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On floristic diversity of Andaman-Nicobar Islands with special reference to insular germplasm conservation outside the islands

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Abstract

"Islands are an enormously important source of information and an unparalleled testing ground for various scientific theories. But this very importance imposes an obligation on us. Their biota is vulnerable and precious. We must protect it. We have an obligation to handover these unique faunas and floras with a minimum of loss from generation to generation." (Ernst Mayr, 1967). The Andaman-Nicobar Islands in the Bay of Bengal is a unique transitional biogeographic zone between the South and Southeast Asia. The article is detailed with floristic uniqueness, diversity, multi-dimensional phytogeographical affinities, threat and endangerment on insular flora of the Andaman-Nicobar Archipelago along with the relevance and efforts on insular germplasm conservation outside the islands.

Introduction

Tropical insular biology has always been remarkable for diversity, speciation and endemism. Insular species are usually characterized by small gene pool, geographical isolation, reduced out breeding and sever competition. These insular characteristics along with natural calamities generate rigorous biotic pressure on insular species which lead to natural deathtraps of island populations. During the past few decades, endangerment of species has become a global crisis, mostly ascribed to anthropogenic activities rather than the natural causes. Tropical insular habitats are mostly have remarkably fragile ecological equilibrium and under strict competition among species, populations and communities. Even a minor ecological alteration will be possible to make serious impact on insular equilibrium and may cause severe damages to the growing stocks. Insular endemics are highly susceptible towards extinction for the reason that they are characterized with small gene pool and least possibility for out breeding even between inter island populations owing to geographical isolation. An assessment on endangerment recorded that destruction of an insular 'keystone species' may destroy up to thirty dependent biological taxa from the insular habitats.

The Andaman-Nicobar islands in the Bay of Bengal have a unique floristic status in phytogeography. From phytogeographical point of view, the insular flora is remarkable as the transitional zone vegetation between the South Asia and Southeast Asia. From economic point of view, this insular floristic region is known to host many economically important timber species, rattans, reeds, medicinal species, insect repellant species, wild relatives of crop plants as well as wild prototypes of popular cultivars (*Cocos nucifera, Areca catechu* etc) and ultimately several lesser known potentially useful ethnobotanical endemic species. Nevertheless, most of the insular elements are scientifically least explored or studied, especially the endemics allied to popular medicinal species in various Indian traditional systems of medicine like *Ayurveda, Sidha, Unani* etc. Similarly, ethnobotanical

medicinal species used by the aboriginals of Andaman-Nicobar islands for various ailments are also waiting for modern phytochemical screening and bioprospecting.

The Andaman-Nicobar Islands

Andaman-Nicobar Islands, the Indian Archipelago in the Bay of Bengal once dreaded as the islands of death, are significantly affluent of dense natural heritage of tropical rainforests. This archipelago comprises about 556 islands, islets and rocks located between the latitudes 6^0 to 14^0 North and the longitudes 92^0 to 94^0 East, about 647 nautical miles away from the Coromandel Coast of the Peninsular India towards east. The Andaman and Nicobar group of islands constitutes approximately 8249 sq km of fragmented land masses stretching over a length of about 912 km with total coastal line of 1962 km and maximum width of 57 km in the Bay of Bengal (Anonymous, 2012). Landfall Island and Great Nicobar Island demarcate the northern and southern extremities of the Andaman-Nicobar Archipelago. The two volcanic islands, *viz*. Narcondom Island and Barren Island, demarcate the eastern boundary while Interview Island and Sentinel Islands delimit the western extremity.

The Andaman Sea is the name designated to the portion of Indian Ocean that lies enclosed between the coast of Myanmar and Malay Peninsula in north and south and the Andaman-Nicobar Archipelago at the other end. The northernmost Landfall Island is about 190 km away from the mainland of Myanmar and the southernmost end of Great Nicobar Island, the Indira Point (earlier named as Pigmalion Point) was submerged as the consequence of the *tsunami* waves in 2004, is about 150 km far from Sumatra Island of the Indonesian group. The Andaman group of islands separated from the Nicobar group by the deep see designated as 10^0 Channel having a depth of about 400 fathoms. The Preparis Channel with a depth of a little more over 100 fathoms demarcates the Andaman Archipelago in north from the Myanmar and the deep Great Channel probably with a depth of 800 fathoms between the Great Nicobar and Sumatra Island isolates Nicobar Islands from the Indonesian Islands. The Andaman group of islands forms a compact chain of islands and islets while the islands in the Nicobar group occur far separated from one another.

The Andaman Archipelago consists of four major groups of islands such as North Andamans, Middle Andamans, South Andamans and the Little Andaman. The former three groups are collectively known as Great Andamans. There are four narrow straits or channels separates the major island in the Andaman group more or less in a north-south direction. They are Austin Strait between North and Middle Andaman, the Homfray's Strait between the Middle Andaman and Baratang Island, the Middle Strait between Middle and South Andaman and finally the Macpherson Strait between South Andaman and Rutland Island. The Little Andaman, the southern extremity of the Andaman Archipelago, is separated from the South Andaman by Duncan Passage. The biggest island in this group is South Andaman Main Island (2021 sq km) and smallest is the Aves Island (0.2 sq km). As regards the Nicobar group of islands, Car Nicobar Island and Battimalv Island comprise the northern group followed by the central group of eight major islands such as Tillanchong, Choura, Teressa, Bompoka, Katchall, Kamorta, Nancoury and Trinkat Islands respectively. The southern group constitutes Little Nicobar, Kondul and Great Nicobar Islands. The general topography of these islands are very irregular and undulating with hills and steep narrow valleys except a few flat islands (Car Nicobar and Choura) in Nicobar group of islands. The irregular deeply indented coastal lines result in many serpentine creeks and handsome coves.

The Andaman-Nicobar Flora and Vegetation (Fig. 1)

"The forest in its pristine glory, if found anywhere in Southeast Asia, it is in the Andaman Islands", commented on the Andaman flora by the renowned phytogeographer, Sir H.G. Champion indicates the diversity and richness of the Andaman forests during 19^{th} century. The range of plant wealth, its diversity and bioprospecting of wild species have important role in the national wealth of any country. Floristic diversity of the Andaman-Nicobar Islands has become a matter of curiosity since the latter part of 19^{th} century and initiated taxonomical enumeration by European botanists (Kurz, 1877; Prain, 1891; Parkinson, 1923) followed by the Indian botanists from the Botanical Survey of India (Vasudeva Rao, 1986; Lakshminarasimhan & Rao, 1996 ; Mathew, 1998; Dagar & Singh, 1999; Dixit & Sinha, 2001; Rao *et al*., 2003; Lal, 2005; Pandey & Diwakar, 2008; Lakshminarasimhan *et al.,* 2011, Murugan *et al.,* 2016). According to recent enumeration by Murugan *et al.* (2016), the floristic combination of Andaman-Nicobar Islands encompass a sum of 2649 plant taxa, comprising 2508 species, 32 subspecies, 103 varieties and 6 forma

under 1109 genera in 238 families belonging different plant groups such as Bryophytes (mosses), Pteridophytes, Gymnosperms and the Angiosperms. The predominant Angiosperms group consists of 2314 species, 31 subspecies, 89 varieties and 6 forma under 1011 genera in 181 families, constituting around 92% of entire flora of the Andaman and Nicobar Islands.

The climatic climax vegetation of Andaman-Nicobar Islands is characteristically tropical lowland rainforests could be designated as "humid tropics" ranging from sea level to an altitude up to 732 m at Saddle Peak, which cover an area of 80.76% of the total land mass (Anonymous, 2009). The tropical warm and humid climate with an average temperature of 32^{o} C along with relative humidity of about 82% and strong influence of both Southwest and Northeast monsoons with an average annual rain fall of about 3200 mm encourage the luxuriant growth of rainforests. The Andaman rainforests, seemingly rather undisturbed among most of the uninhabited islands and are in a state of fragile equilibrium. There are two volcanic islands *viz*. Narcondom Island and the Barren Island in the archipelago. According to Williamson (1981) volcanic islands are typically steeper and become increasingly dissected with age. This has significant implications for island biota because a wide range of altitudinal gradients and associated ecological attributes allows for the persistence of diverse ecological niches.

The dense natural vegetation of the Andaman-Nicobar Islands was studied by Puri in 1960 and classified into different types such as mangrove forests vegetation including the beach forests, Andaman moist deciduous forests, southern tropical semi evergreen forests and riverine forest. Champion and Seth (1968) classified the insular vegetation in detail; nevertheless, some of the forest types classified by Champion and Seth may not be distinct on casual observation because they imperfectly merge into one another in nature. According to Kurz (1876), the geological findings on Nicobar Islands are incredibly substantiating the general pattern of vegetation and distribution of botanical entities. The southern group of islands have rainforest clad from the sea level to the hill top; while occurrence of forests among northern group of islands are limited to the plutonic rocks and towards the slopes and dells of the older alluvium along with grasslands on hilly plateaux and ridges as climax vegetation. Balakrishnan (1989) and Mathew (1998) also classified types of vegetations occurring in Andaman-Nicobar Islands. The insular vegetation of the Andaman-Nicobar Islands can be broadly differentiated into two kinds based on the proximity of sea such as costal or littoral vegetation and inland vegetation.

The Coastal or Littoral vegetation occurs along the sandy and rocky coastal belt of the Andaman-Nicobar Islands. The coastal vegetation consists of four distinct groups of plant communities and has been categorized into marine aquatic vegetation, mangrove vegetation, subtidal vegetation and beach forest principally based on their specific habitats and floristic compositions.

The inland forest vegetation referred to the pristine forests types occurring behind the littoral forests. It has been further classified into several types based on factors soil type, rain fall, micro climate, altitude etc. There are 10 different types of inland vegetations found to occur in Andaman-Nicobar Islands other than minor types of formations. They are Giant evergreen forests, Andaman tropical evergreen forests, Southern hilltop evergreen forests, Semi evergreen forests, Moist deciduous forests, Cane brakes, Bamboo brakes, Grassland vegetations, Inland aquatic vegetation and manmade vegetation.

Phytogeography and floristic affinities (Fig. 2)

The origin of an insular flora depends on various factors like geological genesis of the island, (continental or oceanic) possible sources of immigration of plant species to the insular habitats from near and far landmasses, geographical location (tropical/subtropical/temperate), and climetological features. Relative floristic evaluation of the Andaman - Nicobar Archipelago with that of other major landmasses far-off and nearer reveals intriguing phytogeographical affinities. Geological origin of the Andaman-Nicobar Islands is strongly supporting its continental connection with the Arakan-Yoma Mountain ranges of the Myanmar and these Islands are considered as the emergent peaks of a submerged mountainous range in continuation with the Arakan-Yoma Mountains of the Myanmar to Moluccas Island of the Indonesia (Ridley 1930).

Phytogeographic classification made by Hooker (1906) also supporting the floristic affinities of these islands towards the Southeast Asian botanical elements. Hooker classified Myanmar and Andaman group of Islands together and Malay Peninsula from Kedah to Singapore together with Nicobar group of islands in the eighth and ninth positions in his phytogeographic division of the

Indian subcontinent. The floristic evaluation also supports earlier geological connection between these islands and major land masses of South and Southeast Asia by exhibiting maximum affinities. The Andaman flora obviously exhibits affinities towards the floristic regions of Myanmar and Northeast India in the north, Thailand and Malay Peninsula in the east and also link with Malesian floras like Indonesia, Philippines etc. However, the Nicobar flora predominantly demonstrates maximum affinities towards Malesian flora rather than Southeast Asian elements (Balakrishnan & Ellis 1996). More precisely, the flora of the Andaman-Nicobar Islands is the transitional zone vegetation between the Indo-Malesian floristic regions. As regards to Indian flora, the Andaman-Nicobar biogeographic zone is a stronghold for several Malesian species as extra Indian species within the Indian territory.

The phytogeographical affinities of Andaman-Nicobar Islands show very interesting features. According to Takhtajan (1986), the phytogeography of the Andaman-Nicobar Islands is definitely distinct from the Indian subcontinent. He has classified phytogeography of the Andaman Islands as a province under Indo-Chinese region; while, the Nicobar group of Islands is demarcated under Malesian region. Melville (1973) suggests the islands in the Indian Ocean were formerly fractions of Gondwana Continent during the Paleozoic and Mesozoic periods.

Being a 'Continental Island', the degree of endemism in Andaman-Nicobar Islands is apparently insignificant when compared with 'Oceanic Islands'. The insular endemics comprise 314 taxa which include 300 Angiosperm taxa beneath 179 genera belonging to 68 families, 06 species of Pteridophytes under 03genera belonging 03 families and 08 species of Bryophytes beneath 05 genera belonging to 3 families. The Andaman-Nicobar Angiosperm flora demonstrates around 13% of endemism coupled with multi-dimensional floristic affinities towards nearer and distant geographical regions such as Northeast India, Southeast Asia, Malesia and even to Western Ghats of the Peninsular India and Sri Lanka. There are several insular Angiosperm taxa sharing their endemism with their ancestral Burmese and Indonesian floras (disjunct distribution) by extending their natural occurrence towards these regions outside the islands but not elsewhere in the world except Sri Lanka (e.g. *Mimusops andamanensis*). *Begonia andamensis* is another example of an endemic species that confined the natural occurrence to Andaman Islands and some provinces of its continental parental land mass of Myanmar. According to latest enumeration by the Botanical Survey of India 300 Angiosperm taxa are endemic to the region. It includes three genera such as *Nicobariodendron, Pseudodiplospora* and *Sphyranthera* (Murugan *et al,* 2016)**.** The Western Ghats of Peninsular India and the Andaman-Nicobar Islands have remarkable similarities in climetological features and distribution of floristic elements even up to generic level. The disjunct distribution of endemic plant taxa among Andaman-Nicobar Islands, Sri Lanka and Peninsular India (Western Ghats) are quiet interesting phytogeographical affinities of the Andaman-Nicobar Islands. The genus *Bentinckia* demonstrates disjunct distribution with two endemics being the former in Southern Western Ghats (*Bentinckia condapanna*) and the latter in Nicobar Islands (*Bentinckia nicobarica*). Similarly, *Mimusops andamanensis* is another example of an endangered endemic species common for Andaman-Nicobar Islands and Sri Lanka (Mathew, 2015). The island flora of the Andaman-Nicobar has striking similarities with the floristic elements of the Western Ghats of the Peninsular India, even though, these regions are widely separated by the Bay of Bengal. According to a recent assessment by Mathew (2015), there are 1026 common species for the Andaman-Nicobar Islands and the Western Ghats of the Peninsular India. The common occurrence of several Angiosperms and Gymnosperms (e.g. *Nageia wallichiana Cleidion nitidum*, *Polyalthia rufescens, Salacia reticulata, Dendrobium macrostachyum* etc) among Andaman-Nicobar Islands, Sri Lanka and Peninsular India (Western Ghats), also reinforces Melville's (1973) hypothesis. In this context, it would also be relevant to mention about van Steenis' (1962) 'Land Bridge Theory in Botany'. *Corymborkis veratrifolia, Cymbidium aloifolium, C. bicolour*, *Dendrobium macrostachyum*, *Geodorum densiflorum*, *Nervilia aragoana*, *N. plicata*, *Oberonia iridifolia*. var. *denticulate*, *O. mucronata*, *Pholidota imbricata*, etc are good examples of disjunct distribution between Andaman-Nicobar Islands and the Western Ghats (Mathew, 2015).

The most remarkable feature in the floristic distribution of these islands is the disjunct distribution of several species between the Andaman group and the Nicobar group. Several flagship species of the Andaman forests (e.g. *Pterocarpus dalbergioides*, *Dipterocarpus* spp.) are curiously not found among the islands of Nicobar group. It has also been noticed that several endemic species occurring in Andaman group of

islands not extended their distribution towards Nicobar Islands (e.g. *Pinanga andamanensis, Korthalsia rogersii, Phoenix andamanensis etc.*). Similarly other Malesian and Southeast Asian species like *Ancistrocladus tectorious, Pometia pinnata, Caryota mitis, Licuala peltata* etc., which are common among the Andaman group of islands, are totally absent among the Nicobar group. *Bentinckia nicobarica, Rhopaloblaste augusta, Cyrtandra burttii* etc., are a few examples of endemics exclusively occurring among Nicobar group of Islands. There are certain taxa common to both groups of islands up to generic level. The genus *Podocarpus* is represented by two species in Andaman-Nicobar Islands. *Podocarpus wallichianus*, an endangered Gymnosperm species reported from Great Nicobar and South Andamans (Mount Harriet), while *Podocarpus neriifolius* confined to Andamans. The Great Nicobar Island, the southernmost island in this archipelago, demonstrates outstanding dissimilarity with Andaman group of islands even at family level. Several families well represented among the Andaman group of Islands such as Polygalaceae, Simaroubaceae etc are totally absent in the Great Nicobar Island. The dissimilarity in floristic distribution between the Andaman and Nicobar group of islands may be logically explained by the relative geological genesis of these two island groups. The separation between the Andaman and Nicobar groups might certainly be earlier than their respective separations from the Myanmar in the north and the Sumatra Island of Indonesia in the south. According to Sewell (1839), these two groups of islands were separated during the Triassic period of the Paleozoic era, while their separations from the continental land masses of Myanmar and Sumatra were in Cretaceous (Renvoize 1979). According to another school of thought, the Andaman group and the Nicobar group of islands are the emergent peaks of two different ranges of mountain systems (Rink, 1847) referred to as *".... partly of those stratified deposits which occupied the level bottom of the sea before their appearance, partly of plutonic rocks which pierced through the former and came to the surface through that upheaval.....*

The floristic affinities of this insular biogeographic zone in the Bay of Bengal spread towards many distant geographic regions such as Indo-Pacific regions, Indo-Malesian regions, Indo-African regions and Neo-tropical. *Asplenium nidus, Cyperus pedunculatus, Dodonaea viscosa, Hernandia peltata, Heritiera littoralis, Morinda citrifolia*, *Scaevola sericea, Rhizophora stylosa* etc., are a few examples of insular floristic elements sharing affinities towards the flora of Indo-Pacific regions. *Cynometra iripa, Guettarda speciosa, Lumnitzera racemosa, Sonneratia griffithii* etc., are some insular species sharing affinities towards Indo-Malesian floristic region. *Calophyllum inophyllum, Ximenia americana, Lannea coromandelica* etc., are Indo-African floristic elements found to occur among the Andaman-Nicobar Islands and *Cordia subcordata* is a Neo-tropical element occurring in these Islands.

van Steenis (1962) formulated 'The Land Bridge Theory in Botany' based on a floristic distributional pattern that include Africa/ Madagascar, the Seychelles, India/Sri Lanka and Western Malaysia. In his land bridge hypothesis, van Steenis, emphasize that *"there must have been an isthmian connection between Madagascar and Ceylon (Sri Lanka) over the Seychelles-Comores bank"* operating during the middle to upper Cretaceous, which he named as '*Lemuria*'. However, contemporary knowledge regarding the geological history of the Indian Ocean disproves van Steenis hypothesis, both the timing and existence of such a direct land route (Mckenzie & Sclatern, 1973); nevertheless, the distributional pattern still stands, and for some taxa also includes China, Japan, and Eastern Malaysia. Rao & Chakraborti (1987) also highlighted the floristic affinities of the littoral species of Andaman-Nicobar Islands towards Indo-African, Indo-Pacific and Indo-Malesian regions undoubtedly hallmark its Gondwanaland connections in the remote past.

Wild occurrence of popular cultivars (Fig. 3)

Interestingly, the insular rainforests of the Andaman-Nicobar Islands are known to host wild prototypes of a few popular cultivars like Betle vines, Betelnut palms and Coconut palms. The insular biogeographic zone of the Andaman-Nicobar Islands is considered to be one of the centres of origin of a few economically important popular cultivars like *Cocos nucifera, Areca catechu* and *Piper betle*. Wild populations of coconut palms are found to occur among the various uninhabited islands in Andaman-Nicobar Archipelago. The occurrence of wild coconut palms was first reported by Prain (1891) from the Coco Island (presently under the jurisdiction of Myanmar) very near to Landfall Island of the North Andaman group. Later Balakrishnan & Nair (1979) also reported wild populations of coconut palms from the uninhabited South Sentinel Island of the South Andaman group and Teressa Island, Car Nicobar Island, Tillangchang Island, Katchal Island, Little Nicobar Island and Kamorta Island of

the Nicobar group. Further, Mathew and Abraham (1990) reported wild populations of coconut palms in the North Reef Island of the North Andaman group, while carrying out explorations for the `Flora of India Project' of the Botanical Survey of India. The self-sown wild populations of coconut palms occurring in Nicobar group of islands may probably appear to be a coconut plantation on its first sight. The wild occurrence of coconut palms in many uninhabited islands in this archipelago over a century ago suggests these islands may probably be a centre of origin of coconut palms. Evidence supporting this hypothesis is the association of wild coconut palms with an indigenous crab popularly known as 'Robber Crab' (*Birgus latro*). A mature crab which may weigh up to 06 kg would be able to drag a weight up to 03 kg and it is said to feed upon coconuts after hammering open the coconut shells. However, the 'robber crabs' are not exclusive feeders on coconut for their survival. In fact they are omnivorous creatures and consume small arthropods and fruits of littoral plant species. Interestingly, the existence of this crab is being noted in all coconut growing uninhabited islands of the Andaman group.

Very interestingly, wild populations of *Areca catechu* are reported to occur along the west coast of the Great Nicobar Islands. Wild occurrence of *Areca catechu* was first reported from Great Nicobar Islands by Kurz in 1876. Balakrishnan & Nair (1979) also had reported wild populations of betelnut palms from the Great Nicobar Island. Nevertheless, wild population of *Areca catechu* has not so far been reported anywhere from the Andaman group of Islands. The occurrence of wild betel vines and their variants are also found to occur among the Andaman-Nicobar group of Islands. Sreekumar & Ellis (1990) has reported six different variants of *Piper betle* from Great Nicobar Island also remarkable in the floristic studies of these islands. The Field Gene Bank of JNTBGRI is conserving 11 accessions of wild forms of Betel vines from the Andaman- Nicobar Islands. The wild occurrence of these cultivars among the uninhabited islands of Andaman-Nicobar Archipelago known to occur since the latter part of 19th century indicates the hypothesis that these regions may be one of the probable centres of origin of these popularly known cultivars.

Economic importance of the insular flora (Fig. 4)

The bioprospecting of several insular taxa that are being successfully used by the primitive insular aboriginals for their various needs are still to be evaluated. There are several insular endemics, allied to popularly known medicinal species used in traditional Indian systems of medicines like *Ayurveda, Sidha, Unani* etc, are still waiting for bioprospecting and biochemical analysis. Detailed studies on the economic potential of insular endemics, especially the ethnobotanical species, in the field of drug and pharmaceuticals would certainly be rewarding. The insect repellant properties of *Etlingera fenzlii* used by *Shom Pen* tribe of Great Nicobar Island and *Orophea katschallica* used by *Onges* of Little Andaman Island as bee repellant plants for honey collection are intriguing examples of insular endemics having promising significance in the field of biopesticides. Similarly, *Amorphophallus longistylus*, *Dioscorea vexans*, *Garcinia andamanica*, *G. cadclliana*, *G. calycina*, *G. dhanikhariensis*, *G. kingii*, *G. kurzii*, *G. microstigma*, *Musa sabuana*, *M. balbisiana* var. *andamanica*, *Jasminum andamanicum*, *Myristica andamanica*, *Phoenix andamanensis*, *Oryza indandamanica*, *Vanilla andamanica*, *V. sanjappae, Zingiber pseudosquarrosum etc.* are a few examples of wild endemic germplasm related with popular cultivars, may certainly have remarkable significance in horticulture and plant breeding. There are several indigenous and endemic species of *Calamus, Daemonorops* and *Korthalsia* have much economic value in cane industry. *Calamus andamanicus* and *C. longisetus* are common insular endemics and proved as best cane species in cane industry. *Gigantochloa andamanic*a, another common insular endemic is one of the best reeds, demarcated as a vegetational type by Champion and Seth (1968). There are several lesser known endemic medicinal species with remarkable medicinal properties, (*Alstonia kurzii, Canarium euphyllum, Knema andamanica, Paramignya andamanica, Ophiorrhiza nicobarica, O. infundibularis*) used by the tribes and settlers of the islands for their health care may certainly have promising potentials in the field of modern drugs and pharmaceuticals.

As regards to non-indigenous species of the Andaman-Nicobar flora, David Prain (1891) had made a detailed survey for a period of over four years. He has recorded 123 species in 1866 brought by design and another 61 species as weeds introduced unintentionally along with food grains etc from Andaman Islands. The resurvey by Prain in 1889-1890 an addition of 44 species has been added to the former group, while the latter with 54 species. Pandey & Diwakar (2008) had enumerated approximately 315 Angiosperm taxa as non indigenous species including several cultivars. The insular cultivars of rice and coconut

include several land races also. The rice variety has several landraces from mainland India, Thailand, Malaysian, Burmese and Chinese origin under various local names such as *Jungle dhan, Chinese dhan, Jeera chamba, Black jeera dhan, Black Burma, White Burma, Gol Burma, Burma dhan, Nama dhan, Nona dhan, Ameta, Kapilee, Mushley, Khushbaya, Sen yu, Bhavani, Anamel, Appem, Bhurkhuch* etc. The native variants of insular coconut palms are *Burmanella Green Tall, Carbin Brown Tall, Chunnabatta Brown Tall, Erthinabad Tall, Harminder Bay Giant, Harminder Bay Tall, Kodiaghat Brown Tall, Kurmadera Brown Tall, Malaca Giant, Nicobar Orange, Panighat Green Tall, Panighat Giant, Pokkadera Brown Tall* etc. A comprehensive economic evaluation of potentially useful insular species of the Andaman-Nicobar Islands is yet to be carried out. According to preliminary estimation, there are about 500 insular taxa so far been recognized as useful species for various purposes. Forty species are commercially useful as plywood, timber, fuel wood etc. 10 species for boat and canoe making, 7 species for aircrafts 15 species for construction and furniture, 15 species for fuel wood, 50 species for ornamental value, 14 species as wild edible fruits and 72 species as probable potential medicinal plants of these islands.

Rarity and Endangerment (Fig. 5)

Speciation and extinction are natural vital events in any biological system where evolution is set in motion. Biological extinction of species is a natural part of evolution while on speciation. The biological entities that could not acquire inheritable changes in accordance with the environmental changes (natural selection) will be vanished in due course from the ecosystem is the natural biological extinction while those species which can adapt/modify themselves with the environment will gradually evolves into a new taxon with new inheritable genetic configurations, simply referred to be as speciation. Extinction of a species is the condition where the last living specimen of that species dies. However, it is rather difficult to determine precisely in large diverse complex tropical insular ecosystems. Usually, it is presumed that if an insular species fail to locate within a period of 50 years or more from the natural habitat could be considered as extinct. There are several tropical insular endemics confined to their occurrence at specialized ecological niches with the stress of extreme competition for space and sunlight, which delimit their distribution and resulting in the rarity and extinction. This is one of the reasons for many insular taxa, especially herbaceous endemics of Andaman-Nicobar Islands strictly confined to their occurrence in type localities. The various reasons for endangerment of biological species are changes in climate, genetic problems, changes in soil constitutions, harvest of wild species for food, medicine, ornamental purpose etc, hybridization, disease, various anthropogenic activities, human population increase, interference owing to livestock, over browsing, inter specific competition, intra specific competition, loss of habitat due to fragmentation, exotic species etc., marine perturbation including El-Nino and La-Nino, other shifts, nutritional disorder, predation, over exploitation, pesticides, power projects and power lines, pollution, poisoning, fire, war, and catastrophic events like drought, flood, hurricanes, *tsunami*, typhoons, landslides, volcanic eruption, cyclones etc. The degree of endangerment of insular species among the islands of Andaman-Nicobar has been remarkably increased during the past few decades, mostly owing to human interference and mismanagement. The population statistics of the islands highlights, rapid accumulation of immigrants from various parts of the mainland has dangerously increasing beyond the carrying capacity of the islands. In this context, it is relevant to mention that two species *viz. piper sarmentosum* and *Camellia kissii* are being extinct from the insular natural habitat. The former was a costal plant known to occur from only one place being eroded during the *tsunami* in 2004, while the latter also known only from one population at Wright Myo being destroyed for a human settlement by the Andaman-Nicobar Administration. Nevertheless, both species are under *ex-situ* conservation in JNTBGRI Field Gene Bank.

Catastrophic Impacts on Insular Vegetation (Fig. 6)

The insular flora of Andaman-Nicobar Archipelago is frequently inclined to sever catastrophic events like earthquakes, volcanic eruption, cyclones, storms, *tsunami* etc. There are two volcanic islands in the archipelago *viz.* Narcondom Island and Barran Island, are segments of volcanic arc that continues northward from Sumatra Island of Indonesia to Burma (Myanmar). Narcondom Island is almost a dead volcano in the Andaman Sea bounded with cliffs on southern side and capped with three peaks of maximum height about 700m and with fairly dense floristic profile. The flora and fauna of Narcondom Island is remarkable with critically endangered endemic biological entities like *Strychnos narcondamensis* and *Rhyticeros narcondami* (Narcondom Hornbill).

No evidence of historical volcanism is present, although the summit region is rather with lax vegetation. Authentic historical records on volcanism of this island are not available. Barren Island is a live volcano with occasional eruptions, geographically lies around 140 km towards south-west of the Narcondom Island in the Andaman Sea. The small, uninhabited 3 km wide Island has an approximately 2 km wide caldera with walls of 250- 350 m height. The caldera, which is open to the sea on the west and the lava flows fill much of the caldera floor and have reached the sea along the western coast during historical eruptions. The first recorded eruption of Barren Island was in 1787 and the latest being during the year 2017.

Earth quacks are another catastrophic hazard prevalent among Andaman-Nicobar Archipelago. The geographical region of these islands is in seismic zone V outside the Himalayan belt and has experienced several earthquakes of moderate-to-large magnitude during the historic as well as recent past causing severe damages to the growing stocks. The Sumatra-Andaman earthquake with an epicentre in the Indian ocean near to the western part of Sumatra Island of the Indonesia on 26 December 2004 was the third largest instrumentally observed seismic event in the history, with a very high magnitude in Richter-scale (*Mw*=9.3), triggered into a giant *tsunami*. Several investigations regarding the event revealed that this earthquake ruptured an area greater than 18000 km^2 along around 1300 km boundary between the Indian Plate and the Burma Microplate (Banerjee et al., 2005; Guilbert et al., 2005; Ishii et al., 2005; Ni et al., 2005; Stein & Okal, 2007). The northern part of the insular landmass has uplifted while the southern part got subsided after the earthquake. The impact of the giant *tsunami* waves as high as 15 m triggered on the coastal vegetation was incredibly hazardous to structure and function of mangrove ecosystems and littoral forests at many regions. The earthquake and *tsunami* waves occurred in the Andaman-Nicobar Islands have considerably distorted the costal morphology as well as insular ecology. Coastal areas at many regions in Nicobar group had permanent stagnation of sea water and depth of impounding increases with high tide made sever destructions along the virgin primary forests at littoral zone. According to an official estimation by the Andaman-Nicobar Administration, around 11,000 hectare of agricultural land, 9,100 hectare of plantation area and 4,918 hectare of forest area have been damaged in the territory.

Cyclones are another catastrophic event causing considerable damages to the inland as well as wetland flora of Andaman Nicobar Islands. The records on severe cyclonic storms among Andaman Islands dates back to1792 followed by 1844, 1891 during the British regime and the recent incidents in 1988 and 1990 made severe damages on Andaman flora.

Floristic Conservation Scenario (Fig. 7, 8)

Plant diversity management and sustainable utilization of plant genetic resources in tropical insular habitats certainly have complex framework in order to exercise the optimal balance between conservation of nature and advancing human sustainable living. The strategies for plant genetic resource (PGR) conservation of the Andaman-Nicobar Islands should definitely have broad vision and precise approaches to conserve infinite numbers of insular genes, large number of species and several specialized ecosystems. Ecosystem or habitat approaches to setting biodiversity conservation of the Andaman-Nicobar Islands generally suitable and very essential to preserve specialized insular ecological niches such as mangrove vegetations, volcanic vegetations like Barren Island and Narcondom Island and diverse ecological niches of Saddle Peak and Mount Harriet ranges etc. Since species are the basic units or elements of biological spectrum of any ecosystems, species based conservation is also very important. Taxonomic distinctiveness, economic potential and bioprospecting, endemism, rarity, threat status and taxa with special attributes (plant indicators, keystone species, ethnobotanical species, wild relatives of cultivars etc.) are certain remarkable factors to be considered for species level conservation. From conservation point of view, most of the islands are rather under explored and insufficiently known along with very fragile ecological equilibrium. It invites the urgent necessity of extensive and intensive floristic survey to learn about dwindling insular floristic elements.

The potential viability of any ecosystem shall be assessed from the degree of diversity at specific and genetic level which determine the survival value and stability of communities and ecosystems. Hence the genetic diversity of an ecosystem has a remarkable role in conservation point of view. Indeed the conservation of a biological species is best accomplished through the *in-situ* conservation practices such as biosphere Reserves, National Parks, Wildlife Sanctuaries etc., where genetic diversity shall be maintained through mutual interaction and hence survival value of communities and stability of ecosystems

are well preserved. However, no serious attempts were undertaken among the islands of Andaman-Nicobar until 1977 for an effective net work of *in-situ* forest conservation. According to current forest statistics, a total area of 35213.6 hectares of inland habitats (92 islands) have been declared as Wildlife Sanctuaries and another 36179.43 hectares of bio-geographic area, which include both inland and marine habitats, at different regions of Andaman-Nicobar group of islands significant with remarkable degree of biological diversities, have been demarcated and elevated into the status of six National Parks including the marine habitat of Wandoor region of the South Andaman Islands. The National Parks in Andaman-Nicobar Islands are Campbell Bay National Park (Great Nicobar), Galathea National Park (Great Nicobar), Mahatma Gandhi Marine National Park (South Andaman), Mount Harriet National Park (South Andaman), Rani Jhansi Marine National Park, Havelock Island (South Andaman), Middle Button National Park (Middle Andaman), North Button National Park (Middle Andaman), South Button National Park (Middle Andaman) and Saddle Peak National Park (North Andaman).

One Biosphere Reserve is also in Andaman-Nicobar Islands designated as Great Nicobar Biosphere reserve. Great Nicobar Biosphere Reserve comprises an area of 88500 hectares in Great Nicobar Island. The two national parks in Great Nicobar Island named as Campbell National Park (42623 hectares) and Galathia National Park (11000 hectares), and the biosphere reserve, all together cover major part of this island. The International Coordinating Council of UNESCO's Man and the Biosphere Programme (MAB), which met in Paris from 27 to 30 May, 2013 has added 12 sites worldwide to the World Network of Biosphere Reserves including the island biosphere reserve of the Great Nicobar (http://www.unescobkk.org/news/article/new-sites-in-the-asia-pacific-added-to-unescos-world-biosphere-reserve-network/ accessed on June 24, 2013). According to UNESCO, This island biosphere reserve is characterized by tropical wet evergreen forests and known to host 1,800 animal species, including 200 species of meiofauna in the coastal zone. The island is also home to the indigenous *Shom Pen* people, semi-nomadic hunters living inland, and the *Nicobarese*, who are coastal dwellers dependent on fishing and horticulture. The 6,381tribal inhabitants of Great Nicobar Island derive a wide variety of biological resources from their environment such as medicinal plants and other non-timber forest products.

Only on declaration of an area under wildlife habitat as biosphere reserve or national park or wildlife sanctuary does not by itself ensure its effective conservation and proper protection. There should be many supplementary facilities such as comprehensive and effective working plan for each island, adequate man power, equipments, modern communication facilities, vehicles, mercantile vessels, adequate funds for management, proper monitoring, services of experts, scientists, researchers etc for effective management of the *in-situ* conservation.

The history of *ex-situ* conservation of Andaman plants outside the islands dates back to 1791 when Col. Kyde of East India's garden at Calcutta visited these islands in search of timber species. On his return to Calcutta, he introduced a few timber species in the East India Company's garden at Howrah (Indian Botanic Garden). The establishment of the Botanical Survey of India at Port Blair in 1972 herald a new era in conservation of insular species of Andaman-Nicobar Islands. An arboretum cum experimental garden at Dhanikari, about 20km away from Port Blair, was established by demarcating 20 hectares of natural reserve forest land for the introduction and experimental cultivation of rare and endangered species of the Andaman-Nicobar Islands. The experimental garden at Dhanikari has 211 indigenous species (excluding grasses and sedges) under 180 genera and 75 families. From scientific point of view, modern methods of *ex situ* conservation (field gene bank, cryo preservation, seed bank, pollen bank, and tissue culture repositories) of insular plants outside the islands are also very important and essential owing to several reasons like population explosion, frequent catastrophic events like cyclones, volcanic eruptions, earth quacks, *tsunamis* etc and other natural insular barriers for species extinction. The present human population of Andaman-Nicobar Island has crossed 3.81 lakhs (census report, 2011) which indicates that the population growth has already been crossed beyond the carrying capacity of the inhabited islands. However, serious attempt on germplasm conservation of insular species outside the island has not been undertaken by any organization until the establishment of the field gene bank at the Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI) in 1994.

The Jawaharlal Nehru Tropical Botanic Garden and Research Institute located at the foothills of Southern Western Ghats, about 40 km away from the capital city of Kerala, has undertaken a venture for the *ex-situ* conservation of Andaman species at the field gene bank established in the

Institute. The institute has taken this decision to protect and preserve the insular plant genetic resources outside the islands for the safest long term conservation point of view and advanced research on insular medicinal species. Geographical location and climetological features are two integral factors to be considered for the *ex-situ* conservation of the insular species outside the islands. The climetological features of Andaman Islands and the Southern Western Ghats are more or less similar even though, they are widely separated by the Bay of Bengal. The striking similarities in climatological features and vegetational type of Southern Western Ghats have much relevance in conservation of Andaman species at JNTBGRI campus. JNTBGRI has 121 hectares of forest land with different vegetational types like semi-evergreen, evergreen and degraded patches of forest land. The site is bound on the North by the Western Ghats hillocks, East and South by the river 'Chittar'. The average rainfall of the region is 3000 mm with an average temperature ranges from 20^0 to 33^0 C and have the contour ranging from 20 to 150 m MSL and many rivulets passing across the campus to join the river Chittar.

Natural vegetation of the campus is secondary comprising of deciduous, evergreen, marshy, riverine and open grasslands along with exposed rocks. The institute has been actively engaged in various aspects of conservation of the rare and endangered plant species of the tropical India and enhancement of a field gene bank for tropical medicinal and aromatic plant species. About 25 acres of the campus has been demarcated for the conservation of insular species of timber trees, medicinal plants, palms, bamboos, wild relatives of cultivars and other interesting ethnobotanical, taxonomical and keystone species of the islands. Live germplasm of 160 species were collected from Andaman-Nicobar Islands and introduced into the field gene bank of JNTBGRI. The suitable climatic conditions and ideal ecological niches of the JNTBGRI campus have well promoted the growth and establishment of these species. All Andaman species introduced along with the indigenous species of natural vegetation in the campus and studied their establishment and growth rate. It is found that they are well adapted with new habitat and well established with good performance of growth. Regular deposition of seed collections from the introduced insular species at JNTBGRI seed bank facilitate advanced research on seed viability, germination studies and seed exchange programme. The live Andaman germplasm collections established at the field gene bank of JNTBGRI is considered to be the largest *ex-situ* collection of Andaman plants outside the islands in the world.

Conclusion

Islands are of great relevance for conservation of the global plant diversity. Although they comprise only around 5% of total land surface of the whole planet, approximately 25% of known extinct vascular plants are insular endemics (Kreft *et al*., 2008). According to Kier *et al*. (2009), indices on vascular plant diversity are obviously higher for insular regions than peninsular and continental regions. From conservation point of view, the exclusive efforts carried out by JNTBGRI in *ex-situ* conservation of economically and ethnobotanically important Andaman plant species in mainland India is a hallmark and pioneer attempt facilitating several important scientific studies on insular species. The present *ex-situ* conservation of plant species from Andaman-Nicobar in JNTBGRI include wild relatives of cultivars, wild edible fruit plants, timber yielding species, economically important endemic canes, rare/endangered/ endemic species, taxonomically important species, medicinal and aromatic species, ethnobotanical species, insect repellant species and wild ornamental orchids. There are 11 different wild variants of betel vines from the Andaman-Nicobar Islands have been introduced in the field gene bank of JNTBGRI. There are certain endemic species (*Pinanga andamanensis* and *Korthalsia rogersii*) thought to be extinct from these islands over a century ago have been rediscovered and conserving in JNTBGRI. *Pinanga andamanensis* and *Korthalsia rogersii* are endemic palms were known only from their type collections until the recent rediscovery by the author while working on Flora India Project of the Botanical Survey of India. *Piper ribesioides* is a woody climbing *Piper* species with medicinal properties originally collected by Helfer in 1854 and has no further collection and records from Andaman Islands also been rediscovered and conserving in JNTBGRI. Similarly, *Pteroceras muriculatum*, a critically endangered endemic orchid known only from type collection was rediscovered after a century and introduced at JNTBGRI field gene bank. Conservation of insular species outside the island is very essential since the Andaman-Nicobar Islands are susceptible to frequent catastrophic events like earth quacks, cyclones, volcanic eruptions etc. The recent *tsunami* in December, 2004 was very severe among the Islands of Andaman-Nicobar and washed out growing stocks at several places. The *ex-situ* conservation of Andaman species

in JNTBGRI offer excellent platforms for studies on for advanced research on seed biology, bioprospecting of insular medicinal and aromatic plants, tissue culture standardization of rare and endangered species, plant breeding and genetic studies on economically promising insular species including endemics. The experimental studies carried out on biomass and growth rate of Andaman timber species introduced at JNTBGRI campus proved that most of them are best selections for afforestation programmes along the slopes of the Southern Western Ghats. There are several threatened ethnobotanical species which have much importance in the routine life of most primitive and isolated group of insular aborigines. Conservation of these species has much relevance in the existence of these primitive nomadic tribals groups, who do not have any awareness on cultivation, but exclusively depend on wild plant species for their daily needs. Tissue culture standardization of such rare ethnobotanical species, their large multiplication and reintroduction into natural habitats will certainly be helpful to the existence of vanishing tribal groups of these islands. The *ex-situ* conservation of lesser known ethnobotanical insular species and their bioprospecting, especially the tribal medicinal species, would certainly be rewarded.

ANDAMAN – NICOBAR GERMPLASM COLLECTIONS AT JNTBGRI				
Sl. No.	**Plant name**	**Family**	**Distribution**	**Status**
1	*Abrus precatorius* L.	Fabaceae	Andaman Islands, Pantropic	
2	*Actephila excelsa* (Dalz.) Muell.- Arg. var. *javanica* (Miq.) Pax & Hoffm.	Euphorbiaceae	Andaman – Nicobar Islands, Indo-China, Malesia	EI
3	*Aegle marmelos* (L.) Correa	Rutaceae	Andaman Islands, Indian Subcontinent, Southeast Asia, Malesia, Tropical Africa, United States	
4	*Aglaonema nicobaricum* Hook.f.	Araceae	Nicobar Islands*	E
5	*Amomum andamanicum* V.P. Thomas, M.Dan & M. Sabu	Zingiberaceae	Andaman Islands*	E
6	*Anaxagorea luzonensis* A.Gray	Annonaceae	Andaman Islands, Malesia	EI
7	*Ancistrocladus tectorius* (Lour.) Merr.	Ancistrocladaceae	Andaman-Nicobar Islands, Southeast Asia, Malesia	EI
8	*Ardisia littoralis* Thunb.	Myrsinaceae	Andaman Islands, Indian subcontinent, Malesia	
9	*Areca triandra* Roxb. ex Buch. – Ham.	Arecaceae	Andaman-Nicobar Islands, Northeast India, Malesia	
10	*Baccaurea ramiflora* Lour.	Euphorbiaceae	Andaman Islands, Northeast India, Eastern Himalaya, Myanmar, Malesia	
11	*Barringtonia racemosa* (L.) Spreng.	Barringtoniaceae	Andaman-Nicobar Islands, Indian Sub-continent, Southeast Asia, Malesia, Australia, tropical Africa	
12	*Bentinckia nicobarica* (Kurz) Becc.	Arecaceae	Nicobar Islands*	E
13	*Caesalpinia bonduc* (L.) Roxb.	Caesalpiniaceae	Andaman-Nicobar Islands, Pantropic	

14	*Calamus andamanicus* Kurz	Arecaceae	Andaman-Nicobar Islands*	E
15	*Calamus longisetus* Griff.	Arecaceae	Andaman-Nicobar Islands*	E
16	*Calamus oxleyanus* Teijsm & Binn. var. *oxleyanus* [=*C. helferianus* Kurz]	Arecaceae	Nicobar Islands*	E
17	*Calamus palustris* Griffith	Arecaceae	Andaman Islands, Myanmar, Thailand	EI
18	*Calamus viminalis* Willd. var. *andamanica* Becc.	Arecaceae	Andaman-Nicobar Islands*	E
19	*Calophyllum inophyllum* L.	Clusiaceae	Andaman-Nicobar Islands, Indian Subcontinent, Old & New world Tropics	
20	*Camellia kissii* Wall.	Theaceae	Andaman Islands, Northeast India, Eastern Himalaya, China, Indo-China	EX
21	*Canarium euphyllum* Kurz	Burseraceae	Andaman-Nicobar Islands*	E
22	*Caryota mitis* Lour.	Arecaceae	Andaman-Nicobar Islands, Myanmar, Indo-China	EI
23	*Cheilocostus speciosus* (J. Koenig) C. Specht [=*Costus speciosus* (Koen.) J. L. Sm.]	Zingiberaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia, Malesia	
24	*Chionanthus ramiflorus* Roxb.	Oleaceae	Andaman-Nicobar Islands, Indo-Malesian, Southeast Asia	
25	*Chrysophyllum cainito* L.	Sapotaceae	Andaman Islands, South to Southeast Asia, Malesia, New World	
26	*Cinnamomum verum* J.S.Presl.	Lauraceae	Andaman Islands, South to southeast Asia, Malesia	
27	*Cissus quadrangularis* L.	Vitaceae	Andaman-Nicobar Islands, Indian Sub-continent, Malesia, Middle-east, Southwest Africa	
28	*Cordia dichotoma* G.Forst.	Boraginaceae	Andaman-Nicobar Islands, Malesia, Southeast Asia	
29	*Corypha lutan* Lam.[=C. *macropoda* Linden ex Kurz]	Arecaceae	Andaman Islands & Malesia	EI
30	*Crateva religiosa* Forst.f.	Capparaceae	Andaman – Nicobar Islands, Indian Sub-continent, China ,Malesia	
31	*Cycas zeylanica* (J.Schust.) A.Lindstr. & K.D.Hill	Cycadaceae	Andaman Island, Sri Lanka	EI

32	*Cymbidium aloifolium* (L.) Sw.	Orchidaceae	Andaman – Nicobar Islands, India, Southeast Asia, Malesia	
33	*Cynometra iripa* Kostel.	Caesalpiniaceae	Andaman Islands, Indian Subcontinent, Malesia, North Australia	
34	*Dendrobium crumenatum* Sw.	Orchidaceae	Andaman – Nicobar Islands, India, Southeast Asia, Malesia	
35	*Dendrobium secundum* (Bl.) Lindl.	Orchidaceae	Andaman – Nicobar Islands, Southeast Asia, Malesia	EI
36	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae	Andaman Islands, India, Sri Lanka, Myanmar, Java	
37	*Dillenia andamanica* C. E. Parkinson	Dillanaceae	Andaman-Nicobar Islands*	E
38	*Dinochloa andamanica* Kurz	Poaceae	Andaman – Nicobar Islands*	E
39	*Diospyros andamanica* (Kurz) Bakh.	Ebenaceae	Andaman Islands, Southeast Asia	EI
40	*Diospyros marmorata* R. Parker	Ebenaceae	Andaman Islands*	E
41	*Diospyros montana* Roxb.	Ebenaceae	Andaman-Nicobar Islands, Indian Subcontinent, Malesia to Australia	
42	*Diospyros oocarpa* Thw.	Ebenaceae	Andaman-Nicobar Islands (non indigenous species), India, Southeast Asia, Malesia	
43	*Dipterocarpus alatus* Roxb. ex G.Don	Dipterocarpaceae	Andaman Islands, Southeast Asia	EI
44	*Dipterocarpus grandiflorus* (Blanco) Blanco	Dipterocarpaceae	Andaman Islands, Southeast Asia, Malesia	EI
45	*Dracaena angustifolia* (Medik.) Roxb.	Dracaenaceae	Andaman-Nicobar Islands, Indian Sub-continent	
46	*Dysoxylum cyrtobotryum* Miq. [=*D. andamanicum* King]	Meliaceae	Andaman Islands, Malesia & West Bengal	
47	*Elaeocarpus petiolatus* (Jacq.) Wall.	Elaeocarpaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia	
48	*Elaeocarpus tectorius* (Lour.) Poir.	Elaeocarpaceae	Andaman Islands, Indo – Malesia	
49	*Endocomia macrocoma* (Miq.) W.J. de Wilde subsp. *prainii* (King) W. J. de Wilde	Myristicaceae	Andaman-Nicobar Islands, Southeast Asia	EI
50	*Entada rheedii* Spreng.	Mimosaceae	Andaman-Nicobar Islands, Indian Subcontinent, Malesia	
51	*Epipremnum pinnatum* (L.) Engl.	Araceae	Andaman-Nicobar Islands, Western Ghats, Malesia	

52	*Eulophia andamanensis* Rchb. f.	Orchidaceae	Andaman-Nicobar Islands, Southeast Asia, Malesia	EI
53	*Euphorbia epiphylloides* Kurz	Euphorbiaceae	Andaman Islands*	E
54	*Fagraea racemosa* Jack	Loganiaceae	Andaman-Nicobar Islands, Indian Sub-continent, Malesia	
55	*Ficus hispida* L. f.	Moraceae	Andaman-Nicobar Islands, Indian Subcontinent, Malesia to Australia	
56	*Freycinetia insignis* Blume	Pandanaceae	Andaman-Nicobar Islands, Malesia	EI
57	*Garcinia dhanikhariensis* S. K. Srivastava	Clusiaceae	Andaman Islands*	E
58	*Glycosmis mauritiana* (Lam.) Tanaka var. *andamanensis* (V. Naray.) B.C. Stone	Rutaceae	Andaman-Nicobar Islands*	E
59	*Glycosmis pilosa* V. Naray.	Rutaceae	Andaman-Nicobar Islands*	E
60	*Goniothalamus malayanus* Hook.f. & Thomson	Annonaceae	Andaman-Nicobar Islands and Malesia	EI
61	*Grewia calophylla* Kurz ex Mast.	Tiliaceae	Andaman Islands*	E
62	*Etlingera fenzlii* (Kurz) Škorničk. & M. Sabu	Zingiberaceae	Andaman-Nicobar Islands*	E
63	*Illigera appendiculata* Blume	Hernadiaceae	Andaman-Nicobar Islands, Malesia	EI
64	*Jasminum cordifolia* Wall. & G. Don	Oliaceae	Western Ghats & Andaman Islands*	
65	*Justicia adhatoda* L. [=*Adhatoda zeylanica* Medikus]	Acanthaceae	Andaman Islands, India, Sri Lanka, Southeast Asia, Malesia	
66	*Knema andamanica* (Warb.) W.J.de Wilde	Myristicaceae	Andaman Islands*	E
67	*Korthalsia laciniosa* (Griff.) Mart.	Aracaceae	Andaman-Nicobar Islands, Malesia	EI
68	*Korthalsia rogersii* Becc.	Aracaceae	Andaman Islands*	E
69	*Lagerstroemia hypoleuca* Kurz.	Lythraceae	Andaman-Nicobar Islands*	E
70	*Leea guineensis* G. Don	Leeaceae	Andaman Islands, Northeast India, Malesia	
71	*Licuala peltata* Roxb. ex Buch. – Ham.	Aracaceae	Andaman-Nicobar islands, Northeast India, Myanmar, Malesia	
72	*Luisia* sp	Orchidaceae	Andaman Islands	
73	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	Andaman Islands, Indo-Malesia, Southeast Asia	
74	*Mallotus philippensis* (Lam.) Muell.- Arg.	Euphorbiaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia, Malesia to Australia	

75	*Mangifera sylvatica* Roxb.	Anacardiaceae	Andaman-Nicobar Islands, Northeast India, Malesia	
76	*Mangifera andamanica* King	Anacardiaceae	Andaman Islands*	E
77	*Mangifera camptosperma* Pierre	Anacardiaceae	Andaman-Nicobar Islands, Malesia	EI
78	*Mangifera indica* L.	Anacardiaceae	Andaman-Nicobar Islands, Tropical Asia	
79	*Manilkara littoralis* (Kurz) Dubard	Sapotaceae	Andaman-Nicobar Islands*	E
80	*Mapania kurzii* C. B. Clarke	Cyperaceae	Andaman Island, Malesia	EI
81	*Melastoma malabathricum* L.	Melastomataceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia	
82	*Mimusops andamanensis* King & Gamble	Sapotaceae	Andaman – Nicobar Islands, Sri Lanka	
83	*Morinda citrifolia* L.	Rubiaceae	Andaman islands, India, Sri Lanka, Malesia	
84	*Murraya koenigii* (L.) Spreng.	Rutaceae	Andaman-Nicobar Islands, India, Sri Lanka, Southeast Asia	
85	*Musa balbisina* var. *andamanica*	Musaceae	Andaman-Nicobar Islands*	E
86	*Myristica andamanica* Hook. f.	Myristicaceae	Andaman-Nicobar Islands*	E
87	*Myristica elliptica* Wall. ex Hook. f. & Thomson	Myristicaceae	Nicobar Islands, Malesia	EI
88	*Myxopyrum smilacifolium* (Wall.) Blume	Oleaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia	
89	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	Andaman Islands, Northeast India, Southeast Asia	
90	*Pandanus dubius* Spreng. [=*P. andamanensium* Kurz]	Pandanaceae	Andaman-Nicobar Islands, Malesia	EI
91	*Pandanus leram* Voigt	Pandanaceae	Andaman-Nicobar Islands, Indonesia	EI
92	*Papilionanthe teres* (Roxb.)Schltr.	Orchidaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia	
93	*Parishia insignis* Hook. f.	Anacardiaceae	Andaman Islands, Myanmar, Thailand, Malesia	EI
94	*Phoenix andamanensis* S. Barrow	Arecaceae	Andaman Islands*	E
95	*Phoenix paludosa* Roxb.	Arecaceae	Andaman-Nicobar Islands, Indian Subcontinent, Southeast Asia, Malesia	

96	*Pinanga andamanensis* Becc.	Aracaceae	Andaman Islands*	E
97	*Piper betle* L.	Piperaceae	Andaman-Nicobar Islands (in wild state), Malesia, Indian Subcontinent	Wild in A & N Isl.
98	*Piper ribesioides* Wall.	Piperaceae	Andaman Islands, Myanmar	EI
99	*Piper sarmentosum* Roxb.	Piperaceae	Andaman Islands, Southeast Asia, Malesia	EI
100	*Planchonia valida* (Blume) Blume	Lecythidaceae	Andaman-Nicobar Islands, India, Malesia	
101	*Podocarpus neriifolius* D. Don	Podocarpaceae	Andaman islands, Northeast India	
102	*Polyalthia longifolia* (Sonn.)Thw.	Annonaceae	Andaman Islands, India, Sri Lanka, Tropical Asia	
103	*Pometia pinnata* J.R.& G.Frost	Sapindaceae	Andaman-Nicobar Islands, Malesia	EI
104	*Pongamia pinnata* (L.) Pierre	Fabaceae	Andaman-Nicobar Islands, Western Ghats, Indo-Malesian	
105	*Pseudarthria viscida* (L.) Wight & Arn.	Fabaceae	Andaman Islands, Indian Sub Continent, Myanmar, Malesia	
106	*Psychotria andamanica* Kurz	Rubiaceae	Andaman Islands*	E
107	*Pterocarpus dalbergioides* DC.	Fabaceae	Andaman Islands*	E
108	*Pteroceras muriculatum* (Reichb. f.) P. F. Hunt	Orchidaceae	Andaman Islands*	E
109	*Pterospermum acerifolium* (L.) Willd.	Sterculiaceae	Andaman Islands, Indian Subcontinent	
110	*Pterygota alata* (Roxb.) R. Br.	Sterculiaceae	Andaman- Nicobar Islands, Indian Subcontinent	
111	*Rhopaloblaste augusta* (Kurz) H. E. Moore	Arecaceae	Nicobar Islands*	E
112	*Rhynchostylis retusa* (L.) Blume	Orchidaceae	Andaman Islands, India, Sri Lanka, Southeast Asia, Malesia	
113	*Saraca asoca* (Roxb.) Willd.	Fabaceae	Andaman Islands, Indian Subcontinent	
114	*Sarcostigma kleinii* Wight & Arn.	Icacinaceae	Andaman Islands, Western Ghats, Malesia	
115	*Schefflera venulosa* (Wight & Arn.) Harms.	Araliaceae	Andaman Islands, Indian Subcontinent, Indo-China	
116	*Spathoglottis plicata* Blume	Orchidaceae	Great Nicobar Islands, Malesia	EI
117	*Sphenodesme involucrata* (C. Presl.) B. L. Rob.	Verbenaceae	Andaman Islands, Indian Subcontinent, Malesia	
118	*Strobilanthes sanjappae* Karthik. & Moothy	Acanthaceae	Andaman-Nicobar Islands*	E

119	*Strychnos andamanensis* A. W. Hill	Loganiaceae	Andaman Islands*	E
120	*Syzygium andamanicum* (King) N. P. Balakr.	Myrtaceae	Andaman Islands*	E
121	*Syzygium cumini* (L.) Skeels	Myrtaceae	Andaman Islands , Western Ghats	
122	*Syzygium megacarpum* (Craib) Rathakr. & N.C. Nair	Myrtaceae	Andaman-Nicobar islands, Northeast India, Malesia	
123	*Tabernaemontana crispa* Roxb.	Apocynaceae	Andaman-Nicobar Islands*	E
124	*Terminalia bialata* (Roxb.) Steud.	Combretaceae	Andaman-Nicobar Islands*	E
125	*Terminalia procera* (Roxb.) Steud.	Combretaceae	Andaman-Nicobar Islands*	E
126	*Ternstroemia wallichiana* Ridl.	Ternstroemiaceae	Andaman Islands, Southeast Asia	EI
127	*Tetracera sarmentosa* (L.) Vahl.ssp. *andamanica* (Hoogl.)Hoogl.	Dilleniaceae	Andaman-Nicobar Islands, Northeast India	
128	*Thottea tomentosa* (Blume) Ding Hou	Aristalochiaceae	Andaman-Nicobar Islands, Southeast Asia, Malesia	EI
129	*Thunbergia laurifolia* Lindl.	Thunbergiaceae	Andaman-Nicobar Islands, Malesia (Introduced in Indian subcontinent)	EI
130	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	Poaceae	Andaman-Nicobar Islands, Indian Subcontinent, Eastwards to Southeast Asia	
131	*Vanilla albida* Blume	Orchidaceae	Andaman – Nicobar Islands, Malesia	EI
132	*Vanilla andamanica* Rolfe	Orchidaceae	Andaman – Nicobar Islands*	E
133	*Zanthoxylum ovalifolium* Wight	Rutaceae	Andaman-Nicobar Islands, Indian Subcontinent, Malesia	

E = Endemic EI = Extra Indian Species EX = Extinct

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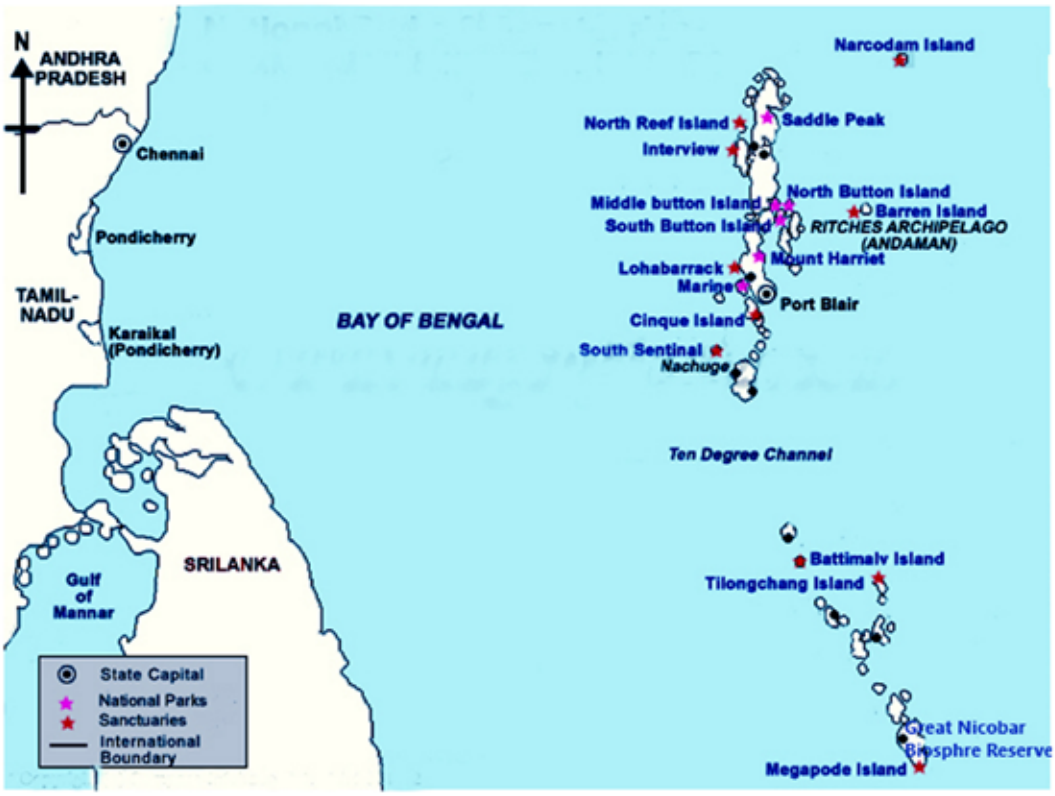
Fig 1. Mangrove vegetation at Baratang Island 2. Mangrove root system of *Bruguiera gymnorhiza* – A red listed mangrove species by IUCN (nursery ground for several arthropods) 3 & 4 Sub-tidal forests with *Phoenix paludosa* and *Acrostichum aurum* (two dominant species of sub-tidal forests) 5. Littoral Forests at Wandoor Marine National Park.6. A view of Evergreen Forests of Mount Harriet from sea.7. Semi Evergreen Forests at Wright Myo. 8. Bamboo Brake (*Gigantochloa andamanica)* at Diglipur.



Major *In Situ* Conservation of Andaman-Nicobar Islands

Phytogeographical Affinities of Andaman-Nicobar Islands

Fig. 2. 1. Major sectors of *in situ* conservation in Andaman-Nicobar Islands (Source - Maps of India)
2. Phytogeographical affinities

Fig. 3. 1. Wild occurrence coconut palms – A view of self sown coconut palms at shore from Nicobar. 2. Self sown coconut palms near Galatia River at Great Nicobar Island. 3. Wild occurrence of Betelnut palms on the shore of Galatia River at Great Nicobar Island. 4-10. Wild intraspecific variants of *Piper betel* from Andaman-Nicobar Islands at Field Gene Bank (JNTBGRI). 11. A fruiting twig of a wild *Piper betel* from South Andamans.12. An accession of wild *Piper betel* from South Andamans at Field Gene Bank (JNTBGRI).

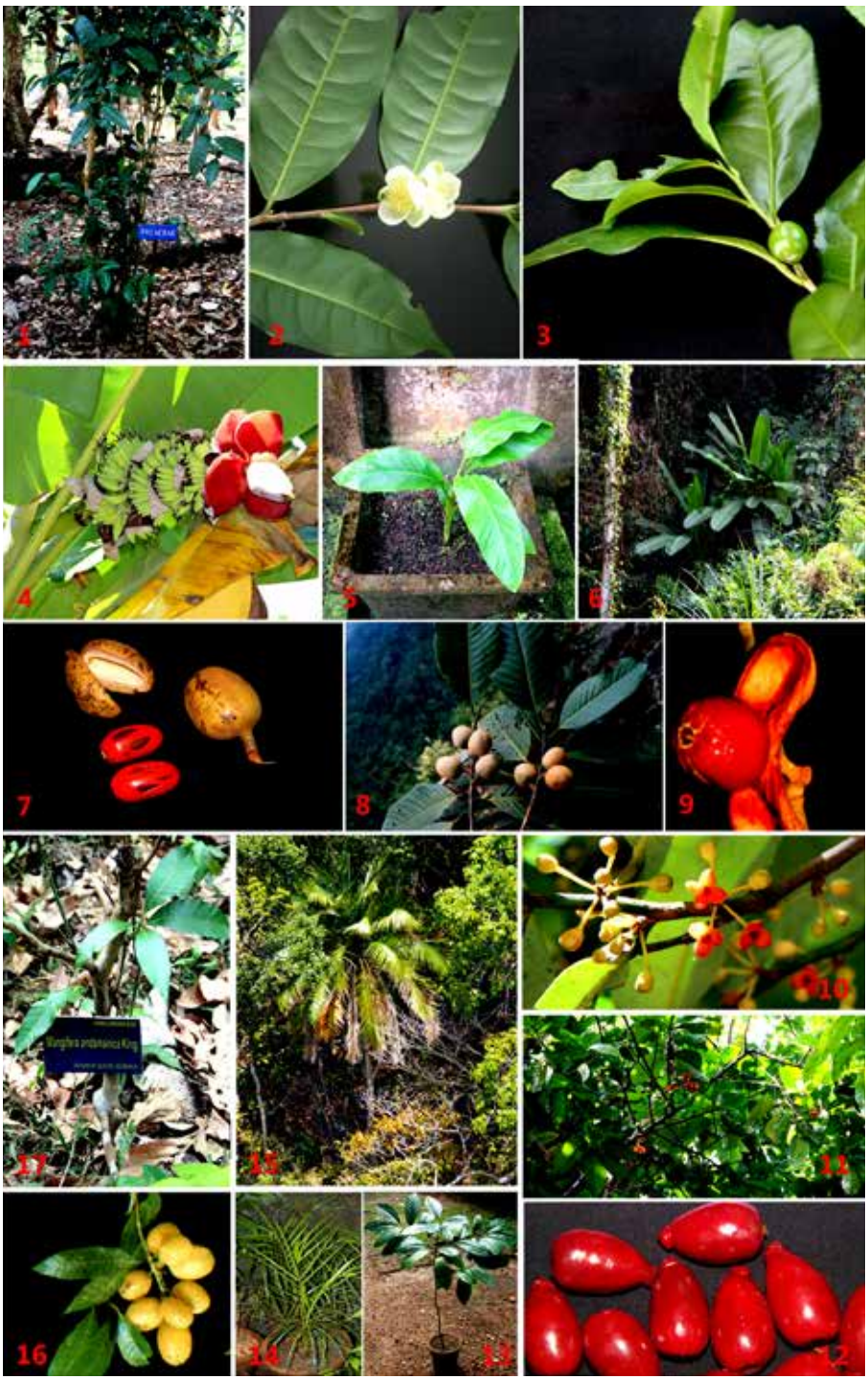


Fig. 4. 1-3. *Camellia kissii* (habit, flowers & fruit) at Field Gene Bank (JNTBGRI). 4. *Musa sabuana* – A wild endemic plantain from South Andaman. 5. *Musa sabuana* – A tiller at Field Gene Bank (JNTBGRI). 6. *Musa balbisiana* var. *andamanica* – Another wild endemic from Middle Andaman. 7 & 8. *Myristica andamanica* – An endemic wild nutmeg (Aril & Fruits). 9 & 10. *Knema andamanica* – An endemic wild relative of nutmeg - Aril, Fruits & Flowers(Field Gene Bank , JNTBGRI). 11, 12 & 13 *Endocomia macrocoma* ssp *prainii* - An endemic wild relative of nutmeg at Field Gene Bank, JNTBGRI (Habit, Aril & Seedling).14. A seedling of *Phoenix andamanensis* - An endemic wild date palm at Field Gene Bank, JNTBGRI. 15. *Phoenix andamanensis* at Kalpong forest (North Andamans). 16. *Mangifera andamanica* – An endemic wild mango from South Andamans. 17. *Mangifera andamanica* – A seedling at Field Gene Bank, JNTBGRI.

Fig. 5. 1 & 2. *Pteroceras muriculatum* (endemic orchid)– A rediscovery after a century at Field Gene Bank, JNTBGRI. 3 & 4. *Piper sarmentosum* at Field Gene Bank, JNTBGRI – An extinct species after *tsunami* from its insular natural habitat. 5 6 & 7. *Mimusops andamanensis* – IUCN red listed endemic (A&N Isl & Sri lanka) – A rediscovery after a century at Field Gene Bank, JNTBGRI. 8, 9 & 10. *Piper ribesioides* – A woody piper rediscoverd from Wright Myo after 150 years at Field Gene Bank, JNTBGRI. 11 & 12. *Podocarpus neriifolius* – A red listed gymnosperm by IUCN at Field Gene Bank, JNTBGRI. 13. *Bentinckia nicobarica* at Katchal Island. 14. *Bentinckia nicobarica* - A red listed gymnosperm by IUCN at Field Gene Bank, JNTBGRI. 15 & 16 *Korthalsia rogersii* – A rediscovery after a century from South Andamans at Field Gene Bank, JNTBGRI (Fruits & Plant). 17. *Pinanga andamanensis*- A rediscovery after a century at Field Gene Bank, JNTBGRI.

Fig. 6. 1. Lost mangrove vegetation at Nancovery Island after *tsunami* in 2004 (Photograph in 2010). 2. Lost mangrove vegetation at Great Nicobar Island after *tsunami* in 2004 (Photograph in 2010). 3, 4, 5 & 6 Coastal regions of Campbell Bay in 2010. 7. Coastal region at Bambooflat, Port Blair after *tsunami* in 2010. 8. Coastal region at Garachrma, South Andaman after *tsunami* in 2010 (gradual succession of mangrove species).

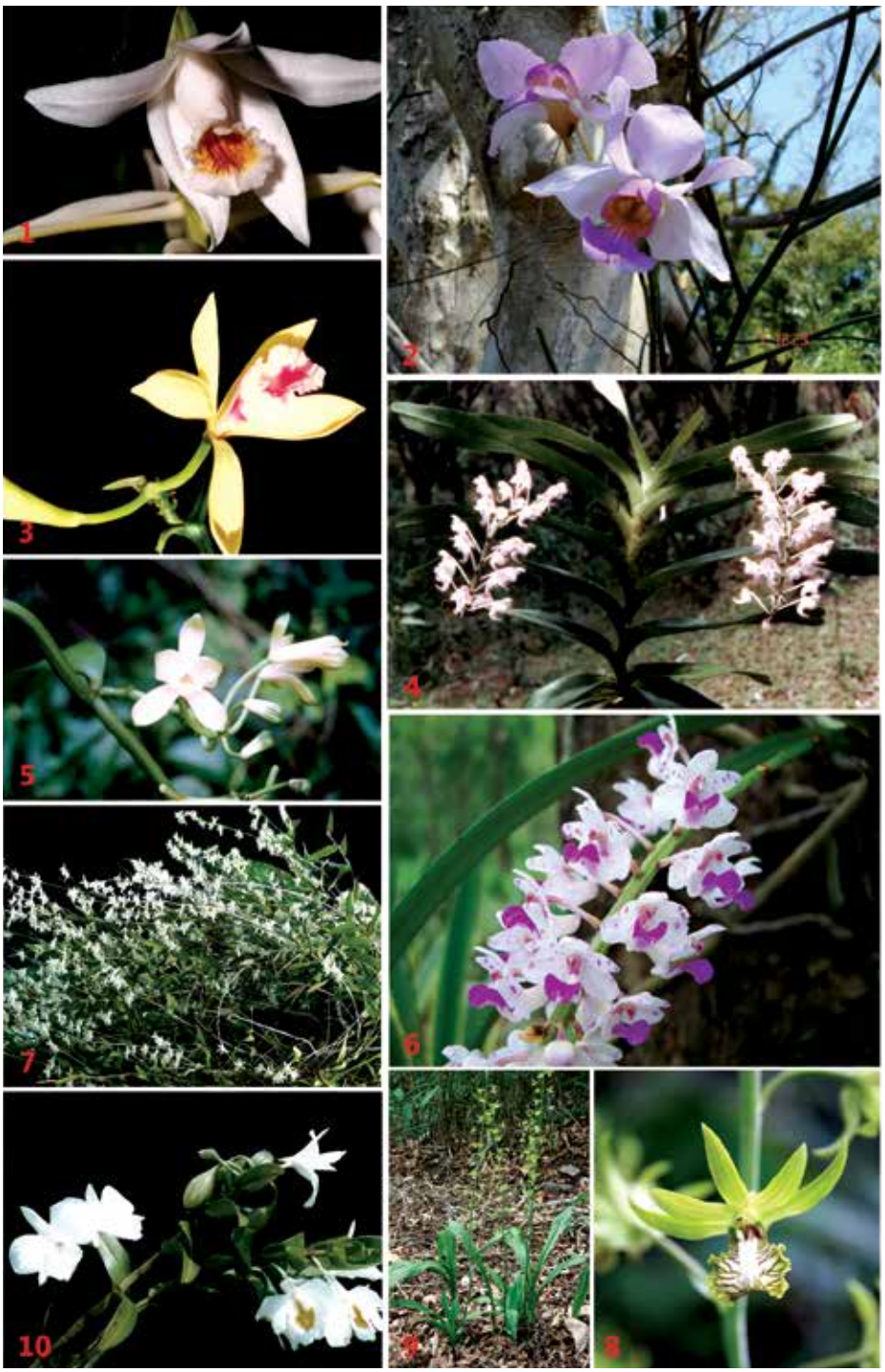


Fig. 7. Andaman – Nicobar orchids at JNTBGRI. 1. *Thunia alba* 2. *Papilionanthe teres* 3. *Vanilla andamanica* 4. *Aerides emericii* 5. *Vanilla sanjappae* 6. *Rhynchostylis retusa* 7. *Dendrobium crumenatum* 8. & 9. *Eulophia andamanensis* 10. *Dendrobium formosum*

Fig. 8. Andaman – Nicobar endemics at Field Gene Bank,JNTBGRI. 1. & 2. *Etlingera fenzlii* – Honey bee repellent species. 3. & 4. *Dillenia andamanica* 5. & 6. *Tabernaemontana crispa* 7. *Strobilanthus sanjappae* 8. *Ophiorrhiza infundibularis* 9. *Terminalia bialata* 10. & 11. *Calamus andamanicus* 12. *Oryza indandamanica* 13. *Rophaloblaste augusta* 14. *Pinanga andamanensis* 15. *Diospyros marmorata* (Marble wood).

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