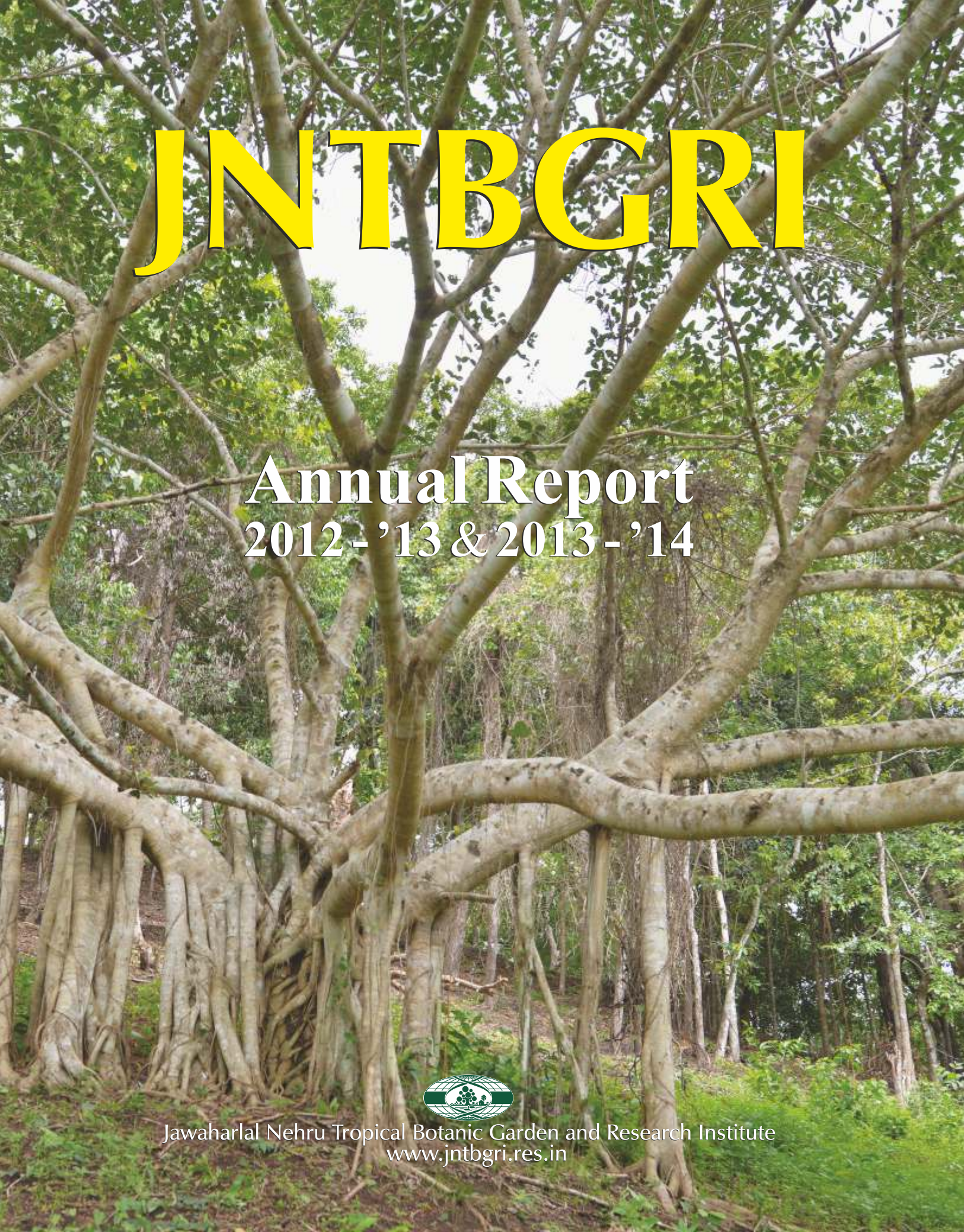

JNTBGRI

Annual Report
2012 - '13 & 2013 - '14

Jawaharlal Nehru Tropical Botanic Garden and Research Institute
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Cover:*Ficus benghalensis* L. (Banyan tree)
Planted in the Arboretum in 1987
Photo: Pradeep Kumar K P

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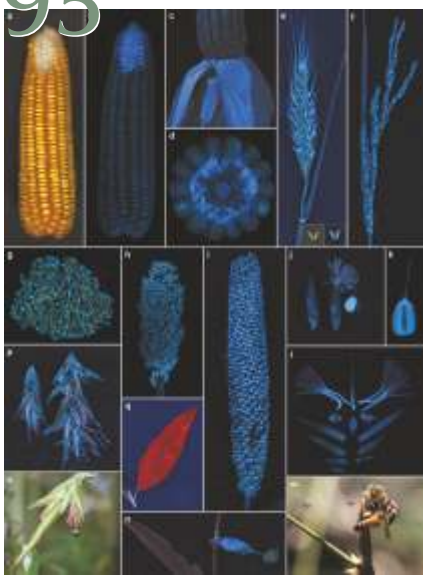

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From the Director's Desk...

During the period from April 2012 to March 2014, the Institute witnessed a great deal of research and developmental activities. The live plant conservatories were enriched manifold through exploration trips successfully undertaken. Distribution and sale of plants to the public, governmental and non-governmental agencies continued uninterrupted. A project on conservation of *Garcinia* species of the Western Ghats and another one on the development of compost from garden waste sponsored by NABARD were initiated. Many studies were undertaken on taxonomy, reproductive biology and breeding to utilize the plant resources in a sustainable manner. Several extension / awareness activities were initiated. A granite sculpture of Van Rheede's "Hortus Malabaricus", the legendary book of medicinal plants adorns the entrance to Itty AchuthanVaidyan's herbal garden. Tissue culture mass multiplication of economically important plants went on through a one crore RKVY project. Conservation biotechnology, bioproduction of plant specific compounds, bioprospecting of plant genetic resources, development of bioinformatics database packages, training and extension services continued. The studies of population structure and gene flow system of endemic plants, reproductive biology of RET species and plant animal interaction were pursued further.

DBT Committee in discussion with the Honb'le Chief Minister about Takeover Plan

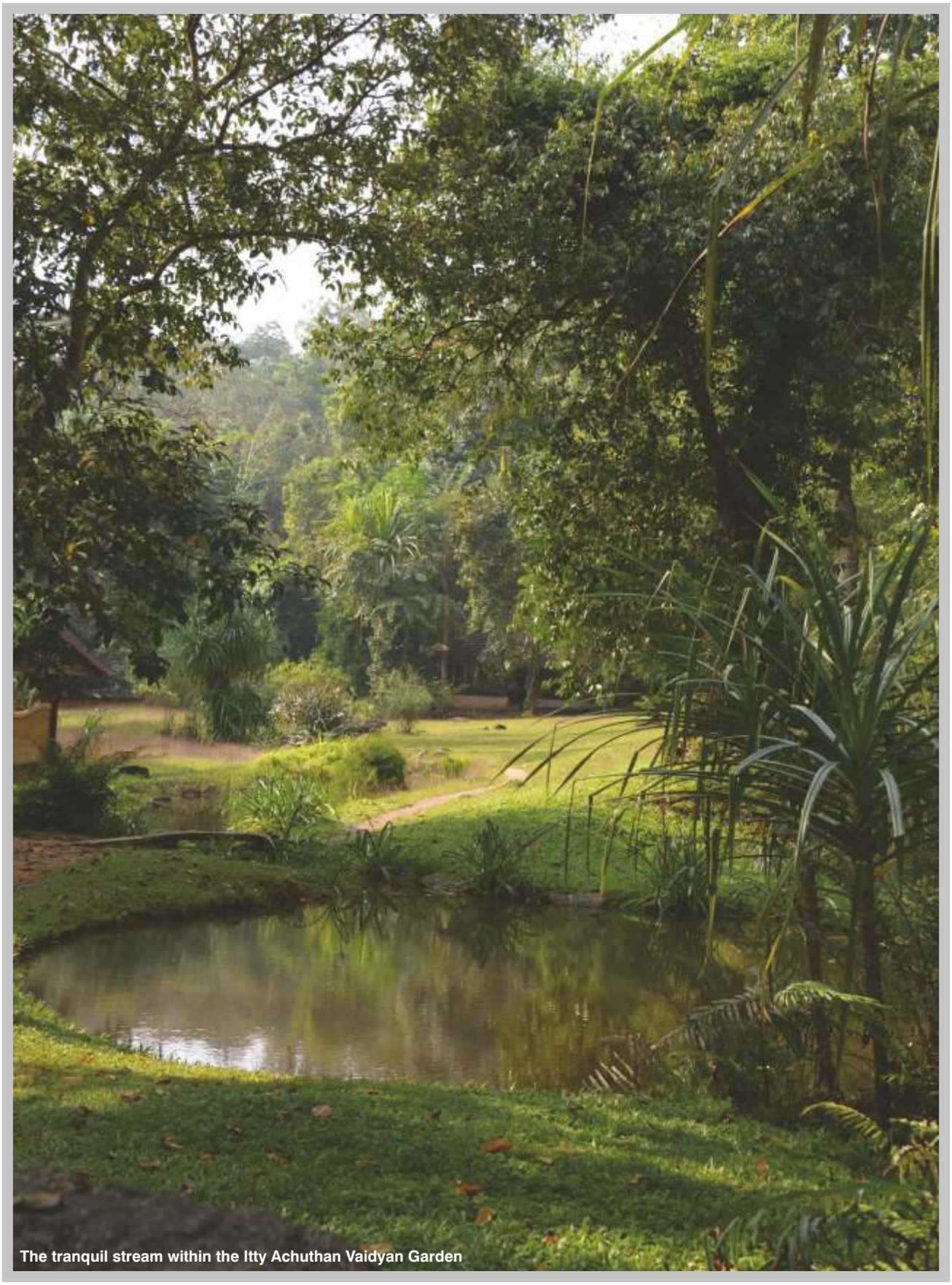
Chemical prospecting of potential plant species continued. Ethnobotanical surveys and documentation of Traditional Knowledge on Biodiversity received top priority. Preclinical drug discovery and elucidation of their molecular mechanism added to the Institute's strength in product development. Phylogenetic, evolutionary and biogeographic studies included molecular aspects of microbes, mushrooms and flowering plants. The Institute library operation and services was automated and accessible to staff from their desktops.

All these activities have become possible only with the total dedication and commitment of JNTBGRI staff, who have always worked for the Institute's excellence.

An effort by all of us to get the Institute taken over in total by the Department of Biotechnology (DBT), Govt. of India has culminated in the grant of a mega project (₹ 6.75 Crore) to the Institute to be implemented in collaboration with a handful of national laboratories at the end of which DBT would consider the same.

Our beloved Chief Minister and all the decision makers of the Govt. of Kerala, the DBT, New Delhi and the other funding agencies have helped us to surge forward. We salute them all and promise that the Institute would continue to go ahead by leaps and bounds in the years to come.

Dr. P G Latha



The tranquil stream within the Itty Achuthan Vaidyan Garden

Division of

Garden Management, Education, Information & Training

The Division looks after the development and maintenance of *ex-situ* conservatories, Arboretum, Bromeliads, Cacti and Succulents, Conservatory for Rare Plants, Fernery, Orchard for lesser known fruit plants, Ornamental garden, Palmetum, Pinetum, Water plants and Wild ornamental plants. Activities of Central Nursery and Visitors' Management Centre are also managed.

The main office complex with the visiting Scientists' Guest House overlooking it.

Arboretum

***Elaeocarpus tuberculatus* planted in 1987**

a. Arboretum a view; b. Inauguration of the yearly maintenance of Arboretum by local laborers under '*Mahatma Gandhi National Rural Employment Guarantee Act (NREGA),* during 2014

Besides the 750 holdings of the previous year, 30 species of elegant tree saplings introduced to the Arboretum include *Calophyllum austroindicum* Kosterm.ex Stevens, *Chionanthus mala-elengi* (Dennst.) P. Green, *Cinnamomum riparium* Gamble, *Dillenia bracteata* Wight, *Dysoxylum binectariferum* (Roxb.) Hook. f., *Elaeocarpus recurvatus* Corner, *Garcinia gummigutta* var. *papilla* (Wt.) N. P. Singh, *Garcinia cowa* Roxb. ex DC, *Garcinia puspangadaniana* Sabu *et al., Goniothalamus wayanadensis* (Bedd.) Bedd, *Hopea erosa* (Bedd.) Slooten, *Syzygium tamilnadensis* Rathakar. & Chithra, *Terminalia travancorensis* Wight & Arn., *Turpinia malabarica* Gamble, *Vatica chinensis* L., and an unidentified *Artocarpus* species. JNTBGRI Arboretum, now holds over 780 tree species. Curious plants such as *Strophanthus hirsutus* and *Kunsteleria keralensis* flowered in the Arboretum. Under *Mahatma Gandhi National Rural Employment Guarantee Act* (NREGA) Yojana of Peringamala Grama Panchayath, weeding and cleaning of the whole Arboretum was carried out which gave a face lift to the Arboretum. Over 3000 seedlings of various native species were sold to the public and NGOs through the Sales Unit.

Ficus

The genus *Ficus* (Moraceae) is one among the largest genera in flowering plants with more than 850 species world over. This tropical genus is represented in India by about 100 species, mainly in peninsular India and North-eastern regions. The plants are of various economic importance such as fruit plants (*F. carica* and *F. auriculata*), medicinal plants (*F. benghalensis* L., *Ficus microcarpa* L. f., *Ficus racemosa* L. and *F. religiosa* L.) form the 'Nalpamara' of Ayurveda and ornamental plants, (Indian rubber plant *F. elastica* and Krishna's butter cup *Ficus benghalensis* cv 'Krishnae').

70 species are represented in our collection, mainly Indian species from all over the country. A few exotic species from Africa are also grown. A bonsai presentation of all these species is also maintained.

***Ficus microcarpa* L. f. planted during 1987**

a. *Ficus auriculata* Lour.; b. *F. benghalensis* var. *krishnae* (C. DC.) Corner; c. *F. benjamina* L.; d. *F. cyathistipula* Warb.; e. *F. dalhousiae* Miq.; f. *F. drupacea* Thunb.

a. *Ficus hispida* L. f.; b. *F. racemosa* L.;
c. *F. microcarpa* L. f.; d. *F. tsjahela* Burm. f.

Humboldtia

The genus *Humboldtia* (Fabaceae-Caesalpinioideae) is endemic to peninsular India with an extended distribution of only one species (*H. laurifolia* Vahl) in Sri Lanka. Out of the seven species in this genus, five are represented in our collection. All the species bear very attractive flowers and are potential ornamental plants.

Humboldtia in the Garden a. *Humboldtia brunonis* Wall. b. *H. decurrens* Bedd. ex Oliv.; c. *H. sanjappae* Sasidh. & Sujanapal; d. *H. unijuga var. trijuga* Joseph & Chandr.; e. *H. vahliana* Wight

Orchard for Lesser Known Fruit Plants

A programme on the conservation and popularization of lesser-known fruit plants of Western Ghats was initiated as early as 1991. After a detailed survey and documentation among the local people and ethnic communities a conservatory orchard was developed which holds about 150 species. Germplasm of *Salacia* (Celastraceae), *Syzygium* (Myrtaceae), *Antidesma* (Euphorbiaceae) and many endemic species are attractions of this collection. Regular programmes on multiplication and distribution of conserved plants are also being done.

a. *Aporosa bourdillonii* Stapf
b. *Debregeasia longifolia* (Burm. f.) Wedd.

Syzygium

The Garden possesses one of the most exquisite collections of members of the genus *Syzygium* Gaertn. (Myrtaceae). This is a well-known group of trees and shrubs comprising more than 1200 species mainly distributed in the Old World tropics from Africa to the West Pacific with major concentration in Malaysia. The genus is popular for the spice plant, ie. *Syzygium aromaticum* (L.) Merr. & Perry which is native to Muluku Islands in Indonesia. Several species bear edible fruits, among which *S. cumini* (L.) Skeels, *S. aqueum* (Burm. f.)

a. *Syzygium aqueum* (Burm. f.) Alston; b. *S. aromaticum* (L.) Merr. & Perry; c. *S. caryophyllatum* (L.) Alston;
d. *S. chemunjianum* Shareef et al.; e. *S. claviflorum* (Roxb.) Wall. ex A. M. Cowan & Cowan; f. *S. cumini* (L.) Skeel;
g. *S. gardneri* Thwaites; h. *S. hemisphericum* (Wight) Alston; i. *S. jambos* (L.) Alston ; j. *S. laetum* (Buch.-Ham.) Gandhi

Alston, *S. malaccense* (L.) Merr. & Perry, *S. samarangense* (Bl.) Merr. & Perry etc. are widely cultivated throughout tropics. The Western Ghats region of Peninsular India represents about 52 species which forms the highest representation in India.

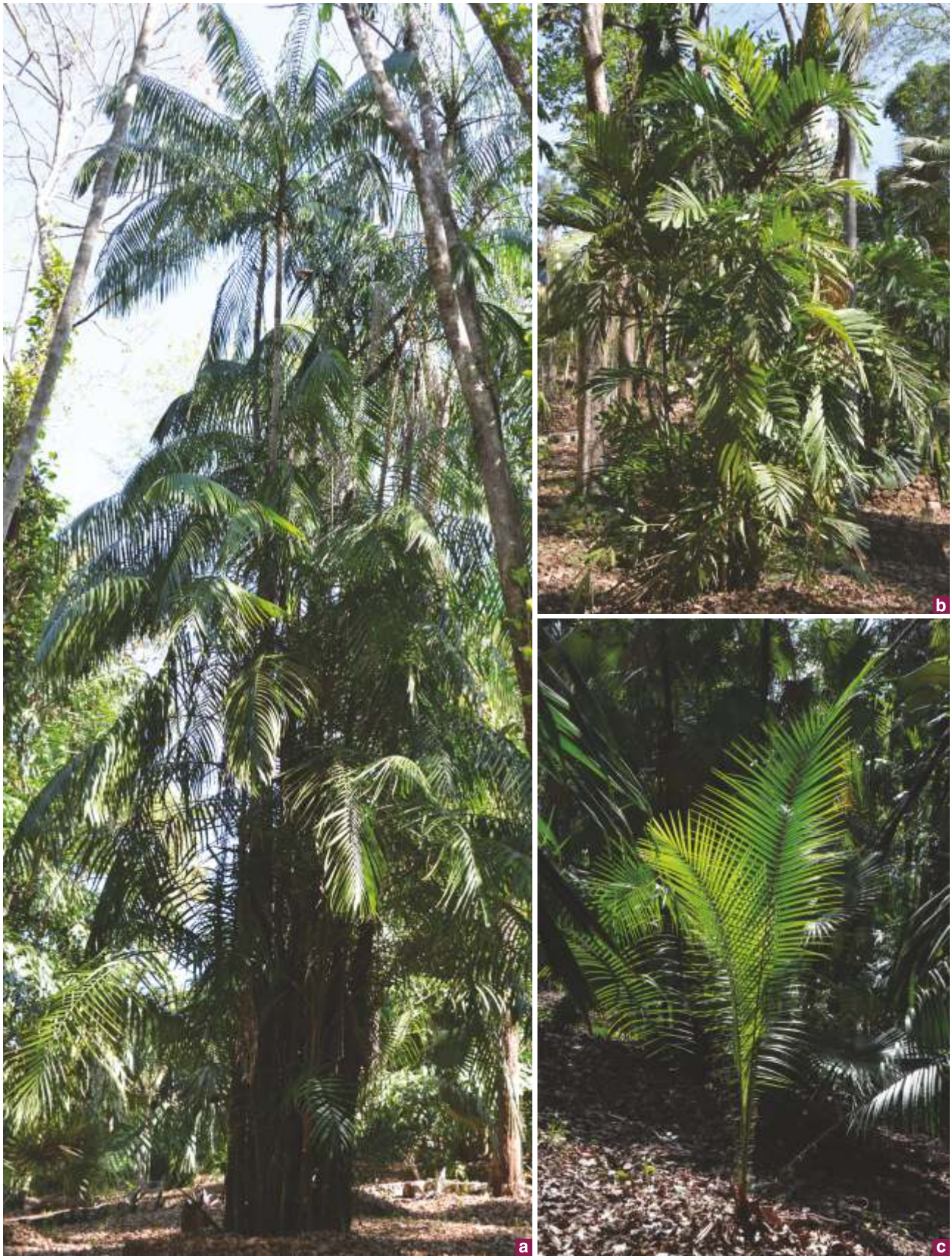
The germplasm collection of the genus *Syzygium* in the Fruit Crops Section was started in 1991 and presently holds 30 species, including many endemics such as *S. bourdillonii* (Gamble) Rathakr. & N.C.Nair, *S. chemunjianum* Shareef & al., *S. mundagam* (Bourd.) Chithra, *S. munnarensis* Shareef & al., *S. munronii* (Wight) Chandr. *S. myhendrae* (Bedd. ex Brandis) Gamble, *S. occidentale* (Bourd.) Gandhi *S. palodense* Shareef & al., *S. ramavarma* (Bourd.) Chithra, *S. travancoricum* Gamble etc.

a. *Syzygium lanceolatum* (Lam.) Wight & Arn.; b. *S. makul* Gaertn. ; c. *S. malaccense* (L.) Merr. & L. M. Perry ;
d. *S. munnarensis* Shareef, Roy & Krishnaraj; e. *S. myhandrae* (Bedd. Ex Brandis) Gamble ; f. *S. neesianum* Arn.;
g. *S. occidentale* (Bourd.) Gandhi; h. *S. palodense* Shareef, E. S. S.Kumar & Shaju; i. *S. rama-varmae* (Bourd.) Chitra;
j. *S. travancoricum* Gamble; k. *S. zeylanicum* (L.) DC.

Palmetum

Calamus brandsii, Calamu gambleii, Calamus shendurunii, *Phoenix andamanicus* and *Borassus flabellifer* saplings were newly added to Palmetum enhancing the strength to 169. Seventy saplings were planted in the field. About 4000 saplings of 5 *Calamus* species were produced for sale and distribution. Walk ways were extended to the newly planted areas. Saplings of ornamental / commercial palms were regularly supplied through Sales Unit.

***Saribus rotundifolius* (Lam.) Blume**


a
b
c

a. *Sabal mauritiiformis* (H. Karst.) Griseb. & H. Wendl.; b. *A view from the Palmetum*

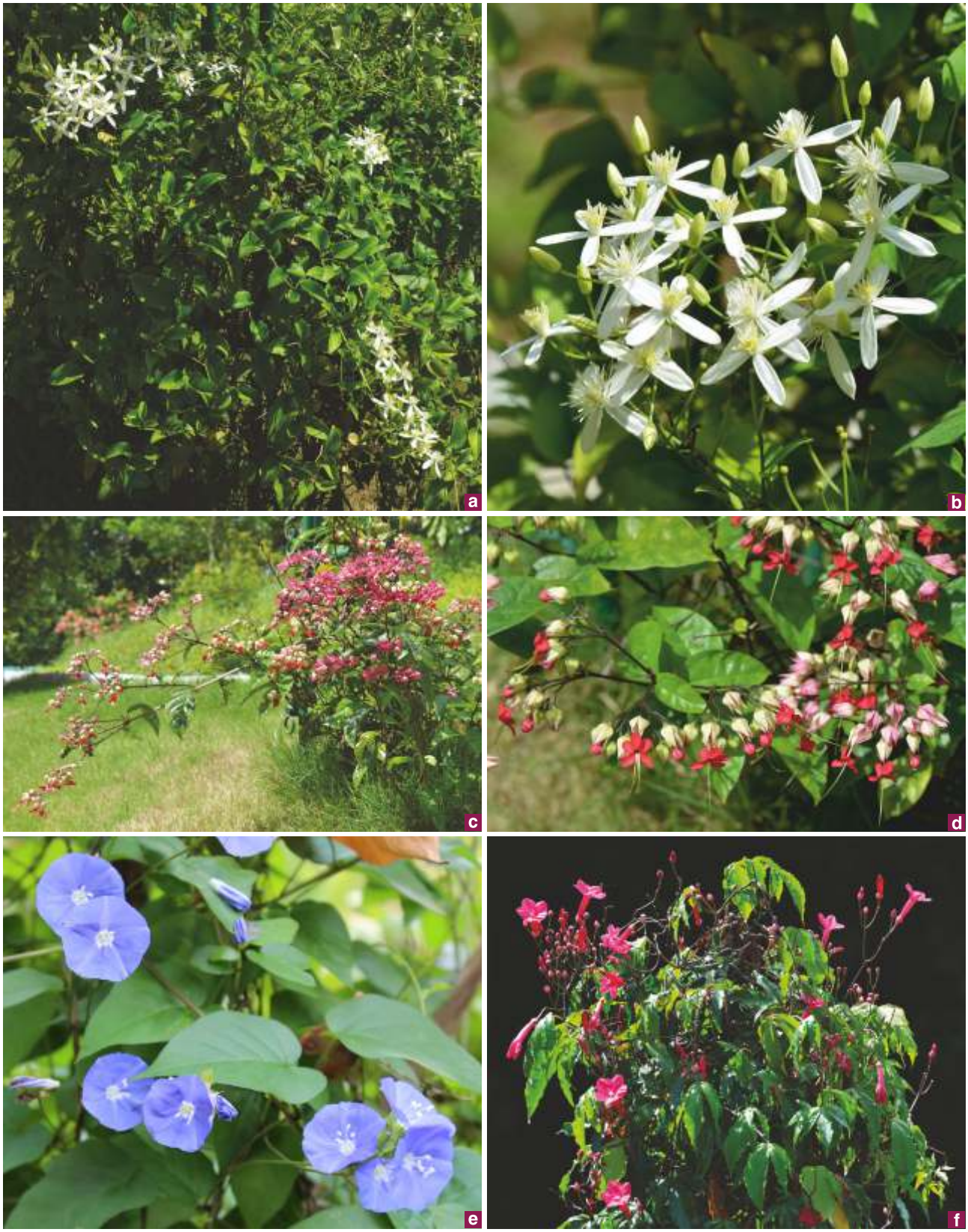
Wild elephant destroyed plants were replaced. A project funded by Kerala Forest Department has been initiated in collaboration with the Division of Biotechnology, on Conservation of *Calamus shendurunii, and C. wightii,* two endangered and endemic rattans of Western Ghats through micropropagation, reintroduction and cryobanking. Seed and Embryo cryopreservation studies of these Calamus species were initiated.

← a. *Oncosperma horridum* (Griff.) Scheff.; b. *Ptychosperma macarthurii* (H. Wendl. ex H. J. Veitch) H. Wendl. ex Hook. f. c. *Attalea speciosa* Mart.

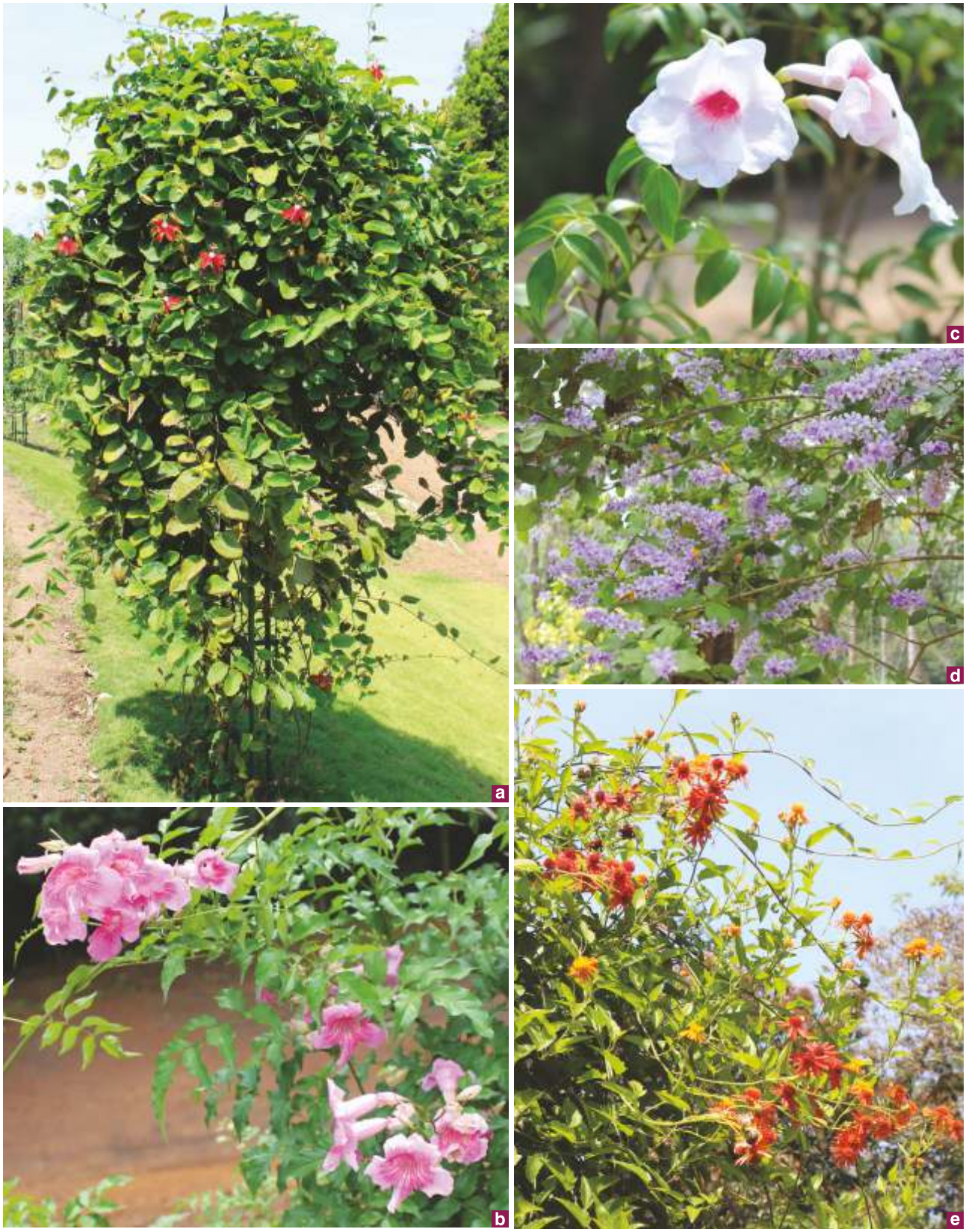
Ornamental Garden

Rose Garden was renovated by displaying 250 plants in pots. Saplings of *Cochlospermum vitifolium*, *Syzygium caryophyllatum, Tabebuia chrysantha*, *Bauhinia acuminata*, *Gustavia augusta*, *Petrea arborea* etc were added to the shrubbery. 'Emblem Carpet Bed' was redesigned due to the addition of the name 'Jawaharlal Nehru' to the title of the Institute. The steep earth cutting of about 200 m on the main road leading to nursery was made into a smooth curvy slope. A Vinery of ornamental climbers such as *Cryptostegia grandiflora* Roxb. ex R. Br., *Ipomoea horsfalliae* Hook., *Jacquemontia pentantha* (Jacq.) G. Don., *Lonicera japonica* Thunb., *Nepenthas khasiana* Hook.f., *Pandorea jasminoides* (Lindl.) K. Schum, *Petrea volubilis* L., *Podranea ricasoliana* (Tanfani) Sprague,

***Dolichandra unguis-cati* (L.) L. G. Lohmann**



a & b. *Clematis terniflora* DC.; c & d. *Clerodendrum thomsonae* Balf. f. 'Delectum'; e. *Jacquemontia pentantha* (Jacq.) G. Don. f. *Ipomoea horsfalliae* Hook.



a. *Passiflora miniata* Vanderpl.; b. *Podranea ricasoliana* (Tanfani) Sprague; c. *Pandorea jasminoides* (Lindl.) K. Schum.; d. *Petrea arborea* Kunth; e. *Senecio confuses* Burtt.

a. *Solandra maxima* (Sesse & Moc.) P.S. Green;
b & c. *Stictocardia beraviensis* (Vatke) Hallier f.

Pyrostegia venusta (Ker Gawl.) Miers, *Senecio confuses* Burtt etc was developed. *Guest House front garden was supplemented with two Cycas circinalis L., planted in symmetry, with a hedge of Acalypha wilkesiana* Mull. & Arg. variety and *Phyllanthus myrtifolius* (Wight) Mull. Arg..

25 new accessions viz. *Asclepias curassavica* 'Silky Gold', *Basella alba*, *Bauhinia acuminata*, *B. tomentosa*, *Cochlospermum vitifolium, Costus erythrophyllus*, *C. speciosus* 'variegata', *Crossandra infundibuliformis*, *Graptophyllum pictum* 'Golden Glow', *Heliconia rostrata, Hibiscus mutabilis* , *Ipomoea* sp., *Jacqemontia pentatha*, *Malvaviscus arboreus*, *M. arboreus* var. *penduliflorus*, *Melampodium paludosum*, *Petrea arborea, Pseudarthria viscida, Pseuderanthemum bicolor*, *Ruellia tuberosa*, *Salvia coccinea, Syzygium caryophyllatum, Tabebuia chrysantha, Tithonia diversifolia, Sansevieria spp. and Aloe sp.* were added to the ornamental plant germplasm. *Bauhinia scandens L., Cnidoscolus aconitifolius (Mill.) I. M. Johnst., Gardenia gjellerupii* Valeton, *Hippobroma longiflora (L.) G. Don, Mirabilis jalapa L., Spathodea campanulata P. Beauv., Zoysia sp. (Korean carpet grass) etc were purchased. Six Bougainvillea* and 2 *Canna* varieties were introduced from NBRI, Lucknow. Annual beds of Balsam, Celosia, Dahlia, Marigold and Zinnia were made to give a fresh

a & b. Terraced landscapes in front of the Main Office Building with informal style planting.

look to the garden. Six *Canna* beds were replanted giving suitable borders of *Coleus, Alternanthera* etc. Herbaria of 50 ornamental plants were prepared. *Gymnostachyum febrifugum* Benth. a lesser exploited wild ornamental was evaluated for ornamental potential and standardization of propagation and cultivation practices.

Bromeliads

Bromeliads are plants belonging to the monocotyledonous family Bromeliaceae, exclusive to the tropical American continents, mostly leading epiphytic/ saxicolous life. However a minority including the most popular member Pineapple (*Ananas comosus*) leads terrestrial life. JNTBGRI initiated a bromeliad collection in 1992 which at present harbours more than 40 species/ cultivars. Plants are kept in a natural style being fixed on tree tops, drift woods and crevices of rubble works. *Aechmea bracteata*(Swartz.) Griseb., *Billbergia pyramidalis* var. *concolor* L., *Pitcairnia tomentosa* Dietrich and *Tillandsia cyanea* Linden ex C. Kochan in the collection terminate with attractive inflorescence, where as *Cryptanthus beuckeri* E. Morr., *Neoregelia corolinae* (Beer) L.B.Sm., *N. spectabilis* (T.Moore) L.B.Sm., *Nidularium* sp. etc are beautiful foliage plants. *Tillandsia chaetophylla* Mez, *T. usneoides* L. and many others catch the attraction with their unique forms.

The Bromeliad Garden

Cacti & Other Succulents

Haworthia reinwardtii (Salm-Dyck) Haw.

***Mammillaria prolifera* (Mill.) Haw**

The popular plant group 'Cacti & succulents' are xerophytic plants variously adapted to store water as well as to check the water loss from the plant body. Plants belonging to the family Cactaceae constitute the major share. Besides certain species of Agavaceae, Aizoaceae, Amarillidaceae, Apocynaceae, Asclepiadaceae, Bromeliaceae, Crassulaceae, Euphorbiaceae, Liliaceae, Scrophulariaceae, etc are also included in the group.

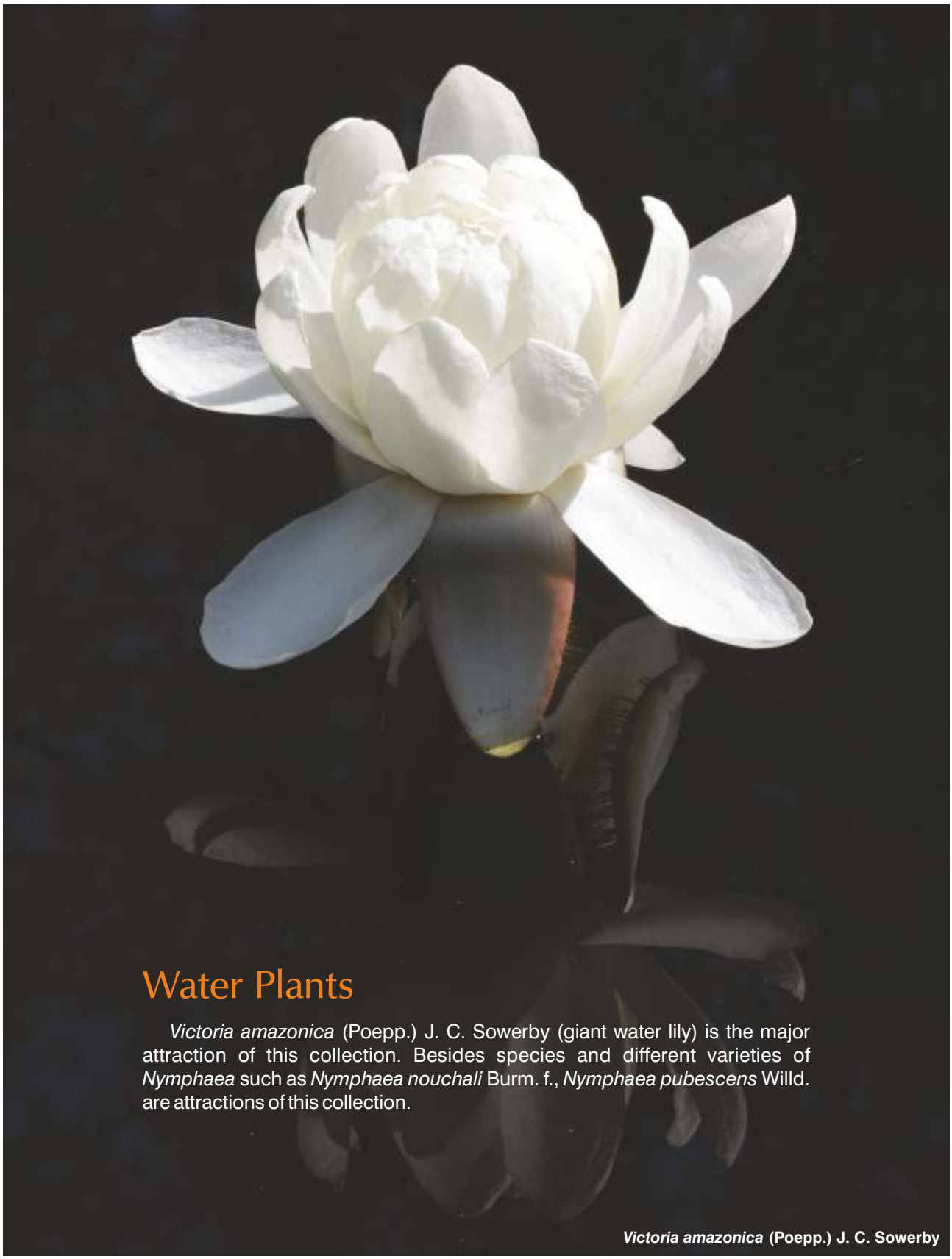
The Prof. A N Namboodiri Cacti House of the Garden holds a collection of about 350 species of succulents including around 100 species of Cacti. Plants are kept in specially landscaped natural style Rock Gardens. Herbaceous *Rhipsalis capilliformis* F.A.C.Weber to huge *Adansonia digitata* L. (Baobab) tree are represented in the collection. *Frerea indica* L. (endemic to South India), *Euphorbia neohumbertii* Boiteau (endangered, endemic species of Madagascar), *Hylocereus undatus* (Haworth) Britton & Rose and *Pereskia aculeata* Mill. (edible fruits) and highly ornamental *Cereus peruvianus* (L.) Mill. *Echinocactus grusonii* Hildm., *Euphorbia stenoclada* Drake, *Pachypodium lamerei* Drake, *Hatiora salicornioides* (Haw.) Britt. & Rose etc are attractions of the collection.

a. 'A. N. Namboodiri Cacti House'
b. *Frerea indica* Dalzell
c. *Euphorbia neohumbertii* Boiteau
d. *Euphorbia antiquorum* L.
e. *Cephalocereus senilis* (Haw.) Pfeiff.

Wild Ornamental Plants

Underutilized wild plants occur in all natural floras. Wild Ornamental Garden is a collection of such potential plants for display and for introduction into the ornamental field. About 50 species are grown in this garden. Flower/foliage Trees such as *Butea monosperma* (Lam.) Taub., *Calophyllum apetalum* Willd., *Dillenia pentagyna* Roxb., *Filicium decipiens* (Wight & Arn.) Thwaites, *Humboldtia decurrens* Oliv., *Humboldtia vahliana* Wight, *Mesua ferrea* L., *Syzygium laetum* (Buch.-Ham.) Gandhi, *Syzygium mundagam* (Bourd.) Chithra etc, shrubs such as *Alstonia venenata* R. Br., *Dichrostachys cinerea* (L.) Wight & Arn., *Melastoma malabathricum* L., *Memecylon wightianum* Triana, *Osbeckia aspera* (L.) Blume, *Thespesia lampas* (Cav.) Dalzell & A. Gibson, climbers like *Bauhinia phoenicea* Wight & Arn., *Diploclisia glaucescens* (Blume) Diels, *Kunstleria keralensis* C.N. Mohanan & N.C. Nair, *Quisqualis malabarica* Bedd., *Thunbergia mysorensis* (Wight) T. Anderson, indigenous succulent *Euphorbia vajravelui* Binojk. & N. P. Balakr., and herbs like *Cheilocostus speciosus* (J. Konig) C. Specht, *Gymnostachyum febrifugum* Benth., *Hedychium flavescens* Carey ex Roscoe, *Turraea alata* (Wight & Arn.) Cheek etc are grown in this garden.

a. *Osbeckia aspera* (L.) Blume; b. *Alstonia venenata* R. Br.; c. *Bauhinia phoenicea* Wight & Arn.; d. *Melastoma malabathricum* L.; e. *Mesua ferrea* L.; f. *Syzygium mundagam* (Bourd.) Chithra; g. *Thespesia lampas* (Cav.) Dalzell & A. Gibson



Water Plants

Victoria amazonica (Poepp.) J. C. Sowerby (giant water lily) is the major attraction of this collection. Besides species and different varieties of *Nymphaea* such as *Nymphaea nouchali* Burm. f., *Nymphaea pubescens* Willd. are attractions of this collection.

***Victoria amazonica* (Poepp.) J. C. Sowerby**

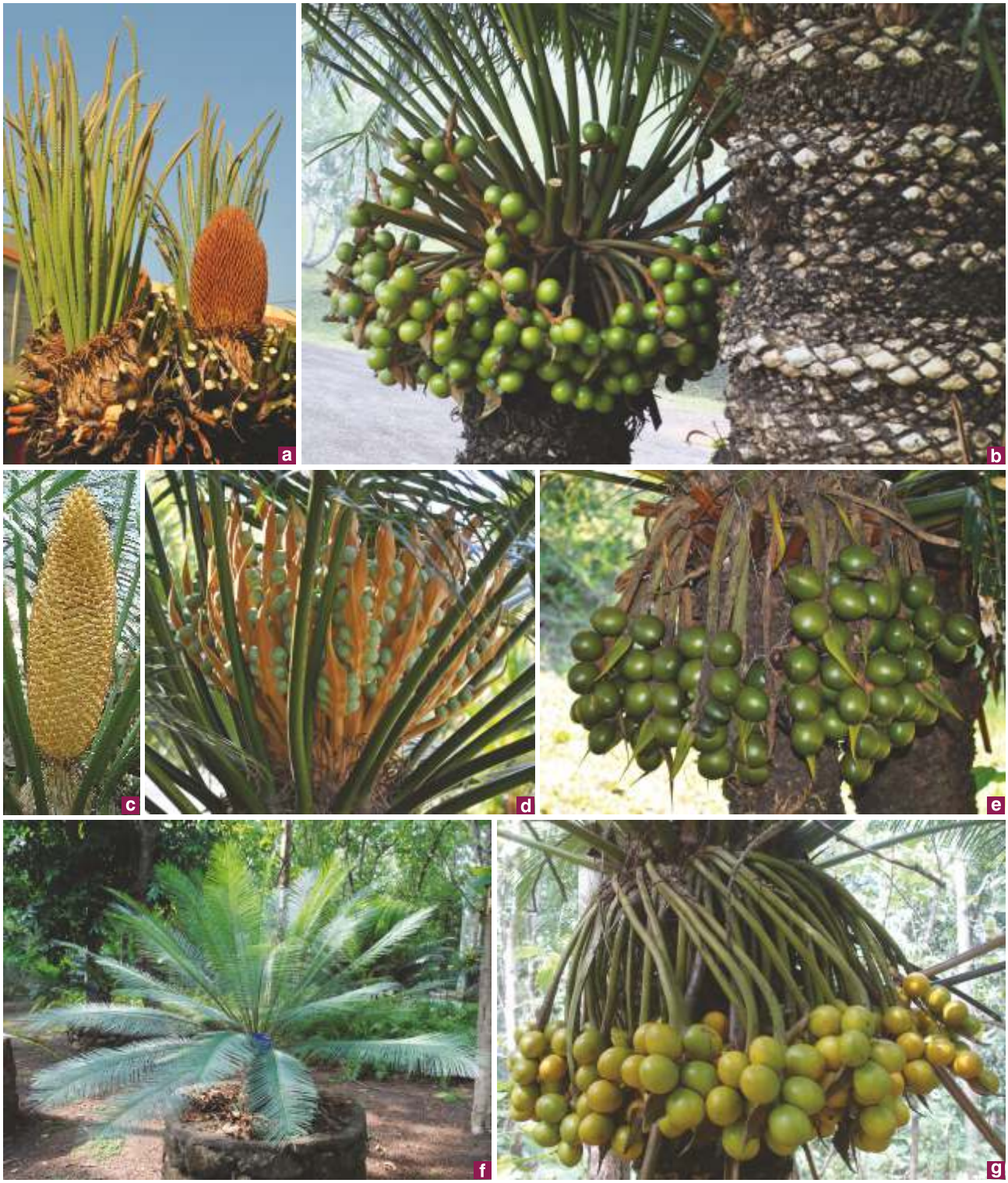
a. Aquatic plants in the reservoir; b. *Nelumbo nucifera* Gaertn.; c. *Nymphaea nouchali* Burm. f.; d. *N. nouchali* var. *caerulea* (Savigny) Verdc.; e. *N. pubescens* Willd.

Gymnosperms

Gymnosperms, the group of primitive plants are represented in 40 species in 15 genera.

The collection was initiated in 1987 with the support of Royal Botanic gardens, KEW, UK. A unique attraction is the collection of *Cycads* (Living fossils). 16 species of cycads under 7 genera are represented in this collection. Almost all the cycads have produced cones in our collection. Besides, 24 species of conifers are also represented.

Female cone of *Cycas circinalis* L.



a. *Cycas circinalis* L. - male cone; b. *C. circinalis* - fruiting; c. *C. zeylanica* (J. Schust.) Lindstr. & K. D. Hill - male cone
d. *C. zeylanica* - female cone; e. *C. zeylanica* - fruiting; f. *C. beddomei* Dyer; g. *C. nathorstii* J. Schust. - fruiting.

The endangered cycad, *Cycas beddomei* Dyer, the threatened and lone conifer of peninsular India, *Podocarpus wallichianus* Presl., the newly reported *Cycas narthostii* J. Schust, Australian cycad *Bowenia serrulata* (W. Bull) Cham. etc are the attractions of the Gymnosperm collection of the Garden.

Fernery

Ten elegant fern species like *Aleuritopteris thwaitesii, Asplenium* sp, *Athyrium anisopterum, Blechnum occidentale, Lepisorus nudus, Lindsaea malabarica, Microsorium mebranaceum, Polypodium* sp. *Pteris gongalensis* and *Trichomanes saxifragroides* were newly added to the existing fern collection which holds more than 250 species of Ferns and Fern allies. *Aleuritopteris thwaitesii,* an endangered fern was relocated after 40 years of its first collection from South India. Propagation of the endangered fern *Marattia fraxinea* was achieved through rhizome division. *Selaginella wallichii, S. microdendron* and *Huperzia squarrosa* were propagated from strobilii.

a. *Nephrolepis biserrata* (Sw.) Schott 'Fuffles' b.Former Scientists Dr Jacob Thomas and Mr P C Benoy visit the Fernery

Central Nursery

Central Nursery served the needs of various garden developmental activities along with distribution and sale of plants to public, Governmental and Non governmental agencies. About 27,600 saplings in 407 accessions were produced. Propagation studies on endemic/RET plants such as *Myristica fatua* var. *magnifica (*Bedd.) Sinclair, *Horsfieldia irya* Gaertn, *Actinodaphne bourdillonii* Gamble, *Vateria macrocarpa* Guptha, *Poeciloneuron pauciflorum* Bedd. and *Garcinia wightii* T. Anderson were carried out. Propagation through air layering was attained in *Garcina wightii, Myristica fatua* and *Actinodaphne bourdillonii*. One accession of *Jasminum azoricum* from Karnataka was added to the *Jasminum* gene pool. Around 6000 saplings were sold and ₹ 5,73,000/- (Five lakh seventy three thousand rupees) was generated.

a. *Jasminum fruticans* L.; b. Farmers in Nursery Training; c. Air-layering done in *Myristica fatua* var. *magnifica* (Bedd.) Sinclair

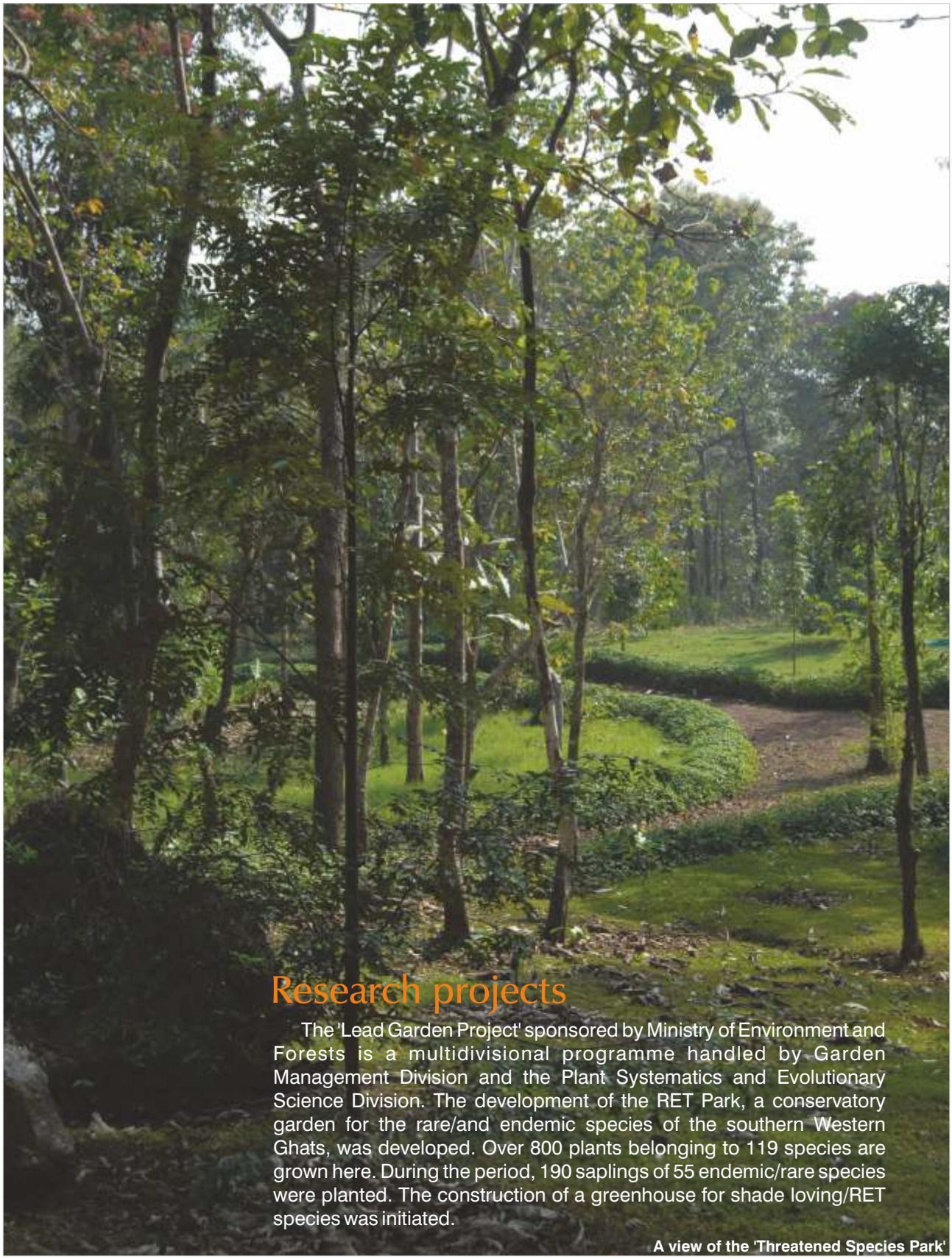
Visitors' Management Centre

The statue of Mother Earth sustains the Garden

A full-fledged Visitors Management Centre was established as part of the Garden Division in 2006. The centres take care of the day to day visitors of the Garden. 75500 students and public visited the Garden during the period (38500 during 2012-13 and 37000 during 2013-14). The visitors were well attended to with audiovisual aids and guidance within the Garden.

The Visitors Management Centre organized exhibitions outside the Garden. Kerala Science Congress Exhibitions at Kanakakunnu, Thiruvananthapuram (2013) and Wayanad (2014), exhibition at National Integration Camp of Youth Welfare Board (Kanakakkunnu, Thiruvananthapuram from 23-to 28th May 2012), Swasraya Bharathi-2012 Science Technology Exhibition (International Stadium, Kochi from 29th Oct. to 5th Nov. 2012), exhibition in connection with the Emerging Kerala meet held at Kochi from 12-14th September 2012, 11th C.V. Raman Memorial Inter School Science Exhibition (S. N. Central School, Nedumgolam, Kollam from 22-24th Nov. 2012) and Palode Mela, February 7-13th 2013. were the major exhibitions conducted.

The 'Iron wood tree', *Mesua ferrea* planted by former Hon'ble Chief Minister Sri. V. S. Achuthanandan on 13. 12. 2006.



Research projects

The 'Lead Garden Project' sponsored by Ministry of Environment and Forests is a multidivisional programme handled by Garden Management Division and the Plant Systematics and Evolutionary Science Division. The development of the RET Park, a conservatory garden for the rare/and endemic species of the southern Western Ghats, was developed. Over 800 plants belonging to 119 species are grown here. During the period, 190 saplings of 55 endemic/rare species were planted. The construction of a greenhouse for shade loving/RET species was initiated.

A view of the 'Threatened Species Park'

Garcinia

A *Garcinia* Garden was initiated as a part of 'Conservation of *Garcinia* species of Southern Western Ghats' a project sponsored by Department of Forests and Wildlife, Govt. of Kerala. Survey, exploration, identification and inventory of the *Garcinia* species in the Southern Western Ghats is the objective of the programme. Saplings of all species of the genus viz. *Garcinia gummigutta, G. indica, G. imberti, G. spicata*

a. *Garcinia celebica* L.
b. *G. intermedia* (Pittier) Hammel
c. *Garcinia x mangostana* L.
d. *G. morella* (Gaertn.) Desr.
e. *G. wightii* T. Anderson
f. *G. gummi-gutta* var. *conicarpa* (Wight) N. P. Singh
g. *G. xanthochymus* Hook. f. ex T. Anderson
h. *G. gummi-gutta* (L.) Roxb.

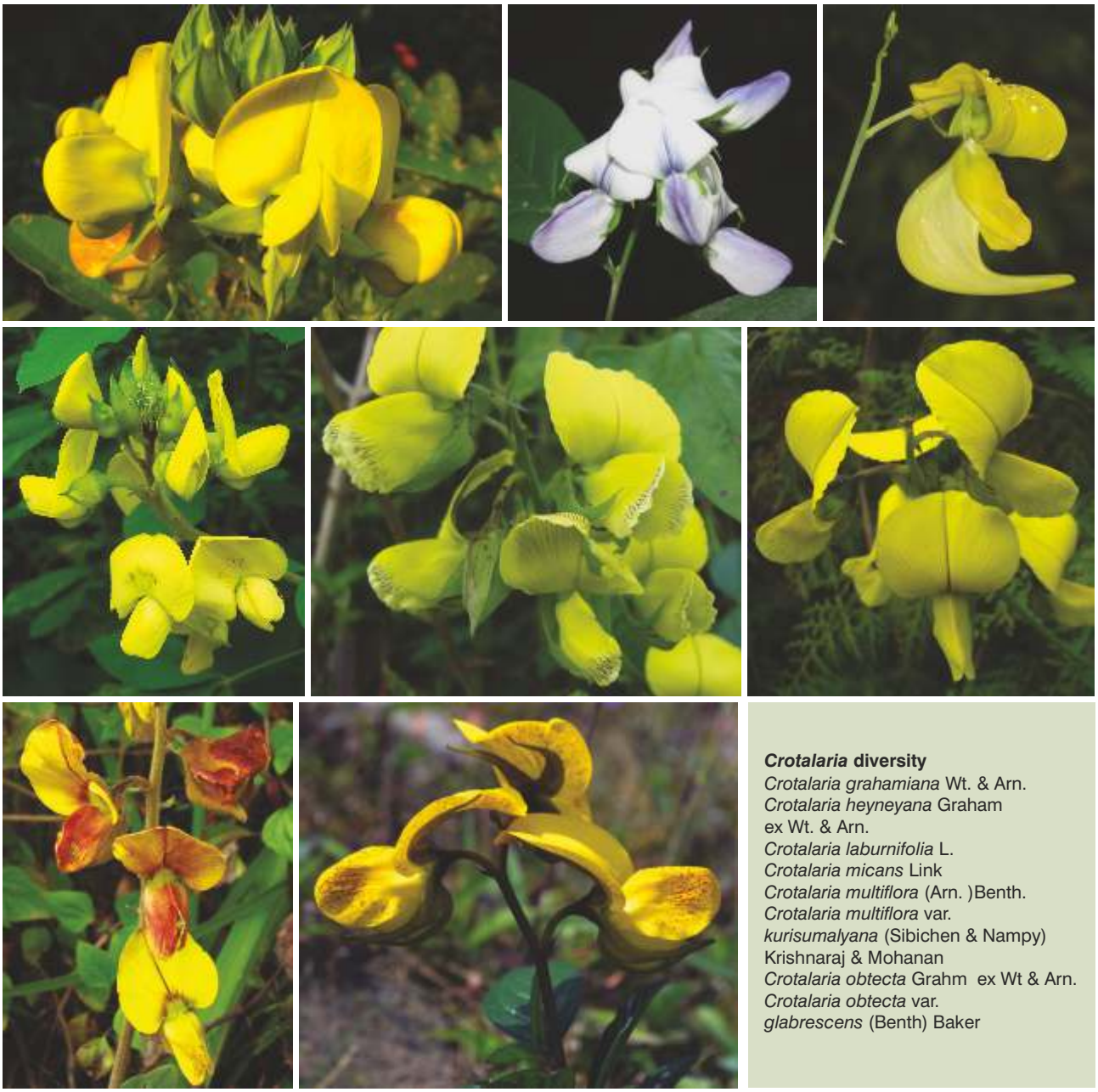
a. *Garcinia imbertii* Bourd.; b. *G. rubroechinata* Kosterm.
c. *G. pushpangadaniana* T. Sabu, N. Mohanan, Krishnaraj & Shareef
d. *G. travancorica* Bedd.; e. *G. spicata* (Wight & Arn.) Hook. f.

and *G. xanthochymus,* were propagated. *G. cowa, G. echinocarpa, G. gumigutta var. conicarpa, G. gummigutta* var. papilla, *G. morella, G. pushpangadaniana, G.rubroechinata, G. talboti, G.travancorica* and *G. wightii* were collected from Western Ghats and the garden was initiated. Besides this 11,000 seedlings of *Garcinia gummi-gutta*, were produced and 8,000 seedlings were supplied to Kerala Forest Department for restoration in the forest areas.

Screening the *Garcinia* species for essential oils, valuable acids, dyes, gums, oleoresins and other valuable secondary metabolites envisaged in the programme is done by the Phytochemistry Division.

'Taxonomic Revision of Leguminosae (Nom. Alt. Fabaceae)

'Taxonomic Revision of Leguminosae (Nom. Alt. Fabaceae) of Kerala State' a JRF project leading to Ph. D. was completed. The study resulted in the documentation of 68 genera, 266 species, 2 sub species and 16 varieties from the State. One taxon new to science, one new report for the country and 7 new reports for the State were recorded. *Tephrosia fusca* was rediscovered after a lapse of 178 years. Thirteen taxa were lectotypified.



***Crotalaria* diversity**
Crotalaria grahamiana Wt. & Arn.
Crotalaria heyneyana Graham ex Wt. & Arn.
Crotalaria laburnifolia L.
Crotalaria micans Link
Crotalaria multiflora (Arn.)Benth.
Crotalaria multiflora var. *kurisumalyana* (Sibichen & Nampy) Krishnaraj & Mohanan
Crotalaria obtecta Grahm ex Wt & Arn.
Crotalaria obtecta var. *glabrescens* (Benth) Baker

Study on the Fern flora of Agasthyamala

A study on the Fern flora of Agasthyamala leading to Ph. D. degree of one of the Technical Officers, documented 138 species, one sub species and one variety under 21 Fern families including 38 RET species and 14 endemic species.

***Huperzia* species from Agasthyamala**

a. Huperzia hamiltonii (Spreng.) Trevis; b. *H. niligarica* (Spreng.) Dixit; c. *H. phlegmaria* (L.)Rothm. d. *H. phyllantha* Hook. & Arn.

Division of
Plant Genetic Resource

Along with its chief mandate on enrichment of the genetic resources of Medicinal and Aromatic plants, Bamboos, Orchids, Carnivorous plants etc through expeditions and maintaining the existing resources in the garden, the PGR Division undertakes taxonomic, phytochemical and reproductive biology studies, breeding experiments to produce new hybrids, studies to utilize the resources in a sustainable manner and extension/ awareness activities.

Medicinal, Aromatic & Spice Plants

A granite sculpture of '*Hortus Malabaricus*', the legendary book on medicinal plants of Malabar region, published by Van Rheede in the 17th century, was installed near the main entrance of the Itty Achuthan Vaidyan's herbal garden and carried out landscaping around it. A granite slab was fixed at the entrance of the Itty Achuthan Vaidyan's garden as part of developing an educational label, which gives introductory information on the garden to the visitors. The traditional 'Stone Lamp' was shifted from the main entrance of garden to the central part of the lawn as a focal point. Maintenance of the architectural features such as 'Kottiyambalam' style entrance and the mud boundary wall of the Itty Achuthan Vaidyan's herbal garden were done. A raised platform has been made around. *Aporosa lindleyana* tree in the garden which is serving as the standard for the mother plant of *Coscinium fenestratum*, and paved with granite sheets, so as to facilitate as a resting place for the visitors. A better drainage facility was made in the garden for the rain water from the slopes.

The succulent garden was re-landscaped by including 11 species/varieties of *Sansvieria* and 3 species of *Aloe*. *Leea indica*, *Humboldtia decurrens* and *Baccaurea courtallensis* were planted near Chittar river side and the natural vegetation adjacent to the herbal garden was replenished. Fifteen species in the demonstration area and three species in the herbaceous beds were replanted.

Mucuna pruriens, *Cheilocostus speciosus* and *Bacopa monnieri,* three medicinally important species of the Western Ghats were selected for the study on '*ex-situ* conservation and assessment of intraspecific variability'. The four varieties of *Mucuna pruriens* such as *M. pruriens* var. *pruriens*, var. *utilis*, var. *hirsuta* and var. *thekkadiensis* were collected and subjected to detailed morphological, taxonometric, palynological and chromosomal studies, and its phylogenetic

Sculpture of 'Hortus Malabaricus'

interrelationship was established and revision for their present taxonomic status was suggested. Karyomorphological studies in 12 accessions of *Cheilocostus speciosus* (J. Koenig) C. Specht collected from different parts of Kerala and Andaman Islands were carried out. Meiosis was studied from PMCs. In Kerala, the species exists in three ploidy levels such as diploid (2n=18) with n=9, triploid (2n=27) with varying number of trivalents, bivalents and univalents (n=3III, 7II, 4I; 2III, 8II, 5I; 1III, 9II, 6I) and tetraploid (2n=36) with n=18, while in Andaman Islands an hexaploid (2n=54) with n=27 was detected, which is reported for the first time. Classification of chromosome types and categorisation based on karyotype symmetry were made. TF % and karyotype formula of the accessions were also determined. Cytomorphological studies of *Bacopa monnieri* have been carried out in eight accessions from Kerala. The species exists in two cytotypic forms, six accessions with 2n=64 and two with 2n=68. The chromosome data indicate that the accessions of the species studied are based on x=16 and 17, the latter an aneuploid derivative of the former. The accessions of both the cytotypic forms have displayed a spectrum of intraspecific plant


Collection of *Sansevieria* species

morphological diversity in many vegetative and floral characters, which can be attributed to genome mixing due to chromosome structural and numerical alterations (aneuploidy) as well as cryptic structural hybridity.

Through plant exploration trips conducted to different parts of southern India, around 105 accessions


Along the aquatic milieu in 'Itty Achuthan Vaidyan's Garden' b

A view of medicinal arboretum

of 62 species including *Nothapodytes nimmoniana, Alpinia abundiflorum, Bacopa monnieri, Pseudarthria viscida* etc were introduced and the Field Gene Bank (FGB) of Medicinal and Aromatic Plants was enriched. In order to ensure their renewed growth, 113 accessions of 12 species like *Bacopa monnieri*, *Adhatoda vasica*, *Aloe vera*, *Cissus quadrangularis*, *Geophila reniformis*, *Plumbago zeylanica* etc were replanted. 255 accessions of 23 species of the FGB were labelled. 114 accessions of 15 species including 14 accessions of *Cheilocostus speciosus* and 80 accessions of *Bacopa monnieri* were replanted in the FGB. Morphological

characterization of 6 accessions of *Pseudarthria viscida* with respect to 75 qualitative/quantitative characters was carried out and the study indicated that the accessions are genetically divergent. Similar studies on *Glycosmis pentaphylla* with respect to 31 qualitative /quantitative characters and *Murraya koenigii* with respect to 41 characters are progressing.

As part of the enrichment of 'Andaman Plot' two exploration trips were conducted to Andaman Islands and 82 species were introduced to the garden, increasing the collections to 160 species enabling it to attain the status of the best *ex-situ* collections of the Island flora in the main land. The unique species collected and introduced were *Mimusops andamanensis*, a critically endangered tree species which is available only in 3 populations in Little Andamans and *Nippa fruticans,* a rare mangrove palm.

For the 'Development of the Systematic Garden of Herbals', plant explorations were conducted to different parts of Kerala and Tamil Nadu and introduced 248 species of 30 families including species like *Ophiorrhiza incarnata, O. barnesii, Impatiens travancorica, Didymocarpus humboldtianus, Ardisia blatteri, Caesalpinia cucullata, Humboldtia sanjappae, H. unijuga, Didymocarpus ovalifolia, Osbeckia wynaadensis, Medinella malabarica, Thottea barberi, Acrotrema agasthyamalayana, Goniothalamus wynaadensis, Aralia malabarica etc*. 354 species of 91 families were planted in the Systematic Herbal Garden. Currently the collection holds 840 species that belong to 130 families. The threatened species, *Strobilanthes kunthianus, S. dupeni, S. lawsonii* and *S. anamallica* were displayed in the house of rare botanicals which at presently holds 198 species.

Under the programme '*Ex-situ* conservation and biosystematic studies on *Piper* species of Kerala forests

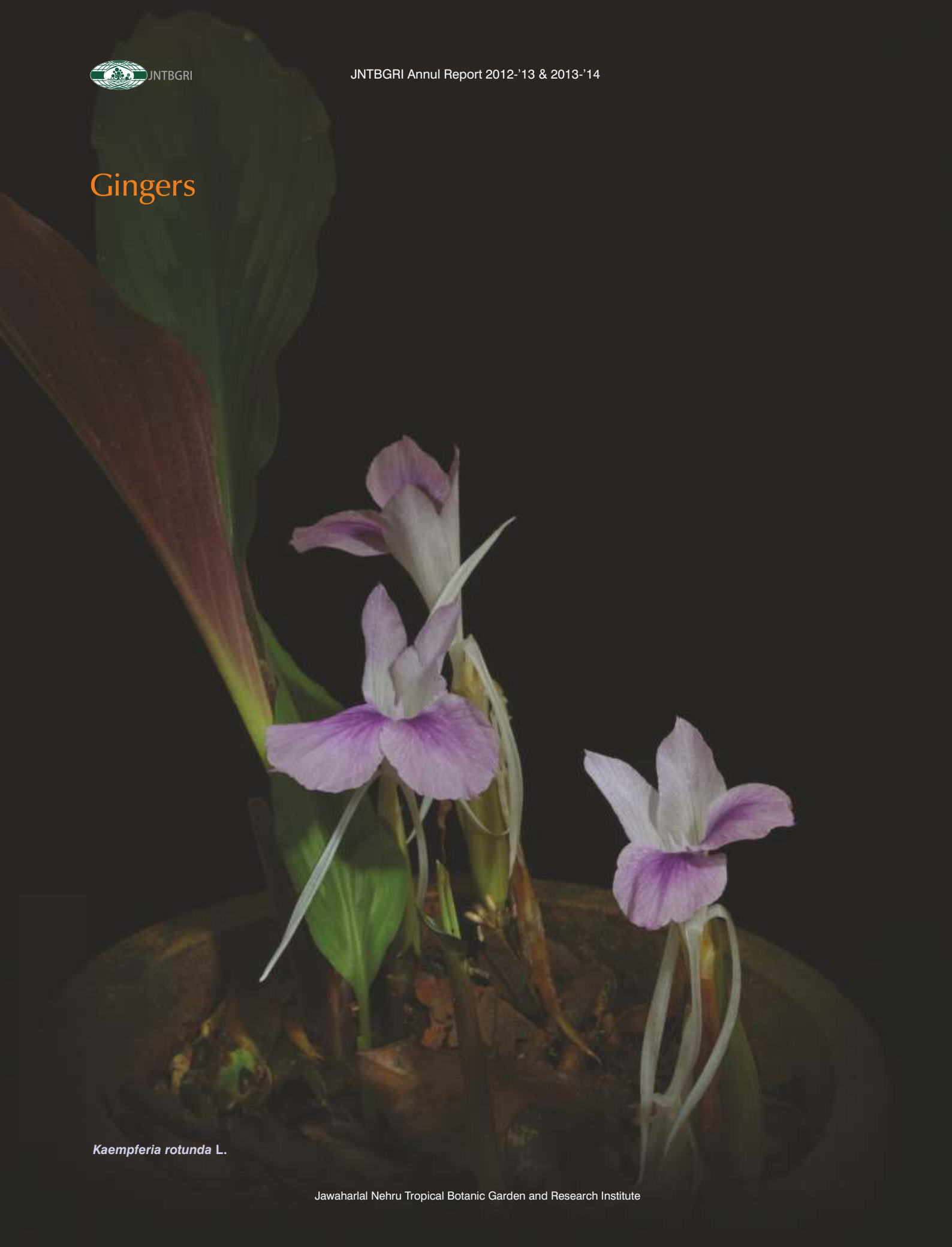
The house for 'Rare Botanicals'

Amomum andamanicum V. P. Thomas *et al*, established in the conservatory garden for Andaman – Nicobar plants

with special reference to intraspecific variants of the wild *Piper nigrum* L., field explorations were conducted to different forest types and introduced nine species of *Piper viz. P. nigrum, P. barberi, P. betle, P. argyrophyllum, P. pseudonigrum, P. trichostachyon, P. hymenophyllum, P. schmidtii* and *P. mullesua.* 22 accessions of *P. nigrum* were characterized with respect to 32 qualitative/quantitative characters and prominent variability was observed in leaf shape, leaf length, leaf breadth, spike length, peduncle length and fruit diameter.Root and fruit samples of 30 wild accessions of *P. nigrum* were collected, shade dried and stored to initiate the estimation of piperine. In collaboration with ATREE, Bangalore, the characterization of genotype of the wild *P. nigrum* was initiated. It was found that 3 microsatellites and 10 ISSR markers responded out of the 10 microsatellites and 20 ISSR markers used.Cytological characterisation of the recently discovered potential genotype of *Piper nigrum* L. 'PMM', which possesses lemon scent in vegetative parts and high piperine and oil content in its fruits, was carried out. Meiotic behaviour in the genotype was normal with regular formation of 26 bivalents with 2 -5 secondary associations, anaphase separation was normal and it exhibited high pollen fertility. Root tip cells showed 2n=52 with very small sized chromosomes (0.78 - 1.39 nm). A haploid genotype has been obtained when crossing *P. nigrum* L. 'PMM' (female) with *P. nigrum* L. 'Karimunda' (male). Mitotic studies showed 2n=26 in root tip cells and confirmed the haploid chromosome constitution of the genotype.

'Bio prospecting of potential gingers: chemical prospecting, morphological characterization and *ex-situ* conservation' is an on-going project in collaboration with the Division of Phytochemistry and Phytopharmacology, funded by DBT, Govt. of India,. Morphological and chemical characterisation of *Alpinia mutica* was carried out. Essential oils were extracted from the leaves, inflorescence, fresh and dried fruits, fruit rind, seeds and rhizome of *A. mutica*. The dry fruit rind of *A. mutica* yielded maximum oil (1.18%) and had a potential aroma due to the presence of high concentration of 1-8 cineole (40.45%).Chemical characterisation of flowers of *Hedychium flavescens* and *H. larsenii* using head-space-GCMS showed presence of fragrant compounds. *H. flavescens* flowers contained 57 volatile compounds, of which 96.49% were identified. The major constituents were isobornyl formate (28.46%), followed by trans-(E)-jasmonol (9.65%) and menthol (6.19%). In the flowers of *H. larsenii,* 44 compounds were detected, of which 97.93% were identified. In this species also the major constituent in the flowers was isobornyl formate (37.46%). The other major compounds were thymoquinone (26. 97%) and terpinen-4-ol (11.71%). Essential oils were also extracted from the rhizome of *Zingiber anamalayanum, Curcuma haritha* and whole plant of *C. vamana*. GC-FID analyses of oil samples were conducted and the data was compared with that of GC-MS.

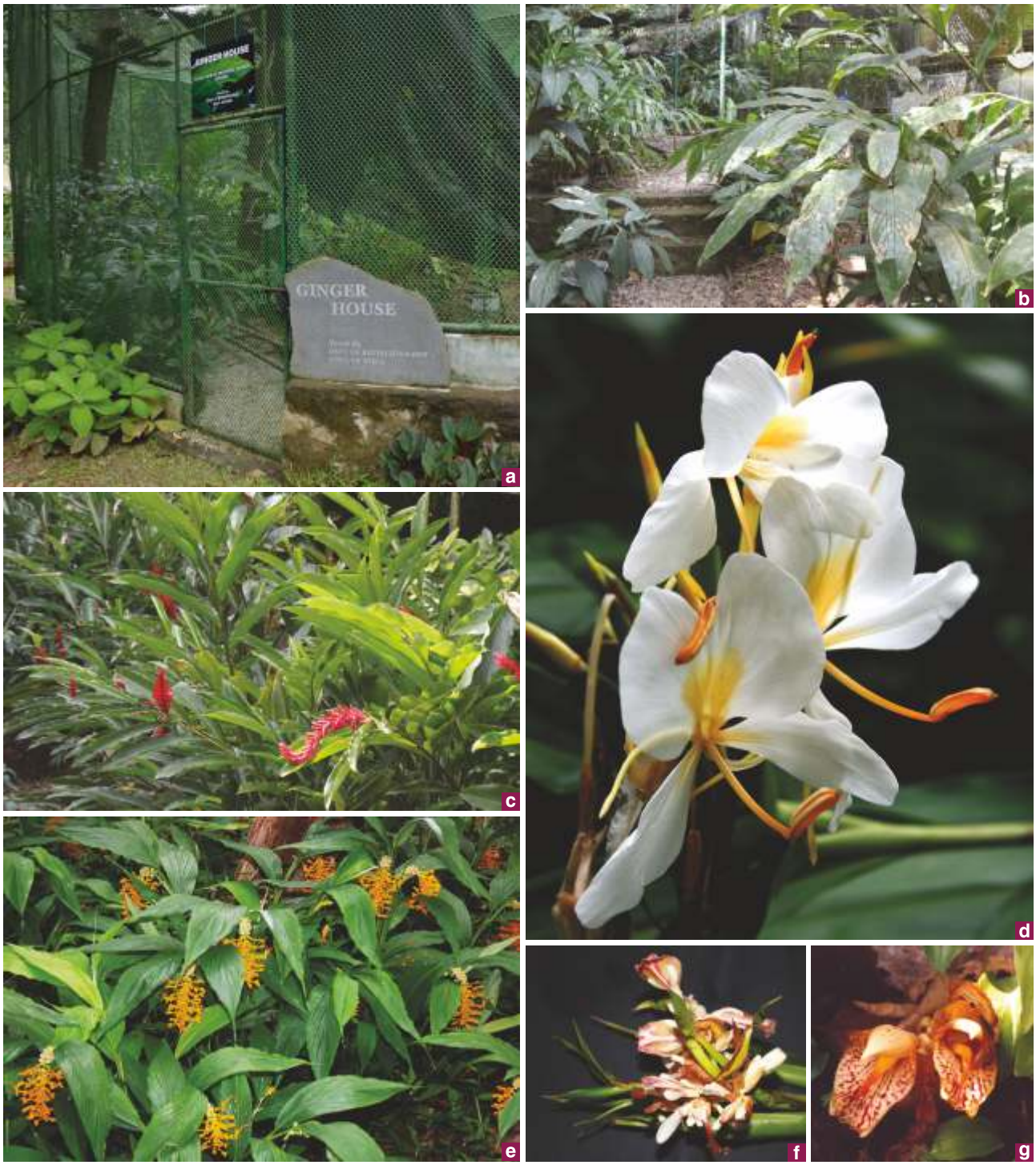
Gingers



***Kaempferia rotunda* L.**

Jawaharlal Nehru Tropical Botanic Garden and Research Institute

A 'Ginger House' of 327 sq. m. area was established using the financial support from Department of Biotechnology, Govt. of India, to facilitate the conservation of ginger germplasm in JNTBGRI. Plant explorations were conducted to different parts of Kerala and Tamil Nadu and 10 species were introduced, of which *Hedychium chrysoleucum, Curcuma mutabilis* and *Amomum fulviceps were* new additions. Presently the 'Ginger House' holds 52 species / cultivars / varieties. *Costus erythrophyllus* and *C. malortianus were*



a, & b. Views from 'Ginger House'; c. *Alpinia purpurata* (Vieill.) K. Schum.; d. *Hedychium coronarium* var. *chrysoleucum* (Hook.) Baker; e. *Globba schomburgkii* Hook. f.; f. *Alpinia calcarata* (Haw.) Rosc.; g. *Zingiber nimmonii* (J. Graham) Dalzell.

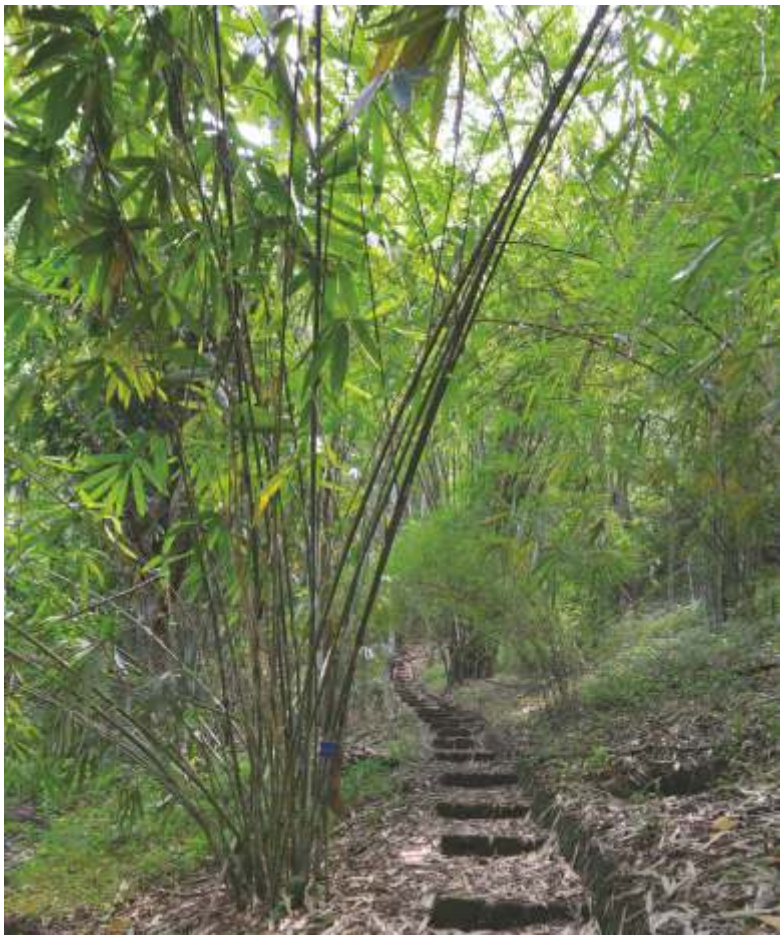
a. *Amomum andamanicum* V. P. Thomas, M. Dan & M. Sabu; b. *Etlingera fenzelii* (Kurz) Skornick. & M. Sabu; c. *Amomum ghaticum* K. G. Bhat; d. *Amomum masticatorium*Thwaites; e. *Costus stenophyllus*Standl. & L. O. Williams

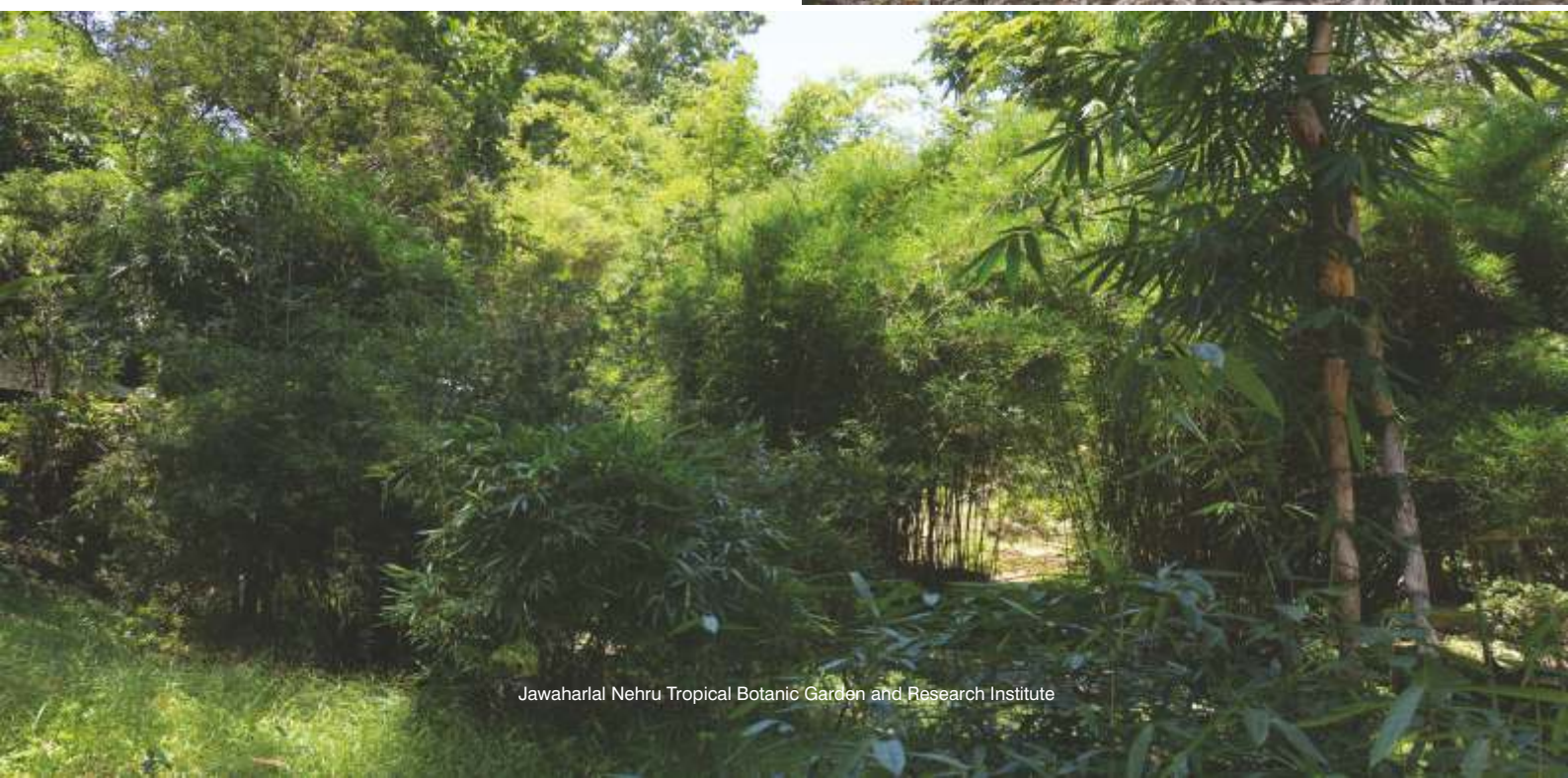
planted as an exterior border of the House. *Amomum mastcatorium* flowered for the first time at JNTBGRI. *Tapeinochilus comosus*(Wax ginger), native to Queensland and *Costus stenophyllus* (Bamboo costus) from Costa Rica are highly potential as cut flowers and landscape beautification. Other than the members of Zingiberaceae and Costaceae, certain species representing Cannaceae, Marantaceae and Musaceae, the allied families of the Order Zingiberales are also grown in the 'Ginger House'. Currently the ginger germplasm includes 83 taxa.

Bamboo Biology

During the period under report, 111 saplings (Acc. Nos.947 to1057) were planted in the Bambusetum raising the total accessions to 1057 of which 8 species and one variety were new additions. The new taxa are *Bambusa multiplex* var. 'red' (66694, Sikkim), *Dendrocalamus* sp. (66695, Sikkim), *Dendrocalamus* sp.(64506, China), *Bambusa* sp. (64505, China), *Bambusa cacherensis* (004, Assam), *Bambusa jaintiana* (005,Assam), *Gigantochloa* sp. (64239, Urav), *Gigantochloa* sp. (003, Assam) and *Schizostachyum* sp. (70517, Arunachal Pradesh). 527 bamboo clumps were neatly labelled or their old labels replaced with new ones.

Expedition trips were conducted to Arunachal Pradesh, Karnataka and various forest areas of Kerala. Offsets of two bamboo species and specimens of two others were collected from Arunachal Pradesh, besides offsets (3), saplings (17) and cutting (one) belonging to Coll. Nos. 64234 to 64249 from Mangalore and Wayanadu forests. Dr Koshy brought two species of bamboos from China and one from Singapore during his visit to these countries and planted them in the garden. Propagules of five species of bamboos from Assam were also received during this period through the Department of Ecology and Environmental Science, Assam University. The collected propagules were planted in the Bambusetum nursery. All these activities enriched the collection of Bamboos in JNTBGRI.





Herbarium specimens of bamboo leaves, sheaths, and flowering culms were collected from *Bambusa bambos, B. pallida, Dendrocalamus brandisii*, *D. hamiltonii, D. sikkimensis, Melocanna baccifera, Gigantochloa* sp., *Ochlandra travancorica, Pseudoxytenanthera stocksii*, *Pseudoxytenanthera* sp., *Schizostachyum brachycladum* and *Schizostachyum* sp. and were processed. 125 specimens were mounted and labelled. The exhibits in the Bamboo museum, bottled specimens and herbarium specimens were cleaned, rearranged properly and labelled.

Along with routine maintenance and enrichment of Bambusetum, studies on the reproductive biology and cytotaxonomy of bamboos were also carried out. Observations were made on the flowering of *Dendrocalamus brandisii* (Munro) Kurz and *Bambusa pallida* and fruiting in *Melaconna baccifera*. Two clumps of *Dendrocalamus brandisii* flowered in 2013, after 22 years of their introduction in the Bambusetum. Of these, one clump (No. 237) was in peak flowering since October 2013. Anthers withered in large numbers and dropped down like 'rain'. High bee activity on these flowering clumps was observed during morning hours. Hymenopteran bees *Apis cerana*, *A. dorsata*, *A. florea* and *Trigona irridipennis* were the common visitors. While the larger *A. dorsata* bees limited their foraging activities

to the inflorescences on the canopy, others even collected pollen from fallen anthers. Millipedes were also found to feed on fallen anthers. During seed set birds, mainly the Plum-headed Parakeets visited the infrutescence to feed on the seeds. Different stages of flower development, duration of male and female stage and their interval and percentage of seed set were also observed in this species. Flowering details such as floret opening and insect visitors in *Bambusa pallida* were also studied. Flowering time, seed setting and seed germination were recorded. One thousand one hundred and forty four florets were marked at anthesis and seed set in these florets were recorded periodically.

Daily fruit fall from four clumps of this species were recorded. Comparison of germinated and non-germinated fruits at different planting depths was recorded for further study. In the case of *Melocanna baccifera* daily fruit fall from four (Acc-58, 359, 403 & 365) clumps were recorded. Here also comparison of germinated and non-germinated fruits at different planting depths was recorded.

An important finding during this period is the ultraviolet (UV) emission from the floral and fruit parts of bamboo and other grass inflorescences which may act as visual cues to pollinators, seed dispersers and seed predators. Grasses are traditionally considered as wind pollinated. However, field observations confirmed frequent insect visits to grass flowers, suggesting insect pollination. Fruit and seed predators inflict heavy losses to cereals and millets during their growth, maturation and storage. The actual factors guiding insects and predators to grass flowers, fruits and seeds are not clear. Experiments conducted by scientists of Bamboo Biology and Phytochemistry Division showed that grass floral parts such as glumes, lemma, palea, lodicules, staminal filaments, pollen and fruits emit attractive blue fluorescence, whereas the stigmatic portions emit red fluorescence at 366 nm. It was confirmed that the blue fluorescent constituent in grass reproductive structures is ferulic acid (FA). Fluorescence spectra of blue-emitting grass floral, seed extracts and isolated FA on excitation at 366 nm showed their emissions at 420–460 nm. We proposed these FA-based blue emissions from grass reproductive structures as enticing visual cues to pollinators (bees, other insects), seed dispersers (birds) and predators (birds, rats). This study provides

Dr. K. C. Koshy's presentation at 13th Conference of IABG at Guangzhou, China, 13 Nov. 2012.

more evidence that insect pollination is possible in grasses. Pollen transfer studies could further confirm entomophily in grasses. These blue emissions could also act as signals attracting insect pests to grains of cereals and millets. Also, FA-based emissions play a crucial role in plant-animal interactions. These findings could also help redefine the functions of grass floral parts and better understanding their morphology. Future studies on signalling molecules and defence mechanisms in grasses could lead to the discovery of novel molecular or fluorescence-based pest, weed control measures.

Under the project investigations on bamboos of the Western Ghats, meiotic studies in four species and pollen fertility studies in two species were carried out. Young spikelets of *Bambusa pallida*, *Dendrocalamus brandisii*, *Pseudoxytenanthera stocksii* and *Sczhizostachyum beddomei* were fixed and temporary meiotic slides were prepared and photographically documented. Pollen fertility studies in *Melocanna baccifera* showed 94.5% fertility with acetocarmine staining. *In vitro* pollen germination in Brewbaker and

Kwack's medium was 51.6%. In *Pseudoxytenanthera stoksii,* 15.46% pollen fertility was obtained with the acetocarmine staining. However *in vitro* pollen germination showed only 3.03% in the Brewbaker and Kwack's medium supplemented with10% sucrose.

During the period, a total of 17725 propagules of 16 species *viz. Bambusa bambos*, *B. membranaceus*, *B. multiplex*, *B. pallida, Bambusa* sp., *B. vulgaris, B. vulgaris* 'Wamin', *Dendrocalamus brandisii, D. giganteus, D. hamiltonii, D. strictus, Gigantochloa nigrociliata, Melocanna baccifera, Ochlandra travancorica, Thyrsostachys siamensis* were planted for raising saplings for sales. Also, 11695 saplings belonging to 21 species were distributed to different agencies and individuals for various purposes including research.

The Institute celebrated the World Bamboo Day on 18th September 2012 with fervour and enthusiasm. The programme was held in the Bambusetum, under the beautiful canopy of bamboo clumps. Seventy participants including students and members of three NGOs took part. They included, Botany Graduate students from Iqbal College, Peringammala, Upper primary Students and teachers from SN UP school, Kollayil, Biodiversity Management Committee of Peringammala Panchayath (local self government), Members from Kerala Sastrasahitya Parishath, Palode and Fighters Eco-Club, Nanniyode.

The function started at 10 am. Dr P G Latha, Director, JNTBGRI delivered an inaugural address. She explained in detail the

World Bamboo Day Celebrations 2012

significance of JNTBGRI Bambusetum. It is the largest and the best scientifically maintained Bambusetum in India harbouring 69 species spread out in an area of 16.28 acres. She made the inaugural distribution of the seedlings of *Bambusa pallida* to the participants.

Dr P J Mathew, Head, Plant Genetic Resources Division, JNTBGRI explained the history of this Bambusetum and how this has grown into such a level during the last 25 years. He praised the dedicated efforts of the Bamboo Biology group and said that this would be a source for future bamboo research and India.

Demonstration of bamboo weaving by traditional communities was the cynosure of the programme. Six traditional bamboo craft workers from Kani and Paraya tribal communities demonstrated their weaving skill which was well appreciated by young and old participants. The baskets, mats etc made by them were purchased by the participants.

Demonstration on bamboo propagation and planting conducted by Mr B. Gopakumar and K. Asokachandran Nair included the traditional offset planting, seed planting, improvised offset size reduction, tiller separation, culm and branch cuttings, layerings etc.

As a mark of the day, a species collected by Mr. N. Salahudeen from Arunachal Pradesh was planted by Dr. P. J. Mathew, in presence of participants.

The student participants enthusiastically participated in the bamboo identification contest.

During the feedback session participants expressed their desire to involve in such workshops and follow up programmes in future.

Carnivorous Plants

***Nepenthes rafflesiana* male inflorescence**

Fourteen carnivorous plant species, mainly *Nepenthes* and their hybrids, were added to the living collections during the period. Most of them were received as gift from individuals and agencies. Shri Ralom Borang, MLA of Arunachal Pradesh generously donated seven *Nepenthes* species, *Nepenthes albomarginata* T. Lobb ex Lindl., *N. chaniana* C. Clarke, C.C. Lee & S. Mc Pherson, *N. glandulifera* C. C. Lee, *N. gracillima* Ridl., *N. rafflesiana* Jack, *N. stenophylla* Mast., *N. truncata* Macfarlane and two hybrids of *N. hamata* x *N. platychila* and *N. maxima* x *N. boschiana*. One species, *Nepenthes bicalcarata* and one hybrid (*N. ventricosa* x *N. ampullaria*)received from Borneo Exotics, Sri Lanka, were introduced and grown in the conservatory. Gurukula Botanic Sanctuary of Wayanad also supplied us with a few carnivorous plants including *Aldrovanda vesiaslosa, Dionaeamus cipula* and one *Nepenthes* sp. Dr Sathish Kumar brought *Nepenthes alata* Blanco from Reunion Island. All the introductions enriched our living collections of carnivorous plants.

A major achievement during the period was the successful production of seeds and seedlings after crossing *Nepenthes mirabilis* and a hybrid. This is the first hybridisation effort in *Nepenthes* in India. The female flowers of *N. mirabilis* were pollinated with pollen from the male plant of a *Nepenthes* hybrid, *N. ampullaria* X *N. veitchii.* The seeds were collected and sown in clay pots containing peat moss. After 23 days the seeds started germinating and produced plants. Besides, two more crosses were made in *Nepenthes* and fruits and viable seeds were produced. Female flowers of *N. mirabilis* were pollinated with pollen from the male plant of *N. khasiana*, the only Indian species. This cross also produced fruits and viable seeds. The matured fruits were harvested and seeds sown in three pots in different media. The seeds in all three pots germinated and produced plants.Another successful crossing experiment was using *Nepenthes rafflesiana* brought from the US and *N. mirabilis* from Thailand. The pollen collected from *N. rafflesiana* were used to pollinate the female flowers of *N. mirabilis*. Pollinated flowers produced fruits containing viable seeds. All the three hybrid seedlings are growing well with small pitchers. Repotting of about 200 seedlings of three hybrids was done for further evaluation of the developed hybrids.

Studies on prey spectra of carnivorous plants continued. Prey spectra analysis of *Nepenthes khasiana* was initiated. Pitchers in two individuals of *N.*

a. A fly being trapped and killed by the sundew; b. *Nepenthes khasiana* male flower; c. Actively growing seedlings of a hybrid between *Nepenthes mirabilis* and *N. rafflesiana.*

khasiana were numbered and their morphological characters such as length and diameter of the pitcher, position of the pitcher (Lower/Higher) in the plant and volume of the digestive fluid at different stages of the development were recorded. Also, from the day of lid opening, number and type of insects were recorded till pitchers dried. Initially insects were classified mainly as crawling and flying and stored in 70% alcohol. 35 insect taxa were collected during the present study. Creeping insects were collected more from the lower pitcher. Flying insects were collected more from the upper pitchers. Certain pitchers had both male and female insects. The most abundant prey both in upper and lower pitchers were ants.

Along with the above programmes, the orchid group carried out a pictorial documentation on the Birds of the Garden. This documentation revealed that our garden has a rich avian fauna with more than 135 species including the Western Ghats endemic birds. Based on this documentation a poster 'Birds of JNTBGRI' was produced, which was funded by KSCSTE under its Science Popularization programme. The documentation of the avifauna is continuing and we intend to publish a coffee table book with details of photographs, scientific and common names, identifying characters and their food, etc.

JNTBGRI celebrated Children's Day 2012 when Her Highness Princess Gouri Parvathi Bayi released the JNTBGRI Publication, 'Plant Wonders, Evolution and Genetics' meant for children to be enthused by biology.

Bulbophyllum putidum (Teijsm & Bim.) J. J. Sm.

Orchid Biology

During the period under report, maintenance and enrichment of the living collection of orchids continued with additions from different regions of North East India, the Western Ghats and Andaman and Nicobar islands. *Dendrobium* sp., *Luisia* sp., *Oberonia* sp., *Papilionanthe teres* (white flowered) and *Thrixspermum* sp. were brought from Andaman (all from near Mayabunder). A total of 24 species *viz*. *Bulbophyllum macranthum*, *Bulbophyllum* (5 spp.), *Ceratostylis subulata*, *Corymborkis veratrifolia, Cymbidium* sp., *Dendrobium* (4 spp.), *Eria* sp., *Hetaeria obliqua*, *Luisia* sp., *Luisiopsis inconspicuua*, *Phalaenopsis speciosa, Phalaenopsis tetraspis*, *Spathoglottis plicata*, *Thrixpsermum* sp., *Trichoglottis* sp. and 2 species of *Vanilla* were introduced from Great Nicobar island. One month long exploration trip was conducted to forest areas of

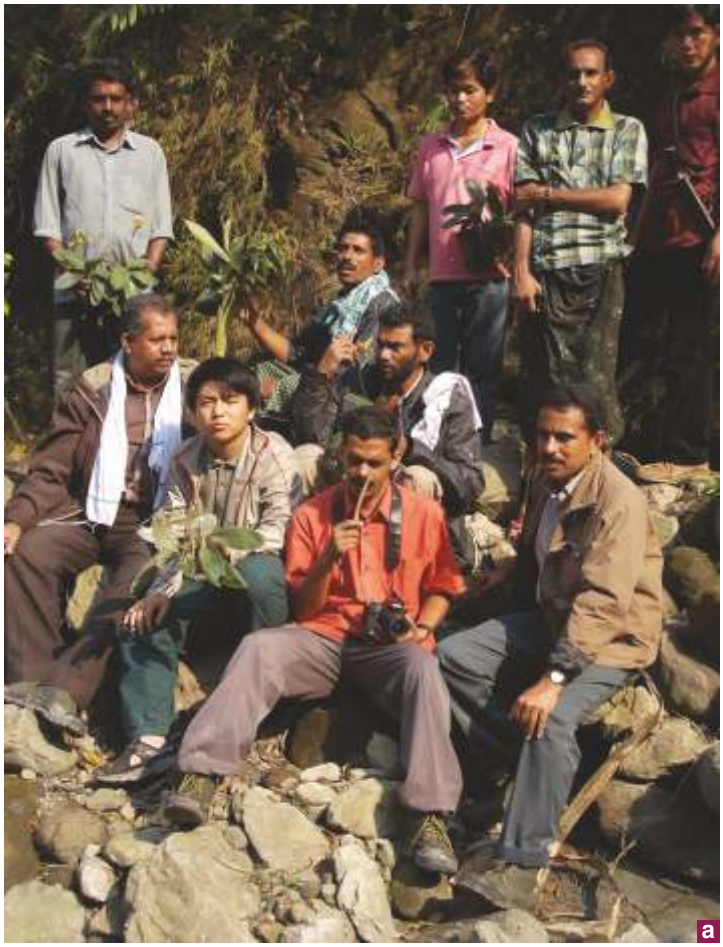
Paphiopedilum primulinum

South Korean team of botanists led by Prof. Nam Sook Lee and Dr. Park in discussion with the Hon'ble Chief Minister Shri. Oommen Chandy.

Arunachal Pradesh, Assam, Kalimpong, Meghalaya and Sikkim and more than 130 species of orchids were collected. Dr. Mathew Dan brought three species of orchids from Dehra Dun *viz*. *Goodyera* sp., *Malaxis* sp., and a *Satyrium* sp. from Kodaikanal, six species of orchids were introduced: *Gastrochilus acaulis*, *Luisia* sp. (aff. *L. tenuifolia*), *Oberonia* sp., *Seidenfadeniella filiformis*, *Vanda testacea* and a *Zeuxine* sp. 20 species of orchids were received on exchange from Anglade Institute of Natural History, Kodaikanal which included species of *Coelogyne*, *Cymbidium*, *Paphiopedilum* and a few others.

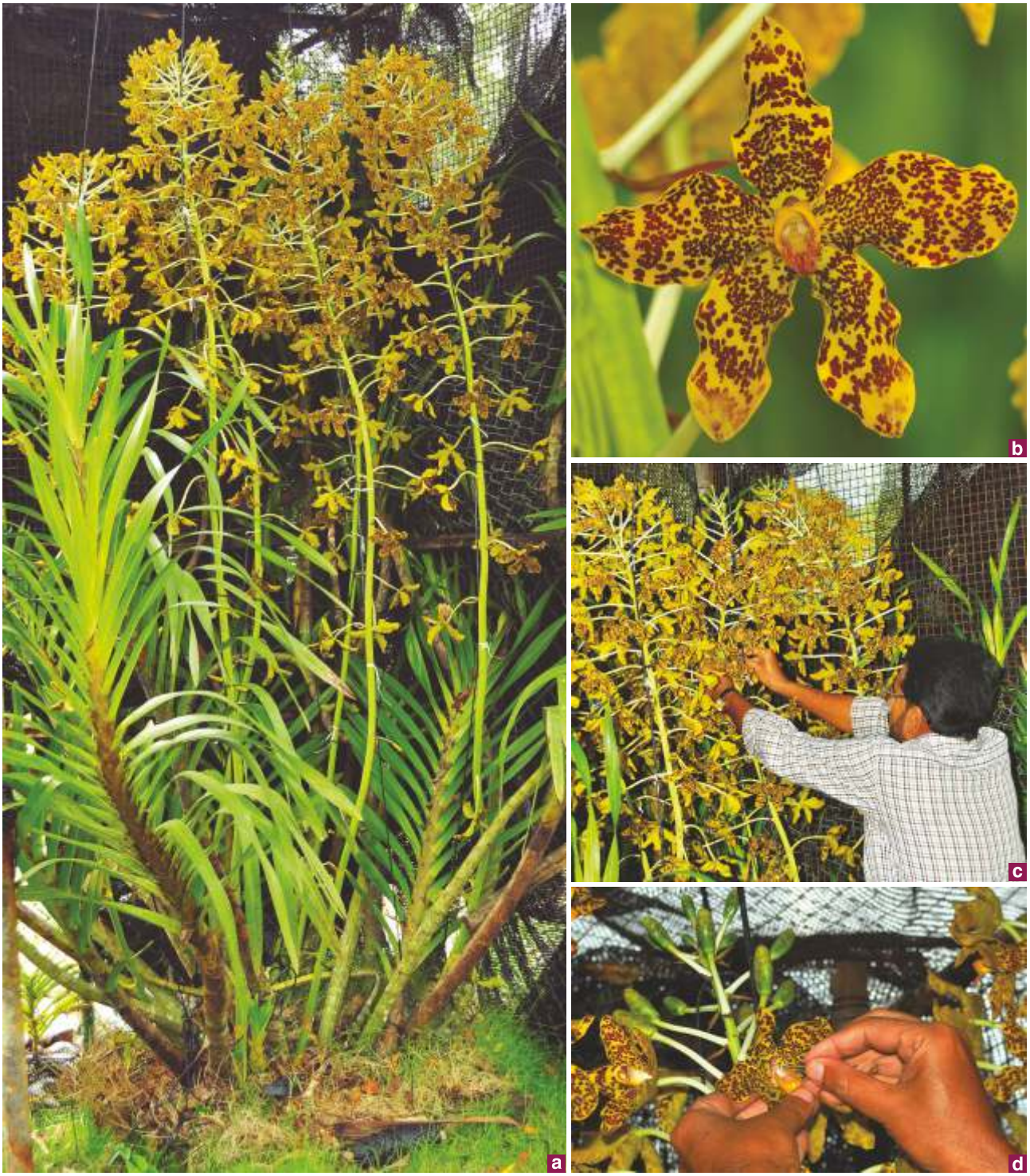
As part of the Orchid Breeding programme, 134 crosses were made using different species and hybrids; 4 mature pods were cultured in the lab; 15 cultures were sub-cultured. Three capsules responded positively and protocorm initiation was observed. Two of the hybrids produced the first flowers. These were crosses between 1. Dendrobium Sonia 17 x *Dendrobium aqueum* and 2. Dendrobium TBGRI Purple Beauty x *Dendrobium formosum.* Some refinements are required in the F1 generation to enrich the flower quality.

Orchids which bloomed during this period were studied, which include several species brought from Arunachal Pradesh like *Cleisostoma paniculatum, Calanthe, Luisia* and *Luisiopsis inconspicuua* from Nicobar islands. Flowering observations showed that *Calanthe* and *Oberonia,* introduced from Arunachal Pradesh are possibly new to science and we intend to name these novelties after Mr. Borang of Arunachal Pradesh who extended immense support in exploring remote areas near the border with China. *Luisiopsis inconspicuua* (Hook. f.) Sathish & Suresh, introduced from Nicobar islands is both a new generic and species



a. JNTBGRI team on an expedition to Arunachal Pradesh in the Upper Siang area in search of *Paphiopedilum*;
b. *P. venustum* (Wall. ex Sims) Pfitzer flowering in the riverine vegetation.
c. Paphiopedilum liemianum flowers for the first time in JNTBGRI

record for Andaman and Nicobar islands. This was earlier recorded only from mainland India and adjoining regions. Taxonomic studies on introduced orchids from Andaman and Nicobar islands revealed that one was *Bulbophyllum apodum* Hook. f. and another one an interesting yellow flowered *Flickingeria. Bulbophyllum macranthum* introduced from the Nicobars on cultivation is flowering frequently. During flowering we



Tiger orchid (*Grammatophyllum speciosum* Blume a. Plant with inflorescence; b. Single flower; c. & d. Pollinating the plant

have observed *Bactrocera* fruit flies visiting for nectar. We intend to undertake a detailed study on this relationship. Even though, All India Co ordinated Project, Taxonomic Studies on Orchids concluded officially on 31st March 2012 after 12 years, taxonomic studies on Indian orchids continued.

Tissue Culture Mass Multiplication of Selected Horticultural Species

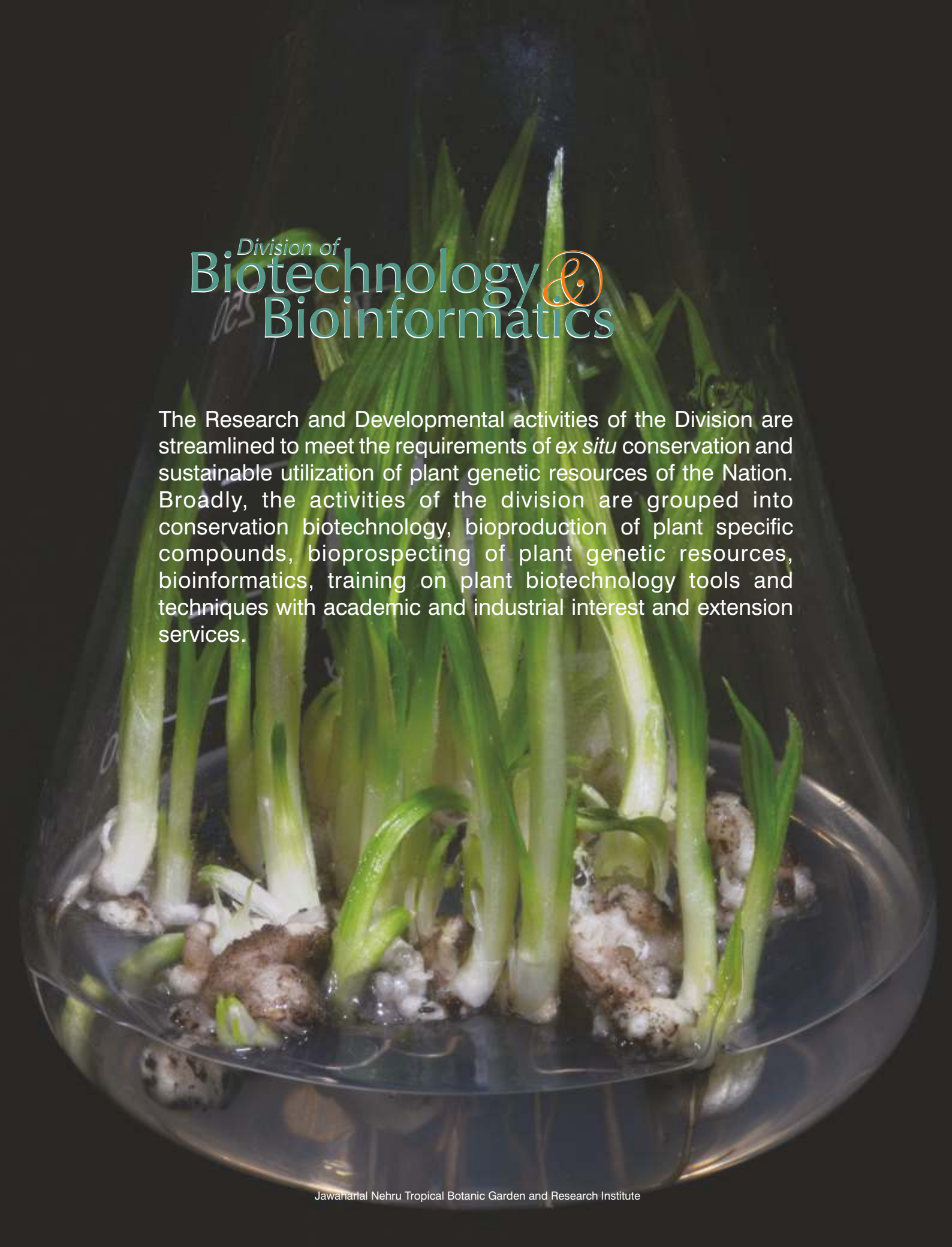
The Unit is framed to develop and implement tissue culture protocols for the production of large quantities of commercially important planting material. As part of the plan funded programme on 'Standardisation of tissue culture techniques and mass production of Ornamentals',micropropagation of 12 taxa comprising cultivars of *Anthurium* such as 'Cesar Violet', 'Hawaii Orange', 'Tropical Red', 'Mauritian Orange', 'Mauritian Red', 'Vesuvius' , 'Rosetta' etc were carried out. Further, we multiplied *Nepenthes khasiana, Phaelenopsis, Peristeria elata, Doritaenopsis* hybrids and *Dendrobium* 'Cleopatra Beauty × Udomsri' etc. During the period, 43,581 tissue cultured plants were transferred to greenhouse conditions.

In connection with the programme 'Micropropagation of commercially important Banana and other Taxa'production of 11 cultivars of banana namely 'Kappa' (Red Banana), 'Nendran', 'Poovan', 'Kaveri' (Pisang Lilin), 'Robusta', 'Rasakadhali', 'Virupakshi', 'Grandnine', 'Nagpoovan' 'Manjeri-Nendran' and 'Zanzibar' have been carried out. Tissue cultured plants of Banana were distributed to various growers who are likely to be the beneficiaries and their feedback reports were encouraging in terms of outperforming yield and survival. During the period, two local cultivars 'Virupakshi' and 'Nagpoovan' from Kodaikanal and Palakkad respectively, were popularised. Total production during the tenure was 47,882 plantlets. During this period, the Unit generated a total income of around 7.3 lakhs rupees through sale of tissue cultured plants. The Unit is also engaged in contract multiplication of Orchids and Anthuriums as per the grower's choice and contract production of one Anthurium and four Orchid varieties were undertaken during the reporting period and 472 culture flasks were released. Another 2500 culture flasks are ready for sale.

Piper nigrum micropropagation programme is a privately funded programme for protocol development and production of Black Pepper (Karimunda). Total estimate is Rs. 2,00,000/-. *In vitro* production of Piper has been achieved only at bench level. Culture establishment is difficult due to endophytic bacteria. Rooted shoots deflasked and transferred to greenhouse showed about 80% survival. At present, about 450 contamination free cultures at different stages of development are maintained.

A Project on 'High-Tech Micropropagation Unit for Mass Production of Economically Important Plants', funded by the Agriculture Department, Government of Kerala under the Rashtriya Krishi Vikas Yojana (RKVY) with a total funding of ₹ 100 Lakhs, for developing facilities for mass production of Banana, Orchids, Anthurium, Pitcher Plant etc and supplying the same at a subsidized rate has been undertaken. 20 equipments/ laboratory amenities such as R. O. Water Purification Unit, Hot Air Oven, Laminar Air Flow, Autoclave, Culture Racks with electrification, Bottle Washing Machine, etc were purchased and installed. The Lab renovation/remodelling work was implemented with the help of Harbour Engineering Dept., Thiruvananthapuram. The work on new growth room, media storage room and inoculation room at the 'Semi Permanent Building' and roofing, false ceiling, flooring, painting etc are almost complete. A greenhouse complex with two poly-houses (3550 sq.ft.), two net-houses (5500 sq.ft.) and Potting-cum-Store House (475 sq.ft.) has been completed. Fog and Mist Irrigation facilities have also been installed.

The newly developed Polyhouse facility



Division of Biotechnology & Bioinformatics

The Research and Developmental activities of the Division are streamlined to meet the requirements of *ex situ* conservation and sustainable utilization of plant genetic resources of the Nation. Broadly, the activities of the division are grouped into conservation biotechnology, bioproduction of plant specific compounds, bioprospecting of plant genetic resources, bioinformatics, training on plant biotechnology tools and techniques with academic and industrial interest and extension services.

Conservation Biotechnology

18 wild accessions of *Musa* from Agastyamalai, Achankoil and Bonacaud were introduced and maintained along with 25 accessions of *Musa acuminata* ssp. *burmannica* from 11 districts of Kerala in the Banana Conservatory which was constructed under *ex-situ* conservation project funded by DST, Govt. of India. Besides, the conservatory is strengthened with two accessions of *Musa balbisiana* and one accession of *Musa accuminata* ssp. *burmanicoides* obtained from National Research Center for Banana, Trichy as reference sample and five accessions of *Musa nagensium* from north Eastern India. During this period, other additions in the conservatory were *Musa laterita, Musa ornata* and 30 seedless diploid (AA) accessions of *Musa* from different banana nurseries in Thiruvanthapuram district. About 15 wild *Musa* accessions were utilized for *in vitro* shoot regeneration.

Musa accessions collected were identified by morphotaxonomical evaluation using the Banana descriptor-INIBAP (1996) & Musalogue (2001) and ploidy confirmation was done using Flow cytometric analysis. A comparative account of the histograms of the wild accessions with the known reference standard showed same diploid level (Fig 1). The estimation of 2C DNA content of the *Musa* accessions are in progress.

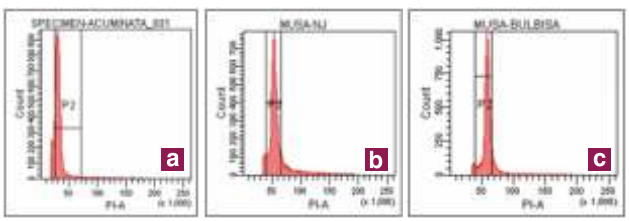


Fig. 1: Flow cytometric histograms indicating ploidy status of wild *Musa* spp. a. *Musa acuminata* ssp. *burmannica* b. *Musa nagensium* c. *Musa balbisiana.*

Pollen germination and storage studies: The effect of sucrose (0 to 20%), boric acid (0.01 to 0.04 %) and calcium nitrate (0.01 to 0.04 %) were tested to standardize the best medium for pollen germination of wild *Musa acuminata* ssp. *burmannica* and *Musa ornata.* Incorporation of 10% sucrose, 0.02% boric acid and 0.03 % calcium nitrate was the best for germination (59% in *Musa acuminata* ssp. *burmannica* and 85% in *Musa ornata*) and this medium is being used to test the viability after storage experiments (Fig 2, 3 & 4).

Fresh and desiccated specimens of pollen and anther of *M. acuminata* ssp. *burmannica* were used for preservation under different temperatures (Ambient Temp: 26 – 32^{0}C, Refrigerator: 10^{0}C, Refrigerator freezer: 4^{0}C, Deep freezer: -20^{0}C and Liquid Nitrogen: -196^{0}C). Pollen/anther stored in refrigerator showed germination up to 30 days but as storage time increased, the germination of the pollen grain decreased. Desiccated pollen stored in refrigerator, deep freezer could not survive more than a week. After 30 days we observed that only cryopreserved pollen/anther survived. During our experiments cryopreserved anther was found to have more germination capability than cryopreserved pollen. So, cryopreservation seems to be a better option for long term conservation and further experiments are in progress to improve the viability.

The phytochemical analysis of wild *Musa acuminata* ssp. *burmannica* and diploid (AA) cultivars ('Matti', 'Chemmatti' and 'Pisang Lilin') using HPLC revealed high 5-Hydroxytryptamine (Serotonin) and 5-Hydroxytryptophan (5-HTP) in the peel of cultivars and

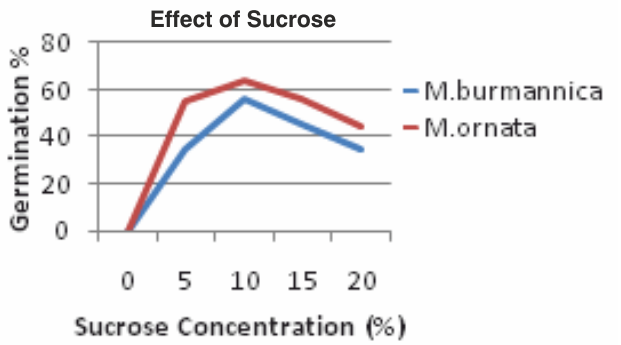


Fig. 2: Effect of Sucrose on pollen germination of *Musa acuminata* ssp. *burmannica* and *Musa ornata*

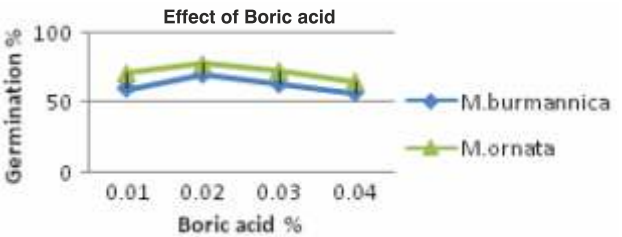


Fig.3: Effect of boric acid on pollen germination of *Musa acuminata* ssp. *burmannica* and *Musa ornata*

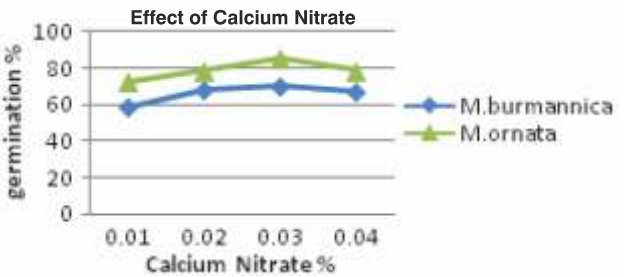


Fig. 4: Effect of calcium nitrate on pollen germination of *Musa acuminata* ssp. *burmannica* and *Musa ornata*

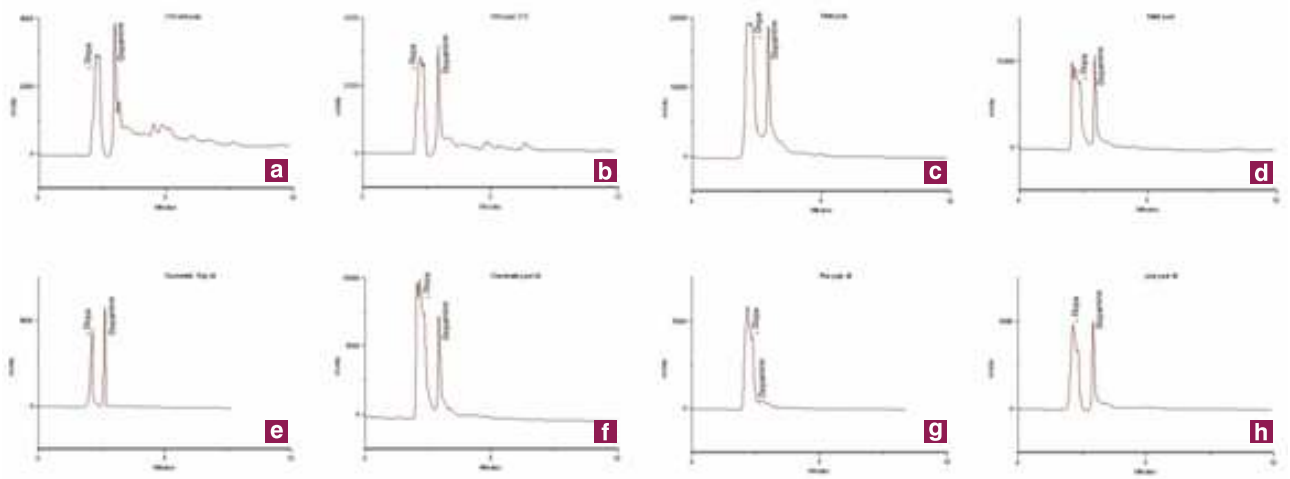


Fig. 5 : HPLC detection of L- Dopa and Dopamine in a. *Musa acuminata* ssp. *burmannica* pulp; b. *Musa acuminata* ssp. *burmannica* peel; c. Matti pulp;d. Matti peel; e. Chemmatti pulp; f. Chemmatti peel; g. Pisang Lilin pulp; h. Pisang Lilin peel.

least in the peel of wild banana. L-Dopa and Dopamine were present in high quantities in the pulp of cultivar 'Matti' and least in pulp of wild and pulp of 'Pisang Lilin' respectively (Fig. 5).

The antioxidant activity of wild and cultivars of *Musa* was determined by using DPPH (2, 2- diphenyl - 1-picrylhydrazyl) assay. Among the samples, 'Matti' pulp showed the best antioxidant activity (Fig. 6).

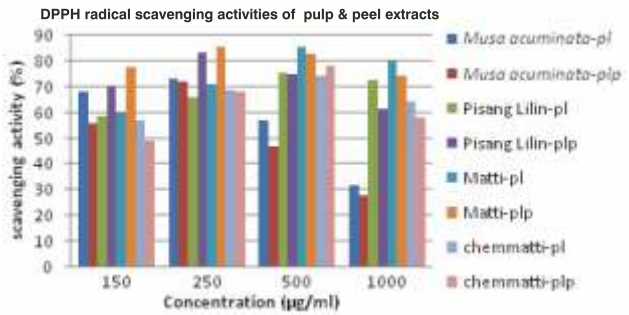


Fig. 6: Antioxidant activity (DPPH) of various *Musa* accessions.

Micropropagation studies using apical and inflorescence meristem of *M. acuminata* ssp. *burmannica* and zygotic embryo of M. *balbisiana* in MS medium supplemented with appropriate concentration of plant growth regulators (PGRs) showed that 6-Benzylaminopurine (BAP) and Indole – 3 – acetic acid (IAA) was suitable for both apical and inflorescence explants and BAP alone was enough for embryo culture. Micropropagated shootlets are being utilized for cryopreservation studies. Cryopreservation of M. *balbisiana* embryo was attempted by simple freezing and encapsulation method and the work is under progress. Shoot proliferation using apical meristem for the varieties 'Chemmatti' and 'Kadali' was optimized in MS medium supplemented with 0.5 mgl^{-1} IAA and 3 mgl^{-1} BAP.

The quantitative analysis of the volatile compounds in the 'Chemmatti' and 'Pisang Lilin' fruits was achieved using GC-MS and the results showed 72.2% of esters of isoamyl alcohol which is the major group of esters with isoamyl isovalerate, isoamyl isobutyrate (10.5%) and isoamyl butyrate (5.3%). Twelve compounds that constituted 89.1% of the oil were identified from Pisang Lilin.

SEM of *Musa* seed: Fresh seed of *Musa accuminata* and *Musa balbisiana* were hand-cut transversely using scalpel to expose the embryo and surrounding tissues. The fresh and dry seeds were mounted directly onto aluminum stubs and coated with a thin layer of gold in the Polaron Sputter Coater. The prepared specimens were then viewed to observe detail cell structures of the testa, operculum and surrounding cells using a Scanning Electron Microscope (Fig. 7). The experiment was designed to determine whether a physical barrier is present whereby water absorption is controlled in *Musa* seed during different stages (fresh seed vs dry seeds). Further studies are required to determine the effect of seed drying on water absorption.

Under the project on micropropagation of *Phaius luridus* and of pollinia and seed cryobank of orchids of Western Ghats, seeds of eight species of orchids (16 accessions; *Eulophia cullenii*, *Acampe ochracea, Aerides crispa, Dendrobium heterocarpum, Taprobanea spathulata, Calanthe masuca, Vanda wightii* and *Vanda thwaitesii*) were deposited in the cryobank. Pollinia of 6 species (6 accessions; *C. masuca, Cymbidium aloifolium, C. ensifolium, E. cullenii, V. thwaitesii* and *V.*

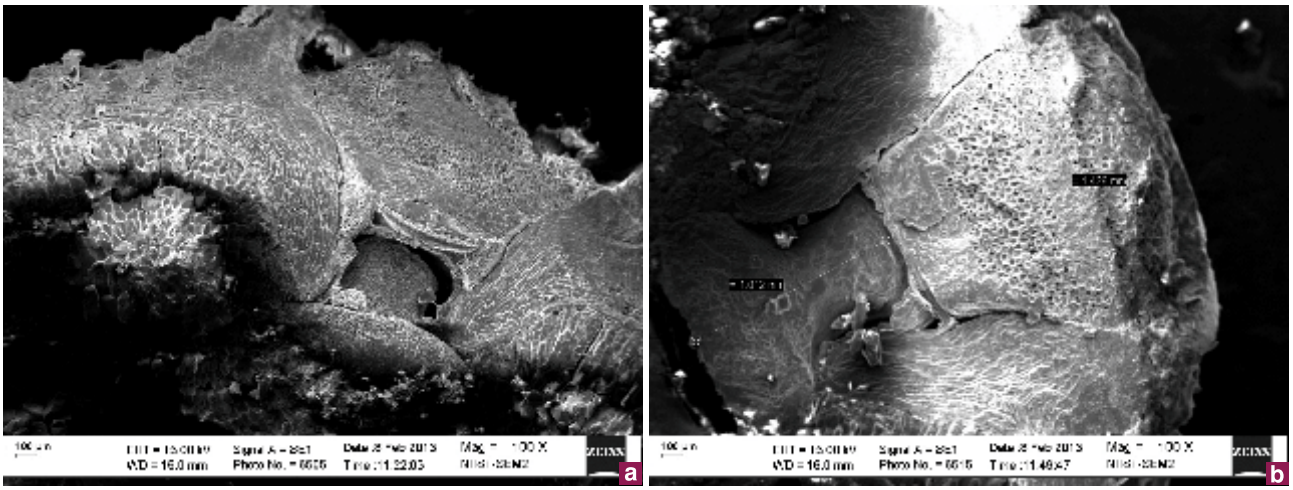


Fig. 7: SEM photographs *of* a. *Musa acuminata* seed and b.*Musa balbisiana* seed

wightii) were deposited in the cryobank after confirming their pollen germinability. For protocorm cryopreservation of *V. thwaitesii*, age of the protocorms and duration of preculture in 0.5M sucrose were optimized to yield maximum recovery after cryopreservation. Hybrids produced using cryopreserved pollinia of *C. aloifolium* (*C. ensifolium x C, aloifolium)* flowered to exhibit floral characters intermediate between both parents (Fig. 8).

Fig.8. A *Cymbidium* hybrid produced utilizing cryopreserved pollinia
a. *Cymbidium ensifolium* (Female Parent); b. *C. aloifolium* (Male Parent)
c. *Cymbidium ensifolium* x *C. aloifolium* (Hybrid)

325 seedlings of 4 hybrids (*T. spathulata x R. retusa, V. wightii x T. spathulata, V. tessellata x T. spathulata* and *A. praemorsa X R. retusa)* produced utilizing cryopreserved pollinia were transferred to the nursery. Protocorms of *V. thwaitesii x T. spathulata* could also be raised. Fruit set obtained in a few new combinations utilizing cryopreserved pollinia include *E. cullenii x C. aloifolium, E. cullenii x C. ensifolium* and *C. ensifolium x E. cullenii.*

Multiple shoots were established using nodal explants of *P. lurides* cultured in Mitra medium supplemented with appropriate PGRs. Seedlings of *Paphiopedilum druryii* reared in the nursery exhibited vigorous growth and the first batch of 25 seedlings produced a maximum of 2-3 suckers, of which, 23 flowered in the nursery during January-February 2014. The growth behaviour, flowering and fruit set obtained through hand pollination revealed effectiveness of micropropagation system for restoration.

Under the DBT sponsored programme on Conservation of *V. thwaitisii, V. wightii and Eulophia cullenii* three endangered orchids of Western Ghats through micropropagation and restoration with tribal

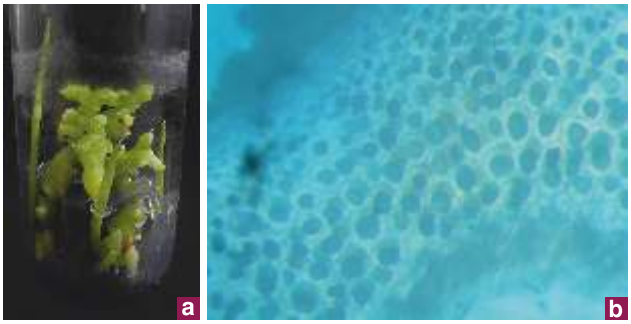


Fig.9a. Multiplication of *Eulophia cullenii* through mini rhizome culture; Fig.9b. Pelotom in the root cortical cells of *Eulophia cullenii* showing intensive micorhizal colonization

participation, a distribution model prepared for the target species enabled to confirm the presence of *V. wightii* in new localities like Nilambur in Kerala and Sullia in Karnataka and *V. thwaitesii* in Coorg district of Karnataka. New geographical coordinates of distribution of *V. wightii* (6), *V. thwaitesii* (7) and *E. cullenii* (6) were also recorded. Population studies conducted in *V. wightii* revealed its distribution at altitudes ranging from 27-870m above m.s.l. extending from Idukki district of Kerala to Dakshina Kannada district of Karnataka. A total of 5178 individuals and 26 host species were identified. *Strychnos nux-vomica* (27.81%) and *Terminalia paniculata* (20.1%) were the dominant hosts. Samples of *V. wightii* (6), *V. thwaitesii* (6) and *E. cullenii* (4) were also introduced to the Institute.

For restoration studies, protocorms of 2 accessions each of *E. cullenii and V. wightii* and 6 accessions of *V. thwaitesii* were raised. A propagation protocol was also developed for *E. cullenii* through culture of axenic seedling-derived mini-rhizomes (Fig.9a). Among the 150-500 seedlings of the target species transferred to the nursery, *E. cullenii* exhibited poor establishment (25%). Sprouted *in vitro* tubers having roots exhibited higher establishment (>80%) in the nursery. The seedlings of *V. wightii* and *V. thwaitesii* showed high survival (>90%) but poor growth.

Mycorrhizal colonization was identified in the roots of *V. thwaitesii* and *E. cullenii* (Fig. 9a) collected from natural populations. Endophytic mycorrhizal fungus whose monilioid cells resembled that of *Epulorhiza epiphytica,* isolated from the roots of *V. thwaitesii* facilitated germination of seeds of both *V. thwaitesii* and *V. wightii* leading to growth of embryos and breaking of seed coat, but did not support further development. Therefore, it is proved that the latter strain is inefficient for symbiotic germination. Endomycorrhiza isolated from *E. cullenii* roots also did not support symbiotic germination of their seeds.

Under the programme of Conservation of *Calamus shendurunii* and *C. wightii*, two endangered and endemic rattans of Western Ghats through micropropagation, reintroduction and cryobanking, funded by Kerala State Forest Department, population survey and consequent study on seed biology conducted showed a decline of their population in the native habitats which may be due to extreme recalcitrance of their seeds. Even though their spread was poor, good density (100 plants in approximate 10,000 m^2 area) was noticed in the occurrence points.

Seeds of *C. shendurunii* and *C. wightii* were highly recalcitrant and desiccation sensitive, and this is a barrier for conventional seed banking in both the species. Isolated zygotic embryos, after attaining physiological maturity tolerated desiccation and proved ideal for cryobanking. Seedlings (100) of *C. shendurunii* were produced for restoration studies. A preliminary trial of reintroduction of 10 seedlings into its native habitat showed 60% establishment when observed after one year.

For *ex situ* conservation of RET medicinal and aromatic plants in the National Gene Bank Project (2006-2012) funded by DBT, Government of India, *in vitro* cultures were raised and complete regeneration protocols were standardized for selected medicinal plants. As part of our continued efforts since 2006 to conserve the plants through *in vitro* propagation and reintroduction, the red listed medicinal plant species (20 accessions of 18 species) were conserved/maintained in the *in vitro* repository with optimized nutrient medium through regular subculture passages.

Under the In-house project on Genetic conservation and chemical characterization of ethnobotanical insect repellent plant species of the Andaman Nicobar Islands, a conservatory was constructed to rear the mericlones of *Etlingera fenzlii* (Kurz) Skornick. (Zingiberaceae). The clonal plants showed 98% establishment in 18 months after transplantation in the conservatory (Fig. 10). All the established plants in the forest habitat as well as in the conservatory exhibited similar morphological and growth characteristics after translocation. Genetic fidelity of micropropagated plants was analysed using ISSR banding profile with 97.26% similarity. There was no significant difference in the yield of essential oil between the micropropagated plants and those originated from rhizome cuttings and the major chemical constituents analysed in the oil of control plants were quite comparable with micropropagated plants of *E. fenzlii.* The oils isolated were analyzed by GC-MS and the constituents were identified by retention indices calculated using homologues of n-alkanes (C_8-C_{22}), comparing mass spectra with published data and by mass spectra library search (Wiley 275 and NIST). Using GC-MS profiles of

Fig. 10. Field established *in vitro* derived plants of *Etlingera fenzlii* in the conservatory.

essential oils, 78.8% of the leaf oil constituents were identified. The predominance of long chain aliphatic compounds (54.2%) compared to terpenoids (24.6%) was a remarkable observation. Among the aliphatic compounds, alcohols dominated (42.1%) with n-dodecanol (23.7%), n-undecanol (8.2%) and n-tetradecanol (5.5%) as the major constituents. Other major compounds identified were the oxygenated sesquiterpenoids, humulene epoxide II (13.3%) and caryophyllene oxide (5.6%).

Optimization of micropropagation protocol for *Myristica malabarica* under in house project is in progress. Shoot cultures were initiated from shoot tip and nodal explants of *M. malabarica* collected from the Kulathupuzha forest ranges. The frequency of shoot bud break was strongly influenced by the season of explant collection and the size of the explants. Mature nodes (3rd and 4th) collected during the post monsoon season showed better response in terms of both bud break and further development. Initiated shoot cultures using nodal explants in different nutrient media revealed high frequency bud break in SH (62.9%) media followed by MS (53%), half MS (51.1%) and modified MS (33%). SH liquid medium supplemented with 1 mgl^{-1}BAP with 0.2 mgl^{-1} NAA and 2 mgl^{-1} BAP with 0.5 mgl^{-1} Kinetin stimulated optimum response for the development of axillary buds.

Bioproduction of Plant Specific Compounds

As part of the project, funded by BRNS Department of Atomic Energy, BARC Mumbai, on 'Phytochemical screening and selection of potential species of *Ophiorrhiza* for tissue culture based mass multiplication leading to production of camptothecin (CPT) - an anticancer compound', seventeen species were collected from different forest segments of Western Ghats. Two of them are reported to be new ie: *Ophiorrhiza wattii* (Silent Valley)and *O. trichocarpon* (Sabarimala). Phytochemical screening of the species showed that only four species, *O.mungos* L. (0.05% g dw), *O. mungos* L.var. *angustifolia* (0.03% g dw), *O.*

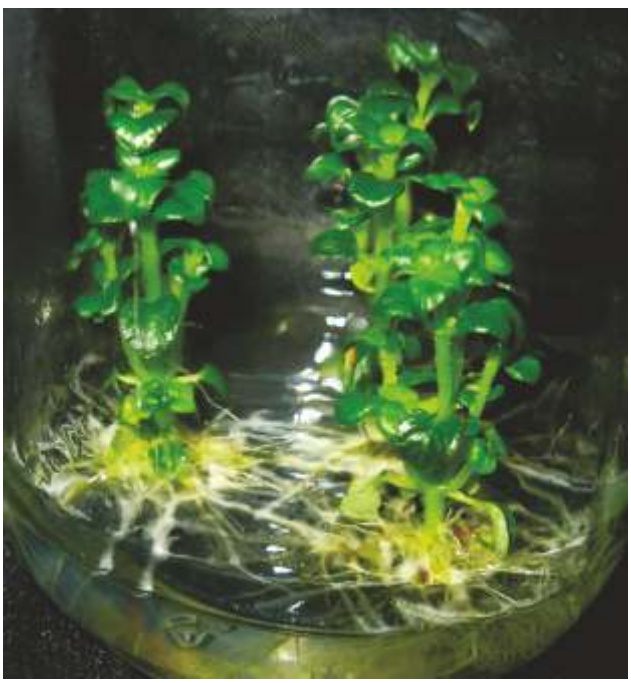


Fig. 11. Rooted plants of *Ophiorrhiza trichocarpos* in *in vitro* condition

pectinata Arn. (0.0039% g dw) and *O. trichocarpon* Blume (0.0028308% g dw) were the prospective species for CPT.

In vitro seed germination in *O. mungos* with different concentrations of BAP and NAA in MS liquid medium with full, ½ and ¼ strength salts was studied in detail. Full strength MS media supplemented with 0.5 mgl^{-1} BAP and 0.1 mgl^{-1} NAA favoured early germination period of 14 days with maximum percentage of germination (FGP) (93.33±1.87) and germination speed (GS) (3.11±0.06) with vigour index (VI) of 185.72±8.90. Seeds inoculated on MS medium with 0.5 mgl^{-1} BAP alone exhibited more or less similar response with highest VI (279.3±43.61). Multiple shoot culture (11.3±0.867) within 30 days were raised using seed and nodal segments in MS medium with BAP (0.1-2.0 mgl^{-1}) in combination with IAA (0.01-0.2 mgl^{-1}) (Fig. 11) Plants could also be regenerated from the somatic embryos induced upon the leaf-derived friable callus tissues in MS medium with BAP 0.25 mgl^{-1}, 2, 4-D 1 mgl^{-1} and NAA 2 mgl^{-1} in 40 days (Fig. 12a.). The embryos transferred onto MS basal agar medium developed into complete plantlets and successfully established in pots. Camptothecin was estimated in multiple shoots, from *in vitro*-derived plants grown in poly bags and compared with that of wild plants and the result showed that multiple shoots had significant level of CPT (Table. 1)

Cell cultures were established using leaf-derived friable callus tissues in MS liquid medium containing NAA (3.0 mgl^{-1}), kinetin (0.5 mgl^{-1}) and 2,4-D (1.0 mgl^{-1}) (Fig. 12b). Influence of different carbon sources such as sucrose, fructose, glucose, maltose (3%) on cell growth was studied over a period of 55 days at 5 day intervals and Growth Index (GI) was 40 in sucrose which is better than other carbon sources. A significant increase in cell growth was recorded on the 20th day of transfer and a decline in growth was noticed after 30th day. The amount of CPT in cell suspension cultures was found to be less (0.01% gm dw) compared to that of the tissue culture plants (0.04 % gm dw).

Under the project, 'Phytochemical screening and selection of potential accession of *Ophiorrhiza mungos* L.' for the development of suitable *in vitro* cultures including multiple shoots leading to the production of camptothecin and production of plumbagin through

Fig. 12.a. *Ophiorrhiza watti*; b. somatic embryos of *O. trichocarpos*; c. suspension culture of *O. mungos.*

hairy root cultures of *Plumbago rosea* L., several hairy root clones of *P. rosea* were induced using different strains of *Agrobacterium rhizogenes* (A4, ATCC 15834, LBA 9402, K 599 and R 1022), and 22 fast growing clones were selected on the basis of growth. GI and plumbagin production of these clones were analyzed by culturing in MS basal liquid medium and the best one (PR 1 ae) was selected. During the scale-up studies using bioreactor, PR 1 ae was found most desirable for enhanced production of root biomass (GI -11.409) and plumbagin (1.418%). With the selected root clone PR 1 ae, time-course analysis on effect of inoculum density was further done over a culture period of 30 days at 10 day intervals with the working volume of 2000 ml and inoculum densities of 1 gl^{-1}, 5 g $l^{-1}$and 10 g l^{-1}. Results showed that inoculum density of 5 g l^{-1} gave greatest GI(11.428) and plumbagin concentration (1.425%). Increasing the density of inoculum does not cause a tremendous increase in growth or plumbagin.

Adventitious roots were induced on leaf segments in MS liquid medium and a maximum GI of 17.53 was obtained in media containing 1 mgl^{-1} IAA and 1mgl^{-1}

Fig. 13. In vitro derived plants of Pandanus established in Polythene bags

Table 1. CPT in multiple shoots, *in vitro* – derived plants grown in poly bags and wild plants

Name of species	Camptothecin in wild plants (% g^{-1} dw)	Multiple shoots (% g^{-1} dw)	In vitro – derived plants grown in poly bags (% g^{-1} dw)
O. trichocarpon	0.0028 ± 0.00042	0.0036 ± 0.0001	0.0042 ± 0.00002
O. mungos var. angustifolia	0.0202 ± 0.00003	0.0248 ± 0.0004	0.0265 ± 0.0004
O. mungos	0.181 ± 0.005	0.30 ± 0.0002	0.28 ± 0.001

NAA over a period of 30 days. Different concentrations and combinations of PGRs were used to find out the optimum concentration and combination of hormones required for maximum root biomass. Maximum biomass production was recorded in media containing 1 mgl^{-1} IAA and 1 mgl^{-1} NAA (GI= 17.53). Adventitious roots of varying inoculum size (1g l^{-1}, 2g l^{-1}, 3g l^{-1}, and 4g l^{-1}) was also tested and it showed that smaller inoculum density (1g/L) roots produced maximum GI (15.84).

More than five thousand plants could be successfully produced and established in polythene bags under a project on development of tissue culture protocol for mass propagation of selected Screw pine, funded by KSIDC, Govt. of Kerala. A germplasm repository of four species of Screw pine comprising plants from Andamam Islands namely; *Pandanus andamanicus* (*P. leram*) and a climbing species of *Pandanus* (*Freycinetia insignis*) was established (Fig. 13).

Trichosanthes cucumerina var. *cucumerina* L. is a high value and demanded medicinal plant in Ayurvedic system of medicine which inhabits at high altitude areas of Kerala. The major secondary metabolite, cucurbitacin B, D, E, I, tetracyclic triterpenoid compounds revealed, anticancer activity against breast cancer by inhibiting STAT3 phosphorylation. As part of the Project on *T. cucumerina*, during the reporting period, scale up of multiple shoot culture of the plant was tried in 1 lt Erlenmeyer flasks and 2L borosilicate Reaction Kettle and growth kinetics was assessed. Shoots growth was rapid and biomass increment was more in Erlenmeyer flasks than Reaction Kettle during a short culture period of 3 weeks (Fig. 14). The concentration of cucurbitacin E and B was estimated in the well grown 3 week – old shoot cultures from 1 L Erlenmeyer flasks, Reaction Kettle, field-grown seedling derived plants in JNTBGRI and cultivated plants in the high altitude habitat. The HPLC analysis using authentic samples of the compounds indicated that the compound production was more in *in vitro* derived multiple shoot cultures (0.082 mg $^{-1}$dw cucurbitacin B and 0.021 mg $^{-1}$dw cucurbitacin E) than in the seedling derived plants and natural habitat.

The rhizogenic normal callus cultures was established using aseptic leaf explants in MS medium supplemented with combinations of auxins (NAA, IAA, 2,4-D) at different concentrations (0.5-5.0 mg^{-1}) and it was found that 2, 4- D, induced fuci-form yellowish roots mediated with callus with an average fresh weight of 7.6 g / leaf segment in the optimized medium(Fig. 15) Phytochemical assays of the cultures are underway.

As part of the Project on selection of elite genotype and *in vitro* studies of *Curculigo orchioides* Gaertn., a commercially important medicinal plant, sixteen accessions were collected from Ernakulam, Thrissur, Alappuzha, Idukki, Kannur, Kasargode, Kottayam and Thiruvananthapuram districts. The morphological parameters of the accessions were recorded, rhizomes were dried for phytochemical analysis and prepared the herbarium. The accessions were successfully established in the shade house. Among the accessions, the highest biomass recorded in terms of fw/dw of the rhizomes was from Idukki district (9.03g /3.08g). A preliminary phytochemical analysis was done with authentic sample of curculigoside using the accession from Thiruvananthapuram district and the HPTLC analysis showed the concentration (0.756 mg g^{-1} dw) in rhizome. Genetic variation analysis of the accessions

Fig.14. Multiple shoot culture of T. cucumerina

Fig.15. Fuci-form yelowish callus mediated roots induced on leaf of *T. cucumerina.*

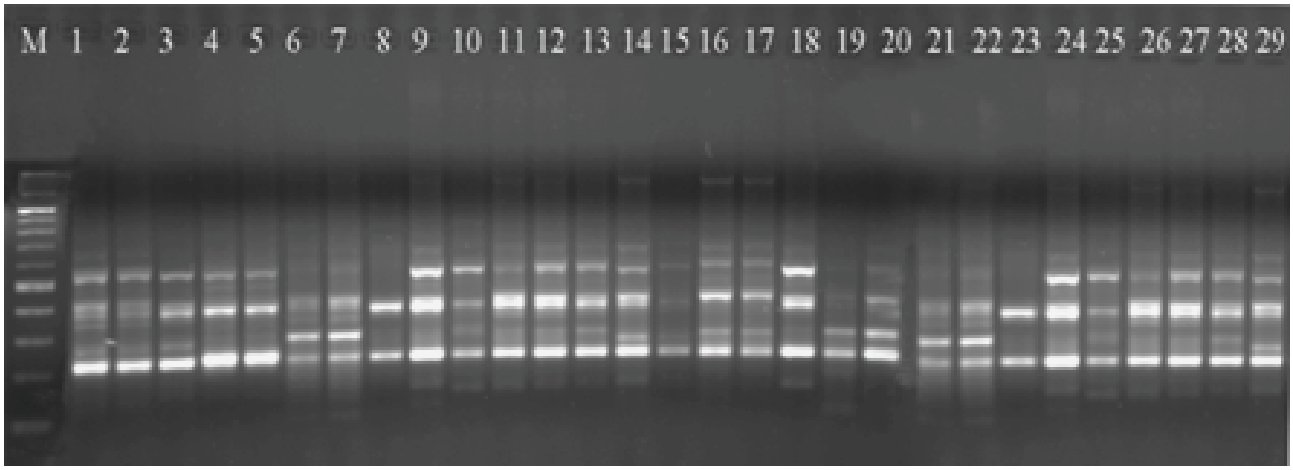


Fig 16. ISSR profile of 29 samples of *C. orchioides* using primer 835 (M– marker)

using ISSR primers is underway. Twenty nine samples were used for genetic variation analysis. Among the 11 primers used, Primer 835 had been amplified best (Fig. 16) and work is underway.

Bioprospecting of Plant Genetic Resources

As part of ongoing project on Chemical and genetic diversity in *Lagerstroemia speciosa* L. Pers, funded by the DBT, Govt. of India, corosolic acid (CRA) content was analyzed in 12 natural populations of *L. speciosa* corresponding to 42 samples seen in the Kerala region of Southern Western Ghats (SWG) using chromatography techniques and genetic variation estimated using SSR markers. Significant variation in percentage distribution of CRA ranging from 0.005 - 0.868% dw was recorded Interestingly, populations from the north SWG showed relatively more active principle (mean =0.321%) than their counterparts in the south (mean= 0.064%). Similarly, SSR data showed relatively high rate of gene flow (Nm= 2.72) and low genetic differentiation (F_{ST}= 0.14). This is an indication that populations from north are genetically more diverse than those in the south (Nm= 0.48; F_{ST}= 0.38). The scatter plot derived by PCA analysis of chemical and genetic data showed similar pattern of clustering that revealed strong association between the two sets of data. (Fig. 17). It is concluded that the observed variation in CRA content in natural populations of the species depends more on the genetic background and less on edaphic factors

Under the DBT programme on Genetic diversity analysis in *Syzygium gambleanum* Rathakr. & Chithra, *Syzygium gambleanum* was collected from the Kalakad Mundanthurai forest region and genetic diversity was analyzed using ISSR primers. The results are suggestive that the wild endemic arborescent species have low genetic variation within population which is supported by Nei's genetic differentiation among population (G_{ST}= 0.31). Possibility of genetic differentiation due to geographical isolation of the populations cannot be ruled out as these wild individuals are not continuously distributed in their natural habitat. The phenogram and PCO scatter plot also supported this model as accessions that are close in space clustered together.

The rate of gene flow (Nm = 1.12) among the population is little higher than Nm= 1 suggesting that genetic differentiation was caused by genetic drift within population. The observed low levels of gene flow (Nm = 1.12) leading to genetic differentiation can occur when (1) habitat fragmentation occurs due to natural or human activities leading to population isolation (2) seed dispersal and pollen transfer rates are adversely affected as they are the main mode of gene flow in natural plant populations (3) lack of suitable animal pollinator for long distance dispersal and the undulated terrain characteristic of the region posing barrier to

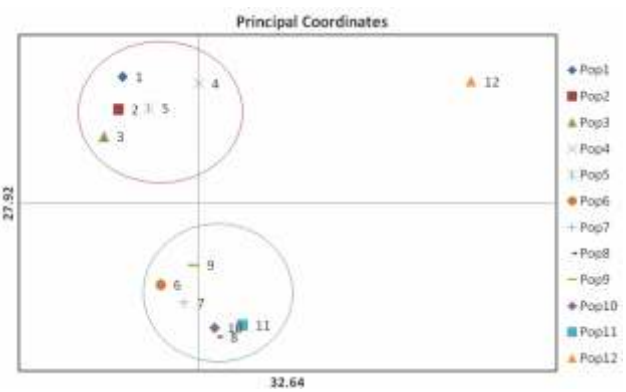


Fig. 17. PCA scatter plot of *Lagerstroemia speciosa*

normal transfer of pollen. Any or all of these must have delimited the rate of gene flow in this wild taxon leading to genetic differentiation among population.

Origin of cardamom is believed to be in the rain forests of southern Western Ghats, where presumably rich and untapped genetic diversity of the cardamom resides. A research programme has been launched to collect the available germplasm from forest segments in southern Western Ghats. During this period, about 85 accessions including wild, cultivars and plants from abandoned plantations were collected and preserved in the Institute. Released varieties of cardamom were obtained from Indian Cardamom Research Institute (ICRI), Myladumpara and Cardamom Research Station (CRS), Pampadumpara. In order to analyze genetic diversity among the collected samples, 24 microsatellite primers were developed, out of which 12 have given polymorphic bands. Genetic diversity analysis of the 7 cardamom accessions using the SSR primers was carried out.

The relative 2C genome size and total number of base pairs of small cardamom were determined using flow cytometer for the first time. The mean amount of 2C nuclear DNA of the cardamom sample was calculated as 2.84 pg. Ratio between DNA content and genome size (1 pg DNA=980 Mbp) indicate that the diploid genome size of cardamom is 2783 Mbp. This is the first report of DNA content and genome size in cardamom. Low variation in genome size has been observed for various germplasm accessions including wild, released varieties and land races. Cardamom accessions were screened for the presence of cardamom mosaic virus using RT-PCR method. Positive bands were observed in some of the accessions.

Genetic diversity analysis in rattan palms

Western Ghats region of India is rich in species diversity of rattans. Over-exploitation of the rattans has exerted severe pressure on existing populations and sometimes resulted in loss of genetic diversity. Genetic diversity, population structure and differentiation of 8 important rattan species (*C. brandisii, C. gamblei, C. nagabettai, C. metzianus, C. rotang, C. hookerianus, C. travancoricus* and *C. thwaitesii*) are being analyzed using microsatellite markers, under the DBT, Govt. of India and KSCSTE funded project. 154 accessions of *Calamus* sp. were collected from forest areas of Pandimotta, Bonacaud, Braimore, Sankili and Cheenikkala. SSR primers were developed from ESTs of related species/genera such as *Calamus mannan,* oil palm and coconut palm. Analysis of genetic diversity in *C. thwaitesii* using 32 SSR primers has been carried out.

Bioinformatics

Sub-Distribution Information Centre (SubDIC), funded by DBT, Govt. of India for developing database and software for biodiversity analysis is functioning at Saraswathy Thankavelu Extension Centre at Puthenthope. *In silico* validation of drug activities of the medicinal plants and other extension activities are initiated at the centre.

As part of the Sub-DIC Programme, a database application package was developed for the rice varieties/hybrids/hybrid derivatives of Kerala. The information about 110 rice hybrid derivatives cultivated in Kerala was collected and incorporated on the database. (www.bioinfotbgri.org/rice). In view of digitizing JNTBGRI library a software application package was developed for the management of library related information (www.bioinfotbgri. org/tbgrilibrary). The various databases updated on the JNTBGRI web server are given in Table 2. During the period, a database software package has been developed which documented good quality images of 4000 herbarium specimens under the ongoing in-house programme on digitizing the herbarium specimens in the Institute

Table 2. The databases maintained on the JNTBGRI web server

Name of database	URL
Plant Info	http://www.jntbgri.in/plantinfo
Garden Info	http://www.tbgri.in/gardeninfo
LitFriend	http://www.jntbgri.in/jntbgri/LitFriend_register.asp
Fungal Database Meliolales	http://www.jntbgri.in/fungi
Biolit	http://www.jntbgri.in/biolit
Sacred Groves of Kerala	http://www.jntbgri.in/sacredgroveonline
Wild Ornamental Plants	http://www.jntbgri.in/ornamentalplants
Endemic Plants of Western Ghats	http://www.jntbgri.in/endemicplants
Virtual Herbarium of JNTBGRI	http://www.jntbgri.in/herbarium
Mushrooms of Wyanad	http://www.jntbgri.in/mushroom
Library Resources of JNTBGRI	http://www.jntbgri.in/jntblib
Germplasm of JNTBGRI	http://www.jntbgri.in/germplasm
Foliicolous Fungi of Sacred Groves	http://www.jntbgri.in/gacredgroves
Foliicolous Fungi of JNTBGRI	http://www.jntbgri.in/jntbgrifungi

Fig. 18. Home page of JNTBRGI virtual herbarium

(www.bioinfotbgri.org/tbgtherbarium) (Fig. 18).

Under the DST, Govt. of India funded programme, development of database on foliicolous fungal flora of Andaman Islands was continued. During this period, 250 accessions of 143 host plants with infected leaves were collected and processed into herbaria for further study. Taxonomic evaluation of the 130 specimens have resulted in 61 taxa of foliicolous fungi which include seven new species and five new varieties. During the survey, it was observed that the insular climatological conditions from December to February were ideal for the growth of foliicolous fungi. Quite a few host plants, like *Hyptis capitata,* which had been severely infected during December showed gradual decline of the infection and exhibited only a little infection during the beginning of summer season in February. Development of a web enabled database, on parasitic fungal taxa associated with plants of sacred groves in Thrissur and Pathanamthitta districts of Kerala State was continued (Fig. 19). Altogether 353 host plants with foliicolous fungal infections were collected from sacred groves of Thrissur and Pathanamthitta (45) and Ernakulum districts(18) About twenty seven fungal taxa including black mildews were identified under

Fig. 19. Home page of the data base of foliicolous fungi of sacred grove.

different genera (*Asterina, Asteridiella, Irenopsis, Lembosia, Meliola*, *Oidium*, *Sarcin, Meliolaster*, and *Prillieuxina).* The databases are www.jntbgri.in/sacredgrovesonline and www..jntbgri.in/sacredfungi.informations.

The up to date maintenance and updating of information in Local Area Network (LAN), Wide Area Network (WAN), internet facility and data /web server facilities in the Institute and Centre at Puthenthope are going on. BTISNET web portal was developed and handed over to BTISNET, DBT with final project report. A copy of the web portal was maintained on the JNTBGRI web server (www.btisnet.nic.in).

In order to validate the efficacy of pharmacological activity of active molecules in medicinal plants using *in silico* method, the phytochemicals from different plants species were docked using different docking tools for anti-venom activity and anti-tuberculosis activity under DBT funded Project and anti-hepatitis B activity under in house programme. For anti-venom activity, phytochemicals from 34 medicinal plants were docked with 14 toxic venom proteins of *Naja naja* and the lead compounds were identified. The results indicated that four plant species (*Acorus calamus, Aegle marmelos, Andrographis paniculata* and *Aristolochia indica*) contained chemical molecules having inhibitory effect on all the fourteen cobra venom proteins. The target proteins, basic phospholipase A2 VRV VIIIa and Anticoagulant class II phospholipase A2 were selected as the lead molecules using the docking software Auto Dock 4.2.(Fig. 20). The subsequent docking of hit molecules, using iGEMDOCK, Patch dock and Swissdock HEX Server indicated that among the four plants *A. marmelos* provided the best lead molecules against nine out of fourteen cobra venom proteins. For anti-tuberculosis activity, phytochemicals from three plants viz. *Alstonia scholaris, Andrographis paniculata* and *Vitex negundo* were docked with the target proteins, Filamentous Temperature Sensitive Protein Z (Ftsz) responsible for bacterial multiplication, Resuscitation

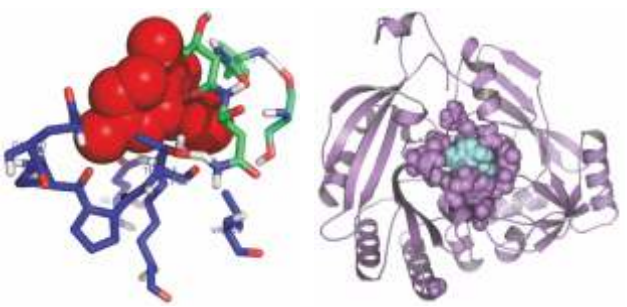


Fig. 20. Docked structure between the target 'basic phospholipase A2' and the ligand molecule derived from Aeglemarmelos.

Promoting Factor B (RpfB) responsible for breaking bacterial dormancy and Decaprenyl Phosphoryl –D-ribose oxidase (DprE1) responsible for the synthesis of arabinans, in *Mycobacterium tuberculosis* and lead compounds having inhibitory effect on these three target proteins were identified. A total of 183 molecules were docked with the target proteins FtsZ and DprE1 using the docking tool Autodock. 19-epischolaricine and Beta amyrin from *A. scholaris* were analysed statistically and identified. They were the most promising leads to inhibit FtsZ and DprE1 respectively. Similarly, the compound Withametelin B in Datura metel was the best lead molecule against FtsZ . Further *in vitro* studies are in progress.

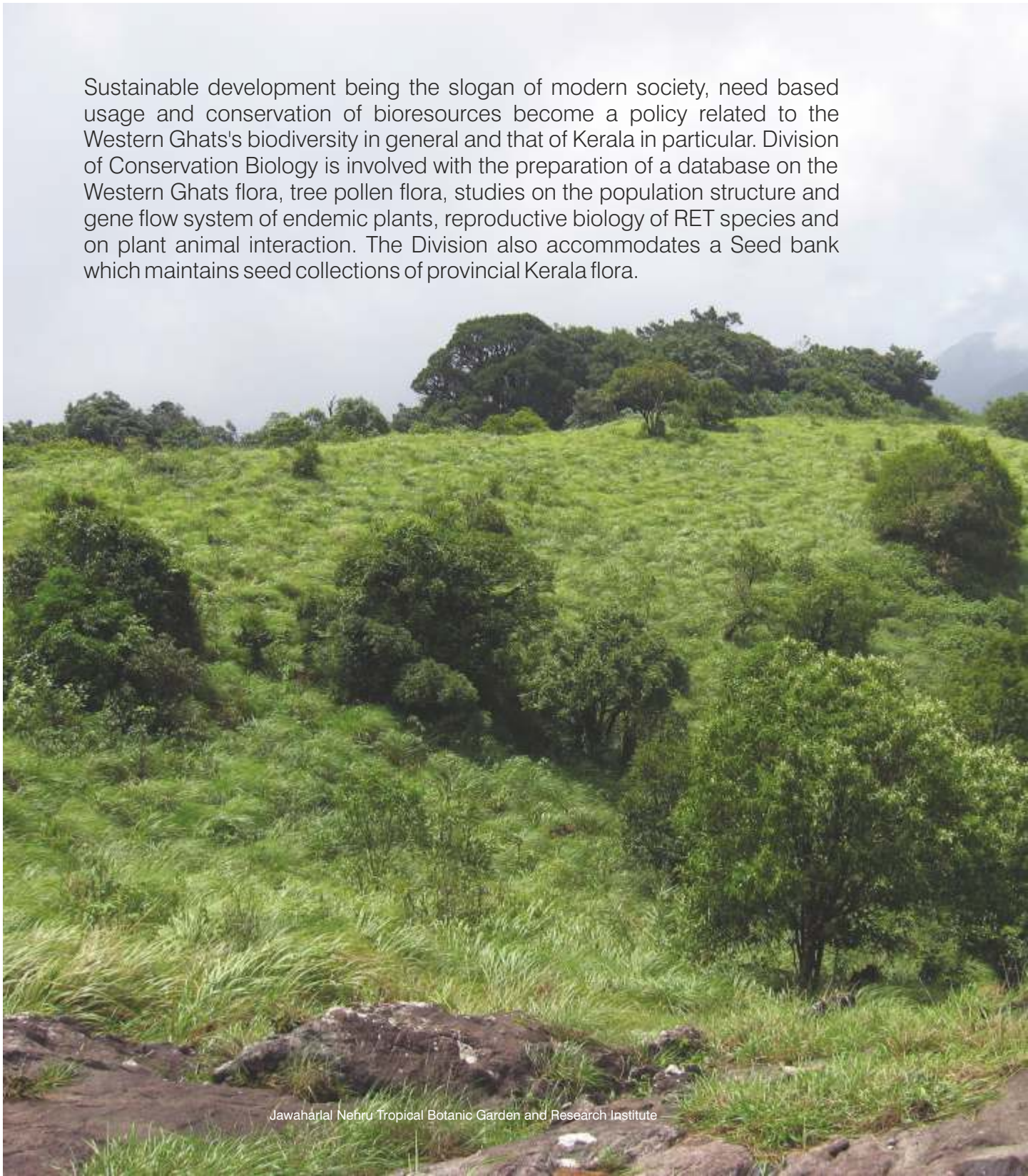
To demonstrate anti-hepatitis B activity about 973 phytochemicals were docked with HBx protein which was involved in the replication of the virus and the best potential lead molecules against Hepatitis B virus were identified like Bacogenin A1 (*Bacopa monniera* (L.) Wettst.), Cycloartenol (*Benincasa hispida* (Thunb.) Cogn., Pakistanine (*Berberis aristata* DC.), Betunilic acid (*Cassia fistula* L.) and Deacetylnomilin (*Citrus limon* (L.) Osbeck). Another target molecule namely HBc, a capsid forming core protein was also identified as a new target from HBV. In *Azadirachta indica* about 125 molecules were docked with HBc using Autodock and a lead molecule, Limocin D with free energy of binding-7.89 kcal/mol was identified.

Hydroponic cultures in *Plectranthus vettiveroides* (Jacob) N.P.Singh & B.D.Sharma had been established under the NMPB funded project. Top shoot cuttings of *P. vettiveroides* were cultivated under hydroponic conditions in six different nutrient media and the best growth and yield was obtained when cultivated in Hoagland's medium. Further experiments are in progress.

Extension activities on developmental programmes of Puthethope Centre continued with twin objectives of maintenance and beautification of the Centre and revenue generation. The centre is credited with the maintenance of 12000 nursery plants belonging to more than 120 different varieties of ornamentals, during the period. Approximately 3000 nursery plants have been raised through seed and vegetative propagation. The nursery was strengthened with 130 ornamental plants of 52 different varieties, procured from local nurseries. The ornamental stock plants include 22000 orchids like *Dendrobium, Mokara, Oncidium* (Dancing Girl), *Aranthera* 'Anne Black', Vanda 'John Club' and *Phalaenopsis*. In addition, a good number of other high value ornamental plants (*Anthurium, Adenium, Euphorbia, Spathiphyllum, Heliconia*) were established and maintained. Appreciable revenue is being generated through the sale of orchids and other ornamental plants.

Division of Conservation Biology

Sustainable development being the slogan of modern society, need based usage and conservation of bioresources become a policy related to the Western Ghats's biodiversity in general and that of Kerala in particular. Division of Conservation Biology is involved with the preparation of a database on the Western Ghats flora, tree pollen flora, studies on the population structure and gene flow system of endemic plants, reproductive biology of RET species and on plant animal interaction. The Division also accommodates a Seed bank which maintains seed collections of provincial Kerala flora.



a. Population structure and gene flow system of endemic plants

Many endemic plant populations are small and have localized distribution. Due to habitat degradation, most of the endemic species are facing a constant threat which drives them to rare, vulnerable or endangered category. Their degree of adaptability became unstable and hence, our understanding right from their identification even from the seed and seedling stage and their biology became a prerequisite for evolving a viable conservation strategy. Conservation of rare and endangered plant species as well as fragile forest ecosystems becomes effective only by studying their population structure. Observations on phenology, ratio of age groups by sex within a population, selective interaction over generations by biotic and abiotic components and seed regeneration process are essential components of *in situ* conservation aspects. Moreover successful conservation strategies depend in part on detailed knowledge of the levels and distribution of genetic diversity within and among populations through gene flow. Gene flow, the successful movement of genes via seed and pollen, is a primary determinant of genetic and species diversity in plant communities. Hence, it is essential to study different aspects involved in gene flow mechanisms such as breeding system, pollination system, seed dispersal system and genetic and population structure of a species in order to evolve effective conservation strategies. Demographic studies in plant populations provide useful information on population dynamics and can also be used to examine the biotic and abiotic factors affecting the plant population dynamics. The information obtained through demographic studies and the gene flow systems could thus be used in conservation and restoration of these endemic and endangered species. The Scientists of the Division have taken up such a study with respect to four endemic tree species of the Western Ghats *Garcinia imberti* Bourd., *Palaquium ellipticum* (Dalz.) Bail., *Cassine kedarnathii* Sasi. & Swarup. and *Cullenia exarillata* Robyns

Garcinia imberti: *Garcinia imberti* (Clusiaceae) is endemic to Travancore hills of the southern Western Ghats. It was originally described by Bourdillon in 1899 from Tirunelveli Hills. IUCN enlisted this endemic species as endangered, vulnerable to environmental and demographic stochastic events, which may ultimately lead to its extinction. Our preliminary floristic survey revealed that *G. imberti* populations were found in Chemmunji hills in Peppara Wildlife Sanctuary. During the period under report fifteen field trips were conducted to various forest areas of Agasthyamala Biosphere Reserve. This was to explore the population distribution, to study

View of a *Cullenia* dominant canopy in Silent Valley

their natural habit and habitat, to identify and establish the study plots (10m x 10m) for studying population structure and demography, establishment of a line transect of 1.5 km for phenological observation and for studying biotic interactions of fruits and seeds. During these trips we have located a new *G. imberti* population in a Shola forest in Ponmudi Hills which comprises a few adult individual trees and seedlings.

In order to study the population structure and dynamics of *Garcinia imberti* Bourd, 12 permanent plots (10m X 10m), nine plots in Chemmunji and three plots in Ponmudi were established. All the plant species including seedlings and saplings and their numbers in the plots were enumerated for species diversity study. In these plots all seedlings, saplings and trees of *G. imberti* were tagged for further studies. Tree height, GBH, number of branches, condition of plant, any type of herbivory or abortion etc were noted. Seedlings and saplings were also observed and their height, branch number if any, number of leaves in the case of seedlings etc. were recorded. A total of 59 adult trees and saplings and 244 seedlings of *G. imberti* were tagged from these plots for further observations. Phenological observations showed that in *G. imberti* fruiting is initiated in June and ripened fruits were available during September - October. Fruiting was over towards the end of November. Along with cessation of fruits, leaf flushing was initiated in November. A high rate of seed predation was also noticed. \

Seedling of *Cullenia exarillata* A. Robyns

Cullenia exarillata: During the period under report, three field trips extending from seven to 14 days were conducted to Silent Valley to study the population demography of *Cullenia exarillata*. As part of this, morphometric measurements (dbh, height, number of branches etc.) of 90 trees of *Cullenia* in one acre study plots at Aruvanpara, Sairandhri and Kummatamthodu were collected. It was seen that the growth in diameter increased from 0.5 cm to 7 cm and height from 10 cm to

2.5 m. No individuals were found missing or dead in the study plots during this period. Study of seedling demography was continued in fifteen 10 x 10 m plots selected at Aruvanpara and Sairandhri. The average seedling density per plot was 0.13 m^{-2}. Mortality rate was observed as 3.88% during the period under report. It was observed that seedling mortality occurred mainly due to the attack of porcupines, deers and rodents.

Cassine kedarnathii: RAPD analysis of *Cassine* was also carried out during this period to know the genetic structure and gene flow system among its five populations at Panthanthodu, Aruvanpara, Sairandhri, Kattuvaramudi and Parathodu in Silent Valley forests following standard methods. The study showed that at individual level, number of polymorphic loci varied from 15 to 28 and percentage of polymorphism varied from 45.16% to 93.82%. This high rate of polymorphism might be due to the effective gene flow. Nei's genetic diversity index (h) was 0.1476 and Shannon's Information Index (I) was 0.2727. This showed the low genetic differentiation among members of *Cassine kedarnathii* in Silent Valley. The coefficient of gene differentiation (Gst) among the individuals of the species was 0.0295. Nei's genetic identity value was 0.9834 and the level of gene flow calculated from Gst was 16.45. These results indicate that populations of *Cassine kedarnathii* in Silent Valley forests are genetically similar and exhibited very low genetic diversity. However, Nei's dendrogram showed that the *Cassine* populations in Silent Valley forests could be divided into three groups: populations of Sairandhri and Parathodu under group one, populations of Kattuvaramudi and Panthanthodu under group two and populations of Aruvanpara under group three.

b. Identification of nuclear tree species and assessment of its impact in landscape conservation: A case study with reference to the tropical rain forests in Silent Valley in the Western Ghats

A nuclear tree species is defined as a species that appears in grassland and remains there attracting animals that defecate or otherwise drop seeds of other species in its vicinity. This paves way to natural afforestation much quicker than man made afforestation. The present project was formulated with a view to identify the nuclear tree species in the forest regeneration process in Silent Valley National Park. The work was started in October 2010. Five grasslands in Silent Valley were selected for this study based on the level of forest regeneration. During the period under report 15 field trips totalling 196 days were conducted to Silent Valley in order to study seed rain in grasslands, to conduct seed germination and seed station experiments, and to study demography of tree seedlings in grasslands and contiguous forests.

Seed traps were placed in both treeless areas and beneath the trees in grasslands to study seed rain. A total of 50 traps, 10 in each grassland, five in treeless areas and five beneath the trees were placed. Seeds of only one species, *Lantana camara*, was recorded from the traps placed in treeless areas. Seeds of fourteen plant species were recorded from the traps placed beneath the trees. Seeds of *Lantana camara, Olea dioica* and *Symplocos foliosa* were the commonly trapped species. A monthly average of 4.97 seeds per trap was obtained from Aruvanpara grassland. But it was 3.93 seeds at Sairandhri, 3.76 seeds at Parathodu

a. A seed station set up for secondary seed predation experiment; b. Seedling of *Olea dioica* Roxb. in the grassland.

and 0.88 seeds at Thoppimala grasslands. In general seed rain was more beneath the trees.

Seed germination experiments were done to know the germination potential of seeds dispersed by animals through endozoochory. Seeds of *Acronychia pedunculata*, *Holigarna beddomei* and *Prunus ceylanica* recovered from scat/dung and seeds trapped in seed traps were subjected to germination experiments. A control treatment was also set using the seeds directly collected from parent trees. Seed germination experiments revealed that those seeds collected from scats/dung germinated quicker than those in controls. The percentage of germination was also high for seeds collected from scats/dung.

Seed station experiments were set up to study the secondary and tertiary seed predation and seed removal by animals in grasslands after seeds were dispersed to the grasslands. Two types of seed stations were used for this experiment. Open seed stations were areas of 25x25cm size marked in grasslands. Control seed stations were enclosures made of aluminium sheets of the same size and 15 cm height. They were fixed on the ground and covered with iron net at the top to prevent seeds from predation. Seeds of thirteen tree species were used for the experiment. This study revealed that rodents are the potential secondary predators in the grasslands.

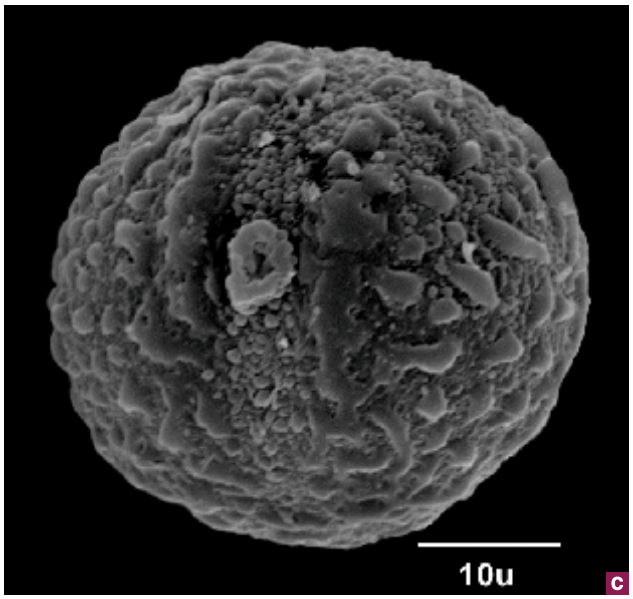
Seedling demography was studied in five grasslands taking twenty five 10x10 meter plots. The average seedling density in the five grasslands was recorded as 0.19 m^{-2}. A grassland wise analysis showed that Parathodu had the highest number of seedlings with a density of 0.39 m^{-2} followed by Aruvanpara (0.28 m^{-2}), Sairandhri (0.22 m^{-2}), Thoppimala (0.11 m^{-2}) and Vannampara (0.04 m^{-2}). Comparison of seedling demography in open areas of grassland and beneath the established trees in grassland showed that tree canopy possesses 33% more seedlings than open areas of grasslands.

Seeds of *Elaeocarpus munroii* Mast. predated by rodents

c. Reproductive biology of RET species of the Western Ghats

Western Ghats is one of the hot spots in India due to rich endemism and at the same time prone to species extinction because of various reasons. The depletion of vegetation may be mainly due to anthropogenic measures, reproductive constraints and habitat degradation. The IUCN Red List of threatened species reported that 39% of the listed species are threatened with extinction. In this context, it is necessary to evaluate the known endemic and endangered species based on field data, such as localities where they grow, structure of population, breeding system, pollination, dispersal biology, pests and disease etc for preparing status report on them to implement proper conservation strategies. If we are not taking adequate steps to protect them, they may be lost forever which will ultimately lead to irreparable damage to the ecosystem where they belong and our option for their uses will be narrowed. Most of our options depend on conservation and sustainable utilization of these genetic reservoirs to overcome unforeseen problems in the near future. For preserving these vast genetic reservoirs, we should adapt or evolve strategies to protect the plants from untimely extinction.

Any conservation approach has to be based on an in-depth study and understanding of plant and environment including reproductive biology which determines the fitness of the species in a given community. By studying the reproductive biology of RET species, we can understand the exact causal factors inducing rarity and can overcome these factors through scientific intervention so as to protect the plants from endangerment. This study will also help in developing strategies to preserve the genetic potential of rare species which is crucial for restoration and reintroduction. So there is an urgent need to analyze the various causes of rarity by studying the reproductive biology of selected plants. In this context, detailed studies on reproductive biology of 25 RET balsams and 10 other rare plants were carried out. During the report period, reproductive biology of *Humboldtia decurrens* Bedd. Ex Oliv., an endemic legume tree species and two endemic balsam species namely *Impatiens maculata*



a., b. Flowers and c. SEM of the pollen grain of *Humboldtia decurrens* Bedd. ex Oliv..

Wight and *I. elegans* Bedd. of the Western Ghats were studied

Humboldtia decurrens Bedd. ex Oliv.: Genus *Humboldtia* (Fabaceae) contains 17 species globally. The study mainly focused on floral phenology, floral morphology, pollination, breeding system and seed biology with an intention of understanding the causal factors that lead to population reduction of *Humboldtia decurrens* in the natural habitat. The candidate species was located in the evergreen forest areas of Kollam and Thiruvananthapuram districts between altitudes of 800-1000m asl. Population consisted of more than 100 individual species. It is a tree of 12-15m high, having brownish bark with prominent lenticels, rough; branches dark brown, pubescent when young and glabrous at maturity. The plant grows in association with other wet evergreen forest species such as *Arenga wightii, Aporosa acuminata, Hydnocarpus macrocarpa, Baccaurea courtallensis, Myristica malabarica, Alstonia scholaris, Vateria indica, Hopea parviflora, Acacia caesia, Lagerstroemia microcarpa, Vitex altissima, Ochlandra wightii, Xanthophyllum arnottianum, Entada rheedei, Myxopyrum smilacifolium* and *Dracaena* sp.

Observations showed that the plants start flowering in the month of November which extends up to June and reaches a peak during March. An inflorescence consists of 20-25 flowers. Two varieties of plant species were observed with pink and white coloured flowers. Flowers are bisexual, 2.5-3cm long, produced in cauliflorous racemes. Fruit is a pod (7-12 x 2.7- 4 cm) and contains 3-4 seeds. The flower buds take 10-15 days from initiation to full bloom. The average life span of each flower is 1-2 days. Flowers open in the early morning between 05.30-06.30h and anther dehisced between 7.30-8.30h. Stigmas remain receptive at the time of flower opening with maximum receptivity between 5.30-15.30h.

Pollen morphology was studied using SEM photography. Pollen grains are tricolporate and 52.25μm in diameter. Pores are ellipsoidal with rounded end. Exine thickness is 2.25 μm. Floral analysis indicated that, each flower has five anthers and four ovules. A single flower has around 4250 pollen grains. The pollen ovule ratio had been worked out as 1062:1

which indicates that the species favour cross pollination. The acetocarmine staining technique revealed that 82% pollen grains are fertile. Pollen viability by FCR test and TTC test confirmed that 75-80% pollen grains were viable on the day of anthesis and its viability gradually decreased on successive days after anthesis. Observations were made on floral visitors between 5.30-12.30h and it showed that several visitors were attracted by mass blooming of pale pink coloured flowers and mild fragrance. The floral visitors are honey bees, stingless bees, ants, wasps and butterflies but only a few of them effected pollination. *Apis cerana* and *Trigona iridipennis* are the most frequent visitors. It is observed that the weaver ants (*Oecophylla smaragdina*) play a significant role in pollination in this species. The plants offer both brooding site and nectar to the ants and in turn they act as pollinator as well as a predator/defender. So both are mutually benefited. Butterflies (*Euploea core, Ampittia dioscorides*, *Papilio arishtolochiae, P. demoleus* etc.) also visited the flowers for nectar. Studies on the pollination efficiency, breeding system and seed biological studies are in progress.

Impatiens elegans Bedd.: The plant was located in the moist shady areas of Rajamala, Mankulam and Neymakkad of Idukki district between altitudes of 800 - 1500 m asl. *Impatiens elegans* starts flowering in the second week of July and extends up to December and reaches a peak during September. The flowers are pale pink coloured with purple eye on the lateral petals and open in the early morning between 05.00-07.00 h and anthers dehisced one day before anthesis. The P:O ratio had been worked out as 1050:1, which strongly

a. *Impatiens elegans* Bedd.; b. *Impatiens maculata* Wight

indicates that some external agents are required for successful pollination. The stigma is not receptive during anthesis and becomes receptive after the shedding of androecia. The stigma was receptive only on the second day of anthesis.

The major pollinators are honey bees (*Apis cerana*, *A. mellifera*), *Trigona* sp, butterflies, beetles etc. Flowers offer only pollen and visual signals to the visitors. The manipulated pollination showed that, the fruit set in open pollination was limited to 22% but increased up to 47% by xenogamous pollination. However, fruit set was not observed in geitonogamous and autogamous pollination. The seed germination was limited to 20%. About 20% of the flower buds and 10% of the tender fruits were infected by caterpillars and insect larvae. The species is poorly distributed in the wild, mainly because of specialized floral mechanisms with cross pollination behaviour, protandry, delayed stigma receptivity, low insect visitation rate, low percentage of seed germination and infestation of flowers and fruits. All these causal factors either alone or in combination with others are responsible for endangerment and narrow distribution of this species in the wild.

Impatiens maculata Wight: The candidate species was located in the moist shady areas of Neymakkad, Devikulam and Kallar valley of Idukki district between altitudes of 1000-1500 m. The new seedlings emerged in the first week of June. The plants start flowering by the end of July which extended up to December with a peak during September. The flowers are pink coloured and open in the morning between 05.00-07.00 h and anthers dehisced one day before anthesis. The flower buds took 12 - 15 days from initiation to full bloom. The average life span of each flower is 3-5 days. The study revealed that the morphological characters, protandrous nature, p:o ratio and stigma receptivity clearly favours cross pollination. The stigmas were receptive only on the third day of anthesis showing maximum percentage (72%) of *in vivo* germinating pollen on the stigmatic surface but at that time its own pollen viability was reduced to 20%. The stigma is non - receptive during anthesis and became receptive on 3rd day and by the time its own stamina column withered. The coherent stigma spreads and exposes the star shaped receptive surface. Honey bees (*Apis cerana, Apis florea*), *Trigona* species and butterflies are the common pollinators. The number of pollinators is not sufficient to pollinate all the flowers in a population. The visitation rate of these pollinators are affected by heavy rain fall, humidity, temperature, poor sunlight etc. The manual pollination experiments demonstrated that it favours both geitonogamous and xenogamous pollination. The percentage of fruit set in the natural condition was limited to around 44 %. In *Impatiens maculata*, about 30% of the flower buds and 20% of tender fruits were damaged by caterpillars and insect larvae which adversely affect the fruit production. The experiment is being continued to study dispersal, seed germination, recruitment etc. to assess the reproductive capacity of the species in natural habitats.

d. Seed Biology and Seed Bank Development

So long as stored seeds sufficiently represent biodiversity of a biome, seed bank complies with the concept of *ex situ* species conservation. From the time of seed origin, development and subsequent spatial dispersal to sprouting, each stage selects an adaptive role in species ecology which provides cues on plethoric evolutionary paradigms. JNTBGRI Seed Bank functions in accordance with the ISTA rules and during the reported period the following were the activities of scientific relevance.

Seed holdings: A total of 1025 active seed collections stored under accepted conditions (15 % moisture, 5% RH, 15˚C) were maintained. Orthodox seeds numbering 38 as base collections are kept with 5% moisture content at preferred conditions of −20˚C. About 4000 seeds were displayed with scientific name, family, accession number and collection locality as seed references. During this period, 227 accessions were collected and accessed as active collections. Apart from these routine seed services, seed viability tests, senile seed replacements and national seed exchanges were also carried out.

Maintenance of Seed Bank: Routine seed bank aspects, seed germination and storage studies were carried out on *Randia dumetorum* (Retz.) Poiret, *Sapindus trifoliata* L., *Syzygium travancoricum* Gamble, *Calamus travancoricus* Bedd. ex Becc. & Hook. f., *Actinodaphne bourdillonii* Gamble. *Coscinium*

Tinospora cordifolia (Willd.) Miers ex Hook. f. & Thomson

fenestratum (Gaertn.) Colebr., *Tinospora cordifolia* (Willd.) Miers ex Hook.f. & Thomson *etc*. Seed germination studies of 14 species of *Sida* was also carried out to know any difference in germination potential.

Sapindus trifoliata L., (the Soap nut tree) is an economically important tree of the family Sapindaceae. Fruits are green, tricarpellary with fruity smell on ripening. Fruit is a drupe with 19.3±0.3mm x 29.4±0.7mm and weight - 10.5±0.5gm. Seeds are black globose with 10.4±0.3 x 9.8±0.3 mm size and single seed weighs 0.82gm. Initial moisture content is 21.4% with corresponding germination rate of 65%. The seeds were stored for short-term in different temperatures such as 30, 10 and -10°C. In -10°C fresh seeds with 21% RH and up to 14% moisture content did not germinate but seeds desiccated to 10% moisture content registered 80% germination.

Gmelina arborea Roxb., belonging to the family Verbenaceae is an important ingredient of the Ayurvedic preparations 'Dasamoola' and 'Chyavanaprasam'. Fruits are yellow drupes with fruity smell, obovate, calyx 2-3.6 mm size and weight is 6.9-10.5gm. Seeds are enclosed in oval-shaped shells with brown colour, 14.9-17.2 x 8.8-11.4 mm, weight varied from 0.5-0.7 gms. Seeds are oval, creamy brown with 6.2-8.8 x 3.5-5.0 mm and 10 seeds weigh 0.39gms. Initial moisture content of seeds is 11.1%. Only after the removal of shell wall 60% seeds germinate. Seeds also showed germination after soaking in water for three days and kept in closed bottles.

Tinospora cordifolia (Willd.) Miers *ex* Hook. f. &Thoms. belongs to the family Menispermaceae. As an important drug bioresource of Indian system of medicine (ISM), is enlisted as threatened with extinction due to overexploitation. The initial moisture content of the seeds was 16.9% with 90 % germination. Desiccated seeds with 9.8% moisture content maintained viability up to 81%. When moisture content was lowered to 7.8%, germination percentage was reduced drastically to 53%. Seed features appear to be an intermediate of those generally described by Hong and Ellis. Pre-treatment of seeds with gibberelic acid (50 ppm) was found to be optimum since over 90% germination was registered within 24 days against 80% germination in 40 days triggered by 100 ppm GA_3. Cryopreserved seeds with 7.8% moisture content retained 65% viability at 20°C in cryopreserved seeds. Seeds with 5.35% moisture content recorded 70% viability at 20°C and 60% viability in cryopreserved seeds. Seeds with 4.2% moisture content have 60% viability in 20°C, and 55% viability in cryopreserved seeds. Fresh seeds in open condition (control) remained viable hardly for three months. At 20°C and -20°C, seeds retained 80% and 70 % viability respectively for six months. The study showed that *T. cordifolia* seed viability can be extended up to six months by storing seeds with 7.8% moisture content at 20°C.

Coscinium fenestratum (Gaertn.) Colebr. (Menispermaceae) is a highly sought medicinal liana distributed in the forests of Western Ghats of Peninsular India, Sri Lanka and Malayan States. In the Red List of Threatened Plants, the conservation status of this medicinal plant is recorded as endangered in India (Walter and Gillet, 1998). Fresh seeds of *Coscinium fenestratum* collected during June to August were cleaned and used for further study. Fresh seeds with moisture content 23% registered only 40% germination within 4-6 months indicating the presence of dormancy. Germination was enhanced to 93% as the initial seed moisture content was reduced to 10% upon 2-3 days exposure to open laboratory conditions. When fresh seeds were pre-treated with GA_3 3000 ppm, 95% germinated. Seeds kept exposed for two months at laboratory conditions lost their viability, while the seeds stored for four to six months inside polycarbonate bottles expressed 90% germination within a month of sowing. Thus the effect of either 10% reduction in moisture content or hermetic storage for more than three months after ripening is the same for alleviating dormancy.

e. Establishment of seed bank and field gene bank of *Saraca asoca* (Roxb.) de Wilde

Final technical report of the Kerala Forest Department project on *Saraca asoca* was submitted. During the project tenure, 1250 healthy seedlings were supplied to Konni Forest Division apart from various schools for fulfilling the concept of *S. asoca* conservation. Trivandrum accessions were selected as elite seed source compared to middle and northern areas of Kerala state. Various plant-animal associations and pathogenic infections related with species were studied. Anatomical features of young leaflets with glands were studied. Seeds are found to be recalcitrant. Existence of species morphovariants (accessions: CHA1 and CHA2) that occupied same region was confirmed. Fast desiccation is found to be better than slow desiccation for viability retention. Storing seeds at both 30°C & 20°C were effective for retaining viability up to 3-4 months. Harvesting maturity was attained between 120-140 DAA (Days after anthesis). Species exhibited polyembryony. Seeds of 10 accessions collected were added to the active collection of the seed

Flowers and fruit development in *Saraca asoca*

bank and also to the field gene bank of JNTBGRI enriched with 10 accessions.

f. Preparation of an illustrated bilingual field guide on medicinal fruits, seeds and their seedlings occurring in Kerala Forests

The aim of the project is to document morphological features of feral fruits and seeds having medicinal value along with that of their seedlings, corresponding passport data and illustrations in the form of a monograph for easy identification in the field. About 50 species having medicinally useful fruits and seeds of Kerala were selected for the study. During this period local collections were made and fruits/seeds of the species were collected. Morphological data on the collected fruits and seeds of 40 species were documented. The collected data of 35 species were drafted according to the proforma along with photographs. Seeds of these species were planted in plastic trays containing top soil for the seedling studies.

g. Flowering Plants of the Western Ghats

Our plant explorations are mainly delimited by political boundaries and phytogeographical zones have rarely been the basis for floristic studies. With the result, we hardly have any comprehensive account on flora of phytogeographical areas like the Western Ghats. Scientists in the Division have successfully completed a comprehensive account on the current status of the flowering plants of the Western Ghats. It covers the following characters for each species: correct botanical name, important synonyms, habit, distribution in the Western Ghats and the world, references to good descriptions and illustrations available in botanical literature, phytogeographical information such as whether these plants are indigenous, endemic or exotic to the Western Ghats, conservation status, details on flowering and fruiting seasons, vernacular names in Malayalam, Tamil, Kannada, Marathi, Gujarati and Hindi and known uses like medicine, food, fodder, dye, timber, tannin, gum, fibre, oil and so on.

During the period, nomenclatural problems of 74 species were solved by referring to relevant taxonomic literature and this data incorporated in the press copy. Details of 48 new species/new records reported from the Western Ghats region were added referring to recent taxonomic journals. Indexing of about 23,000 scientific names and about 13,000 local names were completed. All the minor corrections in the text, scientific name index, local name index and references were also incorporated. Proof read 1683 pages of 5th and 6th press copies. The MS of this work under the title '*Flowering Plants of the Western Ghats, India*' in two volumes are in the press.

h. Assessing the influence of environmental and biotic factors on life history variation and demography of tropical rainforest bulbuls

Birds are important seed dispersers and pollinators of tropical plants and their vulnerability and adaptability

to environmental variations greatly influence the ecosystem health. Both biotic and abiotic factors are known to exert direct and indirect influences on the seasonal timing of life history events which in turn influences population dynamics of both fauna and flora. There is ample evidence that climate change seriously impacts the temperate species and their ecosystem services, but it is less studied in the tropical region. This necessitates studies on the effects of climate and other factors on life history traits of key ecosystem service providers to predict the demographic consequences of expected climatic changes at the global scale.

In this background, a study was initiated to identify and assess how the climatic and biotic factors affect the life history and demography of tropical rainforest bulbuls, which are important seed dispersers and pollinators in the tropical ecosystem. The specific aims are to document the variation in major life-history traits such as breeding season, nest size, clutch size, developmental rates and parental care of passerines along altitudinal gradients and to establish the relative importance of food, competition, predation, weather and habitat as determinants of life history variation.

Three study sites were identified along an elevational gradient in the Silent Valley National Park and surrounding Mannarkkad Forest Division. Point count stations were established in these plots to estimate the relative abundance of the study species and their competitors. The low altitude site was dominated by Red-whiskered Bulbul, *Pycnonotus jocosus*. The middle elevation site was dominated by Yellow-browed Bulbul, *Iole indica* and the high elevation site by Square-tailed Black Bulbul, *Hypsipetes ganeesa.* The globally Near-Threatened Grey-headed Bulbul, *Pycnonotus priocephalus* is not common in any of the sites. The first two species are early season breeders and the latter two are late season breeders in the study sites.

The breeding of both the Yellow-browed Bulbul and Red-whiskered Bulbul started in late November, Grey-headed Bulbul in late January and Square-tailed Black Bulbul in February. A total of 238 nests of pycnonotids including 86 of Yellow-browed Bulbul, 92 of Square-tailed Black Bulbul*,* 52 of Red-whiskered Bulbul and eight of Grey-headed Bulbul were recorded during the reporting period. The clutch size of the monitored nests were 2-3 eggs for Red-whiskered Bulbul, 2 eggs for Yellow-browed Bulbul, 1-2 eggs for Grey-headed Bulbul and 2-3 eggs for Square-tailed Black Bulbul*.* The incubation period ranged between 11 to 14 days and nestling period ranged between 11-13 days in different species. Grey-headed Bulbuls had the lowest nest survival rates (10.79%) followed by Square-tailed Black Bulbul (12.84%), Yellow Browed Bulbul (17.21%) and

Red-whiskered Bulbul

Red-whiskered Bulbul (23.5%). A total of 132 hrs of observation using video camera and direct observation were made during the incubation and nestling periods. Preliminary analysis indicates significant intra-specific and inter-specific variations in the on-bout (mean incubation bout duration in minutes) and off-bout (mean time spent away between two incubation visits in minutes) durations, nest attentiveness (as percentage of total daylight hours spent on the nest), nest trips/h (as the number of times the female went to or from the nest per hour) and feeding trips/h (number of feeding visits/h). Further data is required to decipher the patterns of variation along altitudinal gradients.

The nest predators were identified based on direct observations and video camera recordings at the nest sites and by indirect evidences. Lion-tailed macaque *Macaca silenus,* Nilgiri Palm Squirrel *Funambulus sublineatus,* Jungle Striped Squirrel *Funambulus tristriatus,*Common Vine Snake *Ahaetulla nasuta*, Common Monitor Lizard *Varanus bengalensis,* Common Bronzeback Snake *Dendrelaphis tristis,* Rat Snake *Coluber mucosus,* Ornate Flying Snake

Chrysopelea ornata, Malabar Pit Viper *Trimeresurus malabaricus,* Spectacled Cobra *Naja naja,* Ornate Flying Snake *Chrysopelea ornata,* White-bellied Treepie *Dendrocitta leucogastra,* etc are the major predators of the nests of bulbuls. Bulbuls used 38 plant species as nesting substrates. *Glochidion ellipticum, Lasianthus ciliates, Litsea floribunda* and *Ochlandra travancorica* were the most prefered species. The nest substrate and nest habitat characteristics were measured at multiple spatial scales.

To document the resource abundance, three belt transects were established in the study sites. The phenological patterns of the major food plants and fruit abundance were monitored fortnightly. Bulbuls devoured the fruits of more than 35 plants in Silent Valley National Park. Of these 20 species were eaten by Grey-headed Bulbul and 19, 16 and 12 species by Yellow-browed Bulbul, Square-tailed Black Bulbul and Red-whiskered Bulbul, respectively. The key food plants of bulbuls include *Antidesma menasu, Callicarpa tomentosa, Clerodendrum viscosum, Allophyllus cobe, Litsea floribunda, Litsea stocksii, Olea dioica, Oreocnide integrifolia, Persea macrantha, Symplocos cochinchinensis, Symplocos racemosa, Syzygium cumini, Syzygium sp., Viburnum corriatum, Ziziphus rugosa, Sarcandra chloranthoides, Lantana camara, Leea indica, Maesa indica, Psychotria nigra, Polygonam chinensis, Rubia cordifolia, Rubus ellipticus, Smilax sp., Scurrolla parasitica, etc.* The foraging behaviour and competitive interaction at the intra- and inter-specific levels were monitored by focal animal sampling. The near-perch maneuvers of bulbuls include glean, reach, hang and lunge and the ariel maneuvers were sally and gulp. They handled the food items by gulping, engulfing and biting. The variations in this behaviour among different species are based on the food items. During the breeding seasons bulbuls were not found to take part in the mixed-hunting flocks. The analysis for understanding the cumulative influence of food, competition, predation, weather and habitat on lifehistory variation will be completed in the next phase.

i. Use of research evidence in conservation planning by conservation managers in the Western Ghats biodiversity hotspot, south India.

The status of biodiversity is declining globally, and there is a subsequent need for conservation action to be informed by solid science. However, lack of systematic evaluation of the effectiveness of conservation decision making or practices has been highlighted as a key problem inhibiting advances in scientific conservation management. Recent research have shown that in the absence of easily accessible evidence, conservation managers are obliged to rely on limited and often largely experience based information on traditional land/forest or wildlife management practices. The recent approach in support of decision-making in conservation management is the use of an 'evidence-based framework' of the kind established in the health services. The Western Ghats comprises the major portion of the Western Ghats and Sri Lanka Hotspot, one of 34 global biodiversity hotspots for conservation. There are numerous government and civil society organizations active in scientific research in the Western Ghats and produce large number of peer reviewed papers and other documents. However, the conservation management of the area is largely based on the management/working plans prepared by the wildlife wardens, the custodians of the more than 60 protected areas and the territorial forest divisions that fall within the boundaries of the Western Ghats. Thus there are concerns regarding the degree to which the published research actually contributes to conservation action 'on the ground'. The extent of links and feedback processes between researchers and policy-makers is extremely important in such a system. Despite such complex decision making environment, there is a lack of research addressing how conservation decision makers use research evidence in the Western Ghats.

Synthesis of the empirical evidence on the use of research evidence by conservation managers and capacity building for evidence-based policy making to the conservation managers is the first step to improve effective conservation. So far we collected 20 management/working plans and analysed them to unveil the use of research in scientific management. Compilation of a database on the research publications from the Western Ghats is progressing.

j. Snake Sense: an education and awareness programme to improve knowledge and conservation of snakes.

Conservation education programmes in India mainly focus on the charismatic species such as birds and butterflies. Elusive groups like snakes are rarely mentioned in such programmes. On the other hand, snakes are one of the most threatened species on earth. Direct human killing has been identified as an important cause of population decline in snakes. Majority of such malicious kills of snakes occur in the rural areas because the envenomings and deaths resulting from

snake bites are a particularly important public health problem throughout the rural tropics. India tops in the number of deaths due to snake bite in the world with nearly 11,000 estimated deaths annually. The Spectacled Cobra *Naja naja*, Common Indian Krait *Bungarus caeruleus*, Russell's Viper *Daboia russelii* and Saw-scaled Viper *Echis carinatus* are considered as the 'big four' venomous snakes in this region which cause majority of the deaths from snake bites. The fear and resentment that arose from the high mortality rates due to snake bites result in malicious killing of several non-venomous snakes on sight throughout the region. However, relatively little attention has been devoted to understand the patterns of the direct killing and impact of such mortality on natural population of snakes. Previous studies conducted in Malappuram district of Kerala reported large scale kill of several non-venomous snakes. Among these, the non-venomous Travancore wolf snake *Lycodon travancoricus* is killed in large numbers due to its similarity to the Indian krait. Against this background, this programme was initiated to understand the perceptions and improve knowledge of students, trainee teachers, teachers and general public about snakes, develop a network of stakeholders to prevent malicious killing and save non-venomous snakes, and to improve scientific knowledge on the natural history of snakes in the region.

A series of awareness programmes and workshops were conducted during the present study. More than 1500 people participated in the programmes including more than 120 teachers/trainee teachers. The awareness programmes included power point presentations, photo exhibitions, exhibition of museum specimens, quiz competitions, posters, information leaflets, field visits and handling of snakes whenever encountered. Informal awareness programmes were conducted with the help of an expert group which imparted the snake conservation messages to more than 800 people. Audio modules containing the information on the snake diversity and conservation, and snake bite management including first aid protocols were supplied to several colleges and schools to air the same through their campus radio. Several field trips were arranged for the students to have firsthand experience on snakes. The pre-programme questionnaire surveys revealed the poor knowledge and negative attitudes towards snakes in the region. Students and adult females had more problems with the identification of common species and knowledge on their venom. Of the four venomous snakes namely, Spectacled Cobra, Common Indian Krait, Russell's Viper and Saw-scaled Viper found in the region, only the first one is identified correctly by most of the participants. Among non-venomous species Indian Rock Python, Brahminy Blind Snake and Common Vine Snake were identified correctly by most of the participants. A large number of participants believe that Common Rat Snake and Common Sand Boa are venomous snakes. The Ornate Flying Snake, a colourful snake is misidentified as a highly venomous species and the Travancore Wolf Snake as the poisonous Indian Krait by most of the people.

Comparison of the pre- and post-programme surveys indicates significant improvement in the knowledge and attitude towards the conservation of the snakes in the region. Kills of non-venomous species decreased drastically and this indicates that the conservation education programmes have been successful in bringing tremendous attitudinal changes in the local people towards the conservation of snakes. The reported rescue of several non-venomous snakes from human kill by the participants in this short duration programme show that scientifically designed conservation education programmes focusing on snakes may signinficantly contribute to the conservation and management of snakes in the human dominated landscapes. The training imparted to the teachers and the teacher trainees will help to spread the conservation message to several generations of students in the area.

Division of Phytochemistry & Phytopharmacology

The objectives of the Phytochemistry and Phytopharmacology Division of JNTBGRI are

(i) to carry out chemical and pharmacological studies of potential medicinal and aromatic plants and

(ii) to carry out chemical research for plant improvement and utilization.

During the report period (2012-2014), seven externally-funded research projects from (i) Board of Research in Nuclear Sciences (BRNS), Dept. of Atomic Energy, Govt. of India (ii) Department of Biotechnology, Govt. of India (iii) Department of Science and Technology, Govt. of India (iv) SRS Scheme, KSCSTE, Govt. of Kerala and (iv) Department of Forests and Wildlife, Govt. of Kerala were implemented by the Division. Three in-house projects were also implemented. Ph. D. and other training programmes were also actively pursued.

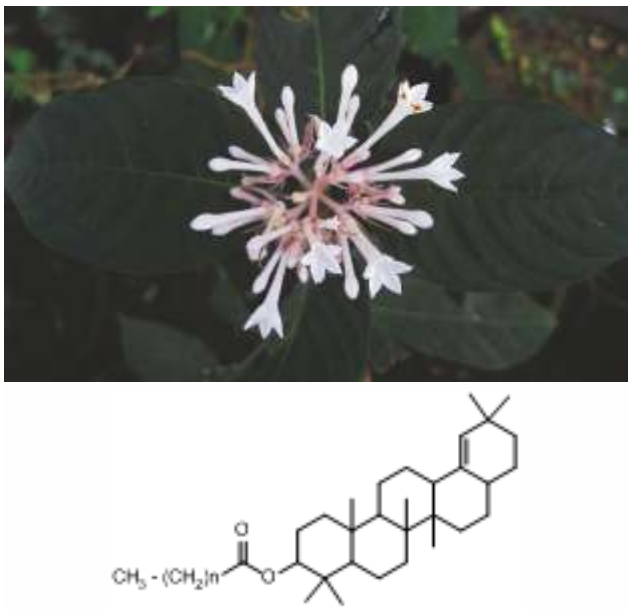
In the BRNS project entitled 'Phytochemical screening and selection of potential species of *Ophiorrhiza* for tissue culture based mass multiplication leading to production of camptothecin - an anticancer compound', camptothecin (CPT) content in a total of 82 accessions (phase I 44, phase II 38) of fourteen species and three varieties of genus *Ophiorrhiza* collected from the southern Western Ghats region in India were estimated by HPTLC-densitometry. *O. mungos* 0.017 to 0.050 (%, dr. wt.) and *O. mungos* var. *angustifolia* 0.013 to 0.048 (%, dr. wt.) accessions showed the highest CPT contents. *O. trichocarpon* (0.0020 to 0.0028%) and *O. pectinata* (0.000017 to 0.0039%) showed moderate contents of CPT. Among *Ophiorrhiza* species screened *O. barberi*, *O. caudata*, *O. nairii* and *O. rugosa* var. *decumbens* showed zero or non-detectable levels of CPT. *O. grandiflora* (0.00011 to 0.00013%), *O. eriantha* (0.00 to 0.000030%), *O. rugosa* var. *prostrata* (0.000016%) and *O. shendurunii* (0.0000050%) showed only very low contents of CPT. *O. mungos* var. *angustifolia* is an established variant and is a small herb which could be relatively easily cultivated or multiplied by tissue culture compared to *O. mungos*. Significant variations in CPT contents were found between the ecotypes/genotypes of the same *Ophiorrhiza* species or variety collected from different geographic locations. This revealed the importance of choosing high CPT yielding *Ophiorrhiza* genotypes or ecotypes for commercial purposes.

For detailed phytochemical analysis *Ophiorrhiza shendurunii* was collected from Pandimotta, Thenmala in May 2012. Dried whole plant (1.2 kg) was sequentially extracted with hexane, chloroform and methanol. Eight compounds were isolated from the hexane and chloroform extracts by column chromatography. ^{1}H NMR, ^{13}C NMR, ^{13}C DEPT, COSY, HMBC, HSQC, IR and mass spectra of the isolates were recorded. Out of eight molecules isolated so far, one is a new molecule, which was characterized by spectroscopic techniques. Two known molecules were identified as germanicol ester and stigmasterol. Further isolation and characterization of secondary metabolites from *O. shendurunii* are in progress.

As part of the Kerala Forest Department project on '*Ex-situ* conservation and biosystematic studies on *Piper*

species of Kerala - forests with special reference to intra-specific variants of the wild *Piper nigrum* L.' estimation of piperin contents in roots and fruits of thirty wild accessions of *P. nigrum* by HPTLC-densitometry was initiated. Piperin estimation in eight sets of *P. nigrum* (roots/fruits, 16 samples) has been completed.

In the DBT funded project, 'Bioprospecting of potential gingers: chemical prospecting, morphological characterization and *ex situ* conservation' essential oils were isolated by hydrodistillation from the fresh leaves,



Ophiorrhiza shendurunii and the new molecule isolated

inflorescence, fresh/dry rhizomes, fruit rind and seeds of *Alpinia mutica.* Highest oil yield was obtained in the dried fruit rind (1.18%). The rind oil has a sweet fragrance. Ethanolic extractions of oleoresins from fruit rind (16.0%) and seeds (11.2%) were also carried out. Physical parameters such as refractive index, specific rotation and specific gravity of essential oils were determined. GC-FID and GC-MS analyses of essential oils were also carried out. Relative percentages of individual components in essential oils were obtained from peak area percent report of volatiles from the GC-FID data. Individual components were identified from GC-MS database matching (Wiley, Flavour and Fragrance Database) and by comparison of mass spectra with published data. GC-MS analysis of dry rhizome oil of *A. mutica* showed the presence of 47 components of which 39 (92.68%) were identified. Major components were β-pinene (20.23%), camphor (13.40%), 1,8-cineole (8.93%), camphene (7.93%) and α-pinene (6.16%). GC-MS analysis of dry fruit rind oil showed the presence of 69 components of which 63 (91.30%) were identified. Major components of fruit rind oil were 1,8-cineole (14. 80%), camphor (11.69%), β-pinene (7.60%) and camphene (4.83%). Both oils showed significant anticancer, antioxidant and antimicrobial activities. Volatile constituents in the fresh flowers of *Hedychium flavescens* and *H. larsenii* were analyzed by using head space-GC-MS. *H. flavescens* flowers showed the presence of 57 volatile constitunets, of which 55 (96.49%) were identified. The major components in *H. flavescens* flowers were isobornyl formate (28.46%), trans-(E)-jasmonol (9.65%), menthol (6.19%) and neoiso-3-thujanol acetate (5.69%). GC-MS analysis of *H. larsenii* fresh flowers showed the presence of 44 components, of which 43 constituents (97.93%) were identified. The major constituents were isobornyl formate (37.46%), thymoquinone (26.97%), terpinen-4-ol (11.71%) and α-longipinene (5.55%).

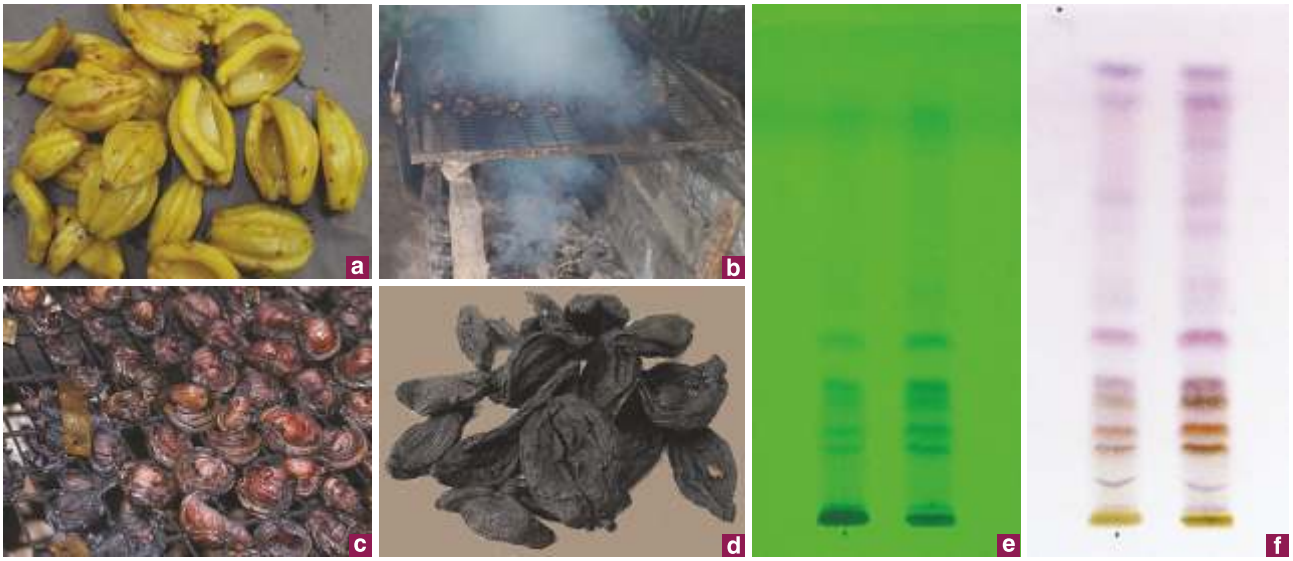
Under the DST funded programme, 'Search for potential biologically active constituents from a hitherto uninvestigated, unique bamboo: *Melocanna baccifera*', fresh fruits of *M. baccifera* (5.9 kg) were collected from JNTBGRI Bambusetum, dried (40°C) and powdered. Loss on drying of the fruits was 82.6%. The fruit powder (900 g) was cold extracted sequentially with hexane, chloroform and methanol and the extracts were concentrated using a rotary evaporator. This resulted in 5.1, 7.3 and 93.0 g of hexane, chloroform and methanol extracts, respectively. All three *M. baccifera* fruit extracts were screened for secondary metabolites by chemical tests. Hexane extract tested positive only for steroids, chloroform extract tested positive for steroids, alkaloids and coumarins and methanol extract tested positive for steroids, alkaloids, coumarins and sugars. *M. baccifera* fruit hexane extract (5 g) was subjected repeated column chromatography to yield four compounds MB1, MB2, MB3 and MB4. ^{1}H-NMR, ^{13}C-NMR, ^{13}C-DEPT, HSQC, HMBC, COSY and IR of these isolated compounds were recorded and analyzed. MB1 was identified as mixture of α-sitosterol and stigmasterol. The chloroform extract after extensive chromatography studies yielded three compounds MB5, MB6 and MB7. MB6 was identified as stigmasterol glucoside. Methanol extract was found to be rich in free sugars, mainly glucose, sucrose and fructose, and other polar compounds. One major alkaloid MB10 and two other water soluble compounds MB8 and MB9 were isolated from the methanol extract. Nutritional analysis of *M. baccifera* fruits was carried out. Mineral/element, vitamin, amino acid analyses, seed bound protein estimation and fatty acid profiling were performed as part of nutritional aspect of *M. baccifera* fruit. Sugar profiles of *M. baccifera* fruits (fruit liquid, seed and seed cover) at various growth stages were analyzed systematically.

a. *Melocanna baccifera* fruit; b. Stigmasterol glucoside

In the SRS scheme, 'Biflavonoids from *Garcinia* species - Chemical, molecular and pharmacological evaluation' funded by KSCSTE, Govt. of Kerala, flavonoid profiles of 13 *Garcinia* species collected from different parts of the southern Western Ghats were used for their chemosystematics. *G. hombroniana* and *G. mangostana* showed close proximity in chemical distribution. *G. imberti, G. morella, G. pushpangadaniana, G. spicata* and *G. xanthochymus* came under the same group while the chemical profile of *G. travancorica* was distinct from other species with the presence of characteristic high polar flavonoid compounds. Total phenolic and flavonoid content assays of thirteen *Garcinia* species were carried out. *G. pushpangadaniana* showed highest phenolic content (884.6 ± 83.51 mg/g) where as *G. gummigutta* showed the minimum (97.45 ± 7.28 mg/g). *G. mangostana* (553.34 ± 9.43 mg/g) and *G. travancorica* (435.53 ± 23.85 mg/g) also had high content of phenolics. *G. xanthochymus* showed highest flavonoid content (252.0 ± 11.03) and *G. indica* showed the minimum (11.1 ± 1.84 mg/g). Phenol and flavonoid contents in *G. cowa*, *G. gummigutta* and *G. indica* were very low. Antioxidant activity studies of *Garcinia* species were also tested. Of the thirteen *Garcinia* species studied, many of the species showed remarkable levels of antioxidant activities using different *in vitro* models like DPPH radical scavenging, reducing power and super oxide radical scavenging assays. Among the species tested, *G. echinocarpa* (6.50 ± 0.8 mg/ml), *G. hombroniana* (8.78 ± 0.23 mg/ml), *G. imbertii* (9.00 ± 1.2 mg/ml), *G. mangostana* (4.00 ± 0.5 mg/ml), *G. spicata* (2.80 ± 0.6 mg/ml), *G. wighti* (16.00 ± 2 mg/ml) and *G. xanthochymus* (4.40 ± 0.9 mg/ml) showed promising levels of DPPH radical scavenging activity compared with standard ascorbic acid with IC_{50} of 3.2 ± 0.5 mg/ml.

As part of the DBT Porject 'Economic and bio-geographic evaluation of the *Cinnamomum* species in some selected parts of India through morphological, chemical and molecular biology studies' two accessions of a *Cinnamomum* species with campharaceous smell were collected from Ponmudi forests of southern Western Ghats. The plant was found rich in camphor by GC-MS analysis. Eleven accessions of *C. malabatrum,* 8 accessions of *C. verum,* 2 accessions of *C. alexi* and 5 accessions of *C. sulphuratum* were collected from different parts of south India and their essential oils were isolated and solvent extracts were also prepared. Wild *Cinnamomum* species such as *C wightii*, *C. palghatensis* and *C. heyneanum* were also collected. Phytochemical analysis of the extracts and oils are in progress.

In the Department of Forests and Wildlife project 'Conservation and sustainable utilization of *Garcinia* species of the southern Western Ghats' post harvest processing of the fruit rind of *Garcinia gummi-gutta* (L.) were studied. Smoke dried fruit rind of *G. gummi-gutta*



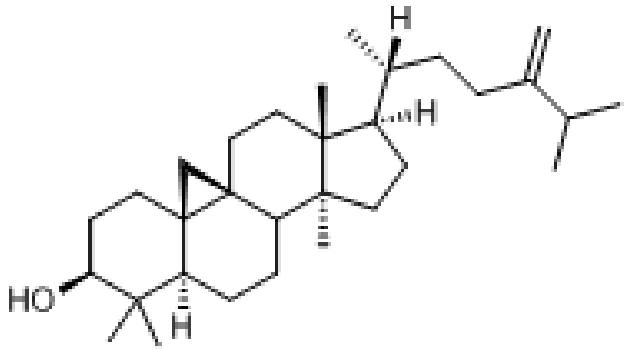
a. *Garcinia gummi-gutta* fruits; b & c. Smoke drying process; d. Smoke dried rinds; e. TLC of methanol extracts of smoke dried fruit rinds and oven dried rinds of *G. gummigutta* under UV 254 nm; f. TLC after derivatisation with anisaldehyde H_2SO_4.

is a popular flavouring agent in Kerala and its chemical profile is not studied. The active metabolites such as polyphenolics, flavonoids, acids and the antioxidant properties of the flavouring agent were evaluated and compared to oven dried samples. The physico-chemical evaluation revealed that rather than chemical composition of secondary metabolites, the enhanced moisture contents and acidity along with smoky odour has significant contribution in the peculiar flavour quality of the traditionally processed rinds. The high moisture content and physical changes due to smoking enhances the leaching of flavour components such as acids more efficiently in the smoke dried rinds.

Under the programme entitled, 'Search for renewable biomass and biofuel sources in *Euphorbia* plants of the southern Western Ghats' fifteen *Euphorbia* species were collected from different localities including JNTBGRI Cacti House. Each species (5 g each, aerial parts) were collected for chemical studies. Latex yields, hexane extract yields and moisture contents were also determined. High latex and hexane extract contents along with lowest content of moisture make *E. pteroneura* the most suitable candidate for further studies as a source of biofuel. Latex (5 ml) was collected from *E. antiquorum*, extracted with ethyl acetate and dried over anhydrous Na_2SO_4. Ethyl acetate extract was column chromatographed over silica gel (60-120 mesh) by gradient elution with hexane and chloroform. Fractions eluted with 30% chloroform in hexane gave the major compound, EaAc3. It (EaAc3) gave positive result for Liebermann-Buchard reaction for terpenoids and its R*f* in 2:3 hexane:chloroform was 0.26. Pure compound was further analyzed by NMR spectroscopic techniques (1H NMR, 13C NMR, DEPT, COSY, HSQC and HMBC) and this led to its characterization as 24-methyl cycloartenol.

Latex collected from 15 *Euphorbia* species were extracted with ethyl acetate. HPTLC analyses of these extracts were carried out along with standard 24-methyl cycloartenol isolated from the latex of *E. antiquorum* as the marker compound. HPTLC profiles revealed 24-methylene cycloartenol as the major compound in extracts of all *Euphorbia* species. HPTLC profiles also revealed *Euphorbia* species as rich in terpenoid compounds, making it ideal for biofuel assessment. Evaluation of the HPTLC profile of the *Euphorbia* species also revealed that the profile can be used as chemotaxonomical data for the identification of *Euphorbia* species. DSC and TG analyses of 8 *Euphorbia* species were carried out at STIC, Cochin University. *In vitro* antioxidant assays using DPPH, super oxide, phosphomolybdate and FRAP assays revealed that among the seven *Euphorbia* species, *E.vajravelui* possessed the highest phenolic contents and antioxidant activities.

Under the project 'Chemical prospecting of plants in Kerala region of Western Ghats for bioactive molecules' search for potentially bioactive secondary metabolites from medicinal plants in the Kerala region of the Western Ghats were carried out.. Isolation of secondary metabolites from medicinal plants was carried out by extensive chromatographic techniques. Structure elucidation of isolates was carried out using UV, IR, ^{1}H-NMR, ^{13}C-NMR and MS techniques. Biological activities of promising compounds were also investigated.



24-methylene cycloartenol

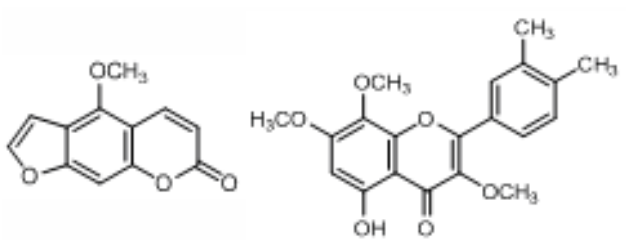
(i) *Melicope denhamii*

Five secondary metabolites (MD-1, MD-2, MD-3, MD-4, MD-5 and MD-6) were isolated from petroleum ether extract of *Melicope denhamii*. On spectral analysis MD-6 was identified as the flavonoid, ternatin. Acetone extract (32 g) was subjected to column chromatography to yield a hydrocarbon mixture, MDAHc-1 in 100% petroleum ether. In 15% ethyl acetate in petroleum ether, MDAc-1 (191-192°C) was obtained. Spectral data and Co-TLC showed that MDAc-1 was same as MD-1 (bergapten). 10% ethyl acetate in petroleum ether gave MDAc-2, a white crystalline compound. Spectral data and Co-TLC confirmed this compound to be same as MD-5. Another compound MDAc-3 was isolated pure (21 mg) from 65% ethyl acetate in petroleum ether.

(ii) *Melicope lunu-ankenda*

The prenylated flavonoid (3,5,4'-trihydroxy-8,3'-dimethoxy-7-(3-methyl but-2-enoxy) flavone) isolated from *M. lunu-ankenda* has been subjected to antioxidant and cytotoxic activities. Solubility of this molecule became a constraint in testing its hepatoprotective and anti-inflammatory potentials.

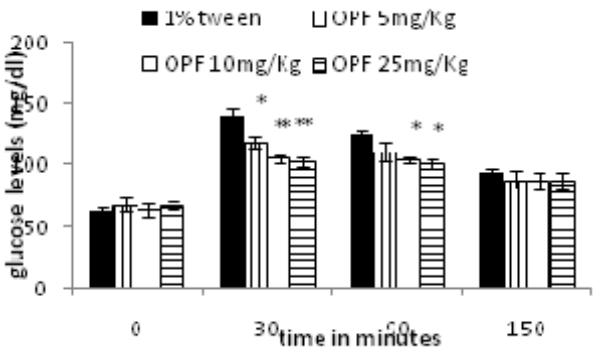
The prenylated flavonoid showed good antioxidant activity in *in vitro* DPPH radical scavenging and lipid peroxidation assays. So *in vivo* lipid peroxidation on the prenylated flavonoid was tested. In this experiment, male mice were divided into four groups of four animals each. Group I served as control and received 2% Tween-80 each day. Group II, III and IV received *O*-prenylated flavonoid dissolved in 2% Tween-80 orally, which was administered at 50 mg/mL, 100 mg/mL and 200 mg/mL for five days. After drug administration on the fifth day, animals were sacrificed and their liver(s) were dissected out. It was homogenized in 0.1 M Tris-HCl to obtain 10% homogenate. 2 mL of this homogenate was mixed with 2 mL TCA-TBA-HCl (1:1:1) and it was kept in boiling water bath for 15 min. This mixture was centrifuged at 1000 rpm for 10 min and OD was taken at 535 nm. Control gave OD as 0.07 but the prenylated flavonoid at 50 mg/mL, 100 mg/mL and 200 mg/mL gave 0.08, 0.09 and 0.11 OD values, respectively. This indicated that the *O*-prenylated flavonoid acted as a prooxidant in *in vivo* lipid peroxidation assay.



a. Ternatin; b. Bergapten

Antidiabetes activity of *O*-prenylated flavonoid in Oral Glucose Tolerance Test was tested on healthy male rats (150-200 g). Twenty four male over night fasted normal rats were divided into four groups of six each. Control group received the vehicle (1% Tween 80, 1ml, p.o). The experimental groups received *O*-prenylated flavonoid isolated from *M. lunu-ankenda* at 25, 10, 5 and 1 mg/kg per orally in 1% Tween 80. The rats of all the groups were loaded with 60% glucose (3 g/kg, p.o.) 30 min after *O*-prenylated flavonoid administration. Blood samples were taken from tail vein just 1 min prior to drug administration, and at 30, 90 and 150 min after glucose loading. Blood serum glucose levels were measured immediately with a glucometer.

Type 2 diabetes was induced in 5 day old Wistar rat pups with an intraperitoneal injection of 80 mg/ kg of streptozotocin (STZ) in citrate buffer. After ten weeks, blood samples were collected from tail vein of streptozotocinized animals and blood glucose levels were determined with one Touch Horizon glucometer. Male animals with blood glucose level ranges 230-240 mg/dl were selected for the efficacy evaluation of the active OPF in type 2 diabetes. Male STZ diabetic rats with comparable body weights (175-185 g) and blood glucose levels (230-240 mg/dl) were divided in to 3 groups of 6 animals each. The control group of diabetic animals received 1 ml of 1% Tween-80 daily, p.o. The test group of diabetic animals received daily dose of *O*-prenylated flavonoid (10 mg/kg) in 1 ml of 1% Tween-80 per orally. Diabetic animals in the standard drug control group received a daily dose of 500 μg/kg glibenclamide in 1 ml of 1% Tween-80, p.o. Weight and sex matched six normal rats were kept as normal control group, received daily dose of 1 ml of 1% Tween-80, p.o. The treatment was continued for 20 days. Blood was collected from tail vein and glucose levels were measured immediately with a glucometer (One Touch- Horizon Glucometer). Blood glucose levels were



Effect of *O*-prenylated flavonoid (OPF) on oral glucose tolerance in fasted and glucose loaded normal rats. Values are mean ± S.D; * P < 0.05; ** P < 0.001 (compared to control). n = 6 in each group. Glucose (3 g/kg) was administered 30 minutes after drug administration (per orally).

determined just before drug administration on day 1 and 1 hr after drug administration on days 5, 10, 15 and 20. After recording body weights on 20th day, the animals were sacrificed under carbondioxide anaesthesia and blood samples were collected to determine serum biochemical parameters. Liver samples were collected for glycogen estimation. Further studies are in progress.

(iii) Fluorescent prey traps in carnivorous plants

Carnivorous plants acquire most of their nutrients by capturing ants, insects and other arthropods through their leaf-evolved biological traps. So far, the best-known attractants in carnivorous prey traps are nectar, colour and olfactory cues. Fresh prey traps of 14 *Nepenthes*, five *Sarracenia*, five *Drosera*, two *Pinguicula* species/hybrids, *Dionaea muscipula* and *Utricularia stellaris* were scanned at UV 366 nm. Fluorescence emissions of major isolates of fresh *Nepenthes khasiana* pitcher peristomes were recorded at an excitation wavelength of 366 nm. *N. khasiana* field pitcher peristomes were masked by its slippery zone extract, and prey capture rates were compared with control pitchers. We found the existence of distinct blue fluorescence emissions at the capture spots of *Nepenthes*, *Sarracenia* and *Dionaea* prey traps at UV 366 nm. These alluring blue emissions gradually developed with the growth of the prey traps and diminished towards their death. On excitation at 366 nm, *N. khasiana* peristome 3:1 $CHCl_3$-MeOH extract and its two major blue bands showed strong fluorescence emissions at 430-480 nm. Masking of blue emissions on peristomes drastically reduced prey capture in *N. khasiana* pitchers. We proposed these molecular emissions as a critical factor attracting arthropods and other visitors to these carnivorous traps. *Drosera*, *Pinguicula* and *Utricularia* prey traps showed only red chlorophyll emissions at 366 nm.

These new findings were published in *Plant Biology* (*Plant Biology* 2013 15: 611-615), and this paper was covered by BBC, National Geographic, Smithsonian Magazine, National Geographic Kids News, Der Speigel (Germany), Deutschlandfunk (German Public Radio), BBC Focus Magazine, EOS/Scientific American/Psyche & Brain BELGIUM NEWS and a lot many other science platforms and web discussion sites.

(iv) UV induced visual cues on grasses

Grasses are traditionally considered as wind pollinated, however, field observations confirmed frequent insect visits to grass flowers, suggesting insect pollination. Fruit and seed predators inflict heavy losses to cereals and millets during their growth, maturation and storage. The actual factors guiding insects and predators to grass flowers, fruits and seeds are not clear. We found attractive blue fluorescence emissions on grass floral parts such as glumes, lemma, palea, lodicules, staminal filaments, pollen and fruits in ultraviolet (UV) 366 nm, whereas the stigmatic portions

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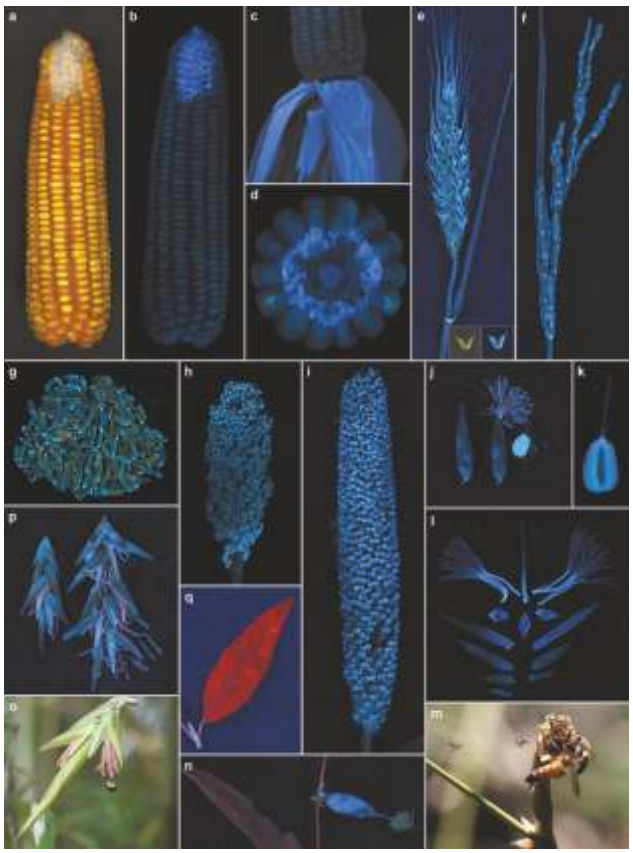
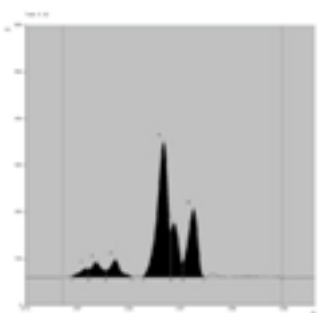


Fluorescence emissions on grass on grass floral parts

were not blue, but red fluorescent. We characterized the blue fluorescent constituent in grass reproductive structures as ferulic acid (FA). Fluorescence spectra of blue-emitting grass floral, seed extracts and isolated FA on excitation at 366 nm showed their emissions at 420-460 nm. We propose these FA-based blue fluorescence emissions in grass reproductive structures as visual cues that attract pollinators, predators and even pests towards them.

(v) Estimation of L-dopa in *Mucuna* pruriens

L-Dopa contents in 30 accessions of *Mucuna pruriens* - *Mucuna pruriens* var. *pruriens* (21), *Mucuna pruriens* var. *hirsuta* (3), *Mucuna pruriens* var. *utilis* (5) and *Mucuna pruriens* var. *thekkadiensis* (1) were estimated using HPTLC-densitometry.

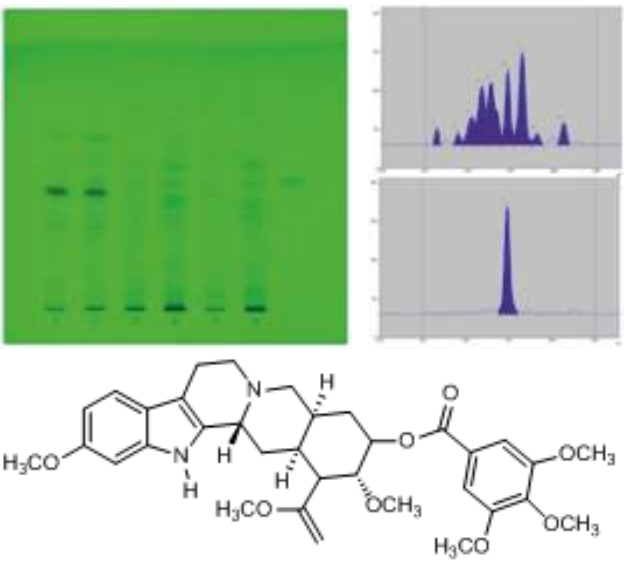


Mucuna pruriens var. *pruriens* extract on HPTLC.

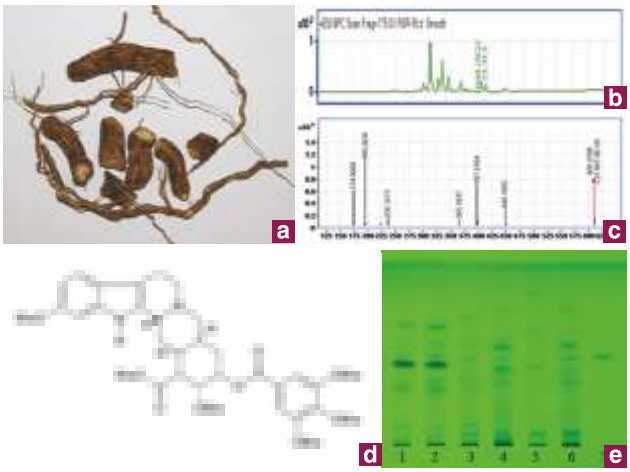
(vi) Distribution of reserpine in Rauvolfia species from India - HPTLC and LC-MS studies

Reserpine content in the roots of six *Rauvolfia* species viz., *R. hookeri, R. micrantha, R. serpentina*, *R. tetraphylla*, *R. verticillata* and *R. vomitoria*, were detected by HPLC-ESI-QToF-MS/MS and estimated by HPTLC. Among the six *Rauvolfia* species, reserpine content was highest in the exotic species *R. vomitoria* (690.2 ng/g, dr. wt.), while among the five Indian species the highest reserpine content was for *R. tetraphylla* (449.7 ng/g, dr. wt.). In the most common Indian *Rauvolfia* species, *R. serpentina,* the reserpine content was comparatively low (252.5 ng/g, dr. wt.). The endemic species *R. micrantha* possessed significant quantity of reserpine (420.9 ng/g, dr. wt.), making it a potential source of reserpine, replacing *R. serpentina* and *R. tetraphylla* that are endangered due to over exploitation.

The objective of the plan-funded project 'Chemical prospecting of aromatic plants of the Kerala region of Western Ghats' is to search for new essential oil sources and potential oil constituents from plants. Their bioactivities viz., antimicrobial, anti-inflammatory, antioxidant activities and their potential for applications in flavour and fragrance industries are also evaluated in this programme. Chemical profiling of hitherto uninvestigated plants are given priority under this scheme. Chemosystematics based on volatile and flavonoid profiles has proven as an efficient supportive tool for plant systematics.



Reserpine



a. *Rauvolfia serpentina* roots; b. +ESI BPC of *R. serpentina* root extract; c. MS/MS of reserpine in *R. serpentina* root extract; d. Reserpine; e. HPTLC of the root extracts of 1: *R. hookeri,* 2: *R. micrantha,* 3: *R. serpentina*, 4: *R. tetraphylla*, 5. *R. verticillata*, 6: *R. vomitoria,* 7. Reserpine standard.

Essential oil analysis of genus *Polyscias*

Genus *Polyscias* belongs to the family Araliaceae. They are glabrous trees or shrubs distributed in tropical and temperate regions of the world. *Polyscias filicifolia* leaves were collected and hydrodistilled. Oil yield: 0.15 ml oil with pale yellow colour, pleasant smell. GC-MS and GC-FID analyses of *P. filicifolia* leaf oil showed 27 constituents of which 25 were identified (99.00%). The major constituents were γ-muurolene (49.47%), β-elemene (8.79%), falcarinole (Z) (6.08%), 7-epi-α-selinene (5.48%) and δ-amorphene (4.07%). *P. balfouriana* leaves were collected and hydrodistilled. Oil yield: 0.15 % v/w with pale yellow colour, pleasant smell. GC-MS and GC-FID analyses of the essential oil gave 35 constituents of which 27 were identified (98.87%). Major oil constituents were Z-β-farnasene (59.64%) δ-cadinene 26.39% and Z-falcarinol (6.01%).

Studies on *Piper* species

Essential oils of the leaves, fruits and roots of *Piper sarmentosum* were analysed by GC and ^{13}C NMR. The major compound from *P. sarmentosum* essential oil was isolated by column chromatography and identified as myristicin by ^{13}C NMR studies. *Piper trichostachyon* leaves and fruit essential oils were analysed by GC-MS.

Metabolic profiling of *Piper nigrum, P. longum* and *P. chaba* by direct analysis in real time mass spectrometry (DART-MS)

DART-MS is an ambient ionization technique introduced recently that provides rapid analysis without sample preparation. Twenty four piperamides were detected in the fruits of *Piper* species studied. Piperine (m/z 286.1438) was present in the fruits of *P. nigrum* and *P. chaba* in high abundance, while pellitorine (m/z 224.2009) was the characteristic peak found in *P. longum*. Dipiperamide (m/z 571.2803) was identified in the fruits of *P. nigrum* and *P. chaba* but absent in *P. longum* fruits.

Genetic conservation and chemical characterization of ethnobotanic insect repellent plant species of Andaman Islands.

Zingiberaceae member, *Hornstdentia fenzlii* is used as bee repellent, and this property has been evaluated scientifically. Behaviour bioassay through y-tube olfactometer bioassays proved the bee repellent activity of the plant and the aliphatic alcohol n-dodecanol has been identified as the major repellent molecule in the plant by GC-EAD analysis.

Division of Ethnomedicine & Ethnopharmacology

The mission of the division is to ensure excellence in ethno-medico-botanical survey, systematic documentation of Traditional Knowledge associated with biodiversity of Kerala State, protection of traditional knowledge associated with plants used for food and medicine under sui generis system and preparation of database. Ethnopharmacological studies mainly focussed on Traditional knowledge based preclinical drug discoveries which involves safety evaluation, *in vitro* / *in vivo* studies like activity guided fractionation, molecular pharmacology and elucidation of cellular / molecular mechanism as also preparation and standardisation of novel herbal remedies / nutraceuticals and other plant based products. Inter institutional collaborative research programmes, product development, technology transfer, commercialization and equitable benefit sharing and implementation of extension / outreach programmes are also undertaken.

Research Highlights and New Developments

During the reporting period, the division implemented 4 externally funded projects (Department of AYUSH, WGDP, UGC and SMPB) and 7 in-house projects (KSCSTE). From the division 3 Ph Ds were awarded, 11 Ph D programmes are being pursued, 2 new Ph D programmes were initiated and 5 dissertation programmes conducted.

Two of our Scientists, Dr PG Latha, Director and Dr SR Suja, Scientist B attended and presented a poster at the 13th International Congress of Society of Ethnopharmacology held at Karl-Franzens-University, Graz. Austria from 2nd to 6th September, 2012.

In the Western Ghats Development Programme (WGDP), the ethanolic extract of *Saraca asoca* (Fabaceae), stem bark (SA) was found to be nontoxic upto 6400mg/kg in the sub acute toxicity (28 days) study. Hepatoprotective activity of SA against ethyl alcohol induced hepatotoxicity was studied in comparison with the standard drug silymarin and SA at 200mg/kg showed significant hepatoprotective effect and this was supported by biochemical and histopathological analysis.

Phytochemical analysis of *Saraca asoca* crude extract (SA) and different fractions – Hexane (H-SA), Chloroform (C-SA) and Ethanol (E-SA) was carried out. They were found to be rich in phytochemicals namely flavonoids, triterpenoids, phytosterols, phenolic compounds, tannins, coumarins and proteins. The estimation of total phenolics, flavonoids and tannins in H-SA, C-SA, E-SA and SA showed that the maximum concentration of these antioxidant compounds are present in SA compared to the fractions. The concentrations of total phenol, flavonoids and tannins in

Saraca asoca (Roxb.) de Wild

Dr P. G. Latha and Dr. S. R. Suja at the 13th International Congress of Society of Ethnopharmacology, Austria

SA were found to be 10.45± 0.24%, 0.46±0.64% and 42.53±2.11% respectively. The least concentration was obtained for the H-SA extract. The major compound in the crude ethanolic extract (SA) was found to be Catechin, and it is the active principle in the SA. The project was completed and report submitted to WGDP (Western Ghats Development Programme Cell).

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a. *Decalepis arayalpathra* (J. Joseph & V Chandras) Venter;
b. *Holostemma ada-kodien* R Br. ex Sehult.

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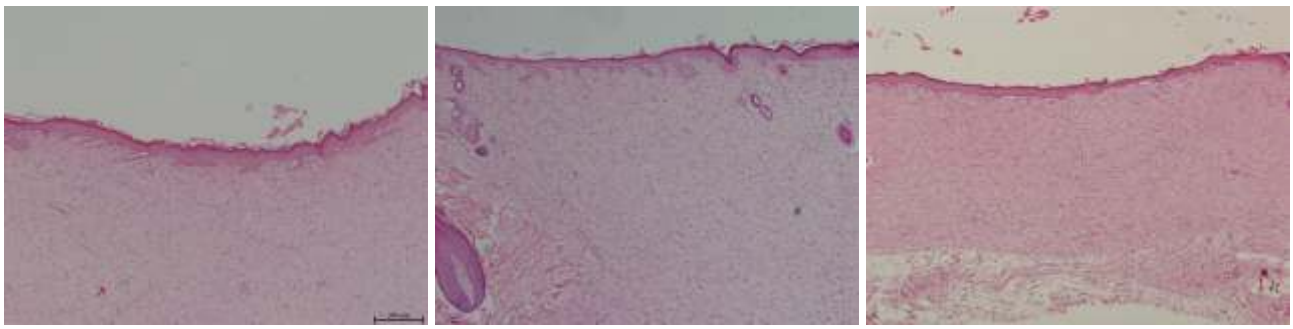
In the UGC project entitled "Antihepatotoxic, Antioxidant and related Pharmacognostic Studies of *Oxalis corniculata* L.", hepatoprotective activity of ethanolic extract of *Oxalis corniculata* L. (OC) (Oxalidaceae) against alcohol induced toxicity was studied in comparison with the standard drug Silymarin. The serum analysis showed that OC has the ability to minimize liver damage caused by the toxins and restore liver function to a reasonable extent. The extract at 100 mg/kg showed significant hepatoprotective effect. Histopathological analysis supports the above claim and OC treated liver showed marked improvement in the liver architecture compared to alcohol control. Total antioxidant activity of *O. corniculata* ethanolic extract was estimated to be 110*µ*g/ml.

In the State Medicinal Plant Board (SMPB) project entitled 'Assessment of Medicinal Plant Resources in Seven Southern Districts of Kerala'during the year 2012-13, a work plan was formulated in consultation with KFRI, Thrissur and State Medicinal Plant Board, Kerala. It included base line data collection, preparation of district wise directory of medicinal plants of all 14 districts of Kerala based on available data, field data collected in the approved format, preparation of Passport script data based on field data, inventory methodology for the estimation of growing stock of selected species, preparation of online data base and retrieval system and submission of periodical reports. The project will be implemented based on this work plan accordingly.During 2013-14,the check list of medicinal plants of Thiruvananthapuram district was completed along with the district wise directory of medicinal plants of Thiruvananthapuram district. The draft passport script data of medicinal plants of Thiruvananthapuram has been prepared and a full-fledged inventory for estimation of growing stock of 39 Medicinal plants of Thiruvananthapuram district have been completed.

As a part of in-house project entitled "Anti-inflammatory, analgesic and anti-arthritic activity of two selected plants of the Western Ghats, Kerala", the chronic toxicity study of the ethanolic extract of *Barringtonia racemosa* (L.) Sprengel (Lecythidaceae) fruits (BR) was conducted, and it was found to be non-toxic upto 2500 mg/kg. The ethanolic extract of *Justicia gendarussa* Burm. f. (Acanthaceae) leaves (JG) showed a dose dependent inhibition of acetic acid induced vascular permeability. In the Xylene induced ear inflammation studies, JG and BR showed a dose dependent inhibition of inflammation. In the DPPH free radical scavenging assay, the extracts of JG and BR showed maximum activity at 500*µ*g/ml and 1000 *µ*g/ml respectively. In the cotton pellet induced granuloma study conducted, JG showed a dose dependent inhibition of granuloma formation with maximum activity



Histopathology of skin at day 21 stained with H&E (125x). (a) Skin of control rat showing epithelization, and granulation tissue (b) Amoxicillin treated rats showing lack of inflammatory cells and large number of blood capillaries(c) ENC (150 mg/kg) treated rats showing large amount of collagen deposition and reduced number of inflammatory cells.

at 500mg/kg dose. The formalin induced arthritic study of JG and BR was completed. Both the extracts showed dose dependent activity that was comparable to the standard, Indomethacin (10 mg/kg).

The coded drug ENC showed significant anti-inflammatory, analgesic, antioxidant and wound healing effects. In acetic acid induced writhing studies, ENC (450 mg/kg) showed 85.24 ± 1.45% inhibition of writhing and the reference drug Aspirin (20 mg/kg) treated groups showed 79.53 ± 2.03% inhibition, when compared to control group. In Hot plate test in mice, the ENC (150 mg/kg and 450 mg/kg) showed significant extension of latency time at 30 and 60 min respectively. In carrageenan induced paw oedema studies, ENC (150 mg/kg) significantly reduced the inflammation by 91.94% whereas aspirin treatment reduced inflammation only up to 77.42% at 180 min.

In the in-house project entitled, "Clinical trial of coded hepatoprotective herbal formulation in collaboration with OUSHADHI, Govt. of Kerala", the chronic toxicity study of coded drug TBGO-1 (1000 mg/kg and 2000 mg/kg) was completed. The drug was found to be non-toxic upto 2000 mg/kg and was supported by biochemical studies of serum samples and histopathological analysis of the liver and kidney samples. The results of the GC-MS analysis of the herbal formulation TBGO-1 and the three ingredients was analyzed and major constituents identified. In the radioactivity assay carried out, TBGO-1 was found to be non-radioactive. HPTLC analysis of the coded ingredients procured from Oushadhi was carried out. The Prototype development of TBGO-1 for clinical trial is in progress at Oushadhi. The HPTLC analysis of the TBGO-1 formulations prepared in Oushadhi was carried out.

Oushadhi conducted field cultivation of one of the main ingredients of the coded drug during the reporting period. Identification and pharmacognostic studies of the same were carried out at JNTBGRI. The HPTLC analysis of samples procured from Oushadhi was completed. The monograph of coded drug was prepared. Standardization of protocol for drug was carried out in JNTBGRI and the standardization of the same at Oushadhi is in progress.

In the in-house project entitled "Search for anti-diabetic/hepato-protective, immuno-modulatory and wound healing plants from traditional/ folklore medical information of Kerala", the biochemical analysis of the serum parameters of D-Galactosamine-induced hepatotoxicity study of the ethanolic extract of coded drug 222 was carried out. The serum parameters like SGOT, SAKP and serum bilirubin levels were significantly reduced in 125 mg/kg treated group compared to the standard control silymarin confirming the hepatoprotective property of the extract. Percentage of total ash of coded drug 222 has been determined as 11.09%, acid insoluble ash as 0.40 % and water soluble ash as 3.53%. Alcohol soluble extractive of the coded drug 222 was determined as 1.6% and water soluble extractive as 3.2%. A provisional patent has been filed.

Acute and sub-acute toxicity studies, Glucose Tolerance Test and mast cell degranulation study of the Neera syrup (samples received from NIIST, CSIR laboratory, Thiruvananthapuram) was carried out. In acute toxicity study, Neera syrup was found to be safe up to 16 ml/kg. The treatment with the syrup did not exhibit any lethality or toxic symptoms. The syrup at 5 ml/kg dose has significant blood glucose lowering effect and it also exhibited significant inhibition of mast cell degranulation.

The flow density study of the coded drug 222 was completed. In paracetamol-induced hepatotoxicity study, the ethanolic extract of coded drug 222(2) at 25 mg/kg and 50 mg/kg doses has significant hepatoprotective activity. In immunomodulatory study of the coded drug 222 (1), drug dose 25, 50, 100 & 200 mg/kg did not show any significant activity when compared to the control group. Radio activity assay of

coded drug 222 samples was carried out. No detectable level of radio activity was found in the coded drug 222 samples. Aflatoxin, Pesticide analysis and profiling of the coded drug 222 have been carried out. There were no detectable levels of Aflatoxin and pesticide residue.

In the Streptozotocin-induced diabetic study, the coded drug 222-(2) KB (5 mg/kg) and 222-(2)-KB (10 mg/kg) showed significant decrease in blood glucose levels and serum parameters such as SGPT, SGOT and SAKP levels, when compared to the standard control glibenclamide.The elevated levels of cholesterol and triglycerides were also significantly decreased in these groups. Under diabetic condition, there was a significant elevation of Protein carbonyl content (PCO) and Advanced oxidation protein products (AOPP) in the pancreatic tissue. But, 222 (2) KB extract (10 mg/kg) treated diabetic rats exhibited significant decrease in their pancreatic PCO and AOPP levels compared to untreated diabetic rats.

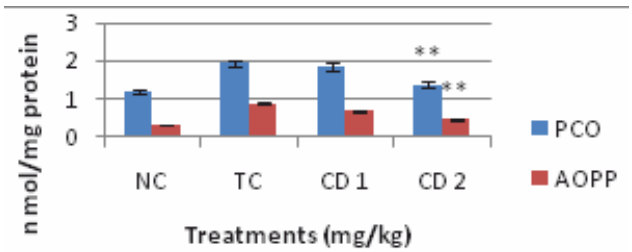
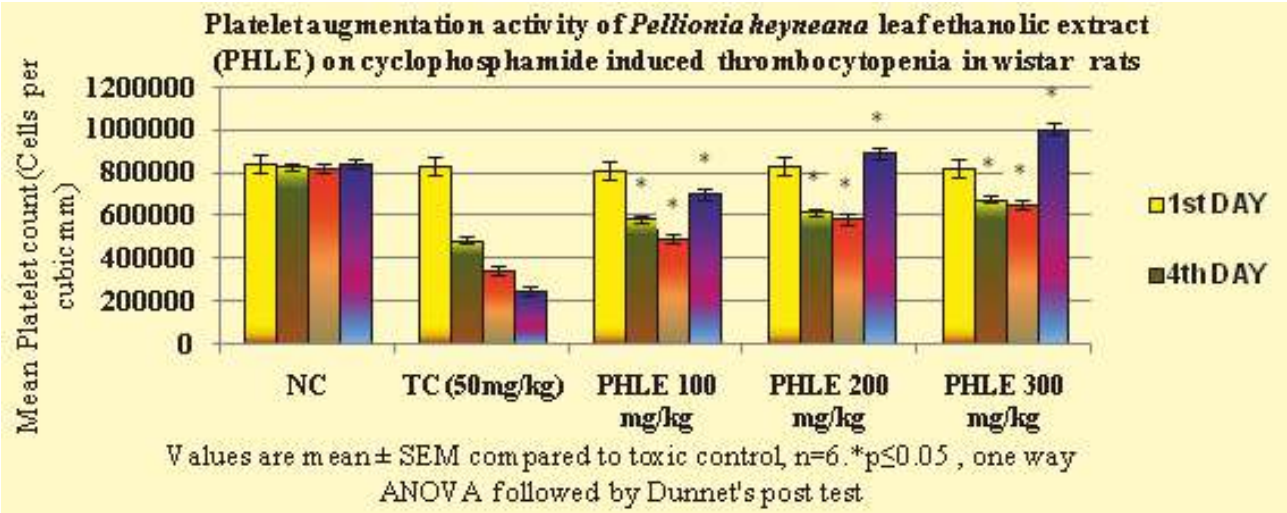


Fig: 1. Concentrations of the protein oxidation markers, Protein carbonyl content (PCO) and Advanced oxidation protein products (AOPP) in the pancreas of Normal (NC), Diabetic (TC) and coded drug (222 (2) KB 5 mg/kg and 10 mg/kg) treated (CD1 & CD2) Wistar rats.

The leaf juice of *Costus speciosus* (Koenig) Smith. Locally called Channakoova. It is used against ear ache by Muthuvan tribe of Munnar in the in-house project entitled "Ethnomedical survey and systematic documentation of traditional knowledge among the different tribal communities of Kerala – an in-depth study and preparation of database", ethnomedical survey and systematic documentation of traditional knowledge among the Muthuvan and Hill Pulaya tribal communities of various settlements in Marayoor and Kanthalloor Grama panchayaths of Idukki district was completed during the year 2012-2013 and the study among the Mannan tribal community of Kumili and Kanchiyar Grama panchayaths, Urali tribal community of Kanchiyar Grama panchayath and Muthuvan tribal community of Munnar Grama panchayath of Idukki district had been completed during the year 2013-2014. A total of 194 knowledge providers were interviewed and 2100 ethnomedical information collected, of which, 1271 are single drug informations, 235 are combination drug informations and 594 are food plant informations. In total, 115 plant species are used as single drugs, 70 plant species are used in combination drugs and 73 plant species are used as food.

In the in-house project entitled "Ethnobotanical survey in the coastal areas of three Southern Districts of Kerala , Traditional Knowledge related to coastal plants from traditional folk (Fisher folk, Vaidyas and other knowledge holders) were systematically documented. During the year 2012-2013, Ethnobotanical survey of Karimkulam and Kadinamkulam Gramapanchayaths of Thiruvananthapuram district were completed and the

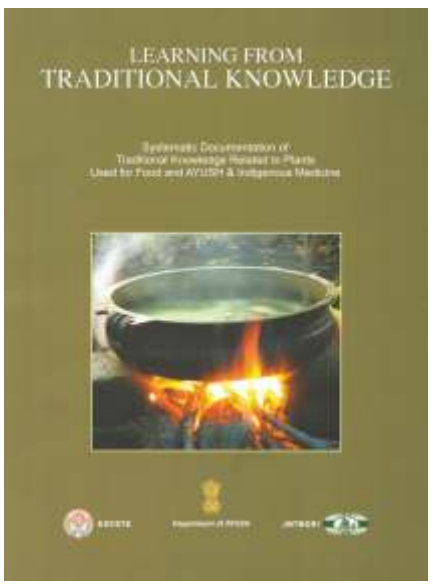
a. *Costus speciosus* (Koenig) Smith
b. *Bacopa monnieri (L.) Pennel*

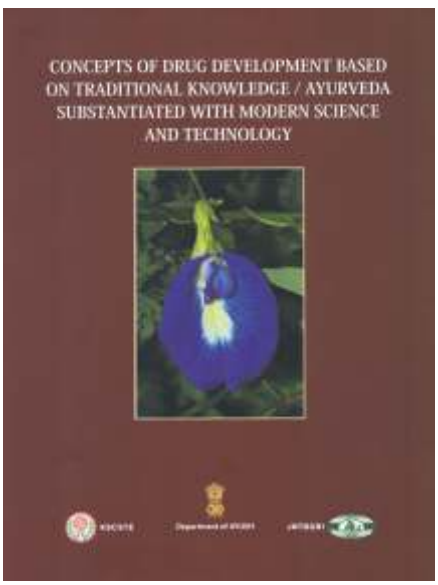


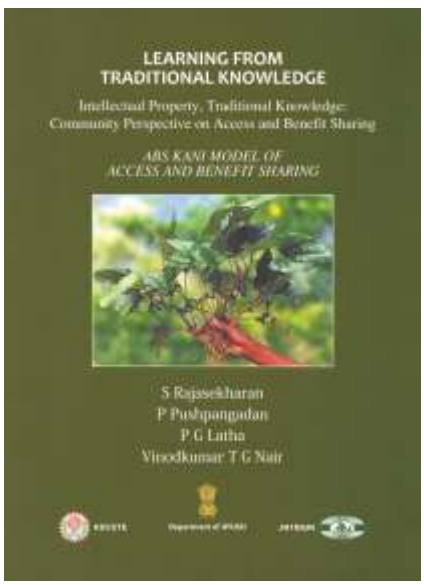
data gathered were analyzed. Ethnobotanical studies of coastal areas of Poovar, Chirayinkeezhu, Vettoor, Varkala, Edava Grama panchayaths and Vizhinjam, Kovalam, Thiruvallam and Veli Corporation wards of Thiruvananthapuram district were completed in 2013-2014.A total of 901 information on 200 plant species used for various ethno-medico-botanical purposes by the local community including fisher folk were collected.

In the in-house project entitled "Evaluation of Platelet augmentation activity of selected medicinal plants of Western Ghats based on Traditional Knowledge",the ethanolic extract of *Pellionia heyneana* (PHLE) (100, 200 and 300 mg/kg) selected for the study, showed potent platelet augmentation activity in Cyclophosphamide-Induced Thrombocytopenic Rat Model. PHLE shows a maximum DPPH scavenging activity of 65.94% at 200μg/ml and IC_{50} of PHLE was found to be 70μg/ml. The *in vitro* anti-lipid peroxidation studies proved the antioxidant potential and free radical scavenging ability of the plant extract. PHLE reduced the lipid peroxidation *in vitro* induced by $FeCl_2$-AA in a dose dependent manner with IC50 value of 79.37μg/ml.

During the reporting period, the Progress report – Phase I (August 2010 – March 2012) of the project, in 3 volumes, along with 6 publications including 'Journal of Folk and Traditional Practices' (Inaugural issue) and the 'Students Handbook on Medicinal and Food Plants' was submitted to the Dept. of AYUSH. The video documentation of tribal medical practice from seven northern districts was carried out and a web based database on Traditional Knowledge on Food and Medicine in collaboration with C-DIT (a Govt. of Kerala undertaking) was developed. 3 IEC materials on Systematic documentation of Traditional Knowledge



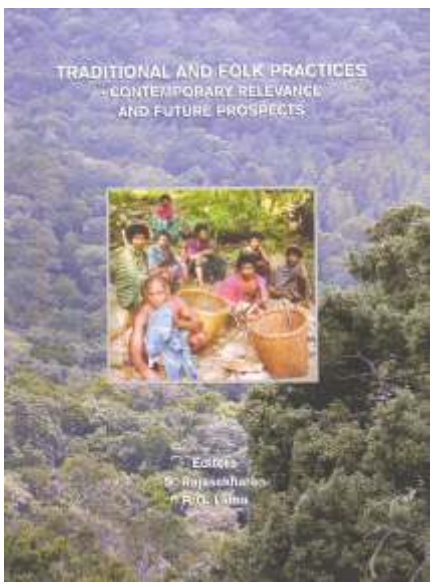


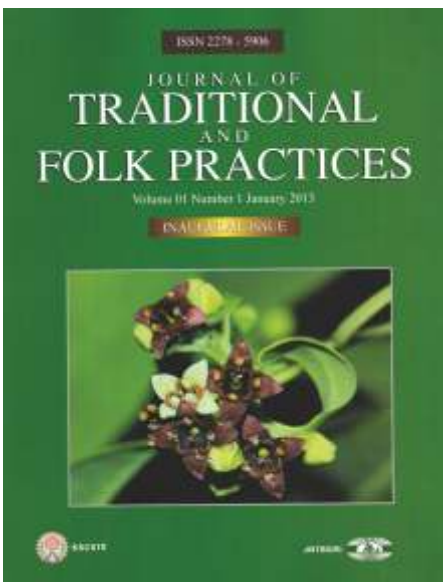


Pellionia heyneana Wedd.

related to plants used for Food, AYUSH and Indigenous Medicine was published.

The ethanolic extract of *Kaempferia rotunda* L. (Zingiberaceae) rhizome (KR) was fractionated with different solvents (petroleum ether, chloroform and acetone) and subjected to *in vitro* antioxidant activity by DPPH (1,1-Diphenyl-2-picryl hydrazyl) and *in vivo* wound healing experiments. In the wound healing experiments, the chloroform fraction showed significant wound contraction and period of epithelialization (11.35± 0.56 days) in the excision wound model ($p \leq 0.01$) in comparison with the control (23. 78 ± 2.5 days) and other fraction treated groups. In the DPPH free radical scavenging activity, the value obtained for chloroform fraction was almost significant in comparison with the IC_{50} of ascorbic acid (12.22 ± 0.46mg/ml) ($p \leq 0.05$). Fractionation and purification of the chloroform extract residue by repeated column chromatography (CC) and/or re-crystallization technique gave a compound, 'Compound- A'. Its spectroscopic analysis and characterization is in progress.





The ethanolic extract of *Pellionia heyneana* Wedd. (Urticaceae) leaves (PHLE) was found to be non toxic upto 2000mg/ kg dose in Swiss albino mice. In the *in vitro* antioxidant study, PHLE extract showed significant reduction of malondialdehyde (MDA) levels (59.12%) of murine hepatic microsomes at dose 200 µg/ml. In the paracetamol induced hepatotoxicity, PHLE treated animals showed significant reduction in the serum enzyme parameters such as SGOT, SGPT, SAKP and serum bilirubin in comparison with the toxin treated group. PHLE (100-400 mg/kg) treated group showed almost

normal histological architecture in comparison with the toxin control treated group. PHLE treatment enhanced the antioxidant activity of the enzymes GSH and CAT and also showed a significant reduction of the levels of MDA.

PHLE showed significant hepatoprotective effect in carbon tetrachloride induced hepatotoxicity study. The PHLE treated animals showed significant reduction in parameters such as SGOT, SGPT, SAKP and serum bilirubin in comparison with the toxin treated group. The results were substantiated by histopathological studies.

The anti-inflammatory activity of *Arenga wightii* (AW) was analyzed by Carrageenan induced paw oedema and cotton pellet induced granuloma in Wistar rats. The extracts showed significant dose dependent inhibition of oedema and granuloma formation and the results

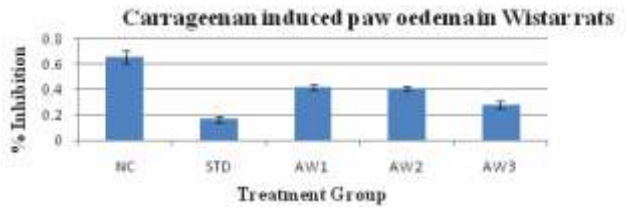


Fig 2. Effect of *Arenga wightii* extract on carrageenan induced paw oedema in Wistar rats. NC (Normal Control), STD (Standard), AW1(AW 125mg/kg), AW2 (AW 250mg/kg), AW3 (AW500mg/kg)

were comparable to the standard drug Indomethacin (10mg/kg). In the analgesic studies (acetic acid induced writhing and hot plate test), AW (250 mg/kg) showed significant analgesic activity which is comparable to the standard Acetyl salicylic acid (100 mg/kg). The total phenolic content of *A. wightii* was determined as 41mg/g GAE and total condensed tannin was determined as 66 mg/g Catechin equivalent.

In cyclophosphamide-induced myelosuppressed animals, there was a significant reduction in total WBC count and differential count. *Morinda umbellata* (MU) at 200 mg/kg dose increased the total leucocyte count and differential count significantly in myelosuppressed rats after 14 days treatment.

The effect of ethanolic extract of *Schumannianthus virgatus* (Roxb.)Rolfe (Marantaceae) rhizomes (SV) against carbon tetrachloride, paracetamol, D-GalN (D-Galactosamine) and alcohol induced liver damage in Wistar rats was studied. SV (100 mg/kg, p.o.) showed a remarkable hepatoprotective activity against Carbon tetrachloride, paracetamol, alcohol and D-GalN induced hepatotoxicity in liver tissues. Hepatotoxins (CCl_4, paracetamol, alcohol and D-GalN) induced a significant rise in SGPT, SGOT, ALP and serum bilirubin and treatment of rats with different doses of plant extract (50mg/kg, 100mg/kg, 200mg/kg) significantly decreased the serum marker enzyme levels. The activity of the extract at dose of 100 mg/kg was comparable to the standard drug, silymarin (100 mg/kg, p.o). These results were supported by histopathological analysis.

The acute, sub chronic and chronic toxicity studies of the methanol extract of *Lagerstroemia speciosa*

Important Ethnopharmacological leads obtained from the plant species during the current period

Name of the Plants	Activity
Saraca asoca (Roxb.) de Wilde	Anti-hepatotoxic, Immunomodulatory
Justicia gendarussa Burm. F.	Anti- inflammatory
Coded plant ENC	Anti inflammatory, analgesic, wound healing
*Oxalis corniculata*L.	Anti-oxidant, hepatoprotective
Kaempferia rotunda L.	Wound healing, Anti inflammatory, anti ulcer and analgesic
Barringtonia racemosa (L.) Sprengel	Anti-inflammatory
*Pellionia heyneana*Wedd.	Platelet augmentation activity
Coded herbal drug 222	Anti-diabetic, Anti- hepatotoxic
Coded herbal drug 0011	Anti-diabetic
Coded herbal drug 0002	Anti-diabetic
Coded drug TBGO-1	Anti hepatotoxic
Arenga wightii Griff.	Antiinflammatory, Analgesic
Schumannianthus virgatus (Roxb.) Rolfe	Antihepatotoxic
Morinda umbellata L.	Immunomodulatory
Macrocybe gigantea (Massee) Pegler & Lodge	Hepatoprotective, immunomodulatory
Asystasia chelonoides var. *chelonoides* Nees	Antioxidant potential
Lagerstroemia speciosa (L.) Pers.	Antidiabetic
Boerhavia diffusa L	Anti-hepatotoxic

Release of 5 books from JNTBGRI on Traditional Knowledge and Medicinal Plants by Hon'ble Chief Minister, Shri. Oommen Chandy on 13. 08. 2013.

Dr. V. N. Rajasekharan Pillai, former Executive Vice President, KSCSTE and Shri A. Shajahan, IAS, Special Secretary, Department of Higher Education, Govt. of Kerala receiving the books from Hon'ble Chief Minister, Shri Oommen Chandy on13. 08. 2013.

leaves (LS) were carried out in Wistar rats. The data obtained from the haematological analysis, serum analysis and histopathological examinations did not reveal any remarkable change, which shows the nontoxic nature of *L. speciosa*. LS (300 mg/kg) showed significant anti-diabetic property, which was substantiated by biochemical and histopathological analysis.

The ethanolic extract o*f Boerhavia diffusa* L. (BD) exhibited a significant hepatoprotection against D-Galactosamine induced hepatotoxicity in Wistar rats, which is evident by a reduction in elevated levels of serum enzymes AST, ALP, ALT and gamma glutamyl transferase and decrease in TP, TB levels.

In vitro antioxidant studies with ethanolic extract of *Asystasia chelonoides* leaves (AC) showed significant free radical scavenging activity in DPPH and FRAP assay and IC_{50} values were calculated to be 300μg/ml and 250μg/ml respectively.

The hepatoprotective potential of ethanolic extract of *Macrocybe gigantea* (MG) was assessed using Acetaminophen and Carbon tetrachloride induced hepatotoxicity studies in Wistar rats. MG exhibited a significant protective action of liver which is evident by a reduction in elevated levels of serum enzymes AST, ALP, ALT, serum bilirubin and cholesterol.

Division of Plant Systematics & Evolutionary Science

The division is devoted to plant systematics in the broad sense, encompassing phylogenetic, evolutionary and biogeographical studies at the family, population, specific and higher taxonomic levels including molecular aspects of microbes, mushrooms and flowering plants. To achieve these objectives, the research activities are focused theme –wise such as i) floristic studies and biodiversity evaluation of ecologically sensitive areas of Westerns Ghats, ii) survey, documentation and analysis of plant resources for sustainable utilization, iii) assessment of threat status of 'Red listed' species, iv) reproductive biology/ecology and ecosystem assessment, v) restoration biology etc. The division also co-ordinated Lead Garden programmes at national level with financial assistance from MoEF, Govt. of India in recognition of our expertise.

Eriocaulon kannurense Sunil, Ratheesh & Nandakumar

Survey, exploration and documentation of floristic wealth of Kerala was continued. 38 plant collection trips were conducted to different regions of Kerala, Tamil Nadu and Karnataka. A total of 6853 herbarium specimens of 1167 species were collected during the period 2012-13 and 7228 specimens belonging to 1430 species during 2013-14. Two interesting specimens of *Antidesma* were collected from Chemunji hills of Agasthyamala Biosphere Reserve. After critical study, one was confirmed as *A. keralense* Chakrab. & Gang, a species which was erected based on the fruiting specimens collected by M. Mohanan in 1979. Thus the present collection has added additional information on flowering characters to the protologue of the species. The other specimen has turned out to be an undescribed one, which is in the process of publication. All the specimens were processed and identified with the help of various flora and compared with the authentic specimens deposited at MH, CALI and TBGT. *Goniothalamus keralensis* E. S. Santhosh Kumar, T. Shaju, P. E. Roy & G. Raj Kumar, *Syzygium dhaneshiana* M.K. Ratheesh Narayanan, S.M. Shareef & T. Shaju, *Memecylon ponmudianum* Sivu, N.S. Pradeep & Pandur., *M. waynadense* Sivu *et al*., *Sonerila veldkampii* M. K. Ratheesh Narayanan, T. Shaju & M. Sivadasan, *Syzygium palodense Shareef* S.M., E.S. Santhoshkumar & T. Shaju, *Impatiens jhonsiana* Ratheesh Narayanan *et al*. and *Memecylon wayanadense* Sivu A.R., N.S. Pradeep & A.G. Pandurangan were described as new species. *Henckelia macrostachya* (E. Barnes) A. Weber & B.L. Burtt, *H. lyrata* (Wight) A. Weber & B.L. Burtt, *Memecylon flavascence* Gamble and *M. lawsonii* Gamble were rediscovered after the type. *Cyperus surinamensis* Rottb. was recorded for the first time from India. *Cyperus papyrus* L., was a new record for the Western Ghats. *Memecylon clarkeanum Cogn., M. parvifolium Thw., M. procerum Thw.* and *M. wightii Thw.* were new records for Peninsular India. *Koilodepas calycinum* Bedd. and *Canscora stricta* Sedgw. were reported for the first time from Kerala.

As part of the **Taxonomic studies of the climbing flora of Kerala state**, 6 collection trips were conducted and 310 specimens belonging to 63 species representing 8 families were collected. Important among them were *Ampelocissus indica* (L.) Planchon, *Asparagus gonoclados* Baker, *Cansjera rheedii* J. Gmelin, *Capparis sepiaria* L., *Derris trifoliata* Lour., *Dioscorea wightii* Hook. f., *Elaeagnus kologa* Schlecht, *Grewia orientalis* L., *Luvunga eleutherandra* Dalz., *Merremia vitifolia* (Burm. f.) Hallier. f., *Piper hymenophyllum* Miq., *Rubus micropetalus* Gardner, *Sarcostigma kleinii* Wight & Arn., *Solanum seaforthianum* Andrews, *Trichosanthes bracteata* (Lam.) Voigt., *Tylophora tetrapetala* (Dennst.) Suresh and *Ventilago bombaiensis* Dalz. All the specimens were prepared for herbarium, identified and incorporated into the existing collections.

a & b. *Memecylon clarkeanum* Cogn.; c. *Koilodepas calycinum* Bedd.; d. *Memecylon ponmudianum* Sivu, N. S. Pradeep & Pandur.

Taxonomic studies of the family Gentianaceae in southern Western Ghats was initiated to assess species diversity occurring in the study area based on fresh collections. Regional and national herbaria such as CALI, BSI and

a. Exacum. tetragonum Roxb.;b. *E. wightianum* Arn.

M.S. Swaminathan Research Foundation, Wayanad were visited and data regarding distribution, phenology, rarity etc. were collected. Ten plant collection trips were conducted to different forest localities in the study area which resulted in the collection of 250 specimens belonging to 16 species along with their photographs and other relevant field data. The specimens were processed for herbarium, studied critically and their taxonomic identities were determined based on the literature and with the authentic specimens deposited in Madras Herbarium (MH) Coimbatore. In addition, detailed descriptions, illustrations, distribution aspects, associated species and other relevant notes were prepared. The important species collected include *Canscora bhattiana* Prasad & K.S. Ravi*, C. diffusa* (Vahl) R.Br. ex Roem. & Schultes, *C. heteroclita* (L.) Gilg, *C. perfoliata* Lam., *C. roxburghii* Arn. ex Miq., *C. stricta* Sedgw., *Enicostemma axillare* (L.) Raynal, *E. pumilum* Griseb., *Exacum courtallense var. boneccordensis* M. Mohanan, *E. sessile* L., *E. tetragonum* Roxb., *E. wightianum* Arn., *E. wightianum* Arn. var. *uniflorum* Henry & Swamin., *Gentiana pedicellata* var. *wightii* Kusn*., Hoppea dichotoma* Willd*, H. fastigiata* (Griseb.) C.B. Clarke, Swertia *beddomei* C.B. Clarke, *S. corymbosa* (Griseb.) and *S. lawii* (Wight ex C.B. Cl.) Burkill. The species *Canscora stricta* Sedgw., hitherto known only from Karnataka, forms an addition to the Flora of Kerala.

Taxonomic studies on the family Asclepiadaceae R. Br. of Southern Western Ghats was continued. 52 specimens representing 13 species were collected, processed and taxonomic identity established. In addition, illustrations, detailed descriptions and other relevant notes were completed for 75 species and the work is being continued. Important collections include *Ceropegia bulbosa* Roxb. var. *bulbosa*, *Cynanchum tunicatum* (Retz.) Alston, *Hemidesmus indicus* var. *pubescens* (Wight & Arn.) Hook. f., *Hoya retusa* Dalz., *Tylophora mollissima* Wallich ex Wight & Arn., *Sarcostemma viminale* (L.) R.Br. 150 specimens of Asclepiadaceae were incorporated in to the existing herbarium -TBGT.

Under **Taxonomic studies of the genus Cinnamomum Schaeffer**, 365 specimens of *Cinnamomum* were collected from different regions of southern Western Ghats. The important collections are *C. chemungianum* Mohanan & Henry*, C. filipedicellatum* Kosterm*., C. keralense* Kosterm., *C. malabatrum* (Burm. f.) Blume, *C. palghatensis* Gangop*., C. perrottettii* Meissn*., C. sulphuratum* Nees, *C. verum* J. S. Presl and *C. wightii* Meissn. All the specimens were identified by cross matching with the authentic

Cinnamomum macrocarpum Hook. f.

a. *S. grandiflora* R. Br. ex Wight & Arn.; b. *S. wallichii* Bennet.

specimens deposited in Madras Herbarium (MH), Coimbatore and Calicut University Herbarium (CALI). As part of *ex-situ* conservation, 370 seedlings representing 8 species were collected and introduced in the field gene bank and their growth performance is being assessed. Air-layering of 4 species were carried out in their respective habitats and are being monitored at regular intervals. The live collections made during the period include *Cinnamomum filipedicellatum* Kosterm., *C. keralense* Kosterm., *C. litseaefolium* Thw., *C. macrocarpum* Hook.f., *C. malabatrum* (Burm.f.) Blume, *C. palghatensis* Gangop., *C. perrottetii* Meissner, *C. sulphuratum Nees, C. verum* J.S. Presl etc.

Taxonomic studies on the genus *Sonerila* Roxb. in Western Ghats was continued. The genus has about 175 species distributed mainly in tropical Asia. In India, it is represented by 35 species of which 30 species and two varieties are distributed in Western Ghats. Out of this 22 are endemics, 10 of which are included under RET category. 25 species were so far collected and illustrations and detailed taxonomic descriptions were completed. In addition, one new variety of *Sonerila rheedii* and a new sub species of *Sonerila zeylanica* were also collected. Some of the interesting collections are *S. barnessii* Fischer, *S. brunonis* Wight. & Arn., *S. devicolamensis* Nayar, *S. grandiflora* R. Br. ex Wight & Arn., S. *pedunculosa* Thwaites, *S. nemakadenis* Fischer, *S. pulneyensis* Gamble, *S. rheedii* Wallich ex Wight & Arn., *S. rotundifolia* Bedd., *S. sadasivanii Nayar*, *S. sahyadrica* Zanker, *S. tinneveliensis* Fischer, *S. versicolor* var. *axillaris* (Wight) Gamble, *S. veldkampii* Ratheesh Narayanan *et al*., *S. wallichii* Bennet and *S. wynaadensis* Nayar.

The study on Inventory, Systematics and Conservation of the family Annonaceae of Southern Western Ghats with emphasis on Endemic, RET Plants was aimed at documenting the species diversity and richness of the family Annonaceae in the Southern Western Ghats to understand their distributional ranges, phytogeography, threat status etc. Annonaceae is considered as a primitive family which had been evolved from the Magnoliaceous line of evolution. It has about 1220 species distributed world over in tropical and subtropical forests. In India, the family is represented by 129 spp., of which nearly 60% are endemics. The family, on account of its high degree

Miliusa wightana Hook. f. & Thoms

of endemism and evolutionary significance, has attracted much attention among the scientific community. An in-depth study of the family will result in generating much more interesting information on systematics, distribution, rarity, endemicity, phenology, herbivory, ecology etc. The study resulted in collection of 200 specimens belonging to 22 species under 8 genera from different regions of Kerala and Tamil Nadu of Southern Western Ghats. Among them, 16 species are grown in the *ex- situ* field conservatories that were raised through seed collection and by conventional propagation. The study also focuses on conserving endemic and RET species through seed bank, arboretum, as part of *ex-situ* conservation.

Studies on the status report of RET species of Western Ghats was taken up to prepare an accurate list of RET species of Western Ghats, with the baseline information on the species concerned and assessing their threat status following IUCN norms and suggesting measures for their conservation both by *in-situ* and *ex-situ* means. IUCN (2010) has estimated that nearly 33418 species of flowering plants around the world comes under threatened category. Our study has identified 900 angiosperm species as threatened taxa from the Western Ghats region based on extensive field surveys, thorough screening of available literature and visiting major herbaria of Southern India. In addition, passport data of individual species including recent botanical name, habit, habitat, altitudinal range, flowering- fruiting season, distribution/ area of occupancy, threat status etc. are being prepared. The family wise representation of the RET species in the Western Ghats region as evident from the study was also prepared. Among the 900 species, 188 are trees, 174 shrubs, 422 herbs, 66 shrub climbers, 37 herbaceous climbers and 13 are woody climbers. It was also observed that 727 species are endemic exclusively to the Western Ghats region and the remaining 173 are non-endemic but with narrow distribution. Of the 727 endemic species, 96 species are exclusively endemic to the Kerala region. Among 900 RET species, 23 are presumed to be extinct as there is no record of occurrence or collection in the last 100 years, 93 are critically endangered, 170 are endangered, 207 are

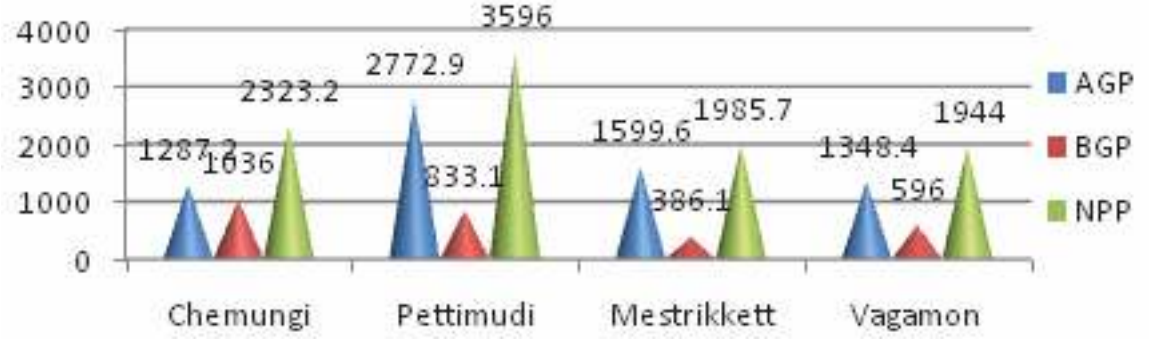
a. *Memecylon heyneanum* Benth. ex Wight & Arn. b. *Shorea roxburghii* G. Don

Cyperus papyrus L.

vulnerable, 359 are rare and for the remaining 48 species, data are insufficient for including in any of these categories. Hence they are included in the 'insufficiently known' category.

Systematics and Phytogeographic Evaluation of Grasses and Sedges in Nilgiri Biosphere Reserve is being carried out to analyze the floristic composition, distribution status and development of conservation strategies of grasses and sedges in Nilgiri Biosphere. Special attempts were made to locate the endemic, rare and endangered, economically important species such as wild relatives of cereals, millets and other cultivated crops. Field trips were conducted to different regions of Nilgiri Biosphere Reserve covering all the seasons from 300 – 2690 m which resulted in the collection of 4,730 specimens of grasses and sedges. A total of 316 species of grasses including 21 varieties in 115 genera and 148 species of sedges (including 3 subspecies and 18 varieties) in 21 genera were identified. Among the collection, *Chrysopogon asper* Blatt. & McCann, *Indopoa paupercula* (Stapf) Bor, *Tripogon capillatus* Jaub. & Spach, *Dimeria borii* Sreekumar *et al,* *Sporobolus tenuissimus* (Schrank) Kuntze., *Cyperus digitatus var. khasianus (Clarke) Kern., Cyperus rubicundus* Vahl*, Fimbristylis dura* (Zoll. & Moritz ex Moritz) Merr., *Fimbristylis woodrowii* Clarke, *Kyllinga brevifolia* var. *stellulata* (Valck. – Sur.) Ohwi form new additions to NBR. The study delimited Andropogoneae and Cypereae as the dominant tribes in grasses and sedges respectively by comprising 37 and 7 genera each. The dominant genera of grasses were *Eragrostis* with 16 spp. followed by *Arundinella* (13), *Ischaemum* (12), *Panicum* (11) and *Isachne* (10). The dominant genera in sedges were *Cyperus* (37), *Fimbristylis* (33) and *Carex* (26). The study added additional information on distribution of 74 grasses and 40 sedges to the NBR out of which 66 grasses and 34 sedges were naturally occurring but overlooked by earlier researchers. The study identified that 20 grasses found in NBR are endemic to Western Ghats, out of which 14 species were strictly endemic to NBR alone. In the case of sedges, 14 species endemic to Western Ghats were collected, among which 7 were strictly endemic to NBR. The high degree of endemism in this area points out the

Fig.1. Bar diagram showing the biomass productivity of study areas



All values are expressed in gm/m^2

Table 1. The species ratio of study sites

Sl. no.	Site	By number			By mass		
		Grass	Non grass	Ratio	Grass	Non grass	Ratio
1	Chemungi	3	6	0.50	1636.8	338.4	4.83
2	Pettimudi	5	9	0.55	1698.1	731.6	2.32
3	Mestrikkett	4	5	0.80	1146.6	453	2.53
4	Vagamon	5	9	0.55	1447.4	208.1	6.95

Table 2. The characteristic features of soil

Sl. no	Sites	Moisture content	Moisture %	p^H	Conductivity	Hygro-scopic coefficient	Wilting %	Max. Water holding capacity (%)	Field capacity (%)	Available water (%)
1	Pettimudi	32.6	42.95	4.84	0.125	8.4	5.75	110	67	61.22
2	Mestrikkett	31.8	47.33	5.08	0.151	10.5	7.12	124.7	83.8	76.5
3	Vagamon	15.6	23.94	4.75	0.12	7.6	5.11	71.36	58.8	53.6
4	Chemungi	24.5	33.36	5.05	0.1	2.88	1.95	65.8	46.08	44.12

Average values in W/V %.

relevance and importance of the study from both conservation and ecological point of view. Both these groups are growing abundantly and form a major part of herbage for grazing of both wild and domesticated animals. About 78 % of grasses and 26 % of sedges have fodder value. 750 specimens were ready for incorporation in to the herbarium of Jawaharlal Nehru Tropical Botanic Garden and Research Institute (TBGT). A comprehensive monograph including identification keys, detailed nomenclature, taxonomic descriptions, photographs, illustrations, phenology, distributions and other relevant notes of both grasses and sedges are under preparation.

Studies on Floristic, ecologic and functional dynamics of selected grasslands of the Western Ghats was undertaken to assess the floristic wealth, to understand ecological and edaphological functioning of the ecosystem and to estimate net primary productivity of montane grasslands above 1500 m, in selected areas such as Chemunji Hills, Munnar and Chembra. This unique ecosystem supports a large number of faunal elements and thus plays a pivotal role in energy balance of nearby forest ecosystems. The studies were carried out by bimonthly field exploration for floristic survey and quantitative inventory of grasslands. The ecological and productivity studies in Chemungi, Eravikulam National Park (Pettimudi), ENP (Mestrikkett), and Vagamon were conducted through transect method after sampling. The study areas are diverse in floristic components and general and physical edaphology. The type of vegetation and dominant species vary in different sites and frequently noticed types were *Ischaemum–Eulalia,-Chrisopogon-Arundinella, Eulalia-Andropogon, Cymbopogon–Ischaemum.* The major deciding factors are altitude, soil type, stage of succession, occurrence of fire, grazing (domestic and wild) and the anthropogenic pressure which plays a key role in the ecological functioning and productivity of these ecosystems (Table 1). Even though the grasslands are

showing average biomass accumulation of 1944 gm/m^2 to 3596 gm/m^2, the productivity and biomass turnover are also dependant on the above factors (Fig. 1). The analysis of soil samples that were collected from the respective sites indicates that the biological, chemical and physical characters are also site specific. The soil is acidic with high percentage of total soluble salt. Hydrological properties are also commendable for protecting the microbial wealth and conserving rainwater. The indicated water regime throughout the year is progressive and positive. (Table. 2) Hence these ecosystems are very vital in protecting wildlife, conserving water and keeping environmental equilibrium.

As part of the programme of Taxonomic evaluation of exclusive endemic angiosperms of Kerala, the Division taxonomically evaluated 267 endemic taxa exclusively for Kerala in 11 endemic belts represented from sea coast to highlands. 24 endemics were known only from type that was not so far relocated. Therefore, efforts were made to locate these endemics. Collection trips were conducted to the areas where more number of

Jawaharlal Nehru Tropical Botanic Garden and Research Institute

endemics occur such as Eravikulam National Park and Chinnar Wildlife Sanctuary in Idukki district and Agasthyamala Biosphere Reserve, Kerala region in Thiruvananthapuram and Kollam districts. A total of 175 specimens of 65 endemic and IUCN red list category species were collected, processed and identified. The important endemics collected during the period include *Ophiorrhiza brunonis* var. *johnsonii* Hook.f., *Sonerila barnesii* C.E.C. Fischer, *Aporusa bourdillonii* Stapf., *Eugenea argentea* Bedd., *Arisaema psittacus* Barnes, *Buchanania barberi* Gamble etc. Other endemics such as *Syzigium bourdillonii* (Gamble) Rathakr. & N.C. Nair, *Litsea beei* Mohanan & Santhosh., *Memecylon agasthyamalayanum* Santhosh et al., *Ophiorrhiza brunonis var. johnsonii* Hook.f., *Impatiens stocksii* Hook. f. & Thoms. etc. were also collected and processed for herbarium voucher specimens. The important Red List category species collected during the study include *Hopea erosa* (Bedd.) Slooten, *Impatiens elegans* Bedd., *Lasianthus blumeanus* Bedd., *Litsea beddomei* Hook. f., *Shorea roxburghii* G. Don, *Pogostemon travancoricus* Bedd., *Premna paucinervis* (Clarke) Gamble, *Psychotria macrocarpa* Hook. f., *Memecylon heyneanum* Benth. ex Wight & Arn.,

Chemunji Hills, Agasthyamala Biosphere Reserve

a. Henckelia macrostachya (E. Barnes) A. Weber & B.L. Burtt; b. *Parasopubia hofmannii* Pradeep & Pramod; c & d. *Sonerila veldkampii* Ratheesh Narayanan *et al*.

Syzygium densiflorum Wall. ex Wight & Arn., *S. occidentalis* (Bourd.) Gandhi, *S. rama-varmae* (Bourd.) Chithra, *Zenkeria sebastinei* Henry & Chandrb. As per the suggestions of the Research Council, geographical co-ordinates of 24 more endemic species from Ponmudi and Chandanathode forest areas of Thiruvananthapuram and Wayanad districts were completed.

Henckelia macrostachya (E. Barnes) A. Weber & B.L. Burtt, a possibily extinct species (Gesneriaceae), was collected from the type locality after a long gap of 75 years. Barnes (1938) had described the species as *Didymocarpus macrostschya* Barnes, based on his collection bearing No.1264, 1266 (Type, K) from the High Range of erstwhile Travancore during the year 1938. The species is known only from this single locality, *viz*. Ottaparai Ridge, lying at an altitude of 5500 ft., near Munnar. The species was recorded as "possibly extinct" by Nayar & Sastry (1997) which signifies its conservation importance.

Four new species, *Sonerila veldkampii*, *Goniothalamus keralensis*, *Syzygium palodense* and *Memecylon wayanadense* were described from Kerala. *Lagenandra nairii* Ramam. & Rajan, a local endemic species, known only from type locality with restricted distribution along the water-logged areas of the downstream of Athirappally water falls in Thrissur district was relocated from Thusaragiri water falls area of Kozhikkodu district and this forms a new distributional record. Likewise, *Impatiens minae* Ratheesh Narayanan *et al.* – hitherto known only from the type locality, Chembra Peak (c.1600 m) in Wayanad district, was relocated from the high altitude region of Anamalai, Pettimudi (c. 1800 m) of Idukki district which is another extended distributional record.

Collection of some local endemic (distribution < 5 sq. km.) species like *Habeneria roxburghii* Nicolson, *Humboldtia brunonis* Wall var. *raktapushpa* Udayan *et al*. (Fabaceae), *Ixora sivarajanii* Pradeep (Rubiaceae), *Leucas beddomei* (Hook. f.) Sunoj *et al.* (Lamiaceae), *Eugenia argentea* Bedd.

Drosera indica L.

a. *Puthuvypin - Vembanad* Wetland (Ramsar Site), Ernakulam District, Kerala; b. *Bruguiera cylindrica* (L) Blume; c. *Bruguiera gymnorrhiza* (L) Savigny; d. *Sonneratia caseolaris* (L.) Engl.

(Myrtaceae) have enriched the herbarium and also is significant from their conservation point of view.

A study was initiated on the mangroves of Puthuvypin - Vembanad Wetland (Ramsar Site), Ernakulam District, Kerala, to evaluate species abundance and diversity of true mangroves and associated species as these mangrove patches in Kerala had diminished in their extent drastically and had acquired a threatened status. Puthuvypin is the single largest stretch of mangrove vegetation (c.101 Ha) in Kerala coming under Vemband Wetland (Ramsar Site) ecosystem in Ernakulam district. This unique vegetation with their specialized ecological characteristics creates a suitable habitat for both flora and fauna. But ironically, more than 23 acres of this fragile ecosystem coming under Coastal Regulation Zone - 1 (CRZ-1) has been transformed into an industrial hub. Preliminary study revealed that there remained only are 12 true mangroves and 21 mangrove associated species out of the15 mangroves and 49 mangrove associates reported earlier. About 175 herbarium specimens were processed, identified and incorporated into the herbarium.

The project on Germplasm Documentation, Evaluation, *Ex-situ* Conservation and Popularization of Local Mango Varieties in Kerala was aimed at producing sufficient quantities of planting materials of the promising types for cultivation and thus conserving the fast depleting wild mango varieties with a view to tap the potential of their genetic resources for future breeding programmes. 84 local mango varieties were collected, identified and plus trees were marked for further evaluation. The voucher specimens were processed for future studies. The seeds in bulk quantities were collected for propagation. A humidity controlled chamber was constructed in the mango conservatory.

Local Mango varieties of Kerala: a. Kalkanda varikka; b. Kolambi; c. Mayipeeli; d. Njettukuzhiyan; e. Vellari; f. A view of Mango Nursery.

Morphometric analysis of the fruits and seeds of 33 varieties was completed, differences recorded and the data processed for further studies. Even though 40,000 seeds were collected from the field, we could raise seedlings of 50% only because of continuous and intermittent rain and wild boar attack. The rescued seedlings have been nurtured well in the mango conservatory of JNTBGRI. Simultaneously *ex-situ* conservation of the local mango varieties is currently progressing in the 5 hectares of area allotted for the

project in the garden site. In addition, market surveys were also conducted and analysed to find out the diversity of the value added products made out of local mango varieties in the State and the seasonal influx of diverse varieties of mangoes in the local markets.

Survey, inventory and sustainable evaluation of mushrooms of Western Ghats

The Indian subcontinent is known worldwide for its varied agro-ecological characteristics and rich biodiversity of flora and fauna. Kerala, floristically the richest state, provides a wide variety of habitats for the luxuriant growth of fungi. But the mushroom diversity today is facing the threat of being lost forever owing to the fast and continuing decline in their habitats due to population explosion and developmental activities. For any meaningful conservation exercise to succeed, the primary emphasis should obviously be on the assessment of the bio-diversity based on survey, collection and identification. With this view, three major research programmes were undertaken to evaluate the macro-fungal wealth of Kerala. The main objectives of these programmes were to recognize the lesser known wild edible mushrooms of Kerala; to develop cultivation protocols for the promising edible ones and to establish a regional reference centre for mushrooms.

The study on Wild edible mushrooms of Kerala was aimed at collecting and documenting the common and lesser known wild edible mushrooms of Kerala forests so that they can be safely gathered and utilized without ill effects by the local people who gather them for food. The study listed 85 taxa of wild edible mushrooms from Kerala representing 25 genera under 13 families. Important among these are the three promising giant mushroom species - *Pleurotus giganteus* (Berk.) Karunarathna & K.D. Hyde, *Macrocybe lobayensis*(R. Heim), Pegler & Lodge and *Macrocybe titans* (H.E. Bigelow & Kimbr.) Pegler, Lodge & Nakasone.

As part of the programme Inventory, documentation and development of cultivation protocol for the lesser known wild edible mushrooms of Kerala, extensive field collection trips were conducted to various forest localities of Kerala to collect germplasm of wild edible mushrooms. Altogether 427 individual collections were made from the forests of Wayanad, Nilambur, Kozhikode, Thenmala, Kulathupuzha, Kallar, Ponmudi, Palode and JNTBGRI campus. Out of these, 11 species belonged to the edible category. Wild edible species collected were used for developing pure cultures in different media such as PDA, MEA, CDA, YEA, YEGA & PMA under aseptic conditions. All the 11 species responded well in these media. All the pure cultures are maintained at JNTBGRI and part of them were deposited at MTCC, Chandigarh. Spawn was successfully developed from pure cultures of these wild edible species and cultivation trials of *Agaricus squamuliferus* (F.H. Moller) Pilat*, Oudemansiella canarii* (Fungh.) Hohn.*, Lentinus squarrosulus* Mont.*, Pleurotus giganteus*(Berk.) Karunarathna & K.D. Hyde *, Macrocybe lobayensis* (R. Heim), Pegler & Lodge*,*

a. *Entoloma brunneocarnosum* Pradeep & Vrinda; b. *E. brunneopapillanum* Pradeep & Vrinda

a. *Entoloma brunneosquamulosum* Pradeep & Vrinda;
b. *E. griseolimosum* Pradeep & Vrinda

Macrocybe titans (H.E. Bigelow & Kimbr.) Pegler, Lodge & Nakasone and *Schizophyllum commune Fr.* ex Fr., using different substrata such as saw dust, paddy straw, sugarcane bagasse, wood shavings, soft wood peeling, soft wood logs etc., under normal conditions are being carried out in the laboratory.

Mushroom Herbarium

During the reporting period, 790 collections representing 53 genera under 16 families were collected, studied and processed for the herbarium. A mushroom herbarium with 14,917 specimens is being maintained at JNTBGRI. All materials of a particular collection is most appropriately kept in a packet of standard size made from good quality brown paper or a zip cover made of good quality plastic. Many collections are duplicates of the same material collected either from the same locality on different days or collected from different localities on the same day. Each specimen is given a herbarium accession number which is unique to that particular collection. Detailed morphological data of each specimen in the herbarium is available from the data books arranged systematically in the laboratory. All the herbarium specimens are stored under controlled climatic conditions to avoid the attack of moulds and mites.

Biotechnological Interventions for Conservation and utilization of forest resources. [Component - 1: Population Structure and Dynamics of *Lagerstroemia speciosa* (L.) Pers.

A network project is being implemented with the financial support of DBT, Govt. of India. Apart from JNTBGRI, University of Agricultural Sciences, Bangalore and Natural Remedies Pvt. Ltd., Bangalore are the collaborating centers.

The candidate species *Lagerstroemia speciosa* is a deciduous element showing tolerance to drought and heat during summer and humidity during monsoon. The plant shows a wide range of pH tolerance, soil types from mostly sandy to clay, a water range from dry to moist etc. The tree is a potential source of Corosolic acid, which is known for its anti-diabetic activity. The plants also possess anti-inflammatory and anti-cancer activity. Against this background, the DBT sanctioned a three year multi-institutional project to identify genetic variability and high yielding genotypes of *L. speciosa* for Corosolic acid by analyzing various populations in Kerala and also to study population structure and dynamics to understand the ecological requirements for implementing suitable *in situ* and *ex situ* conservation measures for sustainable utilization of the species. Accordingly, the Division was entrusted to work on the distribution pattern and reproductive ecology of the species.

Periodic field visits were conducted for understanding the population dynamics of the species including various reproductive attributes. A phenological calendar of the species was prepared based on the repeated field observations at the permanently marked populations across the State. Viable populations at 10 sites across Western Ghats of Kerala portion was located and population structure of all the 10 sites were worked out.

Around 45 accessions were collected from 10 sites

and subjected to genetic diversity analysis using SSR markers. Samples were also provided to Natural Remedies, Bangalore for Corosolic acid content estimation. The study team was able to identify an accession from Malappuram district of Kerala with Corosolic acid content of 0.868 % w/w which is more than any other known populations in the entire Western Ghats.

As part of the mass multiplication of the identified elite clone, air layering was done in the accession of the population at Chaliarmukku, Malappuram. The layerings were found to fail to develop roots during summer season and developed callus. Around 80 days were needed for the rooting of layerages during monsoon period bypassing callus stage. However the establishment rate of the layerages in pots was found to be low due to the lack of active buds. The trials are being continued for fine tuning the air layering with the objective of developing a stock of viable clones.

Lead Garden Programme

The Ministry of Environment and Forests, Govt. of India has recognized JNTBGRI as Lead Garden and extended financial support to develop infrastructure to meet the Global Target set out by BGCI for conserving RET species, promoting Eco-Education and to develop conservation strategies for restoration. Under this programme, an RET Species Park was developed for *ex situ* conservation of extinction prone species and such a collection will act as a gene sanctuary for future restoration programmes. The park was developed in a 6 acre plot with well laid out landscape and irrigation facilities. 677 seedlings of 150 specimens are already being conserved. In addition to this, 834 seedlings belonging to 41 species were further planted. Post planting care and other practices are being regularly carried out.

As part of the development of conservatories, a green house and a shade house are being constructed which will enhance the capacity for propagating the RET species. The park has been made clean and tidy throughout the period by proper weeding, grass trimming, hedge clipping, watering, summer mulching, wild animal protection etc. and is open to visitors throughout the year.

Herbarium Management and Development

The herbarium section processed 7228 specimens representing 1372 species during the period. About 2352 specimens were incorporated to the existing herbarium. In addition, over 283 enquiries were attended to on identification, certification, processing techniques etc. The Travancore Herbarium contains about 2000 specimens which were rearranged in the first floor of the herbarium.

The Survey conducted for enrichment of the herbarium has led to the collection of many rare species and form new additions to the herbarium. The important collections include *Henckelia macrostachya* (Barnes) A. Weber & B. L. Burtt, *Hopea erosa* (Bedd.) Slooten, *Impatiens elegans* Bedd., *Impatiens johnii* Barnes, *Lasianthus blumeanus* Bedd., *Litsea beddomei* Hook.f., *Memecylon heyneanum* Benth. Ex Wight & Arn., *Shorea roxburghii* G.Don, *Premna paucinervis* (Clarke) Gamble, *Piper pseudonigram* Velaydhan & Amal, *Psychotria macrocarpa* Hook.f., *Pogostemon travancoricus* Bedd., *Syzygium bourdillonii* (Gamble) Rathkr. & N.C.Nair, *Syzygium densiflorum* Wall. ex Wight & Arn., *Syzygium myhendrae* (Bedd. ex Brandis) Gamble, *Syzygium rama-varmae* (Bourd.) Chithra, *Zenkeria sebastinei* Henry & Chandrb. etc.

	The present status of the herbarium		
1	Specimens in the herbarium as on March 2014	:	25580
2	Specimens processed	:	7228
3	Species represented	:	1372
4	Mounted for filing	:	2300
5	Unmounted for reference	:	4928
6	Specimens incorporated	:	1992
7	Nomenclature corrections carried out	:	230
8	Specimens received for incorporation	:	2400
9	Identification and labeling	:	1640
10	Indexing of General Herbarium specimens	:	1992
11	Sheets renovated	:	470
12	Enquiries attended	:	800
13	Species additions to herbarium	:	205
14	Genus addition to herbarium	:	30
15	Sheets fumigated		25580

Division of Microbiology

Microbial Bioprospecting

Isolation and cloning of keratinolytic serine protease and antifungal chitinase genes

The keratinases have high activity for insoluble protein substrates such as keratin. The strain *Streptomyces* sp S13A5 which has strong hydrolysis activity on bird feathers was reported. A keratinolytic serine protease designated S13ap was partially purified and some enzymatic properties were examined. S13 ap has an approximate molecular weight of 30 kDa and the optimum pH and temperature for keratinolytic activity was found to be 9.0 and 70^{0}C respectively. Isolation and cloning of keratinase genes are essential to ensure improved enzyme yields for commercialization. In addition, nucleotide sequences serve as a prelude to phylogenetic analysis of enzymes and assist in deciphering structure function relationships. In view of the industrial interest in these enzymes, methods that involve recombinant DNA technology and genetic engineering has been developed to explore their potential.

Bacterial strains, plasmids and growth conditions: *Streptomyces sp S13A5* with high feather degrading activity was grown in Sabouraud's dextrose broth . *Escherichia coli* DH 5α was grown in Luria – Bertani (LB) broth or agar. Whenever needed, the medium was supplemented with ampicillin (100 mg/ml) or kanamycin (50 mg/ml). T4 DNA ligase and all restriction enzymes were purchased from NEB. Plasmid vectors like pGEMT, pXcm kn12 and pET 28a were used in the cloning and expression study. The primers used in this study are listed in Table 1.

Cloning and sequencing of 16s rDNA to identify the phylogeny: Genomic DNA from the selected isolate *Streptomyces* sp S13A5 was obtained by using bacterial genomic DNA extraction kit (Hi Media). The 16s rDNA gene was amplified by PCR using forward primer 27F and reverse primer 1495R. Amplified fragments were cloned on to pGEMT vector.

Cloning and expression of keratinase gene: Sequence homology studies of the keratinase gene available in GenBank indicate that they mostly belong to subtilisin family of serine proteases, sharing significant structural and sequence similarities (98%). Five forward primers and one reverse primer were designed for the present study. The thermal program used to amplify the sequence included one cycle with 5 min DNA denaturation at 95^{0}C, 35 cycles of 95^{0}C (45sec), 58^{0}C (45 sec) and 72^{0}C (2 min), plus one additional cycle with a final 7 min chain elongation at 72^{0}C.The PCR reaction mixture contained 10μM of each primer, 1X of amplification buffer, 25 mM dNTPs, and taq DNA polymerase in 25μl total volume. PCR reaction was

Primers	Sequence (5'- 3') of primers	Flanking site
Ker F1	5'-AAGAATTCAAGGCGGCCAAGATCGTCAGC-3'	Eco R I
Ker F2	5'-AAGAATTCATGAGCGTCGGGGGCGGC-3'	Eco R I
Ker F3	5'-AAGAATTCATGAGCCACGGCGACTTCGG-3'	Eco R I
Ker F 4	5'-AAGAATTCCTGGACCGGATCGACCAGCG-3'	Eco R I
Ker F 5	5'-AAGAATTCATGAGCGAGGAGAGGGCCG-3'	Eco R I
Ker R1	5'-AACTCGAGTTAGAACTGGAGCGACCAGG-3'	Xho I
SP6	5'-TATTTAGGTGACACTATAG-3'	
T7	5'-TAATACGACTCACTATAGGG-3'	

Table 1: Oligonucleotide primers used in this study

carried out in thermal cycler. Cloning of keratinase gene sequences is progressing.

Antifungal chitinase (Family-19 chitinase) is a potential enzyme with application in the biocontrol of fungal pathogens in agriculture and food grain storage. Two of our laboratory strains *Streptosporangium nondiastaticum* TBG75A20 and *Streptomyces clavifer* TBG-MNR13 are with promising antifungal properties. These strains were further screened for their fungal cell wall lytic enzymes (chitinase) using analysis of degrading colloidal chitin and fungal chitin. *S. nondiastaticum* was more potential and its chitinase gene was targeted by PCR technology using degenerative primers designed based on the conserved regions in actinobacterial family-19 chitinase genes.

Chitinase activity of *Streptosporangium nondiastaticum* TBG75A20: Primary screening for chitininolytic activity was done by inoculation of the organism in colloidal chitin agar medium containing 0.2% colloidal chitin. The plates were incubated at 27± 1˚C for a period of 3 days and stained using 0.2% Congo Red solution. The plates were then destained using 4M $NaCl_2$. A zone of clearance of 3 cm diameter was seen in colloidal chitin agar on 3rd day when stained with Congo Red (Fig. 1). The zone formation is due to the chitinolytic property of enzymes produced by the organism.

Genomic DNA isolation and PCR of Chi gene: Genomic DNA was extracted following the method of Murray and Thompson (1980). Four sets of primers were used for PCR basedchitinase gene amplification. The primers used are:

Positive results were obtained in PCR amplification of chitinase gene using 3 set of primers namely CHICF,CHICR; F19F2, F19R and FWCHI35, RVCHI35. Amplification using CHICF,CHICR primers gave 4 bands while F19F2, F19R and FWCHI35, RVCHI35 produced single bands. Primers CHI19F and CHI19R did not give any amplification. 16S rDNA amplification using the primers 27F and 1495R gave a single band (Fig. 2). The PCR products were resolved by AGE and individual bands were cut out and eluted by electro elusion using dialysis membrane. The purified DNA

Sl. No.	Primer	Sequence
1	CHICF	5`-AAGCTCGCSGCSTTCCTSGC-3`
	CHICR	5`-GCACTCGAGSGCGCCGTTGAT-3`
2	CHI19F	5`-TTGACCGAGTGGTCCAGACC-3`
	CHI19R	5`-GTGTGCTGCTCACGCCAG-3`
3	F19F2	5`-GCCTTCCTCGCCAACGTC-3`
	F19R	5`-CCGAGGATCTGGGTGTT-3`
4	FWCHI35	5`-CCCTGATGAATTCCGCTCCGGCTCAG-3`
	RVCHI35	5`-GCGGTGTCGCTCTCGAGAAGCGGATC-3`

PCR Program

PCR step	Temp. (˚C)		Time	Number of cycles
Initial denaturation	94		3 min	1
Denaturation	94		30 sec	
Annealing	CHICF, CHICR	54	30 sec	40
	CHI19F, CHI19R	54		
	F19F2, F19R	50		
	FWCHI35, RVCHI35	50		
	27F and 1495R	54		
Extension	72		1min 30sec	
Final extension	72		10	1
Hold	4		∞	

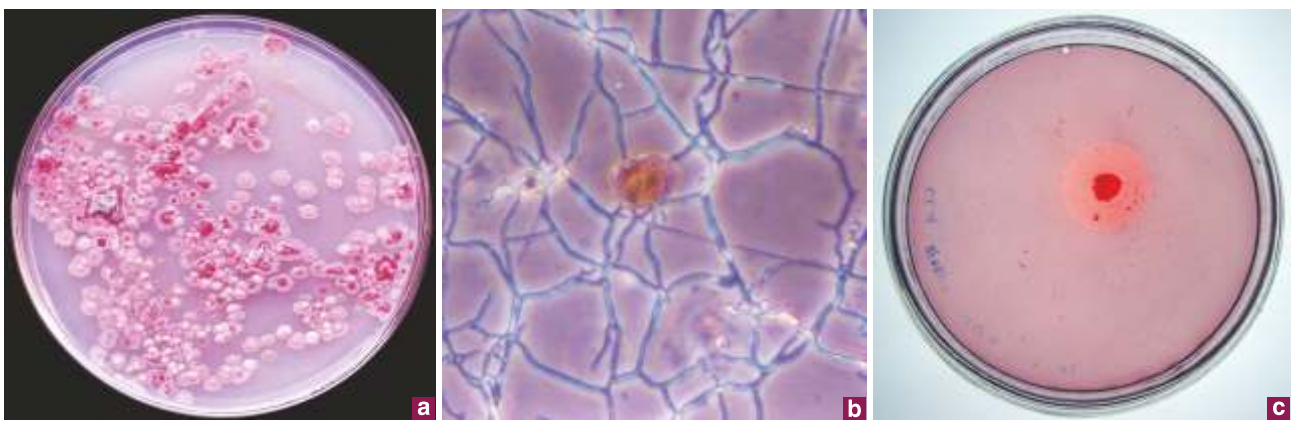


Fig. 1: a. Colony Morphology of *Streptosporangium nondiastaticum* TBG75A20; b. Microphograph showing Sporangium; c. Primary screening with chitinase activity

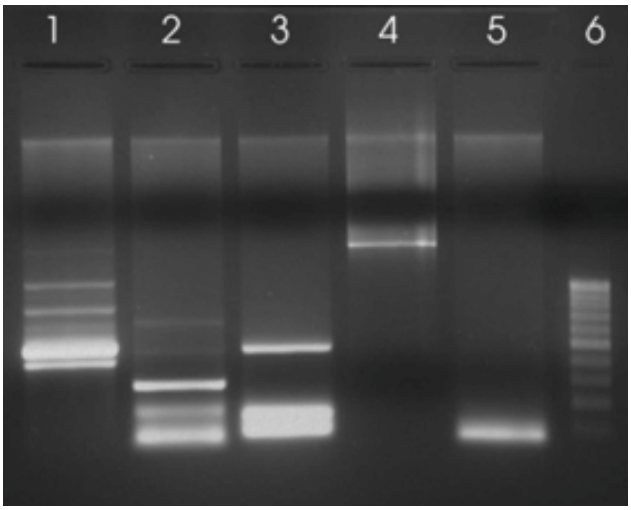


Fig. 2. AGE of PCR amplification of chi gene
1 - Chitinase gene amplification using primers CHICF and CHICR
2 - F19F2 and F19R
3 - FWCHI35 and RVCHI35

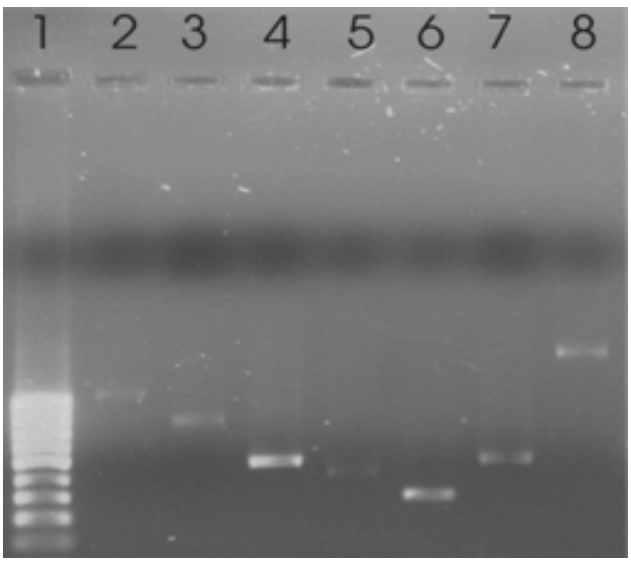


Fig. 3. AGE of purified samples
1 - 100bp DNA marker
2 - 1st band from top of CHICF and CHICR amplification
3 - 2nd band of CHICF, CHICR amplification
4 -3rd band of CHICF, CHICR amplification
5 - 4th band of CHICF, CHICR amplification

samples were resolved by AGE to check for purity (Fig. 3).

Studies on Fungal Tannase

Tannin acylhydrolase or tannase (E.C 3.1.1.20) is an inducible enzyme that catalyses the hydrolysis of ester bonds present in hydrolysable tannins and gallic acid esters. Tannase has wide range of applications especially in food, beverage and pharmaceutical industries.

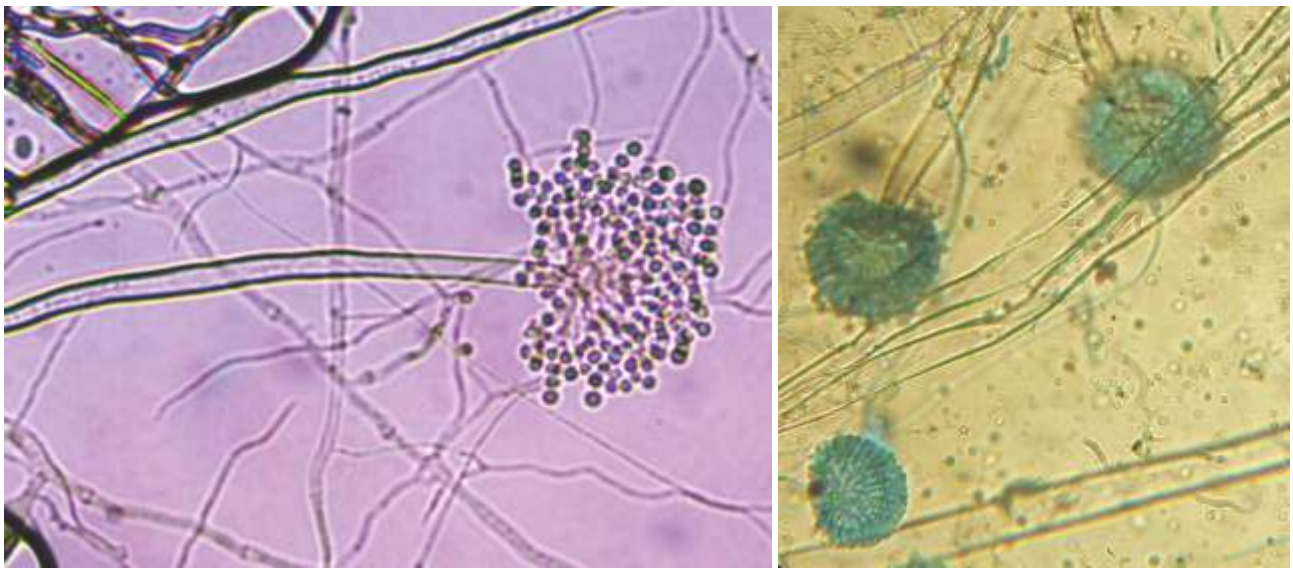
Confirmation of Tannase activity by Secondary Screening : The strains selected after primary screening were confirmed for their activity by secondary screening employing submerged culture technique using tannic acid as the carbon source. The tannase assay was determined based on the formation of chromogen between gallic acid (released by the action of tannase on methyl gallate and rhodanine (2-thio-4-ketothiazolidine). Five strains were selected by secondary screening and named as *Asp* TBG 20(a), 22(d), 24(b), 28 (a) and 30.

Molecular identification of selected strains: The strains were identified by extracting genomic DNA and PCR amplification and sequencing of ITS/18S rDNA region. Homology search was performed using BLAST search algorithm. Alignment of similar sequences was done using CLUSTALW software and the phylogenetic tree was constructed using MEGA4 software.

Improvement of Culture Conditions: Studies on the improvement of cultural conditions required for the production of tannase under submerged fermentation by the *Aspergillus* isolates were carried out in Czapek dox medium containing 1% (w/v) tannic acid, whereby the growth, and production of tannase under different cultural conditions were monitored at an interval of 24 h for 9 days. The results showed that maximal tannase production was achieved on the 4th and 5th days of incubation. After that the amount of tannase decreased considerably with increase in cultivation time. To determine the effect of initial medium pH on tannase production, the medium was adjusted to different pH levels (3-8). The results indicated that maximum tannase activity was observed at pH 4 & 5.

Strains *Asp* TBG 20 (a), 28 (a) and 30 showed maximum activity of 9.2, 8.39, 10.6 U/ml respectively at 30°C whereas the other two strains, *Asp* TBG 22 (d) and 24 (b) showed maximum activity of 8.8, 11.75 U/ml respectively at 35°C. The rapid growth of the fungal culture observed at temperatures between 30 and 35°C also suggested that the fungus is mesophilic. Therefore, temperatures of 40°C and above did not enhance its growth, as the growth of the microorganism may have adversely been affected by heat, while temperatures below 30°C may have resulted in freezing of the protoplasmic membrane which causes inactivation of solute transport systems in the cells. The variation in enzyme production with changes in temperature has also been due to denaturation of some of the heat sensitive biochemical products produced during fermentation and variation of dissolved oxygen tension in the medium with increasing temperatures.

To optimize the concentration of tannic acid required for maximum enzyme production the culture media



Microphotographs of Asp TBG 20 (a) and Asp TBG 22 (d)

were supplemented with tannic acid concentrations from (0.5 to 3%) and it was found that all the strains showed maximum production at a concentration of 1% beyond which there is a decrease in the level of enzyme synthesis. To determine whether any additional carbon source can increase the level of enzyme production, the culture media was supplemented with different carbon sources viz. Glucose, fructose, lactose, maltose, galactose, sucrose etc. Glucose showed an increase in enzyme activity. The results showed that small amounts of glucose can slightly increase the level of enzyme production. But high concentration can effectively decrease the amount of enzyme synthesis and increase the biomass content. This is because of the availability of a readymade carbon source for their growth and metabolic activity and there was no need for tannase mediated synthesis of glucose.

Thermostable Alpha amylase from Streptomyces setonii

The amylase family of enzymes is of great significance due to its wide range of potential application. Characterization and purification of amylase was the aim of this study. The amylase from *Streptomyces setonii* (TBGA19NRAI) was isolated from the forest soil of Neyyar WLS using starch as substrate. Optimal condition for amylase production was standardized earlier with an optimum substrate concentration (2%), incubation period (48 h) with pH 7. The best broth ingredient was found to be valine (0.3%) and Ammonium chloride (0.5%). It was also observed that 1% of casein showed maximum activity and 0.025% of $CaCl_2$ enhanced the production and stability of α-amylase in the medium. The effect of Triton X-100 (0.05%) and Mannitol (0.5%) in the medium improved the α-amylase yield. The enzyme was produced under optimized condition after 48 h of incubation. The crude enzyme was subjected to purification and characterization. The enzyme was purified by ammonium sulphate precipitation, dialysis on sephadex G-100 with specific activity of 6.9 units/ml/mg protein with 1.36 fold purification. Analyses of the enzyme for molecular mass was carried out by SDS-PAGE electrophoresis. Amylolytic activity of enzyme purification and characterization is in progress.

The nucleotide sequences of alpha amylase gene of the desired Streptomyces sp. had been retrieved from the NCBI in FASTA format. The nucleotide sequences so retrieved were subjected to multiple aligment using CLUSTAL W and the conserved regions were obtained. The primers were designed using the conserved regions with primer 3 tool.

Primers Designed

Forward Primer 3'-AGTTCGTCTTCCAGCCGG-5'
Reverse Primer 3'-CACAGGCCGAGACTCACC-5'

- Primers designed for the Amy gene of *S. griseus*
- Studies to analyse the efficiency of *S. griseus* to utilize different starch sources initiated.

Functional Analysis of Small Heat Shock Proteins from Streptomyces spp.

The sHSPs are molecular chaperones which protect cells exposed to stress, by preventing apoptosis induction and the irreversible aggregation of denaturing proteins through oligomer assembly and disassembly. Due to their role in stress tolerance, the study of sHSPs is important in understanding molecular, biochemical and physiological processes in both normal and

aberrant cells. The thermo-stability, disaggregation, and proteolysis inhibition functions of sHSPs can be harnessed for various applications, including agricultural, clinical, nano-biotechnology, proteomics, bio-production, and bio-separation. The research activities carried out under the programme are detailed below.

Organism	Primer	F/R	Sequence
S. albus	SAlbF	*Forward*	5'-ATG CTG ATG CGC ACT GAC-3'
	SAlbR	*Reverse*	5'-CTC GGT GTC GAG GGT GTC-3'
S. venezuelae	SVzF	*Forward*	5'-TCA GCC GGA GAT CTG CTT-3'
	SVzR	*Reverse*	5'-CAC TGA CCC CTT CCG TGA-3'
S. avermetilis	SAvetF	*Forward*	5'-ATG CGT ACC GAC CCT TTC-3'
	SAvetR:	*Reverse*	5'-GCT GAT CTC CTT GCG TTC-3'

Primers were designed to effect the PCR amplification of sHSP genes from the genomic DNA of *S. albus, S. avermitilis and S. venezuelae* using Primer-3 software.

The lyophilized cultures of *S. albus* (MTCC 1137) and *S. venezuelae* (MTCC 327) were grown in broth media recommended by MTCC. Total DNA of the organisms were isolated. Fig.1 shows the agarose gel (1%) electrophoresis of DNA of the organisms. The sHSPs from *S. albus* and *S. venezuelae* were amplified using a gradient PCR (50- 60 °C).

The amplified products were purified using PCR product cleaning kit (Quiagen). The PCR product was cloned into pGEMT easy vector and transformed to *E. coli* JM109. Positive clones were selected by antibiotic resistance and the plasmid was isolated by alkaline lysis method. The plasmid isolated was checked on 1% agarose gel (Fig.2) and the correct clones were picked up by increase in size.

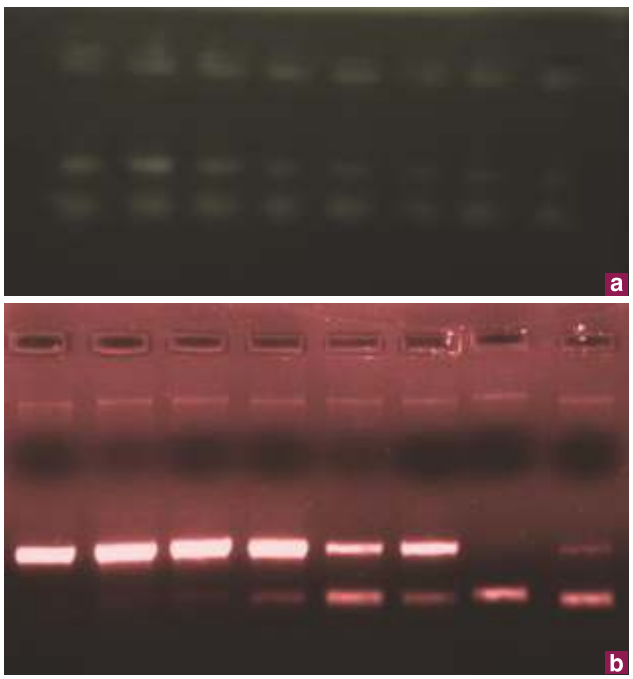


Fig.1. Agarose gel (1%) with PCR products a. *S. albus*; b. *S. venezuelae*.

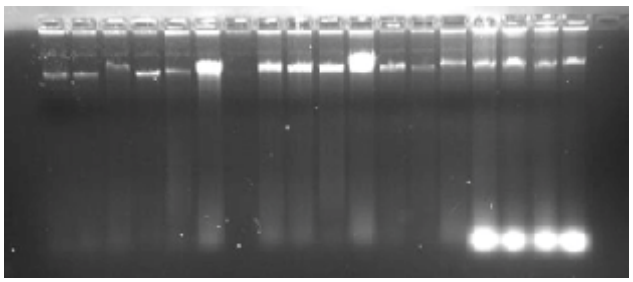


Fig.2. Agarose gel (1%) showing plasmid isolated (pGEMT +sHSP gene of *S. albus* and *S. venezuelae)*

The positive clones were further analysed by the restriction digestion of plasmid DNA by *Eco*RI. The positive clones releasing a 500bp fragment was selected for sequencing.

- Specific primers for sHSP genes were designed.
- sHSP genes of *Streptomyces albus* and *S. venezuelae* were PCR amplified and cloned in TA cloning vector.

Heterologous expression and analysis of small heat shock proteins

As a universal protective mechanism, all organisms undergo a rapid molecular response to adapt to harmful environmental conditions. During these events, a subset of heat shock proteins (HSPs) or stress proteins are synthesized. HSPs perform important functions in the folding and unfolding or translocation of proteins, as well as in the assembly and disassembly of protein complexes. Small heat shock proteins (sHSPs) have a molecular size range from 12 to 43 kDa and a conserved region called 'α–crystalline domain' in the C-terminal. Prevention of thermal inactivation of restriction enzymes using sHSPs (-crystallin) was demonstrated earlier. These studies open a possibility of utilizing the chaperone activities of small heat shock proteins in preserving heat sensitive enzymes. This study aims to employ site directed mutagenesis technique to create additions or deletions in amino acids of 18HSP and to dissect sHSP structure and function at molecular levels. This will help to resolve structural elements composed of single residues, peptides and three-dimensional motifs that influence sHSPs in chaperone activity. The active peptides with chaperonic effects can further be used as an enzyme stabilizer.

Purification of Recombinant HSP18 protein

Cultivation of *E. coli* M15[pREP4] harbouring PQE31/18SHSP(S and P) constructs was sub-cultured and maintained in LB medium containing 100 mg /ml ampicillin and 50mg/ml kanamycin. Recombinant *E coli* was grown in 10ml LB broth containing 100g/ml ampicillin and 25g/ml kanamycin, at 37°C to an OD_{600} of 0.6 and 5 ml was induced with IPTG (0.4 mM).

After 3-4 h incubation at 37°C cells were harvested (12K/2min).

The histidine tagged protein was purified by nickel affinity chromatography (Fig. 3).

Determination of Chaperone Activity

Chaperone activity was assayed by the ability of the recombinant Hsp18 to protect amylase enzymes from heat inactivation. Amylase enzyme (Sigma) was prepared in phosphate buffer (1 µg/ml). Different concentrations of sHSP18 (0.4, 0.04, 0.02, 0.01, 0.005, 0.0025 µg/ml) were prepared. 20 µl of amylase enzyme, amylase +20 µl of each concentration of sHSP18 were mixed in an eppendorf and heat incubated at boiling temperature for 30 min. Starch agar (1%starch) was prepared and wells of 6mm diameter were cut down using a cork borer. 20 µl each of amylase (control, not heated), heated fractions, were poured in to the wells and incubated for 5 h. Enzymatic activity of amylase was detected using iodine solution and measured the clear zone diameter. The result showed that 0.4 µg and 0.04 µg of sHSP18 can protect the heat inactivation of amylase enzyme (Fig. 4).

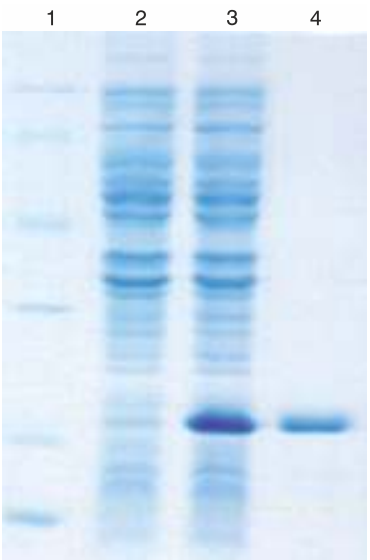


Fig. 3. Ni Affinity Purification of sHSP18. Line 1- marker;
2 - Uninduced cell lysate;
3 - Induced cell lysate;
4 - purified protein.

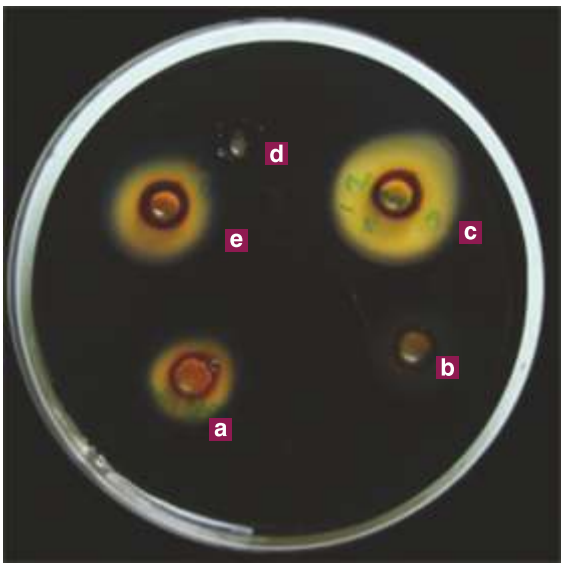


Fig. 4. Chaperone activity of sHSP18.
a. Heated amylase (20ul) + 0.4 µg of sHSP18;
b. Heated amylase (20ul) + 0.04 µg of sHSP18;
c. Heated amylase (20ul) + 0.2 µg of sHSP18;
d. Control, 20µl of unheated

- Recombinant sHSP18 protein was purified by Ni affinity gel
- Chaperonic activity of the *M leprae* s HSP18 was demonstrated by heat inactivation of amylase enzyme.

Genomic and Proteomic Studies on Small Heat Shock Proteins from *Artemia* spp.

Small heat shock proteins (sHSPs) are ATP-independent molecular chaperones that bind to denaturing proteins and thereby protect cells from damage due to irreversible protein aggregation. The thermo-stability, disaggregation, and proteolysis inhibition functions of sHSPs can be harnessed for various applications.

Samples studied

Artemia parthenogenetica was collected from the Thamaraikulam salterns (8°06'N 77°29'E).They were grown in natural sea water of salinity 35 ppt and incubated at room temperature. It was fed with the unicellular brown alga *Isochrysis galbana*. Cysts produced in the culture was isolated, washed and stored in deep freezer. *Artemia franciscana* and *Artemia salina* cysts were obtained from Dalhousie University, Canada and *CMFRI, Vizhinjam* respectively.

Isolation of RNA and cDNA preparation

RNA was isolated from the 3 *Artemia* species using 100 mg cyst samples. Cysts were homogenized in 1 mL TRIzol reagent using micropestle at room temperature and then passed through a 2.5mL syringe. Homogenized samples were incubated at room temperature for 5 min, centrifuged and supernatant collected. 0.2 mL chloroform was added, followed by vigorous shaking and incubation at room temperature for 3 min. The mixture was centrifuged and RNA was precipitated from the aqueous phase by adding 0.5mL 100% ethanol (ice cold), incubated at room temperature for 10 min and centrifuged at 14000 g for 10 min. Supernatants were discarded and pellets washed by vortex mixing in 70% ethanol (ice cold), collected by centrifugation at 10000 g for 10 min, air-dried

for 20 min, dissolved in 50 µl diethyl pyrocarbonate-treated water and stored at -20 °C. cDNA was generated using SuperScript® III Reverse Transcriptase kit from Invitrogen using random hexamers and oligo(dT) primers.

Amplification of COI gene and p26 gene

COI gene is widely used as a DNA barcode to identify animal species because its mutation rate is often fast enough to distinguish closely related species and also because its sequence is conserved among conspecifics.as The Cytochrome c oxidase I gene was amplified from cDNA using the primers COIF 5`-ATTCTACGAATCACAAGGATATTGG-3` and COI5`-TACACTTCAGGATGGCCAAAAAATCA-3`. *EmeraldAmp*® (Takara) mix was used for PCR amplification with the following temperature profiles and conditions: 1 min at 98 °C, 30 cycles of 10 s at 98 °C, 30 s at 50-58 °C gradient, 1 min 30 s at 72 °C and a final extension of 7 min at 72 °C. Total reaction volumes of 25 µl consisted of 0.5 µl template DNA, 12.5 µl Emerald mix, 1 µl of each primer (10 µM).

The small heat shock protein p26 gene was amplified from cDNA using *EmeraldAmp*® Max using similar conditions. The primers used were:

COI gene and p26 gene amplification products from the three *Artemia* species will be sequenced at RGCB.

RNA was isolated from three *Artemia* species and

P26 AF 5`-TACGGAGGATTTGGTGGTATG-3`
P26 AR 5`-ATTGTTGATCTTGCTGGAGTTG-3`
P26 BF 5`-GGTACGGAGGATTTGGTGGT-3`
P26 BR 5`-AAGCTGCACCTCCTGATCTT-3`

cDNA was prepared (Fig. 5). COI gene was amplified from cDNA of all three *Artemia* species, which will be sent to RGCB for sequencing for confirming the species (Fig. 6). p26 gene was amplified from cDNA of the 3 *Artemia* species using the primers P26AF, P26AR and P26BF, P26BR (Fig. 7).

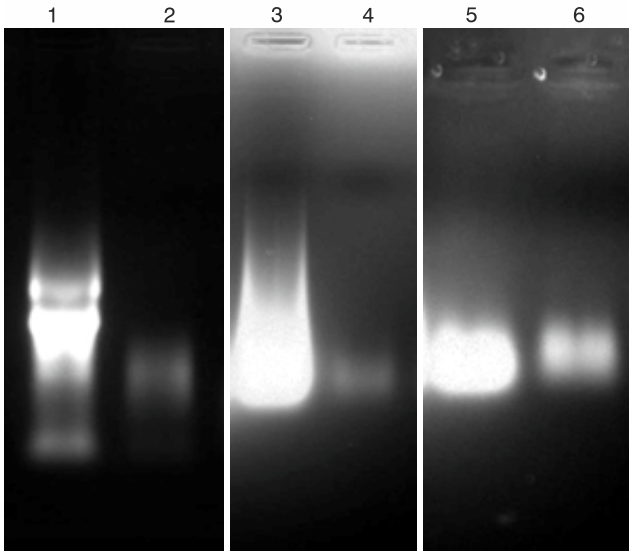
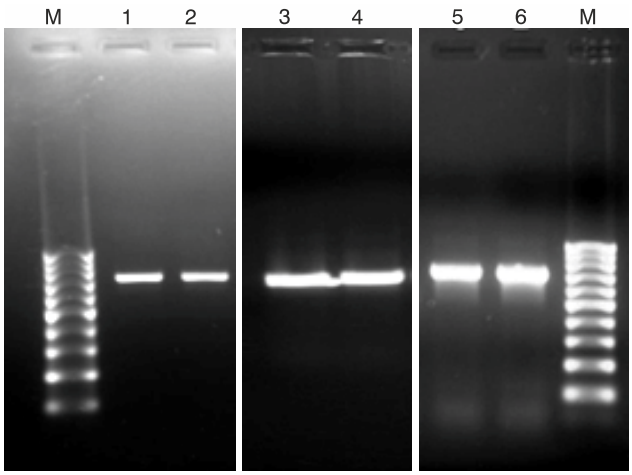


Fig. 5. 1% AGE showing 1. RNA; 2. cDNA from *A. franciscana;* 3. RNA; 4. cDNA from *A. salina* and 5. RNA, 6. cDNA from *A. parthenogenetica*



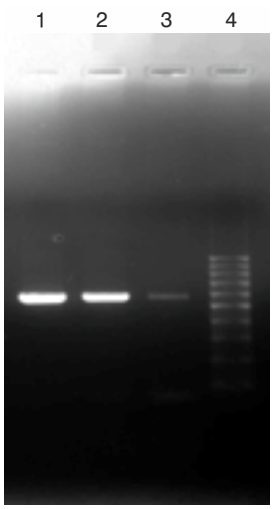


Fig.6. 1% AGE of COI gene amplification. M. 100 bp Marker; 1 & 2 COI from *A. franciscana* cDNA; 3 & 4 COI from *A. parthenogenetica* cDNA; 5 & 6 - COI from *A. salina* cDNA

Fig.7: 1% AGE of p26 gene 1. from *A. franciscana*; 2. from *A. parthenogenetica*; 3. from *A. salina*; 4. 100bp marker

Studies on bacterial cell division protein (FtsZ) inhibitors from wild medicinal and aromatic plants

The problem of antibiotic resistance is worsening worldwide because of the overuse of existing antibiotics. In order to overcome the crisis of antibiotic resistance, there is an urgent need for alternative antibacterial agents that have novel mechanisms of action. Filamentous temperature sensitive mutant Z (FtsZ), is a tubulin homologue, an essential protein for cell-division in prokaryotic organisms. FtsZ is an unexploited and attractive target for antibacterial drug discovery because of its widespread conservation in the bacterial kingdom, its absence in the mitochondria of higher eukaryotes and its known biochemical activity

and molecular structure

FtsZ polymerizes to form a Z-ring at the mid cell that orchestrates bacterial cell division. FtsZ is shown to be essential for bacterial cell division and viability. Since inhibition of function of FtsZ is lethal to bacteria, both GTP-dependent polymerization and enzymatic activities of FtsZ have been targeted for the identification of new antibacterial agents. Present study aims at the screening, isolation and characterization of novel active therapeutic 'lead compounds' with anti-bacterial properties, targeting the inhibition of bacterial FtsZ polymerization. The project intends to screen selected medicinal and aromatic plants of the Western Ghats of Kerala region to isolate potential FtsZ inhibitory molecules.

Antimicrobial screening of different plant extracts and essential oils was done. Methanol extract of 13 different *Garcinia* spp. were screened for antimicrobial activity. Methanol and hexane extracts of *Cinnamomum* were screened by Disc diffusion method for antibacterial activity. Essential oils of four different *Cinnamomum* spp. screened for antimicrobial activity was found to possess antimicrobial activity. Seven different *Euphorbia* species methanol and hexane extracts were screened for antimicrobial activity. Malachite Green Assay was done to evaluate ability of natural compounds to interfere with GTPase activity of FtsZ protein.

- Standardized enzyme coupled FtsZ inhibition assay.
- Essential oil of *Cinnamomum verum* and methanolic extracts of *Euphorbia pteroneuro, Euphorbia tirucalli, Euphorbia antiquorum* showed FtsZ GTPase interfering activity.

Fig. 8. Antimicrobial activity of *Cinnamomum malabartum* against *Bacillus subtilis*

Fig. 9. Antimicrobial activity of *Cinnamomum verum* against *E.coli*

Cloning, expression and purification of small Heat Shock Proteins from *Streptomyces* spp.

Streptomycetes are among the most numerous and ubiquitous soil bacteria, where they play a central role in carbon recycling. Streptomycetes belongs to the order Actinomycetales, which includes a large number of antibiotic-producing species. As a universal protective mechanism, all organisms undergo a rapid molecular response to adapt to harmful environmental conditions. During these events, a subset of heat shock proteins (HSPs) or stress proteins are synthesized. HSP performs important functions in the folding and unfolding or translocation of proteins, as well as in the assembly and disassembly of protein complexes. Small heat shock proteins (sHSPs) have a molecular size range from 12 to 43 kDa and a conserved region called 'α–crystallin domain' in the C-terminal half of these proteins. This study aims at cloning, expression and purification of small Heat Shock Proteins from *Streptomyces* spp

Isolation

Soil samples were collected from Silent Valley and Bonaccord forests. Actinomycetes were isolated by standard dilution method using Glucose asparagine agar medium. A total of 20 Actinomycetes were obtained and maintained at 4^0C by periodical sub-culturing.

Taxonomic studies

Gross morphological observations were made by using cultures grown for 14 days at 28°C on the standard media suggested by the International *Streptomyces* Project (ISP). Micromorphology and sporulation were determined by phase contrast microscopy (Nikon Optiphot-II). Standard physiological tests were performed after growth at 30°C for the recommended incubation periods. The tests to determine utilization of carbohydrates as the sole carbon source for growth were performed. All carbon sources for carbon-utilization tests were ether sterilized and tested at the concentrations of ISP standard.

Molecular Taxonomy

Total DNA preparation from the isolates were carried out according to Murray& Thompson (1980). PCR amplification of approximately 1,500 bp of 16S ribosomal DNA (rDNA) of the isolates were performed using the eubacterial primers 8-28F, 5' AGAGTTTGATCCTGGCTCAG 3' and 1495R 5'-CTACGGCTACCTTGTTACGA -3'. Approximately 30 μg genomic template DNA was used with 10 pmol of each primer per 25 μl reaction volume. Emerald AMPG PCR mastermix (Takara) was used for the PCR following hot start PCR protocols. The PCR products were analysed on 1% agarose gel electrophoresis.

The primer 8-27F and 1495 R was used for 16s rDNA gene sequencing. The sequencing of the PCR products were done in ABI-3130 Genetic Analyzer (ABI, USA) according to manufacturer's specifications. Homology search of the 16s rDNA sequence obtained was performed using BLAST search algorithm. Alignment of similar sequences was done using CLUSTAL X software and the phylogenetic tree was constructed using TREECON® software. Distance estimation was done following Jukes and Cantor (1969). The stability of relationship was assessed from bootstrap analysis of the neighbour-joining data based on 1000 resampling.

Twenty isolates were analysed for its morphological, physiological and biochemical properties following the International Streptomyces Project (ISP) protocols. Based on the morphological characters and 16s rDNA sequence homology, all strains were identified as *Streptomyces* spp. Among these, five were identified up to species level.

List of Isolates Identified

1. *Streptomyces californicus* (TBG-201)
2. *Streptomyces violacens* (TBG-I5II)
3. *Streptomyces exfoliates* (TBG-ALA 4-7)
4. *Streptomyces transhiensis* (TBG-ALA 8III)
5. *Streptomyces samsoni* (TBG-TCAXA)
6. *Streptomyces* sp. (TBG-ALA 8II)
7. *Streptomyces* sp. (TBG-SH10)
8. *Streptomyces* sp. (TBG-S13A5)
9. *Streptomyces* sp. (TBG-N1)
10. *Streptomyces* sp. (TBG-N2)
    Streptomyces sp. (TBG-N3)
11. *Streptomyces* sp. (TBG-N4)
12. *Streptomyces* sp. (TBG-N5)
13. *Streptomyces* sp. (TBG-N6)
14. *Streptomyces* sp. (TBG-N7)
15. *Streptomyces* sp. (TBG-N8)
16. *Streptomyces* sp. (TBG-N9)
17. *Streptomyces* sp. (TBG-N10)
18. *Streptomyces* sp. (TBG-N-11)
19. *Streptomyces* sp. (TBG-N12)

PCR amplification of small HSP gene

Two sets of degenerative primers were designed based on the conserved regions of available small heat shock genes of *Streptomyces* spp. A gradient PCR was carried out to amplify the small heat shock protein encoding gene using different combination of primers.

Fig. 10A&B: *Streptomyces exfoliates* (TBG-ALA 4-7), Colony morphology and microphotograph showing aerial mycelia and spore chains.

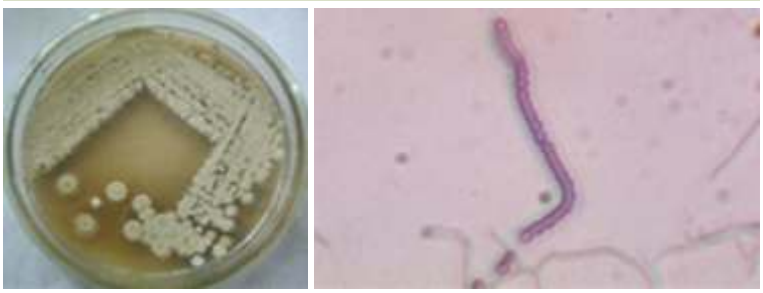


Fig. 11 A&B: *Streptomyces samsoni* (TBG-TCAXA), Colony morphology and Microphotograph showing aerial mycelia and spore chains.

Approximately 30ng genomic template DNA was used with 10pmol of each primer per 25 µl reaction volume. Emarald AMPG PCR mastermix (Takara) was used for the PCR following hot start PCR protocols. The PCR products were analysed on 1% agarose gel electrophoresis.

- 5 Streptomyces isolates were identified at species level and 15 at genus level.
- Further taxonomic studies are in progress.
- Degenerative primers designed based on conserved regions in known *Streptomyces* sHSP genes
- sHSP genes of few *Streptomyces* species were PCR amplified using degenerative primers.

Development of a rhizosecretion system for recombinant protein expression in *Lemna gibba*., L using the candidate molecule, hCAP-18.

Plants are used extensively as the bio-manufacturing platforms due to the characteristic features they possess. Rhizosecretion is the targeted secretion of molecules through the root system of plants. The rhizosecretion phenomenon is used in the hairy root cultures of *Nicotiana tabacum*, and has the potential to be exploited in other plant species also. The hCAP-18 is a mammalian protein, has roles in the defence system in humans. It has anti-microbial and ani-larvicidal properties.

Selection of signal peptides:

Signal peptides are the small polypeptides, which target the movement proteins to different parts of the cell. They are usually N- or C-terminally placed. The most crucial decision in this project was the proper selection of the signal peptide. 10 signal peptides, reported in literature were analyzed in detail and two of them (Calreticulin (Cal) and Immunoglobulin K (IgK) were selected for the study based on their effectiveness reported in literature. The sequences of amino acids for the signals selected are;

1 Careticulin: ATGCTGCTATCCGTGCCGTTGCTGCT CGGCCTCCTCGGCCTGGCCGTCGCC

2 IgK : ATGGAGACAGACACACTCCTGCTATG GGTA CTGCTGCTCTGGGTTCCAGGTT CCACTGGT

List of Primers Designed	
Name	Sequences
F1	5' GCCNCTSGGNGTCTTCTCC3'
F2	5' GTAYGTGRTSKCCTTCGACCT 3'
F3	5' AACATGCTCACCGTCAAGG 3'
RP	5' GCGAGCACAGAATTAAGG 3'

Designing of oligos corresponding to the signal peptide and hCAP-18:

In order to construct the plant expression vector, the nucleotide sequence of the signal peptide and the human protein (hCAP-18) were synthesized using automated oligo synthesizer. There were a total of 6 oligos for the hCAP-18 and 4 each for the signal peptides.

Annealing of oligos and amplification of signal peptide+hCAP-18 using specific primers:

The oligos designed for the signal peptide and hCAP-18 was annealed using the conventional protocol in the annealing buffer. The oligos were designed in such a way that 4 to 5 nucleotides overlap the sequential strands in the complementary strand. The annealing was done in the order of

1. Signal peptide (2 double stranded oligos)
2. hCAP-18 (3 double stranded oligos)

The oligos of signal peptide and the oligos of hCAP-18 were ligated separately and a final ligation was set with signal peptide and hCAP-18 (Fig.13)

The ligated oligos were used in the PCR to amplify the signal+hCAP-18 fragment with designed oligos favouring the release and cloning of the fragment in the plant expression vectors like pCAMBIA and pGA643. The sequences of the primers designed are;

pCAM-F: 5'- TTAGATCTATGCTGCTATCCGTGCC- 3'

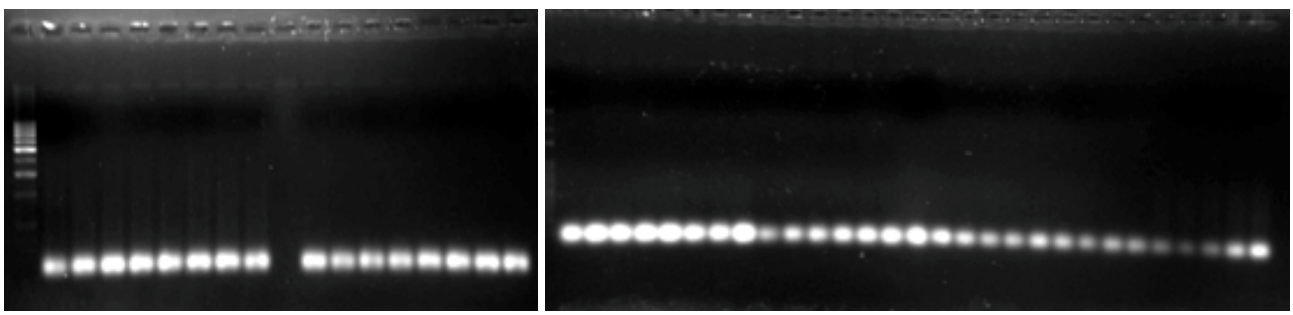


Fig. 12a & b. 1% AGE showing PCR amplification with f1/rp (a) and with f2/rp (b)

pCAM-R: 5'- AACACGTGCTAGGACTCTGTCC- 3'
pGA-F: 5'- TTAAGCTTATGCTGCTATCCGTGCC- 3'
pGA-R: 5'- AAAGATCTCTAGGACTCTGTCCTG- 3'

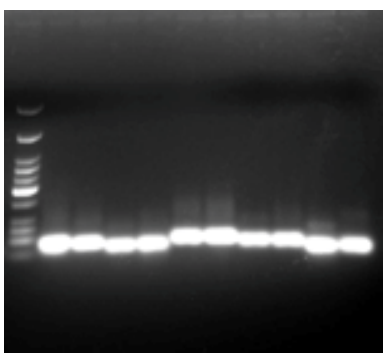
Cloning of signal+hCAP-18 PCR amplicon in pXcmkn12 TA-cloning vector:

The amplified signal+hCAP-18 was cloned in the TA-cloning vector pXcmkn12. For this, the amplicon was ligated to *XcmI* digested (T-termini) pXcmkn12 vector and *E. coli* DH5 alpha cells were transformed with the ligation mixture.

The colonies resistant to the antibiotic were inoculated for plasmid preparation in LB. Plasmid was prepared using the conventional alkali-lysis method (Fig.14). The integration of 158 and 162bp IgK+hCAP-18 and Cal+hCAP-18 were confirmed by restriction analysis (Fig.15)

Release of signal+hCP-18 from pXcmkn12 and cloning in Pcambia : In order to clone the signal+hCAP-18 piece of cDNA, the pXcmkn12- signal+hCAP-18 construct was extracted from the *E. coli* cells and the signal+hCAP-18 fragment was released using the specific restriction sites incorporated in the primers, corresponding to different plant expression vectors. The cloning of signal+hCAP-18 in to pGA643 and pCAMBIA 2301 is in progress.

- Development of a cloning strategy to generate the plant expression vectors
- Synthesis of oligonucleotides comprising of signal peptides from Cal and IgK and the hCAP-18 gene
- Amplification of the signal+hCAP-18 DNA with specific primers
- Cloning of both the sequences in TA cloning vector pXcmkn12
- Confirmation of the clones



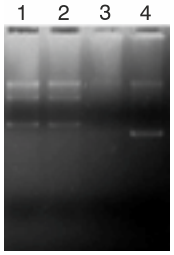


Fig. 13. Annealed oligos of hCAP-18 and signal peptides

Fig. 14. Plasmid extracted from Cal (1) and Igk (2) cultures. Lane 4 represents the control.

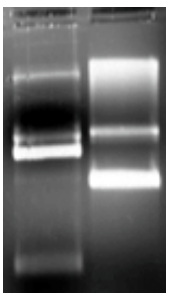


Fig. 15. Restriction digestion of pXcmkn12-Cal. pXcmkn12-Cal plasmids was digested with Bam HI to release the cloned fragment. Lane 1 release of 158bp corresponding to the cloned signal+hCAP18. Lane 2- uncut.

Lichens in the Shendurney Wildlife Sanctuary

The Shendurney Wildlife Sanctuary is located on the Western Ghats in the Kollam district of Kerala state on either side of the Shendurney River and is a valley of lush greenery, acclaimed for its biodiversity. The Shendurney Valley was proclaimed a Wildlife Sanctuary in 1984 and is the only sanctuary in Kollam District. The valley was named Shendurney after an endemic tree species 'Chenkurungi' (*Gluta travancorica*), found here in abundance. The sanctuary is made up of hills interspersed with ravines. Most of the hills are accessible except for a few which are rugged and steep. The highest peak Alvarakurichi is at 1550 m elevation. The total area of the sanctuary is around 100 sq. km and it comprises tropical evergreen, semi-evergreen and moist deciduous and grass lands, of which 45 sq km. forms the core area. The temperature varies from 16-35 °C. The topography of rugged, gentle to steep slopes ranges in height from 90m to 1550m. The sanctuary receives an annual rainfall of 3200mm.

Because of the diverse nature of forest types, the area provides good scope for the study of both macro and micro lichens in different altitudes and in different vegetation types.

- Two collection trips were conducted to Shendurney Wildlife Sanctuary and various forest regions of Idukki District, during the period.
- Collected more than 200 lichen samples of which 70 samples were identified.
- Lichen herbarium holds 3400 exsiccates deposited under TBGT.
- Reported *Fissuria rubigenosa* as new taxa to India.
- Rediscovered two endemic species *Pyxine.*

Foliar Mycobionts in the Botanic Gardens of Kerala

The variety and galaxy of fungi and their natural beauty occupy prime place in the biological world and India has been the cradle of such fungi. Only a fraction of total fungal wealth has been subjected to scientific scrutiny and mycologists have still to unravel the unexplored and hidden wealth. One third of fungal diversity of the globe exists in India. Out of 1.5 million fungi, only 5% are characterized until now. Fungi are not only beautiful but play a significant role in the daily life of human beings besides their utilization in industry, agriculture, medicine, food industry, textiles, bioremediation, natural cycling, as biofertilizers and many other ways.

Floriculture is a branch of science that deals with the cultivation, propagation and commercialisation of attractive plants and their flowers. Foliage of

Fig. 16. *Fissurina rubiginosa* (Fée) Staiger. A new record to India.

Fig. 17. *Parmotrema tinctorum* (Nyl.) Hale. A common edible lichen showing antioxidant and antiglycation activities

the leaves is an important component of the plants, is the main food manufacturing unit, index to health of plants and adds beauty to the individual plants. Leaves are exposed and interact with environment and microbes. Of these, diseases caused by the fungal parasites are the topic of the present study. The results will expand our knowledge on the data of diversity of fungi.

Collection trips were conducted to Malabar Botanic Garden, Kozhikode; Govt. Botanic Garden, Thiruvananthapuram; University Botanic Garden, Kariyavattom, Thiruvananthapuram and Santhigiri Herbal Garden, Pothencode, Thiruvananthapuram. In addition to this, collection trips were also conducted to various forest areas of Ernakulam and Idukki districts and initiated molecular phylogenetic study of folicolous fungi.

Microbial Culture Collections

Culture collections of *Actinomycetes*, *Aspergillus*, Mushrooms etc are regularly being maintained in addition to standard strains for antifungal and antibacterial property studies. Regular monitoring, periodic subculturing and enrichment of cultures are in progress. At present there are 480 *Actinomycetes* strains, 270 fungal strains and 56 Mushroom strains maintained in the lab using standard and specific media.

Community Agro-biotech Resource Centre (CARC)

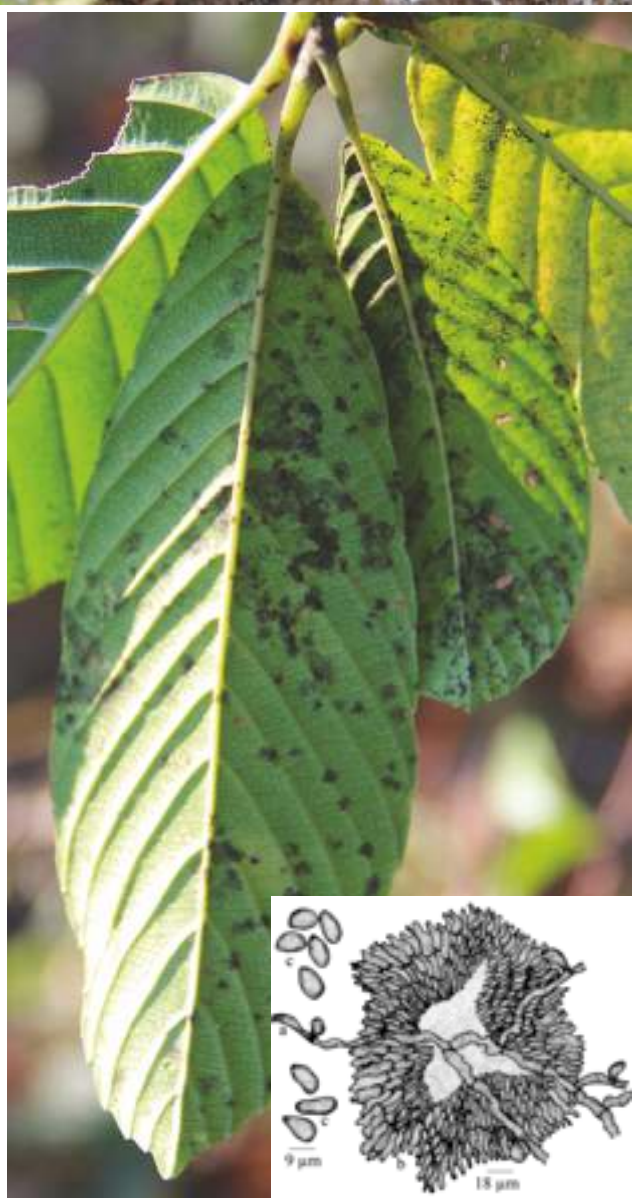


Fig.18. *Asterostomella farrargunjensis* Hosag. *et. al*. on *Tetracera sarmentosa* Vahl

Fig.19. *Meliola palmicola* Wint. on *Licuala peltata* Roxb

The application of biotechnology for societal development has always received special attention since it benefits socially and economically disadvantaged sections of the society. Efforts are required through training and demonstration of appropriate R&D inputs for providing tailor made solutions for location specific problems of different un privileged sections of the society using modern biology and biotechnology. The Community Agro-biotech Resource Centre (CARC) established at JNTBGRI Puthanthope in the out skirts of the capital city of Kerala is aimed to provide training to socially and economically backward populations particularly from rural areas. CARC can act as a nodal centre for human resource development in the areas of agri biotechnology practices.

Establishment of Banana Germplasm:

39 banana varieties collected were planted as part of establishment of banana germ plasm at Puthenthoppu. Three accessions for each variety are maintained. More varieties will be collected to strengthen the collection in coming years. A Banana Fest was organized at Wayanad in connection with the Kerala Science Congress Expo in January 2014.

Compilation of Banana Recipes: 101 Banana recipes available were collected compiled and edited (both in regional language and in English). The pre press matter is now ready. Process for the printing of the same is in progress.

Training Programme on Oushadha Sasya Krishi:

A one day training programme on Oushadha Sasya Krishi was conducted at JNTBGRI Puthenthoppe on 17/02/14 as part of the project activities aiming to empower the local people by providing them hands on training, advice and guidance to cultivate medicinal plants at their own premises and also earning them a good income through the sale of the cultivated plants. They will also be given planting materials which are in high demand and buy back arrangements will also be arranged. Beneficiaries were selected in consultation with Agriculture Officer, Krishi Bhavan, Local Bodies etc. Medicinal plants multiplied to be planted at the site of beneficiaries were supplied to them and regular monitoring is in progress.

Library & Information Services

The Institute Library plays a vital role in facilitating research by providing timely and relevant information to the researchers and scientists. It is one of the best specialized libraries in the field of Botany and allied sciences. Its mission is to build up a relevant collection of information materials and timely dissemination of information. Collection building is one of the important functions of the Library. The Library caters to the needs of researchers from other Institutions as well as students from other Universities. The resources consist of Books, Journals, Back volumes of Periodicals, CDs, Reports, Reprints, Theses, Maps and Atlases. It houses a total no. of:

Books	:	6561
Journals	:	49 (Indian)
Bound volumes	:	3546
Reports	:	899
Reprints	:	1048
Cds	:	32

Library operations and services are automated. Its services are accessible via campus LAN to enable members access from their desktops.

Digital collection includes Scientific Papers, "Classic Books in Botany" (in CDs), Annual Reports and Index to journal articles database.

During the year under report, 44 books were added to the Collection. The database of books and journals is being updated on day-to-day basis with details of recently acquired materials. One Computer is provided for members for Internet browsing alone.

In order to cater to the information needs of the clientele the following services are provided:

- Selective dissemination of Information
- Current awareness services
- Indexing services
- Bibliographic services
- Conference alert services
- Press clippings services
- Reprographic services
- Internet browsing services
- Reference services
- Document Delivery services
- Literature Search Services

Library subscribes to JSTOR "Biological Sciences Collection" including "Global Plants Initiative".

The following lists are compiled and updated regularly:

1. List of latest additions
2. List of Current Journals
3. List of Holdings
4. List of CDs
5. List of Publications
6. List of Patents
7. List of Projects
8. List of Ph. D. Theses

The Library is using the software LIBSOFT which is an integrated multi-user Library Management System that supports all in house operations of the Library. It has different modules like Acquisition, Catalogue, Circulation, Serial Control. Circulation control is bar code enabled.

Sale of the following Books "Bamboos at TBGRI" by Dr. K. C. Koshy, "Flowering Plants of Kerala-A Handbook" by Dr. T. S. Nayar et al and "Introduction to Orchids" by Abraham & Valsala are done through the Library.

Cultural programmes

JNTBGRI Staff organized the Onam Celebrations 2012 on 23/08/2012. Smt. Sobha Koshy IAS, Chief Postmaster General of Kerala Circle inaugurated the celebrations and gave the Onam Message. She said there is no better way to celebrate this wonderful harvest festival in the pristine surrounding of the incredible institute sharing the warmth and hospitality of the staff.

Onam Celebrations 2012 being inaugurated by Smt. Sobha Koshy, IAS, Post Master General of Kerala Circle.

Onam Games !

On 12. 12. 2013, Pt. Viswa Mohan Bhatt, the renowned musician and Grammy Award winner performed on the Mohana Veena designed by him, as a part of SPICMACAY, Thiruvananthapuram Chapter. He was accompanied on the Thabala by Ustad Casius Khan. It was an awesome programme and JNTBGRI enjoyed it profoundly.

Visitors

a, b & c Prof. Eve Syrkin Wurtele, Iowa State University, USA addresses the scientists on 07. 12. 2012.

Scientists interacting with Dr. C. V. Ramakrishnan, father of Dr. Venkatraman Ramakrishnan, Nobel Laureate in Chemistry 2009.

Visit of German doctors to JNTBGRI on 08. 01. 2013

Visually Challenged Children's Camp

Chaksusmukhi – an NGO for visually challenged children spent two days at the campus with their guardians, Dr. V K Damodaran and Dr. Ram Kamal.

Administrative staff of the institute underwent one week training in personality development, soft skills and administrative matters. Seen with the trainers from Government Secretariat.

Research Council of JNTBGRI addresses the Scientific Staff on 13. 06. 2013. Dr. H Y Mohan Ram, Dr. M. Sanjappa, Dr. R D Iyer and Prof. Omana Kumari.

Director JNTBGRI presents a cheque of Rs.One lakh to Smt. Anitha Chandran, w/o late Shri. Chandran, Security Guard on10. 09. 2013.

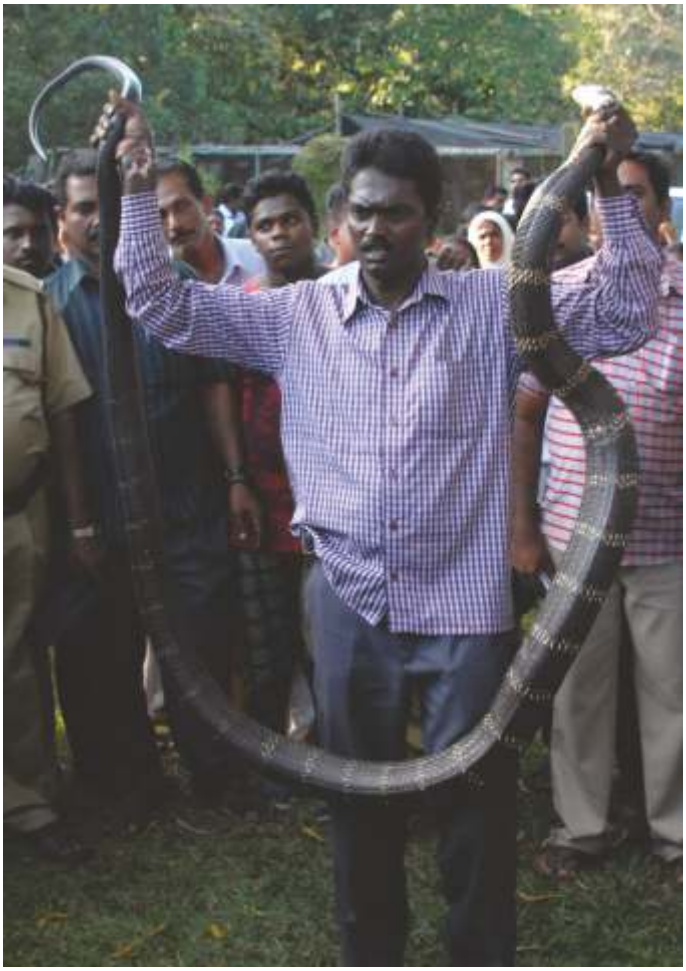
Smt. Sonia Gandhi, UPA Chairperson being presented the orchid '*Cattleya* Miraya' named after her little granddaughter, at the Raj Bhavan, Thiruvananthapuram, watched over by Honourable Governor of Kerala, Shri. Nikhil Kumar, Mrs. Nikhil Kumar, Honourable Chief Minister of Kerala, Shri. Oommen Chandy and Dr. Shashi Tharoor, Honourable Union Minister for Human Resource Development on 29. 09. 2013.

Director and Senior Scientists met Honourable Union Minister for Human Resource Development, Dr. Shashi Tharoor and Smt. Sunanda Tharoor at their residence to discuss the JNTBGRI take over matters with Government of India on 16. 10. 2013.

Discussion with Oushadhi on 'Arogyapacha' - formulation of herbal drug on 20. 09. 2012.

Director, JNTBGRI being conferred the INCITE Excellence Award in Science and Technology 2012 by Shri. Vijayan Thomas, Chairman, KTDC.

Visit of Shri. K. M. Chandrasekhar, Vice Chairman, Kerala State Planning Board, Thiruvananthapuram to JNTBGRI on 10. 10. 2012.



An awesome visitor on the campus - 18 feet long King Cobra deftly handled by Shri. Vava Suresh on 23.12. 2013

Republic Day Celebrations 2014.

Mahatma Gandhi National Rural Employment Guarantee Act Volunteers helped to clear the arboretum.

New Year Celebrations 2014 with Smt. Sreelekha IPS, the Transport Commissioner.

Shri. Oommen Chandy, Honourable Chief Minister of Kerala confers the Fellowship of the Kerala Academy of Sciences on Director, JNTBGRI watched over by Dr. Oommen V. Oommen, Chairman, Kerala State Biodiversity Board, Dr. Radhakrishnan, former Director VSSC, Dr. S. Rajasekharan Pillai, EVP, KSCSTE and Dr. Ajay Ghosh, Director NIIST on 19. 12. 2013.

Dr. Anuradha Balaram, Member Secretary, Kerala State Planning Board visited JNTBGRI on 21. 03. 2014.

Prof. A. Abraham
Birth Centenary Year Celebrations

25 MAY 2013 - 25 MAY 2014

Extension & Training

JNTBGRI launched the year long Birth Centenary Celebrations of Prof. A. Abraham, founder Director of the Institute, on May 25, 2013. Padmasree Dr. P. Pushpangadan, former Director, JNTBGRI was the Chief Guest of the function. Prof. P. M. Mathew and Prof. P. I. Kuriachan, students of Prof. A. Abraham and former Heads, Department of Botany, University of Kerala offered felicitations. As a mark of respect, Prof. P. M. Mathew, Prof. P. I. Kuriachan and Dr. P. Pushpangadan jointly planted a seedling of *Melocanna baccifera,* raised from a flowered clump, at the same spot of the parent plant in Bambusetum, which was lost.

a. The dignitaries planting *Melocanna baccifera* in the garden;"b. Fond Remembrance" Dr. P. G. Latha and Dr. Jacob Thomas with Prof. A. Abraham when he visited JNTBGRI in 1992.c. VIPs under the *Holoptelia integrifolia* tree planted by late Prof. A Abraham on his 78th birthday (25. 05. 1992).

A series of ten memorial lectures by very eminent personalities on diverse disciplines wereorganized in connection with the Prof A Abraham Centenary Celebrations.

Dr. S. Natesh
Former Senior Advisor (Scientist H),
Department of Biotechnology,
Govt. of India.
&
Consultant Advisor
National institute of Immunology

12 August 2013

Dr. S. Natesh is Former Advisor, Department of Biotechnology, Government of India. He served the DBT for over two and a half decades. He was involved in key policy making decisions for promoting new ideas and collaborations. He played his role well in different capacities to spearhead the key initiatives in bioenergy, biomedical research, science, communication and international collaborations.

Topic of presentation

Green Engines of Change: Plants which changed India and the World.

Dr. S. Natesh, Former Senior Advisor, Department of Biotechnology, Government of India delivering the Prof. A. Abraham Memorial Lecture.

26 August 2013

Shri. Montek Singh Ahluwalia
Deputy Chairman,
Planning Commission, Govt. of India

Shri. Montek Singh Ahluwalia, Former Deputy Chairman, Planning Commission. The President of India awarded him Padma Vibhushan, India's second highest civilian honour. He has written on various aspects of India's economic reforms.

Topic of presentation
The need to mainstream sustainability in the development agenda of India.

27 August 2013

Dr. K. Kasturirangan

Member (Science),
Planning Commission,
Govt. of India

Dr. K. Kasturirangan is an Indian Space Scientist who headed ISRO from 1994-2003. He was Member of Rajya Sabha 2003-2009. He received the Padmavibhushan in 2000. He has published over 244 papers in the areas of astronomy, space science and applications.

Topic of presentation

Prospects of Science and Technology in India

Dr. K Kasturirangan visits JNTBGRI

01 November 2013

Dr. Raghavendra Gadagkar

Indian Institute of Science,
Bangalore,
Karnataka

Shri. Raghavendra Gadagkar is a Full Professor at the Centre for Ecological Sciences, IISc Bangalore. He studied evolution of social behaviour using the locally common wasp as a model. He is currently President of INSA. He won the S S Bhatnagar Award in Biology in 1993. He has published over 275 scientific papers.

Topic of presentation

War and Peace: Conflict and Cooperation in an Insect Society

06 November 2013

Prof. (Dr.) M. K. Prasad

Former Pro. Vice Chancellor,
University of Calicut

Prof. M. K. Prasad is one of India's best known evangelists for sane environmental management. He went on to become the PVC of Calicut University. He has authored numerous books on environmental issues and co-authored a techno-economic and socio-political assessment of the Silent Valley Hydro Electric Project.

Topic of presentation

Biodiversity Conservation and Management.

Dr. Rama Rao
Wood Science Institute, Bangalore

Dr. N. Rama Rao is an expert in the field of Ethnobotany and Biodiversity of the Eastern Ghats besides Medicinal plants and Mangroves. He retired from the Institute of Wood Science and Technology, Bangalore in 2014.
He is expert member of marine and aquatic plants under National Wildlife Board, MoEF, Govt. of India. He has travelled abroad extensively and has 80 peer reviewed publications to his credit.

19 November 2013

Topic of presentation
Mangrove Ecology

Dr. M.R. N. Murthy
Indian Institute of Science,
Bangalore, Karnataka.

Dr. M. R. N. Murthy is Professor of molecular biophysics at the Indian Institute of Science (IISc.), Bangalore. His chief contributions are in the area of X-ray crystallography. He was awarded the Shanti Swarup Bhatnagar Award for outstanding contribution to physical sciences, which is the highest honour for a scientist in India, in the year 1992. He initiated structural studies on isometric viruses in India at a time when research on macromolecular protein crystallography was being initiated for the first time in the country at the Molecular Biophysics Unit of IISc.

20 December 2013

Topic of presentation
2014 - The year of X ray Crystallography

17 February 2014

Prof. A. K. Koul
Dean,
Academic Affairs,
BGSB University,
Rajouri, Jammu & Kashmir.

Dr. A. K. Koul received the coveted Panchanan Maheshwari Gold Medal for his contribution to Botany in 1995. He had his teaching career at the University of Jammu and Kashmir and is currently Dean, School of Biosciences, Baba Ghulam Shah Badshah University, Rajouri. He is Fellow of National Academy of Sciences and Indian Association of Angiosperm Taxonomists.

Topic of presentation

Questions in Reproductive Biology

20 February 2014

Dr. Brijesh Kumar

Senior Principal Scientist,
CDRI -Lucknow, U P.

Dr. Brijesh Kumar, Senior Principal Scientist is In-charge of SAIF, CDRI, Lucknow. His current area of interest is application of Mass Spectrometry Tools and identification of marker compounds using statistical software.

Topic of presentation

Chemical identification of Botanicals using MS and LCMS/MS Techniques

22 February 2014

Padmavibhushan M. S. Valiathan

Honorary Advisor,
Manipal Academy of Higher Education,
Karnataka.

Padmavibhushan Dr. M. S. Valiathan, world renowned Indian Cardiac Surgeon, Formerly President of the Indian National Science Academy and National Professor of the Government of India, he has contributed significantly to the development of medical technology in India.

Topic of presentation

Plants and Ayurvedic Healing

Dr. M. S. Valiathan receives his name sake orchid *Paphiopedilum* M S Valiathan, the first *Paphiopedilum* hybrid produced in India by JNTBGRI from Prof C. A. Ninan.

Kerala Science Congress 2013

JNTBGRI was one among the organizers of 25th Kerala Science Congress jointly with KSCSTE and NATPAC. In connection with the Science Congress conducted at the Technopark, Thiruvananthapuram from 28th January 2013 to 1st February 2013 institute organized the Science Expo at Kanakakunnu Palace ground from 27 January 2013 to 5 February 2014.

National Science Expo at Kanakakunnu Palace Ground

Kerala Science Congress 2014

JNTBGRI organized the 26th Kerala Science Congress at Kerala Veterinary University, Pookode, Wayanad from 28th to 31 January 2014. In connection with this, a Science Expo was conducted at the Chandragiri Auditorium, Kalpetta. For the first time in the history of Kerala Science Congress, JNTBGRI conducted a one month statewise procession, the 'Sasthra Jwala' a torch bearing procession, which conveyed the message of Science and Development throughout the state. This was flagged off from Kendriya Vidyalaya, Thiruvananthapuram by the Union Minister Dr. Shashi Tharoor.

Kerala Science Congress January 2014
Wayanad

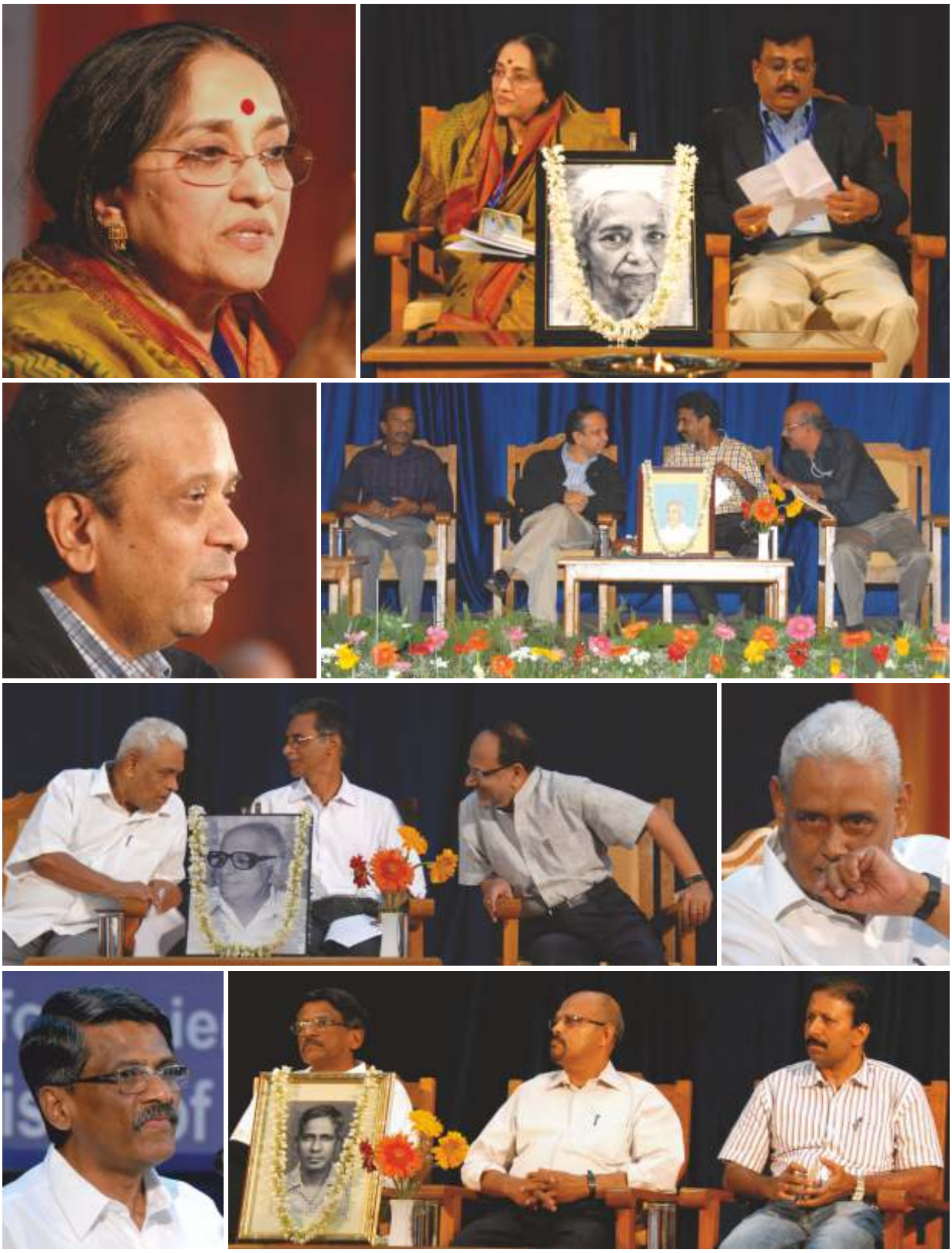
Shri. M. I. Shanavas, MP lighting the lamp at the 26th Kerala Science Congress at KVASU, Wayanad, Kerala.

Some of the speakers at the 26th KSC Inaugural Function. Dr. Gangan Pratapan, Shri M. I. Shanavas MP, Dr. George Varghese, Dr. B. Ashok, Dr. V. N. Rajasekharan Pillai, Dr. A.N.P. Ummerkutty, Dr. M. Abdul Salam, Dr. K. K. Ramachandran, Dr. P. G. Latha.

Kerala Science Congress 2014 Wayanad

Awards, Honours, Distinctions !

Kerala Science Congress 2014 Wayanad



E K Janaki Ammal Lecture being delivered by Dr. Nanditha Krishna, Honourable Director, CPR Foundation, Chennai; P. R. Pisharoty Memorial Lecture delivered by Dr. Tanu Padmanabhan; P T Bhaskara Panikar Memorial Lecture delivered by Prof. M. G. S. Narayanan, the famous Historian; Dr. P K Gopalakrishnan Memorial Lecture delivered by Dr. G. Vijayaraghavan.

Dr. P Pushpangadan addresses the delegates of KSC 2014

Kerala Science Congress 2014 Wayanad








Childern's Science Congress 2014 Wayanad

Entertainments at KSC 2014, Wayanad

Inauguration of the Science Expo at KSC 2014 at Chandragiri Auditorium, Kalapetta, Wayanad.

School students at KSC 2014 Expo at Chandragiri Auditorium, Wayanad.

The Science stalls at KSC 2014 Science Expo.

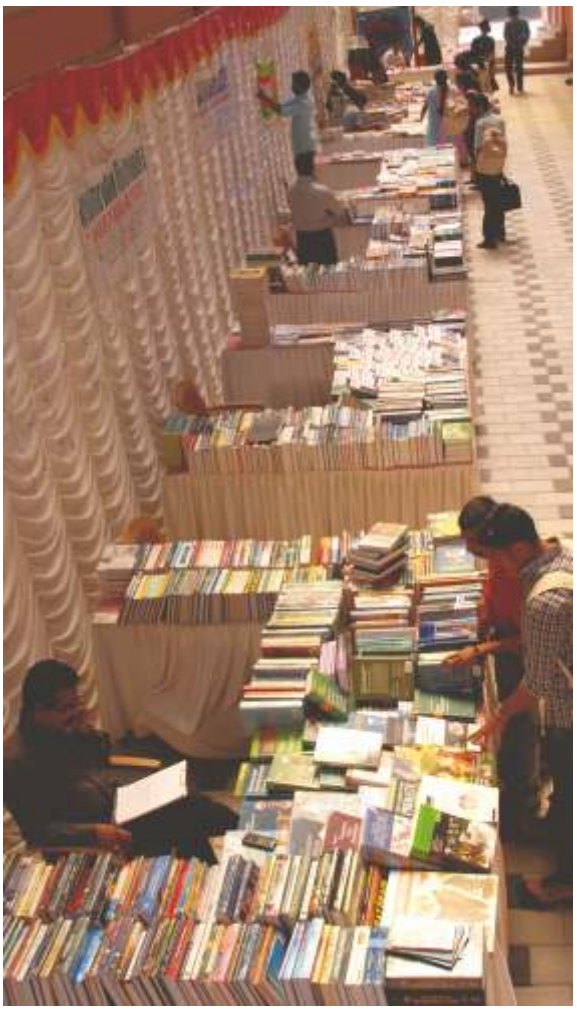






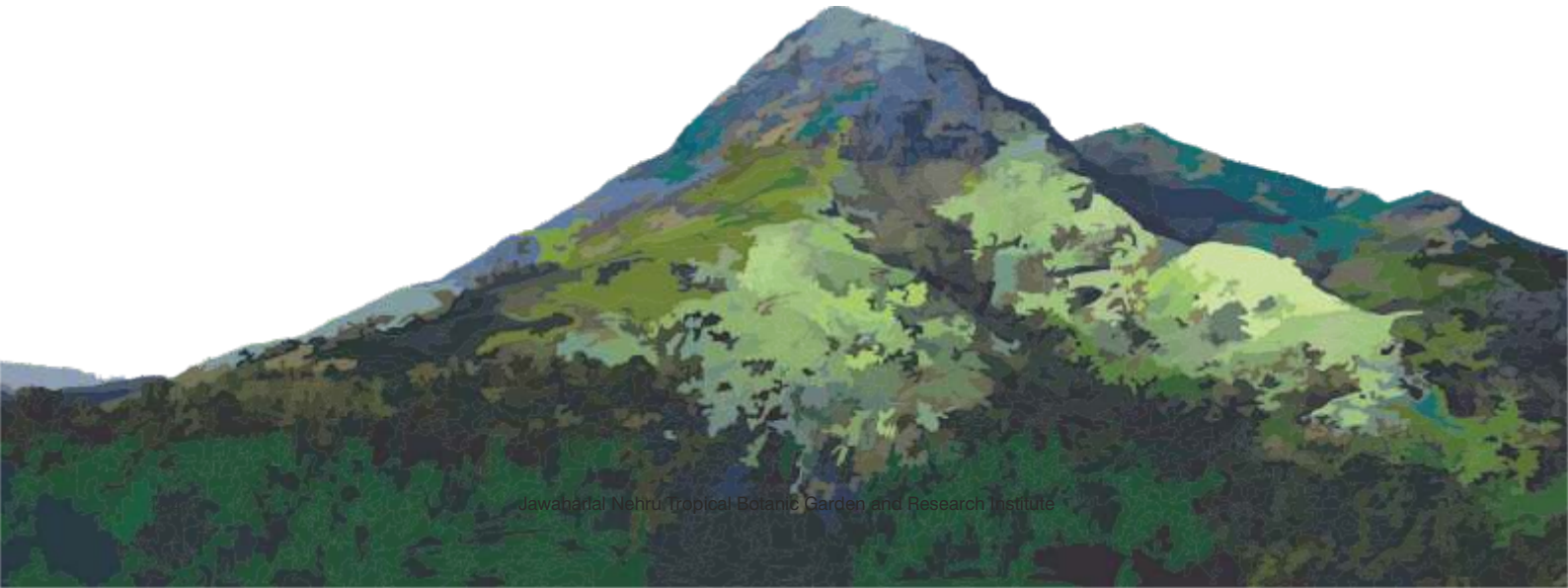



The venue of posters at KSC 2014



A display at Kerala Veterinary University, Pookode, Wayanad

Mr. Vineesh P S , JRF, JNTBGRI receiving Nature Photography Award at during 26th Kerala Science Congress, 2014.



National Science Day 2013

The National Science Day was conducted at the Institute on 28 February 2013. 50 +2 students from Mother Theressa Secondary School, Pangode participanted in the celebrations. Dr. N M Nair, Former Director CPCRI, Ksaragode Presented the lecture on Science day Theme 'Genetically Modified Crops'.

Children's Day Celebrations - 2012

JNTBGRI conducted Children's Day Celebrations-2012 on 15th November 2012. 60 students and teachers from four nearby schools S N Higher Secondary School, Paruthi, Chithara and Mother Theressa Higher Secondary School, Pangode participated. Garden visit, Plant Identification, Painting and Quiz competitions were conducted. Director distributed prizes to the winners.

Children's Day Celebrations-2013

JNTBGRI conducted Children's Day Celebrations-2013 on 15th November 2013. 120 students and 12 teachers from four nearby schools (Karimoncode UPS, Govt. UPS, Peringamala, S N UPS, Kollayil and Gov. UPS Jawahar Colony) participated. Dr. K. P. Vijayakumar, Professor and Head of the Department of Library Sciences, University of Kerala, the Chief Guest of the day, interacted with the participants. All the 4 schools presented their projects on 'Herbs of School Campus', which was evaluated. Karimoncode UPS won the First prize and Govt. UPS Peringamala won the Second prize. After the project presentation the students visited the garden. Plant Identification, Painting and Quiz competitions were also conducted.

Children's Day Celebrations 2013

National Science Day 2014

The National Science Day was conducted at the Institute on 14 February 2014. 50 Graduate students from Iqbal College, Peringamala and NSS College Nilamel were participants in the celebrations. Dr. A. Ajayghosh, CSIR Outstanding Scientist interacted with the participants on the theme 'Fostering Scientific Temper'. Garden visit and a Science Quiz competition were the other programmes of the celebrations.

Student Programme for Excellence in Experimental Designs (SPEED)

A project conceived by Women Scientist's Cell Division of the Kerala State Council for Science, Technology and Environment. It has an objective of providing R & D exposure to students who have aptitude in Science Experiments and Research. The first SPEED programme was organized at JNTBGRI from 21st to 25th May 2013. The subject selected for the training was *Conservation and Sustainable Utilization of the Plant Genetic Resources*. 34 students who had qualified with 'A' Grade in the Kerala Science Fair 2011-'12, 'Sasthrolsavam' attended the training. The programme was inaugurated by Shri. T. P. Sreenivasan, Vice

Shri. T P Sreenivasan IFS, Vice Chairman, Kerala State Higher Education Council, inaugurates the SPEED Programme on 21.05. 2013.

Chairman, Kerala State Higher Education Council. Students were given hands on training in pharmacological evaluation of plant drugs for anti-inflammatory, analgesic, anti-allergic and anti-fatigue properties, extraction and identification of plant metabolites, plant tissue culture, hairy root culture, genetic diversity analysis, effect of growth regulators and cryopreservation.

The participants of SPEED 2013

Central Nursery organized training programmes to 430 farmers (10 programmes of 40-50 farmers each) in Plant Propagation and Nursery practices to the farmers in collaboration with the Agricultural Department, Government of Kerala. Besides training was imparted to 50 farmers under a NABARD programme. Two week training on plant propagation and Nursery techniques was given to 3 technical staff of M S Swaminathan Foundatation, Wayanad.

The Biotechnology & Bioinformatics Division of JNTBGRI conducted six months training course for two students with students' fellowship sponsored by DBT, Govt. of India, as part of BTISNET project programme. Another three months training was given to one B.Tech student on Techniques in Plant Tissue Culture and Hairy Root Culture.

One month training on Systematic Palynology was imparted to a Junior Research Fellow from Centre for Earth Science Studies, Akkulum, Thiruvananthapuram. The training programme covered collection of polliniferous materials from herbarium and field, pollen preparation, pollen slide preparation, pollen morphology and LO analysis of pollen grains.

The Commercial Tissue Culture Unit provided Consultancy service to Finura Bioteks, Nagercoil on technical support for the mass production of Anthurium and Banana and procured 40,000 Rs. towards consultancy fee.

The Commercial Tissue Culture Unit offered consultancy to the Dept. of Botany, Iqbal College, Peringamala, our neighboring institution, for developing a tissue culture lab.

Seed Bank team of the Asia Seed Vault, Korean National Arboretum, Seuol, visited the seed bank of JNTBGRI. Seeds were supplied to other National and Regional Centers like IIHR, PGR division, Bangalore; National Research Institute of Basic Ayurvedic Sciences, Pune; CIMAP Research Centre, Hyderabad; ALRU Ayurvedic Medical College, Koppa,Hyderabad; Government College for Women, Thiruvananthapuram; Department of Botany, Shivaji University, Kolhapur; Department of Botany, University of Kerala, Karyavattom and Kerala Agriculture University, Thrissur. In addition to these seeds of 18 species were supplied for educational purpose.

Video documentation of Kasaragod and Kannur Districts was made as part of the implementation of Activity 4 of the project entitled Systematic Documentation of Traditional Knowledge related to plants used for Food and AYUSH & Indigenous Medicine on 7-14 August 2012. Mr. K. Radhakrishnan, Member, Inter-Media Publicity Co-ordination Committee (IMPCC), Ministry of Information & Broadcasting, Govt of India, attended three IMPCC monthly meetings and presented the Institute's activities of the concerned month. One meeting of the IMPCC was organized by JNTBGRI at Palode on 9th of December 2013.

The Ethnopharmacology and Ethnomedicine Division organized contact and awareness programmes in connection with the implementation of the project on Ethnobotanical survey in the coastal areas of three Southern districts of Kerala at Karimkulam Gramapanchayath of Thiruvananthapuram district and Kadinamkulam Grama panchayath of Thiruvananthapuram district. As part of implementation of the project Ethnomedical survey and systematic documentation of traditional knowledge among the different tribal communities of Kerala – an in depth study and preparation of database, contact and awareness programmes were organized at Marayoor Gramapanchayath and Kanthalloor Grama panchayath of Idukki district. A one day training programme was organized for Staff of the Medicinal Plant Board on 'Estimation of Growing Stock of Medicinal Plants at JNTGBRI' and training was provided by a team of Scientists from KFRI, Peechi on 4th July 2013.

The Garden Management, Education, Information and Training Division supplied saplings to various governmental and non governmental agencies from the Garden like ISRO CMSE centre, Vattiyoorkavu; ISRO Valiamala; CDS Thiruvananthapuram; Grameena Padanakendra, Karakulam, Thiruvananthapuram; M. G. College Thiruvananthapuram, and Legistative Assembly, Thiruvananthapuram.

Regular sale of plants was done through the sales unit of the Garden. Other than students and general public about 70 Governmental and Non Governmental Organizations like Biodiversity Chief Conservator, Uttaranchal; Kerala Forest Department; State Armed Force, Thiruvananthapuram; Kerala State Planning Board; Agricultural Department, Govt. of Kerala; Travancore Devaswom Board; Vikram Sarabhai Space Centre and various Colleges and Schools of the State were also recipients of these plants,

Garden Management Division designed landscapes and gardens for Women & Children Hospital, Thycaud, Thiruvananthapuram; Govt. Hospital, Palode and Post Master General Office, Thiruvananthapuram. Besides this, the staff of the Division were also actively involved in the development and maintenance of *Hortus Malabaricus* Garden at Botany Department, Karyavattom Campus, Thiruvananthapuram and Museum Botanic Garden, Thiruvananthapuram.

Scientists of the Microbiology Division identified

several foliicolous fungi brought from Coorg and from Osmania University.

As part of the project on 'Establishment of a Community Agro-biotech Resource Centre (CARC)', scientists of Microbiology division established germplasm collections of 39 Banana varieties and few medicinal plants at the Puthenthope Centre. A *Banana Festival* was organised at Wyanad and a compiled book on 'Banana Recipes' is ready for publication. A one day training programme on Oushadha Sasya Krishi was also conducted.

Short demonstration classes were given by the Tissue Culture Unit of Plant Genetic Resource Division to about 1,231 school/colleges/university students, NGOs, Floriculturists and others who visited the Garden. Apart from this, training facilities were provided for researchers, farmers etc. A Ph.D student was given one month training on protoplast isolation, purification and culture.

A seminar was organized at JNTBGRI on 21st May 2012 in connection with the Silver Jubilee of the JNTBGRI Bambusetum

As part of its extension activities in JNTBGRI bambusetum, World Bamboo Day was celebrated on 18th September 2012. A workshop was organized with an education programme on bamboo planting and bamboo identification contest, bamboo propagation techniques, demonstrations on bamboo craft making and sapling distribution. The programme was held in the Bambusetum, under the beautiful canopy of bamboo clumps. Seventy participants including college and school students and teachers, Biodiversity Management Committee of Peringammala Panchayath and members of three NGOs took part. Director, Dr P G Latha, inaugurated the workshop and distribution of the seedlings of *Bambusa pallida* to the participants. Dr P J Mathew, Head, Division of Plant Genetic Resources and Dr K C Koshy addressed the gathering. Traditional bamboo craft workers from Kani and Paraya tribal communities demonstrated their weaving skill which was well appreciated by the participants. Shri B Gopakumar and Shri K Asokachandran Nair demonstrated bamboo propagation and planting methods. For these events, JNTBGRI Bambusetum won the First Place of World Bamboo Day Contest 2012which carried a cash award of US$ 250 instituted by the World Bamboo Organisation.

During the period, 9796 saplings belonging to 16 species were distributed to various organizations like NBRI, Lucknow; Kerala Forest Department, Malayattoor Division; MES College, Kakkanadu(250); ; KVUPS, Pangode; Govt. HSS, Bharathannoor; Fr. (Dr.) Britto, Rapinett Herbarium; Kerala Forest Department, Thekkady Range; The Hindustan Newsprint Ltd. Angamoozhy Zone; Uravu', Wayanadu; The English Indian Clays, Thonnackal; S.B.College, Changanacherry; KSEB Lower Meenmutty Power House, Nanniyode; Bishop Haber College, Tamil Nadu; Department of Ecology and Environmental Science, Assam University, Silchar; Heart Touch Home, Tirunelveli; Social Forestry Range Office, Punaloor; St. Stephens College, Pathanapuram; Vazhuthanappally Nursery, Palode; The LPSC, Valiyamala; SHM Engineering college, Kadakkal; The CCF, Biodiversity Conservation, Development & Research, Uttarakhand; M. G. College, Trivandrum etc. Leaf samples of 31 species were issued to Annamalai University for phytolith study. In addition, JNTBGRI participated in the Karshika Mela 2013 at Palode and distributed 400 bamboo saplings.

Plant Genetic Resource Division arranged short demonstration classes to about 1,231 school/colleges/university students, NGOs, Floriculturists and others who visited the Garden apart from researchers, farmers etc. A training class on 'Bamboo Propagation and Management' organized by Department of Ecology & Environmental Science, Assam University, Silchar was conducted on 14.3.2014 for faculty members and village farmers.

One month training was also given to a Ph.D student on protoplast isolation, purification and culture. One South Korean Ph. D. student was given training (11 June-9 August 2012) in orchid taxonomy on the genus *Arundina* and its relationships with other genera.

A Children's Education Programme- Plant Wonders, Evolution and Genetics- for Biology batch of Higher Secondary students and teachers was conducted during 14-23 November 2012 to kindle their interest in biology and evolution in general and botany in particular. A total of 755 students and 49 teachers from 20 schools of two districts of Kerala were given training during this programme. It was inaugurated on 14th November 2012 by Her Highness, Princess Gowri Parvati Bayi of Kaudiar Palace. This was a seven hour programme of lectures and interactions with hands on training in understanding half a dozen plant wonders from Double Coconut to Titan Arum, *Rafflesia, Victoria*, Living fossil Maidenhair Tree (*Ginkgo biloba*) and Baobab Tree (*Adansonia*). This also included an audiovisual programme on biology and chemisty of carnivorous plants. There were also lectures on Charles Darwin and his contributions followed by an hour long film show on Galapagos Islands and Gregor Mendel and the birth of Genetics. During the plant familiarization programme participants were taken out to the field and shown the diverse plants that we have and the

mechanism of their functions. A total of 755 students and 49 teachers from 20 schools were benefited by the programme.

A Refresher Course in Plant Taxonomy was conducted during 11th – 16th February, 2013. The course was designed to improve the knowledge gaps in our taxonomic system and to overcome the shortage of trained teachers, curators and research scholars. Altogether 44 participants representing the states of Uttarakhand, Assam, Orissa, Goa, Karnataka, Tamil Nadu and Kerala were trained. A course book covering Systematics of Algae to Angiosperms, based on morphology and molecular taxonomy was also prepared.

Plant Taxonomy workshop being inaugurated by Dr. M P Nayar, Former Director, BSI.

Ph. D. Awarded

Anuja GI was awarded Ph. D. by University of Kerala for the thesis "Anti-inflammatory and analgesic properties of *Drynaria quercifolia* (L.) J. Smith, a medicinal pteridophyte of traditional importance" under the guidance of Dr. P G Latha.

Padmesh P was awarded Ph. D. by University of Kerala for the thesis "Isolation and characterization of candidate gene(s) involved in the biosynthesis of hypericin- an aromatic naphthodianthrone from *Hypericum* spp." under the guidance of Dr. S Seeni.

Rajeshkumar P P was awarded Ph. D. by Kannur University for the thesis "Rhizosphere and Phylloplane fungi of five medicinal plants in Kerala state" under the guidance of Dr. V B Hosagoudar.

Riju M C was awarded Ph. D. by Kannur University for the thesis "Studies on endomycorrhizal fungi in Poochippara and Valakkadu sections of Silent Valley National Park" under the guidance of Dr. V B Hosagoudar.

Shibu P. Varghese was awarded Ph. D. by University of Kerala for the thesis "Taxonomic studies on the family Hygrophoraceae (Basidiomycetes) in Kerala part of Western Ghats" under the guidance of Dr. K B Vrinda & Dr. C K Pradeep.

Krishnaraj MV was awarded Ph. D. by Kannur University for the thesis "Taxonomic revision of Leguminosae (Nom. Alt. Fabaceae) of Kerala state" under the guidance of Dr. N Mohanan.

Radha R K was awarded Ph. D. by University of Kerala for the thesis titled "*In vitro* propagation and ecorestoration of selected medicinal plants of the Western Ghats" under the guidance of Dr. S Seeni.

Raju Antony was awarded Ph. D. by Kannur University for the thesis "Studies on the Pteridophyte flora of Agastyamala, Western Ghats" under the guidance of Dr. N Mohanan.

Robin P J was awarded Ph. D. by Kannur University for the thesis "Foliar fungal parasites of Ponthanpuzha Reserve forest of Kottayam district in Kerala state" under the guidance of Dr V B Hosagoudar.

Shine V J was awarded Ph. D. by Kannur University for the thesis "Hepatoprotective Studies on *Cyclea peltata* (Lam.) Hook. F. & Thoms." under the guidance of Dr P G Latha.

Shyamal S. was awarded Ph. D. by Kannur University for the thesis "Antihepatotoxic properties of *Pittosporum neelgherrense* (Wight & Arn)" under the guidance of Dr P G Latha.

Sivu A R was awarded Ph. D. by University of Kerala for the thesis "Molecular taxonomy of the genus *Memecylon* (Melastomaceae) in Peninsular India" under the guidance of Dr N S Pradeep and Dr A G Pandurangan.

Sonia Mol Joseph was awarded Ph. D. by University of Kerala for the thesis "Chemistry and bioactivity of medicinal mushrooms and aromatic plants" under the guidance of Dr B Sabulal and Dr. V. George.

Suresh Kumar P C was awarded Ph. D. by University of Kerala for the thesis 'Reproductive Biology of three endangered orchids'. Under the guidance of Dr C Sathish Kumar.

Thomas M T was awarded Ph. D. by the University of Kerala for the thesis "Biosystematic studies on the taxa of *Centella* L. and *Hydrocotyle* L. occurring in peninsular India with special reference to intraspecific variants of *Centella asiatica* (L.) Urb." under the guidance of Dr P J Mathew and Dr Mathew Dan.

Awards, Honors, Memberships in Professional Bodies

Anu Aravind received Best Poster Award, 7th International Symposium of the International Society for the Development of Natural Products, 2012, held at AMITY, Noida.

Biju CK recognized as a Ph.D. guide in Botany by Kannur University.

Biju CK served as examiner for conducting SSLC (IED) Practical Examinations during April 2013.

Cheriyan P Koshy nominated by Govt. of Kerala as Member, National Coir Research and Management Institute, Thiruvananthapuram.

Cheriyan P Koshy, nominated by Govt. of Kerala as Member, State Medicinal Plant Board and State High Level Committee on Protection of River Banks and Regulation of Removal of Sand.

Dhanya B Pillai won 1st prize for the poster entitled 'Establishment of hairy- root of *Plumbago rosea* L and scaling up in air-lift bioreactor" in the National Symposium: Emerging Trends in Biotechnology, 12-13 December 2012, organized by CUSAT, Kochi, 2012

Dr Raj Vikraman nominated as Member in Garden relandscaping, Museum Gardens, Thiruvananthapuram.

Hosagoudar VB Continued as editorial committee member of Plant Pathology & Quarantine.

Hosagoudar VB continued as Associate Editor for mycology in Indian Phytopathology Journal and Bioscience Discovery.

Hosagoudar VB continued as Research Advisor to the Department of Microbiology, Sengammala Thayaar Educational Trust, Mannargudi and is rendering identification services in the foliicolous fungi.

Hosagoudar VB continued as subject Editor of Journal of Threatened Taxa and Editor of Scientific Transactions in Environment and Technovation.

Hosagoudar VB recognised as Ph.D. guide in Botany by Bharathiar University, Coimbatore

Hosagoudar VB selected as a member of editorial committee for the Journal of Theorotical and Experimental Biology &Bulletin of Basic and Applied Plant Biology.

Krishnan PN nominated as Chairman of the Board of Examiners and Question Paper Setters of M. Sc. Bioinformatics Examination of the Calicut University.

Mathew Dan nominated as the Expert Member in the Consultative Group to develop a digital database of plant wealth in Kerala by the Kerala Biotechnology Commission.

Mathew Dan served as a Faculty Member for the Refresher Course for life science teachers at Academic Staff College, University of Kerala.

Mohanan N continued as Public Information Officer (Scientific), as per Right to Information Act 2005.

Mohanan N nominated as Member, Vanamithra Award Committee, Kerala Forest Department 2014.

Mohanan N nominated as Member in Garden relandscaping, Museum Gardens, Thiruvananthapuram.

Pandurangan AG nominated as Co-ordinator, Lead Garden Programme, MoEF, Govt. of India.

Pandurangan AG nominated BR Co-ordinator, Lead Institution for Biosphere Programme, MoEF, Govt. of IndiaPandurangan AG nominated Member, Task Force, State level Steering Committee on Medicinal Plants, Govt. of Kerala.

Pandurangan AG recognized as Research Guide by M. S. University, Thirunelveli.

Praveen VP received the second runner up prize for the best oral and poster presentations of the paper 'Species preference of the crab *Sesarmops intermedius* to seedling predation in mangrove ecosystem of Kerala, India' in the International Conference on 'The 3rd Meeting on Mangrove Ecology, Functioning and Management (MMM3)' , 2-7 July 2012, at Galle, Sri Lanka.

Radha RK nominated as Chair for poster session and also a member of the Judging panel for Poster in the Malaysia International Biological Symposium 2012 (-SIMBIOMAS 2012) at Uniten Bangi, Malaysia July 11-12, 2012.

Rajasekharan S nominated as member in the Judging Committee constituted by Kerala State Council for Science, Technology and Environment (KSCSTE) in connection with the presentation of Students under the 'Sasthrabodhini' Programme, 5-8 July 2012.

Ramesh Kumar KB received Fr. Anthony Mukhath - K.S. Manilal Award in Modern Techniques in Plant Taxonomy, Indian Association for Angiosperm Taxonomy, 2012.

Ramesh Kumar KB recognized as Research Guide in Chemistry by University of Kerala, Thiruvananthapuram, Kerala.

Renjukrishna V awarded Young Scientist Award at Kerala Science Congress, Kottayam on 31st January 2012.

Sabu KK recognized as a Ph.D. guide in Botany by University of Kerala

Sabulal B recognized as Research Guide in Biochemistry by University of Kerala, Thiruvananthapuram, Kerala.

Sabulal B recognized as Research Guide in Chemistry by M. S. University, Thirunelveli.

Sathish Kumar C nominated as the Chair of the reconstituted Indian Subcontinent Regional Orchid Specialist Group (ISROSG) of IUCN/SSC for the triennium 2013-2016.

Shiburaj S awarded BOYSCAST Fellowship 2010-11, Dept of Science and Technology, Govt. of India.

Shiburaj S awarded Canadian National Proteomics Network (CNPN) President's best paper award in 4th Annual CNPN Symposium: Proteomics: from protein structures to clinical applications, Toronto, Canada April 23-25, 2012.

Sreekala AK recognized as a Ph.D. guide by Manonmaniyam Sundarnar University, Thirunelveli, Tamil Nadu.

Sreekumar S has been appointed as Member of the Board of Examiners and Question Paper Setters of M.Sc. Bioinformatics Examinations of the Calicut University.

Sreekumar S has been appointed as the Question Paper Setter of M.Phil. Geoinformatics Examinations of the Cochin University of Science and Technology.

Sreekumar S has served as examiner for conducting SSLC (IED) Practical Examinations during April 2013.

The World Bamboo Organization announced JNTBGRI bamboo group as First Place Winners of 2012 World Bamboo Day Contest which carried a cash award of US$ 250.

Vinodkumar TG Nair recognized as Fellow of National Society of Ethnopharmacology (FNSE) by the National Society of Ethnopharmacology, 2012.

Vrinda KB nominated Chairman, Ph. D. preliminary qualifying examination in Botany, Calicut University, 2012.

Vrinda KB nominated Examinor, Ph. D. qualifying examination in Botany, Calicut University, 2012.

Vrinda KB nominated External Exminer, M.Phil (Botany) Examination, Calicut University, 2012.

William Decruse became Life Member, Kerala Academy of Sciences

Evaluation of Ph. D thesis

Krishnan PN evaluated the Ph.D thesis 'Critical Investigation of Pharmacognosy, Phytochemistry and Antimicrobial Potential of Some Wild Species of Lamiaceae', submitted to Mumbai University.

Krishnan PN evaluated the Ph. D thesis 'Evaluation of antimicrobial and antioxidant potential of different parts of *Mangifera indica* L.', submitted to Saurashtra University, Rajkot, Gujarat.

Mathew Dan evaluated the Ph. D thesis 'Pharmacognostical, Phytochemical and Pharmacological Studies on two species of *Jatropha*', submitted to Manonmaniam Sundaranar University, Tirunelveli.

Mathew Dan evaluated the Ph. D thesis 'Pharmacognostical Ethnobotanical and

Crystallographic Studies of Selected Antiurolithiatic Medicinal Plants', submitted to Mahathma Gandhi University, Kottayam.

Mohanan N evaluated the Ph. D thesis 'Palynological Studies on South Indian Myrtales', submitted to Mahathma Gandhi University, Kottayam.

Mukunthakumar S evaluated the Ph. D. thesis 'Molecular systematics, micropropagation, antimicrobial and phytochemical studies in selected species of *Crotalaria* Linn.', submitted to Bharathidasan University.

Satheeshkumar C evaluated the Ph. D. thesis 'Taxonomic Revision of the genus *Commelina* L. (Commelinaceae) in India' , submitted to Calicut University.

Sudha CG evaluated the Ph. D. thesis 'Evaluation of Hemeoxygenase role in plant defense against metal induced oxidative stress in *Brassica juncea* and *Glycine max* and Molecular Characterization, submitted to BJHOI Banasthali Vidyapith University, Rajasthan.

Latha PG evaluated the Ph. D. thesis 'Anticarcinogenic and Genoprotective effect of mushroom derived components: Studies on triterpenes isolated from *Ganoderma lucidum*', submitted to Mahatma Gandhi University, Kottayam.

Latha PG evaluated the Ph. D thesis 'Antidiabetic and hypolipidemic activities of *Phellinus rimosus* (Berk) Pilat, a polypore mushroom occurring in Kerala', submitted to Mahatma Gandhi University, Kottayam.

Visitors

Shri Montek Singh Ahluwalia, Deputy Chairman, Planning Commission, Govt. of India, New Delhi.

Dr. K. Kasturirangan, Member (Science), Planning Commission, Govt. of India, New Delhi.

Shri K. M. Chandrasekhar, Vice Chairman, Kerala State Planning Board, Thiruvananthapuram.

Prof. (Dr.) K. Vijay Raghavan, Secretary, DBT, Government of India, New Delhi.

Padmavibhushan Dr. M. S. Valiathan, National Professor, Government of India, Mnipal.

Dr. S. Natesh, Former Senior Advisor (Scientist H), DBT, New Delhi.

Dr. Raghavendra Gadagkar, Indian Institute of Science, Bangalore.

Prof. (Dr.) M. K. Prasad, Former Pro. Vice Chancellor, University of Calicut, Kozhikode.

Dr. Rama Rao, Scientist, Wood Science Institute, Bangalore.

Dr. M. R. N. Murthy, Indian Institute of Science, Bangalore.

Dr. Brijesh Kumar, Scientist, CDRI, Lucknow.

Prof. A. K. Koul, Dean, Academic Affairs, BGSB University, J & K.

Pt. Viswa Mohan Bhatt, Renowned Musician, Mumbai.

Dr. A. Ajay Ghosh, CSIR Outstanding Scientist, NIIST, Thiruvananthapuram.

Dr Brian Schrire, Royal Botanic Garden, Kew, UK.

Dr K Haridasan, Joint Director, FRLHT, Bangalore .

Dr Kwang Woo Park , Director, Korean National Arboretum, S. Korea.

Dr Kim and Prof. Nam Sook Lee, Ewha Womans Univ. S. Korea

Dr Sanjay Kumar, Deputy Director General, National Bamboo Mission, New Delhi

Mr Sayuj Koyyappurath from CIRAD, Reunion Island, France.

Dr. Ravi Ralph, IFS, Addl. PCCF & CEO, State Medicinal Plant Board, Govt. of Karnataka.

A seven member team of Pilikula Nisarga Dhama Society (R), Mangalore visited the Bambusetum to study the conservation aspects.

South Korean team from Korean National Arboretum and Ewha Womans University, South Korea visited JNTBGRI during 14-21st July 2012.The team consisted of Dr Kwang Woo Park (Director, National Arboretum) and his colleague Dr Kim and Prof. Nam Sook Lee (Ewha Womans Univ.) and her three students (one of whom, Ms Sangmi reached here in advance for her training in orchid taxonomy). One of the main objectives of this visit was to explore possibilities of tie up in mutually interested areas particularly in orchid taxonomy, seed exchange and deposit of selected Indian species in the Seed Bank of South Korea. As part of this programme, one Ph. D. student of South Korea was given two months training in orchid taxonomy, especially in species description, key construction and write up of scientific and technical papers. The team visited the living collections, seed bank and held discussions with Director and other scientists. They also called on the Chief Minister on 16th July 2012 and appraised the programme. The Hon'ble Chief Minister offered all support during the implementation of the project.

Rod Rice, Sydney Botanic Gardens, Australia visited JNTBGRI during 6-11 December 2012. Rod Rice is an accomplished orchidologist and editor of the journal 'Oasis'.

JNTBGRI facilitated the visit of the members of the high power committee from NCT Delhi, Govt. of India, on 24 Nov. 2012 to the Institute. The committee visited the Institute to study the development of the herbal garden of JNTBGRI, for developing a 70 acre herbal garden at Brahm Prakash Ayurved Charak Sansthan (CBPACS) at New Delhi.

Collaboration with other Institutions

The Bioinformatics Centre jointly with Apex Centre developed web portal site for BTISNet Publications and Library Resources and BTISNET web site.

As per the request from the Managing Director, Malabar Botanic Garden, Ollavana, Kozhikkode a database application package was created for documenting plant diversity of Malabar Botanic Garden, Ollavana, Kozhikkode. Data of about 400 plants conserved at Malabar Botanic Garden were documented on the database. The database can be accessed from the URL www.jntbgri.in

Worked in collaboration with the Kerala Forest Development Corporation in the Project for Identification, Collection, Propagation and *Ex situ* Conservation of Orchids of Western Ghats at Vagamon upon their request

Tissue culture unit of Plant Genetic Resource Division took up a consultancy for developing a tissue culture facility at Iqbal College, Perigamala.

The Division of Plant Systematics & Evolutionary Science is continuing their linkage with the Department of Forests & Wildlife Govt. of Kerala; Department of Entomology, Kerala Agricultural University, Thiruvananthapuram; Department of Entomology, KFRI, Peechi, Thrissur; Department of Zoology, Sacred Heart College, Eranakulam and the Department of Pathology, KAU, Thiruvananthapuram.

The Microbiology Division has International collaboration with Dr. Thomas H. MacRae, Professor and Head, Cell Biology, Department of Biology, Dalhousie University, Halifax, Canada; national collaboration with Dr. Dileep and Dr. Rajiv, Scientists, NIIST, Trivandrum, Prof. K. Dharmalingam, Research Director, Aravind Medical Research Foundation Madurai and Industrial collaboration with with Pelican Biotech, Cherthala.

Patents

A process to prepare a novel herbal formulation with multiple therapeutic effects as antidiabetic, antifatigue, hepatoprotective and antioxidant. Inventors: S Rajasekharan, PG Latha, T Shahul Hameed, SR Suja, N M Krishnakumar. File No. 2277/ CHE/ 2011 (Provisional patent, complete specification filed- August 2012).

Publications

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Gopakumar B (2013). Bamboos for River Embankments. Poster presented at the 25th Kerala Science Congress, Thiruvananthapuram.

Hosagoudar VB (2013). Black Mildews. Paper presented at the National Conference on Recent Trends in Botany, organized by Dept. of Botany, Yashvantarao Chavan Institute of Science, Satara.

Jayakumar KS, Padmesh P, Sajan JS, Deepu S and Pandurangan AG (2013). Estimation of diversity in *Lagerstroemia speciosa*- an antidiabetic drug using SSR markers. Paper presented at the the 25th Kerala Science Congress, Thiruvananthapuram.

Jayakumar KS, Padmesh P, Sajan JS, Deepu S and Pandurangan AG (2013). Estimation of diversity in *Lagerstroemia speciosa*- an antidiabetic drug using SSR markers. Paper presented at the 25th Kerala Science Congress, Thiruvananthapuram.

Jayalakshmi M (2013). Ethnobotanical studies on medicinal plants used by the Hindu Ullada tribe of Pathanamthitta district, Kerala. Paper presented at the National Conference on Emerging Trends in Medicinal Plants and Herbal Products, Dept. of Botany, VHNSN College, Virudhnagar, Tamil Nadu.

Joemon Jacob, Chitra CR, Greeshma P Nair, Anilkumar C and William Decruse S (2013). Effect of cryopreservation on germination of seeds and zygotic embryos of *Calamus shendurunii* Anto, Renuka and Sreekumar, an endemic rattan of Western Ghats. Paper presented at the National Seminar on Forestry and Agriculture, Kerala Forest Research Institute, Peechi and Gregor Mendal

Foundation, Calicut.

Joemon Jacob, Greeshma P Nair and William Decruse S. (2013). Seed and embryo cryopreservation of *Calamus shendurunii*. Paper presented at the National Seminar on Forestry and Agriculture organized by Kerala Forest Research Institute.

Koshy KC (2012). 25 years of Bamboo Conservation at Jawaharlal Nehru Tropical Botanic Garden and Research Institute, India. Paper presented at the 13th Conference of International Association of Botanical Gardens (IABG 2012) held at Guangzhou, China (Symposium: Bamboo Diversity and conservation).

Krishnakumar G, Rameshkumar KB, Satheeshkumar K and Krishnan PN (2012). Isolation and identification of Camptothecin in *in vitro* cultures of *Ophiorrhiza prostrate* D. Don. Poster presented at the International Conference on Advances in Biological Sciences, Kannur.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2012). Mast cell stabilizing and antioxidant properties of *Morinda umbellata* L. Paper presented at the 5th World Ayurveda Congress held at Bhopal, organized by Vijnana Bharati, Govt. of Madhya Pradesh and World Ayurveda Foundation.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2013). Medicinal mushrooms as a source of immunomodulatory compounds. Paper presented at the National Symposium on Medicinal Mushrooms organized by Amala Cancer Research Centre, Thrissur.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2012). The Genus *Morinda*-Medicinal and Socio-Economic Relevance. Paper presented at the National Seminar on Action Anthropology, Traditional Knowledge, Tribal Medicine and Development conducted by Muddha Mooppan Centre for Tribal Medicine Development, Palakkad.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2012). Ethnomedicinal relevance of the Genus *Morinda.* Paper presented at the Second Biodiversity Congress (IBC 2012), Bangalore, organized by Centre for Innovation in Science & Social Action (CISSA) and Govt. of Karnataka.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2013). Mast cell stabilization activity of ethanolic extract of the leaves of *Morinda umbellata* L. Poster presented at the 25th Kerala Science Congress, Thiruvananthapuram.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2013). Noni -an amazing traditional medicinal plant of South-East Asia. Poster presented at the 8th National Seminar on Medicinal Plants conducted by the Pharmacognosy Unit, Trivandrum Ayurveda College at Rajiv Gandhi Centre for Biotechnology.

Krishnakumar NM, Latha PG, Suja SR and Rajasekharan S (2014). Anti-allergic and antioxidant potential of *Morinda umbellata* L.- an important traditional medicine. Paper presented at the 26th Kerala Science Congress, Wayanad.

Krishnan PN (2013). Role of Tissue Culture Technology and Bioinformatics in Biological Research. Special talk on Ph.D. course work at Dept. of Biosciences, MG University.

Latha PG and William Decruse S (2014). Conservation of Orchids of Western Ghats through application of Biotechnology. Paper presented at the National Conference on Orchid Conservation, Improvement and Sustainable Development. Kerala Agricultural University, Vellanikkara.

Manza NA and Radha RK (2013). Cryopreservation of embryonic axes of *Coscinium fenestratum* (Gaertn) Colebr.*,* a critically endangered medicinal plant of the Western Ghats.Poster presented at All India Congress of Cytology and Genetics & National Symposium on Gene, Environment and Health organized by Department of Botany, University of Kerala.

Mathew Dan (2014). The present day relevance of the medicinal plant conservation Lecture delivered at the Workshop on Conservation and Cultivation of Medicinal Plants, organized at Govt. Ayurveda College, Trivandrum.

Mathew Dan (2012). Biodiversity: its forms and assessment. Lecture delivered at the Seminar on Conservation of Biodiversity at Catholicate College, Pathanamthitta.

Mathew Dan (2012). Forms of Biodiversity: its types and assessment. Lecture delivered at Kerala Agricultural University

Mathew Dan (2013). Why Taxonomy? Lecture delivered at the HHMSPB NSS College, Neeramankara.

Mathew Dan (2014). Relevance of Plant Taxonomy. Invited lecture delivered at St. Gregorios College, Kottarakkara.

Mathew Dan served as resource person for the Refresher Course for College Teachers at Kerala University Staff College on 2nd August 2013.

Mathew Dan, Sabulal B and Bejoy M (2012). 'On *Curcuma bhatii* (Zingiberaceae) – the smallest *Curcuma* from southern India Paper presented at the 6th International Symposium on Family Zingiberaceae, at Calicut.

Mathew PJ (2013). Intraspecific variability in *Centella asiatica*- the source plant of asiaticoside. Lecture

delivered *at* the Seminar on Medicinal Plants at CMS College, Kottayam.

Nair ARG, Ravichandran P and Bejoy M (2013). Improved shoot multiplication using paclobutrazol in the triploid banana–'Poovan' (AAB). Paper presented at 3rd International Science Congress. 8-9 December 2013, Karunya University, Coimbatore, Tamil Nadu, India.

Nazarudeen A (2014). Conventional and Modern Aspects of Plant Taxonomy. Lecture delivered at the National Workshop cum Training Programme, Gandhigram University held at the Dept. of Biology, Gandhigram Rural University, Dindigul (Tamil Nadu).

Nazarudeen A (2014). Historical and geographical aspects of Biodiversity. Lecture delivered at the Kerala Agriculture University, Trivandrum.

Nisha NC, Sreekumar S, Biju CK and Krishnan PN (2012). Identification of potential lead compound with cobra toxic venom neutralizing activity in *Acorus calamus* L. Paper presented at the International seminar on World Bioheritage Concerns over Climate change, with a special reference to Ethnic Vegetables organised by the Department of Botany S. N. College, Chempazhanthy.

Nisha NC, Sreekumar S, Biju CK and Krishnan PN(2013). *In silico* screening and identification of lead compounds with cobra venom neutralizing activity in *Wrightea arborea* (dennst.) Mabb. Paper presented at the International Seminar on Molecular secrets of Plant Medicine, Organized by CMS College Kottayam.

Nisha NC, Sreekumar S, Krishnan PN and Biju CK (2014). Cobra venom neutralizing activity: Validation of traditional knowledge in *Aristolochia indica* L. Poster presented at the 26th Kerala Science Congress, Wayanad.

Nisheeda Basheer A, Sreekumar S, Biju CK and Krishnan PN (2013). *In silico* validation of the hepatoprotective activity in *Boerhavia diffusa.* Paper presented at the International Conference on Advances in Biotechnology and Patenting organised by Bharathidasan University, Tamil Nadu.

Pamitha NS, Suja SR, Pradeep NS, Latha PG, Vilash V and Krishnankumar NM (2014). A glance into the pharmacological, phytochemical, morphological and nutritive value of *Macrocybe gigantea* – a wild edible mushroom. Paper presented at the UGC Sponsored National Seminar cum workshop on Techniques in Bioscience.

Pandurangan AG (2014). Delivered an invited lecture on Taxonomy for 21st Century at the National Workshop cum Training Programme on Conventional and Modern Aspects of Plant Taxonomy held at Gandhigram Rural University, Dindugal.

Pradeep CK, Vrinda KB and Shibu P Varghese (2013). Genus *Entoloma* in Kerala state. Paper presented at the National seminar *on* 'Current Perspectives of Fungi in Health Care and Environment' (Kavaastha), organized by the Mycological Society of India at Bangalore University.

Pradeep CK, Vrinda KB and Shibu P Varghese (2013). Genus *Pluteus* in Kerala state. Paper presented at the Indian Mushroom Conference 2013, organized by the Mushroom Society of India at Ludhiana, Punjab.

Prajith TM, Anilkumar C, Cherian P Koshy, Rajani Kurup and Sabulal Baby (2013). Developmental and desiccation oriented seed viability in *Saraca asoca* (Roxb.) W. J. de Wilde. Paper presented at the XIII ISST National Seed Seminar on Innovation in Seed Research and Development, Bengaluru, India.

Prajith TM, Anilkumar C, Cherian P Koshy, Rajani Kurup SR and Sabulal Baby (2013). Development and Desiccation Oriented Seed Viability in *Saraca asoka* (Roxb.) W.J.De Wilde. Paper presented at the XIII National Seed Seminar on Innovations in Seed Research and Development, at UAS, Bengaluru.

Prathibha V, Sreekumar S, Nisha NC, Biju CK and Krishnan PN (2012). *In silico* screening and identification of lead compounds with *Naja naja* anti-venom activity from V*itex negundo* (L.). Paper presented at the National Conference on Computational Biology and Chemistry, Organized by Bioinformatics Division, VIT University, Velloor, TamilNadu.

Praveen VP, Nayar TS and Suresh S (2012). Species preference of the crab *Sesarmops intermedius* to seedling predation in Mangrove Ecosystem of Kerala, India. Paper presented at the International Conference on the 3rd Meeting on Mangrove Ecology, Functioning and Management (MMM3), held at Galle, Sri Lanka.

Radha RK, Manza and William Decruse S (2013). Zygotic embryo cryopreservation of *Myristica malabarica*. Paper presented at the 16th AICG Conference, Department of Botany, University of Kerala, Kariavattom.

Radha RK, Sam P Mathew and Krishnan PN (2012). *Ex situ* conservation of *Hornstedtia fenzli* (Kurz) K. Schum.- The honey bee repellent endemic plant species of the Andaman Nicobar Islands. Paper presented at Malaysia International Biological Symposium 2012 (*i*-SIMBIOMAS 2012) at Malaysia.

Radhakrishnan K (2012). Tribal Medicine with Reference to Kerala. Lecture delivered in the National Seminar on Action Anthropology, Traditional Knowledge, Tribal Medicine and Development, organized by Muddha Mooppan

Centre for Tribal Medicine Development, at Palakkad.

Radhika BJ, Ravichandran P, Bejoy M and Satheesh Kumar K (2013). *In vitro* multiplication of *Musa paradisiaca* L. cv. Nendran using Infloresence. Paper presented at 16th All India Congress of Cytology and Genetics, Department of BotanyKerala University, Trivandrum, India.

Radhika BJ, Ravichandran P, Bejoy M and Satheesh Kumar K (2013). *In vitro* multiplication of *Musa paradisiaca* L.cv Nendran using infloresence. Paper presented at the 16th All India Congress of Cytology and Genetics 22-24 October 2013, Department of Botany Kerala University, Trivandrum, India.

Rafeeq, Rameshkumar KB, Neethu RS, Pandurangan AG and Pradeep NS (2012). Phytochemical and bioactivity evaluation of the *Dioscorea* species of Western Ghats. Paper presented at the 7th ISDNP symposium. AMITY University, Noida.

Rajasekharan S (2012). Protection of Traditional Knowledge: Lessons learned from Kani Model of Access and Benefit Sharing – A Critical Appraisal. Paper presented at the National Seminar on Action Anthropology, Traditional Knowledge, Tribal Medicine and Development, organized by Muddha Mooppan Centre for Tribal Medicine Development, at Palakkad.

Rajasekharan S (2012). Hortus Malabaricus/Ayurvedic Classical Health Tradition and Oral Health Tradition. Invited talk in a special session organized by Kerala State Biodiversity Board.

Rajasekharan S (2012). Role of Natural Medicine and Sports. Paper presented at the seminar organized by the Sports Authority of India at Lakshmibai National College of Physical Education, Kariyavattom, Thiruvananthapuram.

Rajasekharan S (2012). Traditional Knowledge and IPR and Access and Benefit Sharing. Invited talk at KFRI in connection with one week compulsory training course on Conservation and Development of Medicinal Plants and Benefit Sharing with the Local Communities.

Rajasekharan S, Navas M, Vinod Kumar TG Nair, Subash Baby CK, Asharf AK and Seena GR (2012). Herbs for All and Health for All-Empowering Rural Women in Primary Health Care utilizing Local Biodiversity. Paper presented at the Second Indian Biodiversity Congress (IBC 2012) Bangalore, organized by Centre for Innovation in Science & Social Action (CISSA) and Govt. of Karnataka.

Rajasekharan S, Vinod Kumar TG Nair, Navas M, Latha PG and Pushpangandan P (2012). Protection of Traditional Knowledge related to plants used for food and medicine and scope of developing new paradigms on Access and Benefit Sharing. Paper presented at the Seventh International Symposium on Recent Advance in Natural Products, Organized by AMITY University, Noida, UP.

Rajeshkumar PP and Hosagoudar VB (2012). Arbuscular mycorrhizal fungal diversity of Silent Valley National Park. Paper presented at the Swadeshi Science Congress. Organised by Swadeshi Science Movement, Kerala and CPCRI, Kasaragod.

Rajkumar G and Pandurangan AG (2012). Impact of pathogenic incidence in the survival of *Goniothalamus wightii - a* rare endemic species of Southern Western Ghats. In: Proceedings of First National Biodiversity Congress, Thiruvananthapuram. Pp. 175.

Raju Antony (2013). The Pteridophyte Flora of Agasthyamala, Western Ghats. Lecture delivered at Malabar Botanical Garden, Kozhikkode in connection with National Workshop on Plant Taxonomy, Conservation and Propagation Methodology of Primitive Vascular Plants of South India.

Raju Antony (2013). Taxonomy of Pteridophytes. Invited lecture delivered at Brennen College, Thalassery and St. Berchman's College, Changanacherry.

Rameshkumar KB and Mathew PJ (2012). Chemotaxonomy of *Piper* species based on volatile chemical profiles of the leaves. Paper presented at the IAAT seminar, SGB Amravat University, Amravati, Maharashtra.

Rameshkumar KB (2013). Chemical Prospecting of Plant Resources. Invited talk at the National Seminar on Modern Trends and Applications in Life Sciences at theDepartment of Botany, Govt. College, Kottayam.

Rameshkumar KB (2013). Chemistry of Plants. Invited lecture at the Govt. Higher Secondary School, Koothuparamba.

Rameshkumar KB (2014). Advanced Analytical Techniques in Plant Chemistry. Talk delivered at the National Seminar on Research Instrumentation for Interdisciplinary Science, Organized by Iqbal College, Peringamala at YMCA Hall, Thiruvananthapuram.

Rameshkumar KB and Anu Aravind AP (2012). Volatile oil chemistry of *Syzygium* species from Kerala. Paper presented at the 7th ISDNP Symposium. AMITY University, Noida.

Rameshkumar KB, Preeti Chandra Awantika Singh and Brijesh Kumar (2013). Chemical evaluation of the flavour constituents of Black Pepper- A comparative study of GC- MS, LC-MS and DART-MS analyses. Paper presented at the International Conference

on Frontiers of Mass Spectrometry (ICMS-2013). Mahatma Gandhi University, Kottayam.

Rameshkumar KB, Sabu T, Shameer PS and Mohanan N (2012). Chemosystematic studies of a new *Garcinia* species. Paper presented at the IAAT Seminar, SGB Amravati University, Amravati, Maharashtra.

Remya J and Pandurangan AG (2012). Systematics studies on grasses of Nilgiri Biosphere Reserve. Paper presented at the National Seminar on Recent Trends and Future Prospects of Biodiversity and Conservation at Sreenarayana College Punalur.

Renjith R, Sibi CV, Roja G, Venkataraman R, Satheeshkumar K and Sabulal B (2013). Chemical Estimation of Camptothecin in *Ophiorrhiza* Species from Southern Western Ghats. Paper presented at the International Conference on Emerging Trends in Chemical and Pharmaceutical Sciences. Jawaharlal Nehru Technological University, Anantapur.

Renjith R, Sibi CV, Satheeshkumar K, Venkataraman R and Sabulal Baby (2013). Isolation of a pentacyclic triterpene fatty acid ester from *Ophiorrhiza shendurunii* and its identification by NMR, ESI-MS and GC-MS. Paper presented at the International Conference on Frontiers of Mass Spectrometry. Inter University Instrumentation Centre, Mahatma Gandhi University, Kottayam.

Rini Abraham, George K Varghese, Nisha NC and Sreekumar S (2013). Molecular Modeling of *Terminalia cuneata* Roth. against cholesteryl esterase. Paper presented at the International Seminar on Molecular Secrets of Plant Medicine, Organized by CMS College, Kottayam.

Sabnam SA, Resmi L and Rameshkumar KB (2014). Phytochemical and antioxidant evaluation of nine diploid and triploid banana cultivars from Kerala. Paper presented at the Kerala Science Congress, Wayanad.

Sabu KK (2013). Introduction to Molecular Markers. Invited lecture delivered at the Workshop on Molecular Tools and Techniques, Organized by the Inter University Centre for Genomics and Gene Technology (IU-CGGT), University of Kerala.

Sabu KK (2013). Molecular marker techniques. Lecture delivered at UGC Academic Staff College, University of Kerala.

Sabulal B (2014). Carnivorous plants: a unique group of plants, their survival strategies. Invited talk at the Department of Chemistry, Assam University, Silchar (Central University).

Sabulal B (2014). Carnivorous plants: a unique group of plants, their survival strategies. Lecture delivered at the Department of Biotechnology, Indian Institute of Technology, Guwahati.

Safeer PM, Sreekumar S and Krishnan PN (2014). Agrotechniques for conservation, sustainable utilization and commercial cultivation of *Plectranthus vettveroides*. Poster presented at 26th Kerala Science Congress, Wayanad.

Safeer PM, Sreekumar S, Biju CK and Krishnan PN (2012.) Conservation of *Plectranthus vettiveroides* (K.C. Jacob) NP Singh & BD Sharma through popularizing cultivation practices. Paper presented at the Second Indian Biodiversity Congress held at JN Tata Auditorium, Indian Institute of Science, Bangalore.

Safeer PM, Sreekumar S, Krishnan PN, Biju CK and Seeja G (2012). Conservation and sustainable utilization strategies for *Plectranthus vettiveroides*: an economically promising endemic medicinal plant extinct in the wild. Paper presented at the International Seminar on Bioheritage Concerns over Climate Change with a Special Reference to Ethnic Vegetables – Botanica 2012, Organised by the department of Botany S. N. College, Chempazhanthy, Thiruvananthapuram.

Safeer PM, Sreekumar S, Krishnan PN, Biju CK and Seeja G (2012). Agrotechniques for conservation and sustainable utilization of *Plectranthus vettiveroides.* Paper presented at the Second National Symposium on Innovative Approaches and Modern Technologies for Crop Productivity, Food Safety and Environmental Sustainability organized by Society for Applied Biotechnology (India).

Safeer PM, Sreekumar S, Krishnan PN, Biju CK and Seeja G (2013). Influence of soil texture and type on growth and yield in *Plectranthus vettiveroides*. Poster presented at the Indian Science Congress, Kolkata.

Sajan JS, Padmesh P Pillai, Suja SR, Sabulal Baby, Jayakumar KS and Krishnan P N (2013). Estimation of corosolic acid, a Type–II anti diabetic agent, in different parts of *Lagerstroemia speciosa* L. and its *in vitro* evaluation of free radical scavenging activities Souvenir of 3rd International Science Congress, Coimbatore, India 8th-9th Dec, 2013.

Santhosh Kumar ES (2012). Species Diversity, Centres of Species diversity, Megadiversity centres and Hotspots Analysis. Lecture delivered at Kerala Agricultural University.

Sathish Kumar C (2013). Along the River Siang- A Memoir. Lecture delivered at New Year Bash, a Seminar organized by JNTBGRI.

Sathish Kumar C (2013). Nikolai Vavilov: 70th Anniversary of Martyrdom. Lecture delivered at Commemorative Seminar, organized by JNTBGRI.

Sathish Kumar C (2013). Biodiversity of Western Ghats. Lecture delivered at Kerala Development Programme, organized by KSSP.

Sathish Kumar C (2013). Life and Works of Charles Darwin Gregor Johanne Mendel and the Birth of Genetics. Lecture delivered at St. Thomas School, Trivandrum.

Sathish Kumar C (2013). Biology of Carnivorous Plants. Lecture delivered at All Saints' College, Trivandrum.

Sathish Kumar C (2013). Gregor Johanne Mendel and the Birth of Genetics. Lecture delivered for St. Thomas School Students at JNTBGRI.

Sathish Kumar C (2013). An Introduction to Orchids; Biology of Carnivorous Plants. Guest Classes for Madras Christian College at CP Ramaswami Aiyyar Foundation, Chennal.

Sathish Kumar C (2013). The genus *Vanilla* Plum. ex Mill. (Orchidaceae) in South Asia. Lecture delivered at 5th International Orchid Conservation Congress at IUCN and CIRAD at St. Denis, Reunion Island, France.

Sathish Kumar C (2014). The Splendour of Orchids. Lecture delivered at India International Centre, New Delhi.

Sathish Kumar C (2014). Wonderful World of Orchids.Lecture delivered at the Children's Education Programme, Botanic Garden of Indian Republic, NOIDA.

Sathish Kumar C (2014). Orchid Biology, the Science of Orchids, Biology of Carnivorous Plants, Botanical Illustrations. Lecture delivered at Academies Taxonomy Workshop, PSGR Krishnanmmal College for Women, Coimbatore.

Sathish Kumar C (2014). Orchids of Western Ghats. Lecture delivered at Marthoma College, Tiruvalla.

Sathish Kumar C (2014). Orchid Biology, the Science of Orchids, Biology of Carnivorous Plants. Guest lecture delivered at NSS College, Vazhoor, Kottayam

Sathish Kumar C (2014). The Wonderful World of Orchids. Guest Lecture delivered at Gargi College, New Delhi.

Sathish Kumar C (2014). Orchids of Western Ghats. Guest Lecture delivered at Baton Rouge Orchid Society, Lousiana, USA.

Satheeshkumar K (2013). Secondary Metabolite Production through Biotechnological methods. Invited lecture at Madurai Kamaraj University, Madurai.

Satheeshkumar K (2014). Bioproduction of Secondary Metabolites. Lecture delivered at Sree Krishna College of Engineering and Technology, Coimbatore.

Satheeshkumar K (2014). Secondary Metabolite Production and Hairy Root Culture. Lecture delivered at the Department of Biotechnology, Genomic Center, Kariavattom, University of Kerala

Shameer PS, Sabu T, Mohanan N and Rameshkumar KB (2013). Post harvest processing of the fruit rind of *Garcinia gummi-gutta* (L.)- chemical and physical evaluation. Paper presented at the National Seminar on Post Harvest Processing of Fruits and Spices. Madikeri, Karnataka.

Sheeba PM and Pandurangan AG (2012). Taxonomic studies on the family Asclepiadaceae R.Br. of the southern Western Ghats. Paper presented at the National Seminar on Recent Trends and Future Prospects of Biodiversity and Conservation, at Sreenarayana College Punalur.

Shibu P Varghese, Vrinda KB and Pradeep CK (2013). Hygrophoraceae- the wax- gilled mushroom family. Poster presented at the National Seminar on Current Perspectives of Fungi in Health Care and Environment (Kavaastha), organized by the Mycological Society of India at Bangalore University.

Shibu P Varghese, Vrinda KB. and C.K. Pradeep (2014). Agaricus on elephant dung from Western Ghats of Kerala. Poster presented at the International Symposium on Role of fungi and microbes in the 21st century- a global scenario, organized by the Indian Mycological Society at Kolkata.

Shiburaj S, Divya Balakrishnan and Pradeep NS (2014). Cellulolytic enzymes of *Streptomyces clavifer* TBG-MNR13 (MTCC 4150), active against *Pythium aphanidermatum,* a phytopathogenic fungus. Paper presented at the International Symposium on Role of Fungi and Microbes in the 21st century – a global scenario. IMS at Kolkatta.

Shikha P, Latha PG and Suja SR (2013). Anti-inflammatory activity of *Arenga wightii* Griff. Paper presented at the 8th National Seminar on Medicinal Plants conducted by the Pharmacognosy Unit, Trivandrum Ayurveda College at Rajiv Gandhi Centre for Biotechnology.

Shikha P, Latha PG and Suja SR (2014). The analgesic and antioxidant activities of *Arenga wightii* Griff. (Arecaceae). Paper presented at the 26th Kerala Science Congress, Wayanad.

Shikha P, Latha PG, Suja SR and Rajasekharan S (2012). Evaluation of the anti inflammatory and analgesic activities of two selected medicinal plants of the Western Ghats. Paper presented at the National Seminar on Action Anthropology, Traditional Knowledge, Tribal Medicine and Development conducted by Muddha Mooppan Centre for Tribal Medicine Development, Palakkad.

Shikha P, Latha PG, Suja SR, Shyamal S, Shine VJ,

Anuja, GI, Sini S, Krishnakumar NM, Sreejith G, Shoumya S and Rajasekharan S (2012). Ethnopharmacological investigations at Jawaharlal Nehru Tropical Botanic Garden and Research Institute. Paper presented at the Indo-South Africa Workshop on Traditional Medicine System: Sharing Knowledge and Experience, held at JSS College of Pharmacy, Ootacamund.

Shoumya S, Latha PG, Suja SR and Rajasekharan S (2013). Anti hepatotoxic potential of *Saraca asoca* – The sorrowless tree. Poster presented at the 25th Kerala Science Congress Thiruvananthapuram.

Shoumya S, Latha PG, Suja SR and Rajasekharan S (2013). Hepatoprotective and antioxidant potential of ethanolic extract of Saraca *asoca* (Roxb.) De Wilde stem bark against D-Galactosamine induced hepatotoxicity in wistar rats. Paper presented at the 8th National Seminar on Medicinal Plants conducted by the Pharmacognosy Unit, Trivandrum Ayurveda College at Rajiv Gandhi Centre for Biotechnology.

Shoumya S, Latha PG, Suja SR and Rajasekharan S (2014). Hepatoprotective and antioxidant potential of the ethanolic extract of *Saraca asoca* (Roxb.) de Wilde stem bark against ethyl alcohol induced hepatotoxicity in Wistar rats. Poser presented at the 26th Kerala Science, Wayanad.

Sibi C Varghese, Renjith R, Ravichandran P, Roja Gopalakrishnan and Satheeshkumar K (2013). Influence of repeated subcultures on biomass and camptothecin production in *Ophiorrhiza trichocarpos* Blume, a rare medicinal herb. Paper presented at the 3rd International Science Congress, Coimbatore.

Sibi C Varghese, Renjith R, Sabulal B, Ravichandran P, Roja Gopalakrishnan and Satheeshkumar K (2012). *In vitro* mass multiplication of *Ophiorrhiza pectinata* Arn.- an important source of camptothecin. Poster presented at the International Conference on Advances in Biological Sciences.

Silil Kumar S and Sudha CG (2013). Modified nutrient medium, gelling agent and culture conditions influence rapid shoot regeneration on aseptic leaf explants of *Curculigo orchioides* Gaertn., a commercially valuable medicinal plant. Paper presented at the National Symposium on Plant Tissue Culture and Biotechnology for Food and Nutritional Security. Plant Cell Biotechnology Department, CSIR-Central Food Technological Research Institute, Mysore.

Sililkumar S and Sudha CG (2012). Efficient *in vitro* propagation of *Curculigo orchioides* Gaertn. An Endangered and Commercially valuable medicinal Plant for *ex situ* Conservation. Paper presented at National Seminar on Recent Trends and Future Prospects of Biodiversity and Conservation. Department of Botany and Zoology, Sree Narayana College, Punalur, Kollam.

Sililkumar S and Sudha CG (2012). *In vitro* propagation through indirect shoot regeneration from aseptic leaf explants of *Curculigo orchioides* Garten. A commercially valuable and rare medicinal plant. Paper presented at the International seminar on world bioheritage concerns over climate change with a special reference to ethnic vegetables. Department of Botany, Sree Narayana College, Chempazhanthy.

Silja PK and Satheeshkumar K (2013). Sucrose induced rhizogenesis leading to enhanced plumbagin production in cell suspension cultures of *Plumbago rosea* L. Paper presented at the Third International Science Congress, Coimbatore, Tamil Nadu.

Silja PK, Dhanya B Pillai, Binoy Jose and Satheeshkumar K (2012). Enhanced growth and plumbagin production by optimization of inoculum density in adventitious root cultures of *Plumbago rosea* L. Poster presented at the International Conference on Advances in Biological Sciences, Kannur.

Silja PK, Dhanya B Pillai, Satheeshkumar K and Krishnan PN. (2012). *In vitro* differentiation of roots on cell cultures and detection of plumbagin in *Plumbago rosea* L. Poster presented at the National Symposium : Emerging Trends in Biotecnology organized by CUSAT, Kochi.

Sivu AR, Pradeep NS and Pandurangan AG (2012). Studies on sclerid morphology of *Memecylon* species in Peninsular India. Paper presented at the Second Indian Biodiversity Congress, IBC 2012.

Sivu AR, Ramesh Kumar KB, Pradeep NS and Pandurangan AG (2012). Phytochemical and bioactive evaluation of the *Memecylon* species of Western Ghats. Paper presented at the 7th International Symposium of the ISDNP on Recent Advances in Natural products. Amity University, Noida, Uttar Pradesh.

Sony George, Venkataraman R and Sabulal Baby (2013). Chemical Analysis of Fruit Volatile oil of *Melicope denhamii*. Paper presented at the International Conference on Emerging Trends in Chemical and Pharmaceutical Sciences. Jawaharlal Nehru Technological University, Anantapur.

Sony George, Venkataraman R and Sabulal Baby (2013). Isolation of two chromenes from *Melicope denhamii* and their characterization by NMR, ESI-MS and DART-HRMS. Paper presented at the International Conference on Frontiers of Mass

Spectrometry. Interuniversity Instrumentation Centre, Mahatma Gandhi University, Kottayam.

Sony Thomas, Biju CK, Hosagoudar VB, Sreekumar S and Krishnan PN (2012). Exploration of fungi causing black mildew disease on medicinal plants in sacred groves of southern districts of Kerala state. Paper presented at the International Seminar on 'Bioheritage concerns over climate change with a special reference to ethnic vegetables' – Botanica 2012 organised by the Department of Botany, S. N. College, Chempazhanthy.

Sony Thomas, Sreekumar S, Biju CK and Krishnan PN (2012). Biodiversity documentation and database organization of foliicolous fungi in the sacred groves of Kerala State. Paper presented at the Second Indian Biodiversity Congress (IBC 2012): held at JN Tata Auditorium, Indian Institute of Science, Bangalore.

Sreejith G, Jayasree M, Latha PG, Suja SR and Rajasekharan S(2012). Hepatoprotective and anti-oxidant studies of *Oxalis corniculata* L. Paper presented at the National seminar on 'Action Anthropology, Traditional Knowledge, Tribal Medicine and Development, conducted by Muddha Mooppan Centre for Tribal Medicine Development, Palakkad.

Sreejith G, Jayasree M, Latha PG, Suja SR and Rajasekharan S (2013). Amelioration of paracetamol induced liver damage by *Oxalis corniculata* Linn. Paper presented at the 8th National Seminar on Medicinal Plants conducted by the Pharmacognosy Unit, Trivandrum Ayurveda College at Rajiv Gandhi Centre for Biotechnology.

Sreejith G, Latha PG and Jayasree M (2013). Ameoliration of carbon tetrachloride- induced liver damage by *Oxalis corniculata* Linn. Poster presented at the International Seminar on 'Recent Biochemical Approaches in Therapeutics', organized by Dept. of Biochemistry, University of Kerala.

Sreekala AK and Pandurangan AG (2012). Reproductive dynamics of *Impatiens verticillata* Wight (Balsaminaceae) - An endemic balsam of Western Ghats. Paper presented at the International Seminar Botanica 2012, organized by SN College Chempazhanthy, Thiruvananthapuram.

Sreekala, AK (2013). Floral biology, breeding system and reproductive success of *Rauvolfia hookeri* Srinivasan and Chitra (Apocynaceae): A rare and endemic medicinal plant of southern Western Ghats, Kerala. Paper presented at the National Conference on 'Emerging Trends in Medicinal Plants and Herbal Drugs', VHNSN College, Virudhunagar, Tamil Nadu.

Sreekala, AK, Pandurangan AG and Kulloli SK (2012). Reproductive ecology of *Impatiens leptura* Hook.f. (Balsaminaceae) - An endangered balsam of southern Western Ghats. Paper presented at the National Seminar organized by Andhra University, Visakhapatanam.

Sreekumar S (2013). *In silico* screening and identification of lead compounds in herbal medicine with emphasis on the R & D at JNTBGRI. Lecture delivered at the International Symposium on Computational Biology & Drug Design, organised by MACFAST, Thiruvalla.

Sreekumar S (2013). *In silico* screening and identification of lead compounds in plants. Lecture delivered at the International Seminar on 'Molecular secrets of plant medicine', organized by CMS College Kottayam.

Sreekumar S and Biju CK (2013). Delivered lecture on 'Snake venom screening' at Nehru College of Arts and Science, Coimbatore.

Sudha CG (2013). *Ex situ* Conservation and Sustainable Utilization of Rare Medicinal Plants through Biotechnological Tools- Case studies in Jawaharlal Nehru Tropical Botanic Garden and Research Institute. Paper presented at the National Symposium on Plant Tissue Culture and Biotechnology for Food and Nutritional Security, organized by Plant Cell Biotechnology Department, CSIR-Central Food Technological Research Institute, Mysore.

Sudha CG (2013). 'Green the Earth and Clean the Mind'. Lecture delivered at the Public Meeting at Putharikantam Maithanam on 10th March 2013, organized by Brahama Kumari Iswarya Vishwa Vidhyalaya Peetam.

Sudha CG (2013). Delivered a lecture on 'Genetically Modified Crops and Food Security – Global and National Scenario' as part of the National Science Day on 28th February 2013 to College of Teacher Education, Nedumangad, sponsored by KSCSTE and DST.

Sudha CG, Padmesh P, Satheesh Kumar K, Krishnan PN and Latha PG (2012). Bioproduction of active metabolites and bioprospecting of high value and rare medicinal plants for its sustainable utilization. Paper presented at International Conference 'India Bio, 2012', at Bangalore.

Suja SR, Latha PG, Pushpangadan P and Rajasekharan S (2012). *Rhinacanthus nasuta* (L.) Kurz.- A promising ethnomedicinal herbal drug for liver cirrhosis and hepatocellular carcinoma-a novel approach. Poster presented at the 13th International Congress on Society of Ethnopharmacology at Karl-Franzens- University, Graz. Austria.

Viji AR (2013). Nut morphology and its taxonomic significance in identification of sedges of Nilgiri Biosphere Reserve. Paper presented at the National Conference on Nilgiri Biosphere Reserve and Silver Jubilee Celebration (NBRSJC) organized by Dept. of Zoology and Wildlife Biology, Govt. Arts College, Udagamandalam.

Viji AR and Pandurangan AG (2012). The family Cyperaceae in Nilgiri Biosphere Reserve. Paper presented at the National Seminar on 'Recent Trends and Future Prospects of Biodiversity and Conservation', at Sreenarayana College Punalur.

Vilash V, Latha PG, Suja SR and Rajasekharan S (2013). Hepatoprotective and antioxidant effects of *Pellionia heyneana* Wedd. leaf ethanolic extract on paracetamol induced hepatotoxicity in Wistar rats. Paper presented at the 25th Kerala Science Congress, Thiruvananthapuram.

Vilash V, Latha PG, Suja SR and Rajasekharan S (2014). *Pellionia heyneana* Wedd.,- a promising and unexploited ethnomedicinal plant from the traditional knowledge of Cholanaikan tribe. Poster presented at the 26th Kerala Science Congress, Wayanad.

Vilash V, Latha PG, Suja SR, Krishnakumar NM, Shoumya S and Rajasekharan S (2013). *Pellionia heyneana* Wedd.- An ethnomedicinal plant with immunomodulatory and antioxidant potential. Paper presented at the 8th National Seminar on Medicinal Plants conducted by the Pharmacognosy Unit, Trivandrum Ayurveda College, at Rajiv Gandhi Centre for Biotechnology.

Vinod Kumar TG Nair (2012). Systematic Documentation of Traditional Knowledge related to Plants used for Food and Medicine in Kerala and Selected Case Studies. Paper presented at the National Seminar on 'Action Anthropology, Traditional Knowledge, Tribal Medicine and Development', organized by Muddha Mooppan Centre for Tribal Medicine Development, at Palakkad.

Vipinlal Vasudevan, Joseph Mathew and Sabulal Baby (2013). GC-MS Analysis of Low Polar Fraction of *Bauhinia acuminata* Leaves. Paper presented at the International Conference on Emerging Trends in Chemical and Pharmaceutical Sciences. Jawaharlal Nehru Technological University, Anantapur.

Vrinda KB, Pradee, CK and Shibu P Varghese (2013). *Lentinus giganteus*- promising wild edible mushroom from the Western Ghats. Poster presented at the Indian Mushroom Conference 2013, organized by the Mushroom Society of India at Ludhiana, Punjab.

Vrinda KB, Pradeep CK and Shibu P Varghese (2014). Notes on three promising wild edible mushrooms from Western Ghats of Kerala. Paper presented at the International Symposium on 'Role of Fungi and Microbes', in the 21st century- a global scenario, organized by the Indian Mycological Society at Kolkata.

William Decruse S (2013). Cryopreservation: techniques and applications. Lecture given during the Workshop on Plant Tissue Culture and *Agrobacterium* Mediated Transformation conducted by Intergenomic Centre, University of Kerala, Kariavattom.

William Decruse S (2014). Orchids of Western Ghats and their conservation. Lecture given as part of Botany Association series lectures of TKM Arts and Science College, Kollam.

William Decruse S (2013). Pollinia cryopreservation for making wide crosses among orchids of Western Ghats. Paper presented at the 16th AICG conference, Department of Botany, University of Kerala, Kariavattom.

William Decruse S (2013). Statistics in Life Science Research. National Seminar on Trends in Life Science Research, organized by Government College, Kottayam.

William Decruse S (2014). Extended distribution of *Vanda wightii* Rchb. f., an endangered orchid of Western Ghats revealed by ecological niche modeling. Paper presented at the National Conference on Orchid Conservation, Improvement and Sustainable Development. Kerala Agricultural University, Vellanikkara.

Sl. No	Code	Name	Investigator
1	P-101	Development of ideal strategies for conservation of wild *Musa* germplasm of southern Western Ghats through *in vitro* biotechnological interventions	Dr Mukunthakumar S
2	P-102	Phytochemical screening and selection of potential accession of *Ophiorrhiza mungos* L. for the development of suitable *in vitro* cultures including multiple shoots leading to the production of camptothecin and production of plumbagin through hairy root cultures of *Plumbago rosea* L.	Dr Satheeshkumar K
3	P-103	Propagation of *Phaius lurides* and expansion of pollinia and seed cryobank of orchids of Western Ghats	Dr William Decruse S
4	P-104	Genetic conservation and chemical characterization of ethnobotanic insect repellent plant species of Andaman Islands	Dr Radha R K
5	P-105	Molecular characterization of *Mucuna pruriens* - a natural source of L-DOPA	Dr Padmesh P
6	P-106	Establishment of normal and hairy root cultures of *Trichosanthes cucumerina*, a high value medicinal plant	Dr Sudha CG
7	P-107	Study of parasitic fungal taxa associated with plants of sacred groves in Thrissur and Pathanamthitta districts	Dr Biju C K
8	P-108	Digitizing of JNTBGRI herbarium specimens	Dr Sreekumar S
9	P-109	Development and maintenance of the Puthenthope center	Dr Krishnan P N
10	P-110	Cultivation of high value ornamental plants and income generation	Dr Krishnan P N
11	P-111	Development of conservation strategies for seedless diploid (AA) members of *Musa* family through biotechnology	Dr Mukunthakumar S
12	P-112	*In vitro* propagation and eco-restoration of threatened medicinal plant *Myristica malabarica* Lam	Dr Radha R K
13	P-113	Selection of elite genotype of *Curculigo orchioides* Gaertn.- an endangered and commercially important medicinal plant from southern Western Ghats by morphological, molecular and phytochemical characterization for its sustainable utilization and *ex situ* conservation through biotechnological interventions	Dr Sudha C G
14	P-114	Analysis of genetic variability and bioprospecting of wild Cardamom populations	Dr Sabu KK
15	P-115	*In silico* validation of drug activity in plants	Dr Sreekumar S
16	P-116	Population studies and gene flow of threatened and endemic plants of the southern Western Ghats	Dr Nayar T S
17	P-117	Tree pollen flora of the Western Ghats	Dr Nayar T S
18	P-118	Documenting plant based information to support practical conservation and conservation policies-(i) Kerala (ii) the Western Ghats (iii) India.	Dr Nayar T S

Sl. No	Code	Name	Investigator
19	P-119	Infrastructure development in the Division of Conservation Biology	Dr Nayar T S
20	P-120	Anti-inflammatory, analgesic and anti-arthritic activity of two selected plants of the Western Ghats, Kerala.	Dr Latha P G
21	P-121	Clinical trial of coded hepatoprotective herbal formulation in-collaboration with OUSHADHI, Govt. of Kerala.	Dr Rajasekharan S
22	P-122	Search for anti-diabetic/hepato-protective, immuno-modulatory and wound healing plants from traditional/ folklore medical information of Kerala.	Dr Latha P G
23	P-123	Infrastructure development -Construction of new Animal House as per the guidelines of CPCSEA, Govt. of India.	Dr Latha P G
24	P-124	Ethnomedical survey and systematic documentation of traditional knowledge among the different tribal communities of Kerala – an in depth study and preparation of database.	Dr Vinodkumar T G
25	P-125	Ethnobotanical survey in the coastal areas of three southern districts of Kerala.	Dr Radhakrishnan K
26	P-126	Development and maintanance of conservatories: Arboretum, Palmateum and Aquatic plants	Dr Mohanan N
27	P-127	Development and maintanance of conservatories: Ferns and Gymnosperms	Mr Cheriyan P Koshy
28	P-128	Development and maintanance of conservatories: Wild fruit plants	Mr Cheriyan P Koshy
29	P-129	Landscaping and garden management	Dr Raj Vikraman
30	P-130	Management, research and development of Central Nursery of the Garden and the Sales Unit	Dr Mohanan N
31	P-131	Search for renewable biomass and biofuel sources in *Euphorbia* plants of the southern Western Ghats	Dr Ramesh Kumar KB
32	P-132	Chemical prospecting of plants in Kerala region of Western Ghats for bioactive molecules	Dr Sabulal B
33	P-133	Chemical prospecting of aromatic plants of the Kerala region of Western Ghats	Dr Sabulal B
34	P-134	Pharmacological evaluation of *Hemidesmus indicus* root (extract/active fraction) for its utility as a phytomedicine to improve efficacy of ORS	Dr Sabulal B
35	P-135	Establishment of National Collection & Conservation - Education Centre of Medicinal Plants	Dr Mathew P J
36	P-136	*Ex-situ* conservation of genetic resource of selected medicinal plants and assessment of intraspecific variability	Dr Mathew P J
37	P-137	Field Gene Bank development of selected medicinal and aromatic plants	Dr Mathew P J
38	P-138	Development of a Systematic Garden of herbals	Dr Abdul Jabbar
39	P-139	Standardisation of Tissue Culture Techniques and Mass Production of Ornamentals	Dr Bejoy Mathew

Sl. No	Code	Name	Investigator
40	P-140	Micropropagation of Commercially Important Banana and Other Taxa	Dr Bejoy Mathew
41	P-141	Establishment and maintenance of TBGRI Seed Bank	Dr C Anilkumar
42	P-142	Cytotaxonomic investigatioons on Bamboos of Western Ghats	Dr K C Koshy
43	P-143	Conservation of Bamboos of JNTBGRI	Dr K C Koshy
44	P-144	National Collection of Orchids	Dr Satheeshkumar C
45	P-145	Building up of a Conservatory for Carnivorous Plants	Dr Sathishkumar C
46	P-146	Survey, Exploration and Documentation of Floristic Wealth of Kerala.	Dr Pandurangan A G
47	P-147	Inventory, documentation and phylogenetic studies of mushrooms of Western Ghats & Establishment of a regional herbarium for mushrooms	Dr Vrinda K B
48	P-148	Molecular taxonomy and Establishment of microbial culture collections for bioprospecting	Dr Pradeep N S
49	P-149	Development and management of Regional herbarium for Kerala.	Dr Pandurangan A G
50	P-150	Studies on reproductive biology and conservation of selected RET species of W. Ghats	Dr Sreekala AK
51	P-151	Floristic, Ecologic and Functional Dynamics of Selected Grasslands of Western Ghats	Dr Rajendra Prasad
52	P-152	Collection, Identification and Documentation of Foliicolous fungi in Shendurney Wildlife Sanctuary, Kollam, Kerala state	Dr Hosagoudar V B
53	P-153	Collection, Identification and Documentation of Lichens in the Shendurney Wildlife Sanctuary, Kollam, Kerala state	Dr Pradeep N S
54	P-154	Diversity of Foliar Mycobionts in the Botanic Gardens of Kerala	Dr Shiburaj S
55	P-New 001	Molecular and Phylogenetic studies on *Inocybaceae* (Basidiomycotina, Agaricales) of Kerala	Dr Pradeep C K
56	P-New 002	Vegetational and ecological assessment of lateritic zones of North Kerala	Dr Shaju T
57	P-New 003	Inventory, Systematics and Conservation of the Family Annonaceae with emphasise on endemic, RET plants	Dr Rajkumar G
58	P-New 004	Evaluation of platelet augmentation activity of selected medicinal plants of Western Ghats based on Traditional Knowledge	Dr Suja SR

Externally funded projects

Sl. No.	Code	Name	Investigator	Funding Agency
1	A-19	Establishment of Sub-distributed Information Centre at TBGRI under Bio-Informatics programme	Dr Krishnan PN	DBT, Govt. of India
2	A-88	Systematics and phytogeographic evaluation of grasses and sedges in Nilgiri Biosphere Reserve	Dr Pandurangan A G	KFD
3	A-94	Assistance for Improvement of Infrastructure Facilities in Botanical Garden and Centres of ex-*situ* Conservation of Indigenous, particularly Rare, Endangered and Threatened (RET) Plants under Recognition of Lead Garden	Dr Pandurangan A G	MoEF, Govt. of India
4	A-100	Integrated Development of Peppara Dam Tribal Area through Plant Resource Enrichment for Eco-restoration, and Tribal Livelihood Enhancement Activities	Dr Krishnan P N	SC/ST Devpt. Dept. Govt. of Kerala
5	A-101	Establishment of Pathiramanal Biopark	Dr Pandurangan A G	Tourism Dept.
6	A-106	Conservation and restoration of two endemic and critically endangered tree species [*Syzygium gambleanum* Rathakr & Chithra and *Syzygium rama-varmae* (bourd)Chitra] from Agsthyamalai Biosphere Reserve through conventional and non-conventional propagation	Dr Padmesh P	DBT, Govt. of India
7	A-107	*Ex situ* conservation and biosystematic studies on *Piper* species of Kerala forests with special reference to intraspecific variants of *Piper nigrum* L.	Dr Mathew P J	Kerala Forest Dept.
8	A-108	Establishment of seed bank and field gene bank of of *Saraca asoca* (Roxb.) Wilde - A vulnerable medicinal species of the Indian subcontinent'	Dr Anilkumar C	Kerala Forest Dept
9	A-110	Identification of nuclear tree species and assessment of its impact in landscape conservation: A case study with reference to the tropical rainforests in Silent Valley in the Western Ghats	Dr Nayar T S	MoEF, Govt. of India
10	A-113	Development of tissue culture protocol for mass propagation of selected Screw pine (*Pandanus* spp.) plants leading to technology transfer and establishment of tissue culture facility at KIDS	Dr P N Krishnan	KSIDC, Govt. of Kerala
11	A-114	Systematic documentation of traditional knowledge related to plants used for food and AYUSH & indigenous medicine	Dr Rajasekharan S	Department of AYUSH, Ministry of Health and Family Welfare
12	A-115	Biotechnological interventions for conservation and utilization of forest resources	Dr Padmesh P	DBT, Govt. of India

Sl. No.	Code	Name	Investigator	Funding Agency
13	A-116	Development of *Piper nigrum* plantlets by tissue culture	Dr Bejoy Mathew	Mr. Varghese Mammen, Rose Bungalow, TVM
14	A-117	Conservation of *Vanda thwaitisii, V. wightii* and *Eulophia cullenii*, three endangered orchids of Western Ghats through micropropogation and restoration with tribal participation	Dr William Decruse	DBT, Govt. of India
15	A-118	Phytochemical screening and selection of potential species of *Ophiorrhiza* for tissue culture based mass multiplication leading to production of camptothecin- an anticancer Compound	Dr Satheeshkumar K	Dept. of Atomic Energy (DAE), (BRNS), Govt. of India
16	A-119	Preparation of Detailed Project Report for the conservation and preservation package for the cliff area of Varkala	Dr Sathish Kumar C	Dept. of Tourism, Govt. of Kerala
17	A-123	Wild edible mushrooms in Kerala forests – A source of food and income	Dr Vrinda KB	WGDP, Govt. of Kerala
18	A-124	Hepatoprotective properties of *Saraca asoca* (Roxb.) De Wilde stem bark, an important medicinal plant (Fabaceae).	Dr Latha PG	WGDP, Govt. of Kerala
19	A-125	Analysis of genetic diversity in selected rattan palms (Calamus sp.) using microsatellite markers	Dr Sabu KK	KBC, KSCSTE
20	A-128	BTISNET new web site development and integration/interlinking of bioinformatics resources developed by BTIS Centres	Dr Sreekumar S	DBT, Govt. of India
21	A-129	Assessment of genetic diversity and identification of gender specific markers of important north-east and south Indian Rattan palms using SSR analysis	Dr Sabu KK	DBT, Govt of India
22	A-131	Database on foliicolous fungal flora of Andaman Islands	Dr Hosgoudar VB	DST, Govt. of Kerala
23	A-133	Conservation of *Calamus shendurunii* and *C. wightii*, two endangered and endemic rattans of Western Ghats through micropropagation, reintroduction and cryobanking	Dr William Decruse	Kerala Forest Department
24	A-134	Conservation and sustainable utilization of *Garcinia* species of southern Western Ghats	Dr Mohanan N	Dept. of Forests and Wildlife, Govt. of Kerala
25	A-135	Setting up a garbage plant for conversion of garden waste to useful waste and an alternate medium for potting/planting	Dr Mohanan N	NABARD, Govt. of India
26	A-136	Inventory, documentation and development of cultivation protocols for lesser known wild edible mushrooms of Kerala	Dr Pradeep CK	KSCSTE

Sl. No.	Code	Name	Investigator	Funding Agency
27	A-137	Bioprospecting of potential gingers : chemical prospecting, morphological characterization and *ex situ* conservation	Dr Mathew Dan	DBT, Govt. of India
28	A-138	Transcript profiling of differentially expressed gene(s) involved in the downstream step(s) leading to artemisinin biosynthesis on GA3 induction	Dr Padmesh P	KSCSTE, Govt. of Kerala
29	A-140	Search for potential biologically active constituents from a hitherto uninvestigated unique bamboo, *Melocanna baccifera*	Dr Sabulal B	SERB, Govt. of India
30	A-143	*Ex situ* and i*n situ* conservation of *Garcinia imberti* Bourd. – an endangered and endemic tree of the southern Western Ghats	Dr Anilkumar C	KSCSTE, Govt. of Kerala
31	A-144	Biflavonoids from *Garcinia* species - chemical, molecular and pharmacological evaluation	Dr RameshkumarKB	KSCSTE, Govt. of Kerala
32	A-145	Preparation of an illustrated bilingual field guide on medicinal fruits, seeds and their seedlings occurring in Kerala Forests	Dr Anilkumar C	Kerala Forest Dept.
33	A-146	Assessment of medicinal plant resources in seven southern districts of Kerala	Dr Latha PG	State Medicinal Plant Board
34	A-148	Germplasm documentation, evaluation, *ex situ* conservation and popularization of local mango varieties in Kerala	Dr. Nazarudeen A	Forest Dept. Govt. of Kerala
35	A-149	Training on conservation and sustainable utilization of the plant wealth of the Western Ghats	Dr Mohanan N	SPEED Programme of KSCSTE
36	A-150	High-Tech Micropropagation Unit for mass production of economically important plants	Dr Bejoy Mathew	Agriculture Dept. (RKVY) Govt. of Kerala
37	A-151	Cloning, expression and purification of small heat shock proteins from *Streptomyces* spp. and exploration of its industrial applications	Dr Shiburaj S	KSCSTE, Govt. of Kerala
38	A-152	Studies on bacterial plants of Western Ghats of Kerala for the development of novel antibacterial drugs	Dr Shiburaj S	KSCSTE, Govt of Kerala
39	A-153	Establishment of Community Agro-biotech Resource Centre (CARC)	Dr Latha PG	KSCSTE
40	A-154	Development of a rhizosecretion system for recombinant protein expression in *Lemna gibba* L. using the candidate molecule, hCAP-18	Dr Satheeshkumar K	SERB, Govt of India
41	A155	Printing of poster on birds of JNTBGRI	Dr Anilkumar S	KSCSTE, Govt of Kerala

Sl. No	Code	Name	Investigator	Funding Agency
42	A-159	Economic and bio-geographic evaluation of the *Cinnamomum* species in some selected parts of India through morphological, chemical and molecular biology studies	Dr Rameshkumar KB	DBT, Govt. of India
43	A-160	Conservation of *Garcinia imberti* Bourd. an endangered endemic tree of southern Western Ghats through studies on population structure and seed biology	Dr Anilkumar C	DST, Govt. of India
44	A-161	Bioprospecting of actinobacteria from the sacred groves of Kerala for biocatalysts of commercial applications	Dr Asha Poorna	DST, Govt. of India
45	A-163	Assessing the influence of environmental and biotic factors on life history variation and demography of tropical rainforest bulbuls	Dr Balakrishnan P	DST, Govt. of India
46	A-166	Molecular analysis of thermostable α-amylase production in *Streptomyces griseus* (MTCC 3756)	Dr Shiburaj S	KSCSTE
47	A-170	Pharmacological and Molecular expression studies on hepatoprotective herbal formulation against liver fibrosis	Dr Shine VJ	SERB, Govt. of India

JNTBGRI Research Council

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Mr Cheriyan P Koshy	Scientist C
Dr S Binu	Scientist C
Dr A A Prasannakumari	Scientist B
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Mr V Prem Kumar	Asst. Public Relations Officer
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Mr B Jayakumar	Labour Supervisor
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Mr P. Manikandan Nair	Garden Maistry
Mr C Sudarsanan	Gardener
Mr G Vijayakumaran	Gardener
Mr B Harilal Kumar	Gardener
Mr K Vijayakumar	Gardener
Mr S R Kamalesh Kumar	Gardener
Mr K Anil Kumar	Gardener
Mr M Varghese	Gardener
Mr J Rajan	Gardener
Mr V Satheeshan	Gardener
Mr M Shajahan	Ticket Issuer
Mr M Shajahan	Gardener
Mr R Suresh Kumar	Gardener
Mr P Babu	Gardener
Mr D Udayakumar	Gardener
Mr L Thulaseedharan	Gardener
Mr N Pradeep	Gardener
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Mr V Ranjan (under suspension)	Gardener

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Dr Bejoy Mathew	Scientist EI
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Dr M Saleem	Tech. Officer
Mr B Gopakumar	Tech. Officer
Mrs B Radhika	Tech. Officer
Mr M K Sreekumar	Tech. Officer
Dr S Anilkumar	Tech. Asst
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Mr N Venugopalan Nair	Gardener
Mr N Salahudeen	Gardener
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Mrs P Sasikala	Lab. Assistant
Mrs A Leela	Helper

Plant Systematics and Evolutionary Science Division

Dr A G Pandurangan	Scientist F, Head
Dr K B Vrinda	Scientist EI
Dr M Rajendra Prasad	Scientist C
Mr G Rajkumar	Scientist C
Dr C K Pradeep	Scientist B
Dr A Nazarudeen	Scientist B
Mr T Shaju	SSA
Mr DhruvanTandyekal	SSA
Dr V S Usha	Herbarium Assistant
Mrs M P Geethakumari	Tech. Officer
Mrs K P DeepthiKumari	Tech. Officer
Mr R Thulaseedharan	Gardener

Microbiology Division

Dr V B HosaGoudar	Scientist EII (Retd. on 30-05-2013)
Dr N S Pradeep	Scientist C
Dr S Shiburaj	Scientist C
Mr H Biju	Tech. Officer
Mrs A Sabeena	Tech. Officer
Mrs Kumari Girija	Sweeper

Library and Information Services

Mrs A Syamala Kumari	Librarian
Mr K P Pradeep Kumar	Technical Officer (Photography) Grade V
Mrs V Sujatha	Library Assistant
Mrs K V Leena Kumari	Clerical Asst.
Mr C R Vinukrishnan	Clerical Asst.

Administrative Staff

Mr P R Sreekumar	Registrar
Mr K Anil Kumar	Finance Officer
Mr P S Pradeep Kumar	Deputy Controller, Purchase
Mrs S Meenakumary	Section Officer
Mr K Vijayan	Section Officer
Mr M Anilkumar	Section Officer
Mrs B S Ajanthakumary	Office Asst. Grade III
Mrs SubhaSankar R	Computer Operator Grade II
Mr T S Sunil Kumar	Office Asst. Grade I
Mrs S Sofia	Office Asst. Grade I
Mrs S Sudha	Office Asst.Grade I
Mr P S Vishnu	Office Asst. Grade I
MrsAjithakumary T	Office Asst. Grade I
Mrs Padmakumari L	Office Assistant (Deputation from GramaPanchayat)
Dr. Jeeja Albert	P A to Director (Deputation from GramaPanchayat)
Mrs R Prasannakumary	Stenographer Grade II (PA i/c to Director)
Mr K Mohammed Habeebulla	Typist/ Data Entry Operator Gr. I
Mrs N RajalekshmiAmmal	Typist Grade I (Retired on 30-09-2013)
Mrs P S Shyla Devi	Typist
Mr K P Elias	Store Assistant Gr.II
Mr B R Dinesh	Record Keeper Gr. I
Mr S Shafeer Khan	Photocopier Operator
Mr D Mohanachandrakumar	Driver Gr. V
Mr T Mohan Kumar	Driver Gr. III
Mr V Sudheeshkumar	Driver Gr. III
Mr N Hariprasad	Driver Gr. I
Mr S Sanalkumar	Driver Gr. I
Mr G Murukesan Nair	Driver Gr. I
Mr C Sathyan	Helper Gr. I (Retired on 31-10-2013)
Mr B Vijayakumar	Helper Gr. I (Retired on 31-10-2013)
Mrs S Sheeja	Helper Gr. I (Deputation from KFRI)

Mrs J Anithakumari	Helper

Engineering Section

Mr P Pmarkose	Tech. Officer (Engineering)
Mr S Ajith	Tech. Officer (Asst. Work Supervisor)
Mr V S Suresh Kumar	Tech. Asst.
Mrs M R Geetha	Overseer
Mr P Ajithkumar	Tech. Asst.
Mr G Ajayakumar	PABX Operator
Mr M Madhusoodhanan Nair	Pump Operator
Mr Prabhakaran Nair R	Plumber
Mr P S Hanikumar	Label Writer
Mrs K LaliKutty	Sweeper
Mrs Baby Girija	Sweeper
Mr V Gangadhara Pillai	Sweeper/Cleaner

Security

Mr. A. P. Sukumaran Nair	Security Officer
Mr P Jain	Security Guard
Mr K Mohanan	Security Guard
Mr G Somasekharan Nair	Security Guard
Mr C Stanley	Security Guard
Mr R Rajan	Security Guard
Mr K Ramachandran Nair	Security Guard
Mr A Subairkunju	Security Guard
Mr T Sukumaran Nair	Security Guard
Mr K Surendran Nair	Security Guard
Mr S Venugopalan Nair	Security Guard
Mr B Venukrishnan Nair	Security Guard
Mr G Viswambharan	Security Guard
Mr P Vijayakumar	Security Guard
Mr C Jayakumar	Security Guard
Mr A Vijayan	ecurity Guard
Mr P Devaraj	Security Guard
Mr S Vikraman Nair	Security Guard
Mr G Ashok Kumar	Security Guard
Mr K Suresan	Security Guard

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE

PALODE, THIRUVANANTHAPURAM

(A unit of Kerala State Council for Science, Technology and Environment, Govt. of Kerala)

BALANCE SHEET AS AT 31st MARCH, 2013

Liabilities	Sch No	As on 31.03.2013	As on 31.03.2012	Assets	Sch No.	As on 31.03.2013	As on 31.03.2012
Capital Reserve				Fixed Asset			
Institute	IA	3,93,84,125	3,69,80,699	Institute	V A	3,93,84,127	3,69,80,699
External Projects	IB	1,64,57,373	1,27,59,381	External Projects	V B	1,64,57,372	1,27,59,381
General Fund	I	4,79,03,075	4,79,03,075	Capital work in progress	VI	68,85,240	64,54,707
Book Publication Reserve	I	2,09,904	2,09,904				
Loan Funds							
Institute	II	23,290	4,23,291	Current Assets			
				Institute	VII A	4,54,37,057	2,03,37,155
Current Liabilities & Provisions				External Projects	VII B	1,84,67,350	1,40,97,980
Institute	III A	1,26,61,894	1,42,75,149				
External Projects	III B	1,28,972	37,872				
				Loans and Advances			
Unspent Balance				Institute	VIII A	1,19,22,531	1,25,40,783
Institute	IV A	-1,21,97,112	-4,28,59,114	External Projects	VIII B	2,61,515	10,52,731
External Projects	IV B	1,85,99,892	2,33,37,776				
Corpus Fund	IV C	89,82,447	76,97,893				
				Suspense Account	IX	6,02,915	6,02,915
Orchid Frarming Project Reserve		3,00,000	3,00,000				
Control accounts		25,73,594	25,73,594				
Suspense Accounts External Projects		23,63,850	23,63,850				
STEC/CSIR/UGC		4,36,237	4,36,237				
Total		**13,94,40,797**	**10,48,26,352**	**Total**		**13,94,40,797**	**10,48,26,352**

Sd/-
For Mohan &Mohan Associates
Chartered Accountants

For JNTBGRI
Palode, Thiruvananthapuram

Sd/-
R. Suresh Mohan
Partner
Membership No.01398
Firm Reg. No.002092S

Sd/-
Dy Registrar

Sd/-
Registrar

Sd/-
Director

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE

PALODE, THIRUVANANTHAPURAM

(A unit of Kerala State Council for Science, Technology and Environment, Govt. of Kerala)

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH,2013

Expenditure	Sch No	As on 31.03.2013	As on 31.03.2012	Icome	Sch No.	As on 31.03.2013	As on 31.03.2012
To Research & Development Expenses	X	4,08,76,751	3,58,55,518	By Grant From Govt. of Kerala	XVII	135417897	98144481
To Employees Benefits	XI	8,28,04,107	6,26,70,502	By Other Receipts	XVIII	9,53,739	8,72,627
To Administrative Expenses	XII	1,35,37,195	22,64,241	By Open House		2,40,000	-
To Repair and Maintenance	XIII	22,742	8,211	By Interest from Banks		4,15,300	2,20,604
To Prior Period Expenses	XIV	-	4,52,269	By Prior Period Income		37,229	2,17,653
To Other Expenses	XV	34,620	17,619	By Liability from Lease Rent written Off		-	16,24,994
To Expenses of External Projects	XVI	1,49,33,813	1,45,26,389	By Income form Training		2,11,250	1,88,000
To Depreciation		94,92,492	1,00,19,061	**By External Projects**			
				Grant for External Projects	XIX	1,43,61,978	1,41,83,809
				Interest from Banks		5,64,685	3,42,580
				Other Income		7,150	-
				By Depreciation on Asset Acquired out of Grant Written Back		94,92,492	1,00,19,061
Total		**16,17,01,720**	**12,58,13,809**	**Total**		**16,17,01,720**	**12,58,13,809**

Sd/-
For Mohan &Mohan Associates
Chartered Accountants

Sd/-
R. Suresh Mohan
Partner
Membership No.01398
Firm Reg. No.002092S

For JNTBGRI
Palode, Thiruvananthapuram

Sd/-
Dy Registrar

Sd/-
Registrar

Sd/-
Director

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE
PALODE, THIRUVANANTHAPURAM
(A unit of Kerala State Council for Science, Technology and Environment, Govt. of Kerala)

BALANCE SHEET AS AT 31st MARCH, 2014

Liabilities	Sch No	As on 31.03.2014	As on 31.03.2013	Assets	Sch No.	As on 31.03.2014	As on 31.03.2013
Capital Reserve				Fixed Asset			
Institute	IA	4,57,90,693	4,00,63,110	Institute	V A	4,57,90,693	4,00,63,110
External Projects	IB	2,21,74,582	1,64,57,371	External Projects	V B	2,21,74,583	1,64,57,372
General Fund	I	4,79,03,075	4,79,03,075	Capital work in progress			
Book Publication Reserve	I	2,09,904	2,09,904	Institute	VI A	-	68,85,240
Loan Funds							
Institute	II	23,290	23,290	Current Assets			
				Institute	VII A	4,71,00,051	4,54,37,057
				External Projects	VII B	3,21,29,194	1,84,67,350
Current Liabilities & Provisions							
Institute	III A	3,74,17,082	1,42,75,149				
External Projects	III B	3,33,822	1,28,972				
				Loans and Advances			
				Institute	VIII A	1,55,06,552	1,19,22,531
Unspent Balance							
Institute	IV A	-3,83,14,074	-1,22,19,803	External Projects	VIII B	35,75,648	2,61,515
External Projects	IV B	3,53,71,019	1,85,99,892				
Corpus Fund	IV C	1,02,96,561	89,82,447	Suspense Account			
					IX	6,02,915	6,02,915
Orchid Frarming Project Reserve		3,00,000	3,00,000				
Control accounts		25,73,594	25,73,594				
Suspense Accounts External Projects		23,63,850	23,63,850				
STEC/CSIR/UGC		4,36,237	4,36,237				
Total		**16,68,79,636**	**14,00,97,089**	**Total**		**16,68,79,636**	**14,00,97,089**

Sd/-
For Mohan &Mohan Associates
Chartered Accountants

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R. Suresh Mohan
Partner
Membership No.01398
Firm Reg. No.002092S

For JNTBGRI
Palode, Thiruvananthapuram

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Dy Registrar

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Director

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE
PALODE, THIRUVANANTHAPURAM
(A unit of Kerala State Council for Science, Technology and Environment, Govt. of Kerala)

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH,2014

Expenditure	Sch No	As on 31.03.2014	As on 31.03.2013	Icome	Sch No.	As on 31.03.2014	As on 31.03.2013
To Research & Development Expenses	X	4,56,50,857	4,08,76,751	By Grant From Govt. of Kerala	XVII	14,80,07,841	13,54,40,588
To Employees Benefits	XI	9,10,02,139	8,28,04,107	By Other Receipts	XVIII	9,80,554	9,53,739
To Administrative Expenses	XII	1,27,21,885	1,35,37,195	By Open House		-	2,40,000
To Repair and Maintenance	XIII	2,400	22,742	By Interest from Banks		3,95,885	4,15,300
To Prior Period Expenses	XIV	-	22,691	By Prior Period Income		-	37,229
To Other Expenses	XV	6,999	34,620				
To Expenses of External Projects	XVI	1,65,27,687	1,49,33,813	By Income form Training		-	2,11,250
To Depreciation		1,04,38,783	88,13,508	By External Projects			
				Grant for External Projects	XIX	1,52,62,608	1,43,61,978
				Interest from Banks		12,39,263	5,64,685
				Other Income		25,816	7,150
				By Depreciation on Asset Acquired out of Grant Written Back		1,04,38,783	88,13,508
Total		**17,63,50,750**	**16,10,45,427**	**Total**		**17,63,50,750**	**16,10,45,427**

Sd/-
For Mohan &Mohan Associates
Chartered Accountants

Sd/-
R. Suresh Mohan
Partner
Membership No.01398
Firm Reg. No.002092S

For JNTBGRI
Palode, Thiruvananthapuram

Sd/-
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Registrar

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Director