Plant Genetic Diversity of Endemic Species in the Andaman and Nicobar Islands: A Conservation Perspective

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Introduction

Andaman and Nicobar islands possess a distinct identity, not only because of its geography, history and culture but also because of the unique and richest biodiversity of its natural ecosystems and constitute one of the hotspots of biodiversity (N 6° 4' to 13°41' E 92° 12' to 93°57'). The flora is rich because of the close proximity of this archipelago system in the Bay of Bengal lying in north-south direction with 572 Islands and known as 'Green Emerald' and described as 'Islands of the Marigold Sun'. The Andaman group is having an of area 6408 km^2 while Nicobar group is having an area of 1841 km^2 (Map). These Islands are of interest to biologists because of to biologists because of diverse biota and complex bio-geographic features. The combination of complex climatic and physical conditions, extreme topographic relief and broad gradient of biomass provided diverse habitats in which different animals and plants with different evolutionary lineage evolved consequently making Andaman and Nicobar Islands as conservation priority for plant diversity. The growing human population will further increase pressure on this biodiversity in the near future. The present study suggests that conservation priority be given to the endemic plants as well as habitats of primarily evergreen tropical rain forests. In this connection Dhannikhari Experimental Garden cum Arboretum (DEGCA), Botanical Survey of India, Andaman and Nicobar Regional Centre plays an active conservation centre of plant diversity in Andaman and Nicobar Islands. The Garden cum Arboretum is situated 16 km from Port Blair, a site for conservation of RET species. It comprises an area of ca 30 ha. of forest land with 2 ha. of cleared land earmarked for nurseries and multiplication. It represents *ca.* 280 plant species belonging to 180 genera and 75 families of Angiosperms, Gymnosperms, Pteridophytes and Bryophytes.

Map: Andaman and Nicobar Islands

Several studies have measured the genetic diversity of plants on these islands (Parkinson, 1923; Balakrishnan and Rao, 1983; Vasudeva Rao 1986; Ellis, 1987; Rodger & Panwar, 1988; Balakrishnan, 1989; Saldanha, 1989; Lakshminarasimhan and Rao, 1996; Rao, 1996; Mathew, 1998; Dagar and Singh, 1999; Dixit and Sinha, 2001; Srivastava and Rao, 2001; Kameswara et al, 2003; Jagdeesh Lal, 2005; Pandey and Diwakar, 2008; Singh, 2012; Singh and Murugan, 2012b). However, Andaman and Nicobar Islands remain incompletely explored and a large number of taxa are being discovered from the region (Murugan and

Kamble, 2012; Singh and Murugan, 2012a; Singh, 2013b, 2014b; Jagadeesh Ram, 2014).

In recent history, biodiversity in these islands has suffered from heavy natural disasters especially Tsunami and cyclones as well as human disturbances. The local people are poor and have so far relied heavily on natural resources to meet their basic needs e.g. collecting timber as well as non timber forest products for housing, foods, medicines, cash income and fuel wood. In addition, habitats are being fragmented because of the increasing construction of infrastructure for commercial tourism, roads and hydropower projects. Encroachment by the settlers in the forest land has led to the decrease of forest cover. Therefore, there is an urgent need for measures to reconcile the conflicts between biodiversity conservation and local economic interests.

The impact of human activities on the genetic diversity and its conservation is assessed in DEGCA, Botanical Survey of India, Andaman and Nicobar Regional Centre, an active potential centre for conservation of plant species in the Andaman and Nicobar Islands (Singh, 2014a,b) and some perspectives on in situ and ex situ genetic conservation. The present study is to evaluate the major intrinsic and extrinsic factors affecting long-term preservation of plants genetic diversity in the Andaman and Nicobar Islands.

Material and methods

Intensive field survey were conducted in these islands to depict the plant genetic diversity of endemic species along with a conservation perspective in various parts of Andaman and Nicobar Islands and reviewed relevant literature on these aspects. The present conservation status of plant genetic diversity is illustrated here as determined by application of International Union for Conservation of Nature: Conservation Categories and Criteria (IUCN, 2011).

Climate

As these islands are situated in the equatorial belt and are exposed to marine impacts having warm and humid tropical climate, with the temperature ranging between 18°C to 35°C. The islands receive heavy rainfall from both south-west and north-east monsoon, the farmer from May to September later from October to December with the average annual rain fall ranging from 3000 to 3500 mm. Cyclonic winds accompanied by thunder and lightning are very frequent. January to March having fairly dry weather with scanty rainfall. The mean relative humidity is rather high and usually remains between 66% to 85% throughout year.

Vegetation

The tropical wet evergreen forest is seen throughout the Islands on higher altitudes and the moist deciduous forests are found on the slopes. The southern hill-top evergreen forests are seen on hill tops, steep slopes are usually exposed to high winds. Some of the semi evergreen forests also constitute an important part of the vegetation of these islands which includes both deciduous and evergreen species. Forests of mangroves are found along the tidal creeks and outer fringe seaward. The littoral forests are found on alluvial high-level soil beyond the reach of the sea.

Plant genetic diversity in the Andaman and Nicobar Islands

The plant diversity of Andaman and Nicobar Islands comparises 3219 species under 1251 genera and 299 families belonging to Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens and Algae. This data is based on plant collections undertaken during various surveys and historical herbarium specimens as presented in Table 1.

Table 1 : Synopsis of the plant genetic diversity of Andaman and Nicobar Islands

Category	Family	Genera	Species
Angiosperms	178	980	2428
Gymnosperms	3	4	8
Pteridophytes	38	62	142
Bryophytes	18	37	76
Lichens	30	84	383
Algae	32	84	182
Total	**299**	**1251**	**3219**

In addition to above, the plant genetic diversity also comprises of 315 non- indigenous and cultivated species. The plant genetic diversity of Andaman and Nicobar Islands have the highest species diversity which is rather low in comparison to corresponding ratio for

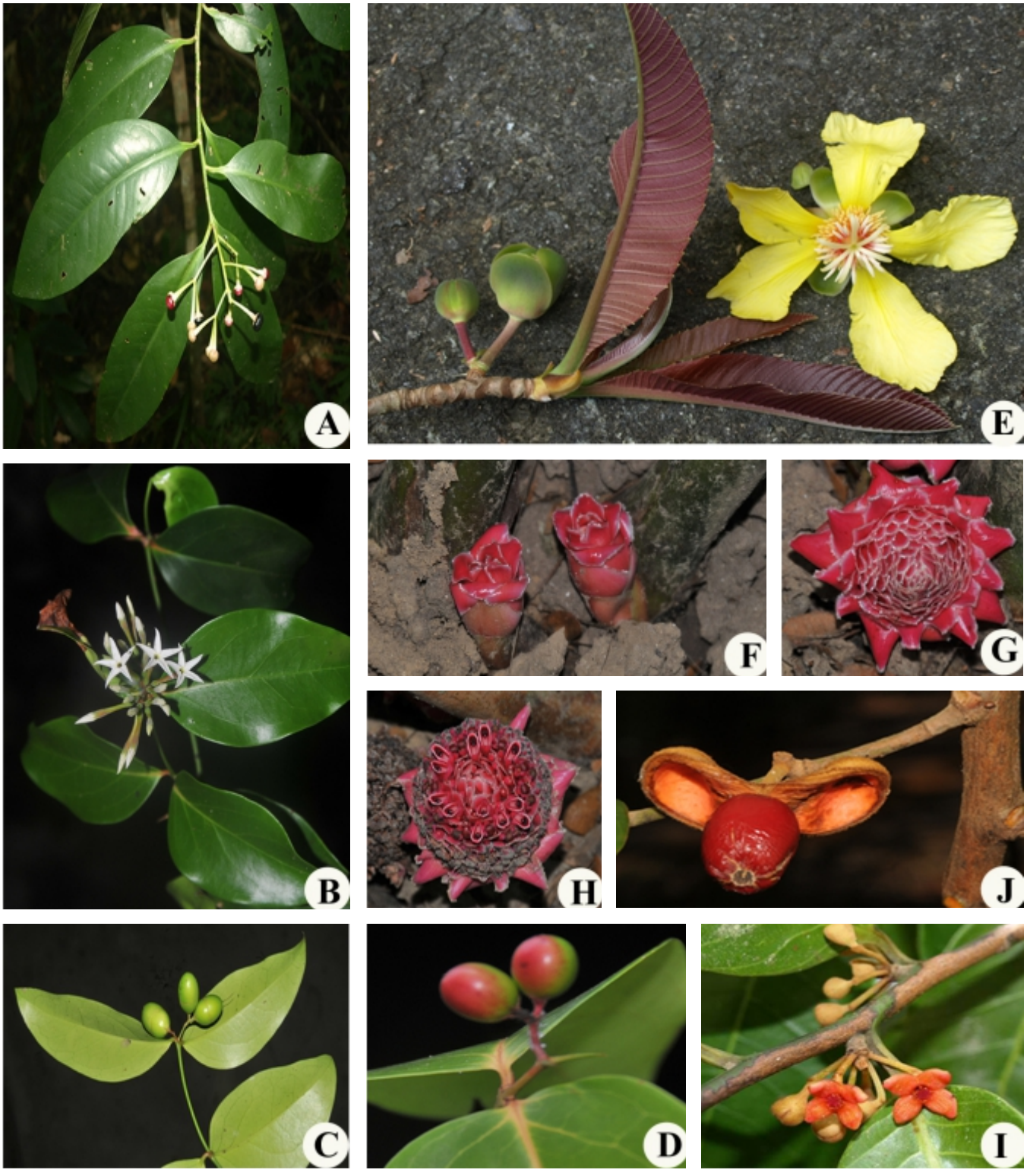

Plate 1 : Endemic plant diversity of Andaman and Nicobar Islands. A : *Ardisia andamanica*-Kurz. B-D : *Carissa andamanensis* L.J. Singh * Murugan. E: *Dillenia andamanica,* C.E. Parkinson. F-H : *Hornstedtia fenzlii* (Kurz) K. Schum. I-J : *Knema andmanica* (Warb.) de Wilde ssp. *andamanica.*

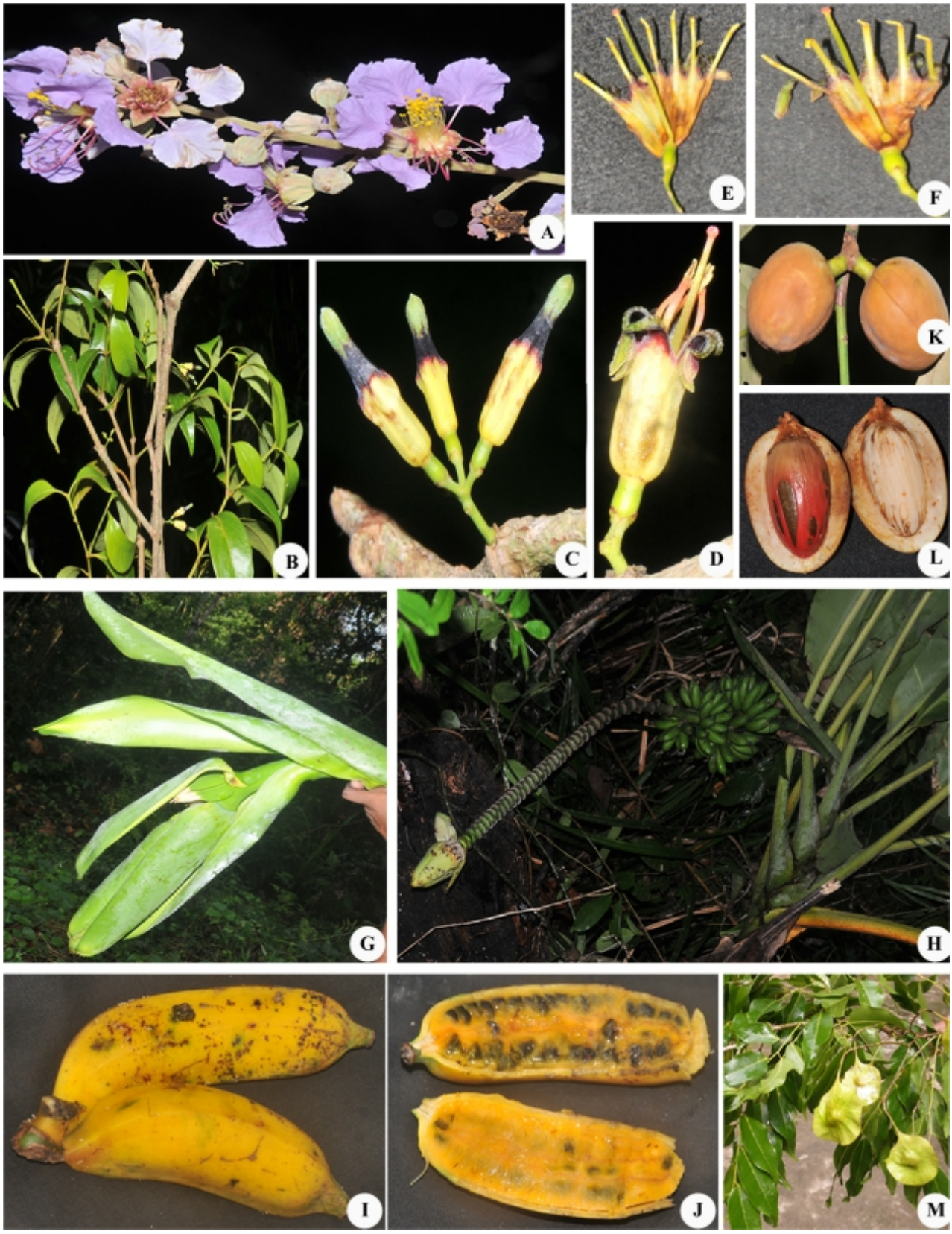

Plate 2 : Endemic plant diversity of Andaman and Nicobar Islands. A :*Lagerstroemia hypoleuca* Kurz. B-F : *Macrosolen andamanensis* L. J. Singh. G-J: *Musa indandamanensis* L. J. Singh . K-L : *Myristica andamanica* Hook. f. M : *Pterocarpus dalbergiodes* Roxb. ex DC.

Table 2. The dominant families in flora of Andaman and Nicobar Islands

Sl. No.	Family Name	No. species	No. Genera
1.	Poaceae	197	80
2	Leguminosae	172	69
3	Orchidaceae	152	63
4	Rubiaceae	147	48
5	Euphorbiaceae	139	41
6	Cyperaceae	115	19
7	Moraceae	66	8
8	Annonaceae	60	20
9	Arecaceae	49	17
10	Meliaceae	36	11

whole of India and shows the small proportion of species to the number of genera and families in this region. It further confirm to the general rule that, within the same floral region, the smaller the flora, the smaller the species genus ratio as presented in Table 2.

Among the dicotyledons, the class Polypetalae shows maximum diversity The largest family of this group is Leguminosae comprising 69 genera and 172 species followed by Annonaceae and Meliaceae. The families represented by single genus and single species are: *Papaveraceae, Bixaceae, Pittosporaceae, Actinidaceae, Linaceae, Erythroxylaceae, Balsaminaceae, Oxalidaceae, Dichapetalaceae, Sabiaceae, Moringaceae, Escalloniaceae, Crassulaceae, Punicaceae, Crypteroniaceae, Turneraceae, Caricaceae, Begoniaceae* and *Datiscaceae*.

The class Gamopetalae finds second place and the largest family of this group and Rubiaceae having 146 species and 48 genera. The families represented by single genus and single species are: Goodeniaceae, Sphenocleaceae, Gentianaceae, Hydrophyllaceae, Orobanchaceae, Pedaliaceae and Symphorematacеae.

The class Monochlamydeae is very interesting to note that it is low diversity among dicotyledons. The largest family of this group is Euphorbiaceae comprising 139 species and 41 genera. The families represented by single genus and single species are: Basellaceae, Chlorathaceae, Monimiaceae, Cassythaceae, Elaegnaceae, Santalaceae, balanophoraceae, Cannabaceae, Casuarinaceae, Salicaceae and Ceratophyllaceae.

In monocotyledons the three biggest families are: Poaceae (197 spp. and 80 genera), Orchidaceae (152 spp. and 63 genera), Cyperaceae (115 spp. and 19 genera). The families represented by single genus and single species are: Costaceae, Sterlitziaceae, Cannaceae, Bromeliaceae, Iridaceae, Taccaceae, Philydraceae, Xyridaceae, Flagellariaceae, Typhaceae, Lemnaceae, Alismataceae and Zannicthelliaceae.

The Gymnosperms are very poorly represented in the area i.e. 8 species belonging to 4 genera and 3 families, which also includes 2 infra specific taxa. The Pteridophytes are quite considerable in this region, comprising 142 species under 62 genera and 38 families, also includes 15 infra specific taxa. Similarly, Bryophytes comprising 67 species under 32 genera and 16 families. Lichens include 383 species in 84 genera and 30 families. Algae is represented by 81 species of sea weeds and 5 species of sea grass.

As per the latest Red list of threatened vascular plant species in India (IUCN, 2011) from Andaman & Nicobar Islands a total of 112 species belonging to 74 genera and 38 families have been mentioned. This includes 78 species in 47 genera and 28 families of dicotyledons, and 32 species in 25 genera and 8 families of monocotyledons.

Endemism

The endemic taxa of Andaman and Nicobar Islands comprising 315 species belonging to187 genera and 74 families. In the above figures the dicots have 229 species under 141 genera and 56 families and monocots comprise 72 species under 38 genera and 12 families and a total of 301 species (179 genera and 68 families) of angiosperms. The degree of endemism is estimated to be ca 10 % of the total flora. However, a total of 315 endemic taxa including four endemic genera within a small geographical area of 8,249 km^2 is a significant feature of the plant genetic diversity.

The endemic diversity among the dicots, family Rubiaceae stands first having 40 species, followed by Euphorbiaceae comprising 33 species and Annonaceae having 17 species. In monocots, *Orchidaceae* comprising 19 species stands first. It is also very interesting to note that all the above four families are also included in ten dominant families of the Andaman and Nicobar Islands. The genera like *Psychotria* (Rubiaceae) having 7 species in dicots and *Calamus* (Arecaceae) having 12

species in monocots are endemic and forms the highest, respectively. The most interesting feature of these Islands flora is four endemic genera *viz. Nicobariodendron* (Hippocrateaceae), *Pseudodiplospora*, *Pubistylus* (Rubiaceae) and *Sphyranthera* (Euphorbiaceae)

Loss of plant genetic diversity in the Andaman and Nicobar Islands

All endemic taxa in the Andaman and Nicobar Islands were evaluated according to IUCN risk categories and criteria (IUCN, 2011). The threat level summary indicates that *Dendrobium tenuicaule* Hook.f., *Eulophia nicobarica* Balakr. & N.G. Nair, *Ginalloa andamanica* Kurz, *Malleola andamanica* Balakr. & Bhargava, *Taeniophyllum andamanica* Balakr.& Bhargava, *Wendlandia andamanica* Cowan are endangered; *Bridelia kurzii* Hook.f, *Hypoestes andamanensis* Thoth., *Litsea leiantha* (Kurz) Hook.f., *Mangifera andamanica* King, Pinanga manii Becc. are considered vulnerable to extinction and *Bombax insigne* Wall. var. *polystemon* Prain, *Buchanania platyneura* Kurz., *Cryptocarya ferrarsii* King, *Dioscorea rogersii* Prain & Burk., *Garcinia cadelliana* King, *Garcinia kingii* Pierre ex Vesque, *Mesua manii* (King) Kosterm., *Nauclea gageana* King, *Prismatomeris andamanica* Ridley, *Psychotria pendula* Hook.f., *Stephania andamanica* Diels, *Syzygium andamanicum* (King) Balakr. are still data deficient.

Threat to plant diversity in the Andaman and Nicobar Islands

Natural disasters are relatively frequent in some area of the Islands and can easily cause local extinction of plant populations. These process often exacerbated by the impact of human activities. The main human threats to plant biodiversity in this locality both directly and in directly. Destruction and fragmentation of natural habitats area the principal cause of species extinction, some localities of Andaman and Nicobar Islands have experiences massive loss of natural habitats in the past, mainly because of tsunami and cyclones but also because of conversion of forests in to residential area. It has meant the permanent replacement of forest, particularly in forest area close to village.

Furthermore, habitat fragmentation may convert a previously more continuous population structure to a meta population structure with local populations becoming so small that they may face a substantial threat of extinction. For example, *Carissa andamanensis* L. J. Singh & Murugan, *Lagersteemia hypoleuca* Kurz, *Mangifera andamanica* King, Pterocarpus dalbergioides Roxb., other such as *Musa indandamanensis* L. J. Singh, facing a potential risk of extinction because of over collection for their manifold value.

Some of the species viz. *Rauvolfia sumatrana*, *R. canescens*, *Thottea paucifida*, *T. tomentosa*, are not only local endemic taxa but have been included in the list of plants that need to be conserved due to relatively scarce populations. They should therefore be considered threatened plants when establishing future conservation priorities because of their extremely restricted distribution. The over exploitation of species of economic interest may seriously threaten plant survival. Some valuable medicinal plants are dwindling in wild habitats because of over collecting; moreover, despite wide spread cultivation of some species in the area, wild population of these species remains severely depleted both in number and size.

In addition to medicinal plants, non-timber forest products have been also subjected to over exploitation, for their horticultural value. According to Singh (2014b) the over exploitation by local people for manifold value and disappearance of mixed forest habitat leading to threats of wild Musaceae: *Musa acuminata* Colla, *Musa balbisiana* Colla var. *andamanica* Singh, Sreekumar, Sharma and Bandyopadhyay and *Musa indandamanensis* L.J. Singh and considered critically endangered and threatened based on IUCN Red List Categories and Criteria (IUCN, 2011).

Timber production is a direct threat to the dominant trees in the evergreen broad level forests because this activity is focused mainly on the species like *Diospyros manrmorata*, *Dipterocarpus griffithii* Miq., *Lagerstroemia hypoleuca Kurz*, *Pterocarpus dulbergioides* Roxb., *Terminalia bialata* Steudel, and *Teterameles nudiflora* R. Br.

In addition, a rapidly warming climate appears to be threatening plant biodiversity in these Islands. According to Singh (2013b) like many other coastal countries, in the Andaman and Nicobar Islands mangrove ecosystems are under severe pressure from natural and anthropogenic causes. Various forms of anthropogenic pressures threaten these natural resources. A lack of understanding of the value and significance of mangrove forests, with reference to their role in sustaining environmental support system of

coastal areas, the maintenance of coastal biodiversity and livelihood security of coastal communities are leading to the destruction of these natural resources. Anthropogenic responses to climate change have the potential to exacerbate the adverse effects of climate change on coastal ecosystems. To date, relative sea-level rise has likely been a smaller threat to mangroves than non-climate related anthropogenic stresses, which have likely accounted for most of the global average annual rate of mangrove loss, estimated to be 1–2%. A great challenge therefore lies in the protection of this unique ecosystem while safeguarding the livelihood security of coastal people not only in Andaman and Nicobar Islands, also at global level.

Prospects for plant genetic conservation in the Andaman and Nicobar Islands

DEGCA, Botanical Survey of India, Andaman and Nicobar Regional Centre is an active potential centres for conservation of plant species in the Andaman and Nicobar Islands (Singh 2014b). Since its establishment in the year, 1972 there have been substantial efforts to establish ex situ and in situ conservation programs at DEGCA directed towards protection of genetic diversity in Andaman and Nicobar Islands. Approximately 95% of the area of the DEGCA is protected as a part of *in-situ* conservation and 2 ha cleared land for raise nursery and multiplication of RET species and especially to protect particular endemics as a part of *ex-situ* conservation. In addition, protected areas under supervision of Department of Forests, Andaman and Nicobar Islands are one of the most effective tools for safeguarding biodiversity *in-situ* stage. The total recorded forest area of the islands is 0.72 million ha which constitutes 87% of the land area. The Reserved and Protected Forests constitute about 40% and 60% respectively. Considering that strict and narrow endemic species are restricted to small areas and that they are therefore highly vulnerable to human disturbance and other forms of environmental change. It is important to study their habitats for any conservation initiatives.

Conclusion

Plant genetic diversity in these Islands has suffered from heavy natural calamities and anthropogenic pressure. Although, hotspots are natural laboratories for studies of plant systematic and ecology. One feature of the floras of Andaman and Nicobar Islands is the **high number of endemics occurring in small areas**. According to Severin and Beierkuhnlein (2011) endemic species display a strong dependency on climatic conditions as a consequence of their limited distribution. Under such circumstances, environmental changes may cause not only the extinction of local populations, but of whole species. Thus, climate change can be considered a potential threat to island biodiversity. More recently, Singh (2013b) stated that like many other coastal countries, in the Andaman and Nicobar Islands mangrove ecosystems are under severe pressure from natural and anthropogenic causes. Various forms of anthropogenic pressures threaten these natural resources. A lack of understanding of the value and significance of mangrove forests, with reference to their role in sustaining environmental support system of coastal areas, the maintenance of coastal biodiversity and livelihood security of coastal communities are leading to the destruction of these natural resources. Anthropogenic responses to climate change have the potential to exacerbate the adverse effects of climate change on coastal ecosystems. To date, relative sea-level rise has likely been a smaller threat to mangroves than non-climate related anthropogenic stresses, which have likely accounted for most of the global average annual rate of mangrove loss, estimated to be 1–2%. A great challenge therefore lies in the protection of this unique ecosystem while safeguarding the livelihood security of coastal people not only in Andaman and Nicobar Islands, also at global level. Although not all endemic taxa in Andaman & Nicobar Islands are immediately threatened for extinction. Some are known so far only from the type collection or from a few collections made in the type locality e.g. *Wendlandia andamanica, Dendrobium gunnari, E. nicobarica*, *Chionanthus palembanicuss*, etc.

The floras of oceanic islands are characterized by the high number of endemics occurring in small areas. Adaptive radiation into diverse habitats and genetic drift are often considered to be important factors producing such extensive speciation (Crawford *et al.*, 1987; Baldwin *et al.*, 1998). Oceanic islands also provide many well-known examples of species extinctions caused primarily by the negative impact of humans (Olson, 1989; Rieseberg and Swensen, 1996; Cronk, 1997; Maunder *et al*, 1998; Stuessy *et al.*, 1998; Raven, 1998).

The present study provide important information about the conservation value of endemic taxa as well as the habitats in this area, the endemic plants and the habitat of evergreen tropical rainforest, mixed forest to which conservation priority should be given. This information is essential for decision making process concerned with biodiversity conservation and sustainable natural resources management in these islands. In terms of protection and maintenance, endemics are seen as a hallmark of local biodiversity (Kessler, 2000). **More over endemism is commonly regarded** as an **important criterion** for the **conservation priority of particular area**, one considered more useful than species richness (Myers *et al.*, 2000; Kier & Barthlott, 2011; Rong *et al.*, 2011.)

The origin of conservation was rooted in a general concern to protect nature because of its intrinsic and aesthetic values. However, although this it is still important in recent decades that it has become apparent that we should conserve the natural world for reason of enlightened self interest for the continued survival and well being human kind. The past decades has been marked by increasing global awareness of richness and diversity of our botanical heritage, its value to humanity and the need for active conservation in face of the rapidly acceleration impact of human development. The United Nations conservation of Biological Diversity (UNCBD) recognized that botanic gardens have both an opportunity and responsibility for significant involvement in conservation. However, in India there has been a culture of gardens since immemorial time. These are an inverse correlation between the number of botanical gardens and arboreta, and the richness of flora. In this connection botanic gardens form an effective network for conservation of biodiversity and utility besides their role in maintaining ecological balance preventing environmental degradation. In Andaman and Nicobar Islands most efforts like raise nursery and transplantation as a part of *ex-situ* genetic conservation via seed banks have been undertaken in the DEGCA (Singh & Murugan 2013c, Singh 2014a,b). Therefore, such type of conservation efforts might be the best strategy for conservation and preservation of threatened plant genetic diversity.

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