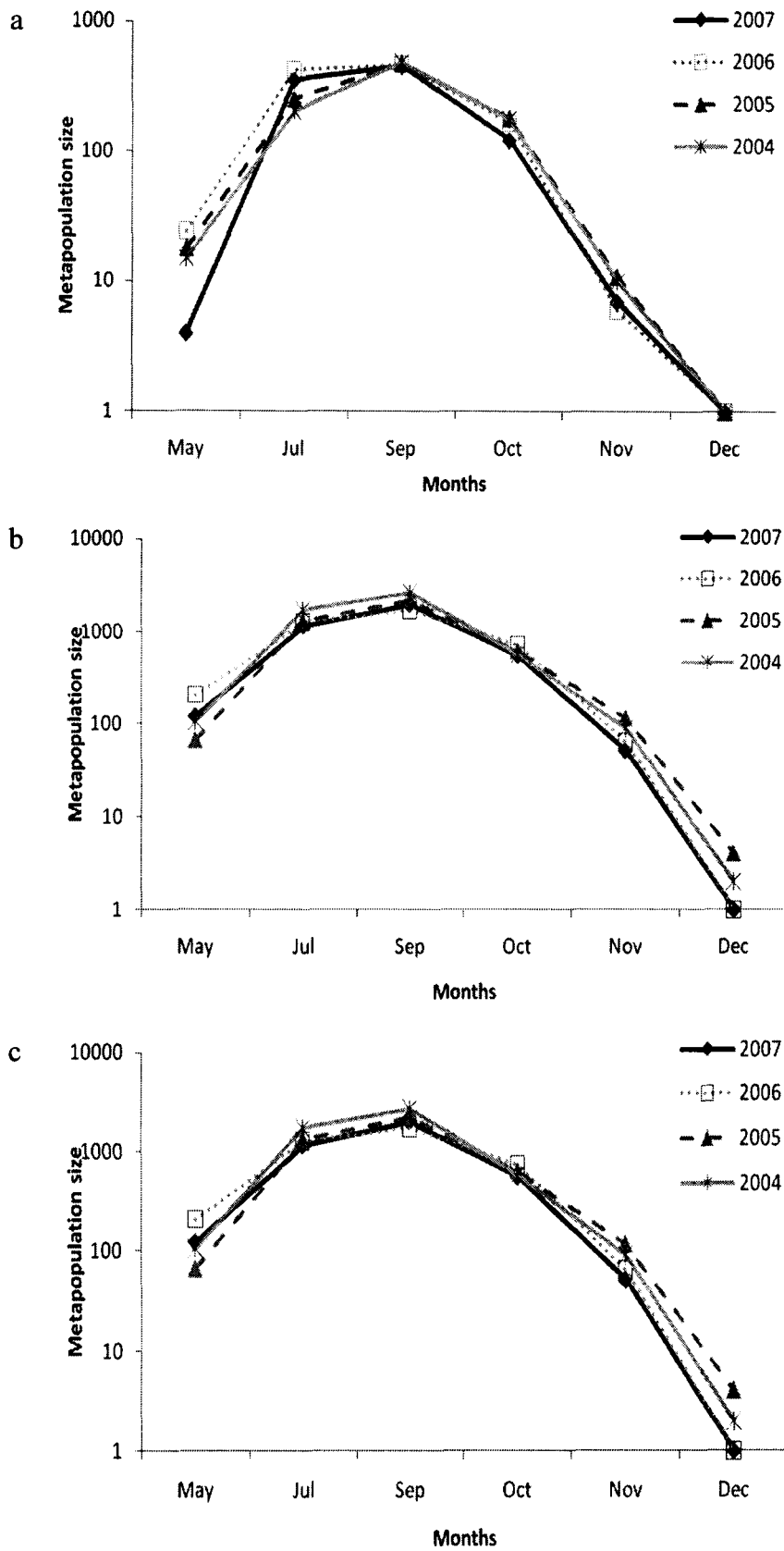


Fig 5.1: Change in metapopulation size of a) *Monotropa uniflora*, b) *Panax pseudoginseng* and c) *Osbeckia capitata*.

Table 5.9: Mean annual seed production and seedling recruitment.

Species	Year	Total number of population (n)	Average annual per population		
			Adults	Seed production	Seedling recruitment
<i>Monotropa uniflora</i>	1 st	7	74	18292	30
	2 nd		85	21053	25
	3 rd		76	18808	31
	4 th		40	9889	15
	Mean (±SE)		69 ± 9.9	17011 ± 2448	25 ± 3.7
<i>Panax pseudoginseng</i>	1 st	54	51	3395	14
	2 nd		57	3858	12
	3 rd		47	3079	10
	4 th		44	2901	11
	Mean (±SE)		50 ± 2.8	3308 ± 209	12 ± 0.9
<i>Osbeckia capitata</i>	1 st	54	38	4589	13
	2 nd		34	4056	11
	3 rd		35	4257	9
	4 th		35	4254	7
	Mean (±SE)		36 ± 0.9	4289 ± 110	10 ± 1.3

Discussion

The local inhabitants and local traditional healers harvest the rhizomes of *Panax pseudoginseng* and the entire plant of *Osbeckia capitata* in a faulty manner that kills the whole plant. In *Panax pseudoginseng*, the rhizomes are harvested only during specific months and only at the time of flowering and fruiting. *Osbeckia capitata* is also collected during the flowering season. Such a harvesting pattern and time does not permit the species to reproduce before it is extracted, thereby reducing the population drastically.

The significant variation in extraction rate among the populations revealed the role of site characteristics in determining the extraction level. The most important site characteristic in this regard for the species was accessibility and vicinity to the villages.

Some plant species are more specialized than others in their resource needs. The niche breadth attempts to measure this quantitatively. The niche breadth of the three species revealed that *Osbeckia capitata* had a wide range of habitat preferences then *Monotropa uniflora* and *Panax pseudoginseng*. This implies that *Osbeckia capitata* will

have a wide range of habitat preferences. Thus, *Monotropa uniflora* had the narrowest niche breadth for all the microenvironmental parameters than *Panax pseudoginseng* and *Osbeckia capitata*. *Osbeckia capitata* had the broadest niche breadth.

The metapopulation size of all the three species showed a maximum during the month from July to October *i.e.*, during rainy season, with a peak during the month of September.

Thus, extraction of plants, regeneration constraints and narrow ecological niche of *Osbeckia capitata* and *Panax pseudoginseng* are the causes of rarity. Narrow ecological niche, regeneration constraints due to shrinking safe sites and poor germination are the causes of rarity for *Monotropa uniflora*.

Some authors have argued that over-exploitation is a more selective threat to species survival than is habitat loss. This is so because habitat loss is a threat to a wide range of taxa, and may not be focused on one species, while over-exploitation selectively poses problems to targeted taxa (Reid & Miller 1989) such as medicinal plants, orchids and timber trees. *Osbeckia capitata* and *Panax pseudoginseng* have been the target of such a threat of over-exploitation, coupled with low regeneration which has seriously jeopardized their survival chances.

ASSESSMENT OF THREAT STATUS AND CONSERVATION RANKING

Introduction

Resource conservation is the management of a particular resource so that it may yield the greatest sustainable benefit to present generation. In order to conserve the medicinal plant resources, efforts have been made by various national and international agencies to formulate appropriate strategies. Goals for biodiversity conservation has been set in the world conservation strategy, which are: i) maintenance of essential ecological processes and life support systems on which human survival and economic activities depend, ii) Preservation of species and genetic diversity and iii) Sustainable use of species and ecosystems, which support millions of rural communities as well as major industries.

In order to make conservation efforts more efficient, it is required to identify species that face extinction. The International Union for the Conservation of Nature and Natural Resources (IUCN) has attempted to list species that are threatened globally. The criteria used to define the categories of threatened species change with new information and the lists of threatened species are accordingly upgraded by the IUCN. The Red List of Threatened Plants (Walter and Gillett 1998) is the most recent attempt to inventory the threatened plant species of the World.

The Red Data Book of Indian Plants (RDB), published by the Botanical Survey of India (Nayar and Sastry 1987; 1988; 1990), focuses exclusively on the Indian flora, more precisely on threatened angiosperms, gymnosperms and pteridophytes. However, the Red Data Book is incomplete and several more species need to be incorporated to the list, as

increasing number of new species populations are being continuously pushed into the verge of extinction.

The non-availability of data on the population of rare species in nature has been a major bottle neck in correct categorization of the species in the *Red Data Book*. Therefore, till recently the categorization has largely dependent on the herbarium records only. In order to make the categorization more realistic, assessment of a few species was undertaken through Conservation Assessment and Management Plan (CAMP) workshops, where data on certain aspects of the species were collated involving multi-disciplinary experts. Yet the hurdle of data deficiency could not be overcome for several species while assigning the threat category to the selected rare species (Kala 2000). Therefore, there is a need to devise a workable protocol for the survey and data analysis pertaining to the threatened species, so that correct conservation status can be assigned to the species. In this chapter, an attempt has been made to develop a protocol for categorization of species based on certain criteria followed globally. Following the protocol so developed, data for the three study species have been collected and threat status has been assigned to each species.

Methods

In order to assess the rarity of *Panax pseudoginseng*, *Monotropa uniflora* and *Osbeckia capitata*, the data were collected over a period of four years. The changes in the number of individuals within a population, fluctuations in the number of populations, and in the geographic range-sizes of the species were monitored.

Population inventory and monitoring

The protocol for field survey was developed to describe the habitats associated with the occurrence of the TES populations. The detailed methods for survey and inventory are:

- Information about potential sites of occurrence: The information on the sites where the species are likely to be encountered was collected from the available literature and from the local people.
- Field survey: Field searches were conducted during the active growth season of each species.
- Population dynamics: The species populations were monitored regularly at 3 months interval beginning from August, 2004 for a period of four years to detect changes in their population size, associated vegetation and habitat.

Assessing Rarity

CDC Rarity Ranking (CDC, 2003)

In order to assign a status rank to a particular species, ten factors were considered and a letter from A to D was assigned to each factor for which there was enough information. A species with all As was ranked S1 whereas a species with all Ds received a S5. Where there was a mixture of letter ranks, the person doing the ranking must use judgment to decide how much weight should be given to certain factors, depending on the species in question. Therefore, each letter was assigned different weights as follows:

A = 1; B = 0.75; C = 0.50; D = 0.25 and U = 0

S1 = 0.80 – 1; S2 = 0.60 – 0.80; S3 = 0.40 – 0.60; S4 = 0.20 – 0.40 and S5 = <0.20

A status rank (S₁ to S₅) was assigned following the Sub-national rank (S-rank) adopted by Atlantic Canada Conservation Data Centre (CDC, 2003) based on the following 10 factors each on a scale from A to D:

- I) *Number of Element Occurrences (Eos)*: An "element occurrence" is generally defined as an area of land or water on which an "element of biodiversity" (plant and animal species or natural community) is or was present. It is a physical location important to the conservation of a species or community, an area worth preserving to ensure the survival of a community or species at risk. For a species it is generally the habitat occupied by a local population, for a community it is the area containing a stand or patch.
- II) *Provincial Abundance*: Abundance is measured in different ways depending on the biology of the species. For plant populations it may be measured by the area occupied by a distinct population.
- III) *Provincial Range*: Denotes the approximate range of the species as a percentage of the province's area. It is defined as the current area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or projected sites of occurrence, but, excluding significant areas where the species does not occur due to unsuitable habitat.
- IV) *Population Abundance Trend*: Population Abundance Trend is an estimate of the change in the number of mature individuals over time, from long term monitoring data and historical accounts, where available. Natural fluctuations will not normally count as part of a decline. An observed decline should not be considered as part of a natural fluctuation unless there is evidence for this.

- V) *Distribution Trend*: The trend in the species' distribution over its provincial range.
- VI) *Number of Protected Element Occurrences*: The estimated number of adequately protected occurrences of the species in the province.
- VII) *Threats to Population*: Threats to population include observed, inferred or projected, such as, 1) direct exploitation, 2) harassment, or 3) ecological interactions with predators, competitors, pathogens or parasites - which may result in population declines. Threats may arise from natural or man-made forces.
- VIII) *Threats to Habitat*: Threats to habitat include observed, inferred or projected habitat alterations (loss, conversion, degradation or fragmentation) that may result in population declines or loss of element occurrences.
- IX) *Environmental Specificity*: The degree of environmental specificity associated with the element.
- X) *Fragility or Sensitivity to Natural Factors*: Fragility indicates the intrinsic vulnerability of the Element to natural, external factors (e.g., fires, drought, storms, insect infestations, siltation etc.).

Other Considerations: Generally, these considerations will raise rather than lower the rank, e.g., "Never sexually reproduces" or "All occurrences are in developing farmland or suburbs".

IUCN Status Determination Protocol

The latest IUCN Red List - Categories and Criteria (Version 3.1, 2000) was used to assess the conservation status of the species. The detailed quantitative Criteria used for classification within the threatened categories (Section V) were used for the study.

- A) *Population reduction*: This measure is used to measure the reduction in population size of a particular species over a period of time (10 years/ 3 generations). This could be based either on direct observation, an index of abundance appropriate to the taxon, a decline in area of occupancy, extent of occurrence and/or quality of habitat, actual or potential levels of exploitation or the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
- B) *Geographic range*: Two of the most commonly applied and easily quantified measures are extent of occurrence (EEO) and area of occupancy (AOO) based on severely fragmented populations, continuing decline or extreme fluctuations in area, extent and/or quality of habitat, number of locations or subpopulations and number of mature individuals.
- C) *Population size*: This parameter is mainly based on the decline or fluctuations in number of mature individuals, mainly on their population structure.
- D) *Mature individuals*: This is done by counting the number of mature individuals in a population.
- E) *Quantitative analysis*: Probability of extinction in the wild in a given span of time is analysed for the species.

Categorization: The species are categorized based on the criteria (A-E) and sub criteria for Critically Endangered, Endangered and Vulnerable. There is a hierarchical alpha-numeric numbering system of the criteria and sub criteria. There are three such levels:

- The first level of hierarchy is indicated by the use of numbers (1-4),

- The second level of hierarchy is indicated by the use of the lower-case alphabet characters (a-e), and
- The third level of hierarchy is indicated by the use of the lower-case roman numerals (i-iv).

Extent of Occurrence (EOO) and Area of Occupancy (AOO)

EOO and AOO were delineated using the conservation assessment tools “cats.avx” an extension for ArcView 3.x, version 1.2. GIS Unit, developed by the Royal Botanic Gardens, Kew (Moat 2007).

This extension provides tools to produce rapid conservation assessments based on IUCN Categories and Criteria (IUCN 2001). Preliminary conservation assessments based on EOO, AOO, number of sub-populations and number of locations can be calculated either for single species. The software calculates a variety of measures relating to a species point distribution or multiple species through a batch process and outputs a preliminary threat rating based on the IUCN Categories and Criteria.

EOO (Extent of Occurrence): The convex hull or minimum convex polygon, used to define EOO, is a line drawn around all distribution points with no internal angle exceeding 180°. This is the same as imagining an elastic band being pulled over all the points. The value reported for EOO is the area within the black line and is measured in km². The convex hull can only be drawn when there are at least three unique distribution points or localities.

EOO rating: The EOO rating is based on the values as listed under the IUCN Categories

and Criteria Version 3.1 (IUCN, 2001). The area value for EOO calculated above is compared with the thresholds set in Criterion B1 and the relevant rating is obtained (Table 6.1).

Table 6.1: The threshold EOO values and respective ratings for various threat categories under IUCN.

EOO (km²)	Rating
<100	Critically Endangered
<5000	Endangered
<20,000	Vulnerable
<45,000	Near Threatened

It should be noted that the category of Near Threatened does not have a threshold in the IUCN Criteria.

EOO Max Diameter: This is the maximum diameter or the longest axis across the EOO convex hull. The distance is measured in kilometer and is used to calculate the sliding scale AOO cell width for calculating Area of Occupancy.

AOO (Area of Occupancy) Cell width (sliding scale): The width of the cell is reported in kilometer. The sliding scale cell width is generated using EOO Max Diameter as follows:

$$\text{Sliding scale AOO cell width} = \text{EOO Max Diameter (longest axis)} / 10$$

AOO Number of cells: This is the number of cells containing at least one point *i.e.* occupied.

AOO Area: In the figure 6.1, 6.2, 6.3 and 6.4 the red cells show ‘occupied’ cells and represent AOO, area being expressed in km². The AOO calculation is done based on the following formula:

$$\text{AOO} = \text{number of occupied cells} * \text{area of individual cell}$$

AOO rating: Like EOO, the AOO rating is based on the values as listed under the IUCN Categories and Criteria Version 3.1 (IUCN, 2001). The area value for AOO is compared with the thresholds set in the Criterion B2 and the relevant rating is obtained:

Table 6.2: The threshold AOO values and respective ratings for various threat categories under IUCN.

AOO (km²)	Rating
<10	Critically Endangered
<500	Endangered
<2,000	Vulnerable
<4,500	Near Threatened

The threshold value for Near Threatened is based on the relationship between the AOO values for CR, EN and VU as was obtained in case of EOO.

Estimating Sub-populations

Two methods were used to estimate the sub-populations viz., Grid Adjacency and Rapoport's mean propinquity method (Willis *et al.* 2003; Rapoport 1982).

Estimating subpopulations

Grid Adjacency

AOO Subpopulations: Grid adjacency is one of the two techniques used to define subpopulations. All contiguous grid cells from the AOO calculations are considered to be one subpopulation and thus, the count of subpopulations is obtained.

AOO Density: The AOO density value is a measure to describe the density of the point distribution. The value is calculated as the number of AOO subpopulations divided by the number of AOO cells. A value between 0 and 1 is awarded where 0 is sparsely occupied *i.e.* all AOO cells are isolated and 1 is densely occupied *i.e.* all cells are contiguous.

$$\mathbf{AOO\ Density = 1 - (AOO\ Subpopulations/AOO\ Number\ of\ cells)}$$

Rapoport's mean propinquity method

Rapoport area: the area represented by the Rapoport subpopulations, *i.e.* within the solid blue line, can be used as an additional measure of the species range. The area is measured in km².

Rapoport subpopulations: The estimation of subpopulations through Rapoport's mean propinquity method is based on the mean line length of a minimum spanning tree (MST), which is a set of lines that connects all points in the minimum possible distance. The MST is represented by the blue dashed line on species maps. Subpopulations are defined when the limb (line) distance is greater than twice the mean limb distance (Willis *et al.* 2003). The solid blue line is a buffer around all lines in the MST that are \leq twice the mean line length. The buffer distance is the mean line length from the MST. Isolated points are also buffered to the mean line length from the MST.

Results

Inventory and monitoring of populations

Monotropa uniflora and *Panax pseudoginseng* could only be located in very few pockets (7 and 6 locations respectively) at altitude ranging from 1125-1810 m a.s.l. and 1427-1917 m a.s.l. respectively. *Osbeckia capitata*, however, was found to occupy more varied type of habitats (54 locations) spreading over an area of 54 km² at altitude ranging from 770-1919 m a.s.l. The mean population size of *Monotropa uniflora* (110 ± 14.1) was greatest among the three species at the beginning of the study, followed by *Osbeckia capitata* (87 ± 2.9) and *Panax pseudoginseng* (72 ± 9.9). The mean population sizes declined over a period of four years for all the three species. However, the decline was highest in case of *Monotropa uniflora*, where the population size declined to 57 ± 15.0 in the year 2007 (Table 6.3).

Table 6.3: The basic population data for *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata* during four years of study.

Locations	2004	2005	2006	2007
<i>Monotropa uniflora</i>				
Laitkor	92	182	119	61
Mawphlang	97	104	123	75

Sutnga	134	125	88	88
Sohra-rim	59	75	71	0
Khathynniew mer	104	107	96	0
Lum Shillong	178	104	203	84
Laitkseh	103	110	70	88
Mean (\pmSE)	110 \pm 14.1	115 \pm 12.5	110 \pm 17.4	57 \pm 15.0
<i>Panax pseudoginseng</i>				
Laitkor	62	76	46	56
Mawphlang	58	56	57	37
Nongkrem	36	35	55	50
Laitryngew	84	84	84	72
Hynniew mer	104	85	72	45
Lum Shillong	85	83	89	71
Mean (\pmSE)	72 \pm 9.9	70 \pm 8.3	67 \pm 7.0	55 \pm 5.8
<i>Osbeckia capitata</i>				
Amlarem	110	108	77	68
Bapung	107	71	107	51
Domiasiat	107	102	86	84
Jakrem	111	106	95	90
Jaraifñ	101	96	95	87
Jatoh Lakadong	105	103	95	45
Jongsha	106	80	106	80
Jowai	95	93	94	79
Kdohule	65	60	71	61
Khathynniew mer	65	60	61	59
Khliehriat	79	70	77	66
Kynroh	124	76	86	77
Kynshi	110	95	87	68
Laitkor	88	95	79	77
Lynniong	117	73	87	81
Mawdiangdiang	127	86	86	81
Mawiong (EKH)	110	113	74	74
Mawlangkhar	117	122	123	122
Mawlieh	103	107	91	87
Mawliehpoh	113	120	113	109
Mawlyndep	122	65	97	67
Mawlyngot	65	60	61	59
Mawmaram	117	106	102	95
Mawphlang	124	121	124	121
Mawryngkneng	77	62	51	56
Mawsmai	71	78	77	63
Mawsynram	75	71	74	70
Mih-myntdu	65	60	61	59
Muswang	77	60	59	50
Mysang	65	60	71	61
Mysyngat	71	68	74	58
Nongkrem	77	60	59	50
Nongriat	69	74	69	63
Nongrim Sadew	80	72	89	53
Nongstoin	77	79	73	77
Pambriew	77	69	68	65
Pariong	69	84	76	56
Phlangwanbroi	89	79	87	68
Pongtung	80	73	78	71
Pynursla	80	77	77	76
Raliang	83	76	46	69

Rambrai	67	78	68	63
Rangblang Sohsynniang	69	73	74	67
Risiang	73	68	74	67
Shillong	72	61	65	64
Sohra-rim	75	70	67	73
Sohryngkham	68	59	75	59
Sutnga	73	58	79	73
Swer	67	77	65	62
Ummulong	74	72	68	69
Umsaw (EKH)	50	62	55	43
Umsaw (WKH)	60	68	74	58
Wahkaji	77	77	65	69
Weiloi	127	95	68	72
Mean (\pmSE)	87 \pm 2.9	80 \pm 2.5	79 \pm 2.3	70 \pm 2.2

Assessment of threat status

The major threats to the populations and habitats of *Panax pseudoginseng* were from unscientific exploitation by local health practitioners. Apart from local exploitation, the main threats to the species come from regular trampling, forest fire, urbanization, cultivation, land slide and soil erosion. On the other hand, mining and quarrying were the main reasons for the decrease in population of *Osbeckia capitata*. Trampling, fire, collection, urbanization, erosion, landslide, habitat destruction, cultivation, grazing were additional factors for species decline. Trampling and clearing of forest patches were the main threats for the population of *Monotropa uniflora*. Low regeneration capacity in the wild was another factor impacting the decline of all the species' populations.

Conservation ranking

The rarity assessment revealed that *Panax pseudoginseng* and *Monotropa uniflora* belong to the S-Rank S1 under the CDC categories that corresponds to Critically endangered (CR) category under the IUCN categories based on the criteria C2b, D and A3a, C2b respectively. *Osbeckia capitata* belongs to the S-Rank S3 under the CDC categories, however, when assessed through the IUCN categories the species was assigned the status of Endangered (EN) based on the criteria A3a, C2a, D (Table 6.4 and 6.5).

Table 6.4: Rank classification of *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata* the ranks as per the CDC ranking for four years.

Monotropa uniflora

CDC Category (4 years)	Criteria	Value	Code
Element Occurrences (Eos)	6-20	7	B
Provincial Abundance (ha)	<800	700-500	A
Provincial Range (%)	<10	7.4	B
Population Abundance Trend (%)	<50	45.9	A
Distribution Trend (%)	<50	16.7	A
Protected Eos	>1	3	C
Threats to Population (%)	<50	48.2	B
Threats to Habitat (%)	<50	16.7	B
Environmental Specificity	High	LI, AT, pH, SOC, TKN & K (B = 1.00)	A
Sensitivity to Natural Factors	Fragile	Collection, trampling, urbanization, cultivation, disruption of association, forest fire, land slide, soil erosion, Low regeneration capacity	A
S-rank	S-1		

Panax pseudoginseng

CDC Category (4 years)	Criteria	Value	Code
Element Occurrences (Eos)	6-20	6	B
Provincial Abundance (ha)	<800	600	A
Provincial Range (%)	<3	0.88	A
Population Abundance Trend (%)	<50	30.8	A
Distribution Trend (%)	Stable	0.88	C
Protected Eos	>1	4	C
Threats to Population (%)	<50	23.6	B
Threats to Habitat (%)	Unthreatened	0.88	D
Environmental Specificity	High	LI, pH, SOC & TKN (B = 1.00)	A
Sensitivity to Natural Factors	Fragile	Harvest, trampling, urbanization, cultivation, forest fire, land slide, soil erosion, Low regeneration capacity	A
S-rank	S-1		

Osbeckia capitata

CDC Category (4 years)	Criteria	Value	Code
Element Occurrences (Eos)	21-100	54	C
Provincial Abundance (ha)	4000-20,000	5400	C
Provincial Range (%)	>10	12.5	B
Population Abundance Trend (%)	<10	7.9	C
Distribution Trend (%)	Stable	100	C
Protected Eos	>1	2	C
Threats to Population (%)	<20	19.5	C
Threats to Habitat (%)	Stable	100	D
Environmental Specificity	Broad-scale	AT (B = 2.43), ST (B = 2.82), pH (B = 2.57) & P (B = 1.96)	C
Sensitivity to Natural Factors	Resistant	Mining, quarrying, Trampling, Fire, Collection, Urbanization, Grazing, Cultivation, Erosion, Landslide, Habitat destruction, Low regeneration capacity	C
S-rank	S-3		



Table 6.5: Classification of the ranks as per the IUCN ranking based on four years of study for *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

<i>Monotropa uniflora</i>		
IUCN Category	Criteria	Values
1. Reduction in Population Size	3. 80% in 10 yrs a) Density/m ²	48% in 4 yrs 5
C. Population Size <250 Mature Individuals	2. Decline in Number of Mature Individuals b) Extreme fluctuation in Mature Individuals	69 46% 69±19.77
IUCN Status		CR
<i>Panax pseudoginseng</i>		
IUCN Category	Criteria	Values
C. Population Size <250 Mature Individuals	2. Decline in Number of Mature Individuals b) Extreme fluctuation in Mature Individuals	48 31% 48±9.08
D. <50 Mature Individuals in all Subpopulation		48
IUCN Status		CR
<i>Osbeckia capitata</i>		
IUCN Category	Criteria	Values
A. Reduction in Population Size	3. 50% in 10 yrs a) Density/m ²	20% in 4 yrs 4 36
C. Population Size <250 Mature Individuals	2. Decline in Number of Mature Individuals a) Population Structure i) All subpopulation <250 Mature Individuals	8% 36
D. <250 Mature Individuals in all Subpopulation		36
IUCN Status		EN

Extent of Occurrence (EOO) and Area of Occupancy (AOO)

The black solid line is the convex hull also known as minimum convex polygon and represents Extent of Occurrence (EOO). The red cells represent ‘occupied’ areas or Area of Occupancy (AOO). Rapoport’s mean propinquity technique for subpopulations is displayed with blue lines where the solid blue line delimits subpopulations, the short dot-dash line represents connected points in the same population and the long dot-dash line shows the connection between isolated points *i.e.* different subpopulations (Figure 6.1 - 6.4). The EOO of *Monotropa uniflora* reduced from 1663.97 km² in 2004 to 332 km² in

2008. However, the EOO of *Osbeckia capitata* and *Panax pseudoginseng* was stable at 4237.08 km² and 196.64 km² respectively (Table 6.6).

The number of occupied cells of *Monotropa uniflora* was 5 throughout the study period with an Area of Occupancy or cell width of 10.78 km which reduced to 4.93 km at the end of the study period. However, the number of occupied cells of *Osbeckia capitata* and *Panax pseudoginseng* was stable at 29 (12.81 km) and 6 (3.87 km) respectively (Table 6.6).

The AOO of *Monotropa uniflora* reduced from 581.03 km² in 2004 to 121.31 km² in 2008. However, the AOO of *Osbeckia capitata* and *Panax pseudoginseng* was stable at 4755.35 km² and 89.93 km² respectively (Table 6.6).

Rapoport's Area and EOO Max Diameter for *Monotropa uniflora* was 5628.25 km² and 107.80 km respectively which reduced to 1680.47 km² and 49.26 km respectively. However, the Rapoport's Area and EOO Max Diameter of *Osbeckia capitata* and *Panax pseudoginseng* was stable at 4819.40 km² and 128.05 km respectively and 923.92 km² and 38.72 km respectively (Table 6.6).

Table 6.6: Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Species name	<i>Monotropa uniflora</i> 2004	<i>Monotropa uniflora</i> 2008	<i>Panax pseudoginseng</i>	<i>Osbeckia capitata</i>
Extent of Occurrence	1663.97	332.62	196.64	4237.08
EOO Rating	ENDANGERED (EN)	ENDANGERED (EN)	ENDANGERED (EN)	ENDANGERED (EN)
Area of Occupancy/Cell width/height (km)	10.78	4.93	3.87	12.81
Number of Cells	5	5	6	29
AOO in km ²	581.03	121.31	89.93	4755.35
AOO Subpopulations (Grid Adjacency)	3	3	4	1
AOO Density	0.400	0.400	0.333	0.966
AOO Rating	VULNERABLE (VU)	ENDANGERED (EN)	ENDANGERED (EN)	NEAR THREATENED (NT)
Rapoport's Area km ²	5628.25	1680.47	923.92	4819.40
EOO Max Diameter (km)	107.80	49.26	38.72	128.05

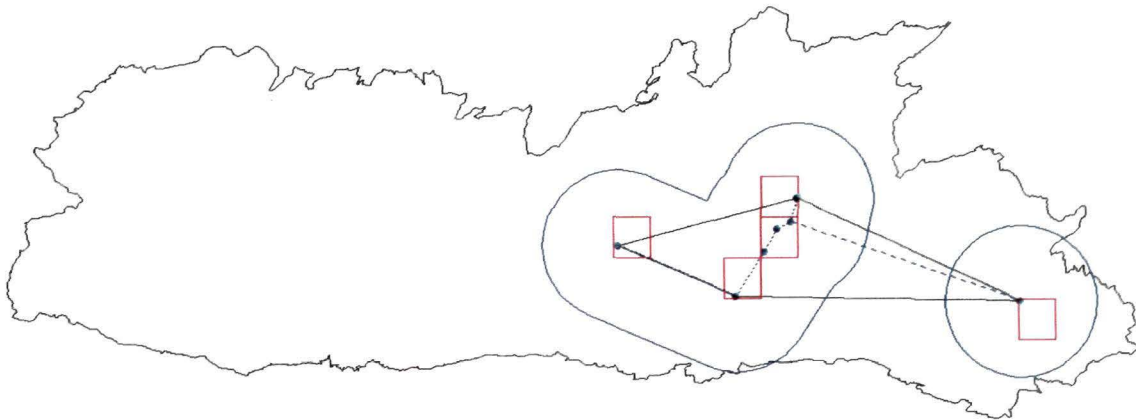


Fig 6.1: Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Monotropa uniflora* in 2004 in Meghalaya. The red cells represent the area of occupancy, the black solid lines represent extent of occurrence, the solid blue line delineates the subpopulations, the short dot dash line represents connected points in the same population and the long dot dash line shows the connections between different subpopulations.

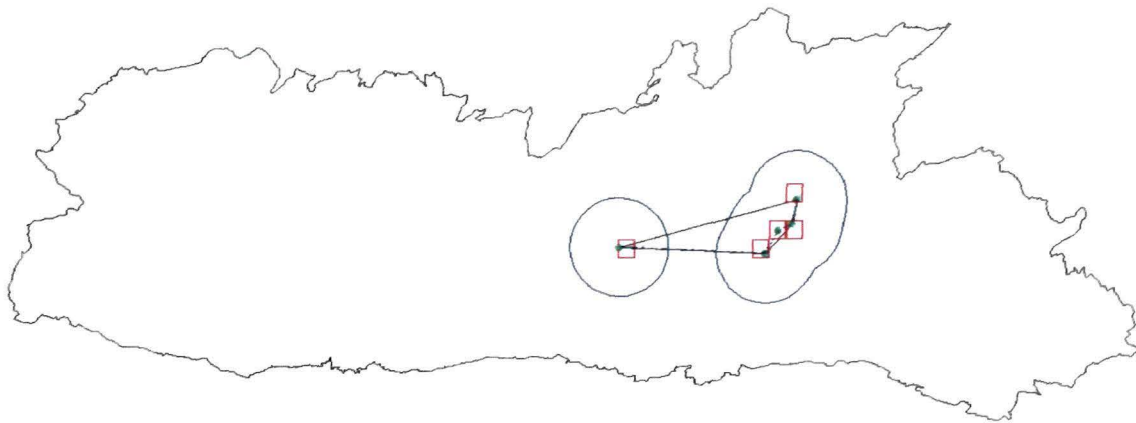


Fig 6.2: Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Monotropa uniflora* in 2008 in Meghalaya. The red cells represent the area of occupancy, the black solid lines represent extent of occurrence, the solid blue line delineates the subpopulations, the short dot dash line represents connected points in the same population and the long dot dash line shows the connections between different subpopulations.

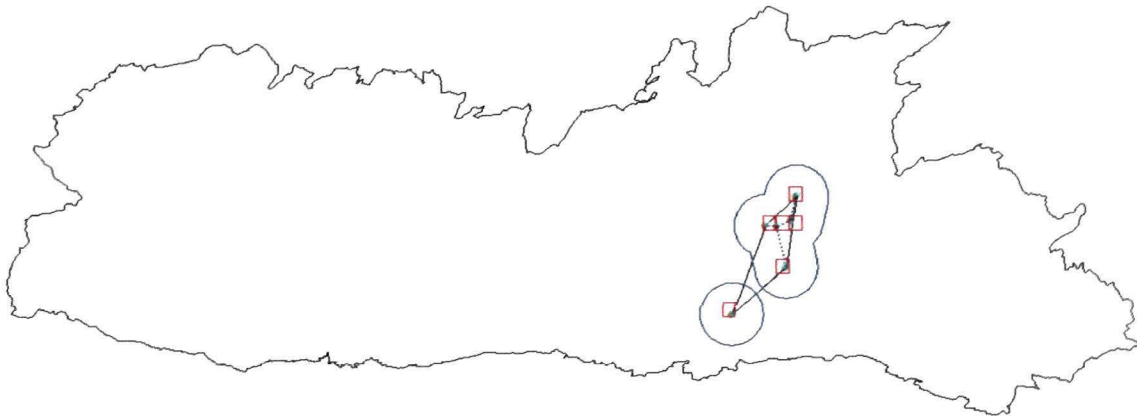


Fig 6.3: Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Panax pseudoginseng* in Meghalaya. The red cells represent the area of occupancy, the black solid lines represent extent of occurrence, the solid blue line delineates the subpopulations, the short dot dash line represents connected points in the same population and the long dot dash line shows the connections between different subpopulations.

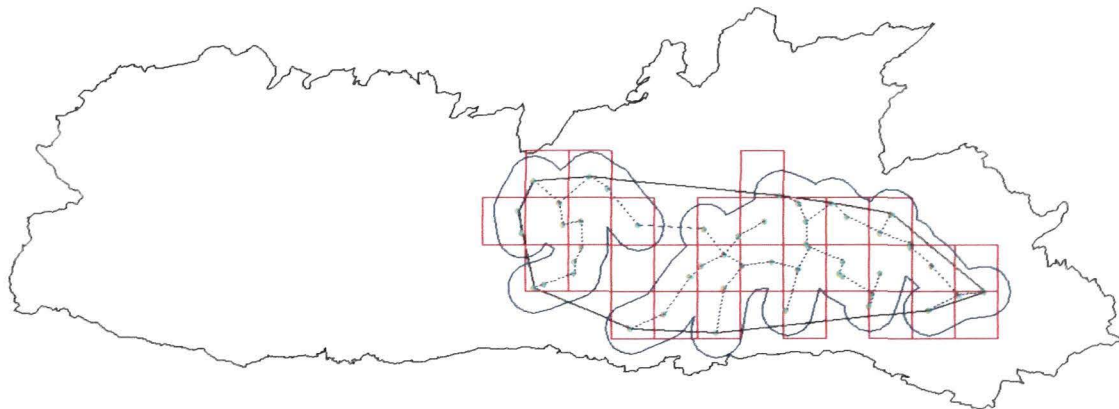


Fig 6.4: Extent of Occurrence (EOO) and Area of Occupancy (AOO) of *Osbeckia capitata* in Meghalaya. The red cells represent the area of occupancy, the black solid lines represent extent of occurrence, the solid blue line delineates the subpopulations, the short dot dash line represents connected points in the same population and the long dot dash line shows the connections between different subpopulations.

Table 6.7: Summary table of the threat status assigned to the three species under different methods. CDC: Atlantic Canada Conservation Data Centre, IUCN: International Union for Conservation of Nature and Natural resources, EOO: Extent of Occurrence and AOO: Area of Occupancy.

Species	Methodology adopted		“cats.avx” software ratings	
	CDC	IUCN		
			<i>EOO</i>	<i>AOO</i>
<i>Panax pseudoginseng</i>	S1	Critically Endangered	Endangered	Endangered
<i>Monotropa uniflora</i>	S1	Critically Endangered	Endangered	Near Threatened
<i>Osbeckia capitata</i>	S3	Endangered	Endangered	Endangered

Discussion

In the 1997 CAMP workshop, *Panax pseudoginseng* was assigned the status of Endangered (EN) according to the IUCN Category and Criteria. However, in the 1998 workshop the status was revised to Critically Endangered (CR). In the 2003 workshop the status remained the same. The results of the present study revealed that the species belonged to Critically Endangered (CR) category based on the population size and the number of matured individuals.

In accordance with the CDC Category and Criteria, threats affected 30.8% of the matured individuals of *Panax pseudoginseng* populations. There was an overall decline of 23.6% at the end of the study period. Narrow niche breadth of the species viz., Light intensity, pH, TKN and SOC alone or a combination of these factors are responsible for the species not being able to thrive in any other conditions. The Levins niche breadth calculated for all these parameters was around 1.00 justifying the narrow niche breadth of the species. Considering all the CDC Categories and Criteria, *Panax pseudoginseng* has been placed under the S-Rank “S-1”.

Monotropa uniflora, on the other hand, was never assessed following the IUCN Category and Criteria. However, Rao and Haridasan (1982 and 1983) have reported it to be “Extremely Rare” and “At Risk”. The results of the present study revealed that the

species was Critically Endangered (CR) based on population size and the number of matured individuals.

In accordance to the CDC Category and Criteria *Monotropa uniflora* showed an overall decline in the number of Element occurrences (7-5) and Provincial abundance (700ha-500ha). A decline in the Provincial Range (6.7%), Population Abundance Trend (45.9%) and Distribution Trend (16.7%) was also recorded at the end of the study period. Threats affected 48.2% of the population and 16.7% of the species habitat. Narrow niche breadth of the species viz., Light intensity, Soil temperature, pH, TKN, SOC and K alone or a combination of these factors are responsible for the species not being able to thrive in any other conditions. The Levins niche breadth “B” calculated for all these parameters was around 1.00 justifying the narrow niche breadth of the species. Considering all the CDC Category and Criteria, *Monotropa uniflora* has been placed under the S-Rank “S-1”.

Osbeckia capitata also was also never assessed according to the IUCN Category and Criteria. The results of the present study revealed that the species was Endangered (EN) based on the Reduction in population size and the number of mature individuals. The population size declined by 19.5% in four years. Similarly, there was a reduction in the number of mature individuals by 4.9% at the end of the study period suggests the status of EN for the species.

In accordance to the CDC Category and Criteria *Osbeckia capitata* showed an overall decline in the Population Abundance Trend (4.9%) at the end of the study period. Threats affected 19.5% of the population. Therefore, considering all the CDC Category and Criteria, *Osbeckia capitata* has been placed under the S-Rank “S-3”.

According to the conservation assessment tools “cats.avx”, the EOO rating for all three species was Endangered (EN). However, the AOO rating for *Monotropa uniflora* shifted from Vulnerable (VU) to Endangered (EN). Similarly, The AOO rating for *Panax pseudoginseng* was Endangered (EN). However, the AOO rating for *Osbeckia capitata* was Near Threatened (NT). Although, these various measures provide a good initial estimate of threat that can be used as a baseline status for the species for future monitoring.

The difference in the ranks in the IUCN and CDC methodologies can be attributed to the difference in the categories and criteria adopted by different groups of plant conservationists. This Red List Category has therefore, been standardized as S1, S2 and S3 corresponding to CR, EN and VU respectively.

MEDICINAL PLANT ENDEMISM IN MEGHALAYA

Introduction

Endemic species are those species, which are restricted to a particular geographical region or ecological unit. Endemism, therefore, signifies unique biodiversity. Endemics are categorized according to their (i) Spatial (Williams *et al.* 1993) distribution, (ii) inferred evolutionary age and affinities, and (iii) abundance. Engler (1882) provided one of the first classifications of endemics according to their evolutionary age and recognized Neoendemics and Paleoendemics. Later on, Favreger and Constandriopoulos (1961) provided a more rigorous basis for assessing the relative age and affinities of plant endemics based on cytological data. Four categories were recognized according to Taxonomic rank and Ploidy level, *viz.*, (i) Paleoendemics – ancient isolated taxa with a high ploidy level, whose diploid ancestors are extinct or unknown, (ii) Shizoendemics – vicariant species of equal ploidy level, resulting from either gradual or rapid divergence, (iii) Patroendemics – restricted diploid species that have spawned younger, widespread polyploid species, and (iv) Apoendemics – polyploid endemics that are derived from widespread species of a lower ploidy level. Shizoendemics, Patroendemics and Apoendemics are further sub-divisions of Neoendemics.

Endemism of species is considered as a key factor for prioritizing the species for conservation due to their restricted distribution. Of the 17,500 plant species present in India, about 5,725 are broadly considered as endemics. These represent 32.7% of the country's flora. India has three biodiversity hotspots, *viz.*, the Western Ghats, the Himalayas and Indo-Burma out of the total 34 hotspots in the world (Mittermeier *et al.*

2004). The Himalayas including Northeast India harbor 3,200 (40%) endemic plant species (Dhar 2002). Meghalaya, has 239 (31.3%) endemic plant species (Lakadong & Barik 2006). Besides endemism it is estimated that about 3000 species of flowering plants fall in one or the other category of threatened plants, which also include several medicinal plants. The Red Data Books (Nayar and Shastry 1988-90) has listed 623 species of which 550 are endemic including some valuable medicinal plants.

A number of studies on medicinal plants have been conducted by several workers in Meghalaya (Kumar *et al.* 1980; Rao and Neogi 1980; Joseph and Kharkongor 1981; Rao 1981a, b; Rao and Shanpru 1981; Kumar *et al.* 1987; Tripathi and Goel 2001; Prabhu 2004; Upadhaya *et al.* 2004) during the past two decades to document the ethnobotanical and medicinal plant wealth of the state. However, these studies are fragmentary. Many of the medicinal plants that were common a few years ago have now become rare. The present study was conducted to prepare an inventory of the medicinal plant resources of the state, identifying the threatened and endemic medicinal plant species. The areas rich in endemic medicinal plant species have also been identified for conservation.

Methods

A detail inventory of medicinal plant species present in the state of Meghalaya was prepared both through primary and secondary data. Primary data was collected from different parts of the state by conducting thorough field surveys at different seasons during the period 2003 – 2007. Secondary data on medicinal plants was collected through available literature (Kumar *et al.* 1980; Rao and Neogi 1980; Joseph and Kharkongor

1981; Rao 1981a, b; Rao and Shanpru 1981; Kumar *et al.* 1987; Tripathi and Goel 2001; Prabhu 2004; Upadhaya *et al.* 2004).

The distribution of threatened and endemic medicinal plant species was prepared through field visits. Field visits were made during the active growth season of the species.

Geographical Positioning System (GPS) was used to locate the exact location (latitudinal and longitudinal distribution) of endemic species restricted to Meghalaya. Further, based on the GPS readings, distribution of the species was mapped on a scaled-map of Meghalaya to determine the areas of concentration of the endemic medicinal plant species.

Global distribution of the selected species

In the present study the technique of ecological niche modeling was used to delineate the potential distributional area of *Osbeckia capitata* by following an empirical approach. This approach was used to confirm the endemism of the species. The other two species viz., *Panax pseudoginseng* and *Monotropa uniflora* were not included in the study because they are not endemic and have been reported from other parts of the world.

Results

Habit of the medicinal plant species

A total of 834 medicinal plant species were recorded in Meghalaya (Annexure 1). These included 266 (32%) herbs, 264 (32%) trees, 177 (21%) shrubs, 93 (11%) lianas and climbers, and 34 (4%) under shrubs (Figure 7.1). These species were distributed in 548 genera and 166 families. The family with the highest number of medicinal plant

species was Rubiaceae (27 genera and 40 species) followed by Asteraceae (27 genera and 36 species) and Fabaceae (22 genera and 29 species) (Figure 7.2).

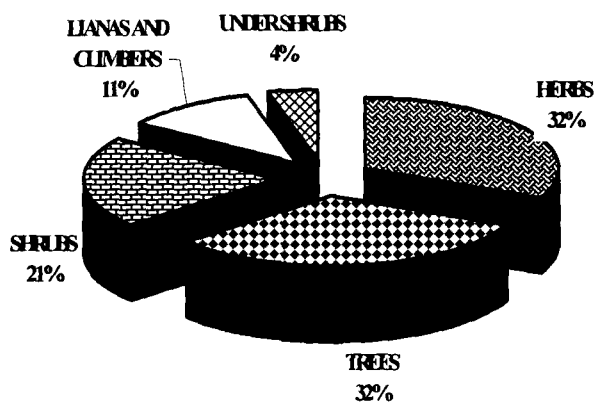


Fig 7.1: Distribution of the 834 medicinal plant species of Meghalaya over different habits.

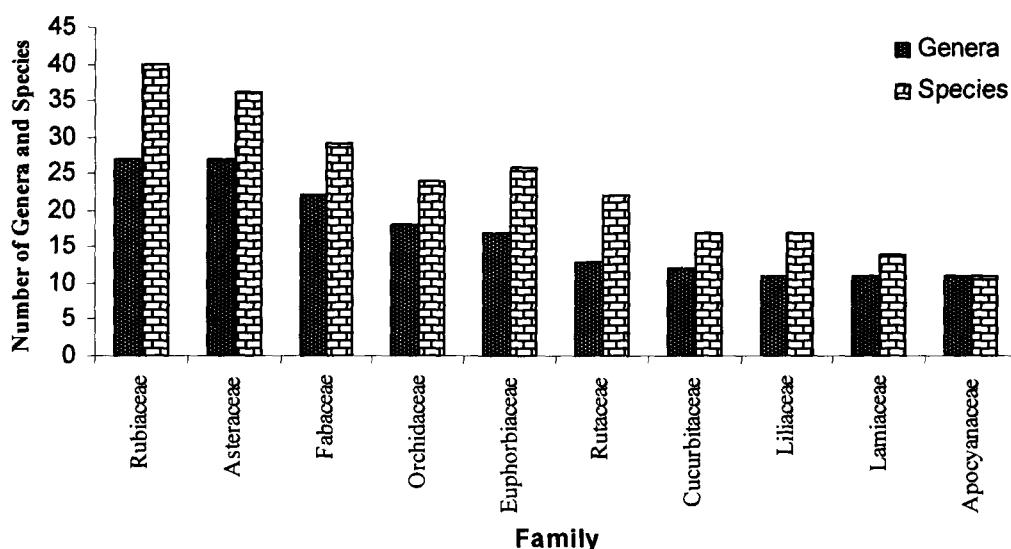


Fig 7.2: Distribution of medicinal plant species under ten dominant families.

Out of the 834 medicinal plant species recorded in Meghalaya, 37 were endemic either to Eastern Himalayas or Northeast India or Meghalaya. These comprised about 4.44% of the total species recorded in the present study. These species were distributed in 32 genera and 29 families. There were 16 (42%) trees, 10 (27%) herbs, 5 (14%) shrubs, 5 (14%) lianas and climbers and 1 (3%) under shrubs (Table 7.1, Figure 7.3). These species

were restricted mainly to sacred groves, community forests and reserved forests and some to grasslands, roadsides etc.

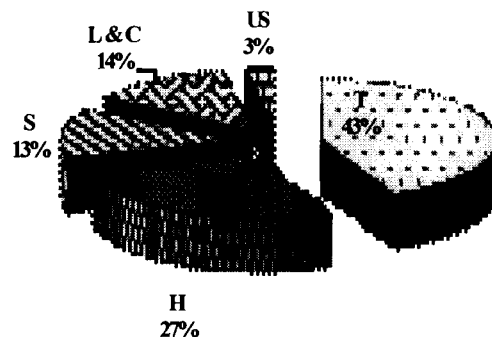


Fig. 7.3: Habit wise distribution of 37 endemic medicinal plant species found in Meghalaya.

Medicinal properties

Several common ailments were found to be treated by these endemic herbal medicines. For instance, 17 (26%) species were used for general types of diseases (fever, body aches, weakness, vomiting, etc.), 10 (14%) for various types of gastrointestinal problems and 10 (14%) for various kinds of gynaecological problems (Figure 5). Of these 37 endemic medicinal plant species, 5 species viz., *Citrus latipes*, *Hymenodictyon excelsum*, *Ophiorhiza subcapitata*, *Piper peepuloides*, and *Polygonum bistorta* are used for general fever, 4 species viz., *Calamus erectus*, *Munronia pinnata*, *Schima khasiana*, and *Xylosma longifolium* for stomachache, and 3 species each in dysentery (*Garcinia cowa*, *Grewia hirsuta* and *Piper griffithi*) and diarrhoea (*Grewia hirsuta*, *Piper griffithi* and *Polygonum bistorta*). There were 3 species that were used as antidote for snakebite viz., *Ochna squarrosa*, *Osbeckia capitata* and *Raphidophora decursiva* and 3 were used for diuresis viz., *Cocculus orbiculatus*, *Paramignya micrantha* and *Polygonum bistorta* (Table 7.1, Figure 7.4).

Table 7.1: List of 37 endemic medicinal plant species found in Meghalaya.

Species	Family	Common name(s)	Habit	Parts used	Ailments
<i>Aeschynanthus superba</i> Cl.	Gesneriaceae	Thylli Masi [K]	US	Bark	Fracture, muscular sprain.
<i>Boehmeria macrophylla</i> D. Don	Urticaceae	Dieng Sokhasim [K]	T	Root	Eczema, wounds.
<i>Calamus erectus</i> Roxb.	Arecaceae	Soh Thri [K]	S	Seed, Root	Indigestion, stomachache, malaria, body ache.
<i>Calamus floribundus</i> Griff.	Arecaceae	Soh Thri [K]	C	Root	Weakness.
<i>Camellia caduca</i> Cl. ex Brandis	Theaceae	Dieng Tyrmem [K]	T	Root	Skin diseases.
<i>Citrus aurantium</i> L.	Rutaceae	Soh Niamtra [K]	T	Leaves, Bark, Flower	Headache, sunstroke, laxative, urinary tract infections.
<i>Citrus latipes</i> Tanaka	Rutaceae	Soh Heh [J]	T	Fruit, Leaves	Body ache, vomiting, cold, fever.
<i>Citrus medica</i> L.	Rutaceae	Soh Manong [K], Dieng Soh Sarman [J]	S	Root, Fruit	Laxative, colic, flatulence, renal & vesical calculi, tumours, amenorrhagia, dysmenorrhagia.
<i>Cocculus orbiculatus</i> DC.	Menispermaceae	Jyrmi Mailum [K]	S	Root, Stem	Anodyne, antiphlogistic, carminative, diuretic, vermifuge, rheumatic arthritis, oedema, oliguria, antibacterial, anti-amoebic activity, asthma, bronchitis, paralysis.
<i>Curcuma montana</i> Roxb.	Zingiberaceae	Sying Syrmit [J]	H	Rhizome	Jaundice, increases lactation, body swellings.
<i>Cymbidium aloifolium</i> Sw.	Orchidaceae	-	Ep	Bulb	Blood coagulant for large bleeding wounds.
<i>Daphniphyllum himalense</i> Muell. – Arg.	Daphniphyllaceae	Dieng Synrangthuli [K]	T	Stem	Boils.
<i>Eleaegnus conferta</i> Roxb.	Eleaegnaceae	Soh Shang [K], Dieng Snlangi [J], Chhokhua [G]	S	Flower, Fruit	Sores, ulcers.
<i>Erythroxylum kunthianum</i> Wall. ex Kurz.	Erythroxylaceae	Dieng Painkhar [K]	T	Bark	Stimulant.
<i>Euonymus lawsonii</i> Cl. & Pr.	Celastraceae	-	T	Bark	Syphilis, indigestion, liver disorder.
<i>Garcinia cowa</i> Roxb. ex DC.	Clusiaceae	Rengran [G]	T	Fruit	Dysentery.
<i>Garcinia pedunculata</i> G. Don	Clusiaceae	Dieng Sohdanei [K]	T	Fruit	Urinary troubles.
<i>Goniothalamus simonosii</i> Hk. f. & Th.	Anonaceae	Kitoksam [G]	T	Fruit	Throat irritation.

<i>Grewia hirsuta</i> Vahl.	Tiliaceae	Soh Synting [K]	S	Fruit, Root	Diarrhoea, dysentery, wounds.
<i>Hedera nepalensis</i> K. Koch	Araliaceae	Pew Shrieh [K]	C	Whole plant	Antiseptic.
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	Dieng Dohlbongsyiar [K] Mibot [G]	T	Bark	Astringent, febrifuge.
<i>Ilex embeloides</i> Hk. f.	Aquifoliaceae	-	T	Bark, Root	Cold, cough, tuberculosis.
<i>Impatiens tripetala</i> Roxb.	Balsaminaceae	-	H	Root	Haematic.
<i>Mahonia pycnophylla</i> Takeda	Berberidaceae	Dieng Niangmat [K]	T	Leaves, Bark	Eye diseases.
<i>Munronia pinnata</i> Harms.	Meliaceae	Samskar [G]	US	Root	Stomachache, vomiting, loose motion.
<i>Nepenthes khasiana</i> Hk. f.	Nepenthaceae	Tiew Rakot [K]	S	Pitcher	Urinary troubles, stomach disorders, night blindness, skin diseases, leprosy.
<i>Ochna squarrosa</i> Planet	Ochnaceae	-	T	Leaves, Root, Bark	Snakebite, menstrual complaints, asthma emollient.
<i>Ophiorhiza subcapitata</i> Wall.	Rubiaceae	Samachik [G]	C	Root, Leaves	Fever, sore throat, tonsils, facial blemishes.
<i>Osbeckia capitata</i> Benth.	Melastomataceae	Soh Pythem [K]	H	Whole plant	Snakebite, muscle swellings.
<i>Paramignya micrantha</i> Kurth.	Rutaceae	-	S	Root	Diuretic
<i>Piper griffithi</i> C. DC.	Piperaceae	Pathi bri [J]	C	Leaves, Stem, Fruit	Stomach troubles, diarrhoea, dysentery.
<i>Piper peepuloides</i> Roxb.	Piperaceae	Beholisam [G]	US	Leaves, Bark	Fever, paralysis.
<i>Polygonum bistorta</i> L.	Polygonaceae	-	H	Rhizome	Diarrhoea, enteritis, bleeding hemorrhoids, gingivitis, febrifuge, diuretic.
<i>Raphidophora decursiva</i> Schott.	Araceae	Dawai Rarbek [J]	C	Rhizome	Snakebite.
<i>Schima khasiana</i> Dyer.	Theaceae	Dieng Ngan [K]	T	Leaves, Bark	Stomachache, allergies.
<i>Sophora acuminata</i> Baker	Fabaceae	Palwang [G]	S	Bark	Pregnancy (purification of blood before & after delivery).
<i>Xylosma longifolium</i> Clos.	Flacourtiaceae	Dieng Kani [K], Phulwal [G]	T	Bark	Stomachache.

* K=Khasi; J=Jaintia; G=Garo; T=Tree; S=Shrub; C=Climber; US=Under Shrub; H=Herb; Ep=Epiphyte

Distribution

The altitudinal distribution of these endemic medicinal plant species revealed that maximum number of these were restricted to low and mid-altitudes ranging from 100-

1600 m a.s.l. whereas, only a few of them were restricted to high altitudes above 1600 m a.s.l. (Figure 7.5). Thirtyone species were restricted to altitudes ranging from 800-1600 m a.s.l. viz., *Aeschynanthus superba*, *Boehmeria macrophylla*, *Calamus erectus*, *Calamus floribundus*, *Camellia caduca*, *Citrus latipes*, *Citrus medica*, *Cocculus mollis*, *Curcuma montana*, *Daphniphyllum himalense*, *Eleaegnus conferta*, *Erythroxyllum kunthianum*, *Euonymus lawsonii*, *Garcinia cowa*, *Garcinia pedunculata*, *Goniothalamus simonsii*, *Hedera nepalensis*, *Ilex embeloides*, *Mahonia pycnophylla*, *Munronia pinnata*, *Nepenthes khasiana*, *Ophiorhiza sub-capitata*, *Osbeckia capitata*, *Paramignya micrantha*, *Piper griffithii*, *Piper peepuloides*, *Polygonum bistorta*, *Raphidophora decursiva*, *Schima khasiana*, *Sophora acuminata* and *Xylosma controversum*. 20 were restricted to altitudes ranging from 400-800 m a.s.l. viz., *Boehmeria macrophylla*, *Calamus erectus*, *Calamus floribundus*, *Citrus aurantium*, *Citrus latipes*, *Citrus medica*, *Cymbidium aloifolium*, *Eleaegnus conferta*, *Garcinia cowa*, *Garcinia pedunculata*, *Goniothalamus simonsii*, *Hymenodictyon excelsum*, *Ilex embeloides*, *Impatiens tripetala*, *Munronia pinnata*, *Ochna squarrosa*, *Osbeckia capitata*, *Piper griffithii*, *Piper peepuloides* and *Polygonum bistorta* and and 15 were restricted to altitudes ranging from 100-400 m a.s.l. viz., *Boehmeria macrophylla*, *Calamus erectus*, *Calamus floribundus*, *Citrus aurantium*, *Cymbidium aloifolium*, *Eleaegnus conferta*, *Garcinia cowa*, *Garcinia pedunculata*, *Goniothalamus simonsii*, *Grewia hirsuta*, *Ilex embeloides*, *Impatiens tripetala*, *Munronia pinnata*, *Piper griffithii* and *Piper peepuloides*. Only six species were found to be restricted at an altitudinal range of 1600-2000 m a.s.l. viz., *Daphniphyllum himalense*, *Erythroxyllum kunthianum*, *Mahonia pycnophylla*, *Munronia pinnata*, *Osbeckia capitata* and *Schima khasiana* (Table 7.2). The distribution of these species also revealed that 26

species were restricted to either Eastern Himalayas or Northeast India of which 12 were restricted only to Meghalaya (Table 7.3; Figure 7.5).

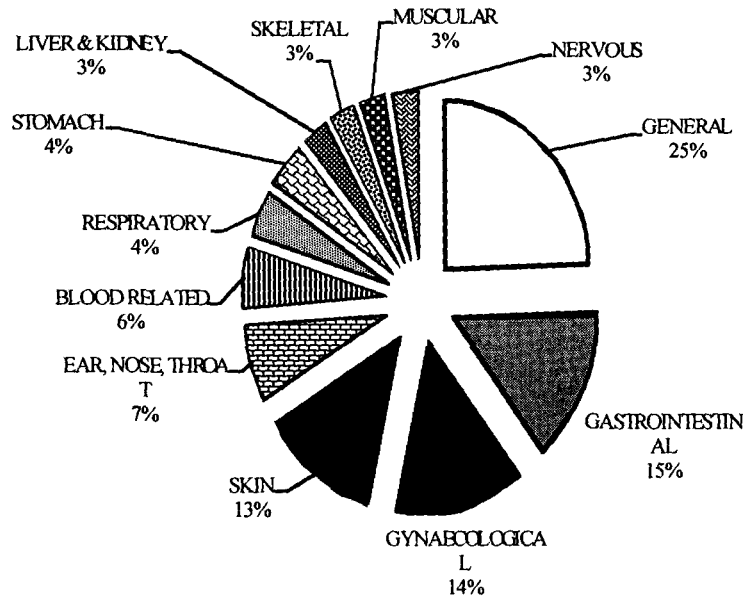


Fig. 7.4: Proportion of 37 endemic medicinal plant species used for treatment of different ailments.

Table 7.2: Worldwide distribution of the 37 endemic medicinal plant species and their distribution in Meghalaya.

Species	Distribution	
	Worldwide	Meghalaya
<i>Aeschynanthus superba</i> Cl.	NE India.	Jowai, Raliang, Laskein, Mynso, Sokha, Nokrek.
<i>Boehmeria macrophylla</i> D. Don	Sub-Tropical Himalayas.	Nokrek, Jowai, Syndai-Muktapur.
<i>Calamus erectus</i> Roxb.	Sikkim, NE India.	Lailad, Trongpleng, Syndai, Sokha-Dawki.
<i>Calamus floribundus</i> Griff.	NE India.	Syndai, Rytang, Sokha-Dawki.
<i>Camellia caduca</i> Brandis	Meghalaya.	Jowai, Mawsynram, Ialong, Mawsmai, Mawphlang.
<i>Citrus aurantium</i> L.	Dehradun, Garhwal, Kumaon, Sikkim, Manipur, Montane forests of peninsular India.	Nokrek.
<i>Citrus latipes</i> Tanaka	Meghalaya.	Nokrek, Umjaisaw-Mynsyngat, Ialong, Raliang.
<i>Citrus medica</i> L.	Kumaon, Pachmarhi, Sikkim, Chittagong, Upper Yan Yanzalin Valley, Satpura hills, Western Ghats.	Nokrek, Umjaisaw-Mynsyngat.
<i>Cocculus mollis</i> Hk. f. & Th.	Nepal.	Cherrapunjee, Jowai, Shillong, Jarain.
<i>Curcuma montana</i> Roxb.	NE India, Konkan.	Nartiang.

<i>Cymbidium aloifolium</i> Sw.	Burma, Bhutan, Nepal, Thailand, Sri-Lanka, India.	Umsning, Nongpoh, Burnihat.
<i>Daphniphyllum himalense</i> Muell.	Temperate Himalayas-Burma.	Ummulong, Thadlaskein, Jowai, Shillong.
<i>Eleaegnus conferta</i> Roxb.	Indo-Malaya, Himalayas, South India.	Nokrek, Tura, Balphakram, Shillong.
<i>Erythroxyllum kunthianum</i> Wall. ex Kurz.	Inda-Burma, NE India.	Ialong, Raliang, Swer, Nokrek, Mawphlang, Jarain, Jowai.
<i>Euonymus lawsonii</i> Cl. & Prain.	Meghalaya.	Nokrek, Raliang, Shillong.
<i>Garcinia cowa</i> Roxb. ex DC.	Indo-Malaya, NE India.	Nokrek, Bagmara.
<i>Garcinia pedunculata</i> G. Don	Indo-Burma, NE India.	Sokha.
<i>Goniothalamus simonsii</i> Hk. f. & Th.	Meghalaya.	Nongkhyllem, Borlong, Mawsmmai, Nokrek, Balphakram.
<i>Grewia hirsuta</i> Vahl.	India, Sri-Lanka, Bangladesh, Burma.	Balphakram.
<i>Hedera nepalensis</i> K. Koch.	Himalayas.	Ialong, Raliang, Swer, Nongkrem, Shillong, Sohra-rim, Jowai.
<i>Hymenodictyon excelsum</i> Wall.	Indo-Malaya.	Nongpoh.
<i>Ilex embeloides</i> Hk. f.	Meghalaya.	Raliang, Dawki.
<i>Impatiens tripetala</i> DC.	NE India.	Balphakram, Dawki.
<i>Mahonia pycnophylla</i> Takeda	Indo-Burma, Eastern Himalayas, Nilgiris.	Ialong, Jarain, Sohra-rim, Elephant falls.
<i>Munronia pinnata</i> Harms.	Eastern Himalayas, NE India, Nilgiris.	Balphakram, Maheskola, Tura, Raliang.
<i>Nepenthes khasiana</i> Hk.f.	Meghalaya.	Lawbah, Pongtung, Pynursla, Mynkre, Nonghulew, Amlarem, Longrein, Jarain, Sutnga, Maheskola, Tura, Bagmara.
<i>Ochna squarrosa</i> L.	Burma, Andamans, Khasi Hills.	Rongrengiri.
<i>Ophiorhiza subcapitata</i> Wall.	Meghalaya (Jaintia Hills).	Jowai.
<i>Osbeckia capitata</i> Benth.	Meghalaya.	Jarain, Amlarem, Sutnga, Pynursla, Jowai, Ummulong, Pongtung, Bapung, Sohra-rim, Khliehriat, Mawphlang, Swer, Shillong, Umsaw, Nongstoin, Nongkrem, Mawsmmai, Mawsynram.
<i>Paramignya micrantha</i> Kurz.	Meghalaya.	Nokrek, Raliang.
<i>Piper griffithii</i> C. DC.	NE India	Raliang, Ialong, Nokrek, Sokha, Mawsmmai, Nongkhyllem.
<i>Piper peepuloides</i> Roxb.	Tropical Himalayas, NE India, Bangladesh, Nepal.	Raliang, Nokrek, Nongkhyllem.
<i>Polygonum bistorta</i> L.	Meghalaya.	Sutnga, Jarain, Bapung, Ummulong, Jowai, Mawsmmai, Mawphlang, Pongtung, Shillong, Amlarem, Sohra-rim, Swer.
<i>Raphidophora decursiva</i> Schott.	Sikkim Himalayas.	Ialong, Raliang, Nokrek, Jowai-Jarain.
<i>Schima khasiana</i> Dyer.	Meghalaya.	Shillong, Jowai, Sohra-rim, Pongtung, Mawphlang, Raliang.
<i>Sophora acuminata</i>	Eastern Himalayas, Bangladesh, Burma.	Mawsmmai, Sutnga.

Baker		
<i>Xylosma controversum</i> Clos.	Meghalaya.	Jowai.

Table 7.3: Elevation-wise distribution of the 12 endemic medicinal plant species restricted to Meghalaya.

Species	Altitude (m)
<i>Camellia caduca</i> Brandis	1000-1600
<i>Citrus latipes</i> Tanaka	500-1500
<i>Euonymus lawsonii</i> Cl. & Prain.	1200-1600
<i>Goniothalamus simonsii</i> Hk. f. & Th.	200-1500
<i>Ilex embeloides</i> Hk. f.	100-1200
<i>Nepenthes khasiana</i> Hk.f.	1200-1500
<i>Ophiorhiza sub- capitata</i> Wall.	1200-1600
<i>Osbeckia capitata</i> Benth.	700-1800
<i>Paramignya micrantha</i> Kurz.	1000-1500
<i>Polygonum bistorta</i> L.	700-1600
<i>Schima khasiana</i> Dyer.	1200-1800
<i>Xylosma controversum</i> Clos.	1000-1500

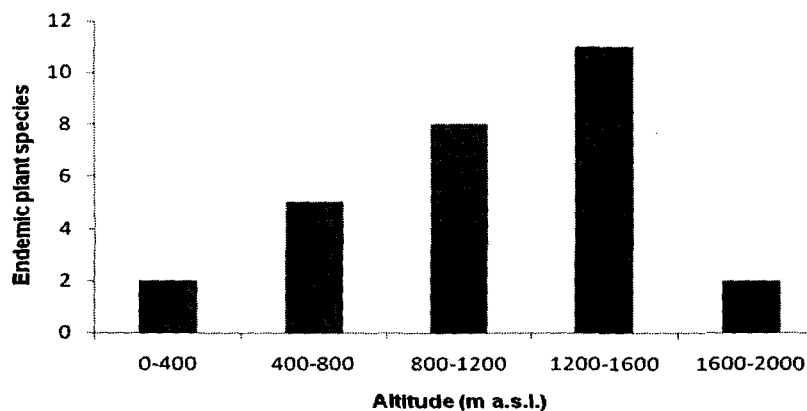


Fig 7.5: Altitudinal distribution of the 12 endemic medicinal plant species restricted to Meghalaya.

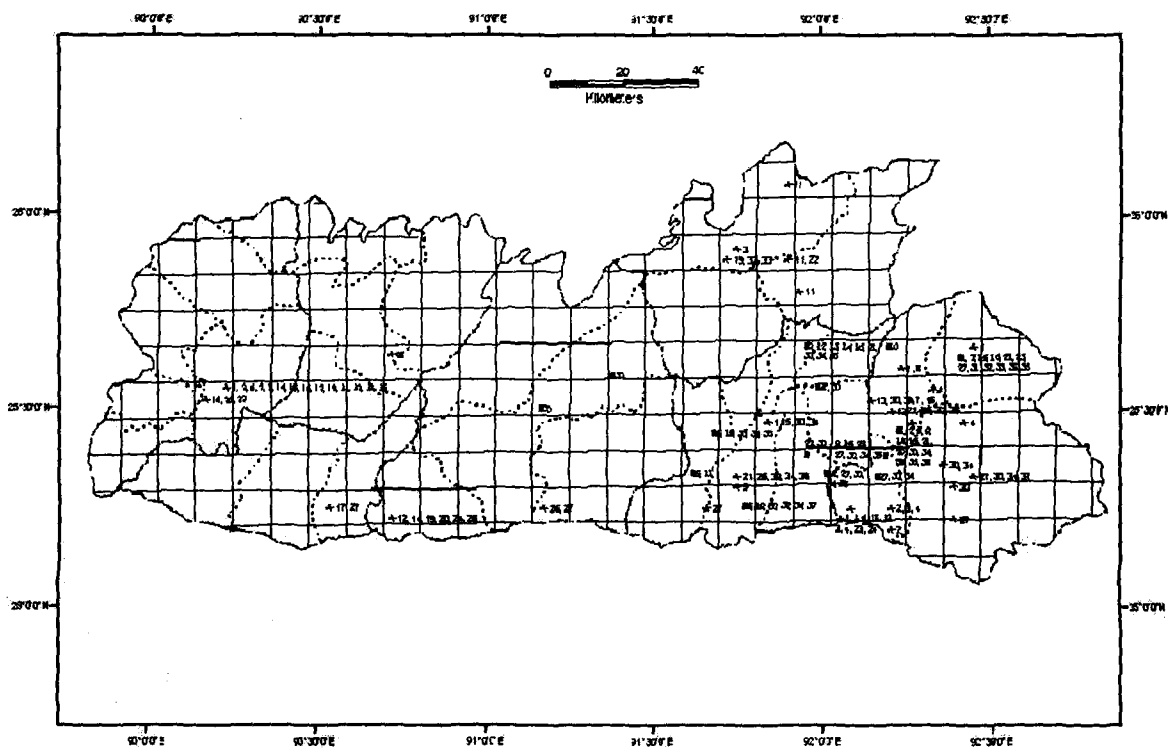


Fig 7.6: Distribution of endemic medicinal plant species in Meghalaya. The serial numbers of endemic medicinal plant species are: 1. *Aeschynanthus superba* 2. *Boehmeria macrophylla* 3. *Calamus erectus* 4. *Calamus floribundus* 5. *Camellia caduca* 6. *Citrus aurantium* 7. *Citrus latipes* 8. *Citrus medica* 9. *Cocculus orbiculatus* 10. *Curcuma montana* 11. *Cymbidium aloifolium* 12. *Daphniphyllum himalense* 13. *Elaeagnus conferta* 14. *Erythroxylum kunthianum* 15. *Euonymus lawsonii* 16. *Garcinia cowa* 17. *Garcinia pedunculata* 18. *Goniothalamus simonosii* 19. *Grewia hirsuta* 20. *Hedera nepalensis* 21. *Hymenodictyon excelsum* 22. *Impatiens tripetala*, 23. *Ilex embeloides* 24. *Mahonia pycnophylla* 25. *Munronia pinnata* 26. *Nepenthes khasiana* 27. *Ochna squarrosa* 28. *Ophiorhiza subcapitata* 29. *Osbeckia capitata*, 30. *Paramignya micrantha* 31. *Piper griffithi* 32. *Piper peepuloides* 33. *Polygonum bistorta* 34. *Raphidophora decursiva* 35. *Schima khasiana* 36. *Sophora acuminata* 37. *Xylosma longifolium*.

Table 7.4: Concentration of 37 endemic medicinal plant species in the state.

Sites	Number of endemic medicinal plant species	Concentration (%)
Nokrek	14	37.84
Jowai	13	35.14
Raliang	12	32.43
Shillong	9	24.32
Ialong	7	18.92
Jarain	7	18.92
Balphakram	6	16.22
Mawsmmai	6	16.22
Mawphlang	5	13.51
Pongtung	5	13.51
Sohra-rim	5	13.51
Sokha	5	13.51

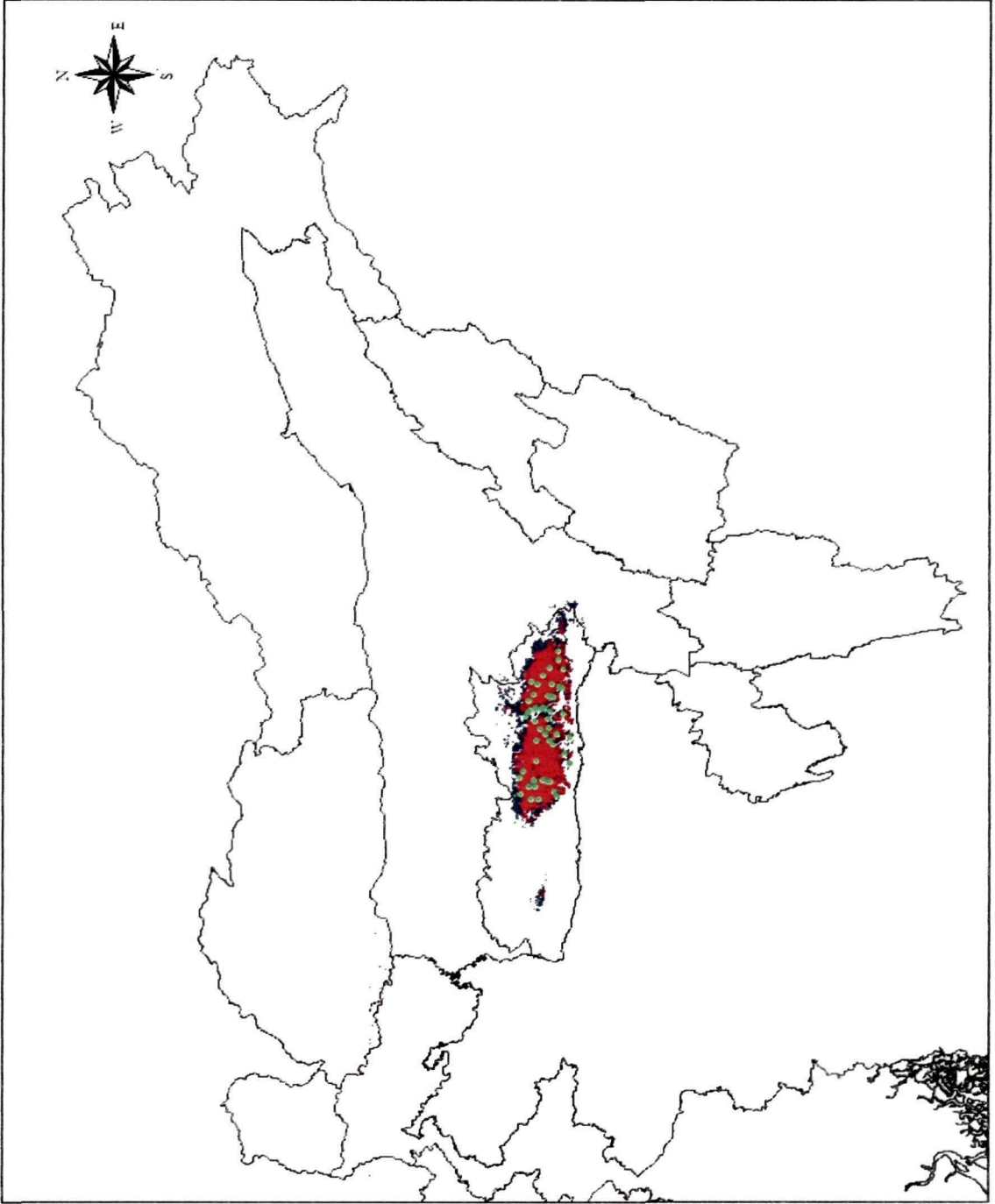


Fig 7.7: Modeled potential distribution area of *Osbeckia capitata* in northeast India. Red color depicts the areas of predicted presence by 6-10 models and blue color depicts predicted presence by 1-5 models. The white color shows the areas predicted to be not suitable. The indigo dots shows the actual records of the species.

Concentration of endemic medicinal plant species

According to the number of species encountered at different sites it was observed that high concentration of endemic medicinal plant species was restricted to Nokrek (West Garo Hills) with 37.8% followed by Jowai and Raliang (Jaintia Hills) with 35.1% and 32.4% of the total species respectively (Table 7.4; Figure 7.6).

Assessment of endemism

Monotropa uniflora has been recorded from Northern California, British Columbia, Southern Canada, Eastern United States, Eastern Texas, Southern Mexico, Northwestern Colombia and Asian countries such as Japan, Southeastern China, Nepal and India. In India the species is found in Darjeeling, Sikkim, Bhutan and Meghalaya (Wallace 1975). In Meghalaya the species is restricted to East Khasi Hills, West Khasi Hills and Jaintia Hills.

Panax pseudoginseng has been recorded from Southeast Asia in countries such as China, Japan and India. In Meghalaya the species is restricted to East Khasi Hills only (Wu *et al.* 2007).

The GARP model revealed the restricted distribution of *Osbeckia capitata* confined to Meghalaya only, confirming it as a biogeographic as well as political endemic to Meghalaya. Although, the model reveals few areas in Bhutan but the species is not present there (Figure 7.7).

Discussion

The uses of the medicinal plant species especially the endemic and threatened ones varied among the different ethnic groups in Meghalaya according to the nature and acuteness of the ailment, and a given species may be used in more than one disease or for

curing a particular disease more than one species may be used. For instance, *Cocculus orbiculatus* is used for curing as many as 15 ailments and *Citrus medica* for 7 ailments.

The endemic species were mostly restricted to low (100-400 m a.s.l.) and mid (400-1600 m a.s.l.) elevation level. Field observations indicate that these species are mostly restricted to undisturbed habitats and protected areas like Nokrek followed by sacred groves at Jowai and Raliang . However, the usage of such plants in medicine by the indigenous tribes in the state has posed a major threat to these species. Due to high level of exploitation and faulty harvesting techniques, many of the endemic species such as *Acanthus leucostachys*, *Calamus erectus*, *C. aurantium*, *C. latipes*, *Curcuma montana*, *Daphniphyllum himalense*, *Elaeagnus conferta*, *Goniothalamus simonsii*, *Hedera nepalensis*, *Hymenodictyon excelsum*, *Ilex embeloides*, *Mahonia pycnophylla*, *Munronia pinnata*, *Nepenthes khasiana*, *Ochna squarrosa*, *Ophiorhiza sub-capitata*, *Paramignya micrantha*, *Piper peepuloides*, *Schima khasiana* and *Sophora acuminate* have been rendered rare (Haridasan *et al.* 1995). Therefore, effective conservation measures for these species needs to be adopted to prevent them from extinction.

The GARP model confirmed the endemism of *Osbeckia capitata* and proves to be a useful tool not only to model the distribution of the species and for delineating areas for conservation purpose but to assess the endemism of a particular species as in the case of *Osbeckia*. The species is endemic to Meghalaya in the Indo-Burma hotspot.

For effective conservation method of these species, identification of the causes of threats is a prerequisite. The areas that were identified in the present study with high concentration of endemic plant species may be considered as priority areas for conservation and thus be protected and special conservation measures may be introduced.

The endemics are generally related to biodiversity rich areas of the state such as Nokrek, Jowai, Raliang, and Shillong. The attachment of these endemic species to such biodiversity rich areas may be due to habitat specificity, low regeneration capacity, geographic isolation, or fragility or sensitivity to natural factors. Thus, such areas of high endemism would indicate high species diversity and implicate critical efforts for conservation of the particular area or region. Inventory of all these endemic species should be carried out following the approach carried out in this direction for the three species. This would help in taking up appropriate conservation measures for the endemics.

PREDICTIVE DISTRIBUTIONAL MODELING AND PRIORITIZATION OF AREAS FOR CONSERVATION

Introduction

Understanding of fundamental ecological niche of the species is a pre-requisite for species conservation. For years, biologists have conducted field surveys to map the potential distributional area of plants and animals. In spite of this, our understanding of the distribution of most species, especially those found in inaccessible areas, is still incomplete. This has been obviously due to time-intensive, costly and hazardous nature of field work.

In Recent years, our capacity to learn more about species distribution has remarkably enhanced by combining reliable point data with strong technological and analytical tools. High-speed computing and GIS techniques have allowed us to model the distribution of a particular species by analyzing the environmental characteristics of its known localities. These mathematically defined models can then be combined with known constraints based on the species' life history to predict where else on the landscape the species might occur. A variety of environmental data are used as the basis for these models, some of which have only recently become widely available. These data include digital elevation model and its derivatives such as aspect, slope, compound topographic index and also satellite data on vegetation cover and landuse/landcover. GIS data layers providing estimates of monthly and annual mean precipitation and temperature are also available (www.worldclim.org/).

Distribution mapping of the species is key to develop effective measures for species conservation (Brooks *et al.* 2004; Samways 2005; Giriraj *et al.* 2008). Through

ecological niche modeling approach, it is possible to identify areas that are suitable for the conservation of a species (Irfan-Ullah *et al.* 2006; Papes 2006), discovery of new sister species (Raxworthy *et al.* 2003) as well as reintroduction of threatened category of species (Martinez-Meyer *et al.* 2006). For ecological modelling, the ecological niche of a species has been defined as the set of ecological conditions within which the species is able to maintain its population without immigration (Grinnell 1917; Holt and Gaines 1992). Several approaches have been used to approximate species ecological niches (Nix 1986; Austin *et al.* 1990; Walker and Cocks 1991; Scott *et al.* 1993, 1996, 2002). Of these, Genetic Algorithm for Rule-set Prediction (GARP) has undergone rigorous testing under diverse ecological conditions and has been proved to be a robust modelling approach.

Most interpretations of ecological niche modeling are restricted to distribution mapping, although new interpretations relating to distribution are being increasingly added to enhance the utility of the models. These interpretations ought to vary depending on the approaches taken for the modeling. For example, in mechanistic approach, physiological variables are directly measured ignoring the biotic interactions. On the other hand, the correlative approach is based on observations that include effects of biotic interactions on distribution of species. The two approaches thus estimate quite different phenomena and therefore the models need to be interpreted carefully in applications (Soberon and Peterson 2005). Although the prime application of the modeling continues to be potential distribution area mapping, efforts to expand the application scope of the modeling to distribution related biological attributes can provide important outputs that could be utilized for species conservation. We hypothesize that population status could be

strongly correlated with the best fit model with highest model agreement. Therefore, population status can be directly ascertained from the model output.

The present study aims to model the potential distribution areas of the three medicinally important species viz. *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*.

Materials and Methods

Species locality data

Locality data of the species were collected through extensive ground survey. First hand occurrence data on 7 locations of *Monotropa uniflora*, 49 locations of *Osbeckia capitata* and 6 locations of *Panax pseudoginseng* were collected from Meghalaya. The longitude and latitude of the locations were recorded using a hand held Global Positioning System (GPS).

Geographic data

For modeling the distribution of *Monotropa uniflora* twenty two environmental parameters were used. They were GIS raster layers summarizing the bioclimatic variables *i.e.* annual mean temperature and precipitation, isothermality, mean temperature of wettest, driest, warmest and coldest quarters, seasonality of precipitation and precipitation of wettest, driest, warmest and coldest quarters with a spatial resolution of 30 arc seconds ($\approx 1\text{km}$) were downloaded from <http://www.worldclim.org>. GIS layers summarizing altitude, slope, aspect, and compound topographic index and NDVI data for the months of June, July, August, September, October and November downloaded from the USGS Hydro-1K dataset (USGS 2001) were also used in the predictive distributional modeling.

For modeling the distribution of *Osbeckia capitata* and *Panax pseudoginseng*, twenty three environmental parameters were used. They included nineteen bioclimatic parameters *i.e.*, annual mean temperature, mean diurnal range, isothermality, temperature seasonality, max temperature of warmest month, minimum temperature of coldest month, temperature annual range, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality, precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmest quarter and precipitation of coldest quarter (worldclim.org). The topographical parameters included altitude, slope, aspect, and compound topographic (USGS 2001).

Before analysis all the layers were resampled to a spatial resolution of 1 km using the spatial analyst module of ArcView 3.3.

Ecological Niche Modeling

In the present study the technique of ecological niche modeling was used to delineate the potential distributional areas of the species by following an empirical approach. GARP has gained considerable importance because the model derives inferences in an iterative, evolutionary computing environment (Stockwell and Peters 1999), besides its ability to handle minimum occurrence points (Papes and Gaubert 2007; Peterson and Papes 2006) and to extrapolate predictions into broad, unsampled areas (Peterson *et al.* 2007). GARP has been extensively used for modeling ecological niches and predicting geographic distribution of species at local (Peterson and Papes 2006) as well as at continental scale (Nyari *et al.* 2006). The technique has been used in such

diverse scenarios as modelling the ecological niches of the vectors of various infectious diseases (Peterson *et al.* 2004; Peterson *et al.* 2006; Levine *et al.* 2007), invasive species (Soberon *et al.* 2001; Ganeshaiah *et al.* 2003; Li *et al.* 2006), plants (Irfan-Ullah *et al.* 2006; Giriraj *et al.* 2008), animals (Raxworthy *et al.* 2003), birds (Papes 2006) and invertebrate species (Herborg *et al.* 2007). The technique has also been successfully used to reconstruct the past ecological niches of several species (Martinez-Meyer *et al.* 2004). In the present context, the ecological niche of the selected plant species can be defined as 'a set of environmental conditions in which the plant species is capable of maintaining its population without immigration' (Grinnell 1917).

The modeling approach in the present study used genetic algorithm as a tool to model the ecological niche of the plant species. Genetic algorithms are algorithms designed to solve problems following natural selection to get an optimized solution for a particular problem from a population of solutions. The algorithm first starts with a set of solutions for a particular problem. The best solutions then reproduce to create a new generation of solutions. Crossovers and mutations occur in the process of reproduction and the bad solutions are eliminated. Genetic Algorithm for Rule-Set Prediction (GARP) is a variant of the family of genetic algorithms which has gained considerable importance because of its ability to solve problems related to species distribution using different solutions termed as rule types *i.e.* atomic rule, range rule, negated range rule and logistic regression rule in an iterative and evolutionary fashion. These rules are subjected to the process of natural selection of crossovers and mutations and the optimized rules are used in determining the species distribution. The ecological niche modeling in the present

study was carried out using a desktop version of GARP, which was freely downloaded from www.nhm.ku.edu/desktopgarp.

For building different subset models of the entire area of occurrence, an algorithm threshold of 0.01 was selected with 1000 iterations as an upper limit for each run. 50% of the total occurrence points were used to generate the rule and the remaining 50% was used for intrinsic testing for model optimization and refinement. Due to the stochastic nature of GARP in giving different outputs at different runs, the model was set to perform 100 tasks. For selecting the 10 best subset models, the inbuilt best subset selection radio button in Desktop GARP was checked with threshold level of 0% extrinsic hard omission and 50% commission. All the 10 best subset models were summed up using the `calcgridsinview.ave` script in ArcView 3.3 to create a composite distributional representation of the ecological niche of the plant species.

The independent validation of the model was done by overlaying the occurrence points with the model projections. To test the predictive accuracy of the subset models binomial probability test was performed.

Table 8.1: Occurrence data for *Osbeckia capitata*, *Monotropa uniflora* and *Panax pseudoginseng*.

Species	Total data points	Model training	Model testing	Number of points correctly predicted
<i>Monotropa uniflora</i>	7	5	2	2
<i>Osbeckia capitata</i>	49	30	19	19
<i>Panax pseudoginseng</i>	6	4	2	2

Visualization of the ecological niches

To visualize the ecological niche of the selected medicinal plant species in a two-dimensional environmental space, the geographic projection of the ecological niche models were related to the original environmental data layers to reconstruct the overall ecological variation across the landscape and the conditions under which the species was

predicted to be able to occur. To accomplish this task, all the layers were combined in Arc View 3.3. The combined grids were then exported in ASCII format and imported into MS EXCEL to enable visualization.

The entire modeling exercise was performed on a DELL Precision 690 WORKSTATION (X64 Edition).

Prioritization of areas for conservation

Areas for conservation were prioritized based on the potential distribution areas of the respective species in the state delineated using Ecological Niche Modeling (ENM) through Genetic Algorithm for Rule-set Prediction (GARP).

Results

Potential distributional area

The predicted potential distributional areas of the selected species in Meghalaya show that the distributional area of the species is confined to the sub-tropical broad-Leaved forest of the Khasi Hills district of Meghalaya.

The exploratory visualization of the ecological niche of the selected species shows the ecological characteristics of the predicted distribution areas. *Monotropa uniflora* distributional range was identified with the available environmental range in Meghalaya. As the population of the species is at its peak in the month of October the visualizations were made for the month of October only. The two-dimensional explorations revealed that the potential distribution of the species is restricted to areas having a higher precipitation range of 2000-6000 mm, temperature range of 15-20°C and altitudinal range of 1000-1900 m a.s.l. (Figure 8.1). Two-dimensional visualization of the precipitation and NDVI in the month of October shows that the species prefers areas

having higher precipitation and a relatively higher NDVI values (Figure 8.2) which indicates more canopy cover.

The two-dimensional explorations revealed that the potential distribution of *Osbeckia capitata* (Figure 8.1) is restricted to areas having a higher precipitation range of 2000-8000 mm, temperature range of 15-19.5°C, altitudinal range of 1000-1900 m a.s.l. and a topographic range of 200-1200 (Figure 8.3).

The two-dimensional explorations revealed that the potential distribution of *Panax pseudoginseng* (Figure 8.1) is restricted to areas having a higher precipitation range of 2000-9000 mm, temperature range of 15-20°C, altitudinal range of 900-1800 m a.s.l. and diurnal temperature range of 6.5-8.8°C (Figure 8.4).

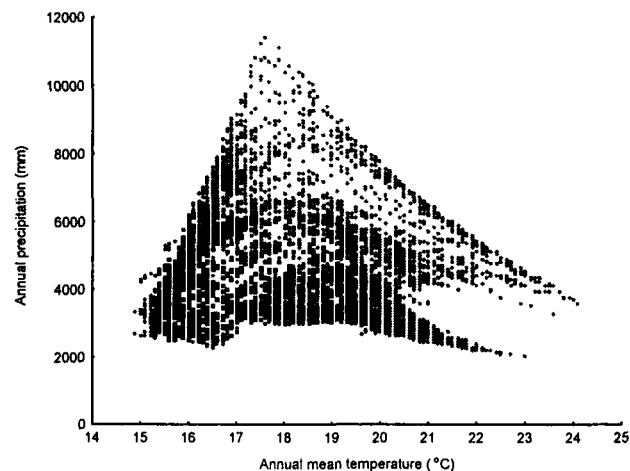


Fig 8.2 a: Visualization of the two-dimensional environmental space occupied by *Monotropa uniflora* in the month of October. Dark boxes represent the niche of *Monotropa uniflora* in the axis of maximum temperature and precipitation of the month of October; and grey boxes represents the overall available environmental conditions.

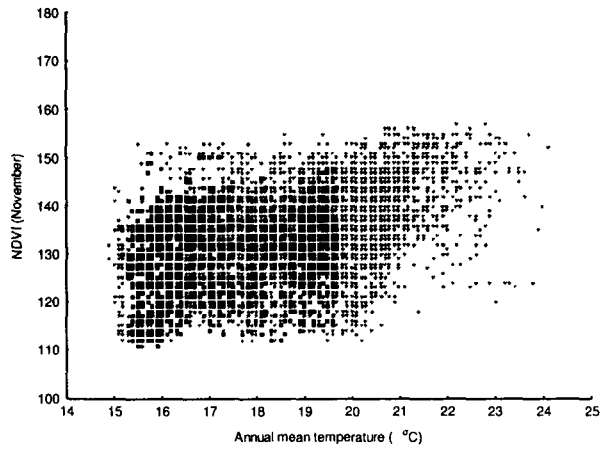


Fig 8.2 b: Visualization of the two-dimensional environmental space occupied by *Monotropa uniflora* in the month of October. Dark boxes represent the niche of *Monotropa uniflora* in two axis of precipitation and NDVI for the month of October; and grey boxes represents the overall available environmental conditions.

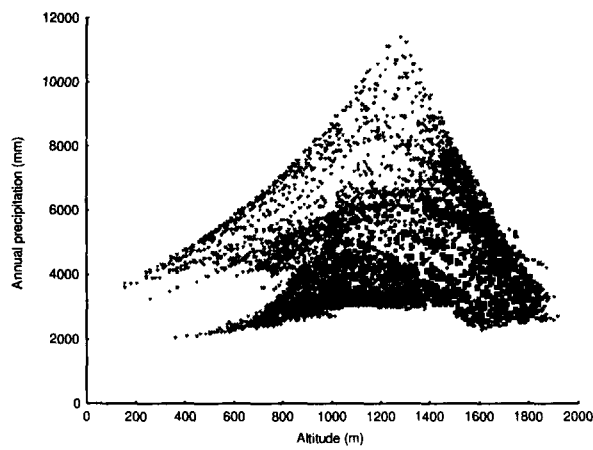


Fig 8.2 c: Visualization of the two-dimensional environmental space occupied by *Monotropa uniflora*. Dark boxes represent the niche of *Monotropa uniflora* in the axis of altitude and precipitation; and grey boxes represents the overall available environmental conditions.

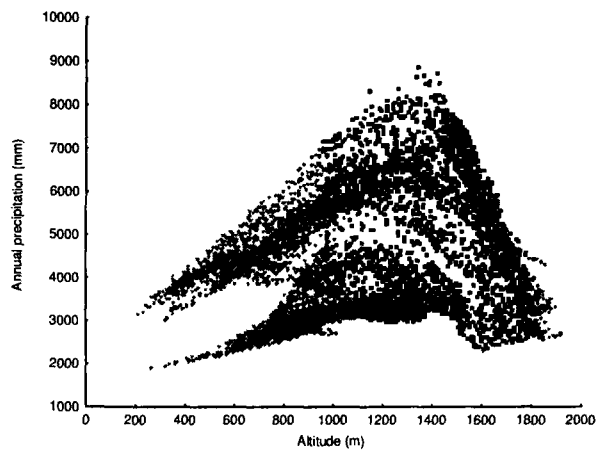


Fig 8.3 a: Visualization of the two-dimensional environmental space occupied by *Osbeckia capitata*. Dark circles represent the niche of *Osbeckia capitata* in the axis of altitude and precipitation; and grey boxes represents the overall available environmental conditions.

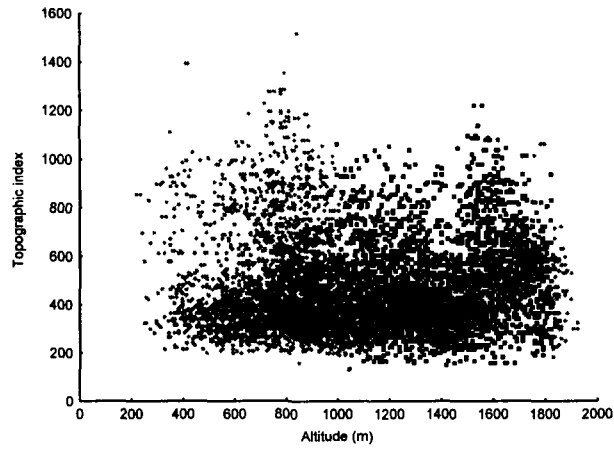


Fig 8.3 b: Visualization of the two-dimensional environmental space occupied by *Osbeckia capitata*. Dark circles represent the niche of *Osbeckia capitata* in the axis of altitude and topographic index; and grey boxes represents the overall available environmental conditions.

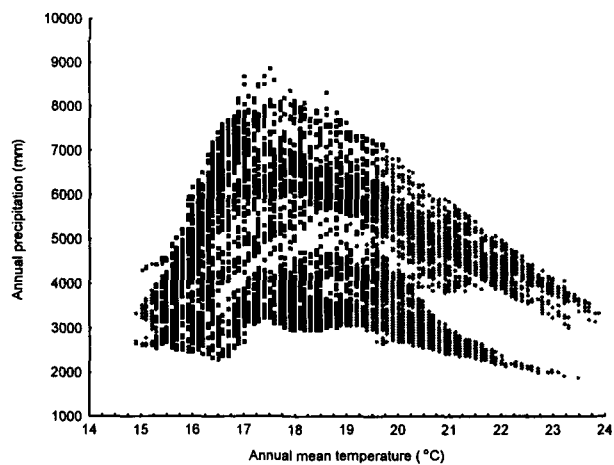


Fig 8.3 c: Visualization of the two-dimensional environmental space occupied by *Osbeckia capitata*. Dark circles represent the niche of *Osbeckia capitata* in the axis of annual mean temperature and annual mean precipitation; and grey boxes represents the overall available environmental conditions.

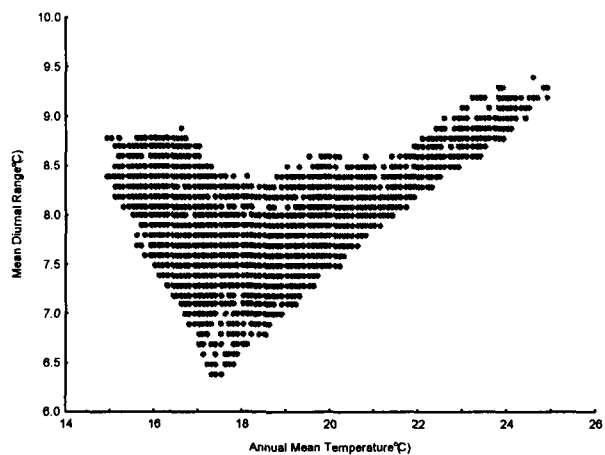


Fig 8.4 a: Visualization of the two-dimensional environmental space occupied by *Panax pseudoginseng*. Dark circles represent the niche of *Panax pseudoginseng* in the axis of annual mean temperature and mean diurnal range; and grey boxes represents the overall available environmental conditions.

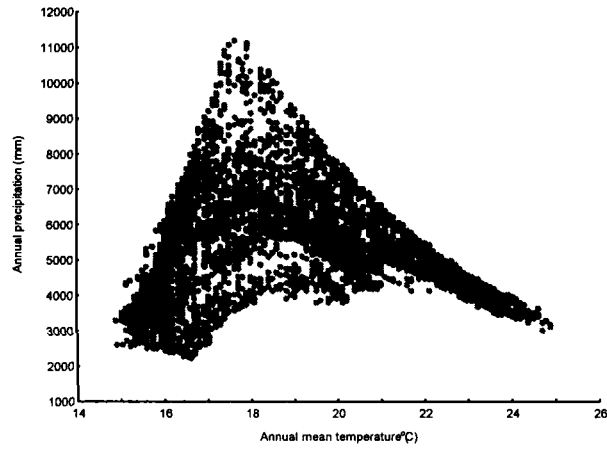


Fig 8.4 b: Visualization of the two-dimensional environmental space occupied by *Panax pseudoginseng*. Dark circles represent the niche of *Panax pseudoginseng* in the axis of annual mean temperature and annual mean precipitation; and grey boxes represents the overall available environmental conditions.

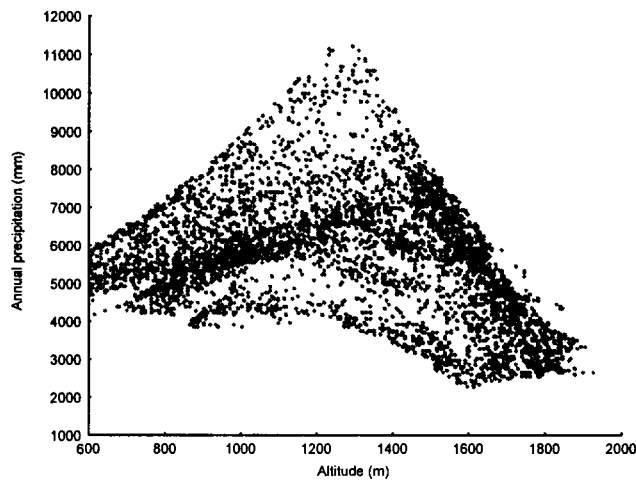


Fig 8.4 c: Visualization of the two-dimensional environmental space occupied by *Panax pseudoginseng*. Dark circles represent the niche of *Panax pseudoginseng* in the axis of altitude and annual precipitation; and grey boxes represent the overall available environmental conditions.

Prioritization of areas for conservation

An area of 5821 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District were identified as the priority areas for the conservation of *Osbeckia capitata*, 1993 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District for *Monotropa uniflora* and 2086 km² in East Khasi Hills District for *Panax pseudoginseng* (Table 8.2).

Table 8.2: Areas prioritized for conservation for the study species.

Name of species	Area prioritized for conservation (km ²)	Districts where located
<i>Osbeckia capitata</i>	5821	East Khasi Hills, West Khasi Hills, Jaintia Hills
<i>Monotropa uniflora</i>	1993	East Khasi Hills, West Khasi Hills, Jaintia Hills
<i>Panax pseudoginseng</i>	2068	East Khasi Hills

Discussion

The ecological niche model highlighted the importance of temperature, precipitation and altitude in the distribution of all the three species. The topography also played an important role in the distribution of *Osbeckia capitata*. Diurnal range and vegetation cover were important determinants of the niche of *Panax pseudoginseng* and *Monotropa uniflora*, respectively.

Although the best predicted subsets of the species niche model explain the potential habitat requirements for the species, they need to be interpreted with caution due to the implications of model accuracy, model assumptions and fundamental versus realized niches. They are informative, but have their limitations and should be used for conservation planning only in combination with targeted field survey.

Modeling the geographic range of a species holds promise in conservation biology as an important improvement over subjective, broad-stroke, shaded, outline maps (Giriraj *et al.* 2008). Fine scale resolution of environmental data is always desirable to develop accurate species distribution pattern to address ecological limiting factors. Predictions of potential distribution of the species in this study would help in developing conservation strategies for monitoring and managing the study species in particular, and for the conservation of several relict, endemic floral and faunal species of Meghalaya.

Research to monitor the population status, distribution and ecology of threatened and endemic plant species, thus, needs to be conducted thoroughly throughout India. In this way, appropriate mitigation measures to stop local extinction as well as to extend legal protection to plants can be implemented in the near future (Agoramoorthy 2007).

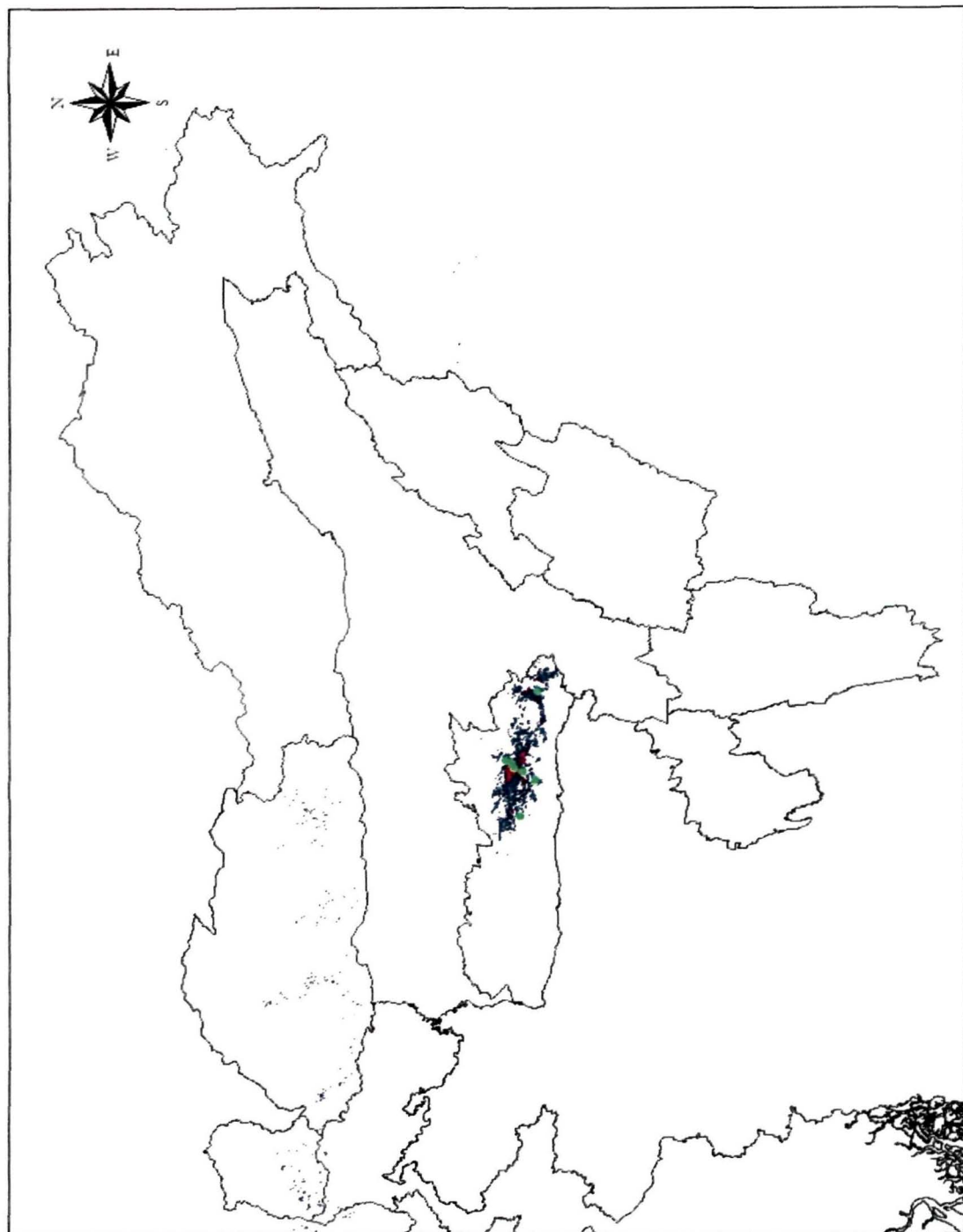


Fig 8.1 a: Modeled potential distribution area of *Monotropa uniflora* in northeast India. Red color depicts the areas of predicted presence by 6-10 models and blue color depicts predicted presence by 1-5 models. The white color shows the areas predicted to be not suitable. The indigo dots shows the actual records of the species

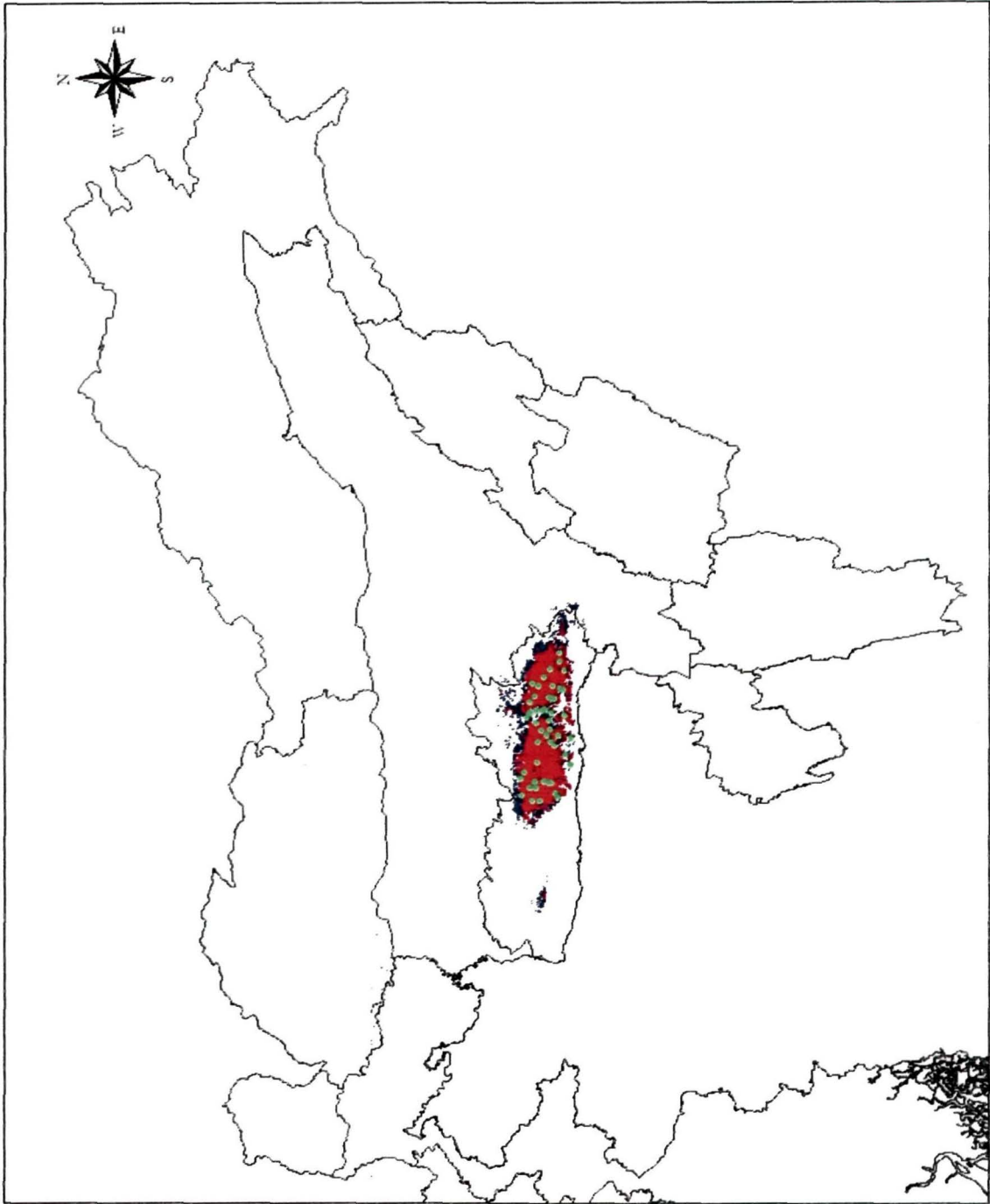


Fig 8.1 b: Modeled potential distribution area of *Osbeckia capitata* in northeast India. Red color depicts the areas of predicted presence by 6-10 models and blue color depicts predicted presence by 1-5 models. The white color shows the areas predicted to be not suitable. The indigo dots shows the actual records of the species.

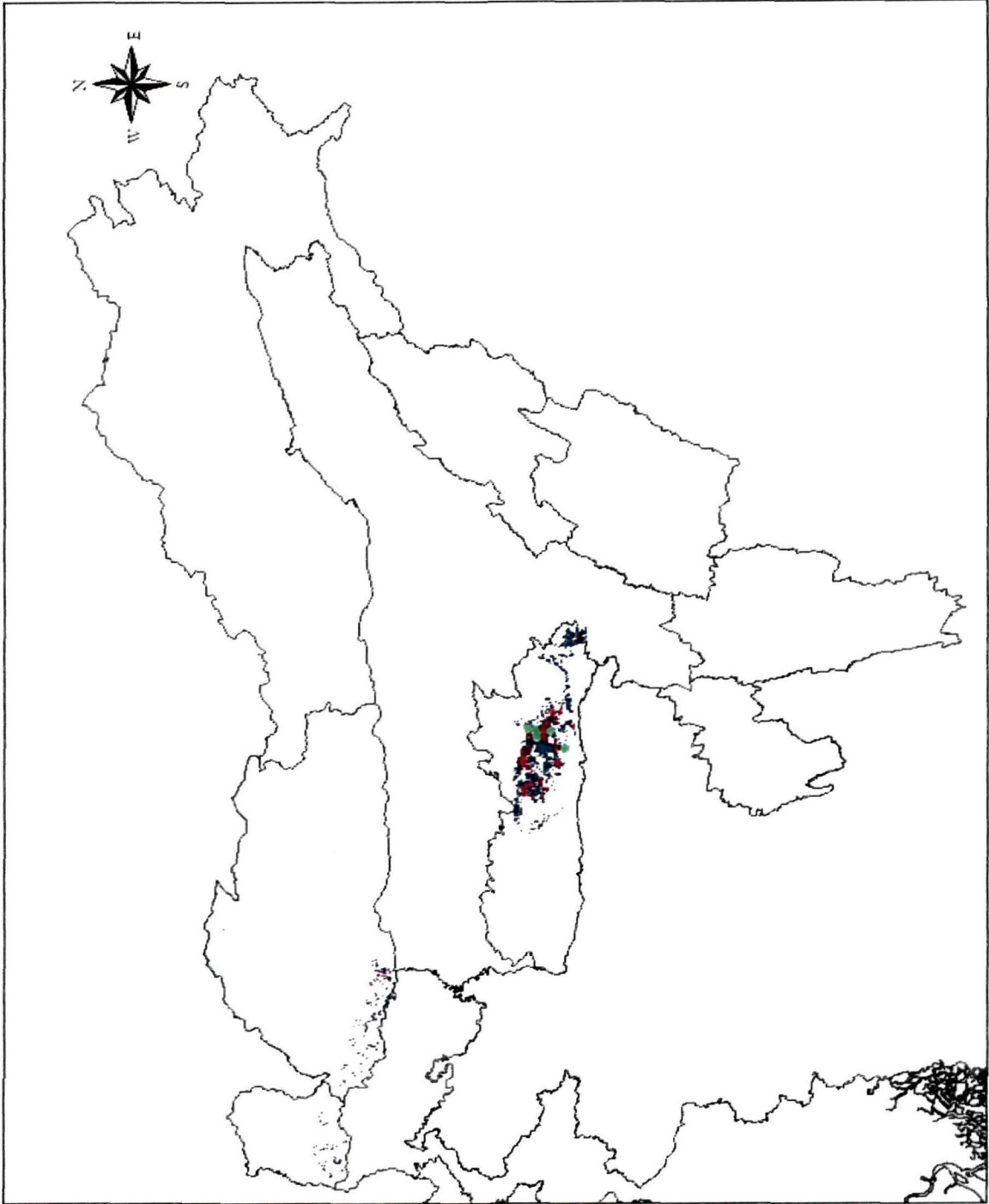


Fig 8.1 c: Modeled potential distribution area of *Panax pseudoginseng* in northeast India. Red color depicts the areas of predicted presence by 6-10 models and blue color depicts predicted presence by 1-5 models. The white color shows the areas predicted to be not suitable. The indigo dots shows the actual records of the species.

Introduction

An increasing number of species are facing the risk of extinction because they occur in specific or highly fragmented areas, have a reduced number of populations or individuals, or are declining (World Conservation Union 1994). Currently, habitat loss due to anthropogenic activity is the single most important cause of plant diversity (Wilcove *et al.* 1998). Besides human-caused changes in the environment, natural stochasticity in populations may also pose additional threat to species persistence (Nakaoka 1996; Menges 1997; Holsinger 2000; Vucetich *et al.* 2000).

Patterns of birth and death that primarily determine population size vary widely among and within species (Roff 1992). The persistence of a population depends on a numerical equilibrium over time. The simulation models based on the schedules of fecundity, recruitment and survival, and the integration of such parameters allow exploration of their relative importance (Schemske *et al.* 1994; Horvitz and Schemske 1995; Caswell 2001). Thus these simulation models help us in understanding the mechanisms that govern population dynamics and estimating extinction probabilities, particularly for endangered species (Schemske *et al.* 1994; Menges 2000).

Population viability analysis (PVA) is one such tool that has traditionally been used to estimate minimum viable populations for threatened taxa. However, the greatest strength of PVA is the opportunity to evaluate the efficacy of various management options (Burgman *et al.* 1988; Shaffer 1990; Boyce 1992; Lindenmayer *et al.* 1993; Ruggiero *et al.* 1994; Mills *et al.* 1996) that aim to build populations up to adequate size

and to reduce the risks of extinction (Given 1994). Most studies on PVA have assessed the impact of various management regimes on plant populations (Haig *et al.* 1993; Lindenmayer and Possingham 1996; Drechsler 1998). However, such applications for threatened plant populations are almost absent (Drechsler *et al.* 1999).

Management recommendations for threatened plants are generally made based on deterministic models (Manders 1987). These models are being static, do not take into account of the random and unpredictable changes in environmental conditions, or any other factors resulting in stochastic extinctions. Stochastic computer simulation models, based on the temporal variation in observed demographic parameters, are considered valuable for PVA investigations (Shaffer and Samson 1985; Menges 1992). Variations in these parameters may be obtained from long-term demographic monitoring data and are influenced by several ecological and genetic factors. Influential factors include environmental variability, intraspecific density, interspecific competition, herbivory, mutualism, pathogens, pollen limitation, dispersal, heterozygosity and allelic diversity (Schemske *et al.* 1994).

The distribution and dynamics of organisms at a large spatial scale have been the focus of ecological research since early part of the twentieth century (Wright 1931; Fisher 1937; Skellam 1951, 1952; MacArthur and Wilson 1967; Levins 1969, 1970). The theories of island biogeography and metapopulation dynamics have been particularly influential in this respect as they have offered a quantitative basis to analyse regional scale ecological dynamics (Hanski and Simberloff 1997). Our understanding on large-scale population dynamics (Hanski 1999). Metapopulation theory states that the scaling from local to regional dynamics may not be straightforward, and that the regional scale

availability of habitat, migration and extinction all play a role in determining whether a system of local populations of a species can persist.

The original metapopulation theory (Levins 1969, 1970) has subsequently been extended to encompass a wider class of population structure, including non equilibrium and mainland-island forms (Hastings and Harrison 1994; Harrison and Taylor 1997; Hanski 1999). In the metapopulation context, the key elements are the processes of interpopulation migration, local population extinction and regional distribution of suitable habitat as discrete patches within a larger matrix of unsuitable habitat. Some authors have defined plant metapopulation dynamics as ‘the product of local population dynamics and dispersal’ (Husband and Barrett 1996) described it as a system of interconnected populations (Antonovics *et al.* 1994). Considering the very few studies though available on plant metapopulations (Husband and Barrett 1996), it is not clear whether metapopulations are very common in plants (Bullock *et al.* 2002).

The identification of populations though show a metapopulation structure is not an easy task. For instance, the persistence and dynamics of metapopulations are critically dependent on the amount and regional configuration of suitable habitat (Hanski 1997). In contrast, the dynamics of a population existing on an undisturbed continuous area of suitable habitat would be an extrapolation of local processes. Thus, determining the form of regional dynamics is not simply a matter of typology, and this links directly to demographic parameters and ecologically important aspects of population organization (Thomas and Kunin 1999).

In this chapter, metapopulation of *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata* were studied using a population viability computer simulation model

(RAMAS Metapop) and PVA was performed to (i) evaluate the finite rate of increase (λ) and stable stage distribution based on the vital rates obtained during four years demographic census; (ii) predict which life stages contribute most to population growth *i.e.*, to investigate the relative importance of the different demographic stages to population growth; (iii) simulate the future metapopulation trend and to assess extinction probability and (iv) estimate the Minimum Viable Population size.

In addition, an attempt was made to investigate how metapopulation influences the regional dynamics of *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Method

Demography

Each subpopulation was enumerated in 20 permanent quadrats of 1 m² size. Within each plot, we followed the fate of each individual from 2004 to 2008. Four life history stage classes *viz.*, seeds, juvenile, young and adults were selected for *Osbeckia capitata* and *Monotropa uniflora*. Six life history stage classes were selected *viz.*, seeds, seedlings, saplings, 4-Leaved, 5-Leaved and 6-Leaved adults for *Panax pseudoginseng*. The initial population sizes, number of fruits per plant and total number of seeds produced per plant were also recorded.

Seed bank

The total number of seeds in the seed bank at time t (years) that germinated in the year $t+1$ was calculated to get the mean annual seedling recruitment rate. Survival rates and fecundity of plants were summarized from field data and were assigned the values based on:

$$\text{Survival (S)} = N_{2(t+1)}/N_{1(t)}$$

$$\text{Fecundity (F)} = S_{(t+1)}/A_t$$

Where, N_t is the probability of a population at time t to survive to time $t+1$; and, A_t is the number of adults at time t and S_{t+1} is the total number of seeds produced at time $t+1$.

Transition matrices and deterministic projections of population growth and size class distribution

The yearly transition probabilities were analysed with stage-based matrix models (Caswell 1989). The stages were represented in a projection matrix with a dimension of four stage classes both for *Osbeckia capitata* and *Monotropa uniflora*, and six stage classes for *Panax pseudoginseng*.

The Lefkovitch Matrix model takes the form:

$$\mathbf{A} \cdot \mathbf{n}_t = \mathbf{n}_{t+1}$$

Where, A = Projection Matrix; n_t = population at time t ; n_{t+1} = Population size at time $t+1$.

Stage matrices in this model is the average of 4 matrices belonging to each of the four census period. Which means that each element in the stage matrix is the arithmetic mean of the corresponding elements in the four matrices. Similarly the elements of the Standard Deviation Matrices are calculated as the standard deviation of the four corresponding estimates.

The finite rate of increase (λ) was also calculated as:

$$\text{The Finite Rate of Increase } (\lambda) = n_{t+1}/n_t$$

Sensitivity determines how much various life-history stage transitions affect the population dynamics by examining how changes in a particular stage affect the magnitude of the leading eigenvalue.

$$\text{Sensitivity } (S_{ij}) = w_i/W$$

Where, w_i is the population vector at the i^{th} generation and W is the sum of all population vector.

One problem with this approach is that some of the variables, *i.e.*, survival rates, are intrinsically restricted in their range to values between 0 and 1, while others, *i.e.*, fecundities, may be very large.

Elasticity is a measure of "proportional" effect, *i.e.*, the effect that a change in a given matrix element has as a proportion to the change in that element:

$$\text{Elasticity } (E_{ij}) = (a_{ij}/\lambda) S_{ij}$$

Where, E_{ij} is the elasticity value and represents the proportion of λ due to transition a_{ij} (de Kroon *et al.* 1986).

Stochastic simulations of population growth and extinction risks

The stable simulations predict population growth based on a specific transition matrix, and is valid for yearly transition only. To introduce temporal variation, stochastic matrix simulation was used, where each transition matrix was assigned a probability to be used in each iteration. The starting vector reflected the average stage distribution that was found over all the years. The average matrix of all the populations for four years were analysed, running 150-250 simulations with 1500 iterations depending on the species. To introduce demographic stochasticity in the stochastic simulations a randomly selected transition matrix was used to decide the fate of all individuals in a population vector (Damman and Cain 1998). Demographic stochasticity is the variation in the average chances of survival that occurs because a population is made up of a finite integer of individuals.

For Demographic stochasticity, the number of survivors for i th stage is drawn from a binomial distribution with 2 parameters- Survival rate 'S' and $N_i(t)$ (as sample size).

$$\text{Demographic stochasticity} = S_i \cdot N_i(t)$$

When Fecundity value is available, the number of young produced by the i th stage was then drawn from a binomial distribution with mean $F_i \cdot N_i(t)$.

Simulations were used to analyse the effect of environmental and demographic stochasticity on the persistence of the populations of the selected species. These simulations allowed to estimate a minimum viable population size from the Time to extinction curve (Time step corresponding to $\leq 5\%$) and Population trajectory curve (population size corresponding to this time step) generated through the simulations.

A stage-based matrix model was constructed for all known populations of the selected species. All matrix construction, manipulation and projection were done using RAMAS Metapop (Ackakaya 2000).

Results

Population Structure

The population structure of the selected species at different sites as depicted provides the distribution of individuals among the populations at a specific time period (Figure 9.1).

In the stage structure for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*, reproductive individuals constituted 5.1%, 6.1% and 13.8% respectively of the total number of individuals. Young populations constituted 18.8%, 15.6% and 14.3% respectively of established plants. The juveniles represented the majority of the established plants, constituting 75.3%, 78.3% and 71.8% respectively.

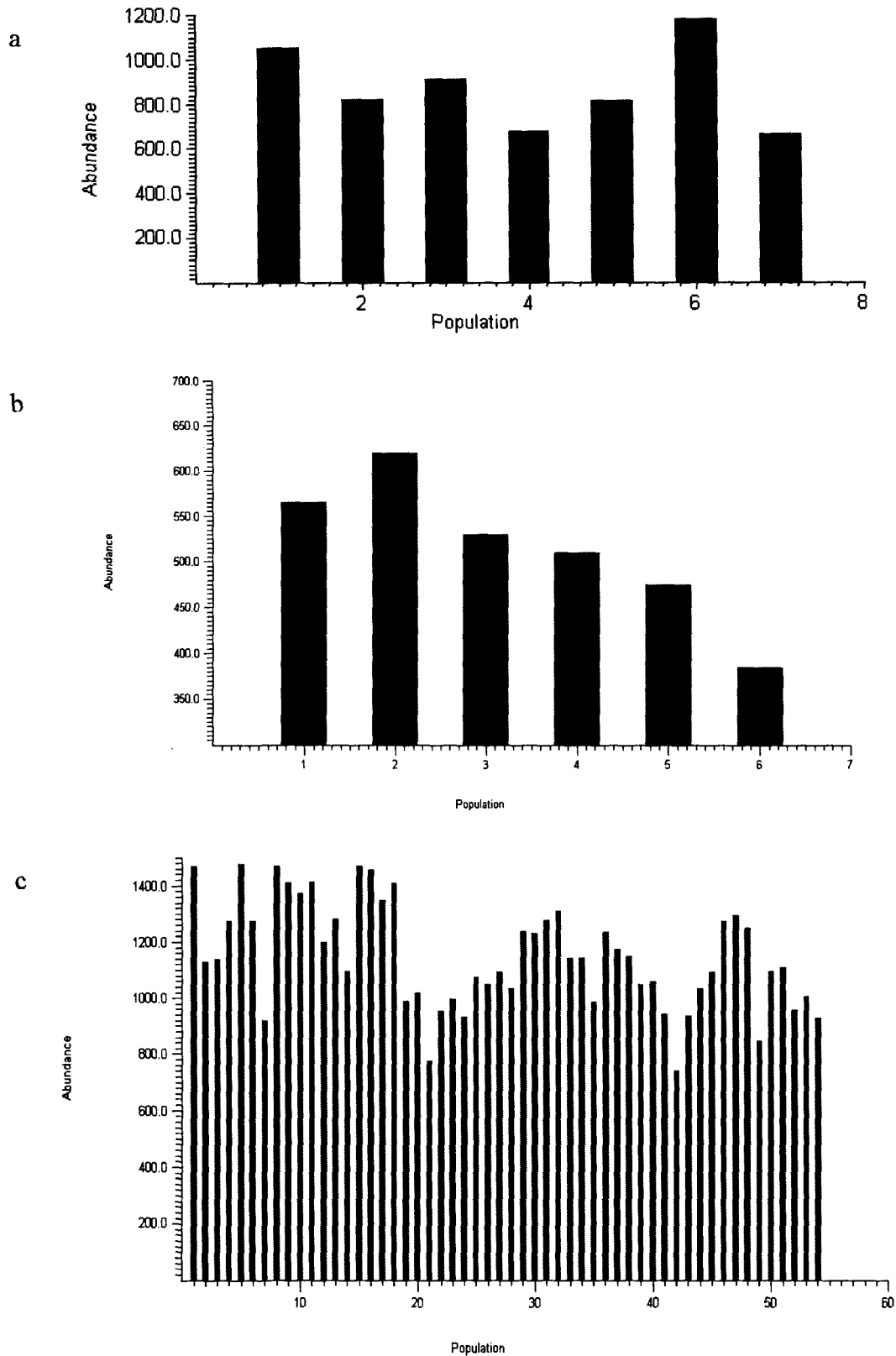


Figure 9.1: Population structure of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

Population Growth Rate (λ) and Stable Age Distribution

Table 9.1 depicts the proportion of individuals in each stage at the start of the simulation and the proportion of individuals in each stage, at the Stable age distribution. The former is based on the information in the Initial abundances and the latter is based only on the Stage matrix used by the population including any modification by the Relative fecundity and Relative survival parameters. It is the result of matrix analysis (eigenanalysis), which ignores density dependence, dispersal, catastrophes, and stochasticity. λ for the selected species were <1 . The λ value for *Monotropa uniflora* was 0.911, for *Osbeckia capitata* it was 0.912 and for *Panax pseudoginseng* it was 0.954 indicating an overall decline in the population size (Figure 9.1).

Reproductive value

The relative contribution of each stage (or age class) for each species to future generations is depicted in Table 9.1. Reproductive value is the number of offspring an individual in a given age class will produce, including all its descendants, relative to the reproductive value of an individual in the first age class. Thus reproductive value for the first age class is always 1.0. Reproductive values are based on the Stage matrix used by a population, including any modification by the Relative fecundity and Relative survival parameters. They are the results of matrix analysis (eigenanalysis), which ignore density dependence, dispersal, catastrophes, and stochasticity (Table 9.1). Reproductive value increased with increasing size, particularly for *Monotropa uniflora* and *Osbeckia capitata*, in which Adults had a relative reproductive value of 4.0 and 3786.8 respectively. However, for *Panax pseudoginseng*, the reproductive value of 157.0 was obtained for 4-Leaved adult stage (156.95).

Table 9.1: Population Growth Rate (λ), Stable Age Distribution and Reproductive value of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

(a) <i>Monotropa uniflora</i>			
Stages	λ	w	Reproductive value
Seeds	0.0000	0.0000	1.0000
Juvenile	0.0346	0.0340	2.0000
Young	0.0096	0.0110	3.0000
Adults	0.0034	0.0040	4.0000
(b) <i>Panax pseudoginseng</i>			
Seeds	0.0000	0.0000	1.0000
Seedlings	0.0373	0.0510	18.3520
Saplings	0.0067	0.0110	84.2030
4-Leaved Adults	0.0073	0.0060	156.9480
5-Leaved Adults	0.0038	0.0040	119.1570
6-Leaved Adults	0.0027	0.0020	80.3540
(c) <i>Osbeckia capitata</i>			
Seeds	0.0000	0.0000	1.0000
Juvenile	0.0069	0.0070	64.8330
Young	0.0011	0.0010	0.0009
Adults	0.0009	0.0009	3786.7910

Stage and Elasticity matrices

The stage and elasticity matrices for the three species for each transition are given in table 9.2 revealed that in *Monotropa uniflora*, the sensitivity of λ was more to fecundity ($E = 0.8858$). However, in case of *Osbeckia capitata* the sensitivity of λ was more towards the transition from Juvenile to Young with an elasticity value 1.0456, whereas, the sensitivity of λ was more towards the transition from saplings to 4-Leaved adults ($E = 0.2167$), seedlings to saplings ($E = 0.2160$) and seeds to seedlings ($E = 0.2159$) was of importance in the case of *Panax pseudoginseng* (Table 9.2).

Table 9.2: Stage and elasticity matrices for (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

(a)	Stage Matrix					Elasticity Matrix			
	Seeds	Juvenile	Young	Adult		Seeds	Juvenile	Young	Adult
Seeds	0.0000	0.0000	0.0000	213.4430	Seeds	0.0000	0.0000	0.0000	0.8858
Juvenile	0.0420	0.0000	0.0000	0.0000	Juvenile	0.0820	0.0000	0.0000	0.0000
Young	0.0000	0.2470	0.0000	0.0000	Young	0.0000	0.0262	0.0000	0.0000
Adult	0.0000	0.0000	0.3110	0.0000	Adult	0.0000	0.0000	0.0140	0.0000

(b)	Stage Matrix					
	Seeds	Seedlings	Saplings	4-Leaved Adults	5-Leaved Adults	6-Leaved Adults
Seeds	0.0000	0.0000	0.0000	79.9540	73.5380	76.6840
Seedlings	0.0520	0.0000	0.0000	0.0000	0.0000	0.0000
Saplings	0.0000	0.2080	0.0000	0.0000	0.0000	0.0000
4-Leaved Adults	0.0000	0.0000	0.5120	0.0000	0.0000	0.0000
5-Leaved Adults	0.0000	0.0000	0.0000	0.5860	0.0000	0.0000
6-Leaved Adults	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000
	Elasticity Matrix					
	Seeds	Seedlings	Saplings	4-Leaved Adults	5-Leaved Adults	6-Leaved Adults
Seeds	0.0000	0.0000	0.0000	0.1148	0.0656	0.0350
Seedlings	0.2159	0.0000	0.0000	0.0000	0.0000	0.0000
Saplings	0.0000	0.2160	0.0000	0.0000	0.0000	0.0000
4-Leaved Adults	0.0000	0.0000	0.2167	0.0000	0.0000	0.0000
5-Leaved Adults	0.0000	0.0000	0.0000	0.1002	0.0000	0.0000
6-Leaved Adults	0.0000	0.0000	0.0000	0.0000	0.0358	0.0000

(c)	Stage Matrix					Elasticity Matrix			
	Seeds	Juvenile	Young	Adult		Seeds	Juvenile	Young	Adult
Seeds	0.0000	0.0000	0.0000	1124.6670	Seeds	0.0000	0.0000	0.0000	0.0081
Juvenile	0.0080	0.0000	0.0000	0.0000	Juvenile	0.0041	0.0000	0.0000	0.0000
Young	0.0000	0.1980	0.0000	0.0000	Young	0.0000	1.0456	0.0000	0.0000
Adult	0.0000	0.0000	0.3890	0.0000	Adult	0.0000	0.0000	0.0169	0.0000

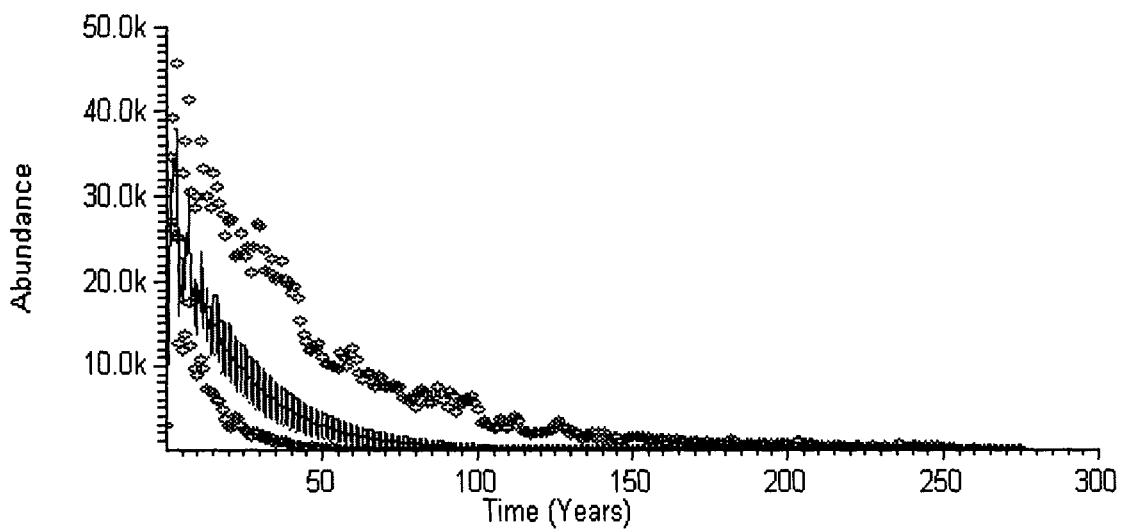
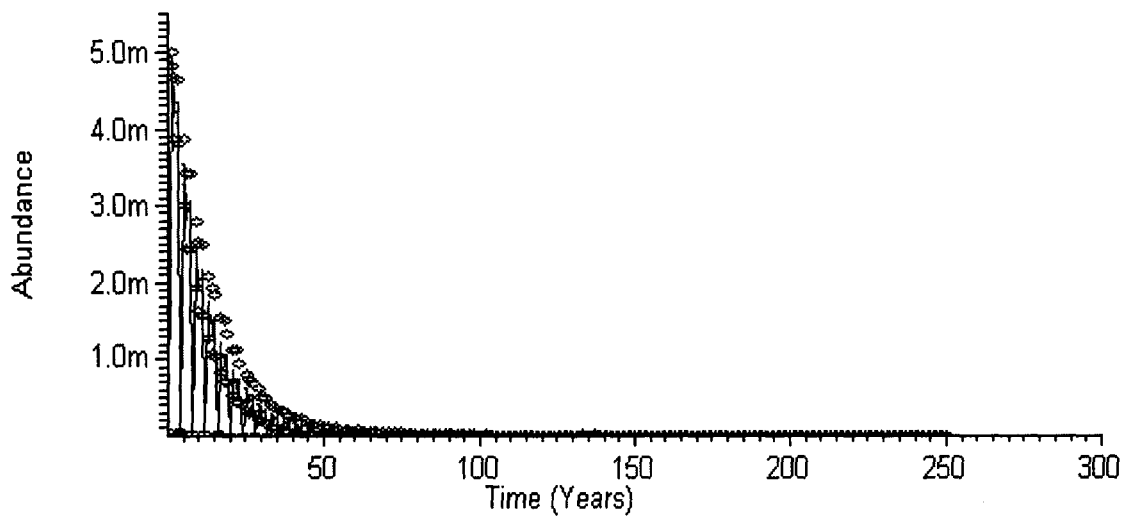
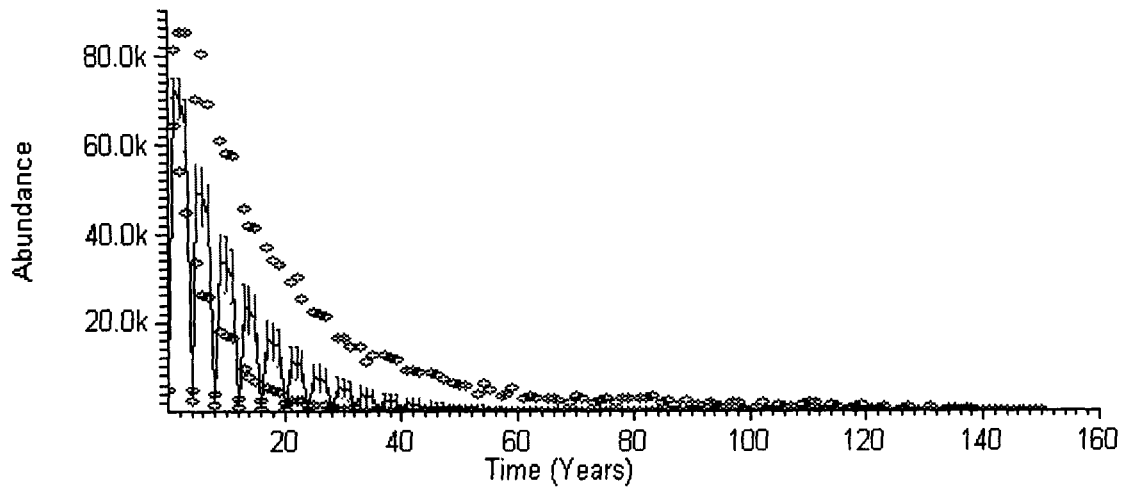


Figure 9.2: Trajectory summary of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

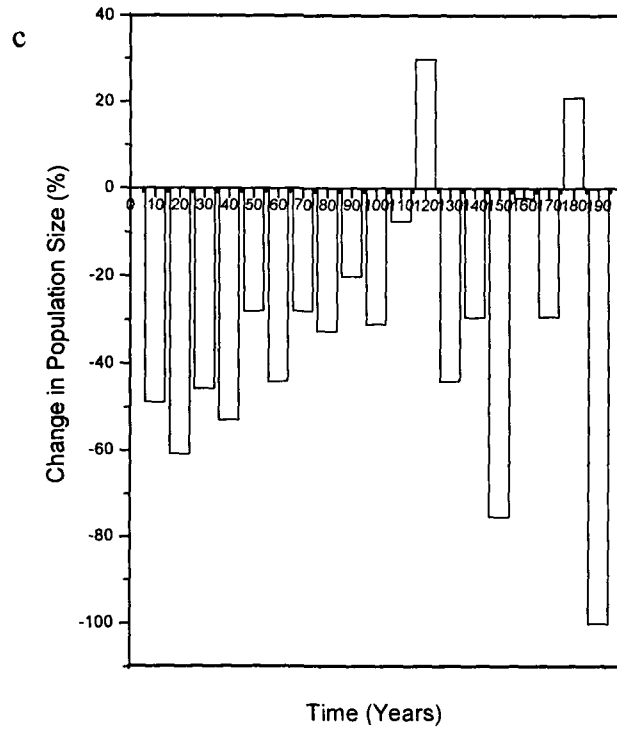
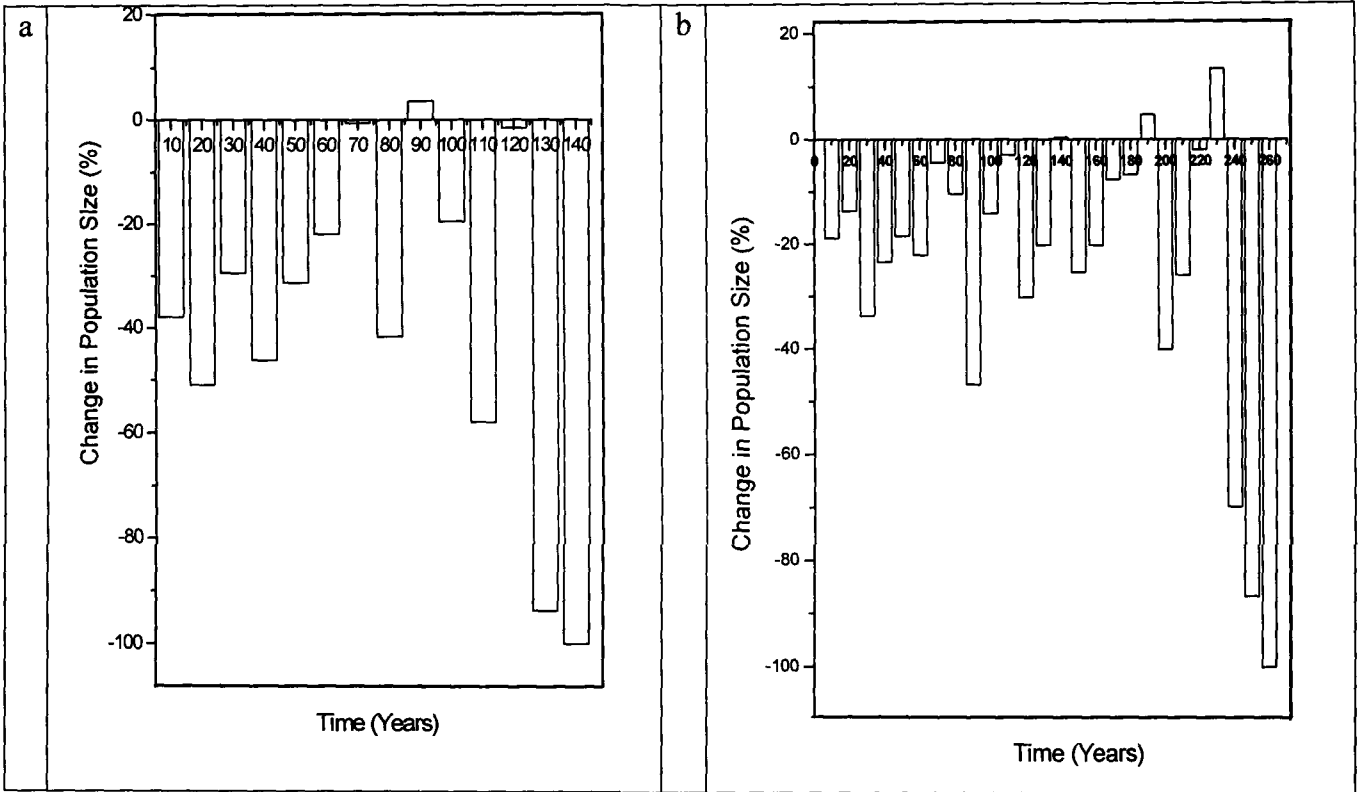


Figure 9.3: Decadal change in Population size of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng*, and (c) *Osbeckia capitata*.

Population abundance and Population size

A statistical summary of the abundance of the metapopulation (and each of its populations) as it changes through time is depicted in figure 9.2. The average, ± 1 standard deviation, minimum and maximum abundances are all output. The ± 1 standard deviations are displayed symmetrically around the mean, regardless of the actual distribution.

Decadal change in population size of the selected species over a period of time is depicted in figure 9.3. In case of *Monotropa uniflora*, it is projected that there would be a 38% decline in the population size in 10 years. Whereas, in case of *Osbeckia capitata* and *Panax pseudoginseng* the decline was projected as 49% and 19% respectively in 10 years. Increase in population sizes at few particular time steps during matrix projection was observed in all three species. There was a 4% increase in the *Monotropa uniflora* populations in 90 years. Similarly, there was a 30% increase in the *Osbeckia capitata* populations in 120 years and 19% in 180 years. In *Panax pseudoginseng* populations there was a 0.28% increase in 140 years, 5% increase in 190 years and 13% increase in 230 years.

Stage Abundance

Figure 9.4 depicts the change in average abundance of each stage of each population through time. It indicates the average number of individuals (over all replications) in each stage of each population. In case of *Monotropa uniflora* populations, the matrix projection revealed that the Adult populations will become extinct first in 135 years followed by Juvenile populations (138 years) and Young populations (135 years). Whereas, in the case of *Osbeckia capitata*, the Juvenile populations would disappear first

in 190 years followed by Adult populations (195 years) and Young populations (201 years). However, *Panax pseudoginseng* populations showed a different trend *i.e.*, 5-Leaved Adult populations will go extinct the earliest in 252 years followed by 4-Leaved and 6-Leaved adult populations (258 years), and Seedlings and Saplings (263 years).

Metapopulation occupancy

Figure 9.5 depicts the occupancy rate *i.e.*, the proportion of time patches remained occupied. It shows a histogram with the average, ± 1 standard deviation, minimum and maximum number of time steps that each population has remained extant *i.e.*, abundance was above the local threshold.

From the metapopulation occupancy, it can be inferred that the number of time steps that each population of *Monotropa uniflora* will remain extant is 97 years. Similarly, that for *Osbeckia capitata* and *Panax pseudoginseng* is 128 and 192 years respectively.

Time to extinction

Figure 9.6 depicts the distribution of time it takes the metapopulation size to fall below the extinction threshold for metapopulation. The dotted vertical line indicates the median of the distribution. This result is based on the total abundance of stages. The graph shows the probability that the metapopulation size will fall below the specified threshold exactly at a specific time step.

In case of *Monotropa uniflora* there is a 50% risk that the metapopulation abundance will fall below the threshold in 69.2 years. Similarly, in the case of *Osbeckia capitata* and *Panax pseudoginseng* there is a 50% risk that the metapopulation abundance will fall below the threshold in 98.8 and 119.2 years respectively.

Table 9.3: Minimum viable population (MVP) size and time to quassi-extinction for *Monotropa uniflora*, *Panax pseudoginseng* and *Osbeckia capitata*.

Species	Time to $\leq 5\%$ Extinction Probability (Years)	Minimum Viable Population Size	Time to 50% Extinction Probability (Years)
<i>Monotropa uniflora</i>	69	2019	69.2
<i>Panax pseudoginseng</i>	114	2429	119.2
<i>Osbeckia capitata</i>	95	19,104	98.8

The minimum viable population size (MVP) for *Monotropa uniflora* is 2019 in 69 years and that for *Osbeckia capitata* and *Panax pseudoginseng* is 19,104 in 95 years and 2429 in 114 years respectively (Table 9.3).

Discussion

Analysis of discrete growth rates (λ) indicated that the populations of all the three species viz., *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*, were declining, since all estimates of λ for the populations were <1 .

The stable stage distribution (w), for a matrix is the relative proportion of individuals in each if the populations were in equilibrium. Comparisons of actual stage distributions with those predicted (w) showed that the population matrix simulation yield an Eigenvalue of $\lambda = 0.911$, 0.912 and 0.954 respectively for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*, which indicates that there is a constant reduction of population by 8.9%, 7.8% and 4.6% respectively at each time step. The Young and Adult stage in *Monotropa uniflora* will grow at the same rate of 0.011 and 0.004 respectively, which also indicates that from the stable stage onwards, there will be 98.9% and 99.6% decline of Young and Adult staged individuals in each time step i.e., year. In the case of *Osbeckia capitata*, the Juvenile stage will grow at the same rate of 0.007 which also indicates that from the stable stage onwards, there will be 99.3% decline of Juvenile staged individuals in each time step (year). However, Seedlings, Saplings and 5-Leaved Adult stages of *Panax pseudoginseng* populations will grow at the

same rate of 0.051, 0.011 and 0.004 respectively, indicating that from the stable stage onwards, there will be 94.9%, 98.9% and 99.6% decline of Seedlings, Saplings and 5-Leaved Adult staged individuals in each time step.

All populations for all the selected three species have the same eigenvector since the same projection matrix was used for all populations. This is based on the assumption that the demographic rates was more or less similar for all populations.

Elasticity analysis, in the case of *Monotropa uniflora*, fecundity contributed the most to population growth. However, in case of *Osbeckia capitata* and *Panax pseudoginseng*, matrix transitions representing growth from one stage to another contributed the most to population growth. Elasticity values of rare plants indicate which life history stages are most critical to population growth (Schemske *et al.* 1994). This has implications in conservation activities. Therefore, while conserving the whole population, special protection to these sub-sets of population will make the conservation effort a success.

The simulated population sizes at a given time step have a skewed distribution. As a result of a skewed distribution, the median is less than the mean. Decadal change in population sizes of the selected species revealed that 100% extinction was projected to 140 years for *Monotropa uniflora*, 190 years for *Osbeckia capitata* and 260 years for *Panax pseudoginseng* although positive increments were shown during matrix projections at certain time steps.

The stage abundance analysis revealed that in *Monotropa uniflora* and *Panax pseudoginseng*, reproductive individuals would go extinct first followed by non-

reproductive individuals. However, in *Osbeckia capitata* non-reproductive individuals would go extinct first followed by the reproductive individuals .

The MVP size for all the three species suggests that appropriate intervening need to be made before it goes extinct. Though extinction and recolonization is a natural process, these species however need immediate attention since whole metapopulation is at stake. Although from MVP estimation we can see that the populations have not yet reached the threshold minimum population size (or effective population size), it is necessary to ensure its persistence by initiating effective conservation efforts.

Thus, the application of population viability analysis in this study has provided explicit population data that helped in describing the potential management actions.

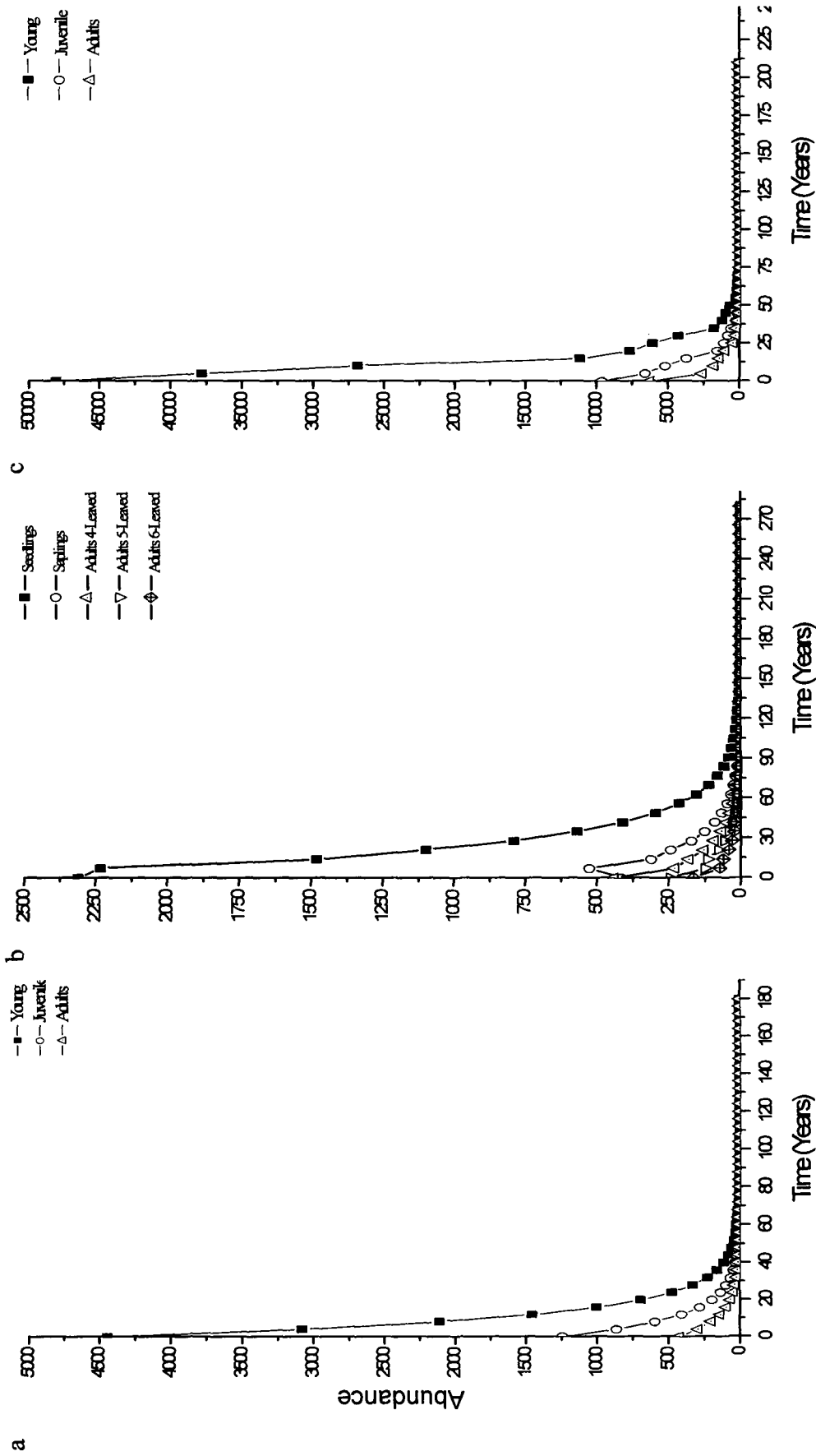


Figure 9.4: Decadal change in Population size of (a) *Monotropa uniflora*, (b) *Osbeckia capitata* and (c) *Panax pseudoginseng*.

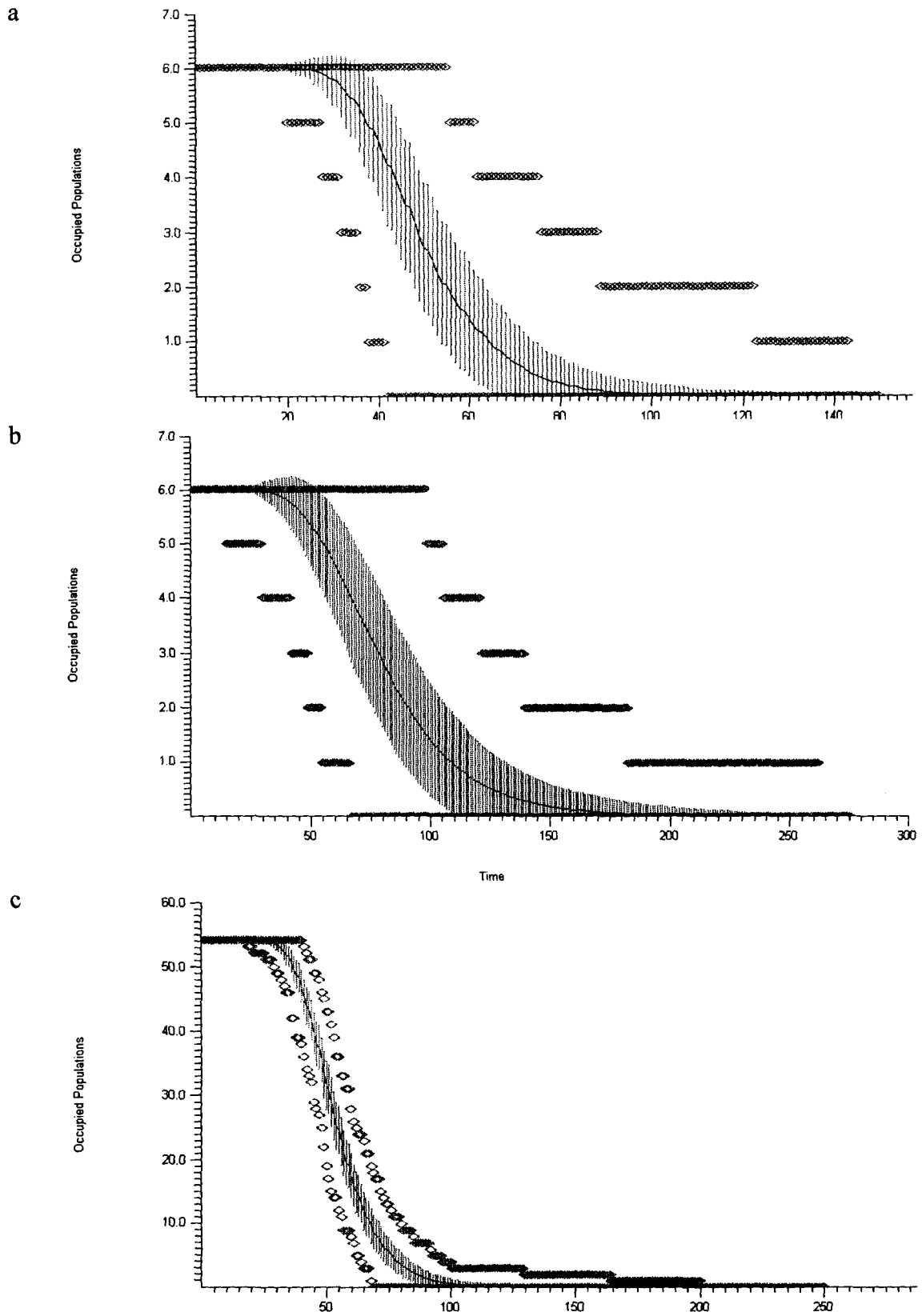


Figure 9.5: Metapopulation occupancy of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

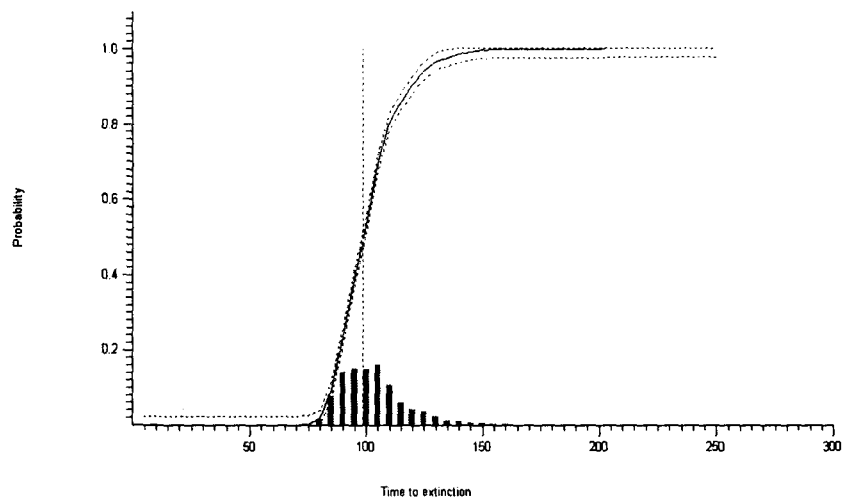
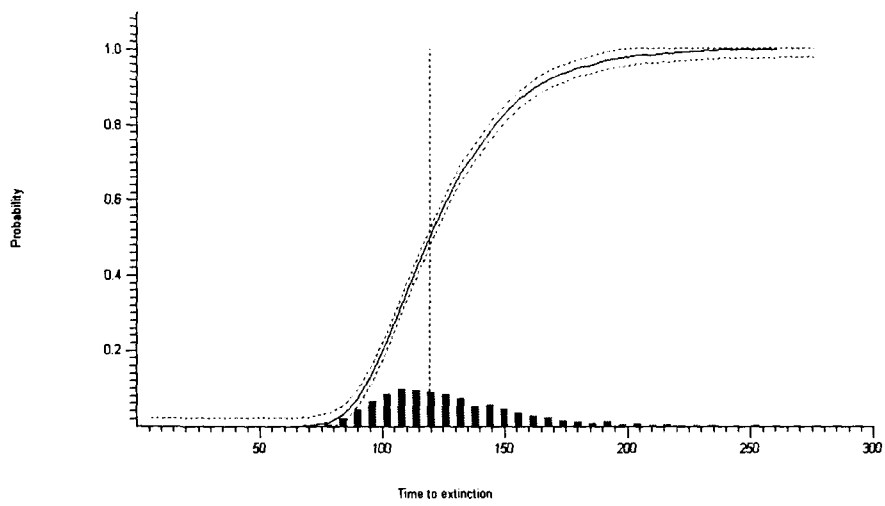
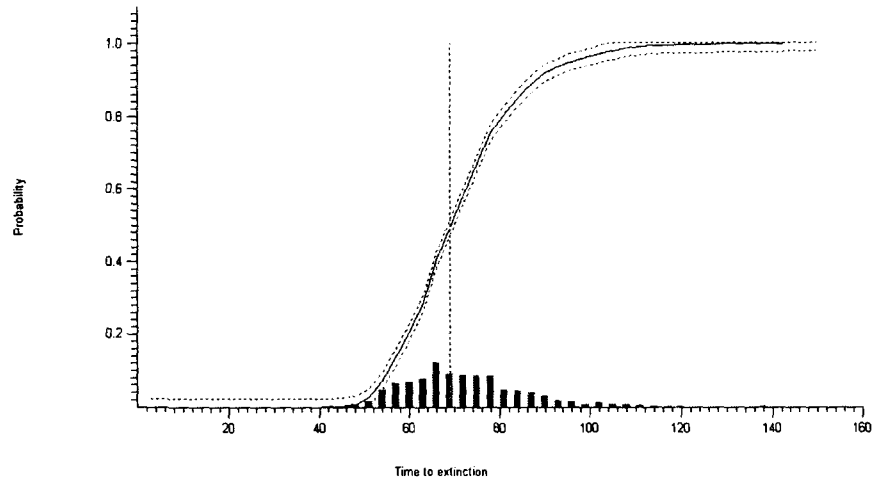


Figure 9.6: Extinction time and time to quasi-extinction of (a) *Monotropa uniflora*, (b) *Panax pseudoginseng* and (c) *Osbeckia capitata*.

Out of 270,000 plant species so far scientifically described, an estimated 70,000 plants have medicinal importance (Balick and Cox 1996). Globally, about 80% of the traditional medicines used for primary health care are derived from plants (Farnsworth and Soejarto 1991; Pei Shengji 2001). In India, over 17,500 species of higher plants are found, of which 6,000 are believed to have therapeutic properties (FRLHT 2007). The north-eastern region of India harbors about 8,000 plant species, of which about 2,500 are used for medicine. Meghalaya is home to 3,126 plant species (Khan *et al.* 1997) of which 834 are used either in pharmaceutical industries in local health care systems (Barik *et al.* 2007). At present, except for the traditional medical practitioners who are dependent on medicinal plants for their vocation, livelihood dependence on medicinal plants amongst the people is minimum (Barik *et al.* 2007). Therefore, there is ample scope for livelihood enhancement through taking up of medicinal plants cultivation and sustained trade in the region (Misra and Dutta 2003).

Because of overexploitation and several other associated factors, many of the medicinal plant species are on the verge of extinction. However, no empirical data is available to assess the threat status of these medicinal plants. The correct threat assessment of the species is crucial for conservation prioritization. Till date in India categorization of threatened species is largely based on herbarium studies. Considering the biasness associated with the herbaria collection, the categorization may not be accurate. Therefore, empirical population data across the generations have been considered as essential criteria for classification by the IUCN and other international

agencies. The protocols followed by these agencies are often too exhaustive and may not be possible to collect data on certain aspects in Indian conditions. The data pertaining to many of the criteria may also take many years of study. Therefore, the need to develop a workable protocol for correct classification of species from threat perspective has been overdue.

The present study was conducted in Meghalaya to assess the threat status of three selected medicinal plant species viz., *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*. The other objectives of the study were, to determine the concentration of endemism in different parts of Meghalaya, to assess the endemism of selected medicinal plant species based on their distribution mapping; and to prioritize the areas for conservation for the selected species. Besides achieving the above objectives, the study has been able to establish a workable protocol with selected population parameters for classifying the plant species from threat perspective based on a short term (4 years) research work. The empirical population data were collected through extensive field study and were analyzed using spatial and mathematical models to achieve the above objectives.

Endemic and Threatened Medicinal Plant Species of Meghalaya

In the present study, a total of 834 medicinal plant species were recorded which are distributed in 548 genera and 166 families (Annexure 1). There were 266 (32%) herbs, 264 (32%) trees, 177 (21%) shrubs, 93 (11%) lianas and climbers, and 34 (4%) under shrubs. The dominant families were Rubiaceae followed by Asteraceae and Fabaceae (Barik *et al.* 2007). Of these 834 medicinal plant species, 37 were endemic either to Eastern Himalayas or Northeast India or Meghalaya. These endemic species were restricted to low (100-400 m a.s.l.) and mid (400-1600 m a.s.l.) elevation zones. The

distribution pattern of these endemic plant species in the state revealed that majority of them are confined to such undisturbed habitats and protected areas as Nokrek Biosphere Reserve (37.8%) and sacred groves at Jowai (35.1%) and Raliang (32.4%). Twelve species were endemic to Meghalaya only. Out of the 116 species classified under varying degrees of threat only 38 were assessed under the IUCN Criteria (IUCN 2001). The rest 78 species were arbitrarily classified as rare, extremely rare, very rare based on herbarium records only. The threatened category of medicinal plant species constituted 13.8% of the recorded medicinal plant species of the state and are distributed over 96 genera and 67 families (Annexure 2) (Lakadong and Barik 2006).

Some of the endemic medicinal plant species of Meghalaya that are threatened are *Acanthus leucostachys*, *Calamus erectus*, *C. aurantium*, *C. latipes*, *Curcuma montana*, *Daphniphyllum himalense*, *Elaeagnus conferta*, *Goniothalamus simonsii*, *Hedera nepalensis*, *Hymenodictyon excelsum*, *Ilex embeloides*, *Mahonia pycnophylla*, *Munronia pinnata*, *Nepenthes khasiana*, *Ochna squarrosa*, *Ophiorhiza sub-capitata*, *Paramignya micrantha*, *Piper peepuloides*, *Schima khasiana* and *Sophora accuminata* (Upadhaya *et al.* 2004, Prabhu 2004, Tripathi & Goel 2001, Haridasan *et al.* 1995, Kumar *et al.* 1987, Joseph and Kharkongor 1981, Rao and Shanpru 1981, Rao 1981a, b, Rao and Neogi 1980, Kumar *et al.* 1980).

Assessment of threat status and conservation ranking

Three medicinally important species viz. *Osbeckia capitata*, *Monotropa uniflora* and *Panax pseudoginseng* were assessed for threat status and conservation ranking based on the IUCN Criteria (IUCN 2001).

The study shows that *Panax pseudoginseng* belong to the Critically Endangered (CR) category which was also classified by CAMP (1998, 2003) under the Critically Endangered (CR) category. *Monotropa uniflora* belonged to Critically Endangered (CR) category, although earlier it was classified as “Extremely Rare” (Rao and Haridasan 1982) or “At Risk” (Rao and Haridasan 1983). *Osbeckia capitata* was assigned the status of endemic and endangered, although, previously it was only assigned the status of “Endemic’ only (Balakrishnan 1981-83).

Methods devised by Atlantic Canada Conservation Data Centre (CDC, 2003) was followed for assigning conservation ranks to the selected species. The data collected from the natural populations of *Panax pseudoginseng* revealed that 30.8% were affected by natural as well as anthropogenic threats and an overall decline of 23.6% was recorded at the end of the four-year study period. The Levin’s microhabitat niche breadth calculated for most of the micro-environmental parameters viz., light intensity, pH, TKN and SOC was 1.00. Thus, based on the population size, number of matured individuals and narrow microhabitat niche breadth, the species was placed under the S-Rank “S-1”.

There was a decline in the number of Element Occurrences (7-5), Provincial abundance (700 ha-500 ha), Provincial Range (6.7%), Population Abundance Trend (45.9%) and Distribution Trend (16.7%) in case of *Monotropa uniflora* populations. At least, 48.2% of the Populations and 16.7% of the habitats were threat affected. The Levin’s microhabitat niche breadth calculated for most of the micro-environmental parameters (Light intensity, Soil temperature, pH, TKN, SOC and K) in case of *Monotropa uniflora* was 1.00. Thus, based on the Element Occurrences, abundance,

population size, number of mature individuals and narrow microhabitat niche breadth of the species, *Monotropa uniflora* was also placed under the S-Rank “S-1”.

Osbeckia capitata, on the other hand, was placed under the S-Rank “S-3” based on a decline in the Population Abundance Trend (4.9%) and population size (19.5%) affected by threats.

Another method for assigning the Conservation ranking was adopted from the IUCN sub-criteria (IUCN 2001) viz., Extent of occurrence (EOO) and Area of occupancy (AOO) under the criteria of Geographic range size (Moat 2007). The EOO and AOO ratings were assessed using the “cats.avx” script (ArcView 3.3) software. The results revealed that *Monotropa uniflora* and *Panax pseudoginseng* belonged to Endangered (EN) category. However, the EOO rating for *Osbeckia capitata* was Endangered (EN) and the AOO rating was Near Threatened (NT).

A good initial estimate of threat is provided by the use of these measures. It may be used as a baseline status for the species for future monitoring. Rank assignment in the two methods of conservation ranking viz., IUCN and CDC are different because of the difference in the categories and criteria adopted by the two methods. However, the categories are now standardized as S1 corresponding to CR, S2 to EN, S3 to VU and S4 to Near Threatened (NT). The parameters used in this assessment have been standardized and can be adopted in future studies for threat classification of a large number of species based on detailed population monitoring.

Endemicity of selected medicinal plant species

Endemic type of the selected species was determined by using predictive distributional modeling and distributional accounts from published literature (Kumar *et al.* 1980; Rao

and Neogi 1980; Joseph and Kharkongor 1981; Rao 1981a, b; Rao and Shanpru 1981; Kumar *et al.* 1987; Haridasan *et al.* 1995; Tripathi & Goel 2001; Prabhu 2004; Upadhaya *et al.* 2004). Results of the predictive distributional modeling using GARP revealed that the distribution of *Osbeckia capitata* was restricted to the Khasi and Jaintia Hills Districts of Meghalaya only. The model was validated by visiting the areas predicted by the model. Ecological niche modeling served as a useful tool to assess the endemism of the species as evident from the results obtained for *Osbeckia capitata*. The species was endemic to Meghalaya only in the Indo-Burma hotspot. The model also confirmed the political or biogeographical endemism of the species. From the published literature it was observed that *Monotropa uniflora* and *Panax pseudoginseng* are widely distributed worldwide. However, the ecological niche model as well as field surveys showed that they have a restricted distribution within Meghalaya and were confined to higher altitudinal zones. Hence, *Monotropa uniflora* and *Panax pseudoginseng* are not endemics.

Genesis of rarity and possible reasons for rarity

The major factors leading to rarity of *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* are overexploitation, microhabitat conditions, metapopulation size and regeneration constraint. The average annual extraction by traditional healers was 6.3% and 11.1% if the total population sizes in case of *Panax pseudoginseng* and *Osbeckia capitata*. However, no extraction was recorded in case of *Monotropa uniflora*. Field observations and interviews with the local inhabitants and traditional healers revealed that, they harvest the rhizomes of *Panax pseudoginseng* and the entire plant of *Osbeckia capitata*. Since it was not possible to locate *Panax pseudoginseng* during other season,

the rhizomes were harvested only during specific months *i.e.*, when the species is at flowering and fruiting stage. Some of the traditional healers have started planting *Panax pseudoginseng* in their home gardens. *Osbeckia capitata* is also collected during the flowering season as identification during that period of time is easy. Because of anthropogenic disturbances and loss of habitats these species showed a decline in population as evident by significant reduction in the population size in all the sites and all the years.

There are some species which have narrow niche while others require wide range of habitat and the distribution of species is thus determined by a set of micro-environmental conditions. *Monotropa uniflora* and *Panax pseudoginseng* were restricted to moist shady localities with a thick layer of litter. However, *Osbeckia capitata* was found to occur in wide range of habitat *viz.* grasslands, rock tops and crevices, sandy areas, road sides, forest periphery, pine forest floor and disturbed patches formed as a result of forest clearings or abandoned cultivated land. Microhabitat niche breadth calculated for each species revealed that *Osbeckia capitata* had a wide range of habitat preferences then does *Monotropa uniflora* and *Panax pseudoginseng*.

The metapopulation size of all the three species showed a peak maximum during the month of September. However, it showed a declining trend in the four years of study indicating a definite decline in the population of the selected species. *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* showed a decline of 48.4%, 26.7% and 6.2%, respectively in the number of individuals by the end of the study period. The low average annual seedling recruitment in all the three species could also be playing a role rendering them as rare. In *Panax pseudoginseng*, the average annual seedling

recruitment was 12 (0.36%) per population. In the case of *Monotropa uniflora* and *Osbeckia capitata*, the average annual seedling recruitment was 25 (0.15%) and 10 (0.22%), respectively (Table 5.9).

Overall, the extraction of plants, regeneration constraints, decline in metapopulation size and narrow ecological niche are the causes of rarity for *Osbeckia capitata* and *Panax pseudoginseng*. Whereas, in case *Monotropa uniflora*, narrow ecological niche, regeneration constraints due to shrinking safe sites, decline in metapopulation size and poor germination are the causes of rarity. Over-exploitation is a more severe threat to species survival than habitat loss. Habitat loss is a threat to a wide range of taxa, and may not be focused on one species, while over-exploitation selectively poses problems to targeted taxa (Reid & Miller 1989, Pandit and Babu 1998) such as medicinal plants, orchids and timber trees. Overexploitation and low regeneration are the major factors responsible for low survival chances in case of *Osbeckia capitata* and *Panax pseudoginseng*.

Population viability analysis

Population viability analysis was done for the three species as an approach to determine the population growth rates of the species, matrix transitions stage contributing the most to population growth, the extinction time and the Minimum Viable Population (MVP).

All three species showed a decline in the population *i.e.*, the population growth rates (λ) were <1 . An Eigenvalue (λ) of 0.911, 0.912 and 0.954 for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*, respectively were obtained when the actual stage distributions were compared with the stable stage distribution (w). This would imply that

there was a constant reduction of population of *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* by 8.9%, 7.8% and 4.6% respectively at each time step.

In case of *Monotropa uniflora*, the young and adult staged will grow at the same rate of 0.011 and 0.004 respectively. This would mean that there will be 98.9% and 99.6% decline of young and adult staged individuals each year. Similarly, the Juvenile stage, in case of *Osbeckia capitata* will grow at the same rate of 0.007 which also indicates that from the stable stage onwards, there will be 99.3% decline of Juvenile staged individuals each year. However, *Panax pseudoginseng* populations will grow at the same rate of 0.051, 0.011 and 0.004 respectively in case of Seedlings, Saplings and 5-Leaved Adult stages which means that from the stable stage onwards, there will be 94.9%, 98.9% and 99.6% decline of Seedlings, Saplings and 5-Leaved Adult staged individuals each year.

As the same projection matrix was taken for all populations, the same eigenvector was obtained for all populations of the three species. Fecundity contributed the most to population growth in the case of *Monotropa uniflora*, whereas, matrix transitions representing growth from one stage to another contributed the most to population growth of *Osbeckia capitata* and *Panax pseudoginseng*. The life history stages most critical to population growth is obtained through such analysis (Schemske *et al.* 1994). Such elasticity values have high conservation implications *i.e.*, special protection to these subsets of population instead of the whole population, will boost conservation efforts of such species.

At a given time step, the simulated population sizes will have a skewed distribution as a result of which the median is less than the mean. Decadal change in

population sizes for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* revealed that 100% extinction was projected in 140, 190 and 260 years, respectively. During matrix projections, positive increments were recorded at certain time steps. Reproductive individuals will go extinct first followed by the non-reproductive individuals in case of *Monotropa uniflora* and *Panax pseudoginseng*, however, it was just opposite in *Osbeckia capitata*.

The MVP is important from conservation point of view. Since, the whole metapopulation is at stake, these species require immediate protection in order to ensure that the MVP of the three species remains much higher than the threshold minimum population size (or effective population size).

Population viability analysis has been applied to compare potential management actions. Long-term and reliable set of demographic monitoring data showing temporal variation in population dynamics coupled with ecological factors affecting the population and detailed autecological information on the species are important for such analysis (Burgman *et al.* 1988).

Prioritization of areas for conservation

Due to economic and logistic constraints in protecting the large area, prioritization of area is a necessary step towards conservation of the species. The major areas for conservation of all the endemic medicinal plants in Meghalaya were identified based on the concentration of endemic species in a given area. Such areas *viz.*, Nokrek, Jowai, Raliang, and Shillong are the biodiversity rich areas of the state to which endemic species are attached. The major causes for restriction of species to these areas can be attributed to habitat specificity, geographic isolation, or fragility or sensitivity to natural factors and

low regeneration capacity of endemics. Areas of high endemism usually indicate high species diversity and, thus, demands special conservation efforts to be implicated on that particular area or region. Nevertheless, when area prioritization is to be done at species level, such broad scale approach becomes less fruitful. Hence, ecological niche modeling approach was used to prioritize the areas for conservation for the selected species, which could also be replicated for all other endemic and threatened category of species in the region. An area of 5821 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District were identified as the priority areas for the conservation of *Osbeckia capitata*, 1993 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District for *Monotropa uniflora* and 2086 km² in East Khasi Hills District for *Panax pseudoginseng* (Table 8.2).

The common important factors those were responsible for the distribution of the three species were temperature, precipitation and altitude. However, other factors regulating the distribution of the three species were topography in case of *Osbeckia capitata*, diurnal range in case of *Panax pseudoginseng* and vegetation cover in case of *Monotropa uniflora*. Nevertheless, the potential niche requirements of the species predicted by the GARP model are informative, but not without any limitations and should be used cautiously in conservation planning. These models need to be interpreted with caution due to the implications of model accuracy, model assumptions and fundamental versus realized niches. Such models would play an important part in conservation planning and would be a promising tool over the old techniques through fine scale resolution of environmental data that would be useful to address ecological limiting factors from accurate species distribution pattern. The models in the present study would

aid in developing management recommendations and future monitoring of the selected species under study, and also for other threatened and endemic species of Meghalaya.

Overall, it may be concluded that the identified areas of concentration of endemics would require immediate conservation efforts to protect these species from extinction. The methods followed in this study and the protocols developed for the study would be extremely useful for studying and classifying the populations of threatened and endemic species. Assessment of endemism and rarity following these methods would help in taking appropriate and effective measures for conservation of the species.

SUMMARY

The present study was conducted in Meghalaya to assess the threat status of three selected medicinal plant species viz., *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng*. The other objectives of the study were, to determine the concentration of endemism in different parts of Meghalaya, to assess the endemism of selected medicinal plant species based on their distribution mapping; and to prioritize the areas for conservation for the selected species. Besides achieving the above objectives, the study has been able to establish a workable protocol with selected population parameters for classifying the plant species from threat perspective based on a short term (4 years) research work. The empirical population data were collected through extensive field study and were analyzed using spatial and mathematical models to achieve the above objectives.

Three possible causative factors for rarity viz., over-exploitation, narrow species niche and regeneration constraint were evaluated in respect of each species. Rarity assessment was done by monitoring the populations, studying the fluctuations in the number of individuals within the population, and change in the geographic range-sizes of the species. Two protocols were consulted and adapted for rarity assessment, viz., Atlantic Canada Conservation Data Centre (CDC, 2003) protocol, and IUCN Categories and criteria (IUCN 2001) protocol. The IUCN criterion of Geographic range size was derived using ArcView 3.3 script “cats.avx” to delineate the AOO and EOO of the selected species (Moat 2007).

A detail inventory of medicinal plant species present in the state of Meghalaya was prepared both through primary and secondary data. The distribution pattern of threatened and endemic medicinal plant species was studied with the help of extensive

field visits and presented. Field visits were made during the peak growing season of the species. A Geographical Positioning System (GPS) was used to pinpoint the exact location of endemic species restricted to Meghalaya. Further, based on the GPS readings, distribution of the species was mapped on a scaled-map of Meghalaya to determine the areas of concentration of the endemic medicinal plant species.

The technique of ecological niche modeling was used to delineate the potential distributional areas of the species. The modeling approach used genetic algorithm as a tool to model the ecological niche of the plant species. The ecological niche modeling was carried out using a desktop version of GARP (Genetic Algorithm for Rule-set Prediction). The independent validation of the model was done by overlaying the occurrence points with the model projections. To visualize the ecological niche of the selected medicinal plant species in a two-dimensional environmental space, the geographic projection of the ecological niche models was related to the original environmental data layers to reconstruct the overall ecological variation across the landscape and the conditions under which the species was predicted to occur. To accomplish this task, all the layers were combined in Arc View 3.3. For *Monotropa uniflora* twentytwo environmental parameters were used. They were GIS raster layers summarizing the bioclimatic variables with a spatial resolution of 30 arc seconds ($\approx 1\text{km}$). GIS layers used from the USGS Hydro-1K dataset (USGS 2001) were also used in the predictive distributional modeling. For modeling the distribution of *Osbeckia capitata* and *Panax pseudoginseng*, twenty three environmental parameters were used. Areas for conservation were prioritized based on the potential distribution areas of the respective

species in the state. The global potential distribution of the species was modelled using GARP to confirm the endemism of the species.

PVA was performed based on the demography of the populations and the size of the seed bank. Transition matrices and deterministic projections of population growth and size class distribution were then performed with stage-based matrix models (Lefkovich Matrix). Matrices were calculated as the standard deviation of the four corresponding estimates. The finite rate of increase (λ) and elasticity analysis were calculated from the matrix projections. Incorporation of stochasticity into the model yielded simulations used to analyse the effect of environmental and demographic stochasticity on the persistence of the populations of the selected species. These simulations allowed us to estimate a minimum viable population size from the Time to extinction curve (Time step corresponding to $\leq 5\%$) and Population trajectory curve (population size corresponding to this time step) generated through the simulations. A stage-based matrix model was constructed for all known populations of the selected species. The matrix construction, manipulation and projection were done using RAMAS Metapop (Ackakaya 2000).

Some of the salient findings of the study are:

- In total, 834 medicinal plant species distributed in different elevational gradient of Meghalaya were listed. Of the total 239 endemic plant species of the state, 37 endemic medicinal plant species are found in Meghalaya, which are endemic to Himalayas, Indo-Burma region and Peninsular India. At least 12 medicinal plants are endemic to Meghalaya only
- The mean population size of *Monotropa uniflora* (110 ± 14.1) was greatest among the three species at the beginning of the study, followed by *Osbeckia capitata* (87

± 2.9) and *Panax pseudoginseng* (72 ± 9.9). The mean population sizes declined over a period of four years for all the three species. However, the decline was highest in case of *Monotropa uniflora*, where the population size declined to 57 ± 15.9 in the year 2007.

- Based on Rarity assessment (IUCN Category and Criteria 2001), *Panax pseudoginseng* and *Monotropa uniflora* belonged to the Critically Endangered (CR) category, whereas, *Osbeckia capitata* was assigned the status of Endangered (EN). Based on the the CDC Category and Criteria *Monotropa uniflora* and *Panax pseudoginseng* were both placed under the S-Rank “S-1”. *Osbeckia capitata* was placed under the S-Rank “S-3”. According to the conservation assessment tools “cats.avx”, the EOO rating for all three species was Endangered (EN). However, the AOO rating for *Monotropa uniflora* shifted from Vulnerable (VU) to Endangered (EN). Similarly, The AOO rating for *Panax pseudoginseng* was Endangered (EN). However, the AOO rating for *Osbeckia capitata* was Near Threatened (NT).
- Overall, the extraction of plants, regeneration constraints, decline in metapopulation size and narrow ecological niche are the causes of rarity for *Osbeckia capitata* and *Panax pseudoginseng*. In case *Monotropa uniflora*, narrow ecological niche, regeneration constraints due to shrinking safe sites, decline in metapopulation size and poor germination are the causes of rarity.
- *Monotropa uniflora* had the highest population at the beginning of the study followed by *Osbeckia capitata* and *Panax pseudoginseng*. The populations of all the three species declined over the study period and the declining was maximum

in *Monotropa uniflora* leaving only a mean population size of 54 from the initial mean population size of 154.

- Decadal change in population sizes for *Monotropa uniflora*, *Osbeckia capitata* and *Panax pseudoginseng* revealed that 100% extinction probability was projected in 140, 190 and 260 years, respectively.
- Elasticity analysis revealed that Fecundity contributed the most to population growth in the case of *Monotropa uniflora*, whereas, matrix transitions representing growth from one stage to another contributed the most to population growth of *Osbeckia capitata* and *Panax pseudoginseng*.
- From the metapopulation occupancy, it was inferred that the number of time steps that each population of *Monotropa uniflora* will remain extant is 97 years. Similarly, that for *Osbeckia capitata* and *Panax pseudoginseng* is 128 and 192 years respectively. In case of *Monotropa uniflora* there is a 50% risk that the metapopulation abundance will fall below the threshold in 69.2 years. Similarly, in the case of *Osbeckia capitata* and *Panax pseudoginseng* there is a 50% risk that the metapopulation abundance will fall below the Threshold in 98.8 and 119.2 years respectively.
- The minimum viable population size (MVP), including the seeds for *Monotropa uniflora* is 2019 and that for *Osbeckia capitata* and *Panax pseudoginseng* is 19,104 and 2429, respectively.
- The major areas of concentration of endemic species in Meghalaya are confined to undisturbed habitats and protected areas like Nokrek Biosphere Reserve (37.8%) and sacred groves at Jowai (35.1%) and Raliang (32.4%).

- The common important factors, highlighted by the ecologic niche models that were responsible for the distribution of the three species were temperature, precipitation and altitude. However, other factors regulating the distribution of the three species were topography in case of *Osbeckia capitata*, diurnal range in case of *Panax pseudoginseng* and vegetation cover in case of *Monotropa uniflora*.
- Ecological niche modeling served as a useful tool to assess the endemism of a species as evident from the present study of *Osbeckia capitata*. The species was found to be endemic to Meghalaya in the Indo-Burma hotspot. The model also confirmed the political or biogeographic endemism of the species.
- An area of 5821 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District were identified as the priority areas for the conservation of *Osbeckia capitata*, 1993 km² in East Khasi Hills, West Khasi Hills and Jaintia Hills District for *Monotropa uniflora* and 2086 km² in East Khasi Hills District for *Panax pseudoginseng*. The major areas of concentration of endemic species in Meghalaya were also identified as the priority areas for the conservation.

Overall, it is recommended that the identified areas of concentration of endemics would require immediate conservation efforts to protect these species from extinction. The methods followed in this study and the protocols developed for the study would be extremely useful for studying and classifying the populations of threatened and endemic species. Assessment of endemism and rarity following these methods would help in taking appropriate and effective measures for conservation of the species.

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Annexure 1: List of the 834 medicinal plant species recorded from Meghalaya.

Species	Family	Common name/s	Habit	Parts used	Ailments
<i>Abelmoschus moschatus</i> Medic.	Malvaceae	Musk mallow [E]	H	Se, R, L	Spasms, Throat Hoarseness & Dryness, Scabies, Hysteria, Nervous Disorders, Gonorrhoea, Venereal Diseases.
<i>Abronia augusta</i> L.	Sterculiaceae	Dieng Tyrkhum [K]	S	R, B, S, L	Uterine Tonic, Dysmenorrhoea, Amenorrhoea, Menstrual Disorders, Abortifacient, Diabetes, Sinusitis, Gonorrhoea.
<i>Abrus pulchellus</i> Thw.	Fabaceae	Meimarangtheng [K]	S	Se	Heavy Loose Evacuation.
<i>Abutilon indicum</i> Sw.	Malvaceae	Hath Kopalial [G]	S	Wp	Diuretic, Demulcent, Laxative, Fever.
<i>Acacia concinna</i> DC.	Fabaceae	X	C	Fl	Deranged Bile.
<i>Acacia pennata</i> Willd.	Fabaceae	Remsu [G], Soh Myrsiang [K], Jermai Skei Ksiah [J]	T	L	Indigestion In Small Children.
<i>Acampe papillosa</i> L.	Orchidaceae	X	Ep	R	Rheumatism
<i>Acanthus leucostachys</i> Roxb.	Acanthaceae	Sam Khatchi [G]	H	Se, Sap, L	Allergies, Abscesses, Renal Calculi, Rheumatism, Worms, Hair Tonic, Eczema, Headache.
<i>Achyranthes aspera</i> L.	Amaranthaceae	Soh Byrthid [K]	S	Se, L, R	Piles, Diuretic, Boils, Abscess, Painfull Delivery, Antifertility, Rabies, Antidiabetic, Pneumonia, Menstrual Disorders, Insect Stings, Snake Bite.
<i>Achyranthes bidentata</i> Blume	Amaranthaceae	X	H	R	Inflammations, Hypotensive, Lumbago, Dysmenorrhoea, Atherosclerosis, Haematuria, Contusions, Sore Throat, Dystocia, Placenta Retention, Post-Partum Haematometra.
<i>Acorus calamus</i> L.	Araceae	The Sweet Flag [E]	S	R, Rh	Kwashiokor, Carminative, Emetic, Stomachic, Fever.
<i>Acorus gramineus</i> Soland.	Araceae	X	C	R	Stimulant, Tonic, Antiseptic.
<i>Acromychia pedunculata</i> Miq.	Rutaceae	Bol Grak [G], Sarmon Blai [J]	T	R, Tw, L, B, S	Rheumatism, Lumbago, Post-Partum Blood-Statia, Furunculosis, Impetigo, Snakebite, Dyspepsia.
<i>Actinodaphne angustifolia</i> Nees.	Lauraceae	X	T	L	Fever.
<i>Adenanthera pavonina</i> L.	Mimosaceae	Dieng Thing [K]	T	B, L, S, ht.wood	Colonorrhoea, Haematuria, Ulcers, Gout, Burning Sensation, Hyperdipsia, Giddiness, Dysentery, Haemorrhages.
<i>Adenostemma lavaenia</i> Kuntze.	Vitaceae	X	H	L	Antiseptic, Stimulant, Sternatutory.
<i>Adhatoda zeylanica</i> Medic.	Acanthaceae	Jakbi dalgapa [G]	S	Wp, L	Inflammation, Bodyache, Cough, Chronic Bronchitis.
<i>Adiantum philippense</i> L.	Pteridaceae	Krah Pniat [J]	H	L	Sprains.
<i>Adina cordifolia</i> Benth. & Hk.f.	Rubiaceae	Dieng Thing Pholo [K]; Saudang [G]	T	B	Febrifuge, Antiseptic, Worms in sores.
<i>Aegle marmelos</i> Corr.	Rutaceae	Belethi [G], Soh Trun [K]	T	Fr, B	Dysentery, Intermittent Fever, Diarrhoea, Apetiser.
<i>Aeschynanthes superba</i> Cl.	Gesneriaceae	Thylli Masi [K]	US	B	Fracture, Muscular Sprain.

<i>Aesculus assamica</i> Griff.	Hippocastanaceae	Bol Rimot [G], Dieng Dula [K]	T	L, B, R	Fever, Body Swelling, Diarrhoea, Cholera, Colic, Chest Trouble, Headache, Dropsy, Chronic Eye Diseases, Bowel Disorder, Beri Beri.
<i>Aesculus indica</i> Colebr. ex Camb.	Hippocastanaceae	X	T	Se	Phlebitis, Haemorrhoids, Varicose Veins, Ulcers, Thrombosis.
<i>Agapetes auriculata</i> Hk.f.	Vacciniaceae	Tynchang Khian [J]	S	S, B	Fracture, Dislocation Of Joints.
<i>Agapetes variegata</i> G. Don	Vacciniaceae	Jalamut [K], Thang Chhang [J]	S	S, B	Fracture, Dislocation Of Joints.
<i>Ageratum conyzoides</i> L.	Asteraceae	Sammok [G]	H	L	Sores, Cuts.
<i>Agrimonia nepalensis</i> D. Don	Rosaceae	Tynning [K]	US	R, L	Toothache, Diuretic, Tonic, Cough.
<i>Alangium chinense</i> Harms.	Cornaceae	Dieng Skhorkhla [K], Dieng Sladoh [J], Phagrang [G]	T	L	Snakebite, Carminative, Circulation, Contraceptive, Hemostatic, Numbness, Poison, Rheumatism, Wound.
<i>Albizia julibrissin</i> Durazz	Mimosaceae	X	T	B, Fl, Buds	Anxiety, Insomnia, Pulmonary Abscess, Trauma, Neurasthenia, Amnesia.
<i>Albizia lebeck</i> Benth.	Mimosaceae	Dieng Sahrin [K]	T	B, L, Fl, Se	Alternative, Aphrodisiac, Astringent, Expectorant, Restorative.
<i>Albizia odoratissima</i> Benth.	Mimosaceae	Khelbi [G], Dieng Saw [K], Dieng Krait [J]	T	B	Ulcers, Leprosy, Skin Diseases, Erysipelas, Bronchitis, Diabetes.
<i>Albizia procera</i> Benth.	Mimosaceae	Kherwi [G], Dieng Rilong [K]	T	L	Ulcers.
<i>Alchornea tiliacifolia</i> Muell. - Arg.	Euphorbiaceae	Ksiang Lenti [J]	T	S	Sprains.
<i>Allium cepa</i> L.	Liliaceae	Piat [K]	H	Buds	Antiperiodic, Antibacterial, Diuretic, Haemorrhoids, Dysentery, Colic, Jaundice, Asthma, Ophthalmia, Oralgia, Malaria, Lumbago, Epilepsy, Tumours, Paralysis, Leucoderma.
<i>Allium hookeri</i> Thw.	Liliaceae	X	H	L	Bodyache.
<i>Allium sativum</i> L.	Liliaceae	Rynsun [K]	H	Buds	Hypertension, Diabetes, Helminthiasis, Angina Pectoris, Anti-Bacterial, Anti-Fungal, Arteriosclerosis, Rheumatoid Arthritis, Cancer, Scorpion Sting
<i>Allium tuberosum</i> Rottl. ex Spreng.	Liliaceae	X	H	L	Urinary Trouble, Diuretic.
<i>Alnus nepalensis</i> D. Don	Betulaceae	Alder [E]	T	B	Stomachache, Dysentery.
<i>Alocasia cuculata</i> Schott.	Araceae	X	S	L	Bodyache.
<i>Alpina calcarata</i> Rosc.	Zingiberaceae	X	H	Rh	Rheumatism, Fever, Bronchial Catarrh.
<i>Alpina galanga</i> Willd.	Zingiberaceae	The Greater Galangal [E]	H	Rh	Bronchial Catarrh, Respiratory Complaints, Depressant.
<i>Alpina nigra</i> Burtl.	Zingiberaceae	X	H	Rh	Colic, Gout.
<i>Alstonia scholaris</i> R. Br.	Apocyanaceae	Dieng Ryteng [K],	T	B, L	Thermogenic, Laxative, Febrifuge, Antipyretic, Malaria,

Sokson [G]

Dyspepsia, Skin Diseases, Leprosy, Pruritus, Chronic & Foul Ulcers, Tumours, Asthma, Bronchitis, Agalactia, Helminthiasis.

<i>Alternanthera sesilis</i> R. Br.	Amaranthaceae	X	H	Wp	Constitution, Burning Sensation, Diarrhoea, Leprosy, Skin Diseases, Dyspepsia, Haemorrhoids, Fever.
<i>Amomum corynostachium</i> Wall.	Zingiberaceae	X	H	Rh	Headache, Gastric Troubles.
<i>Amomum jainii</i> Sunil & Ved Prakash	Zingiberaceae	X	H	Rh	Headaches.
<i>Amorphophalus bulbifer</i> Bl.	Araceae	Jia Thynrewpson [J]	S	S, R	Skin Diseases, Burns.
<i>Ampelocissus latifolia</i> Planch.	Vitaceae	Shymow Sohdoh [J]	C	R	Wounds.
<i>Anacardium occidentale</i> L.	Anacardiaceae	Cashewnut Tree [E]	T	B	Intermittent Fever, Ulcers, Warts & Corns.
<i>Anamirta paniculata</i> Coleb.	Menispermaceae	Crow's Bane [E]	C	L, Fr	Thermogenic, Antifungal, Bronchitis, Foul Ulcers, Flatulence, Skin Diseases, Ringworm, Uterus Contraction After Delivery.
<i>Ananas comosus</i> Merr.	Bromeliaceae	Soh Trun [K]	H	Fr, L	Cardio & Uterine Tonic, Dyspepsia, Helminthiasis, STD's, Amenorrhoea, Dysmenorrhoea, Diuretic, Styptic, Strangury, Flatulence, Colic, Jaundice, Renal & Vesical Calculi, Scabies, Abortifacient, Whooping Cough.
<i>Anemone rivularis</i> Ham.	Ranunculaceae	Bat Soh Plia [K]	H	Se	Antiemetic, Vermifuge, Antidote, Rotting Tissues, Snake Poisoning, Stomach/Intestinal Pain From Worm Infestation.
<i>Angiopteris evecta</i> Hoffm.	Angiopteridaceae	X	H	Wp	Boils, Cough, Deorstruent, Haemostatic.
<i>Anthocephalus chinensis</i> Rich. ex Walp.	Rubiaceae	Dieng Sohlangpathi [K], Mi-Bol [G]	T	L	Flatulence, Chest, Evil Eye, Fever, Gargle, Poultice, Tonic.
<i>Antidesma diandrum</i> Roth.	Euphorbiaceae	Dieng Jypew [K]	T	L	Diaphoretic.
<i>Antirrhinum majus</i> L.	Scrophulariaceae	Snap Dragon [E]	H	Wp	Astringent, Detergent, Diuretic, Liver, Scurvy, Tumor.
<i>Aphanamixis polystachya</i> Parker	Meliaceae	Bol Somphal [G], Dieng Rata [K]	T	B, Se	Liver Disorders, Tumours, Ulcers, Worms, Skin Diseases, Leprosy, Jaundice, Haemorrhoids, Rheumatoid Arthritis, Myalgia.
<i>Apium graveolens</i> L.	Apiaceae	Celery [E]	H	Se, S, L	Aperitive, Jaundice, Nephretic Colic, Urinary Disorders
<i>Aquilaria agallocha</i> Roxb.	Thymelaeaceae	Bol Agar [G]	T	Res. wood	Leprosy, Skin Diseases, Ulcers, Rheumatoid Arthritis, Cough, Asthma, Albuminuria, Pectoralgia, Alexeteric, Bronchitis.
<i>Arachis hypogea</i> L.	Fabaceae	Shana Budam [K]	H	Se	Vehicle For Injections, Ointments & Liniments.
<i>Ardisia humilis</i> auct non. Vahl.	Myrsinaceae	Thai Gidloh Phang [K]	S	R	Diarrhoea, Rheumatism.
<i>Ardisia odontophylla</i> DC.	Myrsinaceae	Beholisam [G]	S	L	Ache (Stomach), Rheumatism.

<i>Ardisia paniculata</i> Roxb.	Myrsinaceae	X	S	R	Haemorrhoea.
<i>Areca catechu</i> L.	Arecaeae	Dieng Kwai [K]	T	S	Stimulant, Dysentery, Worms, Antidote.
<i>Argyria nervosa</i> Boj.	Convolvulaceae	Jatap Masi [K]	C	R, L	Rheumatism, Boils, Skin Diseases, Syphilis, Nerve Tonic, Eczema, Ringworm, Itch, Swellings.
<i>Arisaema consanguineum</i> Schott.	Araceae	Saru Bsein [K]	S	R	Skin Diseases.
<i>Aristolochia cathcartii</i> Hk.f.	Aristolochiaceae	Baro Nirkhut [G]	C	R	Smallpox.
<i>Aristolochia saccata</i> Wall.	Aristolochiaceae	X	L	R, L, Rh	Stomachache, Spleen & Urinary Troubles, Haemorrhage, Alexeteric, Snakebite, Scorpion Stings.
<i>Aristolochia tagala</i> Cham.	Aristolochiaceae	Soh Rynkhiah [K]	C	L, R	Stomachache, Snakebite, Toothache, Rheumatism, Tonic.
<i>Artemesia nilagirica</i> Pamp.	Asteraceae	Byrlud [J]	US	L, Fl	Alexeteric, Asthma, Cephalalgia, Bronchitis, Nervous & Spasmodic Affections, Amenorrhoea, Dysmenorrhoea, Anorexia, Flatulence, Colic, Worms, Hysteria, Measles, Anaemia.
<i>Artocarpus gomezianus</i> Wall. ex Trewl.	Moraceae	Armu [G], Dieng Soham [K]	T	Se, B	Sores, Boils, Purgative, Pimples.
<i>Artocarpus heterophyllus</i> Lam.	Moraceae	Dieng Sohphan [K]	T	L, R, Fr, Se, Wood	Diarrhoea, Fever, Boils, Wounds, Skin Diseases, Laxative, Ulcers, Diuretic, Constipation, Convulsions, Dysopia, Pharyngitis.
<i>Asclepias curassauria</i> L.	Asclepiadaceae	Blood Flower [E]	H	R	Sores, Ulcers, Emetic, Purgative, Vermin.
<i>Asparagus filicinus</i> Buch. - Ham.	Liliaceae	Chana Rieh Sla [J]	C	R	Apetiser, Indigestion.
<i>Asparagus racemosus</i> Willd.	Liliaceae	Wild Asparagus [E]	C	R	Fever
<i>Aster amellus</i> L.	Asteraceae	X	H	R	Cough, Pulmonary Affections, Haemorrhages, Malaria.
<i>Averrhoa carambola</i> L.	Averrhoaceae	Dieng Sohpyrshong [K]	T	L, Fl	Pruritus, Scabies, Intermittent Fevers, Worms, Constipation, Diarrhoea, Hyperdipsia, Hypatodynia.
<i>Azadirachta indica</i> Juss.	Meliaceae	Indian Lilac [E]	T	L, B, Se, Tw	Skin Diseases, Wounds, Anthelmintic, Antiseptic, Toothache & Gum Diseases, Eye Diseases, Leprosy.
<i>Bambusa arundinacea</i> Ait.	Poaceae	Thorny Bamboo [E]	T	Fr, Se, R	Laxative, Inflamed Joints, Haematemesis Diuretic, Leprosy, Skin Diseases, Ulorrhoea, Arthralgia, Ophthalmic, Constipation, Lumbago, Haemorrhoids, Gonorrhoea, Amenorrhoea, Dysmenorrhoea, Inflammations, Ulcers, Nausea.
<i>Calendula officinalis</i> L.	Asteraceae	X	H	Wp	Astringent, Heart Tonic, Carminative.
<i>Barleria cristata</i> L.	Acanthaceae	X	S	Wp	Whooping Cough, Headache.
<i>Bauhinia macrostachya</i> Wall.	Caesalpinaceae	Bemegong [G]	C	Wp	Skin Lesions.
<i>Bauhinia purpurea</i> L.	Caesalpinaceae	Megong [G], Dieng Long [K]	T	Fl, B, Buds	Diarrhoea, Laxative, Ulcers.

<i>Bauhinia vahlii</i> W. & A.	Caesalpinaceae	Megong budu [G]	C	R	Epilepsy
<i>Bauhinia variegata</i> L.	Caesalpinaceae	Darichiksam [G], Dieng Tharloug [K]	T	B, Fl	Tubercular Lymphodenetes, Haemorrhage.
<i>Begonia josaphi</i> A. DC.	Begoniaceae	X	H	Bulb	Stomachache.
<i>Begonia palmata</i> D. Don	Begoniaceae	Achak [G]	H	Wp	Liver Complications, Diarrhoea, Toothache, Venereal Diseases.
<i>Begonia roxburghii</i> Prodv.	Begoniaceae	X	H	Tuber	Fecal Discharges, Diarrhoea, Dysentery.
<i>Begonia thomsonii</i> A. DC.	Begoniaceae	Dawlik [G]	H	L, R	Labour Pains, Cuts, Wounds
<i>Benincasa hispida</i> Cogn.	Cucurbitaceae	Ash Gourd [E]	C	Fr, Se	Syptic, Diuretic, Antiperiodic, Asthma, Cough, Diabetes, Haemorrhages, Epilepsy, Urethrorrhoea, Syphilis, Hyperdipsia.
<i>Berberis wallichiana</i> DC.	Berberidaceae	Dieng Mat shynrang [K]	S	R	Antibacterial, Diarrhoea, Dysentery, Ophthalmia, Dyspepsia, Toothache, Vertigo, Photopsia.
<i>Bergenia ciliata</i> Sternb.	Saxifragaceae	X	H	R	Fever, Diarrhoea, Pulmonary Affections, Anti Scorbutic, Boils, Ophthalmia, Spleen Enlargement, Abscesses, Renal Affections.
<i>Beta vulgaris</i> L.	Chenopodiaceae	Bit [K]	H	R, L, Se	Coughs, Cuts & Burns, Strangury, Paralysis, Otaglia, Cephalalgia, Liver & Spleen Disorders, Anorexia, Flatulence.
<i>Betula alnoides</i> Buch. - Ham. ex D. Don	Betulaceae	Dieng Lieng [K], Bol Nangal [G]	T	Wp, R, L	Snakebite, Gastric Disorder, Headache.
<i>Bidens pillosa</i> L.	Asteraceae	X	US	L	Itchings.
<i>Bischofia javanica</i> Bl.	Bischofiaceae	Bol Asri [G], Dieng Jamew [K], Dieng Satung [J]	T	L, S, B	Mouth & Stomach Ulcers, Athlete's Foot, Stomachache, Pterygium, Burns, Tuberculosis.
<i>Bixa orellana</i> L.	Bixaceae	Arnotta Plant [E]	T	Se, R, B	Antiperiodic, Antipyretic, Intermittent Fevers, Gonorrhoea.
<i>Blechnum orientale</i> L.	Blechnaceae	X	S	Rh	Boils, Anthelmintic.
<i>Blumea balsamifera</i> DC.	Asteraceae	X	S	L	Antibacterisl, Antifebrile, Coryza, Influenza, Impetigo.
<i>Blumea chinensis</i> DC.	Asteraceae	X	S	L	Stomachic, Antiseptic, Diaphoretic.
<i>Blumea lacera</i> DC.	Asteraceae	X	H	Wp	Catarrh, Cephalalgia, Bruises, Wounds, Worms, Bronchitis, Leucorrhoea, Halitosis, Cholera.
<i>Boehmeria macrophylla</i> D. Don	Urticaceae	Dieng Sohkhhasim [K]	T	R	Eczema, Wounds.
<i>Boehmeria platyphylla</i> D. Don	Urticaceae	Labit long [J]	US	L	Eczema.
<i>Boemninghausenia albiflora</i> Reichle ex Meissn.	Rutaceae	X	T	R, Wp	Toothache, Antiperiodic, Lice, Anti Bacterial, Anti Fungal.

<i>Bombax ceiba</i> Linn.	Bombacaceae	Red Silk Cotton Tree [E]	T	R, B, L, Fr, S & prickles	Dysentery, Influenza, Burning Sensation, Blood Impurities, Wounds, Skin Irruptions, Chronic Inflammations & Ulceration Of The Bladder & Kidney, Gonorrhoea & Restoration Of Skin Colour
<i>Bombax malabaricum</i> DC.	Bombacaceae	Dieng Kymphad [K], Dieng Kya [J], Bol Chhu [G]	T	L	Cuts, Wounds.
<i>Bonnaya reptans</i> Spreng.	Scrophulariaceae	Samthamlang [K]	H	Wp	Worms In Skin.
<i>Borreria hispida</i> K. Schum.	Rubiaceae	Ramasam [G]	H	Wp	Thermogenic, Emollient, Dyspepsia, Colic, Flatulence.
<i>Brassica juncea</i> Hk.f. & Th.	Brassicaceae	Sla Tyrso [K]	H	S, Wp	Rubefacient, Vacicant, Emetic.
<i>Brassica oleracea</i> L.	Brassicaceae	Banda Kubi [K]	H	L	Constipation, Diuretic, Pruritus, Skin Diseases, Diarrhoea, Strangury, Worms, Bronchial Asthma, Warts, Urorrhoea, Gout.
<i>Bridelia montana</i> Willd.	Euphorbiaceae	X	T	Wp, R, B	Anthelmintic, Astringent.
<i>Bridelia retusa</i> Spreng.	Euphorbiaceae	Dieng Rishan [K]	T	B	Peptic Ulcers.
<i>Brucea mollis</i> Wall. ex Kurz.	Simaroubaceae	Dieng Lakseien Khlaw [K]	S	Fr, Se	Malaria, Cancer, Stomach Complaints.
<i>Brunella vulgaris</i> L.	Lamiaceae	X	S	Wp	Headache, Tinnitus, Conjunctivitis, Dry Cough, Boils, Spasms.
<i>Buddleja asiatica</i> Lour.	Buddlejaceae	Dieng Tutimyneng [K], Dieng Srarator [J]	S	Wp	Skin Diseases, Abortifacient.
<i>Buddleja macrostachya</i> Benth.	Buddlejaceae	Dieng Jalong Kren [K]	T	B	Masticatory.
<i>Butea minor</i> Buch. - Ham. ex Baker	Fabaceae	Dieng Lapalang [K&J]	S	Se	Intestinal Worms.
<i>Butea monosperma</i> Ktze.	Fabaceae	Bol Uri [G]	T	Fl, R, B, S	Astringent, Diarrhoea, Haemorrhoids, Skin Disorders, Leprosy, Swellings, Fever, Arthritis, Bone Fractures & Efficacious In Birth Control, Purgative, Ophthalmic, Anthelmintic & Tonic, Depurative, Diuretic, Aphrodisiac, Boils, Pimples, Flatulent, Colic, Worms, Piles.
<i>Calamus erectus</i> Roxb.	Arecaceae	Soh Thri [K]	S	Se, R	Indigestion, Stomachache, Malaria, Body Ache.
<i>Calamus floribundus</i> Griff.	Arecaceae	Soh Thri [K]	C	R	Weakness
<i>Callicarpa arborea</i> Roxb.	Verbenaceae	Dieng Lakhoit [K], Khimbar [G]	T	B, L	Fever, Gastritis, Giddiness, Skin Diseases, Headache, Scorpion Sting, Cutaneous Diseases.
<i>Callicarpa macrophylla</i> Vahl.	Verbenaceae	X	S	Fr, Fl	Constipation, Styptic, Alexeteric, Rheumatoid Arthritis, Cephalalgia, Dyspepsia, Diarrhoea, Dysentery, Haemorrhages.
<i>Calotropis gigantea</i> Dryand	Asclepiadaceae	Gigantic Swallow Wort	T	Fl, B, L, R	Cold, Cough, Elephantiasis.

	[E]								
<i>Calotropis procera</i> Br.	Asclepiadaceae	X	S	Fl	Asthma, Cold, Cough, Sore Throat, Sores, Boils.				
<i>Camellia caduca</i> Cl. ex Brandis	Theaceae	Dieng Tynem [K]	T	R	Skin Diseases.				
<i>Camellia sinensis</i> O. Ktze.	Theaceae	Dieng Slasha [K]	S	L	Diuretic, Diaphoretic, Hyperdipsia, Hemicrania, Cardiodynia, Ophthalmia, Haemorrhoids, Inflammation.				
<i>Canna indica</i> L.	Cannaceae	X	H	R	Tumour.				
<i>Cannabis sativa</i> L.	Cannabaceae	Kynja [K]	US	L, Fl	Asthma, Haemorrhages, Tetanus, Bladder Inflammation, Gonorrhoea, Nervous Disorder.				
<i>Canscora andrographioides</i> Griff.	Gentianaceae	Sak-sre [G]	S	R, L	Cuts, Wounds, Skin Diseases.				
<i>Canscora decussata</i> Roem.	Gentianaceae	Canscora [E]	H	Wp	Laxative, Alexeteric, Inflammations, Ascites, Worms, Insanity, Epilepsy, Leucoderma, Skin Diseases, Tuberculosis, Ulcers.				
<i>Canthium parviflorum</i> Roxb.	Rubiaceae	Shiah Soh Ngain [K]	S	L, R	Diuretic, Febrifuge, Strangury, Fever, Leucorrhoea, Worms.				
<i>Capparis assamica</i> Hk.f. & Th.	Capparaceae	Mantori [G]	S	L, R	Headache, Bodyache.				
<i>Capsicum annuum</i> L.	Solanaceae	Sohmynken Jhur [K]	H	Fr	Cancer				
<i>Carallia brachiata</i> Merr.	Rhizophoraceae	Bol Mengrang G, Dieng Soh Syllih [K]	T	Fr, B	Contagious Ulcers, Itches.				
<i>Cardamine impatiens</i> L.	Brassicaceae	X	H	Wp	Stimulant, Diuretic.				
<i>Careya arborea</i> Roxb.	Barringtoniaceae	Soh Kundur [K], Bol Dimbel [G], Styngkrain [J]	T	Fl, B, L, Fr	Thermogenic, Alexeteric, Antipyretic, Pruritus, Tumours, Cough, Dyspepsia, Colic, Haemorrhoids, Worms, Dysentery, Urorrhoea, Leucoderma, Fits, Smallpox, Ulcers, Vaginal Raptures.				
<i>Carica papaya</i> L.	Caricaceae	Soh kynphor [K]	T	L, S	Eczema, Worms, Warts, Corns, Tumours, Burns, Diptheria, Whooping Cough, Dyspepsia, Pollen Alergy.				
<i>Carpesium cernuum</i> L.	Asteraceae	X	H	Wp	Astringent, Diuretic, Anthelmintic.				
<i>Carpesium nepalense</i> Less.	Asteraceae	X	H	Wp	Astringent, Diuretic, Anthelmintic.				
<i>Caryota urens</i> L.	Arecaceae	Soh Thri [K]	T	L, Bu, Nu	Hyperdipsia, Fatigue, Hemicrania.				
<i>Casearia vareca</i> Roxb.	Flacourtiaceae	Dieng Sohlang [K]	S	Fr	Anthelmintic, Anticancer, Earache, Vermicidal.				
<i>Cassia alata</i> L.	Caesalpinaceae	Ringworm Shrub [E]	S	L, Fl, R	Eczema, Constipation, Bronchitis, Asthma, Diuretic.				
<i>Cassia fistula</i> L.	Caesalpinaceae	Soneru [G]	T	Pulp	Laxative, Purgative.				
<i>Cassia mimosoides</i> L.	Caesalpinaceae	X	H	Wp	Cuts, Wounds, Skin Diseases.				
<i>Cassia occidentalis</i> L.	Caesalpinaceae	Jaw-eit-niang-tynthai [J]	H	R, L, Fr, Se	Hepatitis, Skin Diseases, Anthelmintic, Diabetes.				
<i>Cassia sophora</i> L.	Caesalpinaceae	X	H	R	Perpeurium.				
<i>Cassia tora</i> L.	Caesalpinaceae	Taw Blei [K]	H	S	Itch, Cough, Ringworm.				
<i>Castanea sativa</i> Mill	Fagaceae	Soh Ot Heh [K]	T	L	Rheumatism, Lumbago.				
<i>Castanopsis indica</i> A. DC.	Fagaceae	Chakko G, Soh Ot [K]	T	L	Headache.				

<i>Castanopsis tribuloides</i> DC.	Fagaceae	Chhaku [G]	T	L	Weakness
<i>Catheranthus roseus</i> L.G. Don	Apocyanaceae	Madgaskar Periwinkle [E]	H	L, S, R, Fl	Emetic, Sore Throat, Laryngitis, Toothache, Haemostatic, Leukaemia, Breast Cancer, Psoriasis.
<i>Cayratia pedata</i> Juss. ex Gagnep.	Vitaceae	X	L	L	Cough, Bronchitis, Asthma, Joint Pain, Uterine Reflexes, Ulcers.
<i>Cedrus deodara</i> Lour.	Pinaceae	Deodar [E]	T	Wood, B	Diaphoretic, Antiseptic, Ulcers, Diuretic, Fever, Flatulence, Urinary Disorders, Piles, Kidney Stones, Diarrhoea, Dysentery.
<i>Celastrus panniculatus</i> Willd.	Celastraceae	Meilalih [K], Tylle Sochlain [J]	C	Se, B, L, S	Stimulant, Aphrodisiac, Rheumatism, Strengthening Memory, Antidote On Opium Poisoning, Expectorant, Appetiser, Cardiotonic, Diuretic, Anti-Inflammatory, On Itching & Skin Diseases, Paralysis, Asthma, Leucoderma, Beri-Beri & Sores.
<i>Celosia argenta</i> L.	Amaranthaceae	X	S	Se, Infl.	Acute Conjunctivitis, Keratitis, Epistaxis, Haemorrhoids, Uterine Bleeding, Diarrhoea, Leucorrhoea, Hypertension.
<i>Celtis australis</i> L.	Ulmaceae	Dieng Sothhangchi [K]	T	Fr	Amenorrhoea, Colic.
<i>Celtis cinnamomea</i> Lindl. ex Planch	Ulmaceae	X	T	Wood	Blood Purifier.
<i>Celtis tetrandra</i> Roxb.	Ulmaceae	X	T	Fr	Amenorrhoea, Colic.
<i>Celtis timorensis</i> Spanoghe	Ulmaceae	X	T	S	Blood Purifier, Itch, Skin Eruptions.
<i>Centella asiata</i> Urban	Apiaceae	Khliang Syiar [K]	H	L, S, R, Se	Brain Tonic, Leprosy, Tuberculosis.
<i>Cephalotaxus barringtonia</i> Knight ex Forbes	Taxaceae	X	T	L, R	Antitumour Activity.
<i>Cephalotaxus griffithii</i> Hk.f.	Taxaceae	X	T	L, R	Antitumour Activity.
<i>Cephalotaxus mannii</i> Hk.f.	Taxaceae	X	T	L, R	Antitumour Activity.
<i>Chasalia curvisflora</i> Thw.	Rubiaceae	X	S	L, R	Rheumatism, Pneumonia, Head Disorders, Ear & Eye Diseases, Sore Throat, Wounds, Ulcers.
<i>Chenopodium album</i> L.	Chenopodiaceae	Jatira [K]	H	L, Wp.	Laxative, Stomachache.
<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	X	S	Fl, Wp.	Worms, Post-Delivery Pains, Nervous Conditions, Menstrual Disorders.
<i>Chirita oblongifolia</i> Sinclair	Gesneriaceae	Achhumiti sam [G]	H	L	Mental Disorder
<i>Chonemorpha fragrans</i> . Alston	Apocyanaceae	Jermi Longwan [K]	L	R	Stomach Disorder.
<i>Chrysopogon aciculatus</i> Trin.	Poaceae	Samask [G]	H	R	Stomachache.
<i>Cibotium barometz</i> Link.	Cyatheaceae	X	S	R, Rh, S	Lumbago, Styptic, Vermin.
<i>Cinchona calisaya</i> Weddel	Rubiaceae	X	T	B	Antiseptic, Malaria, Pneumonia, Amoebic Dysentery, Rheumatism.

<i>Cinchona ledgeriana</i> Moons ex Trim.	Rubiaceae	X	T	B	Antiseptic, Malaria, Pneumonia, Amoebic Dysentery, Rheumatism.
<i>Cinchona officinalis</i> L.	Rubiaceae	Cinchona [E]	T	B	Antiseptic, Malaria, Pneumonia, Amoebic Dysentery, Rheumatism.
<i>Cinchona succirubra</i> Pavon	Rubiaceae	X	T	B	Antiseptic, Malaria, Pneumonia, Amoebic Dysentery, Rheumatism.
<i>Cinnamomum bejolghota</i> Sw.	Lauraceae	Dieng Lasi Sirmot [K], Chhamejam [G]	T	B	Urinary Troubles, Gall Bladder Stones, Liver Complaints.
<i>Cinnamomum glaucescens</i> Meissn.	Lauraceae	Dieng Ping Wait [K], Kanhmoi [J], Gamsalu [G]	T	Fr	Demulcent, Stimulant.
<i>Cinnamomum tamala</i> Nees.	Lauraceae	Dieng Latyrapad [K], Teji Bol [G]	T	L	Diarrhoea, Colic.
<i>Cirhopetalum maculosum</i> Lindl.	Orchidaceae	X	Ep	R	Longevity
<i>Cirsium involucratum</i> DC.	Asteraceae	Cheih Keng [J]	H	R	Gastrointestinal Disorders, Apetiser, Gripe.
<i>Cissampelos pariera</i> L.	Menispermaceae	Soh Pynjung [J], Jyrmi Salla [K]	S	R, Wp	Diarrhoea, Anthelmintic, Antipyretic, Cardio Tonic, Stomachic.
<i>Cissus adnata</i> Roxb.	Vitaceae	X	S	R, Tu	Blood Purifier, Diuretic, Cuts, Fractures.
<i>Cissus quadrangularis</i> Wall.	Vitaceae	Adamant Creeper [E]	C	L, S	Stomachic, Irregular Menstruation, Scurvy, Fracture, Asthma.
<i>Cissus repens</i> Lam.	Vitaceae	Mei Jakhajrap [K], Jajaw Chhrub [J]	C	L, R	Itch, Skin Diseases, Suppurant.
<i>Citrus aurantium</i> L.	Rutaceae	Soh Niamtra [K]	T	L, B, Fl	Headache, Sunstroke, Laxative, Urinary Tract Infections.
<i>Citrus latipes</i> Tanaka	Rutaceae	Soh Heh [J]	T	Fr, L	Bodyache, Vomiting, Cold, Fever.
<i>Citrus limon</i> Burm.f.	Rutaceae	Soh Jew [K]	T	Fl	Carminative, Antisorbutic, Colic, Anorexia, Helminthiasis, Scabies, Halitosis, Hemisrania, Psychopathy, Bronchitis.
<i>Citrus medica</i> L.	Rutaceae	Soh Manong [K], Dieng Soh Sarman [J]	S	R, Fr	Laxative, Colic, Flatulence, Strangury, Renal & Vesical Calculi, Tumours, Amenorrhagia, Dysmenorrhagia.
<i>Clausena excavata</i> Burm.f.	Rutaceae	Sam Sweng [G], Dieng Tyrur [K]	S	L	Muscular Pain, Fever, Malaria, Diuretic, Colic, Sores.
<i>Clausena heptaphylla</i> W. & A.	Rutaceae	Jalamari [G], Dieng Siang Mat [K]	S	L	Headache.
<i>Cleisostoma williamsonii</i> Garay.	Orchidaceae	X	Ep	L, S	Bone Fractures.
<i>Clematis buchaniana</i> DC.	Ranunculaceae	Mei Lieh [K], Jermat Sniuh [J]	C	S, R	Sores, Skin Diseases, Tumours.
<i>Clematis gouriana</i> DC.	Ranunculaceae	Jyrmi Bytengdoh [K]	H	R	Stomachache.
<i>Cleome gynandra</i> L.	Cleomaceae	X	H	Wp	Rubefacient, Boils, Scorpion Stings, Otalgia, Fits.

<i>Clerodendrum colebrookianum</i> Walp.	Verbenaceae	Dieng Jalemkynthei [K]	S	B, L, R	Sudorific, Spasms, Fever. Rheumatism, Malaria, Blood Pressure.
<i>Clerodendrum fragrans</i> Willd.	Verbenaceae	X	S	R	Antibacterial, Inflammations, Metritis, Menstrual Disorders, Furunculosis, Impetigo, Osteodynia, Icterus, Burns, Wounds.
<i>Clerodendrum hastatum</i> Lindl.	Verbenaceae	Dieng Kymbat Langmong [K]	S	L	Children Sickness.
<i>Clerodendrum infortunatum</i> auct. non Lin.	Verbenaceae	Dieng Kyllasla [K]	S	R	Astringent, Gonorrhoea.
<i>Clerodendrum serratum</i> Moon	Verbenaceae	Samgongol [G], Phlang Rilong [K], Dieng Lamysiang [J]	S	R, B, L	Asthma, Cough, Scrofulous Affection, Dropsy, Fever, Syphilis.
<i>Clerodendrum viscosum</i> Vent.	Verbenaceae	Sli Jerem [J]	S	L	Laxative, Antiseptic, Demulcent, Ascarides, Malaria.
<i>Clerodendrum wallichii</i> Merrill	Verbenaceae	Leh Khynrum Siah Blang [K]	S	L	Skin Diseases.
<i>Coccinia grandis</i> Voigt	Cucurbitaceae	Du-Chujia [G]	C	R, L, Fr	Galactagogue, Leprosy, Skin Diseases, Intermittent Fevers, Agalactia, Asthma, Constipation, Jaundice, Diabetes, Anaemia.
<i>Cocculus orbiculatus</i> DC.	Menispermaceae	Jyrimi Mailum [K]	S	R, S	Anodyne, Antiphlogistic, Carminative, Depurative, Diuretic, Vermifuge, Rheumatic Arthritis, Oedema, Oliguria, Antibacterial, Anti-Amoebic Activity, Asthma, Bronchitis, Paralysis.
<i>Codonopsis javanica</i> Hk.f.	Campanulaceae	X	C	R	Stomachic, Diuretic, Anaemia, Fatigue, Cough, Jaundice, Dyspepsia, Diarrhoea, Nephritis, Albuminuria, Oedema, Haemorrhoids, Metropis, Lymph Diseases.
<i>Coelogyne stricta</i> Schlechter	Orchidaceae	X	Ep	Pb	Fever, Headache.
<i>Coffea arabica</i> L.	Rubiaceae	Dieng Kophi [K]	T	L	Cerebral & Respiratory Stimulant, Diuretic, Typhoid, Asthma, Albuminuria, Whooping Cough.
<i>Coffea benghalensis</i> Roxb.	Rubiaceae	X	S	L	Infants Bath To Reduce Fever.
<i>Coix lacryma-jobi</i> L.	Poaceae	Job's tears [E]	H	R, Se	Menstrual Disorders, Diuretic, Pneumonia, Pectoral Diseases.
<i>Coldenia procumbens</i> L.	Boraginaceae	X	H	L, Wp	Swellings, Boils, Rheumatism.
<i>Colocasia esculenta</i> Schott.	Araceae	Ka Wang [K]	S	L, Corns	Rubefacient, Otalgia, Otorrhoea, Adenitis, Buboes, Laxative, Alopecia, Portal System Congestion.
<i>Combretum decandrum</i> Roxb.	Combretaceae	Dugrek [G], Mei Long Khasaw [K]	C	L	Diarrhoea, Gastric Troubles.
<i>Commelina benghalensis</i> L.	Commelinaceae	Jeha Bhoi [J]	H	Wp	Scorpion Sting.

<i>Commelina patudosa</i> Bl.	Commelinaceae	X	H	Wp	Insect Bites.				
<i>Cordia dichotoma</i> Forst. f.	Boraginaceae	Bol Mingmang [G], Dieng Mong [K], Dieng Pyruluh [J]	T	B, L, Fr	Constipation, Dyspepsia, Fever, Diarrhoea, Leprosy, Skin Diseases, Helminthiasis, Gonorrhoea, Ringworm.				
<i>Cordia fragrantissima</i> Kurz.	Boraginaceae	X	S	Fr, B	Astringent, Anthelmintic, Diarrhoea, Skin Diseases, Diuretic, Lung & Spleen Diseases.				
<i>Coriandrum sativum</i> L.	Apiaceae	Coriander [E]	H	Fl, L, Se, Wp	Carminative, Stomachic, Nausea, Dysentery, Colic, Diarrhoea.				
<i>Corylopsis himalayana</i> Griff.	Hamamelidaceae	Dieng Piur [K], Dieng Lapainer [J]	S	Fl, L, Bu	Diarrhoea, Dysentery, Gastrointestinal Disorders.				
<i>Costus speciosus</i> Sm.	Zingiberaceae	Krah Hei-iang [J]	H	Rh	Astringent, Stimulant, Anthelmintic, Cough, Catarrhal, Fever, Dyspepsia, Skin Diseases, Worms, Snake Bite.				
<i>Crassocephalum crepidioides</i> Moore	Asteraceae	Sagon Nadi [G]	H	L	Wounds, Haematic, Headache, Stomachic.				
<i>Crepis fuscipappa</i> Benth.	Asteraceae	Pan-bihar [G]	H	L	Ear Drop.				
<i>Cretaeva nurvala</i> Buch. & Ham.	Capparaceae	Jongsia [G]	T	B, L	Anti-Periodic, Demulcent, Laxative, Urinary Infections.				
<i>Crinum aiaticum</i> L.	Amaryllidaceae	X	H	Rh, L	Wounds, Post-Partum Haemorrhages, Backaches, Antidote.				
<i>Crinum pratense</i> Herb.	Amaryllidaceae	Lily [E]	H	R, Bu	Diarrhoea.				
<i>Croton caudatus</i> Geisl.	Euphorbiaceae	Sawaka [G], Soh Lambrang [K], Soh Phai Blai [J]	S	L	Sprains.				
<i>Croton roxburghii</i> Balakr.	Euphorbiaceae	Bol Mangchham [G], Dieng Lamasu [K]	T	S, L, B, R	Purgative, Cholagogue, Hepatitis, Rheumatic Swellings, Sprains.				
<i>Croton tiglium</i> L.	Euphorbiaceae	Dieng Kynbat Lasam [K]	T	S	Fltulence, Dyspepsia, Colic, Oedema, Dyspnoea.				
<i>Cryptolepis buchanani</i> R. & Sch.	Asclepiadaceae	Durikhal [G], Kynbat Mangpor [K]	C	S	Cramps.				
<i>Cucubalus bacciferus</i> L.	Caryophyllaceae	X	H	Wp	Haemorrhage.				
<i>Cucumis sativus</i> L.	Cucurbitaceae	Soh Khia [K]	C	Se, Fr	Diuretic, Hyperdipsia, Fever, Insomnia, Cephalalgia, Bronchitis, Jaundice, Haemorrhages, Strangury, Antipyretic, Urodymia.				
<i>Cucurbita maxima</i> Duch. ex Lam.	Cucurbitaceae	Squash Melon [E]	C	Se, Fr	Diuretic, Sedative, Scalds, Burns, Inflammations, Abscesses, Boils, Migraine, Neuralgia.				
<i>Cucurbita moschata</i> Duch. ex Poir.	Cucurbitaceae	Musk Melon [E]	C	Fr, Wp	Asthma, Bronchitis, Headache.				

<i>Cucurbita pepo</i> DC.	Cucurbitaceae	Pathaw [K]	C	Se, Pulp	Tapeworms In Pregnant Women, Nephritis, Urinary Disorders.
<i>Curculigo orchoides</i> Gaertn.	Hypoxidaceae	Sli Tamat [J]	H	R	Diarrhoea, Diuretic, Leucorrhoea, Pruritus, Skin Diseases, Asthma, Bronchitis, Jaundice, Lumbago, Colic, Ophthalmia.
<i>Curcuma amada</i> Roxb.	Zingiberaceae	Mango Ginger [E]	H	Rh	Alexeteric, Laxative, Diuretic, Antipyretic, Anorexia, Sprains, Halitosis, Oralgia, Pruritus, Flatulence.
<i>Curcuma aromatica</i> Salisb.	Zingiberaceae	Jia Lekchiang [J]	H	Rh	Bruises, Sprains, Bronchitis, Coughs, Leucoderma.
<i>Curcuma augustifolia</i> Roxb.	Zingiberaceae	X	H	R	Leprosy, Dyspepsia, Bronchitis, Asthma, Jaundice, Anaemia, Leucoderma, Kidney Stones, Blood Diseases.
<i>Curcuma longa</i> L.	Zingiberaceae	Shynrai [K]	H	Rh	Stomachic, Blood Purifier, Cold, Vermicide, Antiseptic, Antiperiodic, Diabetes, Leprosy, Sore Throat.
<i>Curcuma meghalayensis</i> Sunil & Ved Prakash	Zingiberaceae	X	H	Rh	Bruises, Throat Swellings.
<i>Curcuma montana</i> Roxb.	Zingiberaceae	Sying Syrmit [J]	H	Rh	Jaundice, Increases Lactation, Body Swellings.
<i>Curcuma pseudomontana</i> Graham	Zingiberaceae	X	H	Rh	Jaundice, Increases Lactation, Body Swellings.
<i>Curcuma zeodaria</i> Roxb.	Zingiberaceae	Zeodari [E]	H	Rh	Stomachic, Colic, Cough, Menstrual Disorders.
<i>Cuscuta reflexa</i> Roxb.	Convolvulaceae	Jyrmī Thri [K]	C	Wp, Se	Protracted Fevers, Induration In Liver, Diarrhoea, Antifertility.
<i>Cyathula prostrata</i> Bl.	Amaranthaceae	Small Prickly Chaff Flower [E]	H	R	Constipation, Cough, Bronchitis, Wounds, Ulcers, Pruritus, Skin Diseases, Diarrhoea, Dyspepsia.
<i>Cycas pectinata</i> Griff.	Cyadaceae	Dieng Siagoda [K]	T	B	Scurvy, Cold, Coughs, Fever.
<i>Cyclea peltata</i> Hk.f. & Th.	Menispermaceae	Chota Nirkhut [G]	C	R, L	Smallpox, Cough, Bronchitis, Diarrhoea, Dysentery, Dropsy, Painful Swellings, Fever, Leprosy, Ulcers, Wounds, Vomiting, Dandruff, Cardiac Disorders, Burning Sensation Of Eyes.
<i>Cymbidium aloifolium</i> Sw.	Orchidaceae	X	Ep	Bu	Blood Coagulent For Large Bleeding Wounds.
<i>Cymbidium longifolium</i> D. Don	Orchidaceae	Samdumi [G]	Ep	Bu	Infant Headache.
<i>Cynodon dactylon</i> Pers.	Poaceae	Dhub Grass [E]	H	R, Wp	Diuretic, Epilepsy, Insanity, Syphilis, Piles, Cuts, Wounds.
<i>Cynoglossum furcatum</i> Wall.	Boraginaceae	Ja Byrthied [K]	H	R	Vomiting In Infants.
<i>Cyperus rotundus</i> L.	Cyperaceae	Nut Grass [E]	H	R	Stomachic, Diuretic, Cholera, Urinary Calculi, Amenorrhoea, Bowel Irritations, Febrile, Wounds, Ulcers, Scorpion Stings.
<i>Dalbergia pinnata</i> Prain.	Fabaceae	Sah Kynjirka [J]	S	L	Colic.
<i>Dalbergia sissoo</i> Roxb. ex DC.	Fabaceae	Sissoo [E]	T	R, L, B, Heart	Ophthalmic, Styptic, Gonorrhoea, Menorrhagia, Excoriation, Abortifacient, Leprosy, Leucoderma,

<i>Dalhouisia bracteata</i> Wt.	Fabaceae	Mei Dieng [K]	C	wood	Scabies, Syphilis, Sciatica.
<i>Daphniphyllum himalense</i> Muell. - Arg.	Daphniphyllaceae	Dieng Syrangthuli [K]	T	L	Cuts, Wounds.
<i>Datura fastuosa</i> L.	Solanaceae	X	S	S	Boils.
<i>Datura metel</i> L.	Solanaceae	Thorn Apple [E]	S	Se, L	Coughs, Toothache.
<i>Datura stramonium</i> L.	Solanaceae	Singapor [G]	S	Wp	Antiseptic, Sedative, Poultice For Breast Inflammation.
<i>Datura suaveolens</i> Bercht. & Presl.	Solanaceae	X	S	L, R, Fl	Asthma, Parkinson's Disease, Delirium, Tremor & Mania, Ophthalmia, Boils Ulcers.
<i>Daucus carota</i> L.	Apiaceae	Kajor [K]	H	Fl	Asthma, Chest, Narcotic, Piles, Poison, Tumor, Vermifuge.
<i>Davallia trichomanoides</i> Bl.	Davalliaceae	Krah Bue [J]	H	F, Se, R	Increases Urine Flows, Cuts, Stimulate Mesturation, Worms.
<i>Decaspermum fruticosum</i> J.R. & G. Forst.	Myrtaceae	X	T	Fr	Food Intoxication Leading To Vomiting.
<i>Deeringia amaranthoides</i> Merr.	Amaranthaceae	Soh Langkrem [K]	S	L, R	Womb Cancer, Wounds, Toothache.
<i>Dendrobium densiflorum</i> Wall. ex Lindl.	Orchidaceae	Balگو [G], Langskaw [K]	Ep	L	Sores, Sternutatory.
<i>Dendrobium macraei</i> Lindl.	Orchidaceae	X	Ep	Wp	Fractures.
<i>Dendrobium moschatum</i> Sw.	Orchidaceae	Khleinmasi [K]	Ep	L	Stimulant, Demulcent, Tonic, Snakebite.
<i>Dendrobium nobile</i> Lindl.	Orchidaceae	X	Ep	Wp	Earache.
<i>Dendrocnide sinuata</i> Chew.	Urticaceae	Gilmat Jakma [G], Dieng Synrem [K]	S	R	Eye Problems.
<i>Dendrophloe fulcata</i> Etting	Loranthaceae	Tuthekmi [G]	S	Wp	Fever.
<i>Desmodium gangeticum</i> DC.	Fabaceae	Nai Khong [K]	US	R	Diuretic, Asthma, Swellings, Menstrual Disorders, Pulmonary Tuberculosis, Renal & Vesical Calculi.
<i>Desmodium pulchellum</i> Benth.	Fabaceae	String of Rupees [E]	S	R, L	Fever, Dysentery.
<i>Desmodium triangulare</i> Merr.	Fabaceae	X	S	L	Tooth Sore.
<i>Desmodium triquetrum</i> DC.	Fabaceae	Etang [G]	US	L	Antibacterial, Diarrhoea, Dysentery, Snakebite, Jaundices.
<i>Desmos chinensis</i> Lour.	Anonaceae	Gorchhok [G]	S	R	Piles.
<i>Desmotrichum fimbriatum</i> Bl.	Orchidaceae	X	Ep	Wp	Dysentery, Vertigo.
<i>Dichroa febrifuga</i> Lour.	Hydrangiaceae	X	S	R, L	Stimulant, Demulcent, Aphrodisiac.
<i>Dicliptera roxburghiana</i> Nees.	Acanthaceae	X	H	Wp	Emetic, Febrifuge.
<i>Dicranopteris linearis</i> An.	Gleicheniaceae	X	H	Fronds, Rh	Dysentery, Tonic.
<i>Difflugosa colorata</i> Brem.	Acanthaceae	Samtri [G]	US	L	Anthelmintic, Antibacterial, Asthma.
<i>Dillenia indica</i> L.	Dilleniaceae	Dieng Sohkorbam [K]	T	Fr, L, Wp	Nettlerash. Carbuncles, Chest Complaints, Cholera, Dysentery, Fever, Sores, Cough, Astringent.

<i>Dillenia pentagyna</i> Roxb.	Dilleniaceae	Dieng Sohbar [K], Agatchi Badura [G]	T	Fr, L, Wp	Carbuncles, Chest Complaints, Cholera, Dysentery, Fever, Sores, Cough, Astringent.
<i>Dimocarpus longan</i> Lour.	Sapindaceae	X	T	Fr	Anthelmintic, Stomachic, Febrile Heat.
<i>Dioscorea alata</i> L.	Dioscoreaceae	Asiatic Yam [E]	C	Tu	Diuretic, Diabetes, Leprosy, Gonorrhoea, Helminthiasis.
<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	X	C	Tu	Haemoptysis, Epistaxis, Gout, Scrofula, Pharyngitis, Orchitis.
<i>Dioscorea opposita</i> Hk.f.	Dioscoreaceae	X	C	R	Enteritis, Dyspnoea, Seminal Emmisions, Leucorrhoea.
<i>Diospyros kaki</i> Thunb.	Ebenaceae	Dieng Iong [J&K]	T	Fr	Cough, Dyspnoea.
<i>Diospyros lanceifolia</i> Roxb.	Ebenaceae	Dieng Sohlen [K], Dieng Thang [J]	T	Se	Skin Diseases.
<i>Diospyros malabarica</i> Kostel	Ebenaceae	Indian Persimon [E]	T	B, L, Fr, Fl	Dysentery, Febrifuge, Skin Diseases, Leprosy, Haemorrhages, Diabetes, Burns, Spermatorrhoea, Vaginal Disorders, Leucorrhoea, Urethrorrhoea, Nyctalopia, Anaemia, Scabies.
<i>Diospyros pilosula</i> Hiem.	Ebenaceae	X	T	Wp	Stomach Disorder, Piles, Kidney Stones, Diarrhoea, Dysentery.
<i>Diplocyclos palmatus</i> Jeffrey	Cucurbitaceae	X	C	Wp	Inflammations, Cough, Flatulence, Skin Diseases.
<i>Dischidia benghalensis</i> Coelb.	Asclepiadaceae	Samnakhet [G]	C	L	Cuts, Wounds
<i>Dischidia farrensiana</i> Wall.	Asclepiadaceae	Bandi Kuri [G]	US	R	Cough.
<i>Disporum cantoniense</i> Merr.	Liliaceae	X	H	S	Rheumatism.
<i>Docynia indica</i> Decainse	Rosaceae	Sohphoh Khasi [K]	T	Fr, L	Diarrhoea, Cough, Dysentery, Cold, Indigestion.
<i>Dolichos falcatus</i> Klein	Fabaceae	X	H	R, Se	Piles, Constipation, Ophthalmia, Skin Diseases, Rheumatism.
<i>Dracaena ensifolia</i> Wall.	Liliaceae	Milam [G]	H	R, L	Cold, Malaria, Rheumatism, Kidney Troubles.
<i>Drosera peltata</i> Sm.	Droseraceae	Sundew [E]	H	Wp	Syphilis, Chronic Bronchitis, Asthma, Whooping Cough.
<i>Drymaria cordata</i> Roem. - Schult.	Caryophyllaceae	Pdiat [J]	S	Wp	Sinusitis, Nasal Blockade, Anti-Febrile, Laxative.
<i>Drynaria quercifolia</i> Smith	Polypodiaceae	X	H	Rh	Antibacterial, Anodyne, Typhoid, Cough, Arthralgia, Cephalalgia, Diarrhoea, Foul Ulcers, Migraine, Phthisis, Dyspepsia.
<i>Duabanga grandiflora</i> Walp.	Sonneratiaceae	Dieng Maloi [K], Bol Chhin [G]	T	St, B	Anticancer, Spasmog.
<i>Dysoxylum gobara</i> Merr.	Meliaceae	Bol Chhachhat [G], Sla Luchai [K]	T	L	Malaria, Blood Pressure.
<i>Eclipta prostrata</i> Linn.	Asteraceae	Kala Kera [G]	H	WP	Hepatosplenopathy, Gastropathy, Skin Diseases, Wounds, Elephantiasis, Helminthiasis, Fever, Jaundice, Leprosy, And For Blackening And Strengthening Hair, Gums

<i>Elaeagnus conferta</i> Roxb.	Elaeagnaceae	Soh Shang [K], Dieng S Snlangi [J], Chhokhua [G]	S	Fl, Fr	Sores, Ulcers.							
<i>Elaeocarpus speharicus</i> K. Schum.	Elaeocarpaceae	Udrok [G], Dieng Sohlangskai [K]	T	Se, Fr	Cough, Bronchitis, Neuralgia, Cephalalgia, Anorexia, Fits, Manic Conditions, Melancholia, Mental Disorders.							
<i>Elephantopus scaber</i> L.	Asteraceae	Krah Kheri [K], Aok Astri [G]	H	R, L, Fl	Antipyretic, Diuretic, Dysuria, Urethrorrhoea, Diarrhoea.							
<i>Eleusine indica</i> Gaertn.	Poaceae	X	H	Wp	Diuretic, Laxative, Stomachic, Influenza, Oliguria.							
<i>Elsholtzia blanda</i> Benth.	Lamiaceae	X	US	Wp, L, Fl	Urinary & Kidney Disorders, Cuts & Wounds, Sores.							
<i>Embelia ribes</i> Burm.f.	Myrsinaceae	Mei Kajaodain [J]	S	R, Fr, L	Coughs, Diarrhoea, Fever, Chest & Skin Diseases, Scorpion Stings, Snakebite, Pruritus, Leprosy.							
<i>Embelia tsjeriam-cottam</i> A. DC.	Myrsinaceae	X	T	Fr	Anti-Bacterial, Tuberculosis, Laxative, Tapeworms.							
<i>Emblica officinalis</i> Gaertn.	Euphorbiaceae	Dieng Sohmylleng [K]	T	Fr, Se	Cuts, Jaundice, Anaemia, Dysentery, Asthma, Bronchitis.							
<i>Emilia sonchifolia</i> DC.	Asteraceae	Dodigaru [G]	H	Wp	Sudorific, Antipyretic, Ophthalmic, Asthma, Tympanitis, Intermittent Fevers, Diarrhoea, Otalgia, Cuts, Wounds.							
<i>Engelhardtia spicata</i> L.	Fabaceae	Diengsong Dkhar [K]	T	L, B	Sedative, Carminative, Anthelmintic, Diuretic, Rheumatism, Itch & Burns, Fever, Asthma, Leprosy, Epilepsy.							
<i>Entada purshata</i> DC.	Mimosaceae	Chuii [G], Mei Jynniew K, Tille Nop [J]	L	Se, Po	Dandruff, Food Poison, Cuts, Wounds, Dropsy, Epilepsy.							
<i>Eranthemum pulchellum</i> An.	Acanthaceae	Dojakpi [G]	US	L	Bone Fracture							
<i>Eria muscicola</i> Lindl.	Orchidaceae	X	Ep	Pb	Chest, Heart, Lung, Eye, Ear & Mental Problems.							
<i>Erycbe panniculata</i> Roxb.	Convolvulaceae	X	C	B, L, Wp	Wounds, Boils, Asthma.							
<i>Eriosema himalaicum</i> Ohashi	Fabaceae	Sa Pyrdong [K]	US	R	Worms, Apetiser, Indigestion.							
<i>Eryngium foetidum</i> L.	Apiaceae	Krah Ksad [J]	H	Wp, L	Fever, Stomachic, Tonic.							
<i>Erythrina stricta</i> Roxb.	Fabaceae	Bol Madal [G], Dieng Song [K]	T	B, Fl	Antidote, Biliousness, Itch, Fever, Asthma, Epilepsy, Leprosy.							
<i>Erythroxylum kunthianum</i> Wall. ex Kurz.	Erythroxylaceae	Dieng Painkhar [K]	T	B	Stimulant.							
<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Blue Gum [E]	T	L, Tertiary branch	Antiseptic, Lung Diseases.							
<i>Euodia luru-ankenda</i> Merr.	Rutaceae	X	T	Fl, L, R	Improve Complexion, Fever, Tonic, Emmemnagogue.							
<i>Euonymus lawsonii</i> Cl. & Pr.	Celastraceae	X	T	B	Syphilis, Indigestion, Liver Disorder.							
<i>Eupatorium adenophorum</i> Spreng.	Asteraceae	Kynbat Shipai [K]	US	L	Stomachic, Haemostatic.							
<i>Eupatorium cannabinum</i> Hk.f.	Asteraceae	Kynbat Nongrim [K]	H	L, R	Vulnerary, Cachexy, Dropsy, Swellings Of Legs, Scabies.							
<i>Eupatorium odoratum</i> L.	Asteraceae	Simari [G]	US	Wp	Liver Troubles.							
<i>Eupatorium riparium</i> Regel.	Asteraceae	X	H	L	Cuts, Wounds, Skin Diseases, Swellings, Body Sores.							

					S	Wp	
<i>Euphorbia nerrifolia</i> L.	Euphorbiaceae	Sara [K]					Laxative, Abortifacient, Vermifuge, Bronchitis, Cutaneous Diseases, Dropsy, Intermittent Fever, Jaundice, Leprosy.
<i>Eurya accuminata</i> DC.	Theaceae	Lumbang Pырchit [J]			T	L	Cholera, Dysentery, Stomach Disorders.
<i>Eurya japonica</i> Thunb.	Theaceae	Dieng Pырshit [K]			T	L	Skin Eruptions.
<i>Eusteralis stellata</i> Panigrahi	Lamiaceae	X			H	L	Rashes, Skin Diseases.
<i>Evolvulus nummularis</i> L.	Convolvulaceae	X			H	Wp	Scorpion Stings.
<i>Exacum tetragonum</i> Roxb.	Gentianaceae	Sher-ri-iakti [K]			H	Wp	Fever, Stomachic.
<i>Fagopyrum dibotrys</i> Hara	Polygonaceae	Jarain [K]			US	L, Se	Insect Bite, Headache.
<i>Fagopyrum esculentum</i> Moench	Polygonaceae	Jarain [K]			US	L	Vasoconstrictor
<i>Ficus benghalensis</i> L.	Moraceae	Gonok [G]			T	R, B, L, Fr, Buds	Diarrhoea, Leucorrhoea, Osteomalacia Of Limbs, Burning Sensation, Dysentery, Diabetes, Ulcers, Leprosy, Bruises, Abscesses, Neuralgia, Lumbago, Gonorrhoea.
<i>Ficus benjamina</i> L.	Moraceae	Dieng Jri [K]			T	L	Ulcers, Whitening Of Cornea.
<i>Ficus glomerata</i> Roxb.	Moraceae	Fig [E]			T	B, R, L, Fr	Threatened Abortions, Dysentery, Diabetes, Wounds, Ulcers, Diarrhoea, Haemorrhages, Menorrhagia.
<i>Ficus heterophylla</i> L.f.	Moraceae	X			S	B, R, L, Fr	Fever, Constipation, Dysentery, Coryza, Asthma, Colic, Inflammatory Swellings.
<i>Ficus hirta</i> Vahl.	Moraceae	Chhakhah [G], Dieng Sohlapong [K], Dieng Sohrompian [J]			T	L	Ring-Worm
<i>Ficus hispida</i> L.f.	Moraceae	Jia Jhra [J], Dieng Lapong [K]			T	Fr, L, B	Flatulence, Ulcers, Leucoderma, Jaundice, Anaemia, Haemorrhoids, Epistaxis, Inflammations, Fever
<i>Ficus microcarpa</i> L.f.	Moraceae	Thapsi [G]			T	B, R, L	Dental Caries, Odontalgia, Wounds, Ulcers, Bruises, Flatulence, Colic, Diarrhoea, Dysentery, Hyperdipsia, Haemorrhages, Erysipelas, Dropsy, Leucorrhoea, Colporrhagia, Diabetes.
<i>Ficus religiosa</i> L.	Moraceae	Phrap Thibrong [G]			T	B, L, Fr, Shoots, Se	Antibacterial, Swellings, Burns, Laxative, Wounds, Skin Diseases, Neuralgia, Inflammations, Haemorrhages.
<i>Ficus rumphii</i> Bl.	Moraceae	Phrap Roksang [G]			T	B	Snakebite, Asthma.
<i>Ficus semicordata</i> Sm.	Moraceae	Thylliangsang [J]			T	Fr, B, R	Ophthalmous Complaints, Leprosy, Bladder Complaints, Visceral Complaints, Spasmodic.
<i>Ficus sub-incisa</i> Buch. Ham. ex Sm.	Moraceae	Sli Lechiat [J], Sur Mehblang Shynrang [K]			S	Wp	Spasms.
<i>Fissistigma polyantha</i> Merr.	Anonaceae	Sam jumma [G]			C	S	Tooth Sore.
<i>Flacourtia jangomas</i> Reusch	Flacourtiaceae	Dieng Sohmluh [K]			T	B, L, Fr	Pregnancy (Purification Of Blood Before & After Delivery), Odontalgia, Diarrhoea, Haemorrhoids,

<i>Flemingia macrophylla</i> Prain.	Fabaceae	X		S	R, Wp	Rheumatism, Nausea, Skin Disease, Diabetes, Jaundice, Tumours.
<i>Flemingia vestita</i> Baker	Fabaceae		Soh Phlang [K]	H	Tu	Bodyache, Muscular Pain, Blindness, Cholera, Dysentery, Fever, Fistula, Spleen Complications, Swellings, Ulcers.
<i>Fragaria indica</i> An.	Rosaceae	X		H	Fr, L, Fl	Worms.
<i>Fraxinus floribunda</i> Wall.	Oleaceae		Dieng La-mahek [K]	T	S	Tongue Ulcers, Cuts, Bruises, Eye Diseases.
<i>Galinosa parviflora</i> Blake	Asteraceae	X		H	L, R	Laxative.
<i>Galium asperifolium</i> Wall.	Rubiaceae	X		H	Wp	Bleeding, Snakebite, Insect Stings.
<i>Garcinia cowa</i> Roxb. ex DC.	Clusiaceae		Rengran [G]	T	Fr	Urinary Diseases.
<i>Garcinia kydia</i> Roxb.	Clusiaceae	X		T	Fr	Dysentery.
<i>Garcinia morella</i> Desr.	Clusiaceae		Indian Gambooge Plant [E]	T	Fr	Dysentery, Headache.
<i>Garcinia pedunculata</i> G. Don	Clusiaceae		Dieng Sohdanei [K]	T	Fr	Dropsy, Hydragogue, Blisters, Leprosy, Cough, Asthma, Antibacterial.
<i>Garcinia tinctoria</i> W.F. Wight	Clusiaceae		Arak [G], Dieng Sohkhyllung [K]	T	Fr, B, L	Urinary Troubles.
<i>Gardenia campanulata</i> Roxb.	Rubiaceae		Darichik [G], Sohnai [K]	T	Fr, B	Antiseptic, Boils, Diarrhoea, Dysentery, Dyspepsia.
<i>Garuga pinnata</i> Roxb.	Burseraceae		Dumi [G], Dieng Sohpijar Shynrang [K]	T	Fr, S, L, Fl, Galls	Cathartic, Corpulence, Enlarged Spleen.
<i>Gastrochilus acutifolius</i> O. Ktze.	Orchidaceae		Samsoksu [G]	Ep	L	Pulmonary Affections, Cornea Opacity, Asthma,
<i>Gaultheria fragrantissima</i> Wall.	Ericaceae		Jirhapiong [K]	S	Wp	Vermifuge, Obesity, Splenomegaly, Foul Ulcers, Odontalgia.
<i>Gaultheria nummularioides</i> D. Don	Ericaceae	X		US	Wp	High Fever, Headache
<i>Gelsimium elegans</i> Benth.	Loganiaceae	X		S	Rh	Rheumatism, Hookworms, Carminative.
<i>Gentiana tenella</i> Fries	Gentianaceae	X		H	Wp	Headache.
<i>Geodorum purpureum</i> Br.	Zingiberaceae		Matea-bas [G]	H	L, Tu	Migraine, Hysteria, Poliomyelitis.
<i>Geranium nepalense</i> Sw.	Geraniaceae	X		S	Wp	Febrifuge.
<i>Globba clarkei</i> Baker	Zingiberaceae		Dike-holdiram [G]	H	L, R	Malaria, Whooping Cough.
<i>Glochidion lanceolarium</i> Voight.	Euphorbiaceae	X	Karami [G]	H	R	Erysepalous Affections, Haemorrhages, Sore Throats.
<i>Gloriosa superba</i> L.	Liliaceae		Malabar Glory Lily [E]	T	B	Run-Down Condition.
<i>Glycosmis arborea</i> DC.	Rutaceae		Krah Nongwe [J]	H	Tu	Headache.
<i>Gmelina arborea</i> Roxb.	Verbenaceae		Gambari [G], Dieng Lophiang [K]	S	B, R	Stomach Troubles.
<i>Gnaphalium luteoalbum</i> L.	Asteraceae	X		H	L, Wp	Abortifacient, Stimulant, Anthelmintic, Leprosy.
<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	X		H	L, Wp	Snakebite, Gastric Troubles.
<i>Gomphostema ovatum</i> Benth.	Lamiaceae	X		H	L	Urticaria, Worms.

<i>Gomphostema parviflorum</i> Wall. ex Benth.	Lamiaceae	Khumbal [G]	US	L	Headache.
<i>Gonatanthus pumilus</i> Engl.	Araceae	Shrew Khlaw [J]	S	L, S	Wounds.
<i>Gongronema nepalense</i> Dacne.	Asclepiadaceae	Krah Skun [K]	S	L	Ringworms, Boils.
<i>Goniothalamus sesquipedalis</i> Hk.f. - Th.	Anonaceae	Skum Synsar [K]	T	B	Cuts, Wounds
<i>Goniothalamus simonosi</i> Hk.f. & Th.	Anonaceae	Kitoksam [G]	T	Fr	Throat Irritation
<i>Goodyera procera</i> Hk.	Orchidaceae	Dejongma [G]	Te	Sap	Blood Clot
<i>Gouania tilliaefolia</i> Lam.	Rhamnaceae	Dumigong [G], Mei Tientong [K]	C	L, B, R	Spasms, Fever, Sores, Skin Diseases, Vermin.
<i>Grewia asiata</i> L.	Tiliaceae	Borkhentor [G], Dieng Thabalieh [K]	T	L, R, B, Fr	Astringent, Stomachic, Demulcent, Rheumatism, Pustular Eruptions.
<i>Grewia disperma</i> Rottb.	Tiliaceae	Bol Menga [G], Dieng Tiewsier [K]	T	B, Fr	Burning Sensation, Cough, Skin Diseases, Ulcers, Wounds, Seminal Weakness
<i>Grewia hirsuta</i> Vahl.	Tiliaceae	Soh Synting [K]	S	Fr, R	Diarrhoea, Dysentery, Wounds.
<i>Grewia multiflora</i> Juss.	Tiliaceae	Dieng Tyrbhong [K]	T	B	Astringent, Cough, Skin Diseases.
<i>Gymnocladus assamica</i> Kanjilal	Caesalpiniaceae	X	T	L	Shampoo.
<i>Gynocardia odorata</i> R. Br.	Flacourtiaceae	Dieng Sohliang [K], Balibu [G]	T	Fr	Leprosy, Skin Diseases.
<i>Habeneria goodyeroides</i> D. Don	Orchidaceae	X	Te	Tu	Tonic.
<i>Hedera helix</i> Cl.	Araliaceae	Pew Shrieh [K]	C	Wp	Antiseptic.
<i>Hedychium coccineum</i> Sm.	Zingiberaceae	Samriching [G], Lyngtiang [J]	H	R	Headache.
<i>Hedychium coronarium</i> Koen.	Zingiberaceae	Todoh [J]	H	Fl, Rh	Carminative, Stimulant, Bruises, Sprains.
<i>Hedychium gracile</i> Roxb.	Zingiberaceae	Hatong Gism [G], Latdoh [J]	H	R	Chest Pain.
<i>Hedychium spicatum</i> Buch. - Ham.	Zingiberaceae	X	H	Rh	Arthritis, Colic, Cough, Asthma, Diarrhoea, Dysentery, Dropsy, Headache, Hair Fall, Liver Complaints, Skin Diseases.
<i>Hedychium wardii</i> C.E.C. Fischer	Zingiberaceae	X	H	Rh	Skin Diseases, Body Pains.
<i>Hedyotis corymbosa</i> Lam.	Rubiaceae	X	H	Wp	Febrifuge, Aperient, Diuretic, Diaphoretic, Liver Tonic, Fever, Depression, Jaundice, Heat Eruptions, Hyperdipsia, Giddiness, Dyspepsia, Flatulence, Colic, Helminthiasis, Leprosy, Catarrh.
<i>Hedyotis scandens</i> D. Don	Rubiaceae	Samreteng [G], Jyirmi Skie [K], Tyllie Jumunsem [J]	S	Wp	Gastralgia, Gastric Ulcers, Heartburns, Colic, Vulnerary, Wounds.
<i>Hedyotis uncinella</i> Hk. & Arn.	Rubiaceae	Sher ritarong [G], Hajem	US	L, R	Cough, Skin Diseases.

	[J]							
<i>Hedyotis verticillata</i> Lam.	Rubiaceae	X	H	L	Fever, Skin Diseases. Anodyne, Odontalgia, Lumbago, Malaria, Ulcers, Wounds, Cephalalgia, Antiperiodic, Leprosy, Pruritus, Hysteria, Bronchitis, Asthma, Anaemia, Pectoralgia, Pneumonia, Ascites. Colic.			
<i>Helianthus annuus</i> L.	Asteraceae	Tiew Sngi [K]	H	R, Fl, L, Se	Gripe & Gastric Problems.			
<i>Helicia excelsa</i> Bl.	Proteaceae	X	T	B	Cuts, Wounds.			
<i>Helixanthera ligustrina</i> Danser	Loranthaceae	Suthekmi songepa [G], Marariang [J], Mangkariang [K] Rajamari [G]	S	B	Syphilis, Cuts, Wounds, Bruises.			
<i>Hemerocallis fulva</i> L.	Amaryllidaceae	X	H	R	Swellings.			
<i>Hemiphragma heterophyllum</i> Wall.	Scrophulariaceae	Dieng Latymphu [K & J] Tiew Maloi [K]	H	Wp	Sprains, Inflammations.			
<i>Heptapleurum hypoleucum</i> Kurz.	Araliaceae	China Rose [E]	T	L	Alopecia, Burning Sensation, Menstrual Disorders, Piles, Bronchial Catarrh, Gonorrhoea, Menorrhagia.			
<i>Hibiscus pungens</i> Roxb.	Malvaceae	Rozell Herb [E]	S	Fr, Se, Fl	Diuretic, Antiscorbutic, Billousness.			
<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	Meishein [K] Mei Sohmyrthar [K], Thibe [G]	S	B, L, Fl	Vulnerary, Cardiotonic, Scabies.			
<i>Hibiscus sabdariffa</i> L.	Malvaceae	Soh Lyngkait [K], Soh Tymbia [J]	L	Wp	Gastric Ulcer, Malaria.			
<i>Hiptage benghalensis</i> Kurz.	Malphigiaceae	Bol Matra [G], Dieng Jamew [K]	S	L	Burns.			
<i>Hodgsonia macrocarpa</i> Cogn.	Cucurbitaceae	Miri Nasil [G], Mei dakyma [K]	T	B, Se	Amoebic Dysentery, Vaginitis, Diarrhoea, Jaundice, Fever, Bladder Stone, Tuberculosis.			
<i>Holboellia latifolia</i> Wall.	Berberidaceae	Indian Elm [E]	S	R	Fever, Headache.			
<i>Holharhenna anti-dysenterica</i> Wall.	Apocyanaceae	X	T	B, L	Inflammations, Laxative, Dyspepsia, Flatulence, Colic, Helminthiasis, Skin Diseases, Leprosy, Diabetes.			
<i>Holmskioldia sanguinea</i> Retz.	Verbenaceae	Ja mynrei [K]	H	Rh	Stimulant.			
<i>Holoptelea integrifolia</i> Planch	Ulmaceae	Ja Myrdoh [K]	S	R, Fr, L	Laxative, Haemorrhoids, Diuretic, Strangury, Urethrorrhoea, Vesical Calculi, Gonorrhoea, Syphilis.			
<i>Homalomena aromatica</i> Schott.	Araceae	Langta Krem [K], Bol Rhukhrom [G]	H	L, R	Stomachache, Cholera, Dysentery, Diuretic.			
<i>Homonoia riparia</i> Lour.	Euphorbiaceae	Dieng Sohlap [K], Baliba [G]	T	Fr, Se, B	Antispasmodic, Febrifuge, Laxative, Diuretic, Alcohol Overdose, Intoxication Due To Wine, Rectal Diseases.			
<i>Houttuynia cordata</i> Thunb.	Saururaceae		T	S, B	Leprosy, Fever.			
<i>Hovenia dulcis</i> Roxb.	Rhamnaceae							
<i>Hydnocarpus kurzii</i> Warb.	Flacourtiaceae							

<i>Hydrocotyle javanica</i> Thunb.	Apiaceae	Manamuni [G]	H	Wp							Gastritis, Earache, Dysentery, Fever, Blood Purifier, Bodyache.
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	Dieng Dohlbongsyiar [K] Mibot [G]	T	B							Astringent, Febrifuge.
<i>Hypericum japonicum</i> Thunb.	Hypericaceae	X Lasynrit [K], Dieng Soh Sarlain [J]	H	Wp							Astringent, Alterant, Vulnery.
<i>Hypericum patulum</i> Thunb.	Hypericaceae	X	H	Se							Aromatic, Stimulant.
<i>Hypericum sampsoni</i> Hance	Hypericaceae	X	H	Wp							Vulnery.
<i>Hypianthera stricta</i> W. & A.	Rubiaceae	Bol Diki [G]	T	L							Expectant Mothers.
<i>Hyptis suaveolens</i> Poit.	Lamiaceae	X	US	L							Sunstroke.
<i>Ichnocarpus frutescens</i> R. Br.	Apocyanaceae	Marirang [G]	C	R							Febrifuge, Diaphoretic, Diuretic, Hyperdipsia, Fever, Seminal Weakness, Nephrolithiasis, Strangury, Skin Diseases, Leprosy, Pruritus, Cephalalgia.
<i>Ilex embeloides</i> Hk.f.	Aquifoliaceae	X	T	B, R							Cold, Cough, Tuberculosis.
<i>Ilex khasiana</i> Purk.	Aquifoliaceae	X	T	B, R							Cold, Cough, Tuberculosis.
<i>Illicium griffithi</i> Hk.f. & Th.	Magnoliaceae	X	S	Fr							Carminative, Stimulant.
<i>Impatiens aungustifolia</i> Hk.f.	Balsaminaceae	X	H	L, R							Urinary Complaints, Malaria, Venereal Diseases.
<i>Impatiens tripetala</i> Roxb.	Balsaminaceae	X	H	R							Haematic.
<i>Imperata cylindrica</i> P. Beauv	Poaceae	X	H	Rh							Diuretic, Febrifuge, Urodynia, Pollakiuria, Haematuria.
<i>Indigofera heterantha</i> Brandis	Fabaceae	Chheng budu [G]	S	Wp, Aerial Parts							Cough, Muscular Pain, Cancer.
<i>Inula kappa</i> DC.	Asteraceae	Dieng lalih [J]	US	R							Gastric Troubles, Headache.
<i>Ipomoea batatas</i> Lam.	Convolvulaceae e	Phan Karo [K]	H	R							Laxative, Diuretic, Renal And Vesical Calculi, Diabetes.
<i>Ipomoea digitata</i> L.	Convolvulaceae e	X	C	R							Diminished Lactation, Sore Throat, Hoarseness Of Voice, Cough, Hepatosplenomegaly.
<i>Ipomoea nil</i> Roth.	Convolvulaceae e	Morning Glory [E]	C	L							Purgative, Vermifuge, Inflammation, Leucoderma, Scabies, Dyspepsia, Flatulence, Arthralgia, Gout.
<i>Ipomoea pileata</i> Roxb.	Convolvulaceae e	Charmew Skun [J]	H	L							Skin Diseases.
<i>Ipomoea quamoclit</i> L.	Convolvulaceae e	X	C	Wp, L							Cooling, Carbuncles, Bleeding Piles.
<i>Ipomoea uniflora</i> Roem. & Schult.	Convolvulaceae e	X	C	Wp							Cholera, Vomiting, Dysentery.
<i>Itea chinensis</i> Hk. & Arn.	Saxifragaceae	Myllons [G]	T	L							Skin Diseases.
<i>Ixora accuminata</i> Roxb.	Rubiaceae	Krah Kshang [J]	S	L							Diarrhoea, Dysentery, Influenza.
<i>Jasminum amplexicaule</i> Buch. -	Oleaceae	X	S	Wp, L, B							Stomach Ulcers.

Ham. ex G. Don									
<i>Jasminum dispersum</i> Wall.	Oleaceae	Tiew Lamationg [K]	S	AP	Anticancer, Diuretic Antiseptic, Anodyne, Diuretic, Cephalalgia, Paralysis, Facial Paralysis, Mental Debility, Chronic Constipation, Flatulence, Strangury, Sterility, Ringworm, Leprosy Skin Diseases, Corms.				
<i>Jasminum grandiflorum</i> L.	Oleaceae	Spanish Jasmine [E]	S	Wp	Ringworms In Children.				
<i>Jasminum lanceolaria</i> Roxb.	Oleaceae	Pipli [G]	S	L, R	Indolent Ulcers, Laxative, Cephalalgia, Rheumatism.				
<i>Jasminum pubescens</i> Willd.	Oleaceae	X	S	L, Fl	Antibacterial, Post-Partum Hyperthermic Affections, Lymphadenitis, Metritis, Ostealgia, Impetigo, Abscesses.				
<i>Jasminum sub triplinerve</i> Bl.	Oleaceae	Khia waka [G]	S	L	Rheumatism, Skin Diseases, Eczema, Ring Worms, Scabies.				
<i>Jatropha curcas</i> L.	Euphorbiaceae	Dieng Sohlamohdkhar [K]	S	Se, Wp	Lymphatic Affections, Scrofula, Toothache, Skin Diseases.				
<i>Juglans regia</i> L.	Juglandaceae	Common Walnut [E]	T	L, B, Nut	Urethritis, Fractures, Toothache, Tumours, Anti Microbial.				
<i>Juncus effuses</i> L.	Juncaceae	X	H	Wp	Body Pain.				
<i>Justicia gendarussa</i> L.f.	Acanthaceae	Dija-gipe [G]	H	L	Inflammations.				
<i>Justicia vasculosa</i> An.	Acanthaceae	X	H	Wp	Diuretic, Dyspepsia, Malaria, Rheumatism, Inflammatory Tumours, Sore Eyes, Sore Throat, Swelling, Fever.				
<i>Kaempferia galanga</i> L.	Zingiberaceae	X	H	Rh, L	Burns.				
<i>Kaempferia involucrata</i> King ex Baker	Zingiberaceae	X	H	Rh	Dropsy, Wounds, Ulcers, Tumours, Blood Clots, Vulnerary.				
<i>Kaempferia rotunda</i> L.	Zingiberaceae	Indian Crocus [E]	H	Tu	Dysentery.				
<i>Knema linifolia</i> Warb.	Myristicaceae	Dieng Sohlangorshi [K], Bol Amchi [G]	T	L	Body Pains, Skin Diseases.				
<i>Kydia calynica</i> Roxb.	Malvaceae	Bol Dubak [G], Dieng Lainep [K]	T	L	Liver Diseases.				
<i>Kyllinga brevifolia</i> Rottb.	Cyperaceae	X	H	Wp	Sprains, Contusions.				
<i>Kyllinga monocephala</i> Rottb.	Cyperaceae	X	H	Wp	Sprains, Contusions.				
<i>Kyllinga nemoralis</i> Dandy ex Hutch	Cyperaceae	X	H	Wp	Hypnotic				
<i>Lactuca sativa</i> L.	Asteraceae	Sohlat [K]	H	Wp	Inflammation, Constipation, Anodyne, Diuretic, Febrifuge, Cough, Bronchitis, Fever, Scalding Of Urine, Dropsy, Oralgia.				
<i>Lagenaria siceraria</i> Standley	Cucurbitaceae	Bitter Bottle Gourd [E]	C	Wp	Wounds.				
<i>Lagerstroemia parviflora</i> Roxb.	Lythraceae	Dieng Langsang [K], Bol Sidai [G]	T	L					

<i>Lagerstroemia speciosa</i> Pers.	Lythraceae	Dieng Ther [K], Bol Asari [G]	T	R, B, Se, L, Fr.	Astringent, Stimulant, Febrifuge, Purgative, Ulcers.
<i>Lannea coromandelica</i> Merr.	Anacardiaceae	Dieng Thang [K]; Bol-Agra [G]	T	Se	Narcotic.
<i>Lantana camara</i> L.	Verbenaceae	Dieng Sohphangkhhieh [K]	S	Wp	Vulnery, Diaphoretic, Spasms, Tetanus, Malaria, Epilepsy, Dysentery, Cuts, Wounds, Ulcers, Swellings, Fistula, Pustules, Tumours, Rheumatism.
<i>Lasia spinosa</i> Thew.	Araceae	X	S	L, R	Cuts, Bruises, Diarrhoea, Dysentery, Worms,
<i>Leea alata</i> Edgew	Leeaceae	X	US	R	Tuberculosis, Fistula, Throat Infections, Piles, Colic.
<i>Leea crispa</i> L.	Leeaceae	Mangkhrum [G], Soh Phyrnonar [K]	US	Tu, L	Cold, Cough, Jaundice.
<i>Leea indica</i> Merr.	Leeaceae	X	S	R, L	Wounds, Guineaworms.
<i>Lepidium sativum</i> L.	Brassicaceae	Common Cress [E]	H	R, L, Se	Diarrhoea, Dysentery, Colic, Ulcers, Skin Diseases, Vertigo
<i>Lettsomia strigosa</i> Roxb.	Convolvulaceae	Chyrmew Skun [J]	C	L	Secondary Suppilis & Tenesmus, Diuretic, Antibacterial, Scorbutic Diseases, Sprains, Leprosy, Skin Diseases, Diarrhoea, Dysentery, Scurvy, Abortion.
<i>Leucas linifolia</i> Spreng	Lamiaceae	X	H	L	Cuts, Wounds.
<i>Ligustrum lucidum</i> Ait.f.	Oleaceae	Dieng Sohlapeit [K]	T	Fr	Febrifuge, Snakebite, Headaches, Cold.
<i>Lilium giganteum</i> Wall.	Liliaceae	X	H	L, Bu	Vertigo, Dizziness, Tinnitus, Premature Greying Of Hair.
<i>Lindenbergia ruderalis</i> Z.O.	Scrophulariaceae	X	H	Wp	Antiseptic, Wounds, Foul Ulcers, Boil.
<i>Lindera pulcherrima</i> Benth.	Lauraceae	Dieng Jaburit [K]	T	B	Skin Eruptions, Chronic Bronchitis.
<i>Litchi chinensis</i> Sonnet	Sapindaceae	Dieng Sohmanir [K]	T	Fr, L	Cold, Cough, Worm.
<i>Litsea cubeba</i> Pers.	Lauraceae	Soh Syiang [J]	T	L, B	Animal Bites, Tonic.
<i>Litsea lancifolia</i> Wall. ex Hk.f.	Lauraceae	X	S	B	Ache (Head), Ache (Stomach), Arthritis, Expectorant, Flu, Hysteria, Memory, Paralysis, Parturition, Rheumatism, Swelling, Tonic, Vertigo.
<i>Litsea monopetala</i> Pers.	Lauraceae	Dieng Jalawan [J], Dieng Sohhohtskei [K], Bol Bet [G]	T	L, B, Se	Sprain, Wound.
<i>Litsea sebifera</i> Pers.	Lauraceae	Dieng Jalowan [J], Bol Dhokali [G]	T	B, Be, L	Boils, Ulcers, Rheumatism.
<i>Lobelia angulata</i> Forst	Lobeliaceae	Kensal [G]	H	Wp	Demulcent, Astringent, Diarrhoea, Dysentery, Anodyne, Antidote, Bruises, Wounds, Rheumatism, Antiseptic.
<i>Lobelia chinensis</i> Lour.	Lobeliaceae	X	S	Wp, R	Dyspepsia, Cancer, Emetic, Stomachache.
<i>Lobelia nicotianifolia</i> R. & S.	Lobeliaceae	Lobelia [E]	H	Aerial	Fever, Anthelmintic, Asthma, Depurative. Asthma, Bronchitis.

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<i>Lonicera japonica</i> Thunb.	Caprifoliaceae	Jyrmei-ren [K]	C	L, Fl	Astringent, Pulmonary Diseases.			
<i>Lophatherum gracile</i> Brongn.	Poaceae	X	H	Wp	Hyperpyrezia, Anxiety, Swelling Of Gums, Yellowish Or Reddish Urine, Urethritis.			
<i>Luvunga scandens</i> Ham.	Rutaceae	X	S	Fr, R	Scorpion Sting.			
<i>Lycopersicon lycopersicum</i> Korst	Solanaceae	Soh Saw [K]	H	Fr	Haematinic, Intestinal Antiseptic, Atomic Dyspepsia, Anorexia, Flanulence, Asthma, Bronchitis.			
<i>Lycopodium clavatum</i> L.	Lycopodiaceae	'Main-khla [K]	H	Sp	Dessicative, Rheumatism, Diuretic, Epilepsy, Urinary & Digestive Complaints.			
<i>Lyonia ovalifolia</i> Drude	Ericaceae	Jirhap [K]	T	L, B	Itching, Skin Diseases.			
<i>Macaranga denticulata</i> Muell. - Arg.	Euphorbiaceae	Dieng Lakhor [K], Bol Ajak [G]	T	B	Wounds, Parturition.			
<i>Macaranga indica</i> Wt.	Euphorbiaceae	Dieng Lakhar [K], Sangrow [G]	T	B	Sores.			
<i>Macropanax dispermus</i> O. Ktze.	Araliaceae	Sli Sohresa [J]	T	L	Insectbites.			
<i>Macropanax undulatus</i> Seem	Araliaceae	Dieng Jarasi [K], Achri [G]	T	Gum, L	Aromatic, Headache.			
<i>Maesa chisia</i> Cl.	Myrsinaceae	Dieng Jasim [K]	S	S, Fr, L	Eyedrop, Anthelmentic.			
<i>Maesa montana</i> DC.	Myrsinaceae	X	S	L	Eye Infection			
<i>Mahonia acanthifolia</i> Takeda	Berberidaceae	X	T	B	Eyeras, Moles.			
<i>Mahonia pycnophylla</i> Takeda	Berberidaceae	Dieng Niangmat [K]	T	L, B	Eye Diseases.			
<i>Malaxis accuminata</i> D. Don	Orchidaceae	Jeevak [E]	Te	Sh-base	Febrifuge, Haemataenesis, Fever, Seminal Weakness, Burning Sensation, Dypstia, Emaciation, Debility, *Tuberculosis, Tonic.			
<i>Mallotus albus</i> Muell. - Arg.	Euphorbiaceae	Dieng Thairong [K]	T	Fr, L, R	Earache, Inflammations On Fingers, Toes, Heels Due To Cold.			
<i>Mallotus philippensis</i> Muell. - Arg.	Euphorbiaceae	Bol Khingkhang [G], Dieng Chndon [J]	T	Fr, Se, L, R.	Worms, Catthartic, Bronchitis, Spleen Enlargement, Jaundice, Piles, Skin Diseases, Articular Rheumatism.			
<i>Mangifera indica</i> L.	Anacardiaceae	Dieng Soh Pieng [K], Thekachu [G]	T	B, Fr	Diphtheria, Rheumatism, Nasal Bleeding, Ophthalmia.			
<i>Manihot esculenta</i> Crantz	Euphorbiaceae	Phan Kah [J]	S	R	Constipation, Diarrhoea, Fever, Sores, Boils, Sore Eyes.			
<i>Melastoma malabaricum</i> L.	Melastomataceae	Dieng Khramgai [K], Bol Khakkhu [G]	S	L, Fl	Spermatorrhoea, Diarrhoea, Dysentery.			
<i>Melia azaderach</i> L.	Meliaceae	Dieng Jarasong [K]	T	L, Fr, Se	Skin Diseases, Rheumatism, Antiseptic, Worms, Abortifacient.			
<i>Melia dubia</i> Cav.	Meliaceae	Gingimok [G], Soh Dienglang [K]	T	Fr	Colic, Skin Diseases, Sores.			
<i>Meliosma simplicifolia</i> Walp.	Sabiaceae	Dieng Lapia [K]	T	L	Muscle Pain			

Babarichi [G]

<i>Melissa axillaris</i> Bakh.f.	Lamiaceae	X	H	Wp	Brain Tonic, Fever, Hypochondria, Mouthwash, Stomachic, Tuberculosis.
<i>Mellettia pachycarpa</i> Benth.	Fabaceae	Mak Khal [G]	C	Wp	Insecticide, Ovocide, Piscicide.
<i>Mentha arvensis</i> L.	Lamiaceae	Podina [K]	H	L	Antiseptic, Liver & Spleen Diseases, Asthma, Jaundice.
<i>Mentha piperita</i> L.	Lamiaceae	Peppermint [E]	H	L	Antiseptic, Bruises, Gout, Scabies, Toothache, Swollen Gums, Nervous Disorders, Mumps, Tympanitis, Periodic Discharges.
<i>Messua ferrea</i> L.	Clusiaceae	Karai [G], Dieng Ngai [K]	T	Se, Fl	Skin Diseases, Rheumatism.
<i>Meyna spinosa</i> Link	Rubiaceae	Soh Matan [K]	S	Fr	Cuts, Cracks.
<i>Mezoneuron cucullatum</i> W. & A.	Caesalpinaceae	Memang JakSkel [G]	C	R	"Moila".
<i>Michelia champaca</i> L.	Magnoliaceae	Boi Nabat [G], Shap [K]	T	B, L, Fl, Fr, Se	Diuretic, Febrifuge, Colic, Gout, Rheumatism, Spasms, Cephalalgia, Ophthalmia, Feet Cracks.
<i>Michelia oblonga</i> Wall. ex Hk.f.	Magnoliaceae	Dieng Turoi [K], Bewa Chhamphi [G]	T	B	Aromatic.
<i>Micromelum pubescens</i> Hk.f.	Rutaceae	Silkhol [G], Dieng Jaiaw [K], dieng Tyrpei [J]	T	Wp, R	Phtisis, Chest Troubles, Coughs, Skin Irritations.
<i>Microstylis saprophyta</i> King & Prantl.	Orchidaceae	Walkum [G]	Te	Bu	Burns.
<i>Mikania micrantha</i> HBK.	Asteraceae	German Pula [G]	C	L	Cuts.
<i>Miliusa roxburghiana</i> Hk.f. & Th.	Anonaceae	Dieng Khong [K], Dieng Jwat [J]	T	L	Headache
<i>Mimosa pudica</i> L.	Mimosaceae	Krah More [G], Tiwe Lehraim [K]	S	L, R, S	Antiseptic, Blood Purifier, Burning Sensation, Diarrhoea, Dysentery, Haemophilic, Leucorrhoea, Morbid Condition Of Vagina, Billiousness, Hydrocele, Scorpion Sting.
<i>Mimusops elengi</i> L.	Sapotaceae	Bullet-Wood Tree [E]	T	B, Fr, Se.	Diarrhoea, Dysentery, Constipation.
<i>Mirabilis jalapa</i> L.	Nyctaginaceae	4'o Clock Plant [E]	H	L, R	Leucorrhoea, Urticaria, Tumours.
<i>Mitrephora tomentosa</i> Hk.f. & Th.	Anonaceae	X	T	B	Skin Disease
<i>Molimiera capitulata</i> Herb	Hypoxidaceae	Laliang [J]	H	Rh	Vomiting, Fever
<i>Momordica charantia</i> L.	Cucurbitaceae	Kerela [K]	C	L, R, Fl.	Stomachic, Rheumatism, Gout, Liver & Spleen Diseases, Diabetes, Piles, Leprosy, Jaundice, Wounds, Malignant Ulcers, Snake Bite, Abortifacient Activity.
<i>Momordica dioica</i> Roxb. ex Willd.	Cucurbitaceae	X	C	R	Snakebite.
<i>Monochoria hastata</i> Solms.	Pontederiaceae	Gachli [G]	H	L	Boils.
<i>Monotropa uniflora</i> L.	Monotropaceae	Indian Pipe [E]	H	Wp, R	Eye Ailments, Convulsions & Epilepsy.
<i>Morinda angustifolia</i> Roxb.	Rubiaceae	Dieng Siroi [K], Chhennong [G]	S	R	Dysentery, Fever.

<i>Morinda umbellata</i> L.	Rubiaceae	X	S	L, R	Diarrhoea, Dysentery.
<i>Moringia oleifera</i> Lam.	Moringiaceae	Drumstick Tree [E]	T	L, Fl, Se, R.	Scurvy, Catarrhal Affections, Wounds, Diuretic, Cholagogue, Antipyretic, Gout, Rheumatism.
<i>Morus alba</i> Linn.	Moraceae	X	T	R, L, Fr	Scabies, Smallpox, Diarrhoea, Hepatopathy, Spenopathy Aromatic, Cooling And Laxative, Fevers, Anthelmintic, Purgative, Inflammation Of The Vocal Chords, Astringent.
<i>Morus australis</i> Poir.	Moraceae	Sohlangdkhur [K]	T	Fr, L, B, R	
<i>Morus laevigata</i> Wall.	Moraceae	Rokseng [G], Dieng Bylliut [K], Dieng Pienglyer [J]	T	L	Sores.
<i>Mucuna brateata</i> DC.	Fabaceae	Wakmi [G]	C	Wp	Astringent, Bladder, Diuretic, Dropsy, Elephantiasis, Emmenagogue, Evil Eye, Gall, Hepatitis, Nerves, Purgative, Renitis, Sore, Stimulant, Vermifuge.
<i>Mucuna pruriens</i> DC.	Fabaceae	Cowage Plant [E]	C	Se, R	Aprodisiac, Diuretic, Kidney Trouble, Dropsy.
<i>Mukia maderaspatana</i> Roem.	Cucurbitaceae	X	C	Wp	Vulnerary, Sudorific, Anodyne, Dyspsia, Flatulence, Colic, Ulcers, Asthma, Neuralgia, Notalgia, Odontalgia, Vertigo.
<i>Munronia pinnata</i> Harms	Meliaceae	Samskar [G]	US	R	Stomachache, Vomitting, Loose Motion.
<i>Murraya koenigii</i> Spreng	Rutaceae	Samkhatsi [G]	S	L, B, R.	Stomachic, Astringent, Cough, Rheumatism, Hysteria.
<i>Murraya paniculata</i> Jack	Rutaceae	Sohbhuri [J]	T	L	Stomachic, Stimulant, Astringent, Cough, Rheumatism, Hysteria.
<i>Musa paradisiaca</i> L.	Musaceae	Kait [K]	T	R, S	Tonic For Blood & Veneral Diseases.
<i>Mussaenda frondosa</i> L.	Rubiaceae	X	S	Wp	Febrifuge, Inflammation, Vulnerary, Ophthalmic, Cardiotonic, Cough, Bronchitis, Ulcers, Leucoderma, Pruritus, Jaundice.
<i>Mussaenda glabra</i> Vahl.	Rubiaceae	Kyrthong Blang [J]	S	L	Haemostatic, Boils, Cuts, Wounds.
<i>Mussaenda roxburghii</i> Hk.f.	Rubiaceae	Dieng Jalai [K], Gardek [G]	S	R, B, L	Ulcer, Cuts, Wounds.
<i>Mycetia longifolia</i> O. Ktze	Rubiaceae	Janthro [G]	S	L	Fever.
<i>Myrica esculenta</i> Buch. - Ham. ex D. Don	Myricaceae	Sohphie [K]	T	Fr, B	Stomachic, Antiseptic Asthma, Diarrhoea, Fever, Chronic Bronchitis, Dysentery, Diuresis, Toothache, Cough, Gum Trouble, Earache, Gonorrhoea, Piles.
<i>Myrioneuron nutans</i> Kurz.	Rubiaceae	X	S	S	Eye Complaints.
<i>Myristica kingii</i> Hk.f.	Myristicaceae	Bolong [G]	T	Fr	Mouth Ulcers.
<i>Myrsine africana</i> L.	Myrsinaceae	X	S	Fr	Anthelmintic, Ring & Tapeworm, Laxative, Dropsy, Colic.
<i>Naravelia zeylanica</i> DC.	Ranunculaceae	Jyрмаi Lasam [J], Shamgongiri [G]	C	Wp	Anodyne, Inflammation, Vulnerary, Helminthiasis, Leprosy, Odontalgia, Cephalalgia, Colic, Ulcers, Wounds.
<i>Nelumbo nucifera</i> Gaertn.	Nymphaeaceae	Indian Lotus [E]	H	Wp	Diuretic, Sudorific, Anti Fungal, Antipyretic,

<i>Neolitsea cassia</i> Koster	Lauraceae	X	T	B	Hyperdipsia, Cholera, Diarrhoea, Helminthiasis, Haemorrhages, Ringworms, Spermatorrhoea, Smallpox, Halitosis.
<i>Nepenthes khasiana</i> Hk.f.	Nepenthaceae	Tiew Rakot [K]	S	Pitcher	Bruises, Skin Eruptions, Fever, Flatulence, Spasmodic Affections, Nausea, Vomiting, Urine Haemorrhage. Urinary Troubles, Stomach Disorders, Nightblindness, Skindiseases Leprosy.
<i>Nicotiana tabaccum</i> L.	Solanaceae	Tobacco [E]	H	L	Scabies, Lice, Neuralgic Pains, Toothache, Stimulant, Hernia, Apoplexy, Asphyxia.
<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	Night Jasmine [E]	S	L	Sciatica, Boils, Fever, Eczema, Ringworms.
<i>Nymphaea nouchali</i> Burm.f.	Nymphaeaceae	Indian Water Lily [E]	H	Fl, Rh, Se	Diarrhoea, Dysentery, Dyspsia, Cardiotonic.
<i>Ochna squarrosa</i> Planet	Ochnaceae	X	T	L, R, B	Snakebite, Menstrual Complaints, Asthma, Emollient. Gonorrhoea, Burning Urine, Nephritic Affections, Worms, Gout, Nasal Douche, Constipation, Piles, Otitis, Spasms.
<i>Ocimum basilicum</i> L.	Lamiaceae	Tiew Lahpongnaï [K]	H	L, Se	Stomachache, Constipation.
<i>Oenanthe stolonifera</i> Wall.	Apiaceae	Bopo-goli-teng [G]	H	L	Cathartic
<i>Olax accuminata</i> Benth.	Olacaceae	Dieng Tyrud [K]	T	L	Sore Eyes.
<i>Oldenlandia diffusa</i> Roxb.	Rubiaceae	Chenong [G]	H	L, Sh	Debility.
<i>Oldenlandia nudicaulis</i> Roxb.	Rubiaceae	Chenong-ri [G]	H	L	Febrifuge.
<i>Olea dioica</i> Roxb.	Oleaceae	Poreng [G]	T	B	Boils.
<i>Ophiopogon intermedius</i> D. Don	Liliaceae	Lieng Kadok Sbiat [J]	H	R	Vulnerary, Alexeteric, Laxative, Sedative, Wounds, Ulcers, Snakebite, Helminthiasis, Leprosy, Rabies, Cancer.
<i>Ophiorhiza mungos</i> L.	Rubiaceae	Indian Snake Root [E]	H	R	Fever, Sore Throat, Tonsils, Facial Blemishes.
<i>Ophiorhiza subcapitata</i> Wall.	Rubiaceae	Samachik [G]	C	R, L	Bleeding, Diarrhoea, Colic, Irritable Bowel Syndrome, Enlarged Prostrate Gland.
<i>Opuntia ficus-indica</i> Mill	Cactaceae	Cactus [E]	H	S, Fl, Fr	Rashes, Skindiseases.
<i>Oreocnide integrifolia</i> Miq.	Urticaceae	Khilkhra [G], Tille Jwat [K&J]	T	L	Diarrhoea, Cancer, Diaphoretic, Rheumatism, Dysentery, Enlarged Spleen, Ulcers.
<i>Oroxylon indicum</i> Vent	Bignoniaceae	Dieng Titkongling [K], Dieng Waitblai [J], Khiring [G]	T	B, Fr, L, Se	Snakebite, Muscle Swellings.
<i>Osbeckia capitata</i> Benth.	Melastomataceae	Soh Pythem [K]	H	Wp	Swellings, Body Pain.
<i>Osbeckia nepalensis</i> Hk.f.	Melastomataceae	Sli Lakum [J]	S	R	Scurvy, Warts, Cataracts, Boils, Abscesses, Wounds, Eczema, Diarrhoea, Dysentery.
<i>Oxalis corniculata</i> L.	Oxalidaceae	Phlangkba [J]	H	L, R, Sh.	

<i>Oxalis latifolia</i> Hk.f.	Oxalidaceae	X	H	Wp	Skin Diseases.
<i>Oxyropa cernua</i> Triana	Melastomataceae	Dagal [G]	S	L	Weakness
<i>Paedaria foetida</i> Linn.	Rubiaceae	X	C	WP	Rheumatism, Colic, Spasm, Gout
<i>Paedaria scandens</i> Merr.	Rubiaceae	Jia Sohmuem [J]	S	R, L, Wp	Bacillary Dysentery, Urinary Lithiasis, Dysuria, Dyspepsia, Gastritis, Enteritis, Convalescing Persons, Rheumatism.
<i>Panax pseudo-ginseng</i> Wall.	Araliaceae	X	H	R	Anaesthesia, Headache, Convulsions, Dysentery, Cancer, Neurasthenia, Dyspepsia, Palpitation.
<i>Pandanus furcatus</i> Roxb.	Pandanaceae	X	T	S	Antidote For Snakebite.
<i>Pandanus odoratissimus</i> L.	Pandanaceae	Screw Pine [E]	T	Inf.	Rheumatic Arthritis.
<i>Pandanus sarmentosum</i> Roxb.	Pandanaceae	X	T	R	Aphrodisiac.
<i>Paphiopeditum insigne</i> Stern.	Orchidaceae	Knup Mawsiang [K]	Te	Wp	Amoebic Dysentery.
<i>Parabaena sagittaria</i> Miers.	Menispermaceae	Chiongbombeulu [G]	C	R	Skin Diseases.
<i>Paramignya micrantha</i> Kurth.	Rutaceae	X	S	R	Diuretic
<i>Paramignya monophylla</i> Wt.	Rutaceae	X	S	R	Diuretic.
<i>Paris polyphylla</i> Sm.	Liliaceae	X	H	Wp, Rh	Inflammation, Wounds, Diarrhoea, Fevers.
<i>Parkia roxburghii</i> G. Don	Mimosaceae	Aoelgap [G]	T	B, L, R, Se, Po	Skin Diseases, Ulcers, Cyanophoric, Stomachic.
<i>Passiflora nepalensis</i> Wall.	Passifloraceae	Mi Sohlah [K]	C	L	Malaria, Body Ache
<i>Pavetta indica</i> L.	Rubiaceae	Dieng Longtham [K], Khamkhathek [G]	S	FR, R, L	Diuretic, Visceral Obstruction, Jaundice, Headache, Urinary Diseases, Dropsy, Boils, Itches, Nose Ulcers, Haemorrhages.
<i>Pegia nitida</i> Colebr.	Anacardiaceae	Duchengbrup [G]	S	Wp	Cuts, Wounds.
<i>Peltosanthus bakeri</i> Hk.f.	Liliaceae	Rava-chhongapa [G]	H	L	Gum Bleeding, Nausea
<i>Peltosanthus tetra</i> An.	Liliaceae	X	H	Tu	Fever.
<i>Peltosanthus violacea</i> Baker	Liliaceae	Rava-dalgapa [G]	H	L	Gum Bleeding, Nausea
<i>Peperomia pallucida</i> HBK.	Piperaceae	Sum Lako [J]	H	S, L	Snakebite.
<i>Peperomia tetraphylla</i> Hk. & Arn.	Piperaceae	X	H	Wp	Kidney Troubles.
<i>Persea bombycina</i> Koster.	Lauraceae	X	T	L	Hairfall.
<i>Persea gamblei</i> Koster.	Lauraceae	Omgthat [G]	T	B	Muscular Pains.
<i>Phlogocanthus thyrsoiflorus</i> Nees.	Acanthaceae	Jia Nerymdut [J], Ja Boit [K]	S	L	Insect Stings, Stomach Disorders, Indigestion.
<i>Phlogocanthus tubiflorus</i> Nees.	Acanthaceae	Sam-rongtek [G]	S	L	Fever.
<i>Phoebe attenuata</i> Nees.	Lauraceae	X	T	Be	Sores.
<i>Phoebe lanceolata</i> Nees.	Lauraceae	Dieng Jalong [K]	T	Be	Sores.
<i>Pholidota articulata</i> Lindl.	Orchidaceae	X	Ep	Wp	Tonic.

<i>Pholidota imbricata</i> Lindl.	Orchidaceae	X	Ep	Wp	Navel Pains, Tonic.
<i>Pholidota pallida</i> Lindl.	Orchidaceae	X	Ep	Bu	Cuts, Haemostatic.
<i>Phyllanthus emblica</i> Linn.	Euphorbiaceae	Sohmylleng [K]	T	R B, B, L, Fr	Gonorrhoea, Jaundice, Peptic Ulcer, Conjunctivitis, Dysentery, Leprosy, Anaemia, Grayness Of Hair
<i>Phyllanthus parvifolius</i> Ham.	Euphorbiaceae	X	T	Wp	Astringent, Diuretic, Jaundice, Diarrhoea, Fever, Dysentery.
<i>Phyllanthus reticulatus</i> Poir.	Euphorbiaceae	X	S	Wp	Diuretic, Gastropathy, Ulemorrhagia, Ophthalmodynia, Sores, Burns, Obesity, Bleeding Gums, Smallpox, Asthma, Syphilis.
<i>Phyllanthus retusus</i> Denerst	Euphorbiaceae	X	T	L, B	Astringent, Diuretic.
<i>Phyllanthus urinaria</i> L.	Euphorbiaceae	X	H	Wp	Diuretic, Jaundice.
<i>Physalis peruviana</i> L.	Solanaceae	X	H	L, Wp	Worms, Bowel Complaints, Diuretic.
<i>Picrasma javanica</i> Bl.	Simaroubaceae	Bol Jareng [G]	T	L, B	Febrifuge, Sores, Worms.
<i>Pilea lancifolia</i> Hk.f.	Urticaceae	X	H	L	Fever, Antidandruff.
<i>Pilea umbrosa</i> Wedd.	Urticaceae	Jia Lyer [K]	H	L	Wounds.
<i>Pinus kesiya</i> Royle ex Gordon	Pinaceae	Dieng Kseh [K]	T	B	Cough, Headache, Vertigo, Mental Disorder.
<i>Piper betel</i> L.	Piperaceae	Sla Tympew [K]	C	L	Stimulant, Cough, Cuts & Wounds.
<i>Piper betleoides</i> C. DC.	Piperaceae	X	S	L	Sprains, Fractures.
<i>Piper boehmeriaefolium</i> Wall.	Piperaceae	X	S	L, S	Sprains, Injuries.
<i>Piper griffithii</i> C. DC.	Piperaceae	Pathi bri [J]	C	L, S, Fr	Stomach Troubles, Diarrhoea, Dysentery.
<i>Piper longum</i> L.	Piperaceae	Long Pepper [E]	H	Fr, R	Cold & Cough, Chronic Bronchitis, Diarrhoea, Rheumatism, Paralysis, Insomnia, Epilepsy, Bile Duct & Gall Bladder Obstructions, Dysentery, Leprosy.
<i>Piper mullesus</i> D. Don	Piperaceae	X	S	Fr, R	Cold, Cough.
<i>Piper nigrum</i> L.	Piperaceae	Soh marit [K]	S	Fr	Anti-Blennorriagic, Stomachic, Dyspepsia, Malaria, Haemorrhoids, Delirium, Tremors, Migraine.
<i>Piper peepulooides</i> Roxb.	Piperaceae	Beholisam [G]	US	L, B	Fever, Paralysis.
<i>Pisum sativum</i> L.	Fabaceae	Motor [K]	C	Po	Laxative, Burning Sensation, Skin Diseases, Leprosy, Cough, Bronchitis, Measles, Cuts, Wounds.
<i>Pithecellobium bigeminum</i> Mart.	Mimosaceae	Dieng lapiar [K], Dieng Siaw [J]	T	Se, L	Diabetes Mellitus, Leprosy, Promotes Hair Growth.
<i>Plantago erosa</i> Wall.	Plantaginaceae	Skhur Blang [J]	H	L	Burns, Cuts.
<i>Plantago major</i> Hk.f.	Plantaginaceae	Krah Shit [J]	H	Se, Wp	Tooth & Earaches, Enuresis, Pyorrhoea Alveolaris, Depression & Insomnia, Itching & Burning Urticaria, Chilbains, Pruritus, Bee-Sting, Bleeding Piles.
<i>Plumeria rubra</i> L.	Apocyanaceae	Pogodo Tree [E]	T	R	Cathartic
<i>Pogostemon parviflorus</i> Benth.	Lamiaceae	Sam-sanum [G]	H	L	Headache, Eye Drop.
<i>Polyalthia longifolia</i> Benth. &	Anonaceae	Diengther [K]	T	B	Febrifuge.

Hk.f.										
<i>Polygala persicariaefolia</i> DC.	Polygalaceae	X		H	Wp	Malaria				
<i>Polygala sibirica</i> L.	Polygalaceae	X		H	Wp	Tonic, Vulnerary.				
<i>Polygonum bistorta</i> L.	Polygonaceae	X		H	Rh	Diarrhoea, Enteritis, Bleeding Haemorrhoids, Gingivitis, Febrifuge, Diuretic.				
<i>Polygonum chinense</i> L.	Polygonaceae	Lymbeh [J]		S	L	Antibacterial, Furrunculosis, Impetigo, Ulceration Of The Helix, Scalp Scabs, Cold Sore, Eczema, Boils, Snakebite.				
<i>Polygonum molle</i> D. Don	Polygonaceae	Jaryndem [J]		H	L	Bone Fracture				
<i>Polygonum perfoliatum</i> L.	Polygonaceae	Ma Sienthli [K]		C	L	Tumours, Emollient.				
<i>Polygonum plebejum</i> R. Br.	Polygonaceae	Ma Sienthli [K]		H	Wp, R	Pneumonia, Bowel Complaints.				
<i>Polygonum strigosum</i> R. Br.	Polygonaceae	X		H	L	Skin Diseases				
<i>Pongamia glabra</i> Vent.	Fabaceae	X		T	L, R	Cough, Leprosy.				
<i>Portulaca oleracea</i> L.	Portulacaceae	Jehe Sia [J]		H	Wp	Antiscorbutic, Diuretic, Scurvy, Liver, Kidney, Spleen & Bladder Diseases, Cardio-Vascular Disorder, Dysuria, Haematuria, Gonorrhoea, Sore Nipples, Mouth Ulcers.				
<i>Potentilla fulgens</i> Wall.	Rosaceae	Lynniang [K]		H	R	Toothache, Blood Pressure.				
<i>Pothos kunstleri</i> Hk.f.	Araceae	Garore [G]		C	L, S	Toxicity.				
<i>Pothos scandens</i> L.	Araceae	Durongru [G]		S	L, S	Snakebite, Asthma, Smallpox.				
<i>Pouzolzia hirta</i> Hassk.	Urticaceae	Ja Mymleh [K]		H	Wp	Dislocation Of Joints.				
<i>Pouzolzia indica</i> Gaud.	Urticaceae	Fakrum [G]		H	R, L	Urinary And Spleen Disorders.				
<i>Pouzolzia sanguinea</i> Merr.	Urticaceae	X		S	Tw	Wounds				
<i>Premna latifolia</i> Roxb.	Verbenaceae	Dieng Sohphandkhar [K], Dulchemi Bol [G]		T	L, B	Diuretic, Dropsy, Boils.				
<i>Princepia utilis</i> Royle	Rosaceae	Dieng Shiahmiaw [K]		S	R, Se	Wounds, Rheumatism.				
<i>Prismatomeris albidiflora</i> Thw.	Rubiaceae	Dieng Sohshri [K]		T	L	Stomach Troubles.				
<i>Prunus ceracoides</i> D. Don	Rosaceae	Dieng Sohiongksem [K], Dieng Tyrkhum [J]		T	B	Anti-Abortifacient, Analgesic, Stomachic, Burning Sensation, Cold, Coughs, Seminal Weakness.				
<i>Prunus napaulensis</i> Steud.	Rosaceae	Sohiong [K]		T	Fr, L	Astringent, Diuretic Dropsy.				
<i>Prunus persica</i> Batsch	Rosaceae	Soh Phareng [K]		T	Se	Vehicle For Injections, Demulcent, Lubricant.				
<i>Psidium guajava</i> L.	Myrtaceae	Soh Pyriam [K]		T	Fr, L, R	Coughs, Diarrhoea, Dysentery, Toothache, Painfull Menstruation, Miscarriages, Uterine Bleeding, Premature Labour.				
<i>Psychotria montana</i> Bl.	Rubiaceae	X		S	R	Ulcers, Swellings, Fever, Enlarged Spleen.				
<i>Pteridium aquilinum</i> Kuhn.	Polypodiaceae	X		H	Wp	Diarrhoea, Stomach Cramps, Increases Urine Flow.				
<i>Pterospermum acerifolium</i> Willd.	Sterculiaceae	Rikhabot [G], Dieng Khoh [K]		T	Fl, B, L	Smallpox, Haemostatic.				
<i>Pterygota alata</i> R. Br.	Sterculiaceae	Dieng Klong [K], Mi Bol [G]		T	Se	Opiate.				

<i>Pueraria lobata</i> Ohwi	Fabaceae	Sli Niangtyllie [J]	C	R	Cold With Fever, Acute Gastro-Enteritis, Diarrhoea, Palpitation, Dysentery, Febrifuge.
<i>Punica gratum</i> L.	Punicaceae	Soh Pomkarnet [K]	T	B, Se, Fr	Anthemimetic, Tapeworm, Diarrhoea, Dysentery, Leprosy, Diarrhoea.
<i>Pyrus pashia</i> Buch. - Ham.	Rosaceae	Soh Shur [K]	T	Fr	Haemorrhages, Chronic Diarrhoea, Dysentery.
<i>Quercus semicarpifolia</i> Sm.	Fagaceae	Dieng Shahdngiem [K]	T	Galls	Giddiness, Cold.
<i>Ranunculus diffusus</i> DC.	Ranunculaceae	X	H	Wp	Skin Vesicular Eruptions, Corns, Bruised Pain In Chest.
<i>Ranunculus scleratus</i> L.	Ranunculaceae	X	H	Wp	Oedema, Skin Infections, Diuretic, Laxative, Flatulence.
<i>Raphanus sativus</i> L.	Brassicaceae	Muli [K]	H	Se, L, R	Snakebite.
<i>Raphidophora decursiva</i> Schott.	Araceae	Dawai Rarbek [J]	C	Rh	Snakebite.
<i>Raphidophora hookeri</i> DC.	Araceae	Dhukentri [G]	C	L, R	Mild Anxiety, Chronic Mental Illness, Bowel Diseases, Fevers.
<i>Ranvolfia serpentina</i> Benth. ex Kurz.	Apocyanaceae	Tdong Pait Parao [K]	US	R	Emetic, Purgative, Spleen Affections.
<i>Rhamnus virgatus</i> Roxb.	Rhamnaceae	X	S	Fr	Blood Dysentery.
<i>Rhododendron arboreum</i> Sm.	Ericaceae	Dieng Tiew saw [K]	T	Fl	Diarrhoea, Dysentery.
<i>Rhus accuminata</i> DC.	Anacardiaceae	Dieng Khlaw [K], Dieng Swit [J], Bol Micheng [G]	T	Galls	Haemostatic, Antibacterial, Antifungal, Antiviral, Diarrhoea, Cough, Abnormal Sweating.
<i>Rhus javanica</i> L.	Anacardiaceae	Dieng Sohsmas [K&J]	T	Galls	Phthiasis, Astringent, Diarrhoea, Dysentery.
<i>Rhus succadaenia</i> Gamble	Anacardiaceae	Dieng Khlaw [K]	T	Fr	Skin Diseases.
<i>Rhynchosyllum obliquum</i> Bl.	Gesneriaceae	X	H	L	Rheumatism.
<i>Rhynchosyllum retusa</i> Bl.	Orchidaceae	Tdong miaw [K]	Ep	L	Dog Bite
<i>Rhynchotechum ellipticum</i> A. DC.	Gesneriaceae	Ja Kharia [K], Khilma [G]	S	L	Skin Diseases, Intestinal Inflammations, Contraceptive, Eye Drops, Anti-Fungal, Headache, Fever, Abortion.
<i>Ricinus communis</i> L.	Euphorbiaceae	Oh Rasam [K], Kharanda [G]	S	L, R	Mal-Absorption, Cough, Abnormal Perspiration, Night Sweats, Enuresis, Leucorrhoea, Massive Uterine Bleeding, Seminal Emmisions, Spermatorrhoea, Enteritis, Neurasthenia.
<i>Rosa laevigata</i> Michx.	Rosaceae	X	S	Fr	Billious Affections, Eye Diseases, Burning Of Skin.
<i>Rosa moschata</i> Herrm.	Rosaceae	X	S	Fl	Malaria.
<i>Roscoea purpurea</i> Sm.	Zingiberaceae	X	H	R	Inflammation, Antiseptic, Dysentery, Vulnerary, Diuretic, Ophthalmic, Febrifuge, Rheumatoid Arthritis, Neuralgia, Cephalalgia, Helminthiasis, Leprosy, Leucoderma, Pruritus, Wounds, Ulcers, Tuberculosis, Pharyngitis, Diabetes.
<i>Rubia cordifolia</i> L.	Rubiaceae	Sohmsiem [K], Phlang Soothied [J]	C	R	Stomach Troubles.
<i>Rubus ellipticus</i> Sm.	Rosaceae	Sia Sohpru [J], Dieng Shiah Sohprew [K]	S	Sh, R	Headache.
<i>Rubus niveus</i> Thunb.	Rosaceae	Dieng Sohkhaniiong [K],	S	Sh, R	

	Sohkhuoiong [J]						
<i>Rubus paniculatus</i> Sm.	Rosaceae	X		S	L	Diarrhoea, Stomach Disorders.	
<i>Rubus rugosus</i> Sm.	Rosaceae	X		S	L, Fr	Abortifacient, Fistula, Mouth Sores, Body Swellings.	
<i>Rumex nepalensis</i> Spreng.	Polygonaceae		Tyrso Sniang [K]	H	L, S	Astringent.	
<i>Sabia lanceolata</i> Coleb.	Sabiaceae		Santameh [K], Madri [G]	C	L	Swollen Ankles & Wrists.	
<i>Saccharum officinarum</i> L.	Poaceae		Dieng Pai [K]	H	Wp	Sore Eyes, Sore Throat.	
<i>Saccharum spontaneum</i> L.	Poaceae	X		H	Wp	Diuretic, Haemostatic, Laxative, Burning Sensation, Strangury, Renal & Vesical Calculi, Menorrhagia, Dysentery, Agalactia.	
<i>Salix tetrasperma</i> Roxb.	Salicaceae		Bol Slak [G], Jarynsei [K], Dieng Um [J]	T	L	Swellings, Rheumatism, Piles, Venereal Diseases.	
<i>Sambucus javanica</i> Bl.	Sambucaceae	X		T	Wp	Depurative, Diuretic, Purgative.	
<i>Sanicula elata</i> D. Don	Apiaceae	X		H	Wp	Tonic, Chronic Skin Diseases, Rheumatism, Passive Dropsy.	
<i>Sansevieria zeylanica</i> L.	Liliaceae		Sammogong [G]	H	R	Febrifuge, Purgative, Tonic.	
<i>Sapindus attenuatus</i> DC.	Sapindaceae	X		T	Fr	Pimples.	
<i>Sapindus mukorosis</i> Gaertn.	Sapindaceae		Dieng Spiengsoh [J]	T	Fr	Chlorosis, Epilepsy.	
<i>Saprosma ternatum</i> Hk.f.	Rubiaceae		Dieng Sohainai [K]	S	B, L	Indigestion, Flatulence, Stomach Ache.	
<i>Saraca asoca</i> de Willd.	Caesalpinaceae		Bol Bang [G], Dieng Sohrymsien [K]	T	Fl, Se, B	Haemorrhagic Dysentery, Urinary Discharges, Excessive Menstruation	
<i>Sarcandra glabra</i> Nakai	Chloranthaceae		Soh Krismas [K]	S	Wp	Dysentery, Paralysis.	
<i>Sarcococca saligna</i> Muell. - Arg.	Buxaceae		Tiew Dieng [K]	S	R	Phosphaturia, Gonorrhoea.	
<i>Satyrium nepalense</i> D. Don	Orchidaceae	X		Te	R	Malaria, Dysentery, Tonic.	
<i>Saurauia nepaulensis</i> DC.	Saurauiaceae		Jia Sten [J]	T	B	Fever.	
<i>Sauropus androgynus</i> Merr.	Euphorbiaceae		Dieng Sohpit [K]	S	L, R	Retained Placenta, Tongue Thrashes, Erythema, Measles, Dysuria, Diuretic, Congestion.	
<i>Schefferia venulosa</i> Harms	Araliaceae		Jengjel [G], Jyrmi Mongboi [K], Tille Diyabet [J]	S	L	Skin Diseases.	
<i>Schima khasiana</i> Dyer.	Theaceae		Dieng Ngan [K]	T	L, B	Stomachache, Allergies.	
<i>Schima wallichi</i> Korth.	Theaceae		Dieng Shyngan [K], Dieng Nganbait [J]	T	L	Cuts, Wounds, Worms, Flatulence.	
<i>Schleichera trijuga</i> Willd.	Sapindaceae	X		T	B, Se	Astringent, Itch, Scalp Stimulant, Acne.	
<i>Scoparia dulcis</i> L.	Scrophulariaceae		Krah Lebekor [J]	H	Wp	Inflammation, Febrifuge, Diuretic, Coryza, Hyperthermia, Sore Throat, Cough, Erythema, Measles, Boils, Impetigo.	
<i>Scutellaria discolor</i> Coleb.	Lamiaceae		Khalitchi [G]	H	R, L, Wp	Nausea, Vomiting, Flatulence, Indigestion, Skin Infections, Bronchitis, Fever, Constipation.	
<i>Scutellaria glandulosa</i> Hk.f.	Lamiaceae	X		H	L	Liver Complaints, Malaria, Stomachache.	

<i>Seasamum indicum</i> L.	Pedaliaceae	The Ginger Oil Plant [E] Dieng Krongwattam [K], Dumikron [G]	H	Se	Antioxidant, Synergistic, Emollient, Demulcent.
<i>Securinega virosa</i> Baill	Euphorbiaceae		S	Fr	Stomachache.
<i>Semicarpus anacardium</i> L.f.	Anacardiaceae	Dieng Sohbhala [K]	T	Fr	Liver Tonic, Arthritis, Antiseptic, Cardiotonic, Sudorific, Febrifuge, Beri-Beri, Cancer, Sciatica, Neuritis, Diabetes, Ulcers.
<i>Senecio densiflorus</i> Wall.	Asteraceae	X	US	L	Boils.
<i>Shorea robusta</i> Gaertn.	Dipterocarpaceae	Dieng Blei [K], Bol Sal [G]	T	B	Dysentery.
<i>Sida rhombifolia</i> L.	Malvaceae	Sohkhakhmei [J]	H	L, R	Promote Sexual Vigour, Rheumatism, Flatulence, Colic, Seminal Weakness, Arthritis, Diarrhoea.
<i>Sida acuta</i> Burm.f.	Malvaceae	Soh Byrthidbah [K], Chirota [G]	US	Se	Spermatorrhoea, Gonorrhoea, Leucorrhoea.
<i>Siegesbeckia orientalis</i> L.	Asteraceae	Soh Barthudlib [K]	H	Wp	Rheumatic Arthralgia, Fatigue With Fever, Neurasthenia, Ulcers, Abscesses, Boils.
<i>Skimmia lauroala</i> Sieb. & Zucc.	Rutaceae	X	S	L	Smallpox.
<i>Smilacina fusca</i> Hk.f.	Liliaceae	X	H	R	Malaria, Dysentery.
<i>Smilax aspera</i> L.	Smilacaceae	X	C	R	Blood Purifier, Skin Diseases.
<i>Smilax lanceifolia</i> Roxb.	Smilacaceae	Durastheng [G]	C	R	Rheumatism, Dysentery.
<i>Smilax ovalifolia</i> Roxb.	Smilacaceae	X	C	R	Spermatorrhoea, Weakness.
<i>Smilax perfoliata</i> Lour.	Smilacaceae	Lehkhynrum Doh [J]	C	Fl	Tonic After Delivery, Blood Purifier.
<i>Smilax proliferata</i> Roxb.	Smilacaceae	Narangwa [G]	S	R, L	Hydrocoel, Labour Pain.
<i>Solanum erianthum</i> D. Don	Solanaceae	Dieng Sohomon- niangkodong [K], Khimkhanagong [G]	T	L	Haemorrhoids, Scrofula, Dermatomycosis, Impetigo.
<i>Solanum ferox</i> L.	Solanaceae	X	US	R	Cough.
<i>Solanum khasianum</i> Cl.	Solanaceae	X	US	Be	Inflammations, Arthritis, Hormonal.
<i>Solanum kurzii</i> Br.	Solanaceae	Khimkha [G]	S	Fr	Liver Complaints, Malaria.
<i>Solanum melongena</i> L.	Solanaceae	Soh Baingoniong [K]	S	R, L, Fr	Laxative, Cardiotonic, Neuralgia, Nose Ulcers, Sialagogue, Antitherpetic, Cholera, Bronchitis, Asthma, Odontalgia.
<i>Solanum nigrum</i> L.	Solanaceae	The Black Night Shade [E]	H	Wp	Ulcers, Skin Diseases, Dysentery, Laxative, Asthma.
<i>Solanum spirale</i> Roxb.	Solanaceae	Dieng Sarynangkheindoh [K]	US	Fr	Dysentery, Cold, Vomiting.
<i>Solanum surratense</i> Burm.f.	Solanaceae	X	H	Fr, R	Jaundice, Body Swellings, Cough, Asthma, Chest Pain, Diuretic.
<i>Solanum torvum</i> Sw.	Solanaceae	Dieng Sohngang [K]	S	L, Fr	Wounds, Cough.

<i>Solanum tuberosum</i> L.	Solanaceae	Phan [K]	S	Tu	Skin Ointments & Tablets.
<i>Solena heterophylla</i> Lour.	Cucurbitaceae	X	H	R, L, Se	Cardiotonic, Diuretic, Anorexia, Dyspepsia, Colic, Flatulence, Asthma, Bronchitis, Strangury, Renal & Vesical Calculi, Haemorrhoids, Gonorrhoea, Allergies.
<i>Solidago virga-aurea</i> L.	Asteraceae	X	H	Aerial parts	Diuretic, Urinary Tract Disorders, Nephritis, Cystitis, Kidney & Bladder Stones, Vaginal & Oral Thrush, Sore Throats, Nasal Catarrh, Diarrhoea, Gastroenteritis.
<i>Sonchus arvensis</i> L.	Asteraceae	Kilanjiat [K]	H	Wp, R, Se	Jaundice, Diuretic, Diaphoretic, Antiseptic, Coughs, Phthisis, Bronchitis, Asthma, Pertussis, Demulcent.
<i>Sonchus asper</i> Hill	Asteraceae	X	H	L	Cuts, Wounds, Haemostatic.
<i>Sonchus oleraceus</i> L.	Asteraceae	X	H	L, R	Febrifuge, Hydragogue, Catharrh.
<i>Sonerila maculata</i> Roxb.	Melastomataceae	X	H	R	Stomach Trouble.
<i>Sophora accuminata</i> Baker	Fabaceae	Palwang [G]	S	B	Pregnancy (Purification Of Blood Before & After Delivery).
<i>Spatholobus roxburghii</i> Benth.	Fabaceae	Therlamohdak [K], Marimaru [G]	L	L	Dysentery.
<i>Sphaeranthus indicus</i> L.	Asteraceae	Globe Thistle [E]	H	S, L, Fl.	Small Pox, Anthelmintic, Aphrodisiac, Stomachic.
<i>Sphenodesma pentandra</i> Jack	Verbenaceae	Sli Khlerisaw [J]	C	L	Cuts, Wounds.
<i>Spilanthes acmella</i> L.	Asteraceae	Dieng Shirmitbarngain [J]	H	L, Fl	Toothache, Throat & Gum Affections, Jaw Bones Inflammation.
<i>Spondias pinnata</i> Kurz.	Anacardiaceae	Sli Sohrepid [J]	T	R, B, L, Fr	Menstrual Regulation, Dysentery, Diarrhoea, Muscular Rheumatism, Otalgia, Dyspepsia, Thermogenic.
<i>Stachytarpheta jamaicensis</i> Vahl.	Verbenaceae	X	US	Wp	Purulent Ulcers, Fevers, Rheumatism, Dysentery.
<i>Stemona tuberosa</i> Lour.	Stemmonaceae	X	C	R	Antibacterial, Antiparasitic, Cough, Ascariasis, Oxyuriasis, Impetigo, Scabies.
<i>Stephania glandulifera</i> Miers.	Menispermaceae	Longdong Sla [K]	C	Tu	Yellow Fever.
<i>Stephania hernandifolia</i> Walp.	Menispermaceae	Samtha [G]	C	T	Stomach-Ache
<i>Stephania japonica</i> Miers.	Menispermaceae	Khaarkha [G]	C	L, R	Boils, Fevers, Diarrhoea, Urinary Diseases, Antifertility.
<i>Sterculia roxburghii</i> Wall.	Sterculiaceae	Mimong Chit Udari [G]	T	R	Stomach- Ache
<i>Sterculia villosa</i> Roxb.	Sterculiaceae	Dieng Star [K], Umale [G]	T	B	Throat Infection, Dental Fixture Powders, Lozenges & Paste.
<i>Stereospermum chelonoides</i> DC.	Bignoniaceae	Bol Sel [G], Dieng Sir [J]	T	B, L, R, Fl	Asthma, Cholera, Intermittant Fevers, Brain Affections, Diuretic.
<i>Streblus asper</i> Lour.	Moraceae	Khanchi Bol [G], Dieng [T]	T	R, B, L,	Thermogenic, Vulnery, Inflammation, Ulcers, Sinusitis,

	Soh Khyrdang [K]	Latex	
<i>Strychnos wallichiana</i> Benth.	Dukhonkha [G]	L	B
<i>Stryx serrulatum</i> Roxb.	Dieng Sohbyklong [K], Dieng Jalatpai [J], Bol Misi [G]	S	Resin
<i>Sweria chirayita</i> Kars.	X	H	Wp
<i>Sweria dilatata</i> Wall.	X	H	R
<i>Symplocos chinensis</i> Durcc.	X	T	L, B
<i>Symplocos laurina</i> Wall. ex Rehd. & Wills	Dieng Japei [K], Dieng Latperit [J], Mala Bol [G]	T	B
<i>Symplocos paniculata</i> Miq.	Jamiang [K], Dieng long [J]	S	L, B
<i>Symplocos racemosa</i> Roxb.	Bol Mitap [G]	T	B
<i>Symplocos thaefolia</i> D. Don	Dieng Pei [K]	T	L, Tw
<i>Syzygium cumini</i> Skeels	Sambu [G], Dieng Ramai [K], Dieng Sohtongum [J]	T	B, Se
<i>Syzygium jambos</i> Alston	X	T	B, Se, Fr
<i>Syzygium operculatum</i> Gamble	X	T	Fr, L, R
<i>Tabernaemontana divaricata</i> R. Bt.	Chyllu [J], dieng Jasoh [K]	S	R, Fl, latex
<i>Tacca integrifolia</i> Ken. & Gawl.	X	T	Rh, L
<i>Tagetes minuta</i> L.	X	H	Fl, Wp
<i>Tamarindus indica</i> L.	Khen Thri [G], Dieng Soh Kyntoi [K]	T	L, Fl, Se, Fr.
<i>Tapiria hirsuta</i> Hk.f.	Dachhengrup [G]	S	L
<i>Taxus baccata</i> L.	Dieng Blei [K]	T	L, B
<i>Tectona grandis</i> L.f.	Teak [E]	T	Wp
<i>Terminalia belerica</i> Roxb.	Dieng Rynin [K], Bol Shuri [G]	T	Fr
<i>Terminalia chebula</i> Retz.	Bol Artak [G]	T	Fr

<i>Terminalia citrina</i> Flem.	Combretaceae	Soh Handru-diengartaki [K], Bol OMIT [G]	T	Fr, B	Bleeding & Ulceration Of Gums, Cough, Wounds, Scalds. Laxative, Ulcers, Wounds, Dentrifice, Gum Bleeding & Ulcerations, Diuretic, Cardiotonic.
<i>Ternstroemia japonica</i> Thunb.	Ternstroemiaceae	Dieng Lasaw [K]	T	Fl, B	Cholera, Diuretic, Cardiotonic.
<i>Tetrameles nudiflora</i> R. Br.	Tetrameleaceae	Bol Bok [G], Dieng Taro [K]	T	L, B	Ascites, Dugout, Oedema, Icterus, Rheumatism.
<i>Thalictrum foliolosum</i> Bl.	Ranunculaceae	Popum [K]	H	R	Jaundice, Blood Purifier, Ophthalmic, Atomic Dyspepsia.
<i>Thalictrum javanicum</i> Bl.	Ranunculaceae	X	H	L, R	Eye & Skin Diseases, Sores, Germicidal, Convalescens.
<i>Thevetia peruviana</i> K. Schum	Apocyanaceae	X	T	R, Se	Tumours, Rheumatism, Dropsy, Abortifacient.
<i>Thunbergia coccinea</i> Wall.	Acanthaceae	Kakku-budu [G]	C	L	Bone Fractures.
<i>Thunbergia grandiflora</i> Roxb.	Acanthaceae	Chymew Lahmah [J]	C	L	Snakebite.
<i>Thysanolaena maxima</i> O. Ktze.	Poaceae	X	H	R	Cooling & Cleaning Eyes, Mouthwash During Fever.
<i>Tinospora cordifolia</i> Miers.	Menispermaceae	X	C	Wp, S	Gonorrhoea, Antiperiodic.
<i>Tinospora malabarica</i> Miers.	Menispermaceae	Chymew Ram [J]	C	S	Urinary Diseases.
<i>Toddalia asiatica</i> Lam.	Rutaceae	Soh Sat [K], Saryngkhlian [J]	S	Fr, R, L, Fl	Diaphoretic, Anti Periodic, Anti Pyretic, Anti Bacterial, Vulnerary, Odontalgia, Paralysis, Malaria, Dyspepsia, Colic, Flatulence, Nausea, Epilepsy, Wasp-Stings.
<i>Toona ciliata</i> Roem.	Meliaceae	X	T	Fl, B	Anti Periodic, Dysentery, Cough, Bronchitis, Intermittent Fevers, Verminosis, Leprosy, Ulcers, Menstrual Disorders.
<i>Trema orientalis</i> Gaertn.	Ulmaceae	Phakram [G], Dieng Lata [K], Dieng Lattar [J]	T	Wp, R, B, L	Epilepsy, Diarrhoea, Blood In Urine, Epilepsy, Muscular Pains.
<i>Trevesia palmata</i> Vis.	Araliaceae	Chenathong [G], Dieng Lakor [K]	T	Fl, L	Fever, Facial Paralysis.
<i>Trewia nudiflora</i> L.	Euphorbiaceae	Bol Diktak [G], Dieng Soh lyndot [K]	T	Wp, R	Swellings, Bile & Phlegm, Flatulence, Gout, Rheumatism.
<i>Trichosanthes bracteata</i> Voigt.	Cucurbitaceae	X	C	R, Fr	Thermogenic, Abortifacient, Purgative, Hemicrania, Carbuncles, Gonorrhoea, Otitis, Rhinitis, Epilepsy.
<i>Trichosanthes dioica</i> Roxb.	Cucurbitaceae	X	C	R, Fr	Alopecia Areata, Laxative, Purgative, Febrifuge, Boils.
<i>Trichosanthes tricuspidata</i> Lour.	Cucurbitaceae	Soh Lynshang [K]	C	R, Fr	Thermogenic, Abortifacient, Purgative, Hemicrania, Carbuncles, Gonorrhoea, Otitis, Rhinitis, Epilepsy.
<i>Trifolium repens</i> L.	Fabaceae	X	H	Wp	Diabetes.
<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	Sli Sko [J]	H	R, B, L, Fl	Diarrhoea, Dysentery, Boils, Ulcers, Leprosy.
<i>Urena lobata</i> L.	Malvaceae	Samthe [G]	H	Fl, L, R	Diarrhoea, Boils, Diuretic, Abortifacient, Cough.
<i>Urtica macraei</i> Fedde.	Urticaceae	X	US	R, L, Infl,	Bone Fractures, Dislocations, Tonic, Cleaning Agent

	[G]								
<i>Zanthoxylum armatum</i> DC.	Rutaceae	Bol Meching [G]	T	S, L	Mouth Purifier, Teeth Enamel Diseases.				
<i>Zanthoxylum khasianum</i> Hk.f.	Rutaceae	Soh Tiewshah [K]	S	B, Fr, Se	Carminative, Anthelmintic.				
<i>Zanthoxylum oxyphyllum</i> Edgew	Rutaceae	Jaiur Blai [J]	S	L, Fr	Skin Diseases, Toothache.				
<i>Zanthoxylum rhetsa</i> DC.	Rutaceae	Bol Micheng [G], Dieng Sohmirik [K]	T	Fr	Cough.				
<i>Zehneria umbellata</i> Thw.	Cucurbitaceae	Sohkhia Phlang [K]	C	R, Fr	Seminal Debility, Spermatorrhoea, Stomachic.				
<i>Zingiber chrysanthum</i> Rosc.	Zingiberaceae	Dikgikadi [G]	H	R	Body Pains, Internal Haemorrhages.				
<i>Zingiber officinale</i> Rosc.	Zingiberaceae	Sying [K]	H	Rh	Carminative, Mild Diarrhoea, Colic, Dyspepsia.				
<i>Zingiber rubens</i> Rosc.	Zingiberaceae	X	H	Rh	Giddiness, Cold.				
<i>Zizyphus funiculosa</i> Ham.	Rhamnaceae	Darichik [G]	S	L, B	Gyneacological Disorders.				
<i>Zizyphus mauritiana</i> Lam.	Rhamnaceae	Tengkhii [G], Dieng Sohbroi [K]	T	L, R, Se, B	Sore Throat, Dysentery, Bleeding Gums, Aphrodisiac.				
<i>Zizyphus oenoplia</i> Mill	Rhamnaceae	X	S	R	Anti Septic, Hyper-Acidity, Ascariasis, Wounds.				
<i>Zizyphus rugosa</i> Lam.	Rhamnaceae	Dumakpul [G]	T	Fl	Menorrhagia.				

Fl = Flower, = Root, B = bark, Se = Seed, L = Leaves, Rh = Rhizome, Fr = Fruit, S = Stem, Wp = Whole plant, Pu = Pulp, Infl = Inflorescence, Tw = Twig, Tu = Tuber, Be = Berry, Sh = Shoots, Po = Pods. Bu = Bulb, Pb = Pseudobulb, Sp = Sporophyte, Nu = Nuts. T = Tree, S = Shrub, H = Herb, C = Climber, L = Liana, US = Undershrub, Te = Terrestrial, Ep = Epiphyte.

Annexure 2: List of the 116 threatened medicinal plant species recorded from Meghalaya.

SPECIES	FAMILY	HABIT	STATUS
<i>Acanthus leucostachys</i> Roxb.	Acanthaceae	H	Endemic & Rare
<i>Acorus calamus</i> L.	Araceae	H	Vulnerable
<i>Aeschynanthes superba</i> Cl.	Gesneriaceae	Ep	Endemic & Rare
<i>Aquilaria agallocha</i> Roxb.	Thymeleaceae	T	Endangered
<i>Ardisia odontophylla</i> DC.	Myrsinaceae	S	Rare
<i>Aristolochia cathcartii</i> Hk.f.	Aristolochiaceae	C	Rare
<i>Aristolochia saccata</i> Wall.	Aristolochiaceae	L	Rare
<i>Artocarpus gomezianus</i> Wall.ex.Trewl.	Moraceae	T	Rare
<i>Bergenia ciliata</i> Sternb.	Saxifragaceae	H	Vulnerable
<i>Boehmeria macrophylla</i> D.Don.	Urticaceae	T	Endemic & Rare
<i>Bucea mollis</i> Wall.ex.Kurz.	Simaroubaceae	S	Rare
<i>Butea monosperma</i> Taub.	Fabaceae	T	Vulnerable
<i>Calamus erectus</i> Roxb.	Arecaceae	S	Endemic & Rare
<i>Calamus floribundus</i> Griff.	Arecaceae	C	Endemic & Rare
<i>Camellia caduca</i> Brandis.	Theaceae	T	Endemic & Rare
<i>Cardamine impatiens</i> L.	Brassicaceae	H	Rare
<i>Caryota urens</i> L.	Araceae	T	Rare
<i>Cephalotaxus mannii</i> Hk.f.	Taxaceae	T	Vulnerable
<i>Cibotium barometz</i> Link.	Cyatheaceae	S	Vulnerable
<i>Cinnamomum tamala</i> Nees.&Eberm.	Lauraceae	T	Vulnerable
<i>Citrus aurantium</i> L.	Rutaceae	T	Endemic & Rare
<i>Citrus latipes</i> Tanaka.	Rutaceae	T	Endemic & Rare
<i>Citrus medica</i> L.	Rutaceae	S	Endemic & Rare
<i>Clerodendrum colebrookianum</i> Walp.	Verbenaceae	S	Vulnerable
<i>Clerodendrum hastatum</i> Lindl.	Verbenaceae	S	Endangered
<i>Clerodendrum serratum</i> Moon.	Verbenaceae	S	Vulnerable
<i>Cocculus mollis</i> Hk.f. & Th.	Menispermaceae	S	Endemic & Rare
<i>Codonopsis javanica</i> Hk.f.	Campanulaceae	C	?
<i>Coldenia procumbens</i> L.	Boraginaceae	H	Rare
<i>Cordia dichotoma</i> Forst.f.	Boraginaceae	T	Very Rare
<i>Cordia fragrantissima</i> Kurz.	Boraginaceae	T	Very Rare
<i>Corylopsis himalayana</i> Griff.	Hamamelidaceae	S	Vulnerable
<i>Cretaeva nurvala</i> Buch. -Ham.	Capparaceae	T	Extremely Rare
<i>Croton tiglium</i> L.	Euphorbiaceae	T	Rare
<i>Curcuma angustifolia</i> Roxb.	Zingiberaceae	H	Near Threatened
<i>Curcuma montana</i> Roxb.	Zingiberaceae	H	Endemic & Rare
<i>Cymbidium aloifolium</i> Sw.	Orchidaceae	Ep	Endemic & Rare
<i>Cymbidium longifolium</i> D.Don.	Orchidaceae	Ep	Indeterminate
<i>Dalhousiea bracteata</i> Grah.	Fabaceae	S	Rare
<i>Daphniphyllum himalense</i> Muell.-Arg.	Daphniphyllaceae	T	Endangered & Endemic
<i>Dendrobium densiflorum</i> Wall.	Orchidaceae	Ep	Rare
<i>Dendrobium macraei</i> Lindl.	Orchidaceae	Ep	Vulnerable
<i>Dendrobium moschatum</i> Sw.	Orchidaceae	Ep	Indeterminate
<i>Dendrobium nobile</i> Lindl.	Orchidaceae	Ep	Endangered
<i>Diospyros pilosula</i> Hiren.	Ebenaceae	T	Extremely Rare
<i>Drosera peltata</i> Sm.	Droseraceae	H	Rare
<i>Elaegnus conferta</i> Roxb. ssp. <i>dendroidea</i> Servettaz.	Elaegnaceae	S	Endangered & Endemic
<i>Erythroxylum kunthianum</i> Wall.ex.Kurz.	Erythroxylaceae	T	Endemic & Rare
<i>Euonymus lawsonii</i> Cl. & Prain.	Celastraceae	T	Endemic & Rare

<i>Ficus microcarpa</i> L.f.	Moraceae	T	Very Rare
<i>Ficus sub-incisa</i> Buch.-Ham.ex.J.E.Sm.	Moraceae	S	Rare
<i>Fraxinus floribunda</i> Wall.	Oleaceae	T	Very Rare
<i>Garcinia cowa</i> Roxb.ex.DC.	Clusiaceae	T	Endemic & Rare
<i>Garcinia pedunculata</i> G.Don.	Clusiaceae	T	Endemic & Rare
<i>Gardenia campanulata</i> Roxb.	Rubiaceae	T	Very Rare
<i>Gloriosa superba</i> L.	Liliaceae	H	Endangered
<i>Goniothalamus simonsii</i> Hk.f. & Th.	Annonaceae		Indeterminate
<i>Grewia hirsuta</i> Vahl.	Tiliaceae	US	Endemic & Rare
<i>Hedera nepalensis</i> K.Koch.	Araliaceae	C	Vulnerable & Endemic
<i>Hedychium coronarium</i> Koenig.	Zingiberaceae	H	Endangered
<i>Hedychium spicatum</i> Ham.ex.Sm.	Zingiberaceae	H	Vulnerable
<i>Hedyotis scandens</i> D.Don.	Rubiaceae	S	?
<i>Helicia excelsa</i> Bl.	Proteaceae	T	Rare
<i>Heptapleurum hypoleucum</i> Kurz.	Araliaceae	T	?
<i>Holoptelea integrifolia</i> Planch.	Ulmaceae	T	Very Rare
<i>Hydnocarpus kurzii</i> Ward.	Flacoutiaceae	T	Vulnerable
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	T	Endemic & Rare
<i>Ichnocarpus frutescens</i> R.Br.	Apocyanaceae	H	Rare
<i>Ilex embeloides</i> Hk.f.	Aquifoliaceae	T	Endemic & Indeterminate
<i>Ilex khasiana</i> Purk.	Aquifoliaceae	T	Endangered & Endemic
<i>Illicium griffithii</i> Hk.f.& Th.	Magnoliaceae	T	Critically Endangered
<i>Impatiens tripetala</i> DC.	Balsaminaceae	H	Endemic & Rare
<i>Juglans regia</i> L.	Juglandaceae	T	?
<i>Luvunga scandens</i> Ham.	Rutaceae	S	Extremely Rare
<i>Mahonia pycnophylla</i> Takeda.	Berberidaceae	T	Vulnerable & Endemic
<i>Mimusops elengi</i> L.	Sapotaceae	T	Rare
<i>Mitrephora tomentosa</i> Hk.f.& Th.	Annonaceae	T	Rare
<i>Monotropa uniflora</i> L.	Monotropaceae	H	Rare
<i>Morinda umbellata</i> L.	Rubiaceae	S	Very Rare
<i>Munronia pinnata</i> Harms.	Meliaceae	H	Endemic & Rare
<i>Nepenthes khasiana</i> Hk.f.	Nepenthaceae	H	Endemic & Endangered
<i>Ochna squarrosa</i> Planet.	Ochanaceae	T	Vulnerable & Endemic
<i>Ophiorrhiza sub-capitata</i> Wall.ex.Hk.f.	Rubiaceae	H	E & En
<i>Oroxylum indicum</i> Vent.	Bignoniaceae	T	Vulnerable
<i>Osbeckia capitata</i> Benth.	Melastomataceae	H	Endemic & Rare
<i>Panax pseudo-ginseng</i> Wall.	Araliaceae	H	Rare
<i>Paphiopedilum insigne</i> Pfitz.	Orchidaceae	Te	Vu
<i>Paramignya micrantha</i> Kurz.	Rutaceae	L	Endemic & Rare
<i>Parkia roxburghii</i> A.DC.	Mimosaceae	T	Rare
<i>Picrasma javanica</i> Bl.	Simaroubaceae	T	Very Rare
<i>Piper boehmeriaefolium</i> Wall.ex.C.DC.	Piperaceae	S	Near Threatened
<i>Piper griffithii</i> C.DC.	Piperaceae	C	Endemic & Rare
<i>Piper peepuloides</i> Roxb.	Piperaceae	C	Vulnerable & Endemic
<i>Polygonum bistorta</i> L.	Polygonaceae	H	Endemic & Rare
<i>Pterygota alata</i> R.Br.	Sterculiaceae	T	Very Rare

<i>Raphidophora decursiva</i> Schott.	Araceae	Ep	Endemic & Rare
<i>Rauvolfia serpentina</i> Benth.ex.Kurz.	Apocyanaceae	H	Endangered
<i>Rhynchosstylis retusa</i> Bl.	Orchidaceae	Ep	Indeterminate
<i>Salix tetrasperma</i> Roxb.	Salicaceae	T	Vulnerable
<i>Saraca asoca</i> Willd.	Caesalpinaceae	T	Rare
<i>Schima khasiana</i> Dyer.	Theaceae	T	Endemic & Rare
<i>Schleichera trijuga</i> Willd.	Sapindaceae	T	?
<i>Smilacina fusca</i> Hk.f.	Liliaceae	H	Indeterminate
<i>Sophora accuminata</i> Baker.	Fabaceae	S	Endemic & Rare
<i>Stemona tuberosa</i> Lour.	Stemonaceae	H	Extremely Rare
<i>Sterculia roxburghii</i> Wall.	Sterculiaceae	T	Rare
<i>Streblus asper</i> Lour.	Moraceae	T	Rare
<i>Swertia chirayita</i> Karst.	Gentianaceae	H	Vulnerable
<i>Taxus wallichiana</i> Zucc.	Taxaceae	T	Critically Endangered
<i>Thalictrum foliolosum</i> DC.	Ranunculaceae	H	Vulnerable
<i>Thunbergia coccinea</i> Wall.	Acanthaceae	C	Rare
<i>Valeriana hardwickii</i> Wall.	Valerianaceae	H	Vulnerable
<i>Valeriana jatamansii</i> Jones.	Valerianaceae	H	Vulnerable
<i>Wallichia densiflora</i> Mart.	Arecaceae	T	?
<i>Xylia xylocarpa</i> Taub.	Mimosaceae	T	Rare
<i>Xylosma longifolium</i> Clos.	Flacourtiaceae	T	Rare

* T = Tree, S = Shrub, H = Herb, C = Climber, L = Liana, US = Undershrub, Te = Terrestrial, Ep = Epiphyte.

Curriculum vitae

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Educational Qualification:

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SSLC	1995	Meghalaya Board of Secondary Education	Second	58.00
HSSLC	1997	Meghalaya Board of Secondary Education	Second	59.22
B.Sc	2000	North Eastern Hill University	First	63.63
M.Sc	2002	North Eastern Hill University	Second	58.89

CSIR-UGC NET: Yes

*Title of PhD Thesis: "Assessment of Endemism, Rarity and Conservation Status of a few Medicinal Plant Species of Meghalaya".

M.Sc. Specialization: Angiosperm Taxonomy

Seminar/Symposium attended:

- ✦ International symposium on "**Recent Trends in Plant Ecology and Biodiversity Research**" organized by Department of Botany, NEHU, Shillong, 20th - 22nd May, 2004.
- ✦ National symposium on "**Issues and Challenges for Conservation of Plants and Ecosystems in India**" organized by Department of Botany, NEHU, Shillong, 2nd - 3rd November, 2006.
- ✦ The 96th "**Indian Science Congress Association**" (ISCA) organized by NEHU, Shillong, 2nd - 5th January, 2009.

Papers Published


- ✦ Lakadong, N.J. and Barik, S.K. (2006). Diversity and Distribution of Endemic plants in Meghalaya. In: Pandey, H.N. and Barik, S.K. (eds.) '*Ecology, Diversity and Conservation of Plants and Ecosystems in India.*' Regency Publications, New Delhi, pp.274-311.
- ✦ Barik, S.K., Haridasan, K. and Lakadong, N.J. 2007. Medicinal plant resources of Meghalaya: Endemism, Threat status and Consumption pattern. ENVIS Forestry Bulletin. 7(2): 17-26.
- ✦ Barik, S.K., Lakadong, N.J., Baishya, R., Chettri, A., Das, P., Kayang, H., Marbaniang, D. A new report of *Monotropia hypopitys* L., a myco-heterotrophic plant from India. Journal of Bombay Natural History Society (communicated).

DECLARATION

I declare that the above information is true and correct to the best of my knowledge and belief.

Place: Shillong

Date: 29/11/09


(Nigyal John Lakadong)
Signature of the Candidate

flora. Due to high level of exploitation and faulty harvesting techniques, many of the endemic species have been rendered rare (Haridasan *et al.*, 1995). The growth of human population, loss of traditional values, and change in culture and plant use patterns are some of the main reasons for pushing many of these species into the verge of extinction (Maikhuri and Gangwar, 1993). The Red Data Book of India (Jain and Shastry, 1984; Nayar and Shastry, 1987–90) has listed 623 threatened categories of species, of which 550 are endemic.

The endemism among the plants continues to be a neglected area of research world-wide (UNEP, 1997). In Meghalaya, very few studies are available on endemic plant species. The family Orchidaceae comprises the largest number of endemic species in the Khasi Hills of Meghalaya (Hooker, 1854). Of the approximately 1000 orchid species found in India, 625 species are found in northeast India. Of these, 85 are endemic to the region and 18 are endemic to Meghalaya (Das and Deori, 1983). Kumar (1988–89) recorded 111 rare plants from Balphakram Wildlife Sanctuary, of which 55 were endemic. Rao and Haridasan (1982) provided the information on 70 rare, endangered and endemic plants of the state. Khan *et al.* (1997) provided a list of 96 species endemic to Meghalaya.

Study Sites and Methodology

The study covers the entire state of Meghalaya. The state of Meghalaya lies between 25°47' and 20°10' N latitudes and 89°45' and 92°47' E longitudes covering an area of 22,549 km². Repeated field visits were undertaken in all the seven districts viz., East Khasi Hills, West Khasi Hills, Ri-Bhoi, Jaintia Hills, East Garo Hills, West Garo Hills and South Garo Hills, during the years 2003, 2004 and 2005.

Two hundred and thirty nine endemic plant species were short-listed for detailed study. The endemic status of these species was confirmed following the available flora and other literature (Kanjal *et al.*, 1934–40; Haridasan and Rao, 1985–87; Balakrishnan, 1981–83; Nayar and Shastry, 1988–90). Through field observations, their habits and distribution pattern at different elevations of Meghalaya were studied. The uses of these species were documented based on the interactions with the villagers and also referring to the available literature.

Diversity and Distribution of Endemic Plant Species of Meghalaya, India

N.J. Lakadong and S.K. Barik

ABSTRACT

The state of Meghalaya in north-east India is rich in endemic plant species. The diversity, habitat, habit and ecological distribution of endemic plant species have been studied in this paper. The medicinal and ethnobotanical importances of these species have also been enumerated. The distribution of 239 endemic plant species in different ecological zones of Meghalaya has been described and based on GPS readings, 15 centres of endemism have been identified and mapped. Considering the restricted distributional range of the endemics and their importance in conservation biology, these identified centres of endemism have been recommended for conservation.

Key words: Diversity, distribution, endemic species, centre of endemism.

Introduction

The concept of endemism is useful in qualifying the biological uniqueness of an area (Peterson and Watson, 1998). Endemism is a term applied to species restricted to a particular geographic region or ecological unit. Plants can be endemic to geographic areas, such as mountain peaks, mountain ranges, river basins and watersheds or to political boundaries, such as parks, reserves, states and countries. Plants are also endemic to specific habitats, such as soils and rock types. Because of their unique status in a given flora, endemic species have now become an important concept in conservation biology (Shevock, 1996).

Of the 17,000 plant species found in India, about 5725 species are considered as endemics. These represent 33.5% of the country's

Mapping

A grid map of the state was used for mapping the distribution of all the 239 species based on the GPS readings. Finally, based on the availability of endemic species in different areas, areas of concentration of endemics were identified and were shown on the map.

Results

Habit of the endemic plant species

The geographical ranges and altitudinal distribution of 239 endemic plant species are given in Table 1. The habit-wise distribution of these endemic plant species reveals that maximum numbers of endemics are herbs (36%), followed by trees (27%) and shrubs (25%). Only 8% of the species are lianas and climbers, and 4% are under-shrubs (Fig. 1).

Taxonomic diversity of the endemics

The endemic plant species covered under the study belonged to 178 genera and 79 families with Poaceae (22 genera and 33 species) having the highest number of endemics followed by Orchidaceae (14 genera and 17 species) and Rubiaceae (11 genera and 13 species) (Fig. 2).

Ecological distribution of the endemics

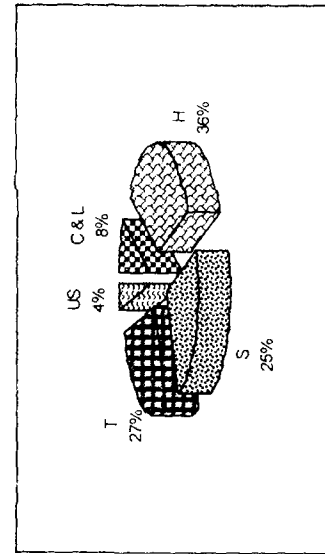


Fig. 1. Habit-wise distribution of endemic plant species of Meghalaya. T: Trees, S: Shrubs, H: Herbs, C & L: Climbers and Lianas, US: Under-shrubs

Table 1. Distribution of the endemic plant species at different altitudinal zones of the state

Species	Family	Habit	Distribution
<i>Ascymanthus sikkimensis</i> Stapf	Gesneriaceae	Ep	Temperate & Sub Himalayas, NE India, Meghalaya
<i>Ascymanthus superba</i> Cl.	Gesneriaceae	US	NE India
<i>Ascymanthus nannii</i> Kurz.	Gesneriaceae	H	NE India
<i>Ascymanthus parasitica</i> Cl.	Gesneriaceae	US	Eastern Himalayas, Meghalaya
<i>Agapetes obovata</i> Hk. f.	Vacciniaceae	S	Meghalaya
<i>Anacloesa ilicoides</i> Mast.	Claccaceae	T	Meghalaya
<i>Ardisia griffithii</i> Cl.	Mysminaceae	T	Meghalaya
<i>Arva nagenensis</i> Griff.	Areaceae	T	NE India
<i>Argostemma khasiana</i> Cl.	Rubiaceae	H	Meghalaya
<i>Argostemma rostratum</i> Wall.	Rubiaceae	H	Meghalaya
<i>Arisaema album</i> N.E. Br.	Araceae	H	NE India
<i>Arinobotrys condatus</i> Wall.	Ammonaceae	L	Meghalaya
ex. Hk. f. & Th.			
<i>Arundinella intricata</i> Hughes.	Poaceae	H	NE India
<i>Aspidopterys elliptica</i> A. Juss.	Malpighiaceae	L	NE India
<i>Aspidopterys oxyphylla</i> A. Juss.	Malpighiaceae	C	Meghalaya
<i>Bambusa mastersii</i> Munro.	Poaceae	T	NE India
<i>Begonia rubrovenia</i> Hk.	Begoniaceae	H	Sikkim, Bhutan, India
<i>Ascymanthus sikkimensis</i>	Gesneriaceae	Ep	Temperate & Sub Himalayas, NE India, Meghalaya
<i>Ascymanthus superba</i>	Gesneriaceae	US	NE India
<i>Ascymanthus nannii</i>	Gesneriaceae	H	NE India
<i>Ascymanthus parasitica</i>	Gesneriaceae	US	Eastern Himalayas, Meghalaya
<i>Agapetes obovata</i>	Vacciniaceae	S	Meghalaya
<i>Anacloesa ilicoides</i>	Claccaceae	T	Meghalaya
<i>Ardisia griffithii</i>	Mysminaceae	T	Meghalaya
<i>Arva nagenensis</i>	Areaceae	T	NE India
<i>Argostemma khasiana</i>	Rubiaceae	H	Meghalaya
<i>Argostemma rostratum</i>	Rubiaceae	H	Meghalaya
<i>Arisaema album</i>	Araceae	H	NE India
<i>Arinobotrys condatus</i>	Ammonaceae	L	Meghalaya
ex. Hk. f. & Th.			
<i>Arundinella intricata</i>	Poaceae	H	NE India
<i>Aspidopterys elliptica</i>	Malpighiaceae	L	NE India
<i>Aspidopterys oxyphylla</i>	Malpighiaceae	C	Meghalaya
<i>Bambusa mastersii</i>	Poaceae	T	NE India
<i>Begonia rubrovenia</i>	Begoniaceae	H	Sikkim, Bhutan, India

Species Family Habit Distribution

Boehmeria macrophylla D. Don.	Urticaceae	T	Subtropical Himalayas, Meghalaya
Calamus erectus Roxb.	Areaceae	S	Meghalaya
Calamus floribundus Gntl.	Areaceae	C	NE India
Callandra griffithii Benth.	Mimosaceae	S	Meghalaya
Cardiophora lobata Wall. ex R.Br.	Cardiophoraceae	H	NE India
Chirita hamosa R.Br.	Gesneriaceae	H	Indo-Malaya, Western Ghats, NE India
Citrus aurantium L.	Rutaceae	T	Dehradun, Garwal, Kumaon, Sikkim, Khasi and Garo Hills, Manipur, Montane forests of peninsular India
Citrus latipes Tanaka.	Rutaceae	T	Meghalaya
Citrus medica L.	Rutaceae	S	Kumaon, Pachmarhi, Nokrek, Umjaisaw-Mynsngal, Rahaug, Umjaisaw-Mynsngal
Coelogyne purpurea Joseph. & Vog.	Orchidaceae	Ep	India, Malaya, Thailand, Western Ghats, Upper Yan Yanzalm, Caro Hills, Chittagong, Sikkim, Khasi and

Coffea parkurii Hk.f.	Rubiaceae	S	Meghalaya (Khasi Hills), Burma, Bhutan, Nepal, Umsung, Nongpoh, Bumhat
Cymbidium mastersonii Lindl.	Orchidaceae	Ep	NE India, Sikkim, Bhutan, Thailand
Cymbopogon khasianus Stapf.	Poaceae	H	NE India
Cyanidium rostratum Wt.	Asclepiadaceae	H	Meghalaya
Didymocarpus razi Kurz.	Gesneriaceae	S	Meghalaya
Diplomertis pulchella D. Don.	Orchidaceae	Ep	India (Assam), Meghalaya, Burma
Dipsacus asper DC.	Rubiaceae	H	Meghalaya
Dorynia hookeriana Decne.	Rosaceae	T	Meghalaya
Elaeagnus conferta Roxb.	Elaeagnaceae	S	Indo-Malaya, Himalayas, South India
Elaeocarpus lucidus Roxb.	Elaeocarpaceae	T	India (E, NE, W, S), West Bengal, Assam, Meghalaya, Andhra Pradesh
Elaeocarpaceae	Elaeocarpaceae	T	Meghalaya, Manipur
Engrostiella leptoptera Bor.	Poaceae	H	NE India
Eria tomentosa Hk.f.	Orchidaceae	Ep	Meghalaya, Bangladesh, Burma
Eriobotrya angustissima Hk.f.	Rosaceae	S	Meghalaya
Eriocaulon cristatum Mast.	Eriocaulaceae	H	NE India
Eriocaulon chinhatum Mart.	Eriocaulaceae	H	Meghalaya, Burma, China
Galium floribundus Gntl.	Areaceae	S	Sikkim, NE India
Galium erectus Roxb.	Areaceae	S	Meghalaya
Callandra griffithii Benth.	Mimosaceae	S	Meghalaya
Cardiophora lobata Wall. ex R.Br.	Cardiophoraceae	H	NE India
Chirita hamosa R.Br.	Gesneriaceae	H	Indo-Malaya, Western Ghats, NE India
Citrus aurantium L.	Rutaceae	T	Dehradun, Garwal, Kumaon, Sikkim, Khasi and Garo Hills, Manipur, Montane forests of peninsular India
Citrus latipes Tanaka.	Rutaceae	T	Meghalaya
Citrus medica L.	Rutaceae	S	Kumaon, Pachmarhi, Nokrek, Umjaisaw-Mynsngal, Rahaug, Umjaisaw-Mynsngal
Coelogyne purpurea Joseph. & Vog.	Orchidaceae	Ep	India, Malaya, Thailand, Western Ghats, Upper Yan Yanzalm, Caro Hills, Chittagong, Sikkim, Khasi and
Cyanidium rostratum Wt.	Asclepiadaceae	H	Meghalaya
Didymocarpus razi Kurz.	Gesneriaceae	S	Meghalaya
Diplomertis pulchella D. Don.	Orchidaceae	Ep	India (Assam), Meghalaya, Burma
Dipsacus asper DC.	Rubiaceae	H	Meghalaya
Dorynia hookeriana Decne.	Rosaceae	T	Meghalaya
Elaeagnus conferta Roxb.	Elaeagnaceae	S	Indo-Malaya, Himalayas, South India
Elaeocarpus lucidus Roxb.	Elaeocarpaceae	T	India (E, NE, W, S), West Bengal, Assam, Meghalaya, Andhra Pradesh
Elaeocarpaceae	Elaeocarpaceae	T	Meghalaya, Manipur
Engrostiella leptoptera Bor.	Poaceae	H	NE India
Eria tomentosa Hk.f.	Orchidaceae	Ep	Meghalaya, Bangladesh, Burma
Eriobotrya angustissima Hk.f.	Rosaceae	S	Meghalaya
Eriocaulon cristatum Mast.	Eriocaulaceae	H	NE India
Eriocaulon chinhatum Mart.	Eriocaulaceae	H	Meghalaya, Burma, China

Species	Family	Habit	Distribution
<i>Fissistigma verrucosum</i> Merr.	Annonaceae	S	NE India, Meghalaya
<i>Garwinia corna</i> Roxb. ex DC.	Clusiaceae	T	Indo-Malaya, NE India
<i>Garwinia pedunculata</i> G. Don.	Clusiaceae	T	Indo-Burma, NE India
<i>Castrodia exilis</i> H.K.F.	Orchidaceae	Tg	Meghalaya
<i>Clopidium acuminatum</i>	Euphorbiaceae	T	Eastern Himalayas, Nongkhyllem, Amree, Balphakram, Shillong, Joksai, Rahaang
<i>Clopidium thomsonii</i> H.K.F.	Euphorbiaceae	T	Bangladesh, NE India, Nongkhyllem, Amree, Balphakram, Shillong, Joksai, Rahaang
<i>Goldfussia glabrata</i> Balak.	Acanthaceae	S	Meghalaya
<i>Gomphostemma lucidum</i> Wall. ex. Benth.	Lamiaceae	US	Meghalaya
<i>Gonolobium simonsii</i> H.K.F. & Th.	Annonaceae	T	Meghalaya
<i>Grisea hirsuta</i> Vahl.	Tiliaceae	US	India, Sri-Lanka, Balphakram
<i>Gymnosporia acuminata</i> Laws.	Celastraceae	T	Indo-Malaya, NE India
<i>Habenaria khasiana</i> H.K.F.	Orchidaceae	Ep	Thailand, India
<i>Haplage acuminata</i> Wall. ex H.K.F.	Malpigiaceae	S	NE India
<i>Hymenanchina assamica</i> Hitchc.	Poaceae	H	NE India
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	T	Indo-Malaya
<i>Ilex embeloides</i> H.K.F.	Aquifoliaceae	T	Meghalaya
<i>Impatiens acuminata</i> H.K.F. & Th.	Balsaminaceae	S	Meghalaya
<i>Impatiens furcata</i> H.K.F. & Th.	Balsaminaceae	H	NE India
<i>Impatiens laevigata</i> H.K.F.	Balsaminaceae	H	Meghalaya
<i>Impatiens tripetala</i> DC.	Balsaminaceae	H	NE India
<i>Isachne clarkii</i> H.K.F.	Poaceae	H	NE India
<i>Isoetes hirtum</i> Hack.	Poaceae	H	Bengal, Bihar, Khasi Hills, NE India
<i>Ixonanthes khasiana</i> H.K.F.	Ixonanthaceae	T	Indo-Malaya
<i>Jasminum listeri</i> Cager.	Oleaceae	S	NE India
<i>Lasiacanthus hookeri</i> Cl. ex H.K.F.	Rubiaceae	S	Meghalaya
<i>Lasiacanthus tubiflorus</i> H.K.F.	Rubiaceae	S	Meghalaya
<i>Lasiocema scandens</i> de Wit.	Caesalpiniaceae	L	Indo-Malaya, Western Ghats, NE India
<i>Latisa inconspicua</i> King. & Pantl.	Orchidaceae	Ep	Assam, NE India
<i>Melastoma pindana</i> H.K.F. & Th.	Magnoliaceae	T	Sikkim, Meghalaya
<i>Millettia caudata</i> Baker.	Fabaceae	S	NE India, Bangladesh
<i>Monrovia pinnata</i> Harms.	Meliaceae	US	Eastern Himalayas, NE India, Nilgiris
<i>Ocimum squarrosa</i> L.	Ochnaceae	T	Burma, Andamans, India, Nilgiris
<i>Ocbeckia capitata</i> Benth.	Melastoma-aceae	H	Meghalaya
<i>Panicum khasianum</i> Munro. ex H.K.	Poaceae	H	East and NE India

Species	Family	Habit	Distribution
<i>Along, Rahaang, Shangdam, Nokrek</i>			
<i>Nokrek, Bagmara</i>			
<i>Sokha</i>			
<i>Nongkhyllem, Amree</i>			
<i>Balphakram, Shillong, Joksai, Rahaang</i>			
<i>NE India</i>			
<i>Bangladesh, NE India</i>			
<i>India, Sri-Lanka, Balphakram</i>			
<i>Syndal, Jura</i>			
<i>Gymnosporia acuminata</i> Laws.	Celastraceae	T	Indo-Malaya, NE India
<i>Habenaria khasiana</i> H.K.F.	Orchidaceae	Ep	Thailand, India
<i>Haplage acuminata</i> Wall. ex H.K.F.	Malpigiaceae	S	NE India
<i>Hymenanchina assamica</i> Hitchc.	Poaceae	H	NE India
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	T	Indo-Malaya
<i>Ilex embeloides</i> H.K.F.	Aquifoliaceae	T	Meghalaya
<i>Impatiens acuminata</i> H.K.F. & Th.	Balsaminaceae	S	Meghalaya
<i>Impatiens furcata</i> H.K.F. & Th.	Balsaminaceae	H	NE India
<i>Impatiens laevigata</i> H.K.F.	Balsaminaceae	H	Meghalaya
<i>Impatiens tripetala</i> DC.	Balsaminaceae	H	NE India
<i>Isachne clarkii</i> H.K.F.	Poaceae	H	NE India
<i>Isoetes hirtum</i> Hack.	Poaceae	H	Bengal, Bihar, Khasi Hills, NE India
<i>Ixonanthes khasiana</i> H.K.F.	Ixonanthaceae	T	Indo-Malaya
<i>Jasminum listeri</i> Cager.	Oleaceae	S	NE India
<i>Lasiacanthus hookeri</i> Cl. ex H.K.F.	Rubiaceae	S	Meghalaya
<i>Lasiacanthus tubiflorus</i> H.K.F.	Rubiaceae	S	Meghalaya
<i>Lasiocema scandens</i> de Wit.	Caesalpiniaceae	L	Indo-Malaya, Western Ghats, NE India
<i>Latisa inconspicua</i> King. & Pantl.	Orchidaceae	Ep	Assam, NE India
<i>Melastoma pindana</i> H.K.F. & Th.	Magnoliaceae	T	Sikkim, Meghalaya
<i>Millettia caudata</i> Baker.	Fabaceae	S	NE India, Bangladesh
<i>Monrovia pinnata</i> Harms.	Meliaceae	US	Eastern Himalayas, NE India, Nilgiris
<i>Ocimum squarrosa</i> L.	Ochnaceae	T	Burma, Andamans, India, Nilgiris
<i>Ocbeckia capitata</i> Benth.	Melastoma-aceae	H	Meghalaya
<i>Panicum khasianum</i> Munro. ex H.K.	Poaceae	H	East and NE India

Worldwide
Meghalaya

Table 1 ... contd.

Species	Family	Habit	Distribution
<i>Paritia sub-capitata</i> H.K.T. Heuvelink	Rubiaceae	S	NE India
<i>Veristylis mauii</i> Mukh.	Orchidaceae	Tr	NE India (Meghalaya)
<i>Phanera khasiana</i> (Thob.) Nees	Caesalpinaceae	L	NE India (Meghalaya)
<i>Phlogacanthus guttatus</i> Nees	Acanthaceae	US	Eastern & Sub Himalayas, NE India
<i>Phlogacanthus wallii</i> C.L. Hitchc.	Acanthaceae	S	Meghalaya
<i>Phloxantha integrifolia</i> Lindl.	Rosaceae	T	Himalayas
<i>Phyllanthus longiflorus</i> Heuvelink	Euphorbiaceae	H	NE & South India
<i>Phyllanthus obovatus</i> Sch. Benth.	Orchidaceae	Tr	NE India
<i>Piper griffithii</i> C.L.C.	Piperaceae	C	NE India, Meghalaya
<i>Piper pectinoides</i> Roxb.	Piperaceae	C	Tropical Himalayas, NE India, Bangladesh, Nepal
<i>Pogostemon strigosus</i> Benth.	Lamiaceae	H	Meghalaya
<i>Polygonum bistorta</i> L.	Polygonaceae	H	Meghalaya
<i>Porana racemosa</i> Roxb.	Convolvulaceae	C	Subtropical Himalayas-Burma
<i>Psidium guajava</i> L.	Rubiaceae	S	Sub-Himalayas, NE India
<i>Pterocarpus densitatus</i> Brenck. Brenck.	Acanthaceae	S	NE India
<i>Rubus khasianus</i> Cardot.	Rosaceae	S	Meghalaya
<i>Schizostachyum dullooa</i> Majumdar	Poaceae	H	NE India
<i>Schizostachyum pallidum</i> Majumdar	Poaceae	H	NE India
<i>Schizostachyum polyanthum</i> Majumdar	Poaceae	H	NE India
<i>Sopora acuminata</i> Baker.	Fabaceae	S	Eastern Himalayas, Bangladesh, Burma
<i>Suaeda macrophylla</i> Sojak	Celastraceae	T	Indo-Malaya, Himalayas
<i>Taphochlamys affinis</i> Brenck.	Acanthaceae	US	Meghalaya
<i>Titchaea pygmaea</i> Lindl.	Orchidaceae	Ep	Eastern Himalayas, NE India
<i>Tritanetaria kanyifatu</i> D. Das	Amnaceae	S	Meghalaya
<i>Tupidanthus calyptratus</i> H.K.T. & Th.	Arabiaceae	T	Meghalaya
<i>Tylophora bestemma</i> Benth.	Asclepiadaceae	H	Meghalaya (Khasi Hills), Nepal
<i>Urena lueta</i> H.K.T. & Th.	Amnaceae	L	Meghalaya
<i>Xylin dolabriformis</i> Taub.	Mimosaceae	T	Indo-Malaya
Subtropical region (900-1800 m a.s.l.)			
<i>Acer cappadocicum</i> Gleitsch	Aceraceae	T	SE Asia-Malaya, Himalayas, Meghalaya
<i>Acer laevigatum</i> Wall.	Aceraceae	T	Temperate Himalayas, Sikkim, Meghalaya
<i>Paritia sub-capitata</i> H.K.T. & Th.	Rubiaceae	S	NE India
<i>Phloxantha integrifolia</i> Lindl.	Rosaceae	T	Himalayas
<i>Phyllanthus longiflorus</i> Heuvelink	Euphorbiaceae	H	NE & South India
<i>Phyllanthus obovatus</i> Sch. Benth.	Orchidaceae	Tr	NE India
<i>Piper griffithii</i> C.L.C.	Piperaceae	C	NE India, Meghalaya
<i>Piper pectinoides</i> Roxb.	Piperaceae	C	Tropical Himalayas, NE India, Bangladesh, Nepal
<i>Pogostemon strigosus</i> Benth.	Lamiaceae	H	Meghalaya
<i>Polygonum bistorta</i> L.	Polygonaceae	H	Meghalaya
<i>Porana racemosa</i> Roxb.	Convolvulaceae	C	Subtropical Himalayas-Burma
<i>Psidium guajava</i> L.	Rubiaceae	S	Sub-Himalayas, NE India
<i>Pterocarpus densitatus</i> Brenck. Brenck.	Acanthaceae	S	NE India
<i>Rubus khasianus</i> Cardot.	Rosaceae	S	Meghalaya
<i>Schizostachyum dullooa</i> Majumdar	Poaceae	H	NE India
<i>Schizostachyum pallidum</i> Majumdar	Poaceae	H	NE India
<i>Schizostachyum polyanthum</i> Majumdar	Poaceae	H	NE India
<i>Sopora acuminata</i> Baker.	Fabaceae	S	Eastern Himalayas, Bangladesh, Burma
<i>Suaeda macrophylla</i> Sojak	Celastraceae	T	Indo-Malaya, Himalayas
<i>Taphochlamys affinis</i> Brenck.	Acanthaceae	US	Meghalaya
<i>Titchaea pygmaea</i> Lindl.	Orchidaceae	Ep	Eastern Himalayas, NE India
<i>Tritanetaria kanyifatu</i> D. Das	Amnaceae	S	Meghalaya
<i>Tupidanthus calyptratus</i> H.K.T. & Th.	Arabiaceae	T	Meghalaya
<i>Tylophora bestemma</i> Benth.	Asclepiadaceae	H	Meghalaya (Khasi Hills), Nepal
<i>Urena lueta</i> H.K.T. & Th.	Amnaceae	L	Meghalaya
<i>Xylin dolabriformis</i> Taub.	Mimosaceae	T	Indo-Malaya
<i>Acer laevigatum</i> Wall.	Aceraceae	T	SE Asia-Malaya, Himalayas, Meghalaya
<i>Acer cappadocicum</i> Gleitsch	Aceraceae	T	Temperate Himalayas, Sikkim, Meghalaya
Worldwide			
			Meghalaya

Table 1 ... contd.

Species	Family	Habit	Distribution
<i>Adiantum griffithii</i> Dyer.	Theaceae	T	Meghalaya
<i>Achimanthus leiosperma</i> Cl.	Acanthaceae	S	Meghalaya
<i>Aschymanthus sikkimensis</i> Stapf.	Cesneriaceae	Ep	Temperate & Sub Himalayas, NE India, Jaisal, Jaram, Shillong, Nokrek
<i>Aschymanthus superba</i> Cl.	Cesneriaceae	US	NE India
<i>Aschymanthus parasitica</i> Cl.	Cesneriaceae	US	Eastern Himalayas, Jowai, Rahaing, Laskem, Mynso, Sohka, Nokrek Mawsmat, Nokrek, Jaram, Jowai, Shangpung, Jalong, Balphakram
<i>Agaptis aborata</i> H.K.f.	Vacciniaceae	S	Meghalaya
<i>Agrostis filipes</i> H.K.	Poaceae	H	Himalayas
<i>Agrostis griffithiana</i> Bor.	Poaceae	H	NE India
<i>Agrostis myriantha</i> H.K.	Poaceae	H	India
<i>Aleodaphne khasiana</i> Kosterm.	Lauraceae	T	Meghalaya
<i>Anacostia ilicoides</i> Mast.	Oleaceae	T	Meghalaya
<i>Aphyllorchis vaginata</i> H.K.f.	Ochridaceae	Tg	Meghalaya (Khasi Hills)
<i>Apos carnea</i> Benth.	Fabaceae	C	Meghalaya
<i>Amia thomsonii</i> Seem.	Araliaceae	T	Eastern Himalayas, Shillong, Nokrek
<i>Ardisia griffithii</i> Cl.	Myrsinaceae	T	Meghalaya
<i>Argostemma khasiana</i> Cl.	Rubiaceae	H	Meghalaya
<i>Arundinaria hirsuta</i> Munro.	Poaceae	S	NE India
<i>Arundinaria manni</i> Gamble.	Poaceae	S	Meghalaya
<i>Barapani, Umtraw</i>			
<i>Barapani, Mawphlang, Shillong, Upper Shillong</i>			
<i>Balphakram, Dawki, Syndai</i>			
<i>Jalong, Rahaing, Jowai, Shillong, Mynso, Nokrek</i>			
<i>Rongling, Jowai, Sohka, Jalong</i>			
<i>Pymsia</i>			
<i>Jengal, Linsaw</i>			
<i>Mawmuh</i>			
<i>Shillong, Nokrek</i>			
<i>Upper Shillong</i>			
<i>Barapani, Mairang, Shillong Peak, Upper Shillong</i>			
<i>Dynpep, Shillong Peak, Upper Shillong</i>			
<i>Peak</i>			
<i>Cherrapunjee, Latlyngkot, Mawdok, Shillong</i>			
<i>Mawsmat, Dawki</i>			
<i>Jalong, Balphakram</i>			
<i>Mawsmat, Nokrek, Jaram, Jowai, Shangpung,</i>			
<i>Jowai, Rahaing, Laskem, Mynso, Sohka, Nokrek</i>			
<i>Shangpung</i>			
<i>Jowai</i>			
<i>Jalong, Rahaing, Jaram, Shillong, Nokrek</i>			

Table 1 ... contd.

Species	Family	Habit	Distribution
<i>Arundinella mitrata</i> Hughes.	Poaceae	H	NE India
<i>Aspidopteryx elliptica</i> A.Juss.	Malpighiaceae	L	NE India
<i>Baliospermum micranthum</i> Muell.-Arg.	Euphorbiaceae	T	Meghalaya
<i>Begonia rubroca</i> H.K.	Begoniaceae	H	Sikkim, Bhutan, India
<i>Berchemia floribunda</i> Brongn.	Rhamnaceae	S	Tropical & Sub Himalayas
<i>Boehmeria macrophylla</i> D.Don.	Urticaceae	T	Subtropical Himalayas, Meghalaya
<i>Boehmeria siduifolia</i> Wedd.	Urticaceae	T	Himalayas (Nepal-Bhutan), Assam, North Burma, Indo-China, West China, Malaysia
<i>Bulbophyllum griffithii</i> Reich.	Ochridaceae	Ep	Sikkim, NE India
<i>Calamus erectus</i> Roxb.	Araceae	S	Sikkim, NE India
<i>Calliandra floribunda</i> Griff.	Araceae	C	NE India
<i>Calliandra psilocalyx</i> Cl.	Mimosaceae	S	Meghalaya
<i>Camellia caduca</i> Brandis.	Verbenaceae	S	Meghalaya
<i>Capparis acutifolia</i> Sw.	Capparaceae	S	NE India
<i>Carex repanda</i> Cl.	Commelinaceae	H	Meghalaya
<i>Carpinus viminea</i> Wall.	Corylaceae	T	Temperate Himalayas & Burma
<i>Cropegia angustifolia</i> Wt. Ex. Lindl.	Asclepiadiaceae	S	Meghalaya
<i>Cropegia longifolia</i> Wall.	Asclepiadiaceae	C	Meghalaya
<i>Chimonobambusa callosa</i> Nakai.	Poaceae	S	NE India
<i>Cherrapunjee, Shillong</i>			
<i>Mawphlang</i>			
<i>Rahaing, Nokrek</i>			
<i>Cherrapunjee, Shillong</i>			
<i>Mawphlang</i>			
<i>Jaram, Garupani, Balphakram, Nokrek</i>			
<i>Jowai, Mawsynram, Jalong, Mawsmat,</i>			
<i>Jowai-Jaram, Jalong</i>			
<i>Syndai, Lintapoh</i>			
<i>Syndai, Rytang, Sohka-Dawki</i>			
<i>Lalad, Tringplem, Syndai, Sohka-Dawki</i>			
<i>Jalong, Nokrek, Jowai</i>			
<i>Burman, Indo-China, West</i>			
<i>Jalong, Rahaing, Mynsngat-Nartiang, Nokrek</i>			
<i>Nokrek, Jowai, Syndai-Muklapur</i>			
<i>Shillong, Jaram</i>			
<i>Dawki, Jaram, Syndai-Muklapur</i>			
<i>Mawsmat, Nokrek, Jowai</i>			
<i>Balphakram, Maheskola, Tura</i>			
<i>Pymsia, Latlyngkot</i>			
<i>Ponglung, Mawphlang, Shillong, Upper Shillong,</i>			
<i>Upper Shillong</i>			

contd.

Species	Family	Habit	Distribution
<i>Chimonobambusa griffithiana</i> Nakai	Poaceae	S	NE India
<i>Chimonobambusa khasiana</i> Nakai	Poaceae	H	Meghalaya
<i>Chimonobambusa polystricha</i> Nakai	Poaceae	S	Meghalaya
<i>Chimonobambusa paniculata</i> Nees	Lauraceae	T	NE India, Meghalaya
<i>Citrus tulipes</i> Tanaka	Rutaceae	T	Meghalaya
<i>Citrus medica</i> L.	Rutaceae	S	Kumaon, Pachmarhi, Nokrek, Umjaisaw-Mynsavgat, Nokrek, Umjaisaw-Mynsavgat
<i>Clematis apiculata</i> H.K.F. & Th.	Ranunculaceae	C	Meghalaya Western Ghats Upper YanTanZabin Valley, Sapura hills, Hills, Chittagong, Sikkim, Khasi & Garo
<i>Cleome grandiflora</i> H.K.F. & Th.	Theaceae	T	India (E & NE), West Bengal, Khasi Hills
<i>Coccoloba mollis</i> H.K.F. & Th.	Menispermaceae	S	Nepal, Meghalaya
<i>Codonopsis viridis</i> Wall.	Campanulaceae	H	Meghalaya (Khasi Hills)
<i>Coelogyne purpurea</i> Joseph	Orchidaceae	Ep	India, Malaya, Thailand
<i>Coelogyne viscosa</i> Rchb.f.	Orchidaceae	Ep	Meghalaya (Khasi Hills)
<i>Coffea jenkensis</i> H.K.F.	Rubiaceae	S	Meghalaya (Khasi Hills) Jowai
<i>Cornus montana</i> Roxb.	Orchidaceae	Ep	NE India, Konkani
<i>Cymbidium eburneum</i> Lindl.	Orchidaceae	Ep	NE India, Sikkim, Bhutan, Thailand
<i>Cymbidium mastersonii</i> Lindl.	Orchidaceae	Ep	NE India
<i>Cymbopogon khasianus</i> Stapf	Poaceae	H	NE India
<i>Gymnanthum deltoideum</i> H.K.F.	Asclepiadaceae	H	Meghalaya (Khasi Hills)
<i>Calamagrostis elatior</i> A. Camus	Poaceae	H	India
<i>Dalbergia volubilis</i> Roxb.	Fabaceae	L	Burma, Bangladesh, India
<i>Daphne shillong</i> Benth.	Thymelaeaceae	S	Sri Lanka, India
<i>Daphniphyllum himalayense</i> Muell.	Daphniphyll- aceae	T	Meghalaya
<i>Daphnum allissimum</i> Wall.	Ranunculaceae	H	Burma Eastern Himalayas
<i>Dendrocalamus sikkimensis</i> Camble, ex. H.K.	Poaceae	T	NE India Meghalaya (Nepal-Sikkim),
<i>Dicentra tornata</i> H.K.F. & Th.	Fumariaceae	H	Meghalaya
<i>Digitalis compacta</i> Veldk.	Poaceae	H	India
<i>Diplomerys pulchella</i> D. Don	Orchidaceae	Ep	India (Assamchat Pradesh, Meghalaya), Burma
<i>Dipsacus asper</i> DC.	Rubiaceae	H	Meghalaya

Table 1 ... contd.

Species	Family	Habit	Distribution
<i>Elephantopus</i>	Orchidaceae	Ep	Meghalaya
<i>Epiphanis</i>	Orchidaceae	Ep	Narayang Jowai
<i>Epiphanis</i>	Orchidaceae	Ep	NE India, Sikkim, Bhutan, Thailand
<i>Epiphanis</i>	Poaceae	H	NE India
<i>Gymnanthum deltoideum</i> H.K.F.	Asclepiadaceae	H	Meghalaya (Khasi Hills)
<i>Calamagrostis elatior</i> A. Camus	Poaceae	H	India
<i>Dalbergia volubilis</i> Roxb.	Fabaceae	L	Burma, Bangladesh, India
<i>Daphne shillong</i> Benth.	Thymelaeaceae	S	Sri Lanka, India
<i>Daphniphyllum himalayense</i> Muell.	Daphniphyll- aceae	T	Meghalaya
<i>Daphnum allissimum</i> Wall.	Ranunculaceae	H	Burma Eastern Himalayas
<i>Dendrocalamus sikkimensis</i> Camble, ex. H.K.	Poaceae	T	NE India Meghalaya (Nepal-Sikkim),
<i>Dicentra tornata</i> H.K.F. & Th.	Fumariaceae	H	Meghalaya
<i>Digitalis compacta</i> Veldk.	Poaceae	H	India
<i>Diplomerys pulchella</i> D. Don	Orchidaceae	Ep	India (Assamchat Pradesh, Meghalaya), Burma
<i>Dipsacus asper</i> DC.	Rubiaceae	H	Meghalaya

contd.

Species	Family	Habit	Distribution
<i>Panicum khasianum</i> Munro. ex. Hk.	Poaceae	H	East and NE India
<i>Paramignya micrantha</i> Kurz.	Rubiaceae	L	Meghalaya
<i>Paetia sub-capitata</i> Hk.f.	Rubiaceae	S	NE India
<i>Peristylis manii</i> Mukh.	Orchidaceae	Te	NE India (Meghalaya
<i>Persia purviflora</i> Haridasam. et. Rao	Lauraceae	T	Meghalaya
<i>Pharus fluvius</i> Lindl.	Orchidaceae	H	Assam, Nagaland, Sikkim, Meghalaya
<i>Phanera khasiana</i> Thoth.	Caesalpiniaceae	L	Meghalaya
<i>Phlogacanthus guttatus</i> Nees.	Acanthaceae	US	Eastern & Sub Himalayas, NE India
<i>Phlogacanthus walllichii</i> Cl.	Acanthaceae	S	Meghalaya
<i>Phlomis integrifolia</i> Balak.	Rosaceae	T	Meghalaya
<i>Phlomis polycarpa</i> Balak.	Rosaceae	T	Himalayas
<i>Phyllomphax obcordata</i> Sch.	Orchidaceae	Te	NE India
<i>Phyllostachys manii</i> Gamble.	Poaceae	H	NE India
<i>Picrasma quassoides</i> Lindl.	Simaroubaceae	S	Tropical SE Asia & Sub Himalayas
<i>Panicum khasianum</i> Munro. ex. Hk.	Poaceae	H	East and NE India
<i>Paramignya micrantha</i> Kurz.	Rubiaceae	L	Meghalaya
<i>Paetia sub-capitata</i> Hk.f.	Rubiaceae	S	NE India
<i>Peristylis manii</i> Mukh.	Orchidaceae	Te	NE India (Meghalaya
<i>Persia purviflora</i> Haridasam. et. Rao	Lauraceae	T	Meghalaya
<i>Pharus fluvius</i> Lindl.	Orchidaceae	H	Assam, Nagaland, Sikkim, Meghalaya
<i>Phanera khasiana</i> Thoth.	Caesalpiniaceae	L	Meghalaya
<i>Phlogacanthus guttatus</i> Nees.	Acanthaceae	US	Eastern & Sub Himalayas, NE India
<i>Phlogacanthus walllichii</i> Cl.	Acanthaceae	S	Meghalaya
<i>Phlomis integrifolia</i> Balak.	Rosaceae	T	Meghalaya
<i>Phlomis polycarpa</i> Balak.	Rosaceae	T	Himalayas
<i>Phyllomphax obcordata</i> Sch.	Orchidaceae	Te	NE India
<i>Phyllostachys manii</i> Gamble.	Poaceae	H	NE India
<i>Picrasma quassoides</i> Lindl.	Simaroubaceae	S	Tropical SE Asia & Sub Himalayas

Species	Family	Habit	Distribution
<i>Piper griffithii</i> C.D.C.	Piperaceae	C	NE India, Meghalaya
<i>Piper pectinoides</i> Roxb.	Piperaceae	C	Tropical Himalayas, NE India, Bangladesh,
<i>Ptilosperum humile</i> Hk.f. & Th.	Ptilosporaceae	S	Meghalaya
<i>Poa khasiana</i> Stapf.	Poaceae	H	India
<i>Pogonanthrum rufi- barbatum</i> Griff.	Poaceae	H	Meghalaya
<i>Pogostemon strigosus</i> Benham.	Lamiaceae	H	Meghalaya
<i>Polygonum bistorta</i> L.	Polygonaceae	S	Meghalaya (Khasi Hills)
<i>Poruna racemosa</i> Roxb.	Convolvulaceae	C	Subtropical Himalayas- Burma
<i>Prunus lenkiana</i> Hk.f.	Rosaceae	T	NE India, Meghalaya
<i>Pteracanthus nobilis</i> Bremk.	Acanthaceae	S	Meghalaya (Jaintia Hills)
<i>Pteracanthus rubescens</i> Bremk.	Acanthaceae	S	Meghalaya
<i>Pteracanthus trophyllus</i> Bremk.	Acanthaceae	S	Meghalaya
<i>Quercus glauca</i> Thunb.	Fagaceae	T	Subtropical Himalayas- Japan
<i>Rhaphidophora calophyllum</i> Schott.	Araceae	Ep	Sikkim Himalayas, Khasi Hills
<i>Panicum khasianum</i> Munro. ex. Hk.	Poaceae	H	East and NE India
<i>Paramignya micrantha</i> Kurz.	Rubiaceae	L	Meghalaya
<i>Paetia sub-capitata</i> Hk.f.	Rubiaceae	S	NE India
<i>Peristylis manii</i> Mukh.	Orchidaceae	Te	NE India (Meghalaya
<i>Persia purviflora</i> Haridasam. et. Rao	Lauraceae	T	Meghalaya
<i>Pharus fluvius</i> Lindl.	Orchidaceae	H	Assam, Nagaland, Sikkim, Meghalaya
<i>Phanera khasiana</i> Thoth.	Caesalpiniaceae	L	Meghalaya
<i>Phlogacanthus guttatus</i> Nees.	Acanthaceae	US	Eastern & Sub Himalayas, NE India
<i>Phlogacanthus walllichii</i> Cl.	Acanthaceae	S	Meghalaya
<i>Phlomis integrifolia</i> Balak.	Rosaceae	T	Meghalaya
<i>Phlomis polycarpa</i> Balak.	Rosaceae	T	Himalayas
<i>Phyllomphax obcordata</i> Sch.	Orchidaceae	Te	NE India
<i>Phyllostachys manii</i> Gamble.	Poaceae	H	NE India
<i>Picrasma quassoides</i> Lindl.	Simaroubaceae	S	Tropical SE Asia & Sub Himalayas
<i>Piper griffithii</i> C.D.C.	Piperaceae	C	NE India, Meghalaya
<i>Piper pectinoides</i> Roxb.	Piperaceae	C	Tropical Himalayas, NE India, Bangladesh,
<i>Ptilosperum humile</i> Hk.f. & Th.	Ptilosporaceae	S	Meghalaya
<i>Poa khasiana</i> Stapf.	Poaceae	H	India
<i>Pogonanthrum rufi- barbatum</i> Griff.	Poaceae	H	Meghalaya
<i>Pogostemon strigosus</i> Benham.	Lamiaceae	H	Meghalaya
<i>Polygonum bistorta</i> L.	Polygonaceae	S	Meghalaya (Khasi Hills)
<i>Poruna racemosa</i> Roxb.	Convolvulaceae	C	Subtropical Himalayas- Burma
<i>Prunus lenkiana</i> Hk.f.	Rosaceae	T	NE India, Meghalaya
<i>Pteracanthus nobilis</i> Bremk.	Acanthaceae	S	Meghalaya (Jaintia Hills)
<i>Pteracanthus rubescens</i> Bremk.	Acanthaceae	S	Meghalaya
<i>Pteracanthus trophyllus</i> Bremk.	Acanthaceae	S	Meghalaya
<i>Quercus glauca</i> Thunb.	Fagaceae	T	Subtropical Himalayas- Japan
<i>Rhaphidophora calophyllum</i> Schott.	Araceae	Ep	Sikkim Himalayas, Khasi Hills

Species	Family	Habit	Worldwide Distribution	Meghalaya Distribution
<i>Rhaphidophora decurva</i> Schott.	Araceae	Ep	Sikkim Himalayas,	Ialeng, Raliang, Nokrek, Jowai-Jaram
<i>Rhododendron fornosum</i> Wall.	Ericaceae	S	NE India	Jowai, Myntang valley, Jarem, Myrso
<i>Rubus assamensis</i> Focke.	Rosaceae	S	Burma, NE India	Ialeng, Raliang, Elephant falls, Jowai
<i>Rubus biflorus</i> Buch.-Ham.	Rosaceae	S	Temperate Himalayas,	Laitkor
<i>Rubus calycinus</i> Buch.-Ham.	Rosaceae	H	Sikkim, Bhutan, Central & Temperate Himalayas, Sikkim	Cherrapunjee, Sohra-rim
<i>Rubus khasianus</i> Cardot.	Rosaceae	S	Meghalaya	Ialeng, Raliang, Nokrek, Entapoh, Laitid, Jowai
<i>Sabia parviflora</i> H.K. & Th.	Sabiaceae	S	Meghalaya	Elephant falls
<i>Salix psilostigma</i> Arn.	Salicaceae	S	Meghalaya	Jarek, Jowai
<i>Schinus khasiana</i> Dyer.	Theaceae	T	Meghalaya	Shillong, Jowai, Sohra-rim, Ponglung,
<i>Schinus molle</i> Dillena	Poaceae	H	NE India	Mawphlang, Raliang
<i>Schinus molle</i> Dillena	Poaceae	H	NE India	Markasa, Nongkhylem
<i>Schinus molle</i> Dillena	Poaceae	H	Meghalaya	Kongrengtri
<i>Schinus molle</i> Dillena	Poaceae	H	NE India	Cherrapunjee, Pynursia, Jaram, Anlamem,
<i>Schinus molle</i> Dillena	Poaceae	H	NE India	Dawki
<i>Schinus molle</i> Dillena	Poaceae	H	NE India	Jowai, Sunga, Syndai
<i>Senecio jowaiensis</i> Balak.	Asteraceae	S	Meghalaya	Jowai
<i>Senecio jowaiensis</i> DC.	Smilacaceae	S	Meghalaya, Nagaland	Ialeng, Raliang

Table 1 ... contd.

<i>Sourria khasiana</i> C.L.	Melastomataceae	H	Meghalaya	Ialeng, Jowai, Jaram, Mawsmai
<i>Sophora acuminata</i> Baker.	Fabaceae	S	Eastern Himalayas,	Mawsmai, Sunga
<i>Symplocos maculata</i> Bremk.	Acanthaceae	S	Bangladesh, Burma	Jowai-Jaram
<i>Symplocos floribunda</i> Wall.	Acanthaceae	S	Meghalaya	Jowai-Jaram, Ialeng
<i>Symplocos affinis</i> Bremk.	Symplocaceae	US	Bhutan, Khasi Hills	Shillong
<i>Tristagma obovatum</i> Gagnep.	Violaceae	L	Meghalaya	Nartang, Rytang
<i>Thamnoctonus prunifolius</i> E.C.	Poaceae	S	NE India, Meghalaya	Raliang-Khongsai
<i>Trachyspermum auratum</i> Sch.	Apiaceae	C	NE India	Sohra-rim, Umam
<i>Trachyspermum khasianum</i> Wolff.	Apiaceae	H	Meghalaya	Jaram
<i>Trelicaria kanihali</i> D. Das.	Annonaceae	S	Meghalaya	Syndai
<i>Tupindanthus calyptatus</i> H.K. & Th.	Araliaceae	T	Meghalaya	Ialeng, Raliang, Jaram, Laskem, Balphakram
<i>Turpinia nepalensis</i> W. & A.	Staphyliaceae	T	Indo-Malaya,	Jowai-Jaram, Nokrek
<i>Tylophora belostemma</i> Benth.	Asclepiadiaceae	H	Meghalaya (Khasi Hills),	Cherrapunjee
<i>Vaccinium zaccinectum</i> Steum.	Vacciniaceae	Ep	NE India, Bangladesh,	Ialeng, Mawsmai, Jowai, Shangdam, Shangpung
<i>Viburnum carlifolium</i> H.K. & Th.	Caprifoliaceae	S	Nepal	Laitkor
<i>Viburnum edorastissimum</i> Ker.	Caprifoliaceae	S	NE India, Burma, China	Mawsmai
<i>Viburnum simonsii</i> H.K. & Th.	Caprifoliaceae	T	Meghalaya	Ialeng, Mawsmai, Jowai, Jaram
<i>Vigna cvxillata</i> Benth.	Fabaceae	H	Himalayas, Shimo-	Nongstom, Umran
			Kumaon, West Peninsular	India, Sri Lanka

contd...

The distribution of the endemic plant species at different elevations of the state shows that a maximum number of 203 species are found in the Subtropical (900-1800m a.s.l.) region, followed by the tropical (upto 900m a.s.l.) region with 106 species, and a minimum number of 21 species are found in the temperate (1800-2100m a.s.l.) region (Fig. 3 and Table 1).

Endemic medicinal plant species

Of the total 239 endemic plant species studied, 36 species were found to be pharmaceutically important or were being locally employed in health care (Table 2). These belonged to 31 genera and 27 families. The habit-wise distribution of these medicinal plant species reveals that 37% are trees, 22% are shrubs, 19% are herbs, 14% are lianas and climbers and 8% are under-shrubs (Fig. 4).

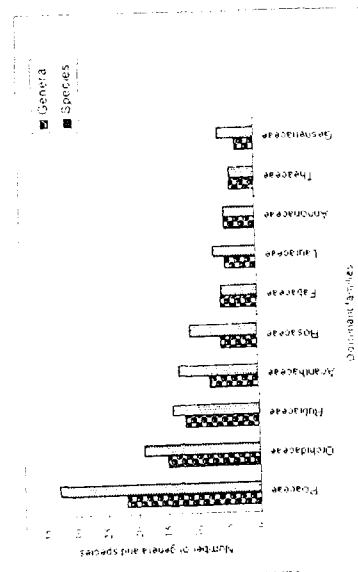


Fig. 2. Dominant families showing high degree of endemism in Meghalaya.

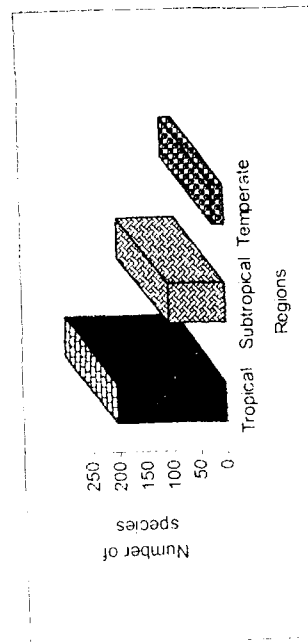


Fig. 3. Distribution of endemic plant species in Meghalaya.

Species	Family	Common name	Habit used	Parts	Ailments
<i>Aschyranthus superba</i> Cl.	Gesneriaceae	Thylli Masti [K]	US	B	Fracture, muscular sprain
<i>Ayios carnea</i> Benth.	Fabaceae	X	S	R	Eczema, wounds
<i>Boehmeria macrophylla</i> D. Don.	Urticaceae	Dieng Sokhasim [K]	S	T	Indigestion, stomachache
<i>Calamus erectus</i> Roxb.	Areaceae	Soh Thit [K]	S	Se	
<i>Calamus floribundus</i> Griff.	Areaceae	Soh Thit [K]	C		
<i>Camellia caduca</i> Cl. ex Brandis.	Theaceae	Dieng Tyem [K]	T	R	Skin diseases
<i>Chitra hamosa</i> R. Br.	Gesneriaceae	X	H		
<i>Citrus aurantium</i> L.	Rutaceae	Soh Namtra [K]	T	L, B, Fl	Headache, sinusitis, laxative
<i>Citrus latipes</i> Tanaka.	Rutaceae	Soh Heh [J]	T	Fl, L	Urinary tract infections
<i>Citrus medica</i> L.	Rutaceae	Soh Manong [K]	S	R, Fr	Headache, sinusitis, laxative
<i>Cocculus molle</i> HK f. & Th.	Menispermaceae	Jyrm Maltum [K]	S	R, S	Bodyache, vomiting, cold, fever
<i>Curcuma montana</i> Roxb.	Zingiberaceae	Syng Symit [J]	H	Rh	Laxative, colic, flatulence, strain
<i>Cymbidium aloefolium</i> Sw.	Orchidaceae	X	Fp	Bu	gery, renal & vesical calculi, tumours, amenorrhagia, dysmenorrhagia

cont.

swellings
jaundice, increases lactation, body
uria, antibacterial, anti-amoebic ac-
tive, depurative, diuretic, vomiting,
rheumatic arthritis, oedema, obg-
Anodyne, antiphlogistic, carmu-
tumours, amenorrhagia,
gery, renal & vesical calculi,
dysmenorrhagia

Bodyache, vomiting, cold, fever
Laxative, colic, flatulence, strain
Tumours, amenorrhagia,
gery, renal & vesical calculi,
dysmenorrhagia

Headache, sinusitis, laxative
Urinary tract infections
Skin diseases

Fracture, muscular sprain
Eczema, wounds
Indigestion, stomachache

Species	Family	Common name	Habit used	Parts	Aliments
<i>Daphniphyllum himalayense</i> Muell.-Arg.	Daphniphyllaceae	Deng Synrangthul [K]	T	S	Boils
<i>Delphinium altilimum</i> Wall.	Ranunculaceae	X Soh Shang [K]; Deng Sniangi [J]; Chokhua [G]	H	S	Sores, ulcers
<i>Elaagnus conferta</i> Roxb.	Elaeagnaceae	X Soh Shang [K]; Deng Sniangi [J]; Chokhua [G]	H	S	Sores, ulcers
<i>Garcinia corua</i> Roxb. ex DC.	Clusiaceae	Rengnan [G]	T	Ft	Dysentery
<i>Garcinia pedunculata</i> G. Don.	Clusiaceae	Deng Sohdaei [K]	T	Ft	Urinary troubles
<i>Gonolobus simonostii</i> H.K.f. & Th.	Anonaceae	X	T	Ft	Urinary troubles
<i>Grewia hirsuta</i> Vahl.	Tiliaceae	Soh Synting [K]	S	Ft, R	Diarthoea, dysentery, wounds
<i>Hedera helix</i> Cl.	Araliaceae	Pew Shrieh [K]	C	Wp	Antiseptic
<i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	Deng Dohlongsyiar [K]	T	R	Astringent, febrifuge
<i>Impatiens tripetala</i> Roxb.	Balsaminaceae	X Miboi [G]	H	R	Haematic
<i>Mahonia pycnophylla</i> Takeda.	Berberidaceae	Deng Niangmat [K]	T	L, B	Eye diseases
<i>Munronia pinnata</i> Harms.	Meliaceae	Samskar [G]	US	R	Stomachache, vomiting, loose motion
<i>Nepenthes khasiana</i> H.K.f.	Nepenthaceae	Tiew Rakoi [K]	S	Pitcher	Urinary troubles, stomach disorders, night blindness, skin diseases
<i>Ochna squarrosa</i> Planet.	Ochnaceae	X	T	L, R, B	Snakebite, menstrual complaints, leprosy
<i>Ophiorniza subcapitata</i> Wall.	Rubiaceae	Samachik [G]	C	R, L	Fever, sore throat, tonsils, facial blemishes

<i>Oscbeckia capitata</i> Benth.	Melastomataceae	Soh Pythem [K]	H	Wp	Snakebite, muscle swellings
<i>Piper griffithii</i> C.D.C.	Piperaceae	Palmbn [J]	C	L, S, Fr	Stomach troubles, diarrhoea, dysentery
<i>Piper pectinoides</i> Roxb.	Piperaceae	X	US	L	Fever
<i>Polygonum bistorta</i> L.	Polygonaceae	X	H	Rh	Diarthoea, enteritis, bleeding
<i>Rhaphidophora decurva</i> Schott.	Araceae	Dawai Karbek [J]	C	Rh	Snakebite
<i>Schinus khasiana</i> Dyer.	Theaceae	Dieng Ngan [K]	T	L, B	Stomachache, allergies
<i>Sophora acuminata</i> Baker.	Fabaceae	Palwang [G]	S	B	Pregnancy (purification of blood before & after delivery)
<i>Xylosma longifolium</i> Clos.	Flacourtiaceae	Dieng Kam [K]; Phulwal [G]	T	B	Stomachache

H = herb; Ep = epiphyte; T = tree; S = shrub; C = climber; US = under shrub; B = bark; R = root; Se = seed; L = leaf; Fl = flower; Fr = fruit; Rh = rhizome; Bu = buds; Wp = whole plant.

Ethnobotany of endemic plant species

Apart from the medicinal uses, many endemic species are used for many other purposes such as planking, house construction, fodder, food, furniture and ornamental uses (Fig. 5 and Table 3). From the Fig. 5, it is seen that 23% of endemics are used as house construction materials, 14% as ornamentals, 25% as fodder and 29% as food items.

Concentration of endemics

Based on the GPS readings, the distributions of the endemic species were mapped. The concentration of endemic species was found in 19 locations in Meghalaya, which were identified as centers of endemism. Of these, Jowai had the highest number of 61 (25.5%) endemic species, followed by Jarain with 51 (21.3%)

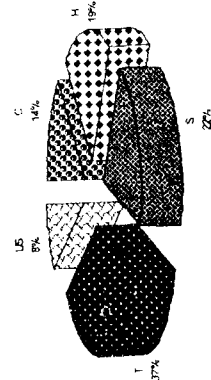


Fig. 4 Habit wise distribution of endemic medicinal plant species.

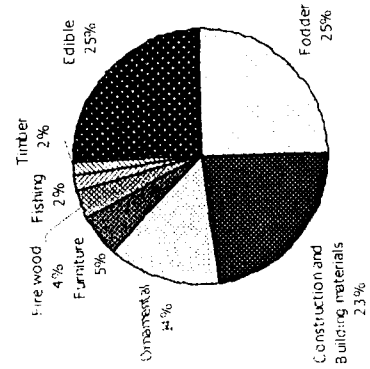


Fig. 5 Ethnobotanical use of endemic plants in Meghalaya.

Sl. Species no.	Family	Habit	Parts used	Uses
1. <i>Acer cappadocicum</i> Gleitsch	Aceraceae	T	Wood	Planking and scantling.
2. <i>Acer laevisatum</i> Wall.	Poaceae	H	Whole plant	Fodder.
3. <i>Agrostis nymphaea</i> Hk.	Poaceae	S	Culms, young	Walling of huts to hold mud plaster, roofing material, lean-porary partition walls, doors, shoots
4. <i>Arundinaria hirsuta</i> Muir.	Poaceae	S	Culms, young	Walling of huts to hold mud plaster, roofing material, lean-porary partition walls, doors, shoots
5. <i>Arundinaria manni</i> Gamble.	Poaceae	S	Culms	Binding material in building huts
6. <i>Aspidopterys elliptica</i> A. Juss.	Malpigiaceae	L	Bark	Edible.
7. <i>Bambusa mastersii</i> Muir.	Poaceae	T	Culms	Poles, walls.
8. <i>Bulbophyllum griffithii</i> Reich.	Orchidaceae	Ep	Whole plant	Ornamental.
9. <i>Calamus erectus</i> Roxb.	Areaceae	S	Fruits, canes	Edible, reeds, furniture.
10. <i>Calamus floribundus</i> Griff.	Areaceae	C	Fruits, canes	Edible, reeds, furniture.
11. <i>Chimonobambusa callosa</i> Nakat.	Poaceae	S	Culms and young shoots	Tying thatch of native houses, young shoots are edible.
12. <i>Chimonobambusa griffithiana</i> Nakat.	Poaceae	S	Culms	Tying thatch of native houses.
13. <i>Chimonobambusa khasiana</i> Nakat.	Poaceae	H	Culms	Making walls.
14. <i>Chimonobambusa polyslachya</i> Nakat.	Poaceae	S	Culms	Tying thatch of native houses.
15. <i>Citrus aurantium</i> L.	Rutaceae	T	Fruits	Edible.
16. <i>Citrus medica</i> L.	Rutaceae	S	Fruits, wood, branches	Edible, agricultural implements and walking sticks.

Table 4. Locations along with the species present in each location

Locations	Species
Sohra-rim	<i>Ischaemum hirtum</i> Hack., <i>Rubus calycinus</i> Buch-Ham., <i>Diplomeris pulchella</i> D. Don., <i>Mahonia pycnophylla</i> Takeda., <i>Hedera helix</i> Cl., <i>Osebeckia capitata</i> Benth., <i>Ilex venulosa</i> H.K.f., <i>Schinia khasiana</i> Dyer., <i>Phyllostachys nanii</i> Gamble., <i>Polygonum bistorta</i> L., <i>Phyllonipha obcordata</i> Sch., <i>Peristylis nanii</i> Mukh., <i>Cymbidium nansteri</i> Lindl., <i>Glochidion acuminatum</i> Muell.-Arg., <i>Digitalis compacta</i> Veldk., <i>Agrostis myriantha</i> Hk., <i>Piptosporum humile</i> Hk.f. and Th., <i>Ischaemum hirtum</i> Hack., <i>Cocculus mollis</i> Hk.f. & Th., <i>Aeschynanthus sikkimensis</i> Stapf., <i>Ardisia griffithii</i> Cl., <i>Hedera helix</i> Cl., <i>Osebeckia capitata</i> Benth., <i>Chimonobambusa khasiana</i> Nakai., <i>Acer laevigatum</i> Wall., <i>Hieracium khasiana</i> Cl. ex. Hk., <i>Chimonobambusa griffithiana</i> Nakai., <i>Chimonobambusa callosa</i> Nakai., <i>Arundinaria hirsuta</i> Munro., <i>Hellebronia humalata</i> Hk.f. and Th., <i>Litsea elongata</i> Hk.f., <i>Euonymus laosoni</i> Cl. & Prain., <i>Elaeagnus conferta</i> Roxb., <i>Arundinella intricata</i> Hughes., <i>Lindera latifolia</i> Hk.f., <i>Cinnamomum pauciflorum</i> Nees., <i>Berchemia floribunda</i> Brough., <i>Schinia khasiana</i> Dyer., <i>Apios carnea</i> Benth., <i>Poa khasiana</i> Stapf., <i>Phyllostachys nanii</i> Gamble., <i>Agapetes rugosus</i> Hk.f., <i>Hymenopogon parasiticus</i> Wall., <i>Persea kingii</i> Kosterm., <i>Synplacos floribunda</i> Wall., <i>Zanthoxylum khasianum</i> Hk.f., <i>Polygonum bistorta</i> L., <i> Pogostemon strigosus</i> Bentham., <i>Daphniphyllum himalayense</i> Muell., <i>Calamagrostis elatior</i> A. Camus., <i>Agrostis griffithiana</i> Bor.
Shullong	<i>Auculosa ticoïdes</i> Mast., <i>Osebeckia capitata</i> Benth., <i>Munronia pinjata</i> Harms., <i>Glochidion acuminatum</i> Muell.-Arg., <i>Tipidanthus calyptiratus</i> Hk.f. & Th., <i>Smitax myrtiltus</i> DC., <i>Rubus assamensis</i> Focke., <i>Aeschynanthus sikkimensis</i> Stapf., <i>Ixora sub-sessilis</i> G. Don., <i>Ardisia griffithii</i> Cl., <i>Impatiens khasiana</i> Hk.f., <i>Neillia thyrsofolia</i> D. Don., <i>Prunus jenkinsii</i> Hk.f., <i>Boehmeria sidaefolia</i> Wedd., <i>Rhaphidophora calophyllum</i> Schott., <i>Rhaphidophora decursiva</i> Schott., <i>Drimycarpus racemosus</i> Hk.f., <i>Rubus khasianus</i> Cardot., <i>Fissistigma verrucosum</i> Merr., <i>Erythroxylum kuntianum</i> Wall. ex Kurz., <i>Hedera helix</i> Cl., <i>Acer laevigatum</i> Wall., <i>Aeschynanthus superba</i> Cl., <i>Hedychium dekanium</i> Rao. and Verma., <i>Euonymus laosoni</i> Cl. and Prain., <i>Paramignya micrantha</i> Kurz., <i>Citrus latipes</i> Tanaka., <i>Ilex embeloides</i> Hk.f., <i>Lindera latifolia</i> Hk.f., <i>Piper griffithii</i> C.D.C., <i>Persea parviflora</i> Haridasan. et. Rao., <i>Impatiens laevigata</i> Hk.f., <i>Piper peepuloides</i> Roxb., <i>Capparis acutifolia</i> Sw., <i>Cinnamomum pauciflorum</i> Nees., <i>Picrasma quassioides</i> Lindl., <i>Tetrastigma obovatum</i> Gagnep., <i>Schinia khasiana</i> Dyer.
lalong	<i>Sonerila khasiana</i> Cl., <i>Tipidanthus calyptiratus</i> Hk.f. and Th., <i>Smitax myrtiltus</i> DC., <i>Mahonia pycnophylla</i> Takeda., <i>Luisia inconspicua</i> King. and Pantl., <i>Vaccinium vacciniaceum</i> Sleum., <i>Viburnum simonsii</i> Hk.f. and Th., <i>Bulbophyllum griffithii</i> Reich., <i>Rubus assamensis</i> Focke., <i>Aeschynanthus sikkimensis</i> Stapf., <i>Ixora sub-sessilis</i> G. Don., <i>Ardisia griffithii</i> Cl., <i>Impatiens khasiana</i> Hk.f.,

Sl. Species no.	Family	Habit	Parts used	Uses
17. <i>Coelogyne purpurea</i> Joseph. & Yog.	Orchidaceae	Ep	Whole plant	Ornamental.
18. <i>Coelogyne viscosa</i> Rehb.f.	Orchidaceae	Ep	Whole plant	Ornamental.
19. <i>Diglossa compacta</i> Veldk.	Poaceae	H	Grass	Eatble
20. <i>Drimycarpus racemosus</i> Hk.f.	Anacardiaceae	T	Bole	Planking, construction and flooring.
21. <i>Elaeagnus conferta</i> Roxb.	Elaeagnaceae	S	Fruits	Eatble.
22. <i>Elaeocarpus prunifolius</i> Mast.	Elaeocarpaceae	T	Fruits	Eatble.
23. <i>Erythroxylum kuntianum</i> Wall. ex Kurz.	Erythroxylaceae	T	Bark	Eatble.
24. <i>Garcinia pedunculata</i> G. Don.	Clusiaceae	T	Fruits	Eatble.
25. <i>Garcinia hirsuta</i> Vahl.	Tiliaceae	US	Fruits	Eatble.
26. <i>Hedera helix</i> Cl.	Araliaceae	C	Whole plant	Ornamental.
27. <i>Hymenodictyon excelsum</i> Wall.	Rubiaceae	T	Leaves	Fodder.
28. <i>Ilex khasiana</i> Turk.	Aquifoliaceae	T	Bole	Timber.
29. <i>Ilex umbellulata</i> Loes.	Aquifoliaceae	T	Bole	Fire wood.
30. <i>Ilex venulosa</i> Hk.f.	Aquifoliaceae	T	Bole	Fire wood.
31. <i>Ixonanthes khasiana</i> Hk.f.	Ixonanthaceae	T	Wood	Furniture.
32. <i>Ixora sub-sessilis</i> G. Don.	Rubiaceae	T	Whole plant	Ornamental.
33. <i>Michelia punduana</i> Hk.f. & Th.	Magnoliaceae	T	Bole, wood	Planking and furniture.
34. <i>Nepenthes khasiana</i> Hk.f.	Nepenthiaceae	H	Whole plant	Ornamental.
35. <i>Polygonum bistorta</i>	Polygonaceae	H	Tubers	Vegetable.
36. <i>Rhododendron formosum</i> Wall.	Ericaceae	S	Whole plant	Ornamental.
37. <i>Trachelospermum auritum</i> Sch.	Apocynaceae	C	Whole plant	Ornamental.
38. <i>Viburnum caryiifolium</i> Hk.f. & Th.	Caprifoliaceae	S	Fruits	Fishing.
39. <i>Xytia dolabriformis</i> Taub.	Mimosaceae	T	Wood	Construction.

H = herb; Ep = epiphyte; T = tree; S = shrub; C = climber; US = under shrub.

Table 4. contd.

Locations	Species
Mawphlang	<i>Neelia thersifolia</i> D. Don., <i>Prunus jenkinsii</i> Hk.f., <i>Boehmeria stidaefolia</i> Wedd., <i>Rhaphidophora calophyllum</i> Schott., <i>Rhaphidophora decursiva</i> Schott., <i>Drimycarpus racemosus</i> Hk.f., <i>Rubus khasianus</i> Cardot., <i>Fissistigma verrucosum</i> Merr., <i>Erythroxylum kunthianum</i> Wall. ex Kurz., <i>Hedera helix</i> Cl., <i>Camellia caduca</i> Brandis., <i>Acer laevigatum</i> Wall., <i>Callicarpa psilocalyx</i> Cl., <i>Sympagis monadelpha</i> Bremek., <i>Aeschmannthus parasitica</i> Cl., <i>Citrus latipes</i> Tanaka., <i>Goldfussia glabrata</i> Balak., <i>Lindera latifolia</i> Hk.f., <i>Piper griffithii</i> C.DC., <i>Persea pumila</i> Haridasan. et. Rao., <i>Avatia thomsonii</i> Seem., <i>Pogostemon strigosus</i> Bentham.
	<i>Peristylis nuntii</i> Mukh., <i>Ischaemum hirtum</i> Hack., <i>Erythroxylum kunthianum</i> Wall. ex Kurz., <i>Osbeckia capitata</i> Benth., <i>Chimonobambusa khasiana</i> Nakai., <i>Camellia caduca</i> Brandis., <i>Chimonobambusa griffithiana</i> Nakai., <i>Chimonobambusa callosa</i> Nakai., <i>Arundinella hirsuta</i> Munro., <i>Heteranthera himalaica</i> Hk.f. & Th., <i>Delphinium altissimum</i> Wall., <i>Carpinus emura</i> Wall. Ex. Lund., <i>Cyananthera delavayi</i> Hk.f., <i>Ischaemum hirtum</i> Hack., <i>Microstegium borianum</i> Sur., <i>Litsea elongata</i> Hk.f., <i>Arundinella intricata</i> Hughes., <i>Scleria khasiana</i> Dyer., <i>Poa khasiana</i> Stapf., <i>Polygonum bistorta</i> L., <i>Pogostemon strigosus</i> Bentham.
Jowai	<i>Cymbopogon khasianus</i> Stapf., <i>Eragrostella leptera</i> Bor., <i>Eriocaulon cristatum</i> Mast., <i>Coelogyne purpurea</i> Joseph. and Yeg., <i>Cocculus mollis</i> Hk.f. & Th., <i>Dipsacus asper</i> DC., <i>Sonerila khasiana</i> Cl., <i>Luisia inconspicua</i> King. and Pantl., <i>Vaccinium vacciniaceum</i> Sleum., <i>Viburnum simonsii</i> Hk.f. & Th., <i>Bulbophyllum griffithii</i> Reich., <i>Rubus assamensis</i> Focke., <i>Andisia griffithii</i> Cl., <i>Impatiens khasiana</i> Hk.f., <i>Neelia thersifolia</i> D.Don., <i>Prunus jenkinsii</i> Hk.f., <i>Rhaphidophora calophyllum</i> Schott., <i>Rhaphidophora decursiva</i> Schott., <i>Rubus khasianus</i> Cardot., <i>Erythroxylum kunthianum</i> Wall. ex Kurz., <i>Hedera helix</i> Cl., <i>Salix psilostigma</i> An., <i>Osbeckia capitata</i> Benth., <i>Porana racemosa</i> Roxb., <i>Quercus glauca</i> Thunb., <i>Habenaria khasiana</i> Hk.f., <i>Gomphostemma lucidum</i> Wall. ex Benth., <i>Mitelia punctata</i> Hk.f. & Th., <i>Liparis acuminata</i> Hk.f., <i>Pteracanthus rubescens</i> Bremek., <i>Chimonobambusa khasiana</i> Nakai., <i>Camellia caduca</i> Brandis., <i>Rhododendron formosum</i> Wall., <i>Acer laevigatum</i> Wall., <i>Aeschmannthus superba</i> Cl., <i>Impatiens acuminata</i> Hk.f. and Th., <i>Schizostachyum polymorphum</i> Majumdar., <i>Aechmanthera leiosperma</i> Cl., <i>Coelogyne viscosa</i> Rehb.f., <i>Dicentra torulosa</i> Hk.f. & Th., <i>Ophiopiza sub-capitata</i> Wall., <i>Senecio joraiensis</i> Balak., <i>Xylosma contraversum</i> Clos., <i>Hedychium dekanium</i> Rao. and Verma., <i>Calliandra psilocalyx</i> Cl., <i>Sympagis monadelpha</i> Bremek., <i>Aeschmannthus parasitica</i> Cl., <i>Baliospermum microanthum</i> Muell-Arg., <i>Turpinia nepalensis</i> W. & A., <i>Boehmeria macrophylla</i> D.Don., <i>Impatiens porcta</i> Hk.f. & Th., <i>Lasianthus hookeri</i> Cl. ex Hk.f., <i>Ilex venulosa</i> Hk.f., <i>Glochidion thomsonii</i> Hk.f., <i>Cinnamomum paniculatum</i> Nees., <i>Aralia thomsonii</i> Seem., <i>Scleria khasiana</i> Dyer., <i>Polygonum bistorta</i> L., <i>Pogostemon strigosus</i> Bentham., <i>Sympagis maculata</i> Bremek., <i>Daphniphyllum himalayense</i> Muell.

Locations	Species
Nokrek	<i>Bulbophyllum griffithii</i> Reich., <i>Aeschmannthus sikkimensis</i> Stapf., <i>Andisia griffithii</i> Cl., <i>Prunus jenkinsii</i> Hk.f., <i>Boehmeria stidaefolia</i> Wedd., <i>Rhaphidophora calophyllum</i> Schott., <i>Rhaphidophora decursiva</i> Schott., <i>Drimycarpus racemosus</i> Hk.f., <i>Rubus khasianus</i> Cardot., <i>Fissistigma verrucosum</i> Merr., <i>Erythroxylum kunthianum</i> Wall. ex Kurz., <i>Cerepega angustifolia</i> Wt., <i>Cerepega longifolia</i> Wall., <i>Aeschmannthus superba</i> Cl., <i>Turpinia nepalensis</i> W. & A., <i>Aeschmannthus parasitica</i> Cl., <i>Baliospermum microanthum</i> Muell-Arg., <i>Garcinia cova</i> Roxb. ex DC., <i>Pharus flavus</i> Lindl., <i>Boehmeria macrophylla</i> D.Don., <i>Impatiens porcta</i> Hk.f. and Th., <i>Lasianthus hookeri</i> Cl. ex Hk.f., <i>Mitelia caudata</i> Baker., <i>Pavetta sub-capitata</i> Hk.f., <i>Litsea elongata</i> Hk.f., <i>Elaeocarpus acuminatus</i> Wall. ex Mast., <i>Puranigya microantha</i> Kurz., <i>Euonymus laursonii</i> Cl. and Prain., <i>Conforla</i> Roxb., <i>Citrus latipes</i> Tanaka., <i>Citrus medica</i> L., <i>Citrus aurantifolium</i> L., <i>Gonolobium simonsii</i> Hk.f. & Th., <i>Lindera latifolia</i> Hk.f., <i>Piper griffithii</i> C.DC., <i>Impatiens laevigata</i> Hk.f., <i>Piper repuladense</i> Roxb., <i>Capparis acutifolia</i> Sw., <i>Apios amica</i> Benth., <i>Acer cappadocicum</i> Glebitch.
Nartiang	<i>Cymbopogon khasianus</i> Stapf., <i>Digitaria compacta</i> Veldk., <i>Luisia inconspicua</i> King. and Pantl., <i>Boehmeria stidaefolia</i> Wedd., <i>Pogonatherum rufobarbatum</i> Griff., <i>Tarphochlamys affinis</i> Bremek., <i>Curcuma montana</i> Roxb., <i>Cinnamomum pauciflorum</i> Nees., <i>Ischaemum hirtum</i> Hack., <i>Schizostachyum pallidum</i> Majumdar., <i>Osbeckia capitata</i> Benth., <i>Chimonobambusa khasiana</i> Nakai., <i>Nepenthes khasiana</i> Hk.f., <i>Chimonobambusa griffithiana</i> Nakai., <i>Arundinella intricata</i> Hughes., <i>Alsodaphne khasiana</i> Kosterm., <i>Pogostemon strigosus</i> Bentham.
Nongstoin	<i>Phyllomphax obcordata</i> Sch., <i>Chimonobambusa khasiana</i> Nakai., <i>Vigna vexillata</i> Benth., <i>Osbeckia capitata</i> Benth.
Mawsynram	<i>Viburnum simonsii</i> Hk.f. & Th., <i>Camellia caduca</i> Brandis., <i>Litsea laeta</i> Wall. ex Nees., <i>Osbeckia capitata</i> Benth.
Nongkrem	<i>Phyllomphax obcordata</i> Sch., <i>Hedera helix</i> Cl., <i>Osbeckia capitata</i> Benth., <i>Codonopsis viridis</i> Wall., <i>Pogostemon strigosus</i> Bentham.
Nongpoh	<i>Luisia inconspicua</i> King. and Pantl., <i>Hymenodictyon excelsum</i> Wall., <i>Cymbidium aleoform</i> Sw.
Mawsmai	<i>Lasianthus tubiferus</i> Hk.f., <i>Sonerila khasiana</i> Cl., <i>Vaccinium vacciniaceum</i> Sleum., <i>Osbeckia capitata</i> Benth., <i>Camellia caduca</i> Brandis., <i>Agapetes obovata</i> Hk.f., <i>Medinilla erythrophylla</i> Lindl., <i>Aeschmannthus parasitica</i> Cl., <i>Baliospermum microanthum</i> Muell-Arg., <i>Sophora acuminata</i> Baker., <i>Coffea jenkinsii</i> Hk.f., <i>Ericybe pungens</i> Prain., <i>Ilex excelsa</i> Hk.f., <i>Neanotis oxyphylla</i> W.H. Lewis., <i>Polygala tricolora</i> Chodat., <i>Viburnum odoratissimum</i> Ker., <i>Elaeocarpus acuminatus</i> Wall. ex Mast., <i>Litsea laeta</i> Wall. ex Nees., <i>Gonolobium simonsii</i> Hk.f. & Th., <i>Piper griffithii</i> C.DC., <i>Polygonum bistorta</i> L., <i>Pogostemon strigosus</i> Bentham.

contd....

Table 4. cont'd

Locations	Species
Nongkhyllem	<i>Schizostachyum dullooa</i> Majumdar, <i>Gastrodia exilis</i> Hk.f., <i>Gonolobus simonsii</i> Hk.f. & Th., <i>Piper griffithii</i> C. DC., <i>Piper pepuloides</i> Roxb., <i>Xulia dolabriformis</i> Taub.
Umiling	<i>Xulia dolabriformis</i> Taub., <i>Elaeocharis lucida</i> Roxb.
Balphakram	<i>Aeschynanthus manii</i> Kurz., <i>Aeschynanthus parasittica</i> Cl., <i>Areca nudgensis</i> Griff., <i>Argostemma khasiana</i> Cl., <i>Argostemma rostratum</i> Wall., <i>Arisaema album</i> N.E.Br., <i>Aspidopterys elliptica</i> A.Juss., <i>Bambusa nasteris</i> Munro., <i>Cardiopteris lobata</i> Wall. ex R.Br., <i>Ceropegia angustifolia</i> Wt., <i>Cymbidium mastersii</i> Lindl., <i>Cymbopogon khasianus</i> Stapf., <i>Didymocarpus razii</i> Kurz., <i>Decynnia hookeriana</i> Decne., <i>Elaeagnus conferta</i> Roxb., <i>Eragrostiella leioptera</i> Bor., <i>Eria tenuitosa</i> Hk.f., <i>Eriocaulon cristatum</i> Mast., <i>Eriocaulon echinulatum</i> Mart., <i>Glochidion acuminatum</i> Muell.-Arg., <i>Gonolobus simonsii</i> Hk.f. & Th., <i>Grewia hirsuta</i> Vahl., <i>Hiptage acuminata</i> Wall. ex Hk.f., <i>Ilex umbellulata</i> Loes., <i>Impatiens jurpa</i> Hk.f. & Th., <i>Impatiens tripartita</i> DC., <i>Isachne clarkii</i> Hk.f., <i>Jasminum listeri</i> Gage., <i>Lastobema scandens</i> de Wit., <i>Munronia pinnata</i> Harms., <i>Peristylis manii</i> Mukhb., <i>Phanera khasiana</i> Thoth., <i>Phlogacanthus guttatus</i> Nees., <i>Phyllanthus longiflorus</i> Heyne. ex Hk.f., <i>Phyllomphax abcordata</i> Sch., <i>Pseudoechinanthera glutinosa</i> Bremek., <i>Pteracanthus denticulatus</i> Bremek., <i>Thelasis pygmaea</i> Lindl., <i>Tupidanthus calyptratus</i> Hk.f. and Th.
Jarain	<i>Aeschynanthus sikkimensis</i> Stapf., <i>Aeschynanthus parasittica</i> Cl., <i>Begonia rubrovenia</i> Hk., <i>Berchemia floribunda</i> Brongn., <i>Callicarpa psilocalyx</i> Cl., <i>Ceropegia angustifolia</i> Wt., <i>Ceropegia longifolia</i> Wall., <i>Coccoloba mollis</i> Hk.f. & Th., <i>Dipsacus asper</i> DC., <i>Elaeocarpus prunifolius</i> Mast., <i>Eragrostiella leioptera</i> Bor., <i>Eria ferruginea</i> Lindl., <i>Eriocaulon cristatum</i> Mast., <i>Erythroxylum kunthianum</i> Wall. ex Kurz., <i>Gomphostemma lucidum</i> Wall. ex Benth., <i>Habenaria khasiana</i> Hk.f., <i>Hedychlorium dekiannui</i> Rao. and Verma., <i>Hiptage acuminata</i> Wall. ex Hk.f., <i>Ilex venulosa</i> Hk.f., <i>Impatiens porecta</i> Hk.f. & Th., <i>Isora sub-sessilis</i> C.Don., <i>Lasianthus hookeri</i> Cl. ex Hk.f., <i>Lasianthus tubiferus</i> Hk.f., <i>Liparis acuminata</i> Hk.f., <i>Litsea laeta</i> Wall. ex Nees., <i>Malonia pycnophylla</i> Takeda., <i>Medimilla erythrophylla</i> Lindl., <i>Michelia pumilana</i> Hk.f. & Th., <i>Mitrasacme nudicaulis</i> R.Br., <i>Neillia thyrsofolia</i> D.Don., <i>Nepenthes khasiana integrifolia</i> Lindl., <i>Photinia polycarpa</i> Balak., <i>Pogostemon strigosus</i> Bentham., <i>Porana racemosa</i> Roxb., <i>Pteracanthus nobilis</i> Bremek., <i>Pteracanthus rubescens</i> Bremek., <i>Pteracanthus urophyllus</i> Bremek., <i>Quercus glauca</i> Thunb., <i>Rhaphidophora calophyllum</i> Schott., <i>Rhaphidophora decursiva</i> Schott., <i>Schizostachyum pallidum</i> Majumdar., <i>Sonerila khasiana</i> Cl., <i>Sympagis maculata</i> Bremek., <i>Sympagis monodelpha</i> Bremek., <i>Trachyspermum khasianum</i> Wolff., <i>Tupidanthus calyptratus</i> Hk.f. & Th., <i>Turpinia nepalensis</i> W. and A., <i>Viburnum simonsii</i> Hk.f. & Th.

endemic species, Nokrek with 42 (17.6%) and Shillong with 41 (17.2%) endemic species (Tables 4 and 5 and Fig. 6).

Discussion

Of the 3128 flowering plant species found in the state, 1173 are stated to be endemics (Khan *et al.*, 1997). These represent 37.5% of the state's flora. From the present study of 239 endemics, it was found that the species diversity and the endemic richness are positively correlated and therefore, biodiversity rich areas of the state such as Jowai, Jarain, Nokrek and Shillong are also rich in endemics. The reason of concentration of endemics in a particular area may be attributed to habitat specificity, low regeneration capacity, geographic isolation, fragility or sensitivity to natural factors, and narrow ecological amplitude of the endemic species.

The wide use of such plants in medicine (36 species) and for other ethnobotanical purposes (39 species) by the indigenous tribes of the state associated with the increasing demand in pharmaceutical industries, have posed a major threat to the

Table 5. The number of endemic species at different centers of endemism in Meghalaya

Locations	Total number of endemic species	Percentage of the total endemics (Out of the total 239)
Jowai	61	25.5
Jarain	51	21.3
Nokrek	42	17.6
Shillong	41	17.2
Balphakram	39	16.3
Raliang	36	15.1
lalong	35	14.6
Mawsmai	22	9.21
Mawphlang	21	8.79
Sohra-rim	10	4.18
Pynursla	9	3.77
Nartiang	8	3.35
Nongkhyllem	6	2.51
Nongkrem	5	2.09
Nongstoin	4	1.67
Mawsynram	4	1.67
Nongpoh	3	1.26
Umsaw	2	0.84
Umiling	2	0.84

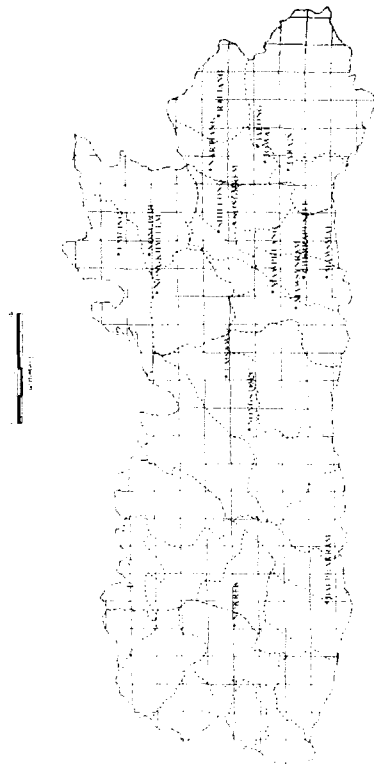


Fig. 6. Map of Meghalaya showing the area of concentration of endemics.

existence of these species. Over-exploitation, unsustainable harvesting techniques, over-dependence on the plants from wild origin and no concern for conservation of their populations are depleting their population size in the wild to an alarming level. Therefore, conservation measures for these species need to be taken up urgently. In order to undertake an effective conservation measure, identification of conservation areas is a prerequisite. The areas identified as centres of endemism in this study are recommended for conservation areas, where complete habitat protection and ban on collection of plant resources should be enforced. Besides, species-specific special conservation measures may be introduced for the betterment of these endemics.

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MEDICINAL PLANT RESOURCES OF MEGHALAYA: ENDEMISM, THREAT STATUS AND CONSUMPTION PATTERN

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Introduction

The use of various plant parts to cure specific ailments by different ethnic groups around the world is in vogue since time immemorial. The world is endowed with a rich wealth of medicinal plants. Of the total 297,000–510,000 (Schippmann *et al.*, 2002) plant species in the world, 70,000 (10-18 per cent) are estimated to be employed in healthcare (Prajapati *et al.*, 2003). In India, of the total 17,500 native plant species, 6,000 (34.3 per cent) are known to have medicinal importance (Foundation for Revitalization of Local Health Traditions, 2007). The Himalayas including Northeast India harbour about 8,000 plant species of which 2,500 (21.3 per cent) have been reported to have important medicinal properties (Trivedi, 2002).

Meghalaya is inhabited by the Khasis, Jaintias and Garos, who have a tradition of practising indigenous medicine system. Of the total 3,331 plant species found in the state (Khan *et al.*, 1997), 834 (31.3 per cent) are estimated to be employed in healthcare (Lakadong and Barik, 2006). The sources of these medicinal plant species could be cultivated plants from homesteads, farm lands, cultivation fields or wild plants from forest lands. The plant parts used could be leaves, fruits, roots or stems and most of these are collected fresh and used. Sometimes the plant parts are collected and stored for future use, particularly when the plant in question is not available.

Meghalaya has a number of tribal village doctors addressing the health care issues in the state, particularly in remote villages. Usually they collect the medicinal plants from their known localities. A few of the folk healers have started cultivating them in their herbal gardens while, some medicinal plants are bought from the markets.

Over-exploitation by the local people has pushed many of the medicinal plants into threatened categories. Of the 17,500 plant species present

The attachment of these endemic species to such biodiversity rich areas may be due to habitat specificity, plant associations and well protected habitats. Thus, protection of areas with high endemism would also protect many other species growing in that area

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in India, about 5,725 are broadly considered as endemics, i.e. species that are restricted to a particular geographical region or ecological unit. These represent 32.7 per cent of the country's flora. Based on the distribution of endemics on the earth's surface, and threats to their habitats, hotspots have been identified globally. Of the total 34 hotspots in the world (Mittermeier *et al.*, 2004), India harbours three *viz.* Western Ghats, Himalayas and Indo-Burma. The Himalayas including Northeast India harbour 3,200 (40 per cent) endemic plant species (Dhar, 2002). Meghalaya is home to 239 (31.3 per cent) endemic plant species (Lakadong and Barik, 2006). Besides, endemism it is estimated that about 3,000 species of flowering plants fall in one or the other category of threatened plants, which also include several medicinal plants. The Red Data Books (Jain and Shastry, 1984; Nayar and Shastry, 1988, 1989, 1990) have listed 623 plant species, of which 550 are endemic that include some valuable medicinal plants.

Some of the studies on medicinal plants of Meghalaya are those by Upadhaya *et al.* (2005), Joseph and Kharkongor (1981), Kumar *et al.* (1980), Kumar *et al.* (1987), Prabhu (2004), Rao (1981a and b), Rao and Neogi (1980), Rao and Shanpru (1981), Tripathi and Goel (2001), etc. conducted during the last three decades mostly to document the ethnobotanical values and taxonomic aspects of the species. However, there is no comprehensive study so far available for medicinal plants of Meghalaya analyzing the endemism, species distribution pattern, threat status, availability and quantity consumed. The present study aims to bridge this information gap by providing vital data on medicinal plants of Meghalaya. Based on the empirical data collected, strategies for cultivation of medicinal plants in the state have been suggested.

Study Site

The study was conducted in the state of Meghalaya, which is characterized by wide variations in topography and elevation. The altitude ranges from 90 to 2,000 m

a.s.l. and the climate shows wide variation depending on the altitude. The total geographical area of the state is 22,549 km² and the state lies between 25°47' and 20°10' N latitude and 89°45' and 92°47' E longitude.

Methods

A list of medicinal plant species present in Meghalaya was prepared consulting published and unpublished literature as well as by collecting primary data. The primary data was collected from different parts of the state by conducting extensive field surveys in different seasons during the years 2003-07.

A list of endemic medicinal plants was prepared by reviewing the available literature (Nayar and Shastry, 1988, 1989, 1990, Haridasan and Rao, 1985-87; Bakakrishnan, 1981-83; Joseph, 1980; Kanjilal *et al.*, 1934-40). The distribution of these endemic medicinal plant species was mapped based on the results of the field survey. Field visits were made during the active growth season of the species. Geographical positioning system (GPS) was used to record the exact location of occurrence of the species such as altitude, latitude and longitude.

Ethnomedicinal uses, availability and consumption of medicinal plants in the state were studied in 25 villages spreading over the Khasi, Jaintia and Garo hills of the state. The data so generated was extrapolated for the entire state by taking into consideration the number of villages in each region and the consumption pattern in the respective region.

Results

Habit

Of the total of 834 medicinal plant species, 266 (32 per cent) were herbs, 264 (32 per cent) trees, 177 (21 per cent) shrubs, 93 (11 per cent) lianas and climbers, and 34 (4 per cent) were undershrub (Fig. 1). These species were distributed under 548 genera and 166 families. The family with the highest number of medicinal plant species was Rubiaceae (27 genera and 40 species)

followed by Asteraceae (27 genera and 36 species) and Fabaceae (22 genera and 29 species; Fig. 2).

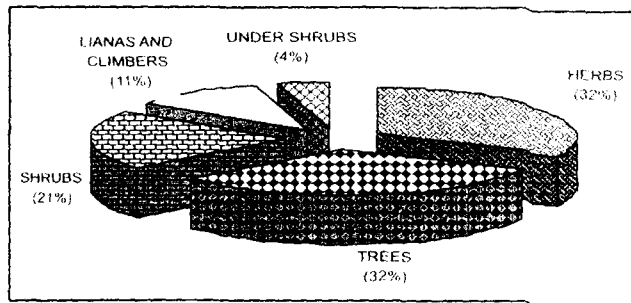


Fig. 1. Habit of medicinal plant species of Meghalaya

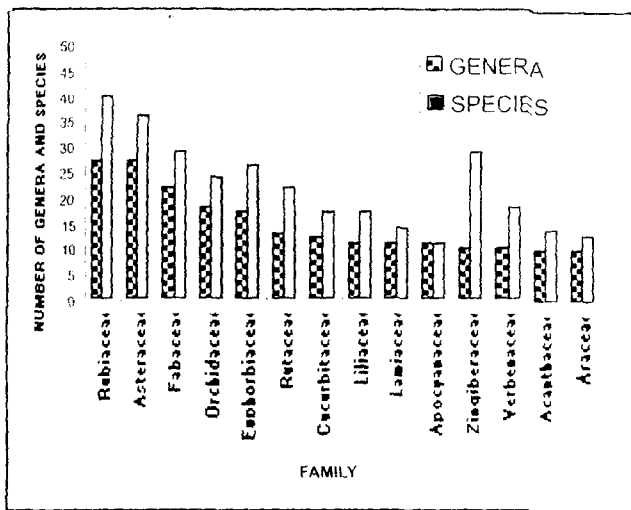


Fig. 2. Dominant medicinal plant families with number of genera and species in Meghalaya

Endemics

Thirty seven medicinal plant species (4.4 per cent of the total medicinal plant species) endemic either to Eastern Himalayas or Northeast India or Meghalaya were reported. These species belonged to 32 genera and 29 families. Sixteen (42 per cent) of them were trees, 10 (27 per cent) were herbs, five (14 per cent) were shrubs, five (14 per cent) were lianas and climbers and one (3 per cent) was undershrub (Table 1).

Medicinal Properties of Endemics

Seventeen (19 per cent) species are used for fever, bodyache, weakness and vomiting, 10 (27 per cent) for gastrointestinal problems and 10 (27 per cent) for gynaecological problems. Five endemic species are

used for fever, four species for stomachache and three species each for dysentery and diarrhoea. Three species are used as antidote for snake bite and three are used for diuresis.

Distribution of Endemics

The maximum number of endemics was found in low and mid-altitude zones ranging from 100 to 1,600m a.s.l. whereas, only a few of them were restricted to high altitudes i.e. above 1,600 m a.s.l. (Table 2). Twenty four species were restricted to altitudes ranging from 800 to 1,600 m a.s.l., 20 were found in altitudes ranging from 400 to 800 m a.s.l. and 15 were restricted to altitudes ranging from 100 to 400 m a.s.l. Only six species were restricted to an altitudinal range of 1,600 to 2,000 m a.s.l. Of the 37 species, 26 species were restricted to Northeast India while 11 were restricted only to Meghalaya.

Concentration of Endemic Medicinal Plant Species

High concentration of endemic medicinal plant species was found in Nokrek (37.8 per cent) followed by Jowai (35.1 per cent) and Raliang (32.4 per cent; Table 3).

Threat Status of Medicinal Plant Species

Of the 834 medicinal plant species, 116 were either threatened or endemic, or both constituting about 13.8 per cent of the total medicinal flora (Table 4). These belonged to 96 genera and 67 families, and 43 per cent of these were trees, 32 per cent were herbs, 16 per cent were shrubs, 8 per cent were lianas and climbers and 1 per cent was undershrubs.

Consumption Pattern of Medicinal Plants Used Under Traditional Healing Systems

Although the consumption data on medicinal plants provided in Table 5 has limitation due to small sample size, it does indicate the pattern of consumption of various medicinal plants in the state. *Oroxylum indicum* (21,931 kg/yr), *Centella asiatica* (25,685 kg/yr), *Embllica officinalis* (20,801 kg/yr).

Table 1. Ethnomedicinal information on 37 endemic medicinal plant species found in Meghalaya

Species	Family	Habit	Part used	Ailment
<i>Aeschynomene stipitata</i> C1	Cesariaceae	Under shrub	Bark	Fracture, muscular sprain
<i>Boehmeria macrophylla</i> D. Don	Urticaceae	Tree	Root	Fezema, wounds
<i>Calamus cretus</i> Roxb.	Arecaceae	Shrub	Seed, Root	Indigestion, stomach ache, malaria, body ache
<i>Calamus floribundus</i> Griff	Arecaceae	Climber	Root	Weakness
<i>Camellia caduca</i> C1, ex Brandis	Theaceae	Tree	Root	Skin diseases
<i>Cinnis aurantium</i> L.	Rutaceae	Tree	Leaf, Bark, Flower	Headache, sunstroke, jaundice, urinary tract infections
<i>Cinnis latipes</i> Tanka	Rutaceae	Tree	Fruit, Leaf	Body ache, vomiting, cold, fever
<i>Cinnis medica</i> L.	Rutaceae	Shrub	Root, Fruit	Laxative, colic, flatulence, renal and vesical calculi, tumours dysmenorrhagia
<i>Coccoloba coriarioides</i> DC	Menispermaceae	Shrub	Root, Stem	Anodyne, antiphlogistic, carminative, diuretic, vermifuge, rh oedema, oliguria, antibacterial, anti-amoebic activity, asthma
<i>Curatoma mothiana</i> Roxb.	Zingiberaceae	Herb	Rhizome	Jaundice, increases lactation, body swellings
<i>Cymbidium alabianum</i> Sw.	Orchidaceae	Epiphyte	Bulb	Blood coagulant for large bleeding wounds
<i>Daphniphyllum himalaense</i> Muell. Arg.	Daphniphyllaceae	Tree	Stem	Boils
<i>Elaeagnus conferta</i> Roxb.	Elaeagnaceae	Shrub	Flower, Fruit	Sores, ulcers
<i>Erythroxylum khamtiense</i> Wall. ex Kurz	Erythroxylaceae	Tree	Bark	Stimulant
<i>Euclea yawsii</i> C1, and Pl.	Celastraceae	Tree	Bark	Syphilis, indigestion, liver disorder
<i>Garcinia cowa</i> Roxb. ex DC.	Clusiaceae	Tree	Fruit	Dysentery
<i>Garcinia pedunculata</i> G. Don	Clusiaceae	Tree	Fruit	Urinary troubles
<i>Goniolobum samonense</i> H.K. and Th.	Anonaceae	Tree	Fruit	Throat irritation
<i>Grewia hirsuta</i> Vahl.	Theaceae	Shrub	Fruit, Root	Diarrhoea, dysentery, wounds
<i>Hedera nepalensis</i> K. Koch	Araliaceae	Climber	Whole plant	Antiseptic
<i>Hemiodia hirsuta</i> ex <i>Isana</i> Wall.	Rubiaceae	Tree	Bark	Astringent, vermifuge
<i>Hex embeloides</i> H.K.	Aquifoliaceae	Tree	Bark, Root	Cold, cough, tuberculosis
<i>Impatiens tripartita</i> Roxb.	Balsaminaceae	Herb	Root	Haemorrhic
<i>Mahonia pycnantha</i> Lakoda	Berberidaceae	Tree	Leaf, Bark	Eye diseases
<i>Maieromia pinata</i> Harms.	Melastomaceae	Under shrub	Root	Stomachache, vomiting, loose motion
<i>Nepenthes khasiana</i> H.K.	Nepenthaceae	Shrub	Pitcher	Urinary troubles, stomach disorders, night blindness, skin di
<i>Ocimum sanctum</i> Planch.	Ochnaceae	Tree	Leaf, Root, Bark	Snake bite, menstrual complaints, asthma emollient
<i>Ophiocoma subcapitata</i> Wall.	Rubiaceae	Climber	Root, Leaf	Fever, sore throat, tonsils, facial blenities
<i>Oxyckia capitata</i> Benth.	Melastomataceae	Herb	Whole plant	Snake bite, muscle swellings
<i>Parabougata m. caltha</i> Kuth	Rutaceae	Shrub	Root	Diuretic
<i>Piper griffithii</i> C. DC.	Piperaceae	Climber	Leaf, Stem, Fruit	Stomach troubles, diarrhoea, dysentery
<i>Piper pectinoides</i> Roxb.	Piperaceae	Under shrub	Leaf, Bark	Fever, paralysis
<i>Polygonatum himalaicum</i> L.	Polygonaceae	Herb	Rhizome	Diarrhoea, enteritis, bleeding haemorrhoids, gingivitis, febrif
<i>Raphidophora dr. arisae</i> Sengou	Anacardiaceae	Climber	Rhizome	Snake bite
<i>Schinus molle</i> Dyer.	Theaceae	Tree	Leaf, Bark	Stomach ache, allergies
<i>Sophora acuminata</i> Baker	Fabaceae	Shrub	Bark	Pregnancy purification, of blood before and after delivery
<i>Xylocarpus longitotum</i> C1, ex	Flacourtiaceae	Tree	Bark	Stomach ache

Table 2. Distribution of the 37 endemic medicinal plant species found in Meghalaya

Species	Altitude		Worldwide	Distribution	
	(m a.s.l.)				Meghalaya
<i>Ascyrinanthus stipitata</i> C.	800-1,500	NE India	NE India		Jowai, Rahaing, Tarskeri, Mynsoi, Sohkhha, Nokrek, Jowai, Syndra-Muktapur
<i>Boehmeria macrophylla</i> D. Don	100-1,000	Sub-Tropical Himalayas	Sub-Tropical Himalayas		Lohit, Trongpleng, Syndra, Sohkhha-Daw
<i>Calamus erectus</i> Roxb.	100-1,000	Sikkim, NE India	Sikkim, NE India		Syndra, Rytiang, Sohkhha-Dawki
<i>Calamus thibetanus</i> Griff.	100-1,000	NE India	NE India		Jowai, Mawsynram, Jalong, Mawsmati, M Nokrek
<i>Zamiella caduca</i> Brandis	1,000-1,600	Meghalaya	Meghalaya		Nokrek
<i>Citrus aurantium</i> L.	100-500	Dehradun, Garhwal, Kumaon, Sikkim, Manipal, Montane forests of peninsular India	Dehradun, Garhwal, Kumaon, Sikkim, Manipal, Montane forests of peninsular India		Nokrek, Umjaisaw, Mynsyngat, Jalong, R. Nokrek, Umjaisaw, Mynsyngat
<i>Citrus latipes</i> Tadeka	500-1,500	Meghalaya	Meghalaya		Cherapunjee, Jowai, Shillong, Jorain
<i>Citrus medica</i> L.	500-1,200	Kumaon, Pachmarhi, Sikkim, Chitragong, Upper Yan-Yanzadim Valley, Sappara hills, Western Ghats	Kumaon, Pachmarhi, Sikkim, Chitragong, Upper Yan-Yanzadim Valley, Sappara hills, Western Ghats		Nurtiang
<i>Coccinula malis</i> H.K. and Th.	1,000-1,500	Nepal	Nepal		Um-sing, Nongpoh, Bumhat
<i>Cinnamomum</i> sp.	1,000-1,300	NE India, Korkum	NE India, Korkum		Um-sing, Nongpoh, Bumhat
<i>Cymbidium schottianum</i> Sw.	1,000-700	Burma, Bengal, Nepal, Thailand, Sri Lanka, India	Burma, Bengal, Nepal, Thailand, Sri Lanka, India		Um-sing, Nongpoh, Bumhat
<i>Daphniphyllum himalaense</i> Muell.	1,500-1,800	Temperate Himalayas-Burma	Temperate Himalayas-Burma		Um-sing, Nongpoh, Bumhat
<i>Elettaria serrata</i> Roxb.	300-1,500	Indo-Malaya, Himalayas, South India	Indo-Malaya, Himalayas, South India		Nokrek, Tura, Balphakram, Shillong
<i>Leptocarpus</i> sp.	1,000-2,000	India, Burma, NE India	India, Burma, NE India		Jalong, Rahaing, Swat, Nokrek, Mawphla
<i>Koeleria</i> sp.	1,200-1,600	Meghalaya	Meghalaya		Nokrek, Rahaing, Shillong
<i>Garcinia conchocarpa</i> Roxb. ex DC.	100-1,500	Indo-Malaya, NE India	Indo-Malaya, NE India		Nokrek, Bumhat
<i>Garcinia pedunculata</i> G. Don	100-1,000	India, Burma, NE India	India, Burma, NE India		Sohkhha
<i>Goniolobos vietnamiensis</i> H.K. and Th.	200-1,500	Meghalaya	Meghalaya		Nongkylem, Borlong, Mawsmati, Nokre
<i>Grewia khasiana</i> Vahl.	100-300	India, Sri Lanka, Bangladesh, Burma	India, Sri Lanka, Bangladesh, Burma		Balphakram
<i>Hedyotis nepalensis</i> K. Koch.	1,200-1,600	Himalayas	Himalayas		Jalong, Rahaing, Swat, Nongkrem, Shillong
<i>Hymenodictyon coccineum</i> Winkl.	500-700	Indo-Malaya	Indo-Malaya		Nongpoh
<i>Hex chlorobolus</i> H.K.	100-1,200	Meghalaya	Meghalaya		Rahaing, Dawki
<i>Impatiens</i> sp.	100-800	NE India	NE India		Balphakram, Dawki
<i>Mahonia pycnantha</i> Takeda	1,000-1,800	Indo-Burma, Eastern Himalayas, Nilgiris	Indo-Burma, Eastern Himalayas, Nilgiris		Jalong, Jorain, Sohra-riim, Elephant Falls
<i>Marrubium pinnatifidum</i> Harms.	100-1,700	Eastern Himalayas, NE India, Nilgiris	Eastern Himalayas, NE India, Nilgiris		Balphakram, Maheskola, Tura, Rahaing
<i>Nepenthes khasiana</i> H.K.	1,200-1,500	Meghalaya	Meghalaya		Lawbah, Pongtung, Pynursia, Mykrie, Nongkrem, Jorain, Sutnga, Maheskola, Tura
<i>Ocimum sanctum</i> L.	400-600	Burma, Andamans, Khasi hills	Burma, Andamans, Khasi hills		Rongrengri
<i>Ophiorhiza subcapitata</i> Winkl.	1,200-1,600	Meghalaya, Jammu hills	Meghalaya, Jammu hills		Jowai
<i>Oxyckia capitata</i> Benth.	700-1,800	Meghalaya	Meghalaya		Jorain, Anlareim, Sutnga, Pynursia, Jowai
<i>Paramignya nitentha</i> Kurz.	1,000-1,500	Meghalaya	Meghalaya		Bapung, Sohra-riim, Kblehriat, Mawphla
<i>Piper griffithii</i> C. DC.	200-1,500	NE India	NE India		Cmsaw, Nongstoin, Nongkrem, Mawsmati
<i>Piper pycnanthoides</i> Roxb.	200-1,500	Tropical Himalayas, NE India, Bangladesh, Nepal	Tropical Himalayas, NE India, Bangladesh, Nepal		Nokrek, Rahaing
<i>Polygonum bistorta</i> L.	700-1,600	Meghalaya	Meghalaya		Rahaing, Jalong, Nokrek, Sohkhha, Mawsmati
<i>Raphidophora decursiva</i> Schott.	1,000-1,500	Sikkim Himalayas	Sikkim Himalayas		Rahaing, Nokrek, Nongkylem
<i>Schinus molle</i> Dyer.	1,200-1,800	Meghalaya	Meghalaya		Sutnga, Jorain, Bapung, Um-mulung, Jowai
<i>Sophora tomentosa</i> Baker	800-1,300	Eastern Himalayas, Bangladesh, Burma	Eastern Himalayas, Bangladesh, Burma		Mawphlang, Pongtung, Shillong, Anlareim
<i>Xylocarpus</i> sp.	1,000-1,500	Meghalaya	Meghalaya		Jalong, Rahaing, Nokrek, Jowai, Jorain
<i>Xylocarpus</i> sp.	1,000-1,500	Meghalaya	Meghalaya		Shillong, Jowai, Sohra-riim, Pongtung, Mawsmati, Sutnga
<i>Xylocarpus</i> sp.	1,000-1,500	Meghalaya	Meghalaya		Jowai

Table 3. Concentration of endemics at different locations in Meghalaya

Site	Number of endemic medicinal plant species	Concentration (%)
Nokrek	14	37.8
Jowai	13	35.1
Railiang	12	32.4
Shillong	9	24.3
Lalong	7	18.9
Jarain	7	18.9
Balphakram	6	16.2
Mawsmai	6	16.2
Mawphlang	5	13.5
Pongtong	5	13.5
Sohrairim	5	13.5
Sekha	5	13.5

Table 4. Threat status of medicinal plant species found in Meghalaya

Species	Habit	Status
<i>Acanthus leucostachys</i> Roxb.	Herb	Endemic and rare
<i>Acorus calamus</i> L.	Herb	Vulnerable
<i>Aeschynanthus superba</i> Cl.	Epiphyte	Endemic
<i>Aquilaria agallocha</i> Roxb.	Tree	Endangered
<i>Ardisia odonophylla</i> DC.	Shrub	Rare
<i>Aristolochia cathartii</i> Hk.f.	Climber	Rare
<i>Aristolochia saccata</i> Wall.	Liana	Rare
<i>Artocarpus gomezianus</i> Wall. ex Trewl.	Tree	Rare
<i>Bergenia ciliata</i> Sternb.	Herb	Vulnerable
<i>Boehmeria macrophylla</i> D. Don	Tree	Endemic
<i>Bruccea mollis</i> Wall. ex Kurz.	Shrub	Rare
<i>Butea monosperma</i> Taub.	Tree	Vulnerable
<i>Calamus erectus</i> Roxb.	Shrub	Endemic and rare
<i>Calamus floribundus</i> Griff.	Climber	Endemic
<i>Camellia caduca</i> Brandis	Tree	Endemic
<i>Cardamine imputiens</i> L.	Herb	Rare
<i>Caryota urens</i> L.	Tree	Rare
<i>Cephalotaxis mammii</i> Hk.f.	Tree	Vulnerable
<i>Cibonium barometz</i> Link.	Shrub	Vulnerable
<i>Cinnamomum tanala</i> Nees. and Eberm.	Tree	Vulnerable
<i>Citrus aurantium</i> L.	Tree	Endemic and rare
<i>Citrus latipes</i> Tanaka	Tree	Endemic and rare
<i>Citrus medica</i> L.	Shrub	Endemic
<i>Clerodendrum colebrookianum</i> Walp.	Shrub	Vulnerable
<i>Clerodendrum hastatum</i> Lindl.	Shrub	Endemic
<i>Clerodendrum serratum</i> Moon	Shrub	Vulnerable
<i>Cocculus mollis</i> Hk.f. and Th.	Shrub	Endemic
<i>Codonopsis javanica</i> Hk.f.	Climber	Data deficient
<i>Coldenia procumbens</i> L.	Herb	Rare
<i>Cordia dichotoma</i> Forst.f.	Tree	Very rare
<i>Cordia fragrantissima</i> Kurz.	Tree	Very rare

<i>Corylopsis himalayana</i> Griff.	Shrub	Vulnerable
<i>Cretaea murvata</i> Buch. - Ham.	Tree	Extremely rare
<i>Croton tiglium</i> L.	Tree	Rare
<i>Curcuma angustifolia</i> Roxb.	Herb	Near threatened
<i>Curcuma montana</i> Roxb.	Herb	Endemic and rare
<i>Cymbidium aloifolium</i> Sw.	Epiphyte	Endemic
<i>Cymbidium longifolium</i> D. Don	Epiphyte	Indeterminate
<i>Dalhousiea bracteata</i> Grab.	Shrub	Rare
<i>Daphniphyllum himalense</i> Muell. - Arg.	Tree	Endangered and endemic
<i>Dendrobium densiflorum</i> Wall.	Epiphyte	Rare
<i>Dendrobium macraei</i> Lindl.	Epiphyte	Vulnerable
<i>Dendrobium moschatum</i> Sw.	Epiphyte	Indeterminate
<i>Dendrobium nobile</i> Lindl.	Epiphyte	Endangered
<i>Diospyros pilosula</i> Hiren.	Tree	Extremely rare
<i>Dioscorea peltata</i> Sm.	Herb	Rare
<i>Elaeagnus conferta</i> Roxb. ssp. <i>deudroides</i> Servetaz.	Shrub	Endemic and endangered
<i>Erythroxylum kumthianum</i> Wall. ex Kurz.	Tree	Endemic
<i>Etionymus lawsonii</i> Cl. and Prain.	Tree	Endemic
<i>Ficus microcarpa</i> L.f.	Tree	Very rare
<i>Ficus submersa</i> Buch.-Ham. ex J.E. Sm.	Shrub	Rare
<i>Fraxinus floribunda</i> Wall.	Tree	Very rare
<i>Garcinia cowa</i> Roxb. ex DC.	Tree	Endemic
<i>Garcinia pedunculata</i> G. Don	Tree	Endemic
<i>Garcinia campanulata</i> Roxb.	Tree	Very rare
<i>Gloriosa superba</i> L.	Herb	Endangered
<i>Goniothalamus simonsii</i> Hk.f. and Th.	Tree	Indeterminate
<i>Grewia hirsuta</i> Vahl.	Under shrub	Endemic
<i>Hedera nepalensis</i> K. Koch	Climber	Vulnerable and endemic
<i>Hedychium coronarium</i> Koenig	Herb	Endangered
<i>Hedychium spicatum</i> Ham. ex Sm.	Herb	Vulnerable
<i>Hedyotis scandens</i> D. Don	Shrub	Data deficient
<i>Helicia excelsa</i> Bl.	Tree	Rare
<i>Heptapleurum hypoleucum</i> Kurz	Tree	Data deficient
<i>Holoptelea integrifolia</i> Planch	Tree	Very rare
<i>Hysteroctopus kurzii</i> Ward.	Tree	Vulnerable
<i>Hymenodictyon excelsum</i> Wall.	Tree	Endemic and rare
<i>Ichnocarpus frutescens</i> R. Br.	Herb	Rare
<i>Ilex embeloides</i> Hk.f.	Tree	Endemic and indeterminate
<i>Ilex khasiana</i> Park.	Tree	Endangered and endemic
<i>Illicium griffithii</i> Hk.f. and Th.	Tree	Critically endangered
<i>Impatiens tripetala</i> DC.	Herb	Endemic
<i>Juglans regia</i> L.	Tree	Indeterminate

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<i>Livingia scandens</i> Ham.	Shrub	Extremely rare
<i>Mahonia pycnophylla</i> Takeda	Tree	Endemic and vulnerable
<i>Mimusops elengi</i> L.	Tree	Rare
<i>Mitrephora tomentosa</i> Hk.f. and Th.	Tree	Rare
<i>Monotropa uniflora</i> L.	Herb	Rare
<i>Morinda umbellata</i> L.	Shrub	Very Rare
<i>Munronia pinnata</i> Harms.	Herb	Endemic and rare
<i>Nepenthes khasiana</i> Hk.f.	Herb	Endemic and endangered
<i>Ochna squarrosa</i> Planet.	Tree	Endemic and vulnerable
<i>Ophiorrhiza sub-capitata</i> Wall. ex Hk.f.	Herb	Endemic and endangered
<i>Oroxylum indicum</i> Vent.	Tree	Vulnerable
<i>Osbeckia capitata</i> Benth.	Herb	Endemic
<i>Panax pseudo-ginseng</i> Wall.	Herb	Rare
<i>Paphiopedilum insigne</i> Pfiz.	Terrestrial	Vulnerable
<i>Paramignya micrantha</i> Kurz	Liana	Rare and endemic
<i>Parkia roxburghii</i> A. DC.	Tree	Rare
<i>Pterisma javanica</i> Bl.	Tree	Very rare
<i>Piper boehmeriaefolium</i> Wall. ex C. DC.	Shrub	Near threatened
<i>Piper griffithii</i> C. DC.	Climber	Endemic
<i>Piper peepuloides</i> Roxb.	Climber	Vulnerable and endemic
<i>Polygonum historta</i> L.	Herb	Endemic
<i>Pterygota alata</i> R. Br.	Tree	Very rare
<i>Raphidophora decursiva</i> Schott.	Epiphyte	Endemic
<i>Rauvolfia serpentina</i> Benth. ex Kurz	Herb	Endangered
<i>Rhynchosyris retusa</i> Bl.	Epiphyte	Indeterminate
<i>Salix tetrasperma</i> Roxb.	Tree	Vulnerable
<i>Samanea indica</i> Willd.	Tree	Rare
<i>Schima khasiana</i> Dyer.	Tree	Rare and endemic
<i>Scheuchzeria trigyna</i> Willd.	Tree	Data deficient
<i>Smilacina fusca</i> Hk.f.	Herb	Indeterminate
<i>Sophora accuminata</i> Baker	Shrub	Rare and endemic
<i>Stemona tuberosa</i> Lour.	Herb	Extremely rare
<i>Stereulia roxburghii</i> Wall.	Tree	Rare
<i>Streblus asper</i> Lour.	Tree	Rare
<i>Swertia chirayita</i> Karst.	Herb	Vulnerable
<i>Taxus wallichiana</i> Zucc.	Tree	Critically endangered
<i>Thalictrum foliolosum</i> DC.	Herb	Vulnerable
<i>Thunbergia cucurbita</i> Wall.	Climber	Rare
<i>Valeriana hardwickii</i> Wall.	Herb	Vulnerable
<i>Valeriana jatanamsii</i> Jones	Herb	Vulnerable
<i>Wallichia densiflora</i> Mart.	Tree	Data deficient
<i>Xylia xylocarpa</i> Taub.	Tree	Rare
<i>Xylosma longifolium</i> Clos.	Tree	Rare

Terminalia chebula (18,298 kg/yr), *Passiflora nepalensis* (16,691 kg/yr), *Rauvolfia serpentina* (14,638 kg/yr), *Paederia scandens* (14,038 kg/yr) and *Swertia chirayita* (12,892 kg/yr) are highly consumed medicinal plants at folk healers' level. *Rubia cordifolia* and *Taxus wallichiana* are being exported outside the state (Table 6).

Discussion

The uses of the medicinal plant species varied among different ethnic groups in Meghalaya. According to the nature and acuteness of the ailment, a given species is being used in more than one disease or for curing a particular disease more than one species is being used. For instance, *Cocculus orbiculatus* is used for curing as many as 15 ailments and *Citrus medica* for seven ailments.

The endemic species were mostly restricted to low (100 to 400 m a.s.l.) and mid (400 to 1,600 m a.s.l.) elevation zones of the state. Field observations indicate that these species are mostly restricted to undisturbed habitats and protected areas such as Nokrek Biosphere Reserve, Jowai sacred forests and Raliang sacred forests. However, overuse of such plants in traditional as well as modern medicine system has posed a major threat to these species. Due to high level of exploitation and faulty harvesting techniques, many of the endemic species such as *Acanthus leucostachys*, *Calamus erectus*, *C. aurantium*, *C. latipes*, *Curcuma montana*, *Daphniphyllum himalense*, *Elaeagnus conferta*, *Goniothalamus simonsii*, *Hedera nepalensis*, *Hymenodictyon excelsum*, *Hex embeloides*, *Mahonia pycnophylla*, *Munronia pinnata*, *Nepenthes khasiana*, *Ochna squarrosa*, *Ophiorrhiza sub-capitata*, *Paramignya micrantha*, *Piper peepuloides*, *Schima khasiana* and *Sophora accuminata* have been rendered rare (Haridasan *et al.*, 1995). Therefore, effective conservation measures for these species needs to be adopted to prevent them from extinction.

Table 5. Estimated annual raw drug (medicinal plant parts) consumed through Folk Healers in Meghalaya

Medicinal plant species	Annual raw drug consumption in Meghalaya (kg)			
	Garo Hills	Khasi Hills	Jaintia Hills	Total
<i>Acorus calamus</i> (kynbat ksuid)	-	9,306	-	9,306
<i>Adhatoda zeylanica</i> (diengkhlou)	-	-	1,388.3	1,388
<i>Aegle marmelos</i> (selpri/belethi)	3,136.8	-	-	3,137
<i>Ageratum conyzoides</i> (saphlang ke)	-	-	163.3	163
<i>Allium sativum</i> (rynsun syntiew ner)	-	2,831.4	-	2,831
<i>Alpinia galanga</i> (lakud)	-	2,262.8	-	2,263
<i>Artemisia vulgaris</i> (jaiaw)	-	1,386.0	-	1,386
<i>Asparagus racemosus</i> (memang tamatchi)	5,228.0	-	-	4,356
<i>Averrhoa carambola</i> (amlenga)	1,568.4	-	163.33	1,732
<i>Azadirachta indica</i> (neem)	-	-	1,225.0	1,225
<i>Begonia roxburghii</i> (jagaw)	-	574.2	-	819
<i>Bergenia ciliata</i> (kynbat parnon)	-	2,262.8	-	2,263
<i>Canna indica</i> (kynshiang)	-	1,980.0	-	1,980
<i>Cannabis sativa</i> (bhang)	-	-	163.3	163
<i>Cassia fistula</i> (snaru)	6,979.4	-	-	6,979
<i>Centella asiatica</i> (mana muni)	4,705.2	12,731.4	8,248.3	25,685
<i>Chenopodium ambrosioides</i> (jada)	-	-	408.3	408
<i>Cissus quadrangularis</i> (samritchu)	4,211.1	-	-	4,211
<i>Clematis gonriana</i> (bat bieng doh)	-	5,088.6	-	5,088
<i>Clerodendrum colebrookianum</i>	-	1,702.8	-	1,703
<i>Commelina benghalensis</i> (jataid)	-	1,386.0	-	1,386
<i>Curcuma amada</i> (dike tegatchu)	2,038.9	-	-	2,038
<i>Curcuma zedoaria</i> (holdiasok)	6,979.4	-	2,041.7	9,021
<i>Cyperus rotundus</i> (satuin ke)	-	-	245.0	245
<i>Datura stramonium</i> (tiew shulim)	-	2,831.4	-	2,831
<i>Dillenia pentagyna</i> (tagatchi)	1,568.4	-	-	1,568
<i>Dioscorea bulbifera</i> (bat bteng)	-	851.4	-	851
<i>Drymeria cordata</i> (wai ke)	-	-	490.0	490
<i>Emblica officinalis</i> (ambare)	18,820.8	1,980.0	-	20,801
<i>Eupatorium adenophorum</i> (latnaiong)	-	3,385.8	2,041.7	5,427
<i>Fagopyrum cymosum</i> (jarain)	-	3,108.6	-	3,108
<i>Ficus bengalensis</i> (dienggrri)	-	-	163.3	163
<i>Flacourtia jangomas</i> (darechik budu)	1,307.0	-	-	1,307
<i>Flickingeria fugax</i>	-	1,702.8	-	1,703
<i>Gerbera maxima</i>	-	851.4	-	851
<i>Gynocardia odorata</i> (bolribu)	1,568.4	-	-	1,568
<i>Hedychium coronarium</i> (gong)	5,228.0	-	-	5,228
<i>Hedyotis scandens</i>	-	2,262.8	-	2,263
<i>Holarrhena antidysenterica</i> (bolwatra)	3,136.8	-	-	3,136
<i>Houttuynia cordata</i> (jam yrdoh)	-	-	4,491.7	4,491
<i>Justicia gendarusa</i> (dojagipe)	4,914.3	-	-	4,914
<i>Kaempferia galanga</i> (wakprata)	1,150.2	-	-	1,150
<i>Knema tinifolia</i> (bolanchi)	4,940.5	-	-	4,940
<i>Litsea monopetala</i> (boldokakki / lahambol)	3,136.8	-	-	3,136
<i>Morinda angustifolia</i> (chenong)	6,979.4	-	-	6,979
<i>Mussaenda frondosa</i> (syntu slalich)	-	-	571.7	571
<i>Myrica esculenta</i> (sophie)	-	2,554.2	-	2,554
<i>Nepenthes khasiana</i> (tiew rakot)	-	1,386.0	491.8	1,878
<i>Nicotiana tabacum</i> (duma)	-	-	245.0	245
<i>Oroxylum indicum</i> (kiring)	21,931.4	-	-	21,931
<i>Oxalis corniculata</i> (ladaw ke)	-	-	980.0	980
<i>Paederia scandens</i> (psasim)	1,307.0	12,731.4	-	14,038
<i>Passiflora nepalensis</i> (soh brap)	-	16,691.4	-	16,691
<i>Phlogacanthus tubiflorus</i> (alot)	2,091.2	-	-	2,091
<i>Pinus kesiya</i> (dieng kseh)	-	1,128.6	-	1,128
<i>Piper longum</i> (bat sohmorit)	-	1,386.0	-	1,386
<i>Piper peepuloides</i> (sohmrit khlaw)	-	9,900.0	-	9,900
<i>Pithecellobium heterophyllum</i> (mongnal)	2,091.2	-	-	2,091
<i>Potentilla fulgens</i> (laniang kynthei)	-	9,900.0	-	9,900
<i>Pouzolzia hirta</i>	-	851.4	-	851
<i>Psidium guajava</i> (saptian)	-	-	1,796.7	1,796
<i>Rauvolfia serpentina</i> (dogrikme)	14,638.4	-	-	14,638
<i>Rhus acuminata</i> (bolnicheng)	1,568.4	-	-	1,568
<i>Rhus javanica</i> (sama)	-	-	1,715.0	1,715
<i>Ricinus communis</i> (dieng kastor)	-	-	571.7	571
<i>Rubus rugosus</i> (soh nep bah)	-	1,386.0	-	1,386
<i>Schefflera venulosa</i> (jengjil)	1,150.2	-	-	1,150
<i>Schima wallichii</i> (dieng puh lich)	-	-	408.3	408
<i>Senecio cappa</i> (sla jalich)	-	1,128.6	-	1,128
<i>Setaria palmifolia</i> (syntiew lakot)	-	1,702.8	-	1,703
<i>Stephania hernandifolia</i> (samkusim)	575.1	-	-	575
<i>Swertia chirayita</i> (chirota)	11,763.0	1,128.6	-	12,892
<i>Tamarindus indica</i> (cheeng)	-	862.6	-	862
<i>Terminalia bellirica</i> (chirore)	5,803.1	-	-	5,803
<i>Terminalia chebula</i> (srtak)	18,298.0	-	-	18,298
<i>Tinospora cordifolia</i> (jyrmi khlaw)	-	2,262.8	-	2,263
<i>Viburnum colebrookianum</i> (syntuiap bru)	-	-	81.7	81
<i>Zingiber officinalis</i> (syng)	-	-	408.3	408

Table 6. Estimated annual export of raw drugs (medicinal plant parts) from Meghalaya to outside the state

Market centre from where exported	Medicinal plant species	Quantity per annum (kg)
Damalgre	<i>Terminalia chebula</i>	1,500 (till 2001)
	<i>Terminalia bellirica</i>	
	<i>Emblica officinalis</i>	
Nongstoin	<i>Acorus calamus</i>	1,000
	<i>Taxus wallichiana</i>	1,500
	<i>Centella asiatica</i>	1,000
	<i>Rubia cordifolia</i>	2,500
Diskiangpungsiar, Nonngstoin	<i>Rubia cordifolia</i>	2,000
	<i>Centella asiatica</i>	40
	<i>Rauvolfia serpentina</i>	30

For effective conservation of these species, identification of the causes of threats is a prerequisite for regulation of threat factors. The endemic-rich areas identified in the present study may be considered as priority areas for conservation and thus be protected, and special conservation measures may be introduced. The endemics are generally related to biodiversity rich areas of the state such as Nokrek, Jowai, Raliang, and Shillong. The attachment of these endemic species to such biodiversity rich areas may be due to habitat specificity, plant associations and well protected habitats. Thus, protection of areas with high endemism would also protect many other species growing in that area.

The medicinal plants in Meghalaya are mostly found in wild and there is not much effort for their cultivation. Thus, it is natural that much of the collection in the state has a wild origin. Perhaps *Cinnamomum tamala* is the only medicinal crop that is available from cultivated source. The stakeholders of medicinal plants sector are different, so is the method of collection and processing. As in the rest of the country, the current practices of harvesting of medicinal plants in Meghalaya are unsustainable. Many pharmaceutical companies are also responsible for inefficient, imperfect, informal and opportunistic marketing of medicinal plants. There is a vast, secretive and largely unregulated trade in medicinal plants, mainly from the wild. Such unfair trade continues to grow in the absence of a medicinal plant policy and absence of any regulatory mechanism for extraction of wild medicinal plants, particularly from the community and privately owned forests. Confusion also exists in

the identification of plant materials where the origin of a particular drug is assigned to more than one plant (*Piper longum* and *P. mullesua*). This leads to adulteration of raw materials. All these affect the market both directly and indirectly. Marketability of products is a crucial factor in determining the failure or success of medicinal plant sector. The market outlets in Meghalaya are mostly for local use, although only a few are meant for export. Besides conservation aspects, a clear understanding of the supply related issues and the factors driving the demand and size of the medicinal plants market is a vital step towards medicinal plant development planning.

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