
Orchid House

Orchids

Shade House

Bryophytes

Fern House

Ferns

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# ESTABLISHMENT OF BIORESOURCES NATURE TRAIL AT NILAMBUR IN THE KERALA PART OF WESTERN GHATS

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# CONTENTS

## EXECUTIVE SUMMARY

The Kerala Forest Research Institute has developed about 10 ha of land into a Bio-resources Nature Park at its Sub Centre at Nilambur. 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. In order to improve the facilities in the Bioresources Nature Park, through its Botanical Garden Scheme, the Ministry of Environment and Forests, Government of India has financed a short-term project to the Kerala Forest Research Institute. The specific aim of the project was to improve facilities in different theme areas like Fern House and Bryophyte House, to collect plant propagules of endangered and endemic ferns, bryophytes and angiosperms and to assemble them in appropriate theme area in the Bioresources Nature Trail, thereby help in increasing public awareness of the value of biodiversity conservation needs. During the project period, walls of the Fern House and Bryophytes House were painted using plastic emulsion paint. The metallic nets and frames of these thematic houses were also painted with synthetic enamel paint of suitable colour. Non-slippery floor tiles were fixed in both the houses. In the Fern House, potted plants were displayed by arranging them on the concrete platform. Since the platform was damaged in many places due to constant watering and stagnation of water here and there, ceramic tiles were fixed to make these platforms neat, clean and attractive. The roof of Fern House and Bryophyte House are damaged in several places. Therefore, old fibre glass roofing materials were dismantled. New MS-angle iron frames were made and fixed to the purling of each House. Over the iron frame, UV-coated corrugated poly-carbonate clear colour sheets of thickness 2-mm were laid. Using the aluminium flat, steel screw, bolts, metal washers and silicon glue the sheets were fixed. An array of overhead mist outlets which ensure high humidity has been installed both in the Fern House and Bryophyte House. Irrigation facilities such as pipe line, sprinklers and mist outlets provided in the Bioresources Nature trail were inadequate even to manage the existing plants in the garden. Thus, irrigation facility has been strengthened. One of the major threats for managing Bioresources Nature Trail at Nilambur was the damage caused by wild boar. Therefore, the entire length of the major parts of the Bioresources Nature Trail were covered by the chain-link fence. During the project period, emphasis has also been given to collect plant propagules of endangered and endemic ferns, bryophytes and angiosperms and assemble them in appropriate theme area in the Bioresources Nature Trail. As part of the present Project, twenty-one rare and endemic bryophyte species, forty-eight fern species (twenty-five rare and twenty-three common species) and seventeen angiosperm species belonging to different conservation status have been planted in the Bioresources Nature Trail.

## 1.INTRODUCTION

The habitat loss of flora and fauna in the face of growing human population, and economic as well as social factors causing over-exploitation and endangerment of biological resources are the major issues in biodiversity conservation. According to Nayar (1997) at the present rate of habitat loss, by the year 2030 about 1/3 of biodiversity in India would be extinct or would remain in isolated refugia of non-viable populations which may enter into the vortex of extinction. It is also reported that compared to other biomes, the loss of tropical forests could lead to highest extinction of species. This is because of the fact that the tropical forests support communities with a rich array of species and such 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 km2 of which the forest cover is about 10,336 km2. These tropical forests have a flora of about 10,035 species, which represent 22 percentage of Indian flora including 3800 species of Angiosperms, 4 species of Gymnosperms, 331 species of Pteridophytes, 300 species of Bryophytes, 520 species of Lichens, 325 species of Algae and 4800 species of Fungi (Nayar, 1997). When the endemic species alone are considered, in India, there are about 5,725 endemic taxa of angiosperms which represent 33.5% of Indian flora. Being a part of the Western Ghats, one of the hot spots in the world, Kerala has about 1,381 endemic angiosperm species (Sasidharan, 2002). Of these, 496 species come under rare, vulnerable and endangered species categories, occurring in isolated populations. Further analysis of individual taxonomic groups of plants indicates that in each group, particularly endemic species are under threat. For instance, in the Kerala part of the Western Ghats out of 331 fern taxa reported 147 taxa are rare, which include 35 endemic species. Thirty-four species of Bryophytes reported from Kerala are rare and of these, four are endemic species. Based on a study conducted in Kerala, 254 species of macrolichens under 43 genera belonging to 18 families were reported (Kumar, 2000). Out of them, 63 species are new records to Peninsular India while 109 species are new records to Kerala and two species are reported for the first time from southern India. In all these studies, the necessity of establishment of ex situ conservation centres has been highlighted with an aim to conserve and optimally utilize the genetic resources of above-mentioned plant groups. One of the attempts made by the International Union of Conservation of Nature (IUCN) to conserve the world's biodiversity is the establishment of the Botanic Gardens Conservation Secretariat (BGCS) in 1987 to unite and promote the role of botanic gardens in conserving endangered or valuable species. In 1990, BGCS became independent (as Botanic Gardens Conservation International (BGCI) and has grown to include over 400 member institutions in more than 80 countries (Leadly et al., 1993). The recent trend is that botanic gardens should focus on and give priority to the cultivation of the native flora of their own region particularly those that are threatened, and those, which will add significantly to the scientific as well as conservation value of the resource (BGCI, 1993). In August 1999, over 5,000 botanists from 85 countries, who attended the XVI International Botanical Congress at St. Louis, USA noted in resolution that two-third of the world's plant species are in danger or extinction. They also identified the need for a

new coordinating body associated with the UN to be established to monitor the status of plants throughout the world. The need of taking steps to conserve plants of different groups in *in-situ* and in ex-situ areas like botanical gardens or in gene banks or preferably combination of these strategies has also been recognized (Greuter and McNeill, 2000). In India, several premier organizations have the mandate to inventorying, monitoring and conserving biodiversity. These organizations include Botanical Survey of India (BSI), Zoological Survey of India (ZSI) and Forest Survey of India (FSI). Several other supporting institutions in the attempts of in-situ and *ex-situ* conservation include CSIR, DBT, DST, etc (Stork and Samways, 1994). The BSI and ZSI along with other collaborating institutions have also been instrumental in cataloging the endemic species of flora and fauna, and preparing red data books on threatened plants of India. Several states have also engaged in documenting their biodiversity. This includes the biodiversity documentation prepared by the Kerala Forest Research Institute for plants and animals in Kerala State. In the country, several botanical gardens have been established for ex-situ conservation. Similarly, several small-scale botanical gardens exist in Universities to help the students in the field of botany, especially plant taxonomy.

It may also be pointed out that the Indian subcontinent comprises two major hotspots of biodiversity namely, Himalayan region and the Western Ghats. Here, apart form the protected areas, even areas outside the protected areas such as agroforestry systems and sacred groves are rich in flora and fauna. However, our primary and secondary and even higher institutions of learning do not have such curricula, which help students to appreciate the richness of bio-resources and their ecological and socioeconomic importance. Students are hardly ever exposed to different kinds of ecosystems and hence they 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, to serve multifold objectives of ex-situ conservation of different groups of plants and promotion of nature education and ecotourism, different approaches are needed. With this background, 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; Chandrashekara and Sasidharan, 2010). 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. With the financial support from the Ministry of Environment and Forests, Government of India, the Kerala Forest Research Institute has made an effort to improve facilities in the Bio-resources Nature Park. Details of the activities undertaken are given in the following Section.

## 2. LOCATION AND CLIMATE

Nilambur, in Malappuram District of Kerala State (Figure 1) is the place where the world's first commercial 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 in the KFRI Sub Centre campus (760 15' 28'' E longitude and 110 18' 14" N latitude) (Figure 2). The Teak Museum provides information on cultivation, management, utilization and socio-economics, ecology and other aspects of teak (Tectona grandis) - the reputed timber species of South-east Asia. Each month, an average of about 9,000visitors including farmers,general public, students and researchers visit the Teak Museum and adjacent Bioresources Nature Trail, both located in the KFRI Sub Centre campus (Figure 3).


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


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

## 3. ACTIVITIES UNDERTAKEN

### A. Improvement of facilities in Fern House and Bryophyte House

The Fern House in the Bioresources Nature Trail at Nilambur, which is of 120 $m^2$ in size, houses terrestrial, lithophytic, hydrophytic and epiphytic ferns. The Fern House is a four armed building, with pathways in the centre and stepped walls on which the specimens can be displayed.

The Bryophytes House is a 294 $m^2$ building with a floor sunken 2 m down the ground level. From the floor square pillars arise to eye level on which the bryophytes are left to grow on appropriate substrata. Each pillar harboring bryophytes are provided with drip nozzles to ensure moisture round the clock.

The brick walls of the Fern House and Bryophytes House were painted using plastic emulsion paint. The paint of suitable colour was selected to match with the landscape of the Bioresources Nature Trail. Painting with plastic emulsion paint was also undertaken as the walls were stained with algal growth and soil. Similarly, the metallic nets and frames of these thematic houses were getting rusted due to moisture being maintained in the house. Therefore, metallic nets and frames were painted with synthetic enamel paint of suitable colour.

Figure 3. Thematic Houses before renovation

The floor of the Fern House and Bryophyte House was uneven and muddy. In order to make it neat, non-slippery floor tiles were fixed. In the case of Fern House, potted plants were displayed by arranging them on the concrete platform. However, the platform got damaged in many places due to constant watering and stagnation of water here and there. This had resulted in uneven surface on the concrete platform. Therefore, tiles were fixed to make these platforms neat, clean and attractive.

The roof of Fern House and Bryophyte House were damaged in several places (Figure 3). In some other places, the roof sheets were discoloured and required quantity of light was not available for the plants for optimal growth. Therefore, old fibre glass roofing materials were dismantled. New MS-angle iron frames were made and fixed to the purling of each House. Over the iron frame, UV-coated corrugated poly-carbonate clear colour sheets of thickness 2-mm were laid. Using the aluminium flat, steel screw, bolts, metal washers and silicon glue the sheets were fixed (Figure 4).

An array of overhead mist outlets which ensure high humidity has been installed both in the Fern House and Bryophyte House.


Figure 4. A Thematic House after renovation

## B. Strengthening the irrigation facilities in the Bioresources Nature Trail

In Bioresources Nature Trail at Nilambur, the specimens collected from various locations have been categorized and presented under the following eight titles- the orchid house, fern house, hydrophytes garden, bryophyte house, xerophytes and succulents garden, the medicinal plants garden, palm garden and the gymnosperm garden. All the themes are presented in a landscaped garden carpeted with grass. The ambience of the general area is also enhanced by a wide variety of ornamental plants.

Irrigation facilities such as pipe line, sprinklers, mist outlets provided in the Bioresources Nature trail were inadequate even to manage the existing plants in the garden (Figure 5). Thus, irrigation facility has been strengthened. These facilities are providing adequate moisture for both the existing plants and the plants added during the project period to grow well even in the hot and humid condition of Nilambur.

Figure 5. Irrigation facilities were improved throughout the Bioresources Nature Trail

## C. Fencing

One of the major threats for managing Bioresources Nature Trail at Nilambur is the damage caused by wild boar. About 4 years back, bamboo fence was provided around major areas of the Nature Trail, to prevent the attack of wild boar. However, the bamboo fence was found not effective as wild boar entry into the garden did not stop. Thus, it was decided to provide aesthetically good and strong fence made of chain-link. The entire length of the major parts of the Bioresources Nature Trail is now covered by the chain-link fence. The height of the fence is 1.5 m and at 2 m intervals angle iron legs were provided. These legs were fixed to the ground using concrete and rubble. In order to avoid the entry of piglets through the fence, base of the chain –link fence was fixed properly to the ground using metal hooks and wire. Angle iron legs, hooks and chain-link were painted to prevent corrosion.

## D. Field work for collection of plant materials

Under this activity, emphasis has been given to collect plant propagules of endangered and endemic ferns, bryophytes and angiosperms and assemble them in appropriate theme area in the Bioresources Nature Trail. Plants assembled in the Bioresources Nature Trail are listed below

### i) Bryophytes

In the Thallophyte and Bryophyte House of the Bioresources Nature Trail, bryopytes like *Bryum coronatum, Bryum wightii,Campylopus ericoides, Chandonanthus birmensis, Cyathodium cavernarum, Marchantia linearis, Notothylas levieri, Octoblepharum albidum, Phaeoceros laevis, Philonotis hastate, Philonotis thwaitesii, Radula kurzii, Riccardia multifida* and *Riccia frostii* are already growing. As part of the present Project, following 21 rare and endemic bryophyte species (Udar and Jain, 1984; Asthana *et.al.*, 1995; Awasthi *et al.*, 2000; Nair and Madhusoodanan, 2001) were collected (Figure 6 Table 1).

Table 1. List of rare and endemic bryophytes introduced in the Bryophyte House of Bioresources Nature Trail at Nilambur

| |
|---|
| **Musci** |
| *Atrichum undulatum* |
| *Bryum wightii* |
| *Bryum argenteum* |
| *Bryum roseum* |
| *Calymperes sundebanense* |
| *Campylopus flexuosus* |
| *Entosthodon wichurae* |
| *Isopterygium albescens* |
| *Leucobryum mitteni* |
| *Rhodobryum gaganteum* |
| *Mnium sp.* |
| *Macromitrium sulcatum* |
| *Trichypus bicolor* |
| **Hepaticae** |
| *Asterella wallichiana* |
| *Calycularia crispula* |
| *Dicranolajeunea yoshinagana* |
| *Dumortiera hirsuta* |
| *Fossombronia cristulata* |
| *Marchantia palmata* |
| **Anthocerotae** |
| *Anthoceros cripulus* |
| *Notothylas dissecta* |
| *Anthoceros sp.* |


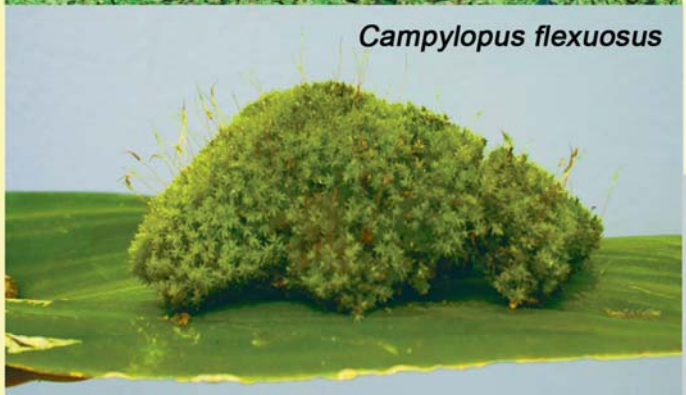



Figure 6. Some rare and endemic bryophytes introduced in the Bryophyte House of Bioresources Nature Trail at Nilambur

In the forests of Kerala and Karnataka, during the post-monsoon season when the ground is moist, pure patches of each of above-mentioned species were located. Pieces of each species were collected separately, labeled and transported to the Bryophyte House. Over specially constructed square pillars made of bricks, pieces of bryophytes were fixed firmly and moistened. In approximately a month, all species of bryophytes have established well. Each pillar harbouring bryophytes was provided with drip nozzles to ensure moisture round the clock. With the introduction of these twenty-one species, the total number of species in the bryophytes house has become thirty-five.

### ii) Ferns and fern allies

Based on the available literature (Nair et al., 1994; Manickam and Irudayaraj, 1992; Nayar and Geevarghese, 1993; Madhusoodanan et al., 2001) a list of rare and endemic ferns and fern allies was prepared. During the field visits to different forests of Kerala and Karnataka, forty eight species (twenty-five rare species and twenty-three common species) were collected and planted in the Fern house of the Bioresources Nature Trail at Nilambur (Figures 7 and 8).


Seventy three fern species were already growing in the Fern house of the Bioresources Nature Trail at Nilambur. Thus, together with thirty eight rare and endemic ferns and fern allies species, total number of species in the Fern House has increased to one hundred and twenty one. (Table 2.)

Figure 7. Some rare fern species planted in the Fern House in the Bioresources Nature Trail at Nilambur

Figure 8. A view of the Fern House in the Bioresources Nature Trail at Nilambur

Table 2. List of species in the Fern house of Bioresources Nature Trail at Nilambur, Kerala

| No. | Species | Status |
|---|---|---|
| | Actinopteridaceae | Rare |
| 1. | *Actiniopteris radiata* | |
| | Adiantaceae | Rare |
| 2. | *Adiantum capillus-vineris* | |
| 3. | *Adiantum caudatum*# | Rare |
| 4. | *Adiantum concinnum* | |
| 5. | *Adiantum incisum* | |
| 6. | *Adiantum latifolium* | |
| 7. | *Adiantum lunulatum* | Rare |
| 8. | *Adiantum nagnum*# | |
| 9. | *Adiantum peruvianum* | |
| 10. | *Adiantum raddianum* | |
| | Angiopteridaceae | |
| 11. | *Angiopteris evecta* | |
| | Aspleniaceae | |
| 12. | *Asplenium aethiopicum* | |
| 13 | Asplenium formosum | |

| No. | Species | Status |
|---|---|---|
| | Actinopteridaceae | |
| 14 | *Asplenium indicum*# | |
| 15 | *Asplenium phyllitides*# | |
| | Athyriaceae | |
| 16 | *Athyrium hohenackerianum* | |
| 17 | *Athyrium sp.* | |
| 18 | *Diplazium dilatatum*# | |
| 19 | *Diplazium esculentum* | |
| | Azollaceae | |
| 20 | *Azolla pinnata* | |
| | Bennstaedtiaceae | |
| 21 | *Microlepis speluncae* | |
| | Blechanaceae | |
| 22 | *Blechnum braziliensis*# | |
| 23. | *Blechnum gibbum* | |
| 24 | *Blechnum occidentale* | |
| 25 | *Blechnum orientale* | |

#, Introduced in the fern house as part of this Project.

-cont'd-

Table 2 (cont'd). List of species in the Fern house of Bioresources Nature Trail at Nilambur, Kerala

| No. | Species | Status |
|---|---|---|
| 26 | *Stenochlaena palustris*# | |
| | Ceratopteridaceae | |
| 27 | *Ceratopteris thalictroides* | |
| | Cyatheaceae | |
| 28 | *Cyathea gigantea* | Rare |
| 29 | *Cyathea spinulosa*# | Rare |
| | Davalliaceae | |
| 30 | *Araiostegia pulchera*# | Rare |
| 31 | *Davallia bullata*# | Rare |
| 32 | *Davallia fejeensis* | |
| | Dipterridaceae | |
| 33 | *Doodia dives*# | |
| | Dryopteridaceae | |
| 34 | *Arachniodes aristata*# | Rare |
| 35 | *Dryoptris cochleata*# | |
| 36 | *Tectaria caudunata* | |
| 37. | *Tectaria polymorpha* | |
| 38 | *Tectaria wightii*# | |
| | Equisetaceae | |
| 39 | *Equisetum ramosissimum* | |
| | Hemionitidaceae | |
| 40 | *Pityrogramma calomelanos* | |
| 41 | *Parahemionitis cordata* | |
| | Hymenophyllaceae | |
| 42 | *Crepidomanas bilobiatum*# | Rare |
| 43 | *Hymenophyllum exsertum*# | Rare |
| | Lindsaeaceae | |
| 44 | *Lindsaea ensiformis* | |
| 45 | *Lindsaea malabarica*# | Rare |
| 46 | *Lindsaea odorata*# | Rare |
| 47 | *Odontosoria chinensis*# | Rare |
| | Lomariopsidaceae | |
| 48 | *Bolbites braziliensis* | |
| 49 | *Bolbites heterochaelate* | |
| 50 | *Bolbites preseliana* | |

| No. | Species | Status |
|---|---|---|
| 51 | *Bolbites semicordata* | |
| 52 | *Bolbites virens* | |
| 53 | *Bolbitis prolifera* | |
| 54 | *Egenolfia asplenifolia* | |
| | Lycopodiaceae | |
| 55 | *Huperzia ceylanica*# | Rare |
| 56 | *Huperzia macrostachys*# | Rare |
| 57 | *Huperzia squarrosa*# | Rare |
| 58 | *Lycopodium japonicum*# | Rare |
| 59 | *Lycopodium wightianum*# | Rare |
| | Marsileaceae | |
| 60 | *Marsilea minuta* | |
| | Oleandraceae | |
| 61 | *Nephrolepis biserrata* | |
| 62 | *Nephrolepis bostoniensis* | |
| 63 | *Nephrolepis duffii* | |
| 64 | *Nephrolepis exaltata* | |
| 65 | *Nephrolepis hirsutula*# | |
| 66 | *Nephrolepis plumosa* | |
| 67 | *Nephrolepis tuberosa* | |
| | Ophioglossaceae | |
| 68 | *Botrychium daucifolium*# | Rare |
| 69 | *Helminthostachys zeylanica* | |
| 70 | *Ophioglossum reticulatum*# | Rare |
| 71 | *Ophioglossum vulgatum* | |
| | Osmundaceae | |
| 72 | *Osmunda regalis* | |
| | Polypodiaceae | |
| 73 | *Lepisorus nudus*# | |
| 74 | *Leptochilus bahupunctika* | Rare |
| 75 | *Microsorum linguiforme* | Rare |
| 76 | *Microsorum punctatum*# | |
| 77 | *Microsorum punctatum 'Flabellatum'* | |
| 78 | *Phymatosorus scolopendria* | |
| 79 | *Platycerium hilli* | |

#, Introduced in the fern house as part of this Project.

-cont'd-

Table 2 (cont'd). List of species in the Fern house of Bioresources Nature Trail at Nilambur, Kerala

| No. | Species | Status |
|---|---|---|
| 80 | *Pyrrosia lanceolata* | |
| 81 | *Pyrrosia mollis* | |
| 82 | *Pyrrosia porosa* | |
| | Psilotaceae | |
| 83 | *Psilotum nudum* | |
| | Pteridaceae | |
| 84 | *Acrostichum aureum* | |
| 85 | *Idiopteris hookeriana*# | Rare |
| 86 | *Pteris argyraea* | |
| 87 | *Pteris confusa*# | Rare |
| 88 | *Pteris ensiformis*# | Rare |
| 89 | *Pteris longipes*# | |
| 90 | *Pteris pellucida*# | Rare |
| 91 | *Pteris quadriaurita 'Argentia'* | |
| 92 | *Pteris vittata* | |
| | Salviniaceae | |
| 93 | *Salvinia molesta* | |
| | Schizaeaceae | |
| 94 | *Anemia rotundifolia* | |
| 95 | *Lygodium flexuosum*# | |
| 96 | *Lygodium microphyllum* | |
| 97 | *Schizaea digitata*# | Rare |
| | Selaginellaceae | |
| 98 | *Selaginella chrysocaulos*# | Rare |
| 99 | *Selaginella crassipes*# | Rare |

| No. | Species | Status |
|---|---|---|
| 100 | *Selaginella delicatula* | |
| 101 | *Selaginella dixitii*# | Rare |
| 102 | *Selaginella inequalifolia* | |
| 103 | *Selaginella involvens* | |
| 104 | *Selaginella lepidophylla* | |
| 105 | *Selaginella metallica*# | |
| 106 | *Selaginella plana* | |
| 107 | *Selaginealla radicata*# | Rare |
| | Sinopteridaceae | |
| 108 | *Cheilanthes mysoorensis* | |
| 109 | *Cheilanthes opposite*# | |
| 110 | *Cheilanthes tenuifolia*# | |
| 111 | *Doryoptris concolor*# | |
| 112 | *Doryoptris ludens*# | |
| | Thelypteridaceae | |
| 113 | *Amphineuron terminans* | Rare |
| 114 | *Christella dentata* | |
| 115 | *Cyclosorus interruptus* | |
| 116 | *Macrothelypteris torresiana*# | Rare |
| 117 | *Pronephrium articulatum*# | |
| 118 | *Pronephrium triphyllum* | Rare |
| 119 | *Trigonospora cialtata*# | |
| | Vittariaceae | |
| 120 | *Vittaria elongata* | |
| | | |

#, Introduced in the fern house as part of this Project.

### iii) Angiosperms

During the Project period, four endemic xerophytic plants namely *Kalanchoe olivacea* (Crassulaceae), *Caralluma indica* (Asclepiadaceae), *Argyreia cuneata* (Convolvulaceae) and *Lippia javanica* (Verbenceae) were collected and introduced in the Xerophytes and Succulent plant garden of the Bioresources Nature trail. Similarly, four rare and endangered orchids namely *Bulbophyllum aureum*, *Coelogyne mossiae*, *Eria albiflora* and *Ipsea malabarica* were also collected and planted in the Orchid House.

Kerala Forest Research Institute, in 2003 has organised a Workshop on Conservation and research needs of the rare, endangered and threatened (RET) tree species in Kerala part of the Western Ghats (Kallarackal et al. 2003). During this Workshop, 32 RET tree species have been provisionally identified for conservation and research. During the Project period, propogules

of nine such tree species namely, *Anacolosa densiflora*, *Buchnania lanceolata, Canarium strictum, Cinnamomum sulphuratum, Dipterocarpus bourdilloni, Dysoxylum malabaricum, Gluta travancorica, Kingiodendron pinnatum* and *Myristica malabarica* were collected and planted in the garden of Bioresources Nature Trail.

## 4. CONCLUSION

The ultimate goal of this Project was 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. Thus the specific aims of the project undertaken in the Bioresources nature trail at Nilambur to improve facilities in different theme areas like Fern House and Bryophyte House, to collect plant propagules of endangered and endemic ferns, bryophytes and angiosperms and to assemble them in appropriate theme area in the Bioresources Nature Trail was to play a significant role for increasing public awareness of the value of biodiversity conservation needs. The success of this project is evident during the project implementation period itself (July 2009 to January 2011). On an average every month 14,126 visitors visited these gardens (Figure 9). These gardens enriched with several wild, rare and endemic species, as part of this project are helping to increase awareness of the ecological, economic and cultural significance of these species and their potential value as genetic resources. These gardens are also helpful for local schools and colleges as they 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.

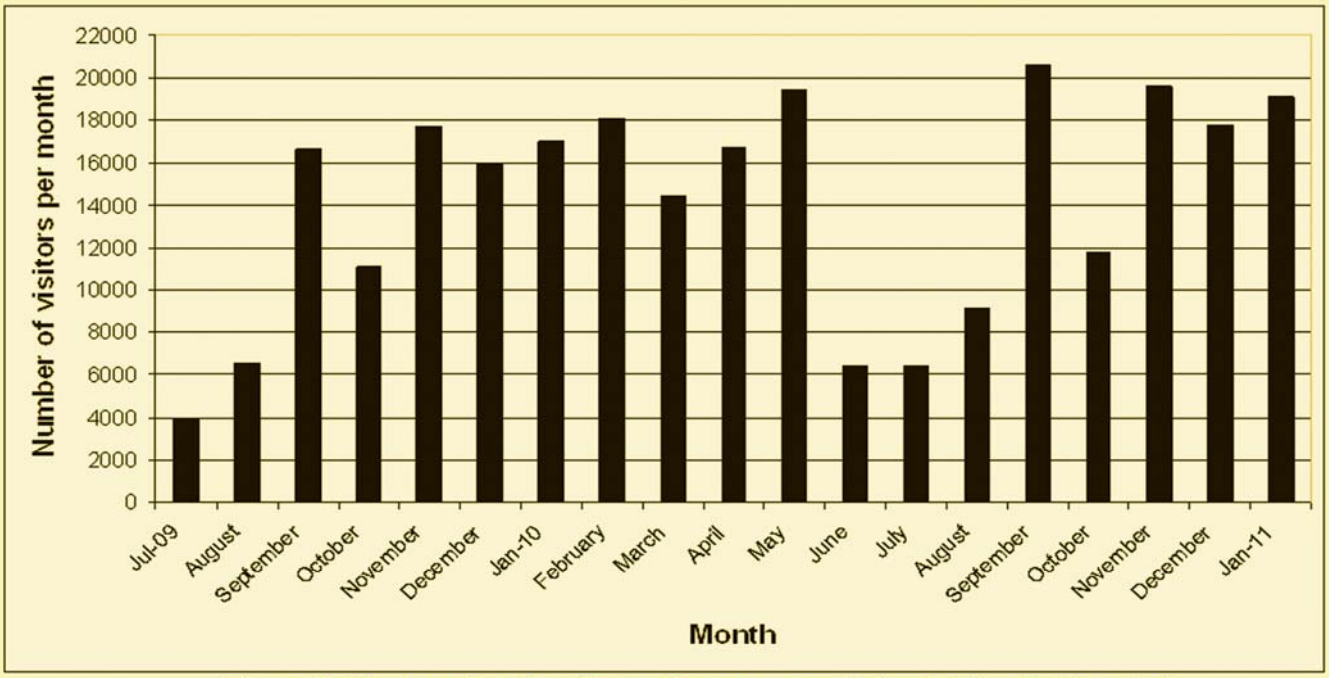


Figure 9. Number of visitors to the Bioresources Nature Trail established at Nilambur in the Kerala part of Western Ghats

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 ex-situ gardens of ferns, bryophytes and angiosperms which have high conservation status 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 twenty one bryophytes, thirty eight ferns and fifteen angiosperm species, which fall under rare category of IUCN (IUCN,2000), can be seen in the *ex-situ* gardens of Bioresources Nature Trail at KFRI Sub Centre, Nilambur. 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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