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ESTABLISHMENT OF *EX-SITU* GARDENS OF SPECIES OF *DALBERGIA* AND MONOCOTYLEDONS IN A BIORESOURCES NATURE TRAIL IN THE KERALA PART OF WESTERN GHATS

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Abstract of Project Proposal

Code	KFRI 432/04
Title	Establishment of *ex-situ* gardens of species of *Dalbergia* and monocotyledons in a Bioresources Nature Trail in the Kerala part of Western Ghats
Objectives	1. To establish, along a Bioresources Nature Trail, a live collection of species of *Dalbergia* and monocotyledons with particular reference to palms, rattan and bamboo and other species which have conservation value and academic importance. 2. To promote nature education and ecotourism.
Project period	April 2004 to March 2009
Whether funded by external agency	Western Ghats Cell, Planning and Economic Affairs Department, Government of Kerala
Scientific personnel	U.M. Chandrashekara N. Sasidharan

EXECUTIVE SUMMARY

The Project was taken up to develop ex-situ gardens of monocotyledons and species of *Dalbergia* in the Bioresources Nature Trail located at Kerala Forest Research Institute (KFRI) Sub Centre campus, Nilambur. In a span of five years, about 1.5 ha area adjacent to the Teak Museum in the KFRI Sub Centre has been transformed into a palm and rattan garden which harbors 14 indigenous and 30 exotic species. Among indigenous species planted in the garden, *Calamus vattayila* is endemic to the South India whereas species like *Arenga wightii, Calamus lakshmanae, Calamus metzianus* and *Pinanga dicksonii* are endemic to the Western Ghats. *Bentinckia condapanna, Calamus dransfieldii, Calamus nagbettai* and *Calamus travancoricus* are endemic to the southern Western Ghats. Species like *Arenga wightii, Calamus longisetus, Calamus nagbettai* and *Pinanga dicksonii* fall under the category of vulnerable in the IUCN Red List. Similarly, species like *Bentinckia condapanna, Corypha umbraculifera* and *Korthalsia lacioniosa* fall under the category of rare species. Over 198 species belonging to monocotyledon families (other than palms and rattans) were planted in the garden in different theme areas such as bamboo garden, orchid house, medicinal plant garden, hydrophyte garden, and xerophytes and succulent gardens. Among them species like *Ochlandra travancorica, Pseudoxytenanthera ritcheyi, Pseudoxytenanthera stocksii, Gastrochilus flabelliformis* and *Curcuma neilgherrensis* are endemic to the Western Ghats. On the other hand, species such as *Ochlandra scriptoria, Anoectochilus elatus, Bulbophyllum rosemarianum, Seidenfia intermedia* and *Trichopus zeylanicus* are endemic to the southern Western Ghats. Under this project, species of *Dalbergia viz. D. beddomei, D. candenatensis, D. horrida, D. lanceolaria, D. latifolia, D. melanoxylon, D. paniculata, D. rubiginosa, D. sissoides, D. sissoo* and *D. volubilis* were planted. Among these eleven species, *D.beddomei* and *D. horrida* are endemic to the Peninsular India, while *D. candenatensis* and *D. rubiginosa* are endangered species.

For planting in the *ex-situ* gardens, plant specimens were collected primarily from the natural forests of Kerala while the geographic area of collection extends through natural forests of Karnataka to many locations in India. However, ornamental and commercially important plants were procured from private nurseries. All the species have been identified, labeled and presented in such a way that visitors can observe the characters of each one of them.

The success of this Project was assessed by recording the visitors to the gardens within two years (April 2008 to March 2010) of the completion of the Project. It was evident by the fact that on an average every month 11,485 visitors from the general public and 1,785 students have visited these gardens. These gardens are helping to increase awareness on the ecological, economic and cultural significance of the wild plant species and their potential value as genetic resources. The students from the local schools and colleges are visiting the gardens as it enable them to observe variability and adaptive modifications in the plant world, literally at their hometown.

However, like any other *ex-situ* garden, most species cultivated here are on an average represented by only two or three specimens and the genetic diversity within wild species is not reflected. In this context, the need for collecting more specimens, covering a range of diversity of wild species, particularly of endemic and RET species, to facilitate germplasm distribution is highlighted. Importance of establishment of a seed bank/gene bank of germplasm in this *ex-situ* garden to conserve genetic material has also been highlighted.

1. INTRODUCTION

Biodiversity in the tropics is under threat due to habitat loss for flora and fauna in the face of growing human population and socio-economic factors causing over-exploitation and endangerment of biological resources. It has been cautioned that at the present rate of habitat loss, by the year 2030 about a third of the biodiversity in India would be lost or be limited to isolated refugia of non-viable populations which may enter into the vortex of extinction (Nayar, 1997). When different biomes in India are considered, the loss of tropical forests could lead to the highest extinction of species. This is because of the fact that the tropical forests support communities with a rich array of species and the complex web of interactions are likely to be more fragile than relatively simple and robust temperate ecosystems (May, 1975). For instance, situated on the lap of the Western Ghats in the southwest corner of India, Kerala covers an area of about 38,863 km^2, of which the extent of forest cover is about 10,336 km^2. From the forests of Kerala about 10,035 plant species (22 percentage of total number of plants in India) distributed among angiosperms (3,800 species) gymnosperms (4 species), pteridophytes (331 species), bryophytes (300 species), lichens (520 species), algae (325 species) and fungi (4,800 species) are reported (Nayar, 1997). When the endemic species alone are considered, Kerala has about 1,381 endemic angiosperm species (Sasidharan, 2002), including about 331 monocotyledonous species (Nayar, 1997). It is also reported that out of 1,381 endemic angiosperms, 496 species come under rare, vulnerable and endangered species categories, occurring in isolated populations. Further analysis of individual taxonomic groups of plants also indicated that in each group certain species, particularly endemic species, are under threat.

In the Western Ghats region, even areas outside the protected areas such as agroforestry systems and sacred groves are rich in flora and fauna. However, our primary, secondary and even higher institutions of learning do not have such curricula, which help students to appreciate the richness of bioresources and their ecological and socioeconomic importance. Very often students are not exposed to different kinds of ecosystems and hence are unable to observe and identify plants in the field. In this context, attempts need to be made for effective nature education and appreciation of bioresources in the country, which will inculcate in students and teachers at large, the importance of biodiversity conservation. Thus, the Kerala Forest Research Institute, at its Sub Centre at Nilambur has developed about 10 ha of land into a Bioresources Nature Park (Chandrashekara *et al.*, 2009). The Bioresources Nature Park has conservation themes for the lower groups of plants such as algae, bryophytes and pteridophytes, plants found in specialized ecological niche such as xerophytes (cacti and succulents) and hydrophytes (aquatic plants), beneficial plants (*eg.* medicinal plants) and ornamental plants (*eg.* orchids), with special reference to endemic and rare, endangered and threatened (RET) species.

It may also be mentioned here that from the Kerala part of the Western Ghats, a total of 21 species belonging 10 genera of palms are reported (Renuka *et al.*, 1996). Among these 21 species, 5 species are in vulnerable category, 3 species are critically endangered and 2 are rare species. Similarly in Kerala, eighteen species of Dalbergia have been recorded (Nair, 1986). Many of these species are of economic value mainly as timber species, medicinal plants, forage sources and as plants that yield gums, resins, oils *etc.* Besides, species such as *Dalbergia acacifolia*, *D. beddomei*, *D. horrida*, *D. horrida var. glabrescens*, *D.malabarica*, *D. sissoides* and *D. travancorica* are endemic to Peninsular India.

In all these studies, the necessity of establishment of *ex- situ* conservation centres has been highlighted with an aim for conservation and optimum utilisation of the genetic resources of the above mentioned plant groups. Thus, Kerala Forest Research Institute, with the financial assistance of Planning and Economic Affairs (WGC) Department, has made an effort to develop *ex-situ* conservation areas in the Bioresources Nature Park of KFRI Sub Centre, Nilambur, with the following specific objectives:

a) To establish, along a Bioresources Nature Trail, a live collection of species of *Dalbergia* and monocotyledons with particular reference to palms, rattans and bamboo and other species which have conservation value and academic importance.
b) To promote nature education and ecotourism.

2. LOCATION AND CLIMATE

Nilambur, in Malappuram District of Kerala State (Figure 1) is the place where the world's first teak plantation was raised during 1842-1844 by H.V. Conolly, the then collector of Malabar. The historic importance of Nilambur also inspired the establishment in the year 1995, a Teak Museum at the KFRI Sub Centre campus (76^0 15' 28" E longitude and 11^0 18' 14" N latitude) (Figure 2). The Teak Museum provides information on cultivation, management, utilization and socio-economic, ecology and other aspects of teak (*Tectona grandis*)- the reputed timber species of South- east Asia. Each month, an average of about 9,000 visitors including farmers, members of the general public, students and researchers visit the Teak Museum and adjacent Bioresources Nature Trail, both located in the KFRI Sub Centre campus (Figure 3). It was aimed to establish *ex-situ* gardens of monocotyledons and *Dalbergia* in the Bioresources Nature Trail.

Figure 1. Map of Kerala showing Nilambur where the Bioresources Nature Trail is present.

The altitude of the KFRI Sub Centre campus is about 65 m above msl. The annual rainfall is around 2,360 mm, and it is during the month of July that the area receives the maximum precipitation of about 422 mm whereas in January, February and March the precipitation is about 30.4 mm, 8.26 mm and 26.4 mm respectively. The mean maximum and minimum temperatures are 37°C and 17°C respectively. Surface soil is red (oxisol) fine loamy and the sub-surface soil is gravel and red sandy. During the dry period, the humidity is very less and herbs and shrubs tend to dry in the absence of subsoil moisture.

Figure 2. Imagery from Digital Globe Geo-eye showing the Teak Museum and Bioresources NatureTrail at Nilambur

Figure 3. A view of the Bioresources Nature Trail at KFRI Sub Centre campus, Nilambur

3. METHODS

3.1 Plant collection

The plant specimens were either collected from natural forests/ponds or procured from collections of other research institutes or bought from commercial nurseries. The specific locale of collection of the various groups of plants is given along with the description of *ex-situ* conservation area/gardens in Section 4.

3.2 Specimen maintenance

The collected specimens were maintained live either by planting in soil or in earthen pots. The water plants are placed in tanks of varying sizes. Plants which require critical ambient conditions to survive are maintained by controlling light and humidity till they are planted in appropriate seasons and in appropriate places in the garden.

The specimen thus collected have been categorized and presented under the different *ex-situ* conservation areas such as palm and rattan gardens, bamboo gardens, Dalbergia germplasm area, *etc.* Monocotyledons other than bamboos, rattan and palms are presented in different thematic areas already present in the Bioresources Nature Park.

4. THEMATIC ZONES IN THE BIORESOURCES NATURE TRAIL

4.1. Palm and rattan garden

The palm and rattan garden is established in about 1.5 ha area (Figure 4). This is an assemblage 66 palms including of 30 indigenous and 36 exotic palms. The exotic species include those which are commonly seen in Indian parks, gardens and along avenues. For each species, 2-5 plants were planted.

Figure 4. A view of the palm and rattan garden

Since the soil is lateritic and gravelly, for planting each seedling, pits each of 1.2 x 1.2 x 1.2 m size were dug. The pits were later filled up with top soil and compost to a height of 60 cm below the ground level. Later the seedling was planted at the centre of the pit, covered with soil up to collar level. Between palm, a spacing of 5 x 5 m was maintained. Planting was done by the onset of south-west monsoon, *i.e.* May-June. Shade, using shade-nets which allow about 75% light, was provided during the first year after planting for young seedlings. A plant guard made of fish net was fixed around each seedling to protect them from wild boar and bandicoots.

Arenga hookeriana

Calamus rotang

Calamus vattayila

Chamadorea seifritzii

Around each plant, an area of 1 x 1m was cleared and its border was raised using laterite bricks. The height of the brick border was around 25 cm above the ground level. The basin thus formed was filled with partially decomposed leaf litter and freshly fallen leaves. Mulching was done at the close of north-east monsoon (October- November). The purpose of mulching was to avoid weed growth around palms seedling, control soil erosion and add organic matter to the soil by mulch decomposition. However, despite mulching, some seedlings showed poor growth. In such cases, inorganic fertilizer (100 gm urea, 200 gm super- phosphate and 200 gm muricate of potash) was provided in split dose during May-June, September-October, December and February. During dry summer months, plants were irrigated daily at the rate of 25-32 liters of water per plant.

The palm garden is located in a gently sloping area. Thus trenches were dug across the land to conserve excess water during the rainy season and control soil erosion. The garden is developed not only for educational purpose, but also for the enjoyment it offers to the visitors by having a turf grass, several ornamental plants planted around teak and other trees interspersed in it. Apart from the lawn grass, *Arachis pintoii, Wedalia chinensis* and *Heterocentron elegans* are planted in blocks. The garden is enclosed in a live fence composed of plants such as *Bougainvillea buttiana, B. glabra, B. peruviana,*

B. spectabilis, *Hibiscus rosa-sinensis* 'Kalyani' *H. rosa-sinensis* 'Perey Lancester hybrid', *H. rosa-sinensis* 'Prolific', *H. rosa-sinensis* 'Snowflake', *H. syriacus*, *H. tiliaceus* 'Tricolor' and *Pandanus amarillyfolia*. However, since animals like wild boar and rabbits, which are common in the campus, damage plants, a split bamboo fence was constructed around the garden.

Korthalsia laciniosa

Phoenix sylvestris

The specimens (Table 1) were collected from natural forest areas of Nilambur, Nelliampathy in Kerala, Chickmagalore in Karnataka and villages in Palakkad District. Some of the specimens were also provided from the palmatum established in KFRI (Renuka, 2008). Plants were also brought from Lalbagh in Bengaluru, Atmanilayam Nursery, Parassala and Tropical Botanical Garden and Research Institute, Palode.

Pinanga dicksonii

Corypha umbraculifera

Table 1. List of species planted in the palm and rattan garden of Bioresources Nature Trail at Nilambur.			
1.	*Aiphanes horrida*	34.	*Corypha utan**
2.	*Areca catechu**	35.	*Cyrtostachys renda*
3.	*Areca sp.*	36.	*Daemonorops kurzianus**
4.	*Areca triandra**	37.	*Daemonorops rarispinosus**
5.	*Arenga engleri*	38.	*Dypsis decaryi*
6.	*Arenga hookeriana*	39.	*Dypsis lutescens*
7.	*Arenga wightii**, WG,V	40.	*Elaeis guineensis*
8.	*Arenga sp.*	41.	*Howea foresteriana*
9.	*Bentinckia condapanna**, SWG,R	42.	*Howea sp.*
10.	*Bismarckia nobilis*	43.	*Hyophorbe lagenicaulis*
11.	*Borassus flabellifer**	44.	*Korthalsia laciniosa**, WG, R
12.	*Calamus baratangensis**	45.	*Korthalsia rogersii**
13.	*Calamus brandisii**, WG,T	46.	*Lantania lontaroides*
14.	*Calamus dransfieldii**, SWG	47.	*Licula grandis*
15.	*Calamus lakshmanae**, WG	48.	*Licula spinosa*
16.	*Calamus longisetus**, WG,V	49.	*Livinstona rotundifolia*
17.	*Calamus metzianus**, WG	50.	*Mascarena revaghaniis*
18.	*Calamus nagbettai**, SWG,V	51.	*Nypa fruticans**
19.	*Calamus pseudotenuis**, WG	52.	*Phoenicophorium borsigianum*
20.	*Calamus rotang*	53.	*Phoenix pusilla**
21.	*Calamus stoloniferus**	54.	*Phoenix roebelenii*
22.	*Calamus thwaitesii**	55.	*Phoenix sylvestris**
23.	*Calamus travancoricus**, SWG	56.	*Pinanga dicksonii**, WG, V
24.	*Calamus vattayila**, WG	57.	*Pritchardia pacifica*
25.	*Caryota urens**, WG	58.	*Ptychosperma macarthurii*
26.	*Chamaedorea elegans*	59.	*Raphis excelsa*
27.	*Chamaedorea metallica*	60.	*Ravenea insigns*
28.	*Chamaedorea seifritizii*	61.	*Ravenea rivularis*
29.	*Chambeyroni lepidota*	62.	*Roysteonia regia*
30.	*Cocos nucifera**	63.	*Syagrus romanzoffiana*
31.	*Cocothrinax alata*	64.	*Wallichia disticha**
32.	*Cocothrinax sp.*	65.	*Washingtonia robusta*
33.	*Corypha umbraculifera**, WG, R	66.	*Wodyetia bifurcata*
* Indigenous species. WG: endemic to the Western Ghats, SWG: endemic to the southern Western Ghats, V: Vulnerable, R= Rare, T, Threatened.			

4.2. Bamboo Garden

An area of 0.25 ha, adjacent to the already established plots of edible bamboo in the Sub Centre campus, was demarcated. Since it was decided to plant three to five propagules per species of bamboo due to the space limitation, a linear design of planting was adopted. The propagules of *Bambusa striata*, *Bambusa tuldoides 'Ventricosa'* and *Dendrocalamus asper*, obtained from the bambusetum established in KFRI Field Station at Palappilly, Tropical Botanical Garden and Research Institute, Palode and a few private nurseries in Thrissur, Wayanad and Bengaluru, were planted. A list of bamboo species, including those planted as part of the present project in the KFRI Sub Centre are listed in Table 2.

Table 2. List of species in the bamboo garden of KFRI Sub Centre, Nilambur

1.	*Bambusa balcooa*	14.	*Dendrocalamus giganteus*
2.	*Bambusa bambos*	15.	*Dendrocalamus hamiltonii*
3.	*Bambusa multiplex*	16.	*Dendrocalamus longispathus*
4.	*Bambusa nutans*	17.	*Dendrocalamus membranaceus*
5.	*Bambusa pallida*	18.	*Dendrocalamus strictus*
6.	*Bambusa polymorpha*	19.	*Dendrocalamus stocksii* WG
7.	*Bambusa striata*	20.	*Melocanna baccifera*
8.	*Bambusa tulda*	21.	*Ochlandra scriptoria* SWG
9.	*Bambusa tuldoides* 'Ventricosa'	22.	*Ochlandra travancorica* WG
10.	*Bambusa vulgaris*	23.	*Pseudoxytenanthera ritcheyi* WG
11.	*Bambusa wamin*	24.	*Thyrsostachys oliveri*
12.	*Dendrocalamus asper*	25.	*Thyrsostachys regia*
13.	*Dendrocalamus brandisii*		

WG: endemic to the Western Ghats, SWG: endemic to the southern Western Ghats.

Ochlandra travancorica

For planting bamboos, pits were prepared about 1-2 months in advance *i.e.*, during the months of March-April. After clearing the land pit locations were marked on the ground through measurement to ensure the desired spacing. Pits of 1.2 x 1.2 x 1.2 m were dug to provide adequate room for the spread of root system. The pits were later filled up with top soil and compost up to a height of 60 cm below the ground level. A few days before planting, soil in the pit was turned over thoroughly and weeds and competing vegetation within a radius of 1.5 m from the pit were removed. Later the propagule was planted at the centre of the pit and covered with enriched soil up to the collar level. A spacing of 7 x 7 m between two palms was maintained. Planting was done by the onset of south-west monsoon, *i.e.* May-June. If there was no rain while planting, plants were irrigated with 12–20 litres of water per plant in order to provide the required moisture to the rhizome and roots, and to compact the loose soil around the plant. Watering was done at daily intervals initially and once in three days later till the rain commenced. Plant guard made of fish net was fixed around each plant to protect it from wild boar and bandicoots.

Spot weeding was done at a radius of 60 cm around the plants after out-planting. Since the summer in this locality is harsh and dry, mulching around each plant was done to encourage growth through reduced evaporation of soil water. During the post-monsoon season, the soil was loosened to improve aeration. A few plants did not survive and thus replanting was done as and when the casualty was noticed.

Dendrocalamus asper

Bambusa pallida

To protect the plants from fire during the dry season, fire-line, which is about 5 m wide was established. In the project period, during January-February, the soil was heaped around the developing clump followed by mulching with green foliage and leaf litter to allow and ease shoot production.

Dendrocalamus giganteus

Dendrocalmus hamiltonii

4.3. Orchid house

With the financial support of the Department of Biotechnology, Govt. of India, the KFRI has already established an Orchid House (Figure 5) in the Bioresources Nature Trail at KFRI Sub Centre (Chandrashekara *et al.*, 2009). The Orchid House, with an area of about 109.68 m^2, houses 76 species of orchids, which represent both terrestrial and epiphytic orchids. As a part of the present project, the Orchid House has been enriched by introducing species and varieties (Table 3) which were not represented.

Figure 5. Orchid House in the Bioresources Nature Trail at Nilambur

Planting was done in pots. Mud pots and plastic pots of 15-25 cm diameter with several large holes on the sides and bottom were used. The pots were filled with broken terracotta tile and brick bits, chopped coconut husk and charcoal. The plant propagules after dipping in fresh and clear cow-dung solution were planted above the medium and provided proper support. The clear supernatant from a solution of fresh cow-dung was also used for irrigation for a few days. Orchids were sprayed with the supernatant liquid of cow-dung slurry once in a month. Foliar spray of fertiliser mixture of N, P_2O_5 and K_2O in the ratio 3:1:1 during vegetative period and 1:2:2 during flowering period was applied. Such a mixture with a dose of 2-3 g per litre of water was applied to the soil twice a week.

Dendrobium 'Joy Concert x Samut Song Kram'

Table 3. Orchid species and hybrids planted in the Orchid House of Bioresources Nature Trail at KFRI Sub Centre, Nilambur
Acampe praemorsa
Aerides ringens
Anoectochilus elatus[SWg]
Anoectochilus sp.
Bulbophyllum rosemarianum[SWg]
Calanthe sylvatica
Cleisostoma tenuifolium
Cottonia peduncularis
Cymbidium ensifolium var. haematodes
Dendrobium chrysanthum
Dendrobium fimbriatum
Dendrobium nutans
Epidendrum radicans
Eria dalzellii [Wg]
Eulophia spectabilis
Gastrochilus flabelliformis[Wg]
Habenaria brachyphylla
Habenaria plantaginea
Liparis odorata
Nervilia crociformis
Phaius tankervillae
Pholidota imbricata
Polystachya concreta
Porpax reticulata
Seidenfia intermedia [SWg]
Seidenfia rheedii [SWg]
Spathoglottis plicata
Vanilla planifolia
Zeuxine longilabris
Hybrids of Orchids
Arachnis (pure white)
Arachnis (yellow ribbon)
Arachnis (light yellow with brown spot)
Arachnis (white with light brown spot)
Arachnis (light yellow with red spot)
Arachnis hybrid 'Muhammed Haneef'
Arachnis 'Anne Black'
Arachnis 'Muskiflora'
Aranda [Arachnis x Vanda]
Cattleya 'Coerula Capri'
Dendrobium 'Chrysanthemum'
Dendrobium 'Joy Concert x Samut Song Kram'
Dendrobium 'Madam Pompadour'

Dendrobium nutans


Acampe praemorsa


Bulbophyllum rosemarianum

Nervilia crociformis


Gastrochilus flabelliformis

Seidenfia intermedia


Dendrobium densiflorum


Porpax reticulata

Table 3 (cont'd). Orchid species and hybrids planted in the Orchid House of Bioresources Nature Trail at KFRI Sub Centre,Nilambur
Dendrobium 'Madam Viper'
Dendrobium 'Martico White'
Dendrobium 'Ooty'
Dendrobium (Black)
Dendrobium (light rose)
Dendrobium (dark rose)
Dendrobium 'Sonia 19'
Dendrobium 'Sonia 28'
Dendrobium 'Waibu Beauty'
Dendrobium 'White'
Mokara 'Calypso'
Mokara 'Calypso'Dark Rose
Mokara 'Chark Kuan Pink'
Mokara 'Cintha Manis'
Mokara 'Getty'
Mokara 'Kelwin'
Mokara 'Madam Funny'
Mokara 'Pani'
Mokara 'Philippines' x 'Kaisum'
Mokara light violet
Oncidium 'Dancing Girl'
Oncidium 'Bob Cat'
Oncidium 682
Oncidium 954 UCO
Phalaenopsis (light green)
Phalaenopsis (pink)
Phalaenopsis (white)
Spathoglottis plicata `alba'
Vanda 'Arun Sree Beauty'
Vanda 'Suksamran Sunlight'
Vanda 'Patoharee's Delight'
Vanda 'Kultana Gold'
Vanda 'Masaco yamuda x Tokyo Blue'
Vanda 'Vasco Pine River Pink'
Vanda coerulea
Vanda 'Ruby Prince'
Vanda 'Robert Delight'
Vanda spathulata
Vanda tessellata
WG: endemic to the Western Ghats, SWG: endemic to the southern Western Ghats


Arachnis `hybrid'


Cattleya 'Coerula Capri'


Dendrobium 'Madam Viper'


Mokara 'Kelwin'


Dendrobium 'Joy Concert x Samut Song Kram'


Phalaenopsis


Oncidium '950 UCO'


Mokara 'Cintha Manis'


Vanda 'Masaco yamuda x Tokyo Blue'


Spathoglottis plicata `alba'

4.4. Medicinal plant Garden

In the KFRI Sub Centre, Nilambur, as a part of another project, a medicinal plant garden has already been established (Figure 6) (Chandrashekara *et al*., 2009). Plants which have been introduced in this garden as part of the present project are listed in Table 4.

Figure 6. Medicinal plant garden in the Bioresources Nature Trail at Nilambur

For each species, a raised bed (45 cm high, supported with roof tiles) of 2 m x 2 m was formed (Fig. 6). At the time of bed preparation, 2 kg of compost was applied as basal dose for each bed. After planting, mulching with partially decomposed leaves was done to protect soil as well as for good growth of plants. Weeds were removed regularly, while the earthing up and compost application were done every alternate month. Soil was kept sufficiently moist by watering daily once or twice.

Table 4. Monocot species planted in the Medicinal Plant Garden of the Bioresources Nature Trail at KFRI Sub Centre, Nilambur

Species	Family
Aloe vera	Aloaceae
Crinum asiaticum	Amaryllidaceae
Acorus calamus	Araceae
Amorphophallus campanulatus	Araceae
Asparagus racemosus	Asparagaceae
Ananas comosus	Bromeliaceae
Commelina benghalensis	Commelinaceae
Costus pictus	Costaceae
Costus speciosus	Costaceae
Cyperus distans var. distans	Cyperaceae
Cyperus pilosus	Cyperaceae
Cyperus rotundus	Cyperaceae
Dioscorea bulbifera	Dioscoreaceae
Dioscorea hispida	Dioscoreaceae
Dioscorea pentaphylla	Dioscoreaceae
Curculigo orchioides	Hypoxidaceae
Gloriosa superba	Liliaceae
Urginea indica	Liliaceae
Maranta arundinacea	Marantaceae
Maranta arundinacea 'Variegata'	Marantaceae
Stachyphrynium spicatum[PI]	Marantaceae
Ensete superbum[PI]	Musaceae
Pandanus amaryllifolius	Pandanaceae
Pandanus odorifer	Pandanaceae
Aristida setacea	Poaceae
Coix lacryma-jobi	Poaceae
Cynodon dactylon	Poaceae
Heteropogon contortus	Poaceae
Hygroryza aristata	Poaceae
Saccharum officinarum	Poaceae
Trichopus zeylanicus[SWG]	Trichopodaceae
Smilax zeylanica	Smilacaceae
Alpinia calcarata	Zingiberaceae
Alpinia galanga	Zingiberaceae
Curcuma amada	Zingiberaceae
Curcuma aromatica	Zingiberaceae
Curcuma longa	Zingiberaceae
Curcuma neilgherrensis[WG]	Zingiberaceae
Curcuma zedoaria	Zingiberaceae
Hedychium coronarium	Zingiberaceae
Kaempferia galanga	Zingiberaceae
Kaempferia rotunda	Zingiberaceae
Zingiber officinale	Zingiberaceae
Zingiber zerumbet	Zingiberaceae

PI: endemic to peninsular India, WG: endemic to the Western Ghats, SWG: endemic to the southern Western Ghats.

4.5 Hydrophyte gardens

Hydrophytes can be broadly categorized into floating hydrophytes, submerged rooted hydrophytes, floating leaved, anchored or rooted hydrophytes and emergent rooted hydrophytes. In the Hydrophytes Garden of the Bioresources Nature Trail at Nilambur (Figure 7), monocotyledonous species representing the above mentioned hydrophyte categories were planted (Table 5; Figure 7). Planting was done in concrete pools and tubs of different dimensions. The bottom of pools and tubs was filled with rich clayey soil to provide enough nutrition. Water plants are heavy feeders, and will not bloom unless they receive proper nutrition.

Thus the soil was enriched by providing well-decomposed cattle dung manure. The manure was first placed in the bottom and then covered with clayey soil to prevent the floating of manure. Around the ponds/tubs some ornamental leaf or flower beds were also placed. The ponds and tubs were cleaned occasionally and plants were trimmed as and when required. Once in a year, replanting was done after the organic matter from the bottom of the container were taken out completely and replaced with fresh nutrient rich clayey soil.

Figure 7. A view of the Hydrophyte garden in the Bioresources Nature Trail at Nilambur

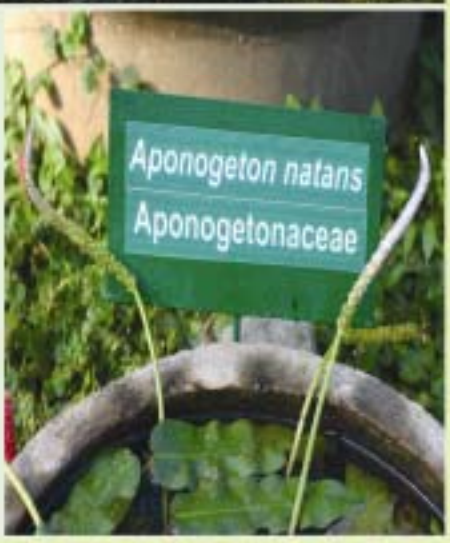
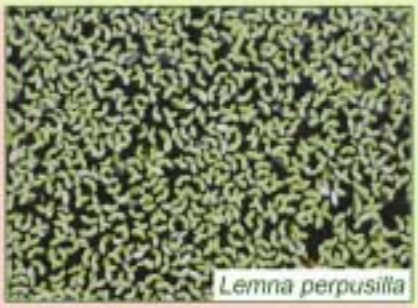


Table 5. Monocot plants planted in the Hydrophytes Garden of the Bioresources Nature Trail at KFRI Sub Centre, Nilambur
Alismataceae
Baledelia ranunculoides
Echinodorus paleofolius
Limnophyton obtusifolium
Sagittaria guayanensis
Aponogetanaceae
Aponogeton natans
Araceae
Acorus calamus
Cryptocoryne spiralis
Arecaceae
Nypa fruticans
Cyperaceae
Cyperus distans var. distans
Cyperus malaccensis
Cyperus pangoreii
Cyperus tenuispica
Fuirena ciliaris
Hypolytrum nemorum
Eriocaulaceae
Eriocaulon cinereum
Eriocaulon robusto-brownianum
Eriocaulon xeranthemum
Lemnaceae
Lemna perpusilla
Spirodela polyrhiza
Poaceae
Coix lacryma-jobi
Desmostachya bipinnata
Echinochloa frumentacea
Saccharum spontaneum
Sacciolepis indica


Spirodela polyrhiza


Lemna perpusilla


Limnophyton obtusifolium


Eriocaulon cinereum


Cyperus pangoreii


Cryptocoryne spiralis


Baldelia ranunculoides


Echinodorus paleofolius


Saccharum spontaneum


Schoenoplectrus auriculatus

4.6 Xerophyte and succulent gardens

Plants adapted to dry or desert conditions are collectively known as xerophytes. One of the most important adaptations seen in such plants is for the prevention of water loss. The four main ways by which xerophytes prevent water loss are reducing transpiration, increasing water storage, having modified plant parts like thorns, and growing during early hours and cooler seasons. Succulents are xerophytes that have developed storage structures, in which they hoard water, enabling them to survive periods of drought.

Figure 8. A view of the rock garden in the Bioresources Nature Trail at Nilambur

Figure 9. A view of the xerophyte and succulent house in the Bioresources Nature Trail at Nilambur

Succulents require plenty of air and sunshine. Such outdoor xerophytes and succulents were planted in a specially designed rocky mound (Figure 8). However, many of them cannot withstand direct scorching sunshine. Therefore, in the Bioresources Nature Trail at KFRI Sub Centre, to grow succulent plants a house, with fibre glass roof and the wall half-way brick worked and the rest with metal grill was constructed. A raised platform was used for positioning potted plants to ensure adequate flow of wind (Figure 9).

Table 6. Plants planted in the xerophyte and succulent gardens of the Biore sources Nature Trail at KFRI Sub Centre, Nilambur

Species	Family
Beaucarnea recurvata	Agavaceae
Cordyline terminalis	Agavaceae
Furcrea foetida	Agavaceae
Yucca aloeifolia	Agavaceae
Yucca whipplei	Agavaceae
Aloe bakeri	Aloaceae
Aloe barbadensis	Aloaceae
Aloe brevifolia	Aloaceae
Aloe jucunda	Aloaceae
Aloe juvenna	Aloaceae
Aloe variegata	Aloaceae
Aloe vera	Aloaceae
Gasteria liliputana	Aloaceae
Gasteria verrucosa	Aloaceae
Haworthia attenuata	Aloaceae
Haworthia cuspidata	Aloaceae
Haworthia fasciata	Aloaceae
Haworthia humulus	Aloaceae
Haworthia limifolia	Aloaceae
Haworthia reinwardtii	Aloaceae
Eucharis korsakovii	Amaryllidaceae
Pancratium triflorum	Amaryllidaceae
Zephyranthes carinata	Amaryllidaceae
Zephyranthes rosea	Amaryllidaceae
Aptania cordifolia	Araceae
Ananas nanus	Bromeliaceae
Cryptanthus bivittatus	Bromeliaceae
Cryptanthus praetextus	Bromeliaceae
Neoregalia carolinae	Bromeliaceae
Commelina benghalensis	Commelinaceae
Murdania pauciflora	Commelinaceae
Tradescantia spathacea	Commelinaceae
Tradescantia zebrina	Commelinaceae
Sansevieria cylindrica	Liliaceae
Pandanus sanderi	Pandanaceae

A list of species planted is given in Table 6. Plastic pots were used for some plants which require less watering and low soil moisture. However, clay pots were used for tall plants because they provide stability to plants and can help to mitigate the effects of over-watering. The size of the pots was just large enough to accommodate the plants; neither too big nor too small to prevent to damage the plants and encourage plant growth. The xerophytes and succulents which have fibrous roots were planted in clay or plastic pans. The pots and pans with drainage holes at the bottom and the sides were used since they allow water and air to pass through ensuring enough aeration of the roots and quick drying of pot compost, thus promoting root growth and minimising the possibility of root rot.

Yucca aloifolia

For preparing the pot compost, red and laterite soil was collected. The soil was ameliorated with lime and enriched with organic matter. Both xerophytes and succulents, in general, prefer well-drained, porous pot compost. Thus in the pot compost medium to coarse sand to clay and silt were mixed at a ratio of 6:2:2. All the ingredients, before mixing, were subjected to solarisation.

Sansevieria cylindrica

Before planting in pots, the roots were examined carefully. Roots showing any indication of rot or other infection was removed and the fungicide treatment given. Inside the pot, tile pieces were placed over the drainage holes arch-wise. Then about ¼th of the pot was filled with small pieces of bricks followed by a layer of gravel or coarse sand to ensure good drainage and to check the soil from being percolated out with water. To leave room for watering, the pot was filled leaving a gap of 2-3 cm at the top. As xerophytes and succulents in general are shallow rooted, planting was also done reasonably shallow. Planting was always done with fresh dry compost.

Furcrea foetida

Beaucarnea recurvata

After this, plants were placed in shady but airy locations for a few days. First watering was done after 15-20 days. Subsequent watering was done twice a week during summer and once in a week during rainy season.

Care was taken to avoid damp environment, over watering, insufficient drainage and watering in warm pot compost. As a precautionary measure, routine spray and soil drenching with a standard fungicide at 3-4 weeks interval throughout the year was done.

4.7 Genepool of Dalbergia

In the KFRI Sub Centre campus, two species trail plots, namely evergreen forest species plot and a miscellaneous tree species plot were established as a part of two earlier research projects. Since there was no space in the campus to establish a separate *Dalbergia* genepool garden, it was decided to plant different species of *Dalbergia* in available spaces of the two above mentioned plots.

Figure 18. *Dalbergia horrida* and *D. rubiginosa* planted in the geenpool of *Dalbergia* of Bioresources Nature Trail at Nilambur

At least 20 seedlings/wildlings per species were collected. Wildlings of *D. beddomei* were collected from the stream banks of Periyar Tiger Reserve area. *D. candenatensis*, in general, is a component of mangrove vegetation. Its wildlings were collected from the Valapattanam estuary in Kannur District. From the moist deciduous forest patches in the Kanjirakadavu of New Amarambalam Forest Range of Nilambur Forest (South) Division, the wildlings of *D. horrida and D. laceolaria* were collected. Individuals of *D.latifolia, D.paniculata and D. sissoides* were collected from moist deciduous forests tracts of Nilambur, Vanaimpuzha and Nedumkayam respectively. In the moist deciduous forest patches of Dhoni Reserve Forests in Palakkad Forest Division and Kasaragode Forest Range in Kannur Forest Division it was noticed that the distribution of seedlings of *D. rubiginosa and D. volubilis* was sparse. Therefore, a survey was made in the forests of neighbouring state of Karnataka, from where the two species were reported. During this survey, wildlings were collected from the river banks adjacent to semi-evergreen and moist deciduous forests of Kempuhole Forest Reserve and Agumbe Forest Range. Private nurseries in Thrissur, Bangalore and Mysore were the sources of seedlings of *D. sissoo* and *D. melanoxylon*.

Under this project, eleven species namely *Dalbergia beddomei, D. candenatensis, D. horrida, D. lanceolaria, D. latifolia, D. melanoxylon, D. paniculata, D. rubiginosa, D. sissoides, D. sissoo* and *D. volubilis* were selected for planting. These species were identified following a dichotomous key for the genus *Dalbergia* given by Nair (1986). Among eleven species, *D.beddomei, D. horrida* are endemic to peninsular India, while *D. candenatensis* and *D. rubiginosa* are endangered species.

5. DISCUSSION AND CONCLUSION

The major objective of the Western Ghats Development Programme of the Department of Economic and Planning Affairs, Govt. of Kerala, is to undertake activities for a) preserving biodiversity of the Western Ghats, b) creating awareness among the people on biodiversity richness of the Western Ghats, c) educating the people for preservation of the "Resource Trinity"-Land, Water and Biomass, and d) developing approaches for sustainable utilization of natural resources to prevent further ecological degradation in the Western Ghat region. One of the goals of Kerala Forest Research Institute is to disseminate knowledge and information on forest-related matters to end-users, farmers, students, general public and transfer of technology to stakeholders for social benefits. Thus the specific aim of the project to establish an *ex-situ* garden of Dalberigias and monocotyledons in the KFRI Sub Centre at Nilambur was to play a significant role for increasing public awareness of the value of biodiversity conservation needs. The success of this project is evident by the fact within two years (April 2008 to March 2010) of the completion of the Project on an average every month 11,485 visitors belonging to the general public and 1,785 students have visited these gardens (Figure 10).

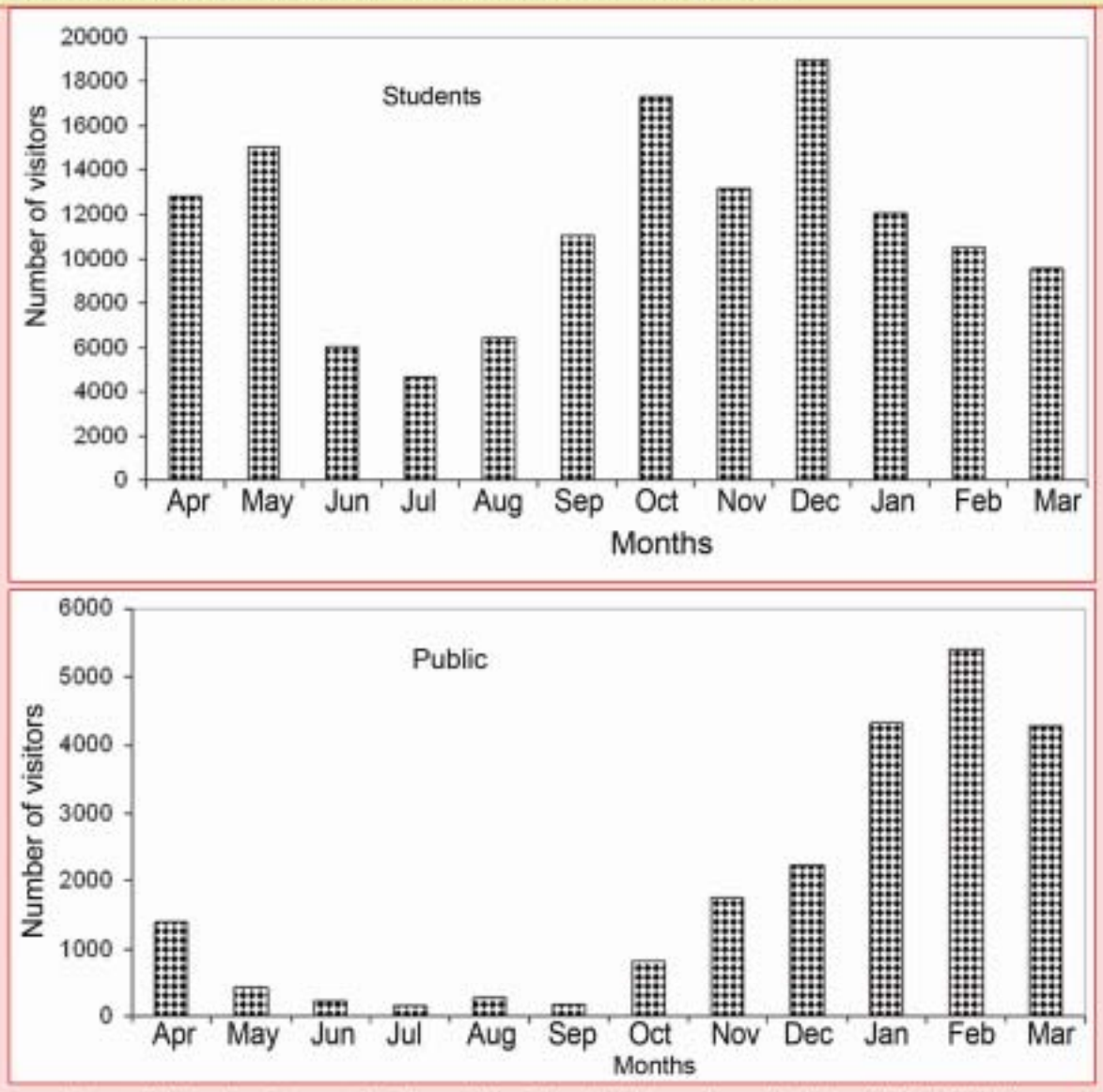


Figure 10. Number of general public and students visited in each month during 2008-2010 to the Bioresources Nature Trail at KFRI Sub Centre, Nilambur.

These gardens having several wild monocots and Dalbergias are helping to increase awareness of the ecological, economic and cultural significance of the wild plant species and their potential value as genetic resources. These gardens are also helpful to the local schools and colleges as the gardens are enabling the students to make frequent visit and observe variability and adaptive modifications in the plant world, literally at their hometown. The gardens are providing an opportunity to the visitors, particularly the student community, to develop a general aesthetic regard and respect for plants.

In fact, the Convention on Biological Diversity (CBD) advocates that the *ex-situ* gardens should involve in national issues of biodiversity conservation and sustainable development. At the same time, the CBD expects from each signatory country to offer *ex-situ* gardens more chances to gain greater importance, profile and recognition of their central role in plant conservation. Thus in the context of recommendations of CBD and National Biodiversity Conservation Action Plan, the newly established *ex-situ* gardens of monocotyldons and Dalbergia at KFRI Sub Centre campus will enable to contribute as one of the most effective multipliers for increasing public awareness, education and training. It may also be mentioned here that live specimens of over eleven species endemic to Western Ghats, eight species to the southern Western Ghats and another eight species endemic to Peninsular India can be seen in the newly established *ex-situ* gardens. Among them six species come under vulnerable category of IUCN while one under threatened category and another three under rare category of IUCN (IUCN, 2000). However, like any other *ex-situ* garden, most species cultivated here are on an average represented by only two or three specimens and the genetic diversity within wild species is not reflected. In this context, further attempts can be made to collect more specimens covering a range of diversity of wild species, particularly endemic and RET species, to facilitate germplasm distribution. Collection of accessions directly from the wild also reduces the effect of domestication on the genetic make-up of the accessions. Attempts can also be made in this garden to start a seed bank/gene bank. To start with, a gene bank/seed bank of germplasm that is very well documented from their living plant collection can be established.

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