

JNTBGRI

Annual Report
2014 - '15 & 2015 - '16



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Jawaharlal Nehru Tropical Botanic Garden and Research Institute

JNTBGRI Annual Report

2014 - '15 & 2015 - '16

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Cover : Itty Achuthan Vaidyan's Garden
Photo : K P Pradeep Kumar

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From the Director's Desk



Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), previously known as TBGRI, was established in 1979 under Govt. of Kerala as an autonomous R&D organization in the foothills of the Western Ghats at Palode, Thiruvananthapuram. The main objective of the Institute is to establish a conservatory botanic garden of tropical plant resources in general and of the Western Ghats in particular. It also undertakes mission oriented research programmes to develop appropriate technologies for the sustainable utilization of plant genetic resources. The Institute has become a part of the Kerala State Council for Science, Technology and Environment (KSCSTE) in 2003 and become a premier Institute under KSCSTE. The Institute had grown by leaps and bounds over the last 37 years and made its presence globally being a demonstrator for implementing the provisions of the CBD. The Institute is recognized as one of the Lead Gardens of peninsular India, Co-ordination centre of Biosphere Programme and Centre of Excellence in Botanic Research by the Ministry of Environment, Forest and Climate Change, Govt. of India.

The Institute initiated a good number of research and socially committed programmes during the period from April 2014 to March 2016. Important among these were the implementation of a project worth of ₹ 6.75 crore sanctioned by DBT, Govt. of India, reviving the green Industry in central Kerala by establishing an integrated R&D centre at Kodungallur to the tune of ₹ 18.99 crore supported by Kerala State Industrial Development Corporation, Govt. of Kerala, development of Bamboo nursery with the financial support of State Bamboo Mission, established green belt around Vellayani lake with State Biodiversity Board, optimum use of man power under Mahatma Gandhi National Rural Employment Guarantee Act (NREGA) for the uplift of the garden, official partner for National Games 2015 by establishing greening of Games village and different stadiums, development of aquatic conservatory etc.

Scientists of Garden Division were engaged in managing live plant conservatories and enriched with new introduction constantly and make the field gene bank as an active centre of *ex-situ* conservation. The Plant Genetic Resource Division develops package of practices for medicinal plants, ornamentals, Agri-horticulture crops etc. to cater the different sections of stakeholders – scientists, students, farmers, agri business entrepreneurs. The Biotechnology division study on metabolic pathways of useful secondary metabolites and standardized propagation protocol for RET species.

Conservation biology group engaged in gene flow analysis of important tree species in forest ecosystems and determining the casual factors inducing rarity. Ethnomedicine division actively involved in surveys and documenting Traditional Knowledge from different tribal/indigenous population with prior informed consent for validating the time tested wisdom. Microbiology division working on waste management with an objective of developing wealth from the waste by converting into organic nutrients and other useful products. This group successfully implemented a model waste management programme at Sasthamangalam ward covering about 4000 houses in collaboration with Thiruvananthapuram Corporation. Phytochemistry division engages in identifying useful molecules from the wild plants for commercial importance and scientists from Plant Systematics and Evolutionary Science division conduct survey on flowering plants and mushrooms and bring new discoveries to the science. Visitors Management Centre (VMC) continue to entertain publics and extend Eco-educational programmes to students in addition to distribute plants through sale. During the period 14 students received their Ph. D. degree in different disciplines. The Institute published 2 books, 10 chapters in books and 158 research papers in National and International journals. All these achievements have become possible only with dedication of our staff who have always devoted for the Institute's excellence.

In this backdrop, I am greatly privileged to present the Annual Report of JNTBGRI, showcasing the achievements of this Institute for the period 2014-15 to 2015-16. I place on record Dr. Suresh Das, Executive Vice President, KSCSTE, for his support and guidance in the activities and progress of the Institute. I thank Shri. M. C. Dathan, Scientific Advisor to Hon'ble Chief Minister and Dr. S. Pradeep Kumar, Member Secretary for the unstinting support. I greatly acknowledge various funding agencies such as AYUSH, CSIR, DBT, DST, ICAR, ICMR, KFD, KSIDC, KSMPB, MoEF & CC, NABARD, NMPB, RKVY, UGC, VSSC, WGDP etc. who have helped in continuing research programmes and finally made these achievements a reality. We salute to all and promise that the Institute would continue to serve the Nation in the years to come.

01.12.2017

Dr. A. G. Pandurangan





Division of
**Garden Management, Education,
Information and Training**

The division is responsible for the development and maintenance of ornamental landscapes, *ex-situ* conservatories (Arboretum, Palmetum, Fernery, Pinetum, Orchard for lesser known fruit plants, Cacti and other Succulents, Water plants, Wild Ornamentals and the Conservatory for rare plants) and educational displays disseminating botanical knowledge. A Central Nursery supporting the activities of different conservatories and sale and distribution of plants is also maintained. The division is also responsible for the management of visitors in the garden.



PHOTO: PRADEEP KUMAR K P

Natural vegetation adjacent to Arboretum

Arboretum

The Arboretum maintains a collection of 760 tree species including special groups such as *Humboldtia* (5 species), *Terminalia* (7 species), *Ficus* (70 species) and *Garcinia* (12 species). Fifteen new tree species viz. *Aglaiia elaeagnoidea* (A. Juss.) Benth., *Cinnamomum riparium* Gamble, *Dysoxylum binectariferum* (Roxb.) Hook. f., *Elaeocarpus recurvatus*

Corner, *Garcinia assamica* Sarma, Shameer & Mohanan, *Garcinia gummi-gutta* var. *papilla* (Wt.) N. P. Singh, *Garcinia cowa* Roxb. ex DC, *Garcinia lanceifolia* Roxb., *Garcinia nervosa* Miq., *Garcinia pushpangadianiana* Sabu et al., *Goniothalamus wayanadensis* (Bedd.) Bedd, *Memecylon subcordatum* Cogn., *Symplocos rosea* Bedd., *Syzygium*



claviflorum (Roxb.) Wall. ex A. M. Cowan & Cowan, *Syzygium tamilnadensis* Rathakar. & Chithra and one new species of *Artocarpus* were added to the collection during the report period. A 'Star Tree garden' comprising tree species representing the 27 'birth stars' was developed in the northern end of the Arboretum. About 4500 tree saplings belonging to

15 species were generated of which around 700 were sold out through the plant distribution section. The central government programme, *Mahatma Gandhi National Rural Employment Guarantee Act* (NREGA) Yojana of Peringamala Grama Panchayath was effectively made use in weed clearing of the Arboretum.

A view of the Reservoir with Arboretum on the left side



PHOTO: PRADEEP KUMAR K P

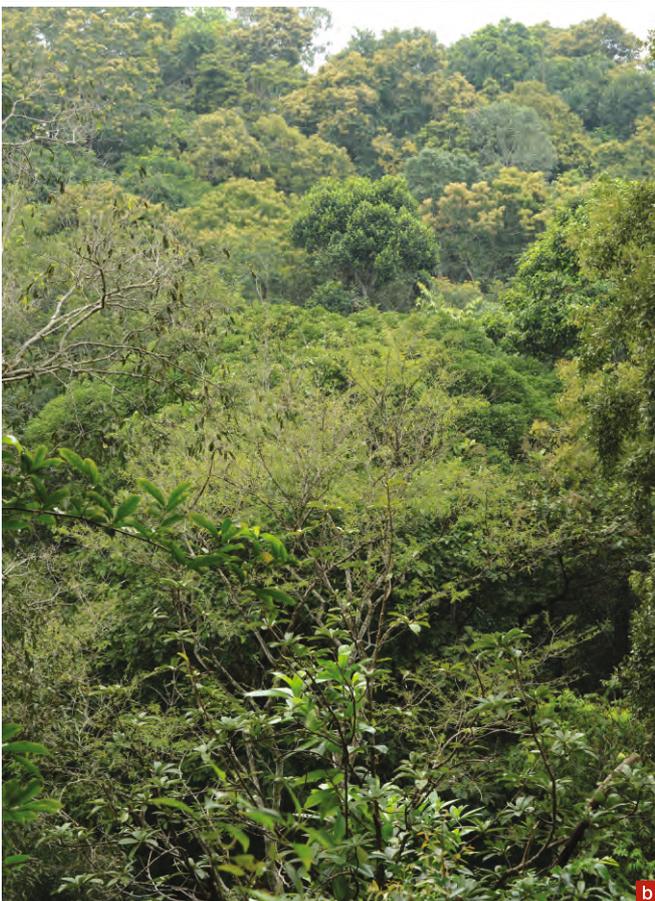


a. A view of the Arboretum when initiated in 1985; b. The same area after 30 years (2015)



PHOTOS: PRADEEP KUMAR K P

a, b & c. Views from the Arboretum



a, b & c. Views from the Arboretum

Palmetum

The Palmetum maintains 170 palm species, of which 26 are indigenous. During the report period the planting was extended by adding 75 specimens. Eight field exploration trips conducted during the report period which resulted in adding of *Calamus shendurunii* Anto, Renuka & Sreek., *Calamus*

wightii Griff., *Areca catechu* L. 'Dwarf' and two unidentified species of *Areca* to the Palm germplasm. Around 2500 palm saplings were propagated and handed over to the Sales section. 1000 palm saplings of species such as *Arenga wightii* Griff., *Calamus nagbettaii* R. R. Fernald & Dey, *Calamus*



PHOTO: PRADEEP KUMAR K.P.

The Palmetum



a & b. Flowers of *Arenga wightii* Griff.; c. Flowers of *Corypha umbraculifera* L.; d. *Phoenix pusilla* Gaertn. in fruiting; e. *Calamus hookerianus* Becc.; f. *Sabal minor* (Jacq.) Pers.; g. Fruits of *Calamus shendurunii* Renuka et. al.



Shri. Marapandyan IAS, Executive Vice President i/c in the Palmetum



Caryota mitis Lour. flower and fruiting



a. *Nephrosperma van-houtteanum* (Wendel ex. Van Houtte) Balf. f.; b. *Areca triandra* Roxb. ex Buch.-Ham.; c. *Caryota mitis* Lour.; d. *Coccothrinax barbadensis* (Lodd. ex Mart.) Becc.

vattayila Renuka, *Calamus travancoricus* Bedd. ex Becc. and *Phoenix pusilla* Gaertn. were supplied to the State Biodiversity Board on 'Establishment of green belt around Vellayani Lake'.

Seed storage and dormancy studies of the Palm germplasm were also undertaken.

Fernery

The Fern collection holds 258 taxa of Ferns and Lycophytes including about 60 threatened species. During the report period about 300 new accessions belonging to 96 species were added to the Ferns and Lycophytes germplasm through plant collection trips to different Western Ghats forest regions viz. Bonaccord, Chemunji Hills, Munnar, Ponmudi and Wayanad. Five species viz. *Colysis hemionitidea* (Wall. ex C. Presl) C. Presl, *Pteris semipinnata* L., *Pyrrhosia ceylanica* Sledge., *Tectaria puberula* (Desv.) C. Chr. and *Tectaria trimenii*

were added new to the collection. *Tectaria trimenii* (Bedd.) C. Chr., collected from Periya, Wayanad formed a re-discovery after the laps of 150 years from earlier collection by R. H. Beddome from South India. *Tectaria puberula* (Desv.) C. Chr., collected from Moozhiyar, Pathanamthitta Dist, hitherto known from Kenya, formed a new record for Asia. Twenty species of 200 seedlings were planted in the Fern Garden. *Nephrolepis biserrata* (Sw.) Schott cv. *furcans* and other ornamental ferns were planted there as hedge.



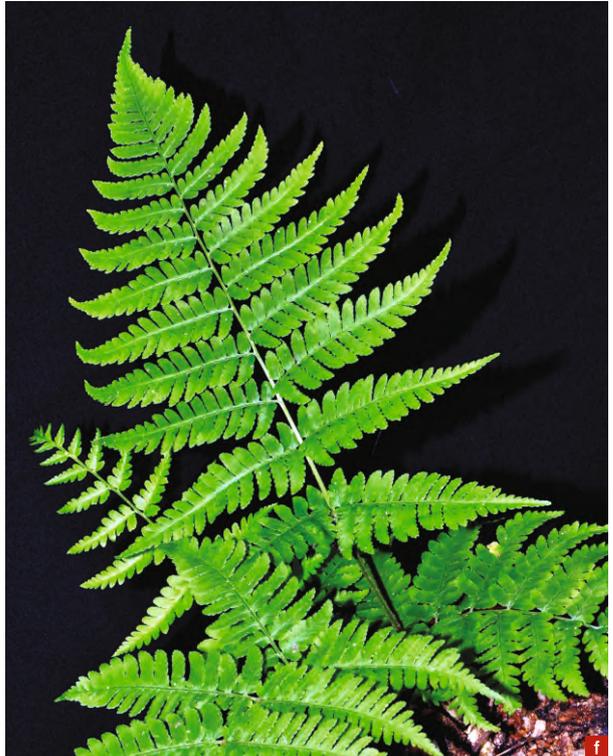
Selaginella wildenovii 'Electric fern' growing on stream bank in the field

As a part of the standardization of propagation methods and multiplication of RET ferns and lycophytes, the threatened species viz, *Marattia fraxinea* Sm., *Pteris gongalensis* T. G. Walker, *P. reptans* T. G. Walker and *Tectaria puberula* (Desv.) C. Chr. were multiplied by rhizome division method. The horticulturally important species namely *Selaginella wallichii* (Hook. & Grev.) and *Selaginella microdendron* Baker were multiplied from the strobili.

Eight species of *Selaginella* collected from Munnar were identified and keys were prepared for easy identification. One hundred herbarium sheets of Ferns and Lycophytes were prepared for TBGT Herbarium. Fern specimens were identified for the Kerala Agricultural University, Brennen College, Tellecherry, St. Dominic College, Kanjirappally and Catholocate College, Pathanamthitta as part of extending scientific expertise.



a. Fernery, inside view; b. *Microsorius* sp. an ornamental fern in the Fernery; c. *Cyathea gigantea*, 'Tree fern' in the fern Garden



a. *Nephrolepis biserrata*
b. *Selaginella wildenovii*
c. *Cyathea gigantea*
d. *Blechnum orientale*
e. *Psilotum nudum*
f. *Dryopteris cochleata*

Gymnosperms

The Gymnosperm collection holds more than 40 species. The seven out of the 10 Cycad genera represented by 18 species forms the major attraction. *Cycas annaikalensis* Rita Singh & P. Radha, the critically endangered species is the new addition during the

period. About 200 saplings of *Zamia furfuracea* L. f. ex Aiton were raised from artificially pollinated seeds. Ornamental species like *Podocarpus taxifolius* Kunth, *Podocarpus* spp. and *Thuja occidentalis* L., were multiplied through vegetative means.



PHOTOS: PRADEEP KUMAR K P

a. Executive Vice President, Dr. Suresh Das visiting the Pinetum; b. The Cycas garden



a. *Encephalartos gratus* Prain - male cone; b. *Encephalartos gratus* Prain - female cone; c. *Nageia wallichiana* (C. Persel) Kuntze

Orchard of Lesser Known Fruit Plants

The orchard maintains 230 species of underutilized fruit plants, mostly from the Western Ghats. *Salacia* (6 species), *Eugenia* (4 species) and *Syzygium* (28 species) are the interesting special groups in the collection. Their procurement, maintenance, systematic identification, standardization of seed and vegetative propagation means, quality improvement programmes, dissemination to the public through Sales and Distribution Centre are carried out in the Orchard section. 15 species such as *Alphonsea sclerocarpa* Thw., *Antidesma keralense* Chakrab. & Gangop., *Artocarpus insignis* (Cempadak), *Celtis timorensis* Span.,

Elaeocarpus oblongus Gaertn., *Elaeocarpus rugosus* Roxb., *Flacourtia jangomas* (Lour.) Raeusch. (Sweet lovi-lovi), *Garcinia dulcis* (Roxb.) Kurz (Mundu), *Hylocereus undatus* (Haworth) Britton & Rose (Dragon fruit), *Malpighia emarginata* DC (Aserola cherry), *Morinda citrifolia* L., *Plinia cauliflora* (Mart.) Kausel (Jabotica), *Salacca zalacca* (Gaertn.) Voss (Snake fruit), *Spondias dulcis* L. and *Xanthostemon chrysanthus* (F. Muell.) Benth. (Golden penda) were newly added to the existing collection. About 12,000 seedlings and grafts were raised and sold to the public through the Plant Sales and Distribution Section.



a. *Alangium salvifolium* (L.f.) Wangerin. subsp. *salvifolium*; b. *Antidesma alexiteria* L.; c. *Eugenia mooniana* Wight; d. *Eugenia uniflora* L.

Ornamental Garden



PHOTO: PRADEEP KUMAR K P

The ornamental gardens are mostly concentrated towards the entrance, main roads and building premises for beautification to attract the general public and inspire them to love the nature. Besides *ex-situ* conservation and educational display of tropical ornamental plants are also aimed through these collections. 850 species/cultivars are conserved in the ornamental garden, out of which about 200 are indigenous.

The major landscape work taken up during 2014-16 was the re-landscaping of the Front Garden. An area of about 20,000 sq. ft, adjacent to the road leading to Nursery from the main entrance, was reconstructed. About 16,000 sq. ft. Korean grass lawn was made. The area was further beautified by providing Bamboo steps and granite stone barriers. Golden Cypress (*Cupressus* sp.) was planted in row for adding beauty



Ornamental Garden with Shrubbery and Vinery in the lawn background

to the lawn. The 613 feet long foot path within the area was paved with rough-finished, (3x1) sq. feet granite pieces. Visitors sitting area was developed on the side of the road supplementing 8 wooden Park Benches. A Vinery with 30 species of ornamental vines trained over specially designed GI structures was developed. Besides beautification of the area, the vinery was also developed as an educational display for botany students on morphology of climbing adaptations. *Aristolochia littoralis* Parodi, *Aristolochia grandiflora* Sw., *Bauhinia scandens* L., *Chonemorpha grandiflora* (Roth) M. R. Almeida & S. M. Almeida, *Clematis paniculata* var. *dioscoreifolia* (H. Lev. & Vaniot) Rehder, *Cryptostegia*

grandiflora Roxb. ex R. Br., *Hugonia mystax* L., *Jacquemontia pentantha* (Jacq.) G. Don., *Nepenthes khasiana* Hook. f., *Pandorea jasminoides* (Lindl.) K. Schum., *Passiflora coccinea* Aubl, *Passiflora trifasciata* Lem., *Petrea volubilis* L., *Podranea ricasoliana* (Tanfani) Sprague, *Pyrostegia venusta* (Ker Gawl.) Miers, *Solandra grandiflora* Sw., *Solandra maxima* (Sesse & Moc.) P. S. Green, *Stictocardia beraviensis* (Vatke) Hallier f., *Strophanthus amboensis* (Schinz) Engl. & Pax, *Strophanthus gratus* (Wall. & Hook.) Baill., *Tristellateia australasiae* A. Rich. etc. are some of the curious vines in the collection.

Renovation of the Educational Displays in the area was also done. The natural style platform made out of rough

Ornamental Garden a picturesque view, showing the Red Palm Avenue, Rose Garden, Island beds and the 'India' Carpet Bed





Vascular Plant Evolution Display

granite pieces for the 'Angiosperm Fossil Display' elevated its accent in the lawn background. The renovated 'Vascular Plant Evolution Display' comprises of sequentially raising eight steps, made of laterite stones, representing the advancement in evolution, starting from Psilopsida, passing through Sphenopsida, Lycopsida, Filicales, Cycadales, Ginkgoales, Coniferales and end with Angiosperms. Representatives of each group are displayed on the respective steps, except for Ginkgoales where a photograph of *Ginkgo biloba* L. the sole live species that grow in temperate conditions only is displayed. The plants displayed under each group are *Psilotum nudum* (L.) Griseb (Psilopsida), *Equisetum ramosissimum* Desf. (Sphenopsida), *Huperzia hamiltonii* (Spreng) Trev. and *Huperzia squarrosa* (G. Forst.) Trev. (Lycopsida), many ferns & fern allies (Filicales), *Dioon*



Front area Garden



Angiosperm Fossil Display

spinulosum Dyer ex Eichl., *Encephalartos gratus* Prain etc (Cycadales), *Platycladus orientalis* (L.) Franco, *Podocarpus macrophyllus* (Thunb.) Sweet. etc (Coniferales) and different species representing dicots and monocots (Angiosperms).

About 210 new accessions were made in the ornamental plant germplasm through field collections, exchange and purchase from plant nurseries. *Achimenes grandiflora* (Schltdl.) DC., *Aristolochia littoralis* Parodi, *Azadirachta indica* A. Juss., *Blighia sapida* König, *Carpobrotus edulis* (L.) N. E. Br., *Christella dentata* (Forssk.) Brownsey & Jermy, *Combretum indicum* (L.) DeFilipps Dwarf, *Equisetum ramosissimum* Desf., *Gustavia gracillima* Miers, *Hamelia patens* Jacq. (variegated), *Hibiscus* 'Sylvia Goodman', *Hugonia mystax* L., *Huperzia hamiltonii* (Spreng) Trev., *Huperzia squarrosa* (G. Forst.) Trev., *Ipomoea purpurea* (L.) Roth, *Loropetalum chinense* var. *rubrum* Yieh, *Lycopodiella cernua* (L.) Pic. Serm., *Majidea zanguebarica* J. Kirk ex Oliv., *Malpighia glabra* L. 'Dwarf', *Nephrolepis duffii* T. Moore, *Olea europaea* L., *Ophioglossum reticulatum* L., *Pentalinon luteum* (L.) B. F. Hansen & Wunderlin, *Platynerium bifurcatum* (Cav.) C.

Chr., *Selaginella wallichii* (Hook. & Grev.) Spring, *Spondias pinnata* (L.f.) Kurz cv., *Syzygium myrtifolium* Walp., *Tillandsia usneoides* (L.) L. are new addition to the ornamental plant germplasm. Besides a few additions belonging to genera such as *Abutilon*, *Caralluma*, *Carissa*, *Cereus*, *Conocarpus*, *Crinum*, *Hoya* and *Sansevieria* are yet to be identified to the species level.

The section was also involved in many intra institutional and extra institutional extension activities. Plant materials of different species of *Polyscias* and *Euphorbia* were provided to the Phytochemistry division for research studies. *Dracaena terniflora* Roxb. roots were provided for the research works in the division of Ethno-medicine. About 250 *Molineria capitulata* (Lour.) Herb. saplings were supplied to the Palmetum section. 36 herbarium specimens of ornamental plants were deposited in the TBGT Herbarium. As a part of environmental restoration activities, proposed the plan and supplied planting materials of trees and shrubs for landscaping the premises of Shanghumukham Beach Temple.



View from Ornamental Garden

Cacti and other Succulents

The collection that comprises about 350 species. Eighty new accessions were added in the cacti and other succulents during the report period through plant exploration trips to different Western Ghats regions viz. Maruthamala, Munnar, Marayur, Chinnar etc and purchase from local nurseries.

Among them *Cylindropuntia arbuscula* (Engelm.) F. M. Knuth, *Carpobrotus edulis* (L.) N.E. Br., *Kalanchoe laciniata* (L.) DC., *Euphorbia ingens* E. Mey. ex Boiss. and an unidentified species of *Crinum* are new to the collection.

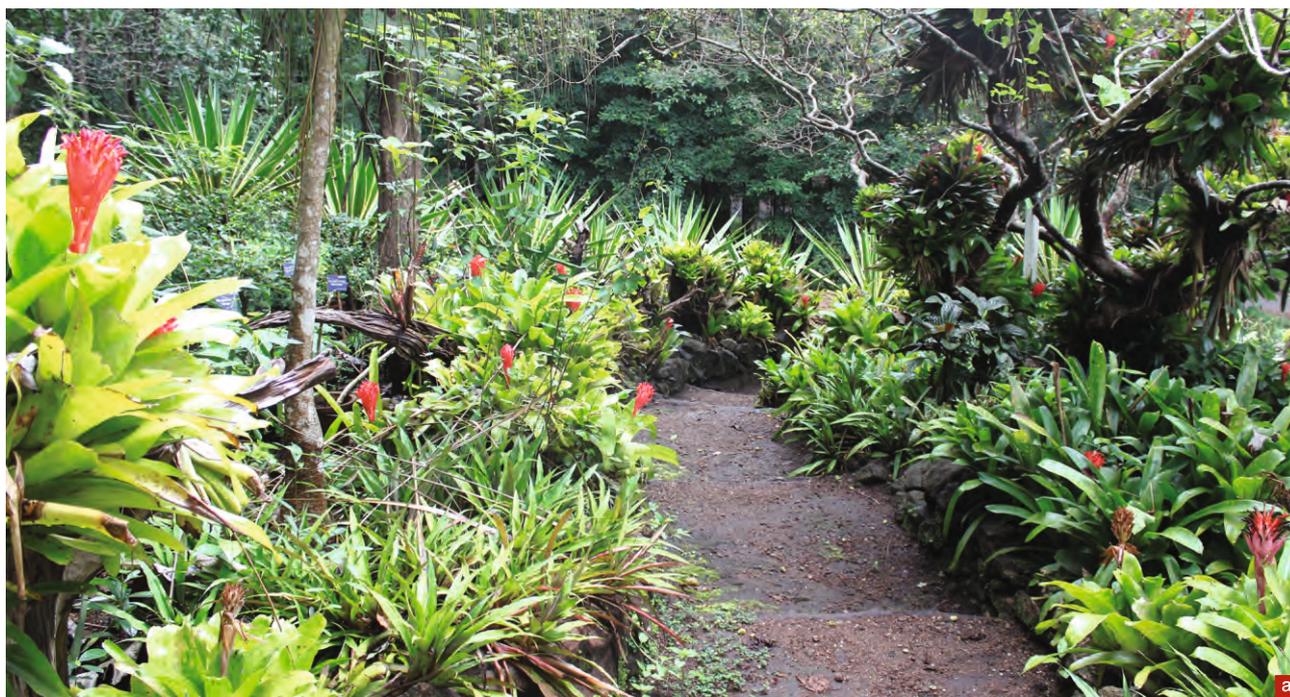


a. Inside view of A. N. Namboodiri Cacti House; b. Rockery.

Bromeliads

40 species of bromeliads are nurtured in this unique exotic collection. Among the 5 new accessions during the report

period, *Tillandsia usneoides* (L.) L. is a new addition to the garden.

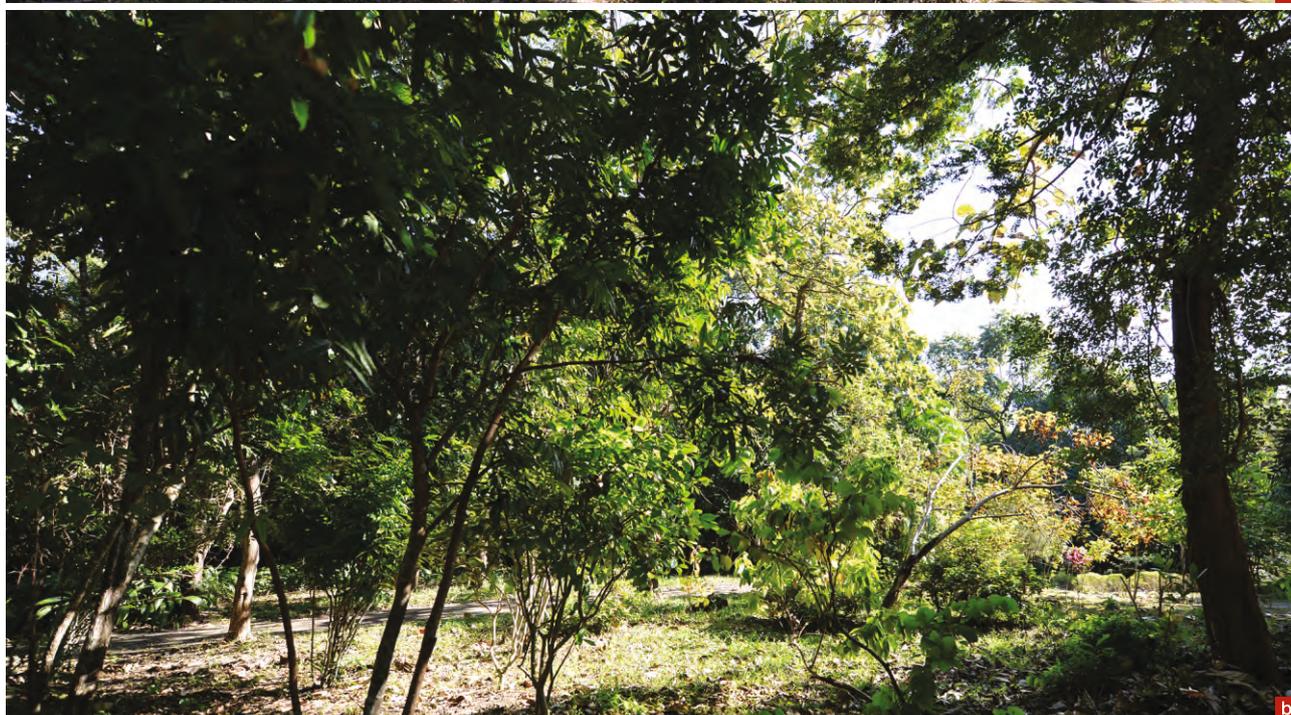


a. & b. Bromeliad Garden

Wild Ornamental Garden

The ornamental section of the Garden Management Division maintains a collection of over 50 species of underexploited wild ornamental plants, especially the ones with landscape applications. The evaluation studies on their

roles in landscaping as well as standardization of easy propagation means are conducted for selected species. Potential of *Dillenia pentagyna* Roxb. an ornamental tree that could generate structural mobility in tropical landscapes and



a. & b. Views from Wild Ornamental Garden

Gymnostachyum febrifugum Benth. as a garden plant for herbaceous border, edge or ground cover were studied and

published. *Bauhinia scandens* L., *Eranthemum capense* L., *Pancratium triflorum* Roxb. were added new in the collection.



a. *Arenga wightii* Griff.; b. *Dienia ophrydis* (Koenig) Ormerod & Seidentf.; c. *Ixora nigricans* R. Br. ex Wight & Arn.; d. *Syzygium laetum* (Buch.-Ham.) Gandhi

Central Nursery and Sales Unit

The unit is mainly engaged with the multiplication of plants for different units of the Garden on demand as well as for the sales and distribution to the public. Propagation standardization of threatened and other endemic species as well as their multiplication to restore in the natural habitat is also carried out. The unit offers training programmes in plant propagation and nursery management. The beneficiaries include Government organizations, farmers, plant growers, students etc. The unit maintains a stock plant collection of some of the commercially important plants for sales and distribution. The collection of *Jasmine* germplasm consisting of about 42 species is of one such kind attracting attention of the Botanists as well as the general public.

During the report period over 50,000 saplings belonging to 310 species/varieties were developed through multi-staged process of seeds/cuttings sowing and transplanting. 276 plants propagated in the Nursery were supplied to different garden units of the institute including the RET species park. Another 156 potted plants with educational interests were supplied to the Extension Unit of the Garden Division for arranging Exhibition displays outside.

In total 16129 number of plants were sold through the sales counter and about 2000 saplings were distributed free of cost to Schools and NGOs. The beneficiaries include Kerala Forest Department, Planning Board, Agriculture Department



Sales counter

etc. Even if sold on nominal price, ₹ 11,58,658/- (Rupees Eleven lakh fifty eight thousand six hundred and fifty eight) was generated through the sales of plants.

Training on general nursery practices including propagation of plants through conventional and special techniques as a part of the curriculum was arranged on demand to 100 selected students of SKV High School, Nanniyode. The three batches of farmers trained under the ATMA programme of Agricultural Department, students from the Agricultural Department office, Aluva were other beneficiaries. Along with other sections of the Institute, the



Nursery training

Central Nursery also arranged projects for the school children participated the work-shop conducted by the 'Shasthra Sahithya Parishath' in JNTBGRI.

As a part of propagation standardization of endemic and threatened species, 'air layering' successfully developed in *Flacourtia montana* Graham. *Litsea travancorica* Gamble and *Salacia malabarica* Gamble. Rooting initiated through hormone treatment in *Vateria indica* L. Studies on *Flacourtia montana* Graham. (Flucourtiaceae) and *Cordia obliqua*. var. *tomentosa* (Wallich) Kazmi (Boraginaceae) are in progress.

Water Plants Collection



Even though there was a modest collection including the Giant water lily (*Victoria amazonica* (Poepp.) J. C. Sowerby) already maintained, an active gathering of aquatic plants was taken up during 2014-16 period. During the reporting period a remarkable addition was made in the germplasm collection through field explorations to various parts of Thiruvananthapuram and Kollam districts and Tamil Nadu. In total 43 new accessions were made in this period. *Ammania baccifera* L., *Aponogeton natans* Engl. & Kr., *Azolla pinnata*, *Bacopa monnieri* (L.) Pennel, *Ceratophyllum demersum* L., *Eclipta alba* (L.) Hassk., *Eichhornia crassipes* (Mart.) Solms, *Hydrilla verticillata* (L.f.) Royle, *Ipomoea aquatica* Forssk., *Lemna minor* L., *Limnocharis flava* (L.) Buchenau, *Lindernia hyssopoides* (L.) Benth., *Monochoria hastaefolia* C. Presl,

Nymphaea micrantha Guill. & Perr., *Nymphaea nouchali* Burm. f. var. *versicolor* (Hook. f. & Thomson) R. Ansari & G. Jeeja, *Nymphaea nouchali* Burm.f. var. *nouchali*, *Nymphaea omrana* Hort ex Gard. var. *rosea* (Sims) R. Ansari & G. Jeeja, *Nymphaea omrana* Hort ex Gard. var. *omrana*, *Nymphaea pubescens* Willd., *Nymphaea arubra* Roxb. ex Andrews, *Nymphoides indica* (L.) Kuntze, *Nymphoides parviflora* (Griseb.) Kuntze, *Ottelia alismoides* (L.) Pers., *Pistia stratiotes* L., *Salvinia minima* Baker, *Salvinia adnata* Desv., *Spirodela polyrrhiza* (L.) Schleid., *Trapanatans* L., *Typha angustifolia* L., and *Utricularia gibba* subsp. *exoleta* (R. Br.) P. Taylor. Species of *Alternanthera*, *Cabomba*, *Ceratopteris*, *Hygrophylla*, *Isoetis*, *Lagenandra*, *Lindernia*, *Ludwigia*, *Marsilea*, *Potamogeton* etc are among the introduction.



a. *Aponogeton natans* (L.) Engl. & Krause; b. *Crinum viviparum* (Lam.) Ansari & Nair; c. *Nymphaea micrantha* Guill. & Perr.; d. *Nymphaea nouchali* var. *versicolor* (Sims) R. Ansari & Jeeja; e. *Nymphoides cristata* (Roxb.) Kuntze

Organic farming through terrace cultivation

Organic cultivation of vegetables encouraging home yard cultivation in public was taken up as a small scale project during 2015-16. The open terrace at the top of the main office building was selected for the purpose. Vegetables viz. Lady's finger, Brinjal, Long bean, Cluster bean, Tomato, Spinach, Chilly, Bitter gourd, Snake gourd and Cucumber were cultivated in pots being provided with proper supports. Bio-

fertilizers and bio-pesticides were only used in growing the vegetables. The harvested vegetables were sold among the staff for reasonable price. ₹ 53,324/- (Rupees Fifty three thousand three hundred and twenty four) generated through the sale of vegetables during the one year period was deposited in the Corpus fund of the Institute.



Views of organic farming



a



b



c



d



e



f



g

a-g. Terrace cultivation of vegetables



Division of Plant Genetic Resource

The vision of Plant Genetic Resource Division is to conserve genetic resources of bamboos, orchids, carnivorous, medicinal, aromatic and spice plants discovering new information. Altogether over 2000 species/varieties are maintained in all these groups. The Division undertakes taxonomic, biosystematic and phytochemical studies, breeding and hybridization experiments, propagation of rare/potential taxa, studies to utilize the resources in a sustainable manner and extension/awareness activities.

Bamboo Biology





Bambusetum: Toperies developed using *Bambusa multiplex*

'Conservation of Bamboos at JNTBGRI' is an ongoing plan funded project through which the Bambusetum of the Institute is being developed and maintained. The Bambusetum presently harbours more than 78 species introduced from various parts of India and abroad, along with 35 hybrids developed in JNTBGRI. The entire collection serves as

Rhizome/Clonal Bank for future and for sapling production of desired clones/species. Bambusetum also functions as a demonstration plot where farmers can familiarize with different species so as to enable them to select better species suitable for cultivation.

Seven plant explorations were organized to various parts of Kerala, Tamil Nadu, Karnataka and Assam including Kalasagiri and surrounding areas, Thalacauvery Wildlife Sanctuary, Agasthyamalai Biosphere Reserve and periphery of Kaziranga Wildlife Sanctuary. Different accessions of 23 species were introduced of which four are new additions to JNTBGRI. Some of the important collections are of *Bambusa mizorameana*, *Schizostachyum dullooa*, *Phyllostachys* sp., *Dendrocalamus longispates*, *Pseudosasa japonica*, *Melocalamus compactiflorous*, *Gigantochloa albociliata*, *Bambusa jaintiana* etc. Twelve species were planted in Bambusetum during the period among which *Neololaba atra*



A view of Bambusetum



Schizostachyum beddomei in flowering



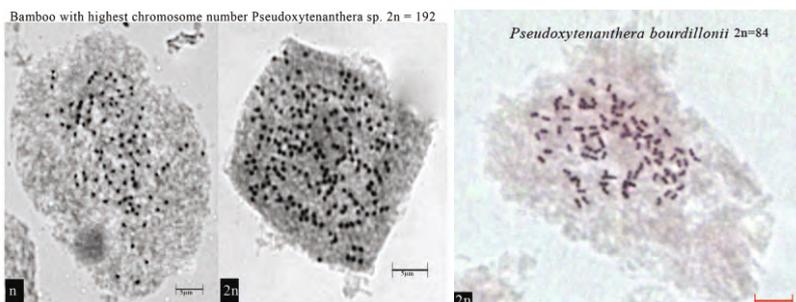
Bambusetum : *Pseudoxytenanthera ritcheyi*

is a new addition. 797 herbarium specimens were deposited in TBGT and 7 specimens in BLATT (Blatter Herbarium, Mumbai). Scanning Electron Microscopic studies of bamboo pollens were initiated in collaboration with the scientists of NIIST, Thiruvananthapuram.

As part of studies on bamboo hybridization, 76 crosses were made, 7 seeds were obtained and resulted in 3 F1 seedlings. Details of new shoots and culm sheaths of already established in 18 bamboo hybrids and their parents were photographically documented. Flowering and fruiting characteristics were observed in species such as *Bambusa bambos*, *Melocanna baccifera* and *Dendrocalamus brandisii*. A comparative study was made between the culms and sheaths of *Pseudoxytenanthera* sp. (Acc. No. 520) and *P. stocksii* (Acc. No. 515).

'Cyto-taxonomic investigations on bamboos of the Western Ghats' is another plan funded project through which mitotic and meiotic studies of different bamboo species and bamboo hybrids were carried out. Some of the findings are: the chromosome number ($2n$) is 72 in *Ochlandra wightii*, *O. setigera*, *Pseudoxytenanthera ritcheyi*, *Neololaba atra* etc where as in *Ochlandra keralensis*, *O. beddomei*, *O. sivagiriana* etc $2n$ is 48. Chromosomal aberration (unipolar movement) was obtained in one accession of *Pseudoxytenanthera* No. 520. Cytological studies on 35 bamboo hybrids were also initiated. Pollen viability studies were conducted in *Pseudoxytenanthera stocksii* which showed 48% viability.

'Search for potential biologically active constituents from a hitherto uninvestigated, unique bamboo: *Melocanna baccifera*' was taken up through a project funded by DST-SERB. This interdisciplinary project was implemented in association with Phytochemistry and Pharmacology Division. The fruits of *M. baccifera* were carefully marked and observed their growth periodically till maturation. Fruits samples at various stages of development from the date of fertilization, viz. 14 days, 21, 28, 35 and 42 days were collected for chemical analysis. New shoots of *M. baccifera* were also used for



Pseudoxytenanthera sp. ($2n = 192$; *P. bourdillonii* $2n = 84$)



a, b, c : A view of Bamboo nursery

the estimation of active compounds. About 25 kg of mature fruits, 4.5 kg fresh leaves and 25 ml root exudate were given for analyses. Final technical report of the project was submitted to DST.

The development of a 'Bamboo Nursery in JNTBGRI' was carried with financial support from Kerala State Bamboo Mission. The major achievements of the project were the development of following permanent infrastructures such as a high-tech green house of 10 x 5m, a net house (12 x 5m)

including a potting and work area. Production of bamboo saplings in large scale for distribution was one of the main activities of this project. For mass production of saplings 21 commercially viable and horticulturally important species such as *Bambusa bambos*, *B. tulda*, *B. multiplex*, *Dendrocalamus brandisii*, *Cephalostachyum pergracile*, *Dinochloa andamanica*, *Gigantochloa nigrociliata*, *Thyrsostachys siamensis* etc. were selected. In total, 49,131 saplings were raised and 26,812 saplings were distributed to



a. His Excellency William Waven, High Commissioner of Seychelles appreciated the plant wealth of the Institute; b. Guests from Ministry of Labour and Human Resource, Bhutan



Planting a new bamboo seedling replacing old clump

beneficiaries representing various individuals as well as Departments/Organisations and Institutions including, Urban Biodiversity Wing, G.H.M.C., Hyderabad; Collectorate, Kottayam, Thenmala Ecotourism; Sahyadri School, Anchal; Kerala State Biodiversity Board; Forest Range, Konni; Vana Samrakshana Samithi, Achenkovil; KFDC, Arippa; Madras Christian College, Chennai; KMML, Chavara, Kollam; Manaveeyam Thiruvonakkootam, Social forestry Programme, Thiruvananthpuram; The Periyar Tiger Reserve, East Division, Thekkady; CAFCO, Chathannoor, Kollam; Sree Eramath Dharma Sastha Temple, Eramam; Deva Matha College, Kuravilangad etc.

Carnivorous Plants

'Building up of a Conservatory for Carnivorous Plants' is an ongoing plan funded programme. The conservatory for Carnivorous Plants is one of the most appreciated centres in JNTBGRI, where an array of insectivorous plants are being maintained and displayed. As female plants of *Nepenthes khasiana* are not available in JNTBGRI, for breeding experiments, a few cuttings were brought from BSI Shillong with the kind consent of Dr A. A. Mao. Ten cuttings of female plants were collected from Barapani Experimental

Garden and another 10 cuttings from the personal collection of Mr Jatindra Sarma I.F.S. at Hamren near Maghalaya. They were planted for rooting. Out of the nine species of *Nepenthes* seeds received from Raju Suchde (Mumbai), Agni Mitra (Port Blair) and S. K. Singh (Shillong), three species (*Nepenthes khasiana*, *N. albomarginata* (spotted) and *N. ventricosa* (red) were germinated. Four hundred and thirty seven *Nepenthes* hybrid plants were replanted/repotted.

The prey spectra of different species of *Nepenthes*



a. *Nepenthes* sp.; b. *Nepenthes ventricosa*



a. *Nepenthes khasiana*
 - Fruit bunch containing seeds
 b. & c. *Nepenthes ampullaria*
 d. *Nepenthes sanguinea*
 e. *Dionaea muscipula*
 (Venus flytrap)

cultivated in the Nepenthes House have been tracked. Surprisingly, a green frog was found sitting inside the pitcher, an unusual visitor, probably waiting to catch some insects, a joint prey capture venture!

Orchid Biology

National Collection of Orchids' is an ongoing plan funded project through which daily maintenance and upkeep of the orchidaria are continued. *Bulbophyllum macranthum* Lindl. introduced from Great Nicobar Island has nicely acclimatized to our environment. Its flowers spread a peculiar smell of the nectar and soon attracted *Bactrocera* fruit flies which were functioned as pollinators and rewarded with the nectar. A video on fruit fly visit and the pollination was recorded.

A total number of 153 crosses were done between different species and hybrids during this period. Of these, 17

pods were harvested and cultured (one produced plants/protocorms). In the last one decade Tiger Orchid *Grammatophyllum speciosum* Blume flowered for three times. Though the flowering in this species is usually after one or more years rest, it consecutively flowered in 2014 and 2015. Earlier it was observed that self sterility was preventing fruit set, despite artificial pollination trials using different flowers from different inflorescences. In 2015, Dr. Teoh Eng Soon (Singapore) supplied the pollinia of Tiger Orchid on request and a series of crosses were made at different intervals which



a. Freddy, Michael and Reghu at Mukurthy N. P.; b. Collecting Orchids - Periya, Wayanad.; c. & d. Dr. H. Y. Mohan Ram and Dr. M. Sanjappa at Varkala cliff



Phaius Bina Devi Pradhan

resulted in fruit setting. The embryo culture done with the support of Biotechnology Division produced seedlings in active stages of growth. Seeds from one of the fruits were dusted on the coconut husk used as media for growing sun loving orchids in the open orchidarium. Surprisingly many of them started germinating with the help of the mycorrhizal

fungus available in the media, quickly getting healthier and about 50 seedlings were subsequently transferred to pots.

One of our hybrids between *Aranthera* Mohamed Haniff and native *Vanda thwaitesii* Hook. f. pollinated on 07/03/2008 produced its first flowers during April 2015 after a long period. Unlike the parents, the flowers of this new hybrid are markedly



reddish orange especially in the dorsal sepal and petals. Orange colour has camouflaged the deep red colour of the female parent and on evaluation the flower quality and longevity were found much superior to the female plant. This first Holttumara hybrid produced in India will be proposed to call after the Father of our nation 'Mahatma Gandhi'.

Sander's Vanda F. W. Sander is a primary hybrid registered by Sanders (St. Albans) in 1948 by crossing *Vanda tessellata* with *V. tricolor* var. *suavis* (the latter was originally considered a distinct species). The same crossing was repeated here when *V. tricolor* var. *suavis* flowered after many years. The remake hybrid raised through this cross flowered in 2015, after 10 years. The colouring pattern and fragrance of its flowers are sober but unique. In the hybrid the very pleasant fragrance of female parent and also its colouration, shape and texture of sepals and petals united to the lip pattern of the male parent.

Phaius wallichii collected from Arunachal Pradesh in 2013 flowered in 2015 and it perfectly matched with Wallich's original drawing in *Plantae Asiaticae Rariores* (Vol.2). Another accession flowered during the period is *Phaius* Bina Devi Pradhan, a hybrid between *Phaius flavus* and *P. tankervilleae* registered by Udai C. Pradhan (1995) who has gifted this hybrid. A dwarf *Arundina* brought from Shillong in 2013 flowered for the first time. It could be an ideal material for breeding.

a. *Bulbophyllum macranthum* with *Bactrocera* flies; b. *Bulbophyllum lasiochilum*; c. *Satyrium nepalense*; d. *Oberonia borangii* - A new species from Arunachal Pradesh



e. Dr. C. Sathish Kumar interacting with Post Graduate students



a. Our hybrid *Holtumara* Mahatma Gandhi - The first *Holtumara* hybrid produced in India. b. *Vanda* F. W. Sander (1948) The remake hybrid raised in JNTBGRI

Study and sketching of a new *Oberonia* collected from Arunachal Pradesh was completed and on discussion with Dr. Pedersen (Denmark) and his student (Thailand), it was later confirmed as a new species and proposed the name

Oberonia borangii, commemorating Mr. Ralom Borang of Arunachal Pradesh. Another interesting finding from Great Nicobar Island is *Luisiopsis inconspicua* which forms a new generic and species record for Andaman & Nicobar Islands. A manuscript on reappearance of *Vanilla parishii* Rchb. f., a misunderstood species was communicated to Kew Bulletin. *Calanthe devogelii* from Arunachal Pradesh was subjected to detailed study. A manuscript on the Sect. *Stachyobium* of *Dendrobium* with a novelty called *D. turbinatum* from Western India was also prepared.

The specimens given by various researchers were taxonomically determined and some of the beneficiaries were Prof. H. Y. Mohan Ram, Santanu Dey, Nagaland, Anoop Balan, Indian Cardamom Research Institute, Ingrid Klefback, Sweden, Alfred Joe, Calicut University, Jose, Thumpamon, Dr Kaliamoorthy, Yercaud, Dr S K Chaturvedi, Jharkhand University and so on. Consultation with Olaf Gruss on *Paphiopedilum* and *Phalaenopsis* is being continued.

A field trip was conducted to Nilgiris during October 2014 along with Dr Michael Moeller, Principal Scientific Officer, Royal Botanical Gardens, Edinburgh and also visited Calicut University and Gurukula Botanical Sanctuary. Two culture bottles of *Vanda bicolor* and *Dendrobium loddigesii* received from Dr Rajkumar Kishor (Manipur) were subcultured. Two fruits of *Grammatophyllum scriptum* received as gift also cultured producing healthy protocorms/ plants. Pollinia of *Cymbidium macidum*, an Australian species, *Renanthera monachica* Ames (Luzon, Philippines), *Phalaenopsis bellina* (Rchb. f.) Christenson (Borneo), *Thunia bensoniae* Hook. f. (North East India to Indo-China), *T. bracteata*, *Vanda denisoniana* Benson & Rchb. f. (Indo-China) and 3 plants of *Nepenthes* (probably *N. alata*) were collected for breeding experiments from the private orchid collection of Mr Jose at Thumpamon. Dr Rajkumar Kishor, Imphal, Manipur gifted three species of *Aeschynanthes*, two *Hoyas*, *Kaempferia parviflora*, *Dendrobium loddigesii* and *Vanda bicolor* (two flasks each), *Dendrobium falconeri*, *D. parcum*, *D. chrysotoxum* and *Coelogyne nitida*. Capsules of *Vanda coerulea* and *Pleione maculata* were also collected from Imphal. Santanu brought *Hedychium rubrum*, *Sthaliathus involucreatus*, *Zingiber* sp., *Kaempferia rotunda*, *Cymbidium tigrinum*, *Coelogyne schultesii*, *Dendrobium regium*, *Bulbophyllum* sp., *Eria* sp. and *Vanilla parishii* from Nagaland. Huge clumps of *Paphiopedilum hirsutissimum*, *P. villosum* and *P. insigne* were collected from Shillong, Meghalaya. Dinesh Rawat of Green Mall, Kolkata gifted two plants of *Nepenthes* sp. Seventeen species of orchids were collected during a week-long expedition to Wayanad and Brahmagiri.

As many as 170 different orchid species and hybrids have been added during this period including 20 species from Anglade Institute, Shembaganur; *Arachnis senapatiana*,



a



c

c. *Grammatophyllum speciosum* seedling - raised naturally



b

a. *Tuberolabium nicobaricum*; b. *Tuberolabium nicobaricum* new sp.

Dendrobium williamsonii, *D. tamenglongensis* and *Bulbophyllum rothschildianum* from Nagaland; *Grammatophyllum scriptum* var. *album* from Singapore; *Aerides emericii* from Car Nicobar Island, *Renanthera* 20thWOC, *Renanthera* Lion's Splendour, Mokara, *Phalaenopsis* (21 Nos.), *Oncidium*, *Bulbophyllum* and

Dendrobium; *Bulbophyllum lasiochilum* Par. & Rchb. f., *Paphiopedilum callosum* (Rchb. f.) Pfitz., *Vanda liouvillei* Finet and *V. lilacina* Teijsm. & Binn. Maintenance and up keeping of horticulturally high value monopodial and sympodial orchid hybrids comprising more than 15,000 plants representing Aranthera Anne Black, Aranda Eric Mekei, Arachnis Maggie Oie, Aranda Nancy, Renanthera, Arachnis Capama, Mokara, Vanda John Club, Vanda Miss Joaquim, Vanda Diana, Vanda Leo-Lukya are growing in 12 beds in the Open Orchidaria is an ongoing major activity. The medium for these plants were replaced with new coconut husks. Organic nutrient spray developed by mixing the supernatant from soaked cow dung and ground nut cake was sprayed to entire portion of hybrids. Fish emulsion prepared with trace elements was also sprayed twice in a month. The Carpet grass landscape in front of the open orchidarium was regularly maintained. Ornamentally potential Anthuriums and Philodendrons were also maintained. The Community Pot-centre, where the orchid hybrid seedlings and Anthuriums are cultivated is also being maintained. Repotting of 95 *Paphiopedilum*, 100 *Phalaenopsis*, 2000 monopodial orchids, 132 terrestrial orchids and 400 *Anthurium* hybrids were done. Regulated the spreading of aquatic weeds in the Check dam spreading along the side of the Open orchidarium. Introduced more than 30,000 just hatched fishes from the Fisheries department in the Check dam.



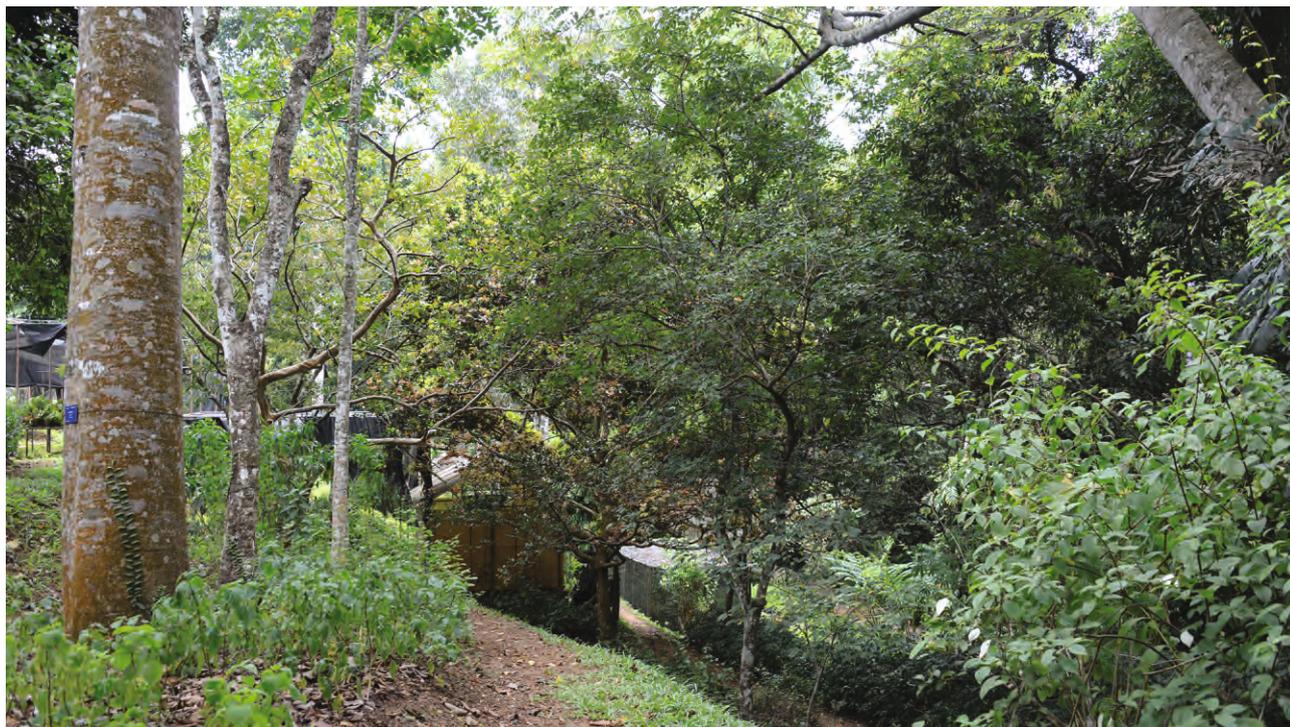
a. Barking deer; b. Common palm civet copy; c. Jungle cat kitten; d. Mountain imperial pigeon

Medicinal, Aromatic and Spice Plants





'Establishment of National Collection and Conservation–Education Centre of Medicinal, Aromatic and Spice Plants' is an ongoing plan project by which the medicinal plant collection of JNTBGRI is being maintained. Thirty six species were introduced during the period through explorations conducted in different regions of Courtallam and Nagercoil of Tamil Nadu and also from Wayanadu, Kannur and Kozhikode. Two medicinal rice cultivars such as *Oryza sativa* 'Njavara' and *O. sativa* 'Uma' and *Arachis glabrata* are the new additions during the period and some lost species such as *Sphaeranthus indicus*, *Pergularia daemia*, *Ipomoea obscura*, *Marselia quadrifida* etc. were replaced. *Achyranthus aspera*, *Pterocarpus santalinus*, *Tinospora malabarica*, *Alternanthera sessilis*, *Curculigo sumatrana*, *Holoptelia integrifolia*, *Citrus aurantifolia*, *Punica granatum*, *Solanum torvum*, *Abroma angusta*, *Erythrina variegata*, *Dracaena terniflora*, *Artanema sesamoides*, *Thalium geniculatum*, *Ceratopteris thalictroides*, *Pellionia heyneana* 'variegata', *Sapindus laurifolia*, *Ceiba pentandra*, *Adenia hondala*, *Ensete superbum*, *Polygonum* sp., *Clitoria ternatea* f. *albiflora*, *Gossypium arboreum*, *Lagenandra* sp., *Adhatoda beddomei*, *Thottea pomudiana*, *T. idukkiana*, *Alangium salvifolium* var. *decapetalum*, *Psilanthus travancoricus*, *Pavetta* sp., *Murraya koenigii*, *Solanum aculeatum* and *S. viarum* were planted in different suitable places of the garden to fill the gaps or to enrich the site.



'Ex-situ conservation of genetic resource of selected medicinal plants and assessment of intraspecific variability' is an ongoing plan-funded project through which characterization of selected medicinal plants are being carried out. Such a study on *Centella asiatica* and *Mucuna pruriens* was completed where as characterization of *Bacopa monnieri*, *Cheilocostus speciosus*, *Piper nigrum* and *Clitoria ternatea* are progressing. Morphological characterization of 40 accessions of *Cheilocostus speciosus* was completed and tabulated. Variability with respect to height of the plant, stem colour, leaf pattern and characters of inflorescence were very prominent. Cytological studies on these accessions revealed four ploidy levels which very well supported the morphological variations. SEM analysis of pollen grains of selected accessions also expressed striking variability in agreement with the cytological as well as morphological variations. Molecular characterization was initiated and DNA isolation of 40 accessions was completed. Sixty accessions of *Bacopa monnieri* introduced from different agro-climatic conditions of Kerala are being maintained and the morphological characterization was completed. Selected 24 accessions were subjected to cytological studies and determined an aneuploid derivative. SEM analysis of pollen grains from 16 accessions were carried out and the characterization is in progress. Estimation of the active constituents Bacoside A and Bacopaside I in 60 accessions of *B. monnieri* was carried out through HPTLC and validated in terms of accuracy, precision, repeatability and linearity and the selection of elite

accession is in progress in collaboration with Phytochemical and Phytopharmacological Division. DNA isolation of 60 accessions of *B. monnieri* was completed and the molecular characterization using IISR primers is in progress.

The characterization of different species of the genus *Piper* from Western Ghats and wild accessions of *Piper nigrum* is another ongoing programme. Detailed morphological characterization of 13 *Piper* species collected from various locations in Kerala forests were completed and the similarity coefficient was determined. Mitotic studies on 15 accessions of *P. nigrum* were completed and the characterization is in progress. Phytochemical characterization of piperine content in fruits and roots of 30 wild accessions of *Piper nigrum* through HPTLC was completed in collaboration with Phytochemistry and Phtopharmacology Division.

The study on *Clitoria ternatea*, a potential medicinal as well as ornamental species was taken up in the reporting period. Forty nine accessions of *Clitoria ternatea* representing 7 variants were introduced from different regions are being established in nursery and maintained in pots. The variants represents accessions with difference in flower colour such as blue, light blue, violet, pink and white. Also there are forms with typical zygomorphic flowers as well as actinomorphic flowers having five uniform petals. Morphological characters of 45 accessions with respect to 91 characters (43 qualitative and 48 quantitative characters) were tabulated for statistical analysis. Anatomical studies of the root of selected accessions were initiated.





'Field Gene Bank development of selected medicinal and aromatic plants and characterization of germplasm' is an ongoing plan funded project. Five plant explorations were conducted in Kerala and Tamil Nadu and introduced 27 accessions for Field Gene Bank. Some of the accessions introduced are *Gloriosa superba* (5550), *Glycosmis pentaphylla* (5555), *Holostemma ada-kodien* (5556), *Curculigo orchoides* (5558), *Desmodium gangeticum* (5559), *Elephantopus scaber* (5560), *Piper nigrum* (5566), *Anaphyllum beddomei* (5570), *Pellionia heyneana* (5573), *Piper nigrum* (5566), *Cissus quadrangularis* (5554) etc. Two accessions of *Plumbago zeylanica* and five accessions of *Elephantopus scaber* were replanted in the conservatory house. Seed germination studies of three species from Andaman Islands

viz. *Areca triandra*, *Mimusops andamanensis* and *Caryota mitis* were carried out. The germplasm collection of the economically and medicinally important genus *Piper* was rearranged and displayed with labels in a Conservatory House at FGB. The collection presently holds 16 species of *Piper*, 3 cultivars of *P. betle* and 4 cultivars of *P. nigrum*.

Micro-morphological characterization of seven accessions of *Pseudarthria viscida* employed with 13 qualitative and 14 quantitative characters was carried out. Interspecific micro-morphological characterization of the leaves of genus *Plumbago* was carried out. Leaf morphology employed with 4 quantitative and 7 qualitative characters of wild Betle Vines (11 accessions) from Andaman - Nicobar Islands was also carried out. Thirty three new labels indicating different accessions of 30 species of the Field Gene Bank and 44 labels for Andaman plants were displayed. Seedlings of *Mimusops andamanensis* (10 nos.), an RET species from Andaman Islands and *Ardisia oxyphylla* Wall. ex DC. (93 nos.) were raised and replanted in pots. *Barringtonia* sp. was planted in Andaman plot. *Dalbergia travancorica* Thoth. (Fabaceae), an endemic taxon known only from type collection during the colonial period and thought to be extinct has been relocated from a sacred grove of Thiruvananthapuram district in Kerala and published. *Pseudarthria viscida* (L.) Wight & Arn. – a new generic record





a. *Alpinia calcarata* (Haw.) Roscoe; b. *Amomum andamanicum* V. P. Thomas, Dan & M. Sabu; c. *Atlantia racemosa* Wt.; d. *Argemone mexicana* L.; e. *Bauhinia acuminata* L.; f. *Bauhinia scandens* L.; g. *Butea monosperma* (Lam.) Taub. ; h. *Calophyllum apetalum* Willd.; i. *Clausena austro-indica* B. C. Stone & K. N. Nair; j. *Costus erythrophyllus* Loes.; k. *Crateva religiosa* G. Forst.



a. *Curcuma aromatica* Salisb.; b. *Ensete superbum* (Roxb.) Cheesman.; c. *Etlingera fenzlii* (Kurz) Skornick.; d. *Euphorbia antiquorum* L.; e. *Euphorbia vajravelui* Binojk. & N. P. Balakr.; f. *Evolvulus alsinoides* (L.) L.; g. *Geophila repens* (L.) I. M. Johnst.; h. *Globba schomburgkii* Hook. f.; i. *Hedychium larsenii* Dan & C. S. Kumar; j. *Ixora johnsonii* Hook. f.; k. *Knema attenuata* (Wall. ex Hook. f. & Thomson) warb.; l. *Musa velutina* Wendl. & Drude; m. *Operculina turpethum* (L.) Silva Manso



and *Dendrobium herbaceum* Lindl. – a new record for Andaman-Nicobar Islands were new findings during the period.

The plan funded project 'Development of a Systematic Garden of herbals' is aimed for establishing a collection of plants systematically arranged according to the Natural System of plant classification so as to provide awareness to

students. The garden is spread over one hectare of land near Field Gene Bank which currently holds 317 species belongs to 81 angiosperm families. Fifty three species belong to 30 families were collected from different localities of Tamil Nadu and Kerala and introduced to the Systematic Garden of which 18 species representing 12 families (Plantaginaceae, Capparaceae, Portulacaceae, Commelinaceae, Haemodoraceae, Chenopodiaceae, Nyctaginaceae, Agavaceae, Crassulaceae, Amaryllidaceae, Balsaminaceae, Pontederiaceae) are new additions. Plant collection trips were conducted to Veli, Bonaccord, Chemunji, Kollam, Ashramam, Aranmula, Thenmala, Aryankavu and Courtallum through which 133 accessions were introduced, of which 35 species are new additions such as *Ariopsis peltata*, *Agrostistachys borneensis*, *Claoxylon anomalum*, *Diotacanthus grandis*, *Glycosmis macrocarpa*, *Gomphostemma eriocarpon*, *Gordonia obtusa*, *Hedyotis villosa-stipulata*, *Henckelia repens*, *Osbeckia virgata*, *Piper peepuloides*, *Salacia agasthyamalayana*, *Saprosma corymbosa*, *Sonerila tinneveliense*, *Strobilanthus decurrens*, *S. wightianus*, *Symplocos macrophylla*, *Biophytum poterioide* etc. Sixty five species were planted in the field during the reporting period. A total of 520 species belonging to 93 families were labelled. The conservatory house for 'Rare Botanicals' is being maintained and introduced 21 RET species such as



a. *Acranthera grandiflora*; b. *Dalbergia travancorica*; c. *Mimusops andamanica*; d. *Pseudarthria viscida*



a. & b. Release of book 'Bee's Herbal Garden' at KSCSTE; c. His Excellency H. E. William Waven, High Commissioner of Seychelles visiting the garden; d. Planting "Maramanjil" seedlings on World Environment Day 2016

Litsea beeii, *Diospyros malabarica*, *Erythroxylon moonii*, *Goniothalamus keralensis*, *Nothopegia travancorica*, *Apollonias amottii* etc. The house currently holds about 220 species from the Western Ghats and Andaman Islands. All plants in the conservatory were labelled. Selected rare species such as *Begonia fallax*, *Begonia albo-coccinea*, *Gomphostemma eriocarpon*, *Goniothalamus cardiopetalus*, *Ophiorrhiza schendurunii*, *Premna paucinervis* etc were multiplied through conventional propagation techniques. During the floristic explorations, *Cinnamomum travancoricum* Gamble has been rediscovered after a period of 113 years from Munnar region and *Ophiorrhiza munnarensis* C.E.C. Fisch. has been rediscovered after 74 years of its first collection from Sabarimala hills in Pathanamthitta district in Kerala. Conducted field oriented taxonomy classes for 62 Graduate/Post Graduate students who visited the Systematic Garden from various colleges/ Universities.

'Bioprospecting of potential gingers: chemical prospecting, morphological characterization and *ex-situ* conservation' was a project in collaboration with Phytochemistry Division, funded by Dept. of Biotechnology, Govt. of India, which was completed in March 2015 and the Final Technical report was submitted. *Alpinia mutica*, *A.*

malaccensis, *Hedychium larsenii*, *H. flavescens*, *Zingiber nimmonii* and *Z. neesanum* were the six candidate species for the project. In order to multiply potential candidates, Propagation study was carried out. The rhizome cuttings of *A. mutica* showed 99% sprouting within 50 days, and its seeds showed 80.5% germination within 40 days. The rhizome cuttings of *H. flavescens* showed 92% sprouting within 60 days and its seeds showed 56.3% germination within 28 days. The essential oils from *Zingiber nimmonii* and *Z. neesanum* were isolated and subjected to GC-FID characterization. The major constituents in *Z. nimmonii* was β -caryophyllene (21.98), 4-terpineol (21.1), β -humulene (12.04), and β -pinene (10.1). In *Z. neesanum* the major constituents were (E)-1-(3', 4'-dimethoxyphenyl) butadiene (33.23), (E)-1-(3', 4'-dimethoxyphenyl) but-1-ene (15.90), apiole (7.78), and β -pinene (7.70). *Z. anamalayanum*, a recently reported endemic species was also studied and the major constituents of its essential oil were determined as β -2-carene (52.83), camphene (9.83) and endo-fenchol (9.42). Setting up of a 'Ginger House' was one of the major outcome of this project. Two unidentified *Costus* species and *Alpinia mutica* from Arunachal Pradesh were planted inside the Ginger House



adding the strength of the house to 55 taxa. Two accessions of *Alpinia mutica* were planted exterior to the house. *Hedygium flavescens* saplings were planted in the bank of river Chittar, near the water falls. Seeds of *Etingera fenzlii* an Andaman species and its allied species *E. elatior*, the exotic 'Torch Ginger' were sowed and found 45% and 1% seed germination respectively. Two accessions of *Amomum* were introduced from Assam and one accession of *Curcuma zanthorrhiza* from Kannur. Introduced 21 accessions of *Etingera elatior* received as a gift from Prof. Vikraman Nair, a Horticulturist and planted in the central quadrat area of the Main Building.

'Production and supply of quality seedlings of selected medicinal plants' is an annual programme supported by Kerala State Medicinal Plants Board for the last three consecutive years. The objectives of the programme are production of quality seedlings of selected medicinal plants, supply of seedlings to different target groups and popularisation. Seed germination trials were conducted in *Aegle marmelos* (66%), *Syzygium cuminii* (54%), *Samadera indica* (92%) and *Pongamia pinnata* (93%). Seedlings were also procured from authentic nursery men from Kerala and Tamil Nadu. During the period, 29,947 seedlings of 26 medicinal species, mostly trees, were raised and 14,957 seedlings were distributed to 246 beneficiaries including Educational Institutions, Govt. Departments Institutions/ Departments, like Centre for Development Studies, Thiruvananthapuram, Kerala Minerals and Metals Ltd., Chavara, Kollam, Rajeev Gandhi Institute for Development Studies, Thiruvananthapuram, Grama Panchayats, Educational Institutions, Social Forestry Programme, State Forest Department etc. This is a successful activity since as a



Supply of medicinal plant seedlings

Botanic Garden, the Institute has an important role to play in the popularisation of economically important plants of Western Ghats, which in turn promotes *ex situ* conservation of these species. As an outcome of this project, saplings of edible medicinal plants such as *Phyllanthus emblica*, *Punica granatum*, *Citrus medica* and *Murraya koenigii* were distributed among the staff and casual labourers of JNTBGRI for domestication.

'Establishing 'Green Belt' in the premises of Vellayani lake' was a one year project funded by Kerala State Biodiversity Board. Five different sites around the Vellayani Lake were visited and suitable species for each site was selected for propagation. Seedlings of selected species were procured through repeated plant exploration trips conducted to Ponmudi, Bonaccord and Chemunji. Some of the species selected for the programme are *Syzygium cuminii*, *Cassia fistula*, *Bassia neerifolia*, *Vateria indica*, *Symplocos cochinchinensis* and *Mesua ferrea*. For the purpose, 1,500 seedlings belong to 9 species were raised and supplied to the State Biodiversity Board.

'Identification of elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardisation of their extracts' is a multidisciplinary project with taxonomical, horticultural, phytochemical and molecular characterization aspects as its components, funded by DBT, Govt. of India, commenced in June, 2015. The taxonomical, conservation and cultivation aspects of the candidate species are entrusted to this Division. Fifty five accessions of *C. asiatica* and 12 accessions of *B. monnieri* accessions were collected from different regions of Kerala and Tamil Nadu through 10 field explorations and being maintained in Field Gene Bank. Edaphic and ecological data on collection sites were documented. Around 300 gm. of each accessions were given for phytochemical analyses. References on distribution and flowering season of *C. asiatica* were documented from different Floras.



Awareness to farmers and NCC cadets

Tissue Culture Unit

The Tissue Culture Unit of the Division is working on non-conventional propagation of selected commercially important plants as part of Institute's lab-to-Land Programme and generating income for the institute. The Unit has developed *in vitro* production protocols for many ornamental /crop/ medicinal plants. At present we are operating two in-house and two external projects.

Remodelling and extension of existing laboratory building into high-tech tissue culture production lab with the assistance from Rastriya Krishi Vikas Yojana (RKVY) were completed by March 2015. The equipments were shifted back to the lab and serviced to working condition and production started from the modernised facility by the end of May 2015.

Under the programme 'Mass Production of Ornamentals', through micropropagation is being carried out in 21 (Institute/contact multiplication) taxa of high value ornamentals comprising of mainly *Anthurium* and Orchid hybrids. The multiplication programme has been initiated after lab renovation and expecting plants from the new lab after 8-16 months. *Anthurium* hybrids such as 'Cesar Violet', 'Hawaii Orange', 'Tropical Red', 'Rosetta', 'Mauritian Orange' 'Mauritian Red', 'Chikas' (new), 'George' (New) and Dora (New) cultures are at initial multiplication stage. Green capsule cultures of a new *Doritaenopsis* hybrid ('Tiang Duke') were initiated. During the period, 35,000 tissue cultured plants were deflasked from 1900 bottles. In addition, we are also multiplying *Nepenthes khasiana* under this programme.

'Micropropagation of Banana and other taxa' is another plan funded project. As part of banana micropropagation programme, 11 cultivars such as Kaveri, Nendran, Poovan, Red Banana, Robusta, Poomkalli, CV Rose, Swarnamukhi,

Nagpoovan, Big Ebang (new introduction) and Chengalikodan (new introduction) were multiplied from disease free suckers. The shoots multiplied were isolated, rooted and transferred to greenhouse condition. Well rooted shoots with 5 cm and above were deflasked carefully and planted in the greenhouse for acclimatisation. Deflasking is being carried out regularly from February 2016 onwards and 51000 plantlets were transferred for hardening. Some of them were sold and most of the recent plants are ready for sale. A tour was conducted to Parassala and Nagercoil for collecting lesser-known varieties of banana. One grower-cum-nursery owner, Mr. Vinod, Parassala, having more than 100 varieties of banana spared us with 3 suckers of 'Pookkali', one 'Big Ebang' and an inflorescence of 'CV Rose' for tissue culture purpose. Micropropagation work started in 'Pookkali', and 'CV Rose' (inflorescence) was progressing well and the 'Big Ebang' planted for elongation. Three collection trips were also conducted to Thrissur, Karunagapally etc to collect banana suckers.

As part of *Piper nigrum* micropropagation programme, a privately funded project to develop *in vitro* multiplication protocol and production, a tissue culture system for *P. nigrum* cv. 'Karimunda' for minimising entophytic bacterial contamination has been developed. Based on our protocol, about 5000 cultures of Black Pepper were developed.

With an aim to promote innovation among farmers/nursery men, introduced a contact production facility for multiplying plants of their choice. During the period, eight growers benefited through this facility. Under this programme, we have undertaken *in vitro* propagation of 19 taxa of orchids and three hybrids of *Anthurium*, mostly hybrids developed by the





A view of tissue culture lab

growers. During the tenure we released 717 flasks comprising 12 taxa under this programme.

The 'Lab renovation and modernisation' was the major programme undertaken during this period. Condensing our long years of tissue culture experience, expertise and the technologies developed encouraged to develop a central plant production programme not only to help small and medium farmers of the State but also to generate reasonable revenue to JNTBGRI. This leads to establish a modernised micropropagation lab with 0.5-0.7 million production capacity p.a. with major aid under Rastriya Krishi Vikas Yojana (RKVY) from State Agri. Dept., a 100% centrally sponsored scheme (CSS). In continuation of the previous year's works, the modernisation and establishment of the High-Tech Micropropagation Lab have been finished with facilities like Clean Room with 11 air flow stations; Growth Room with multi-tier culture racks with a capacity to accommodate 43200 bottles at a time; Media Preparation Section having media filling & capping machine and autoclaving facility of 1400 bottles/batch; Washing Unit having bottle brushing machine and RO water purification system etc and Hardening Unit having 9000sq.ft Poly-house with programmable mist/fog irrigation facility. The lab was handed over after renovation by the end of March 2015 and production will be initiated from the

new lab soon.

Production of quality plants and Income Generation through its sales is a major mandate of the unit. During the period we revised the price list and introduced subsidy. Due to lab renovation, and reorganisation we could produce only 99569 plantlets from the lab. Currently the Unit harbors about 35000 cultures in the lab at different stages of development and 30000 plants in the greenhouse. During this period, the Unit could generate a total income of ₹ 546228/- through sales of tissue cultured plants/flasks and training.

Miscellaneous programmes

The study on birds of JNTBGRI campus was continued and 22 species were additionally observed during this period, enhancing the total number of species recorded as 138 out of which around 10 are endemic to the Western Ghats. The newly observed bird species are Oriental honey buzzard (*Pernis ptilorhynchus* Lesson), Stork-billed kingfisher (*Pelargopsis capensis* Linnaeus) and Indian cuckoo (*Cuculus micropterus* Gould). A colour poster 'Birds of JNTBGRI' comprising the photographs of 99 species were published with the financial assistance of KSCSTE. Manuscript for a hand book on birds of JNTBGRI was completed with the details and photographs of 136 species. Study on mammals of JNTBGRI campus is also

progressing and so far 30 species coming under 9 Orders and 19 Families were located and documented. The study on the food plants of the Common palm civet through scat analyses is a continuing programme. So far identified the seeds of 17 plant species in the scat samples collected in different seasons, among which 13 species are native. This points out the role of Civet as an effective seed disperser of several

species. A three day visit was conducted to National Center for Biological Studies (NCBS), Bangalore to get acquainted with the camera trap device, which is highly essential for studying pollinators in Orchids, animal interaction in carnivorous plants and also the mammalian diversity in the campus, because majority of the insects / animals are either nocturnal or shy. The process for procuring the equipment was initiated.

Division of **Biotechnology and Bioinformatics**

Division has a broad vision to implement Research and Developmental activities for the conservation and sustainable utilization of plant genetic resources of the Western Ghats with food, medicinal and ornamental values. The R&D activities of the Division are categorized into conservation biotechnology, bioproduction of plant specific compounds, bioprospecting of plants through molecular analysis and bioinformatics section. Besides, the Division is imparting training on plant biotechnology tools and techniques with academic and industrial line of interest and other extension services for income generation to achieve the moral and social obligation to the Society.

Conservation Biotechnology

During the reporting period, a collection trip to North eastern state of Assam was conducted and wild species viz: *Musa balbisiana*, *M. flaviflora*, *M. aurantiaca*, *M. velutina* and *M. itinerans* were collected. *Musa sikkimensis* and one cultivar were obtained from Sikkim. Altogether 10 species and 2 subspecies viz. *Musa acuminata* subsp. *burmannica*, *M. acuminata* subsp. *burmanicoides*, *M. aurantiaca*, *M. balbisiana*, *M. flaviflora*, *M. indandamanensis*, *M. itinerans*, *M. laterita*, *M. nagensium*, *M. ornata*, *M. sikkimensis* and *M. velutina* are conserved in the Banana Conservatory.

The external project funded by DBT focuses on establishing a pollen cryobank of wild *Musa*. Wild *Musa* were collected from various regions of Agasthyamala Biosphere Reserve and are reared at the conservatory. Studies on pollen viability of wild *M. acuminata*, *M. ornata* and *M. laterita* have been initiated. The pollen viability was assessed using various stains (iodine-potassium iodide (IKI), 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) and 1,2,3-triphenyl tetrazolium chloride (TTC)) and different culture media. Experiments conducted so far indicate that MTT is a better indicator of viability of *Musa* pollen (i.e. % of pollen stained with MTT resembles the % of actual pollen tube germination observed in optimal medium more accurately).

An attempt was made to determine the ploidy of pollen of wild *Musa* with slight modifications from the protocol described by Kron and Husband (2012). Various methods viz: filter burst method, vortexing with acid washed glass beads and chopping with razor blade were tried to isolate the pollen nuclei, of which vortexing with glass beads produced best results. Nuclei were then stained with Propidium Iodide and

then passed through flow cytometer to determine the ploidy. The development stage of pollen (bicelled or trinucleate) at which dispersal takes place can be determined using this technique. For this young leaf of respective mother plants were used as control. Pollen of *M. laterita* and *M. acuminata* has been analyzed and all have been found to be in a bicelled stage at dispersal (Fig.1).

As part of the establishment of pollen cryobank of wild *Musa* in DBT funded project, the pollen morphology of freshly collected pollen grain of *M. acuminata* ssp. *burmannica* from Ponmudi was studied. The pollen grain was spheroidal as well as inaperturate. Pollen is $111.17 \pm 10.18 \mu$ in diameter with weakly verrucated, $\pm 1\mu$ thick exine.

As part of the in house programme on diploid cultivar conservation, different cultivars were collected from Alappuzha, Kottayam, Palakkad, Thrissur (BRS, Kannara) districts of Kerala and from TNAU, Coimbatore. These specimens were analyzed for determining their ploidy and only diploid cultivars were selected for further study (Table 1). Conformation of ploidy of the collected specimens was carried out as per the protocol of Dolezel et al. (2007).

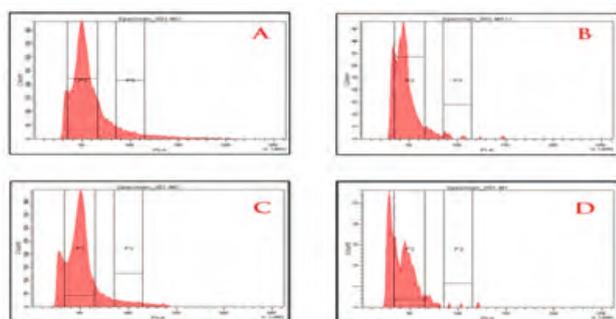


Fig. 1: Flow cytometry of *Musa* pollen (A) Diploid peak of *Musa acuminata* leaf as control (B) Peak of *Musa acuminata* pollen (C) Diploid peak of *Musa laterita* leaf as control (D) Peak of *Musa laterita* Pollen

SI No	Cultivars	Ploidy
1	Anakkomban (BRS)	2n
2	Anakkomban (Wayanad)	3n
3	Rose (BRS)	2n
4	Pakka (BRS)	2n
5	Chundillakannan (Wayanad)	2n
6	Chundillakannan (Kottayam)	2n
7	Chendu (Tamil Nadu)	2n
8	Kannan (Alappuzha)	2n
9	Cultivar (Assam)	4n
10	Cultivar (Sikkim)	3n

Table 1: Showing ploidy of selected cultivars revealed by flow cytometry analysis

Long term conservation of selected cultivars viz 'Matti' and 'Chemmati' using cryopreservation have been initiated. As an initial step the respective cultivars have been inoculated in cauliflower like callus (ideal for cryopreservation) producing media with high BAP. Tissue culture plants of cultivars Matti, Chemmati, Kannan, Pisang lilin, and Chendu have been maintained in the lab.

As part of the ongoing Plan Project on conservation of diploid *Musa* cultivars, 13 *Musa* cultivars were collected from

Wayanad and Kozhikode districts of Kerala and reared in the conservatory for *Musa* species. These specimens were analyzed to determine their ploidy level and only diploid cultivars were selected for further study. Out of the 13 cultivars, ploidy determination was carried out for 10 cultivars as per the protocol of Dolezel et al. (2007). Intact nuclei were isolated and stained with Propidium Iodide and then subjected to flow cytometry. Initially a known diploid species (*Musa acuminata*) was kept as control such that the peak of G1 stage cells were registered at 50 (X axis) and unknown samples are compared against it. Consequently, diploid plants showed peak at 50

Sl. No.	Cultivars	Ploidy
1	Kannan	2n
2	Koombillakannan	2n
3	Charapadatti	2n
4	Poojakadali	2n
5	Adukkakannan	2n
6	Sooryakadali	2n
7	Karayannan	2n
8	Adukkkan	2n
9	Kattuchingan	3n
10	Malayannan	2n

Table 2 : Ploidy of selected cultivars of *Musa* analyzed by flowcytometry

and triploid at 75 and so on. Following cultivars were found to be diploid (Table 2). Later genomic constitution was determined by molecular analysis. Plants of Matti, Chemmatti, Kannan, Pisang lilin, Chundilla Kannan, Chendu have been initiated and maintained under *in vitro* conditions for cryopreservation studies.

Genetic relationships among 6 diploid *Musa* genotypes (*M. acuminata* ssp. *burmannica*, *M. balbisiana*, 'Matti', 'Chemmatti', 'Pisang lilin' and 'Njalipoovan') were analyzed using microsatellite markers (SSR). Genomic DNA of the *Musa* accessions was extracted using a modified method of

Murray and Thompson (1980) and quantified by agarose gel electrophoresis. A primer test was performed through SSR markers described by Crouch et al. (1999). Dendrogram was prepared and the results revealed that, *M. acuminata* ssp. *burmannica*, Matti, Chemmatti and Pisang lilin clustered in one group and *M. balbisiana* and Njalipoovan clustered in the second group (Fig. 2) and it was in accordance with their genetic makeup.

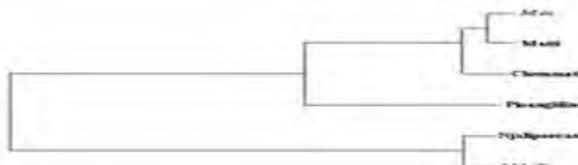


Fig. 2 : Dendrogram generated by SSR analysis of 6 diploid *Musa* genotypes

Confirmation of amines like Serotonin, 5 hydroxy tryptophan, Dopamine and L-dopa in *Musa* cultivars (Matti, Chemmatti, Pisang lilin) was carried out by using LC-MS-ESI analysis (CDRI, Lucknow). All the tested cultivars showed the presence of these valuable amines (Fig. 3).

Seeds from 3 accessions of *Vanda thwaitesii* and one accession of *V. wightii* were deposited in the cryobank as part of the on going plan project on Micropropagation of *Phaius luridus* and expansion of pollinia and seed cryobank of orchids of Western Ghats. Viability evaluation of seeds stored for more than 2 years in cryobank was carried out. The results showed that all the 5 collections of *V. spathulata* retained viability after 2 years of storage. Three accession each of *V. thwaitesii*, *V. tessellata* and *V. wightii*; two accessions of *Cymbidium aloifolium* and one accession each of *Eulophia spectabilis*, *Dendrobium heterocarpum* and *Coelogyne nervosa* were the other species retained viability after extended period of storage in LN. *Geodorum densiflorum* and *Eulophia cullenii* failed to retain their seed viability after 2 years of storage in LN, which requires further optimizations. Besides, pollinia of *Vanda wightii* and *Dendrobium ovatum* were deposited in the

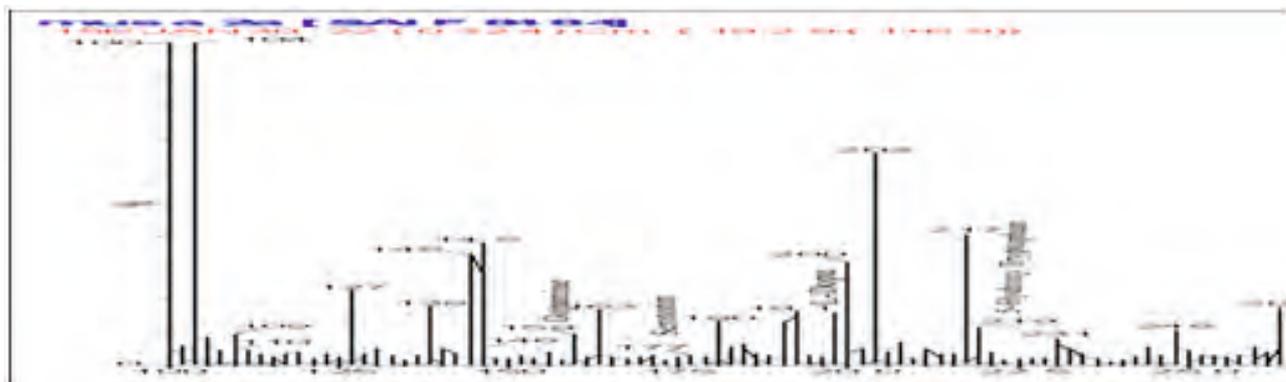


Fig. 3 : LC-MS-ESI data analysis showing the presence of amines in *Musa* cultivar 'Chemmatti'

cryobank. Pollinia completed 2 years of storage were evaluated for viability/fertilizing ability and it was confirmed in *Acampe praemorsa*, *Dendrobium macrostachyum*, *Eulophia epidendrea*, *E. pulchra*, *Rhyncostylis retusa*, *V. tessellata* and *Vanda wightii*.

Seedlings of hybrids *Vanda spathulata* x *Acampe praemorsa*, *V. spathulata* x *V. wightii*, *A. praemorsa* x *Rhyncostylis retusa*, *Eulophia cullenii* x *E. nuda* and *V. thwaitesii* x *V. spathulata* produced utilizing cryopreserved pollinia were transferred to nursery. The other hybrids reared in the nursery are *Vanda tessellata* x *Luisia macrantha*, *E. specabilis* x *E. cullenii*, *V. spathulata* x *Rhyncostylis retusa*, *Vanda spathulata* x *V. tessellata* and *V. wightii* x *V. spathulata*.

Seedlings of *Paphiopedilum druryii*, a critically endangered species reared in the nursery flowered second time in the nursery and a few of them were with double flowers. Viable seeds were obtained through hand pollination of flowers produced in the seed culture-derived plants and protocorms were obtained through culture in Mitra *et al* medium. Thus *in vitro* system continuously produced this plant for popularization without disturbing the natural localities. The seed culture derived plants were reared and kept available for sale in the Division. The sale of 67 plants during this period could generate a total income of Rs. 67,000 to the corpus fund of the Institute and the sale programme is continuing.

Propagation of *Phius luridus* through seed culture was succeeded. However, the species exhibited poor fruit set and seed germination and therefore could produce 15 seedlings from 2 capsules. They also showed poor field establishment and none of the five seedlings transferred to the nursery survived.

At the final stage of DBT funded Project on "Conservation of *Vanda thwaitesii*, *V. wightii* and *Eulophia cullenii*, three endangered orchids of Western Ghats through micropropagation and restoration with tribal participation" the collected populations of *V. thwaitesii* were subjected to genetic diversity analysis using ISSR markers and the results showed poor genetic diversity and negligible gene flow necessitating effective conservation strategies to save them from extinction. Reinforcement of 402 seedlings of *V. wightii* was carried out in Idukki Wildlife Sanctuary and Anchuruli Reserve Forest. 85% of them (311 Nos) showed survival/establishment when monitored after 8 months of planting. Reinforcement of *V. thwaitesii* (313 seedlings) was made at Idukki Wildlife Sanctuary and Thirunelli Reserve forest and 65% of them (206 seedlings) showed survival/establishment after 9 months. *Eulophia cullenii* reintroduced at JNTBGRI campus showed 76% establishment, if 2nd and 3rd generation seedlings were planted while 97.5% of the 4th and 5th generation seedlings established and carried over to next generation. Translocation

introduction of *V. wightii* (323) and *V. thwaitesii* (308) seedlings made at JNTBGRI campus gave 93 and 97% survival respectively, after 4 months of planting.

Under the project funded by Kerala Forest Department on Conservation of *Calamus shendurunii* and *C. wightii* two endangered and endemic rattans of Western Ghats through micropropagation, reintroduction and cryobanking, a total of 300 seedlings of *C. shendurunii* were raised in nursery beds and a sample of 10 plants planted into their native locality in Shenduruneey WLS. When observed after one year, 6 of them showed establishment with new leaves. Experiments on zygotic embryo cryopreservation were continued and observed that embryo of *C. shendurunii* from partially mature seeds tolerated LN exposure. Thus the embryos from partially mature seeds were proved as the most ideal material for cryobanking of *C. shendurunii*. Preliminary experiments suggest that *C. wightii* also have similar behavior but has to be confirmed through further trials. Secondary embryogenesis was initiated from immature zygotic embryos of *C. shendurunii*, which was spontaneous. A reliable protocol in this regard has to be developed.

As part of the in-house project on "Genetic conservation and chemical characterization of ethanobotanical insect repellent plant species of the Andaman Nicobar Islands", shoot cultures regenerated from rhizome bud explants of *Etilingera fenzlii* (Zingiberaceae) are maintained in the *in vitro* repository. Five thousand mericlones are maintained in the conservatory as well as in the *in vitro* bank for translocation/reintroduction to natural forest habitats of Andaman Nicobar Islands. Besides, an attempt has been made to develop efficient microrhizome induction system in *E. fenzlii* on MS medium supplemented with varying concentrations of Abscisic acid (ABA) a stress hormone and sucrose at various levels to develop a protocol for production of planting material for essential oil extraction, the attempt provided the possibility of exploiting the factors for enhanced production of microrhizomes with low concentration ABA (0.1mg⁻¹) and higher levels of sucrose (8%) with 43 days of incubation at 24 ± 20C with a photoperiod of 12 hours at 2500-3000 lux.

The active chemical constituents identified through GC-MS include n-dodecanol, Humelene epoxide, n-undecanol and caryophyllene oxide from the essential oil of *E. fenzlii* were analyzed through electroantennographic detection (GC-EAD) and Y tube Olfactometer bioassays were confirmed high repellent property against honey bees (*Apis dorsata*) and mosquitoes. Perusal of the acute and dermal toxicity analysis manifested that essential oil of the whole plant (oil extracted from seeds/leaf and pseudostem) did not divulge any

significant toxicity and was found to be safe up to 2000 mg/Kg in *in vivo* concentration. Essential oil also demonstrated antifungal activity against pathogenic fungi such as *Aspergillus niger* and *Penicillium expansum* along with antibacterial properties. Evaluation of Hepatoprotective potential of essential oil of *E.fenzlii* in ethanol induced hepatotoxicity in Wistar albino rats are in progress.

The in-house project on “*In vitro* propagation and ecorestoration of threatened medicinal plant *Myristica malabarica* Lam.” has been continued and seedlings of seven accessions of *Myristica malabarica*, a dioecious tree were collected from Kulathupuzha, Kallar, Ponmudi and Shenduruni forest ranges. These specimens were analyzed for identification of sex specific DNA markers because attempts to identify the sex of the species at an early stage have remained frustratingly unsuccessful. The study is in progress. Experiments for culture initiation and proliferation from shoot tip, nodal explants and excised embryonic axes of new accessions have been initiated.

As part of the completed projects on “National Gene Bank for Medicinal and Aromatic Plants - Strengthening and expansion of National Gene Bank for medicinal and aromatic plants” (DBT, Government of India and KSCSTE, Government of Kerala) and *Ex-situ* conservation of RET medicinal plants (NMPB, Government of India) - A total of 28 accessions of 23 species are also maintained in the *in vitro* repository (*Acorus calamus*, *Anaphyllum wightii*, *Aristolochia tagala*, *Baliospermum montanum*, *Celastrus paniculatus*, *Coleus forskohlii*, *Curcuma aromatica*, *C. longa*, *Decalepis arayalpatra*, *Hearacleum candolleum*, *Holostemma adakodien*, *Justicia gingiana*, *Mahonia leschenaultii*, *Myristica malabarica*, *Nothapodytes nimmoniana*, *Piper barberi*, *P. trichostachyon*, *Rauvolfia beddomei*, *R.serpentina*, *Rubia cordifolia*, *Trichopus zeylanicus* subsp. *travancoricus* and *Utleria salicifolia*).

Bioproduction of Plant Specific Compounds

Camptothecin (CPT), an indole alkaloid, has been recognized as a potential anticancer molecule widely used for treating various types of cancers all over the world. The derivatives of CPT namely: topotecan and irinotecan are the two important anticancer drugs popularly used for treating colon and breast cancers. The compound, CPT is still extracted from plants that resulted vast toll of natural population. In order to develop alternative methods for ensuring the availability of source plants, suitable biotechnological methods have been used in selected medicinal plants for the extraction of the compound.

As part of the In house Project on Production of Camptothecin and plumbagin from *Ophiorrhiza* species and

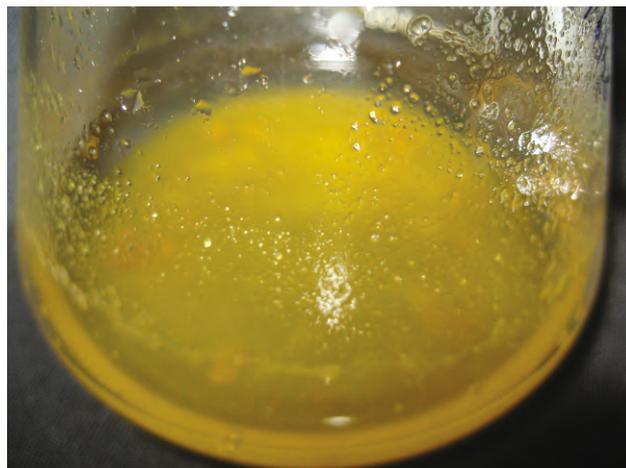


Fig. 4. Cell suspension cultures of *Ophiorrhiza pectinata*

Plumbago rosea L., experiments have been carried to develop appropriate *in vitro* culture systems for the production of camptothecin in selected species of the genus *Ophiorrhiza* (Rubiaceae) namely *O. mungos*, *O. pectinata* and *O. trichocarpos* and plumbagin from *Plumbago rosea*. Experiments on *Pyrenacantha volubilis* (Icacinaceae), a camptothecin producing important medicinal plant were also carried out as part of Ph. D. programme during the reported period.

Cell suspension cultures of *O. pectinata* have been established and studied the growth pattern of cell cultures over a period of 28 days at an interval of 4 days (Fig. 4). The data showed that cell growth was maximum (7.12 ± 1.63 g) on the 16th day of transfer after a lag phase of 10 days with a growth index (6.12 ± 1.08) in half strength Murashige and Skoog (1962) liquid medium supplemented with 3mg/L IAA. After 16 days, colour of the cells turned to brown indicating end of cell growth and reached a stationary phase in 20 days.

In addition, influence of different abiotic and biotic elicitors on growth and synthesis of camptothecin in the cell suspension cultures of *O. mungos* has been studied in detail and found that 50 μ M Jasmonic acid critically influenced the synthesis of camptothecin (0.8 ± 0.05 mg/gDW) with reduced cell growth. Period of incubation of cells fed with elicitors also had significant role in maintaining the cell viability as well as production of camptothecin. Cell viability was found stable in cultures treated with Jasmonic acid (25 or 50 μ M) for five days.

As part of Ph. D. programme, *in vitro* regeneration studies have been successfully conducted in the seedling-derived nodal segment of *P. volubilis* (Fig 5). Shoot multiplication was obtained in aseptic seedling-derived nodal segments cultured in MS solid medium supplemented with 0.3mg/L BAP and 0.3 mg/L IAA in 25 days. Experiments for rooting of the shoots are in progress.

For the bioproduction of plumbagin (2-hydroxy, 2-methyl



Fig. 5. Multiple shoots of *Pyrenacantha volubilis*

1-4 naphthoquinone), an important medicinal compound accumulating in the tuberous roots *Plumbago rosea* L., a novel culture vessel model using a Reaction kettle (2 L) flask was attempted for the experiments on scaling-up of hairy roots developed using *Agrobacterium rhizogenes* (Fig. 6). The roots cultured in Murashige and Skoog basal liquid medium for 25 days in a Reaction kettle (2 L) flask customized with a polypropylene mesh for support with continuous aeration using a fish tank aerator yielded good root growth (120.0 ± 0.52 g/L) with plumbagin (1.5% gDW). Root biomass was twelve-fold in Reaction kettle against five-fold biomass with 1.1% DW plumbagin in shake flask cultures.

Trichosanthes cucumerina var. *cucumerina* L. is a high value medicinal plant in Ayurvedic preparation which is inhabiting in high altitude areas of Kerala. An average of 30-40 tons of raw material generated through cultivation is customized by leading pharmaceutical firms in Kerala. The major secondary metabolite, cucurbitacin B, D, E, I, a tetracyclic triterpenoid compounds revealed, anticancer activity against breast cancer by inhibiting STAT3 phosphorylation. As part of the in-house Project on *T. cucumerina*, during the reporting period, work was initiated to make a comparative analysis for morphological, phytochemical and antimicrobial activity of leaf, stem between the plants collected from a high altitude and low altitude habitats. The fruits and plants collected from high and low altitude habitats and observed specific difference in morphology of the fruits between the samples from two habitats. The concentration of the total extracts



Fig. 6. Scaling up studies of hairy root cultures of *Plumbago rosea*

of leaf and stem (5g powder for each sample) of low altitude and high altitude eluted in different solvents (hexane, chloroform, methanol and water) was determined. Between the habitats, concentration of the total extract was more in the samples of high altitude habitat and among the solvent tried, more concentration was eluted in water (Table. 3). The determination of compounds in each extract and antimicrobial activity studies are in progress. However, the ISSR analysis of six accessions of both types of plants (globoid and slightly elongated fruits) carried out showed 27% polymorphism which indicated that the two types of *T. cucumerina* are

Solvents	Leaf (LA)	Yield in %	Leaf (HA)	Yield in %
Hexane	0.130gm	2.60%	0.210gm	4.20%
Chloroform	0.101gm	2.02%	0.190gm	3.80%
Ethanol	0.203gm	4.06%	0.270gm	5.4%
Distilled water	0.613gm	12.26%	0.700gm	14.0%

Table 3. Yield of total extracts of leaf samples from low altitude (LA) and high altitude (HA) habitats



Fig. 7. Hairy root cultures of *Trichosanthes cucumerina* established in shake flasks

morpho-variants. Aseptic seedlings were raised using the seeds from ripened mature fruits of the plant .

Juvenile explants of the 1-2 weeks old seedlings were optimized for hairy root initiation using different strains of *Agrobacterium rhizogenes*. Bacteria were eradicated by transferring the hairy roots, repeatedly in MS medium containing 500mg/l ampicillin. Bacteria-free roots were grown profusely in MS hormone free basal medium (Fig. 7).

A preliminary studies on antibacterial activity using the methanol extract of leaf and stem samples from high altitude habitat was tested for the antibacterial activity. Kanamycin was used as positive control and *Salmonella typhi*, *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas auregenosa*, *Escherichia coli*, *Klebsiella pneumoniae*, *Vibrio cholera*, were the organisms. The results indicated that methanol extract had negligible activity against *Pseudomonas* and no activity was observed on other strains. Experiments on anti-fungal activity and antibacterial activity using other extracts including aqueous extracts are under way.

The HPLC analysis of the fusciform rhizogenic callus grown in MS medium with optimized concentration of 2,4-D which was initiated during previous period produced 0.106

Samples	Total Extract (g)	Cucurbitacin B (mg /g–l dw)	Cucurbitacin E (mg/g –l dw)
Multiple shoot cultures	0.188	0.082	0.021
Rhizogenic callus culture	0.196	0.106	0.041
Cultivated plants in Munnar	0.346	0.067	0.0094
Filed-grown seedling	0. 231	0.0075	0.0036

Table 4: Concentration of Cucurbitacin B and E in different samples analyzed using HPLC

mg–l dw cucurbitacin B and 0.041 mg–l dw cucurbitacin E which was slightly more than that obtained in multiple shoot cultures (Table 4).

The determination of antimicrobial activity of the leaf samples *T. cucumerina* of both low and high altitude habitats was initiated by testing the anti-bacterial activity initially. Pure cultures of six bacterial organisms of MTCC such as *Pseudomonas aeruginosa*, *Vibrio cholera*, *Salmonella typhi*, *Bacillus subtilis*, *Staphylococcus aureus* were used for the test by disc method in Mueller Hinton agar medium. Antibiotics Kenamycin was used as positive standard. The plates were incubated at 37°C temperature for 24 hours and observed growth inhibition zones, including the diameter of the disc were measured using centimetre scale. The results showed that chloroform extract of high altitude – derived plants showed pronounced activity compared to other extracts and samples. The work is under progress for a complete evaluation.



Fig. 8. *Agrobacterium rhizogenes* (MTCC 532) induced hairy roots in *Trichosanthes cucumerina*

Different MTCC strains of *Agrobacterium rhizogenes* (MTCC 532 and MTCC 2664) were analyzed for hairy root induction and found that MTCC 532 was virulent in inducing both callus and roots (Fig. 8). Attempts were initiated to isolate the transgenic roots and callus separately for bacteria eradication using ampicillin. The already initiated transgenic roots during the previous period were obtained free from bacteria and they were used to study the growth. Growth of the

hairy roots was investigated for a period of 4 weeks by measuring RGU using the formula, RGU: [(length of lateral roots) + primary root length) / (number of root tips)]. The results showed that roots elongated within 2nd day and started to initiate lateral roots on 4th day and growth declined on between 2nd and 3rd week. Similar pattern of growth has been

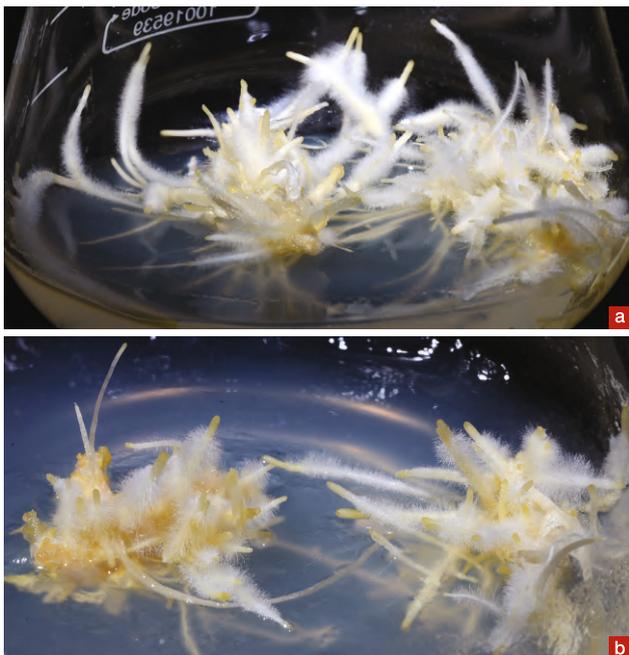


Fig. 9. Morphological differences of the hairy roots in *Trichosanthes cucumerina*

showed in shake flask culture. Morphological difference in hairy roots was noticed during the experiments as in certain cultures roots were thick and more pubescent (Fig. 9a) and very short, thick and yellowish (Fig. 9b). Based on this observation attempts were carried out to establish different hairy root clones.

The in-house project on Selection of elite genotype and *in vitro* studies of *Cuculigo orchioides* Gaertn., a commercially important medicinal plant was continued. Collection of

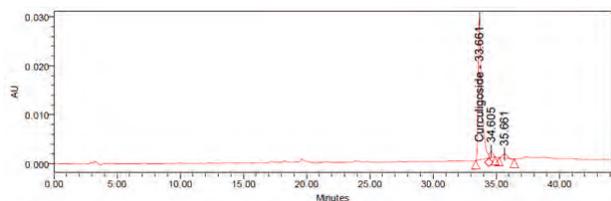


Fig.10. HPLC chromatogram of authentic standard of curculigoside

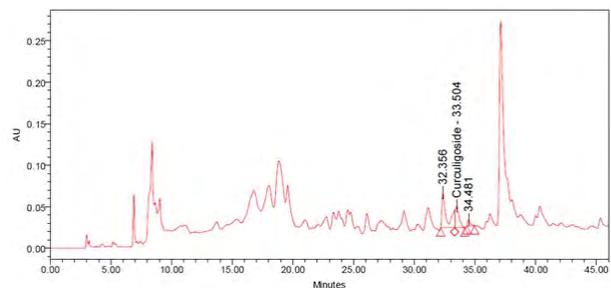


Fig. 11. HPLC Chromatogram of rhizome sample from Pathanamthitta district

accessions from different district was continued and during the period, 12 accessions were collected (Pathanamthitta (Thengamam, Pazhakulam, Kadambanadu), Palakkadu (Kuttipuram, Thirtala, Pattambi), Thrissur (Vellanikara, Pathamkallu, Kalathode) and Malappuram (Changaramkulam, Perumbadapu, Edapal). The accessions were established in the pots and reared in shade house after recording morphological data. As seen with the other accessions collected during the previous period, difference was noticed in the size and length of leaf and rhizome among accessions. DNA was extracted using genomic plant DNA extraction kit from 14 accessions and the genetic variation analysis of the accessions using ISSR primers is underway.

Phytochemical analysis of 10 accessions was done using HPLC. Shade dried powder (5 gm) from each accessions was extracted with water-acetone (3: 2 v/v) at 4°C with maceration. Extract was filtered through Whatman No 1 filter paper and combined extract was evaporated at 40°C under reduced pressure and separated the ethyl acetate fraction which was subjected to HPLC. The mobile phase was acetonitrile (0.1%): phosphoric acid (25:75) at a flow rate 1 ml/min and chromatogram was monitored at 286 nm. The concentration of the curculigoside was determined using authentic standard which has Rt 33.661 min (Fig. 10). In all the samples curculigoside was detected by comparing the retention time of authentic standard as in the sample from Pathanamthitta district (Fig. 11). The work has to be completed for all samples which is in progress.

Bioprospecting of plant genetic resources

As part of the ongoing project on analysis of phytochemical and genetic diversity in natural populations of *Lagerstroemia speciosa* (L.) Pers, funded by DBT, Govt. of India, an elite population of *L. speciosa* was identified earlier. During this period, a viable *in vitro* cloning protocol of the elite *L. speciosa* accession was established from nodal explants of 25 years old tree in *Schenk and Hildebrandt* (SH) medium supplemented with 1 mg/L BAP. Shoot initials obtained after 4 weeks from axillary bud of primary explants (Fig. 12a) were



Fig. 12. In vitro studies in *Lagerstroemia speciosa*

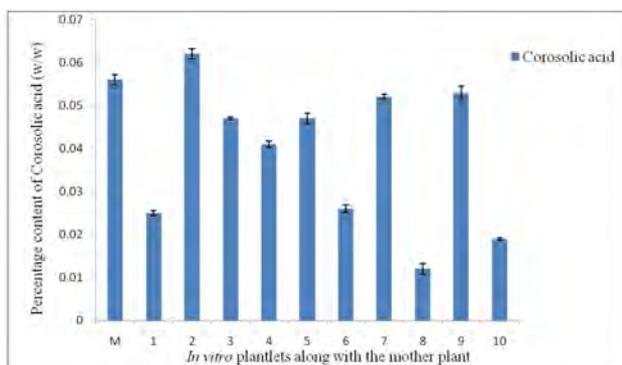


Fig. 13. Corosolic acid content in the mature leaves of *L. speciosa*, including mother plant (M) and randomly selected *in vitro* derived plantlets (No. 1 to 10) using HPLC analysis. (Mean \pm SE of three replicates).

dissected out and individual shoots were subcultured at 4 weeks interval in the same medium supplemented with 0.5 mg/L BAP for multiple shoot cultures to scale up (Fig. 12 b). The shoot clumps in multiplication medium showed elongation and rooting when transferred to SH basal medium at 4 weeks interval and were ready for field transfer. In a very short duration of 24 weeks, ~2450 rooted plantlets could be harvested from a single nodal explant. Rooted plantlets, after 2 weeks of hardening in mist house ($28 \pm 20^\circ\text{C}$ and $80 \pm 5\%$ RH) followed by transfer to the shade net house (50%) resulted in 75% establishment. True-to-type nature of the regenerants

was confirmed through ISSR analysis.

Estimation of CRA content, by HPLC analysis of leaf samples of *in vitro* plantlets of *L. speciosa* showed variation in active principle distribution in these. The percentage distribution of CRA was found to vary from 0.012 to 0.062 % DW with mean value of 0.0384 ± 0.005 in mature leaves (Fig. 13) wherein, it was from 0.004 to 0.007 % DW with mean value of 0.005 ± 0.001 in young leaves, of the same plant. The data suggest that mature leaves are ideal source with highest amount of CRA.

To explain differential synthesis of CRA during leaf ontogeny in micropropagated plants and relative CRA content in different parts of the mother plant, RT-PCR analysis was used. The relative expression of three upstream genes viz., HMGR (MVA pathway) DXR and DXS (MEP pathway) along with the downstream gene catalyzing oxidative hydroxylation reactions (CYP450H) presumed to be involved in the final step(s) of CRA synthesis was studied. The relative gene expression profiles obtained for various tissue of the mother plant clearly indicates that rate limiting steps of terpenoid biosynthesis is highly expressed in leaf tissue compared to other parts (Fig.14). Furthermore, 18 to 25 fold increase in HMGR expression in mature and young leaves of the mother plant respectively, indicates the preference of MVA over MEP in terpenoid synthesis in *L. speciosa*. Interestingly, nearly 20 fold increase in CYP450H in the mature leaves conclusively demonstrates the positive correlation between CRA synthesis and gene expression. Consequently, the expression profile of these genes in the *in vitro* plantlets during leaf ontogeny, where an incremental increase in CRA production is observed, also showed concomitant increase in the expression of HMGR and CYP450H (Fig. 14 b).

Apparently, the terpenoid biosynthesis genes in the mother and *in vitro* derived plantlets showed similar pattern of expression and found to be in concordance with CRA synthesis. Therefore, the observed differential synthesis of CRA in the young and mature leaves is due to modulation in the expression of regulatory genes in terpenoid biosynthesis

As part of the ongoing project "Metabolic pathway analysis of L-DOPA synthesis in *Mucuna pruriens* L. by characterization of catecholamine pathway with emphasis on modulation of tyrosine hydroxylase gene", funded by DBT, Govt. of India, elicitor mediated *in vitro* studies were carried out. Mature seeds of *Mucuna pruriens* were obtained from NBPGR, New Delhi (IC385928). The surface sterilized seeds were transferred onto MS basal nutrient medium of different strength (full, half and quarter) for seed germination studies. Among the various strength of nutrient media tried, maximum percentage (98%) of seed germination was observed in full strength MS basal medium, in fourteen days. For culture

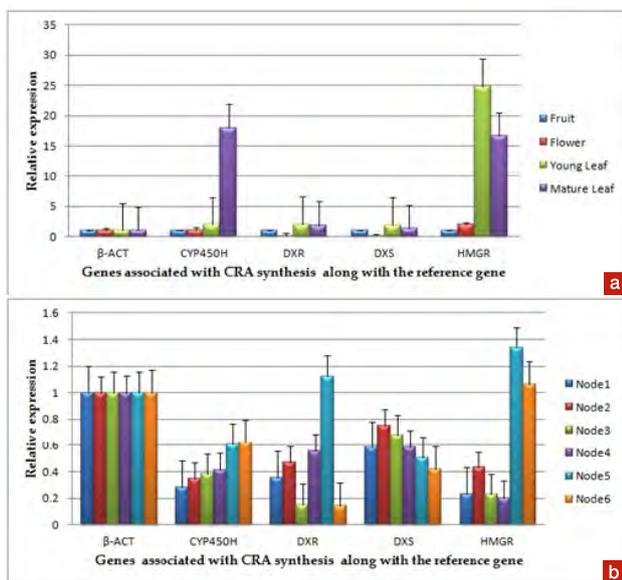


Fig. 14 : Relative expression levels of terpenoid biosynthesis genes in (a) the fruit, flower, young and mature leaf of *L. speciosa* mother plant (b) the leaves of the *in vitro* plantlets at different stages of maturity from apical (young) to basal (old) node

initiation, axenic shoots were separated aseptically and nodal segments of approximately 1 cm were dissected out carefully and implanted in full MS medium supplemented with various concentrations of BAP ranging from 0 to 25 mgL⁻¹. Among the various concentrations tried, MS medium augmented with 0.5 mgL⁻¹BAP induced shoot initiation after fifteen days of culture.

Callogenesis from axenic seedling derived leaf segment culture

Leaf disc of size 1.0×0.5cm dissected out from fifteen day old axenic seedlings were implanted in full strength MS medium supplemented with concentrations of 2,4-D ranging from 0.0 to 2.0 mgL⁻¹, to induce callogenic response. However, 0.2 mgL⁻¹ 2, 4-D was found to be optimum for maximum proliferation of callusing within two weeks of culture (Fig. 11). Duration of subculture period was limited to two weeks, for the harvest of proliferative mass of callus culture.

To study the increase in L-DOPA concentration in *in vitro* cell cultures with respect to elicitor induction, various concentrations of Jasmonic acid (JA) in the range 0.0 to 5.0 mgL⁻¹ was supplemented into the MS media along with 0.2mgL⁻¹ 2, 4-D. L-DOPA production was found to increase with increase in concentration of JA (Fig. 15). However, higher JA concentration subsequently resulted increased browning/necrosis rate. Therefore, JA at a concentration of 0.05 mg/L was found to be optimum for the callusing as well as L-DOPA production.

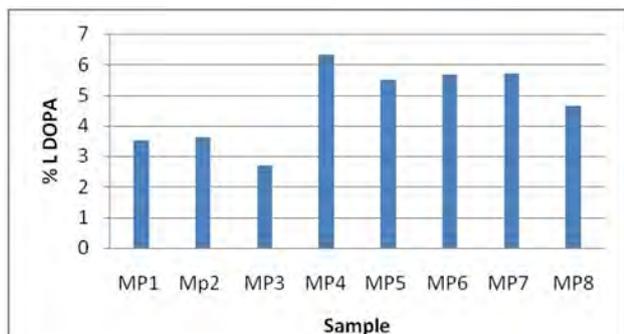


Fig. 15. L-DOPA production in different samples of *Mucuna pruriens*

Conservation Genetics

Rattans are one of the most important non-wood forest produces and in general they need specific habitats to grow and flourish. Owing to unsustainable utilization, lack of replanting, and habitat destruction, these forest resources are under threat. In this background, as part of a KSCSTE funded research project, the genetic variation and differentiation of the endemic rattan palm, *Calamus brandisii* Becc. (Fig.16) have been assessed with microsatellite markers. Narrow

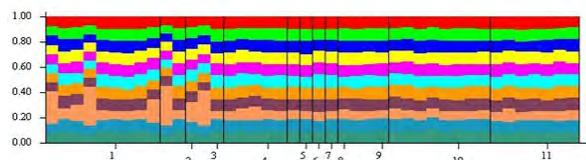


Fig. 17. A model based population structure of 42 individuals of *Calamus thwaitesii*

distribution (only found in moist evergreen forests of southern Western Ghats) coupled with highly specific habitat preferences (occurring above 1000m a.s.l.), warrant an assessment of its conservation status.

Genetic variability estimates obtained for *C. brandisii* were evaluated in comparison with a widespread congener (*C. thwaitesii* Becc.) analyzed with identical molecular markers. The genetic similarity between the individual samples of *C. brandisii* ranged from 0.709 to 1 with an average value of 0.912 in comparison to that of *C. thwaitesii* where it ranged from 0.554 to 0.976 (mean 0.898). Other estimates like Shannon's Information Index, percentage of polymorphic loci and observed heterozygosity were 0.0466, 0.0011, 13.3% for *C. brandisii* and 0.3389, 0.2231, 100% for *C. thwaitesii* respectively. When *C. brandisii* showed no population differentiation, the same as predominantly found in many populations of *C. thwaitesii* (Fig.17). Our results reveal that the restricted distribution underlies low levels of genetic variability and lack of genetic differentiation of *C. brandisii*. Being a habitat specific species, the forest area needs to be well protected to prevent the species from endangerment and to ensure continued evolution.

DBT funded project on Assessment of Genetic Diversity and Identification of Gender Specific Markers of Important North-East and South Indian Rattan palms using SSR Analysis, in collaboration with Assam Agricultural University was at the final stage during the period. Thirty-two



Fig. 16. *Calamus brandisii* in Bonaccord

microsatellite primers analyzed in forty-two samples from eleven populations of *Calamus thwaitesii* from Kerala and Karnataka showed 72% polymorphism. Considerable genetic differentiation ($F_{ST} = 0.28$) was found between the populations and the level of theoretical gene flow was estimated as 0.21 which, indicates a low migration rate between populations of the *C. thwaitesii*. Mean genetic identity among the samples was 0.87. The analyses generated valuable information shedding light on the genetic diversity, population structure and gene flow parameters of *C. thwaitesii*.

Genetic studies in wild genotypes of cardamom

MicroRNAs (miRNAs) are a class of naturally occurring small non-coding RNAs of about 18-25 nucleotide length. They are reported to have central role as post-transcriptional gene expression regulators. Even though several varieties of cardamom are developed and are well studied for yield, physiology, nutrient response, pathology, etc, little is known with respect to wild genetic resources of cardamom. A comparative study of cultivar and wild genotypes of cardamom using modern tools would certainly help to unravel the useful stretches of genome sequences including miRNAs in the later. In a study funded by the Plan programme of the Institute, we carried out miRNA profiling of five cardamom cultivars and a wild genotype to identify and characterize miRNAs that are potentially involved and differentially expressed in various metabolic and developmental processes through an analysis pipeline developed in-house (Fig. 18). Mapping of the reads against miRBase 21.0 identified a total of 161 conserved miRNAs from the two libraries. Nine novel miRNAs from the wild, five from the cultivar and the differentially expressed miRNAs between wild and cultivar genotypes were identified. The known and predicted targets of the miRNAs in wild and its cultivar varieties were also determined. The novel miRNAs identified are found to be involved in diverse cellular processes including development, transcription, protein degradation, detoxification and nutrient status. The outcome of the study could be effectively utilized for cardamom breeding from the wild genotypes

miRNAs are reported to have central role in regulation of drought, salinity, cold, nutrition starvation, oxidative and heavy metal stress. Cardamom cultivation in Kerala is having bumper production potential but the plants are highly susceptible to pests, diseases and abiotic stress. Among

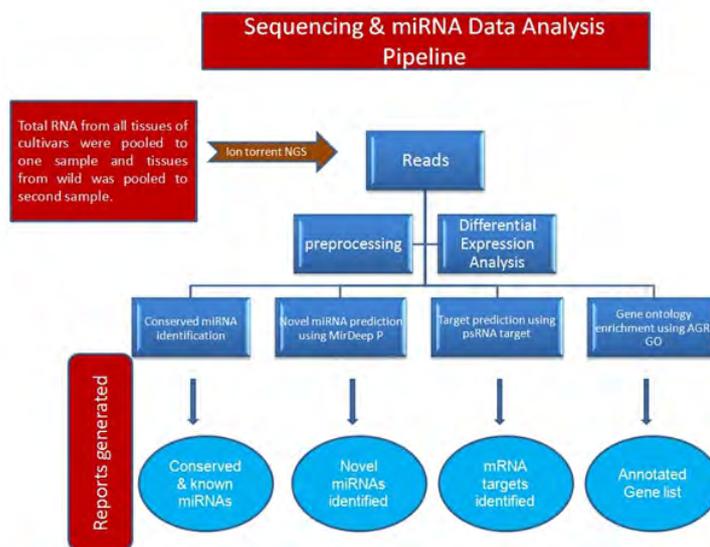


Fig. 18. Analysis pipeline developed for genome-wide characterization of microRNAs in cardamom cultivars and their wild progenitor

various abiotic stress factors, sensitivity to drought is severe and this study could enhance our understanding on miRNA mediated plant response to drought stress regulation in cardamom. In this study, two small RNA libraries named as control and treated were prepared from plants raised under well irrigated and drought stressed treatments respectively. The Ion Torrent sequencing of this two small RNA libraries created 3,938,342 (C) and 4,083,181 (T) primary reads under control and treated conditions. The sequence length distribution of collapsed reads from both control and drought stress small RNA libraries is shown in (Fig. 19). A total of 150 conserved microRNAs were identified from both the control and treated libraries. Discovery of 9 novel miRNAs from the control and 15 from the treated small RNA libraries suggested that many miRNAs are inducible and are differentially expressed in response to drought stress conditions. This study has important implications for further identification of gene regulation under abiotic stresses, differential expression analysis, target prediction, pathway analysis and validation.

The presence of polysaccharides and polyphenols in

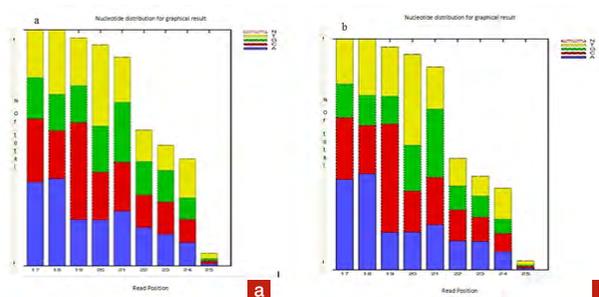


Fig. 19. Distribution of small RNAs in (a) control and (b) drought stress libraries

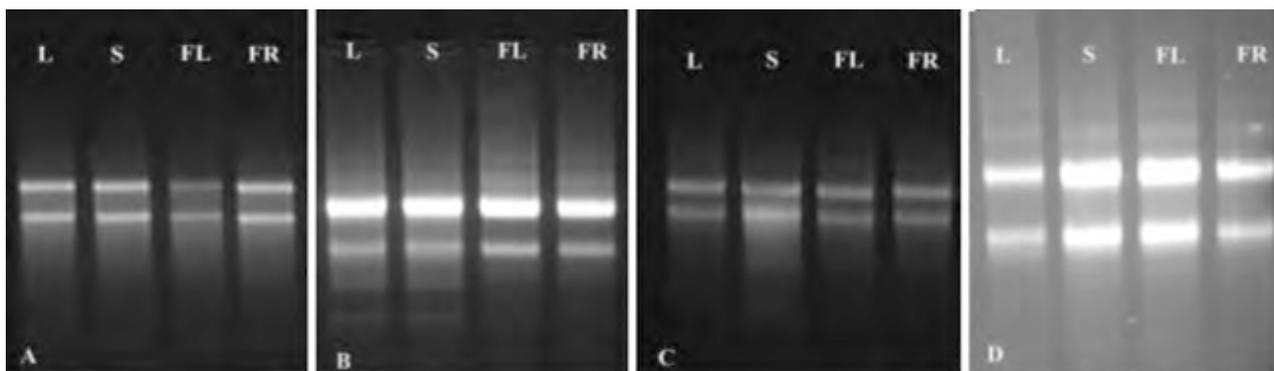


Fig. 20. Total RNA resolving through 1.2% Agarose gel. A. RNA samples isolated using miRNeasy+CTAB method, B. RNA samples isolated using RNeasy Plant Mini Kit+CTAB method, C. RNA samples isolated using miRNeasy Mini Kit, D). RNA samples isolated using RNeasy Plant Mini Kit. L represents cardamom leaf tissue, S represents cardamom stem. FL represents cardamom flower and flower buds pooled, FR represents cardamom young fruits.

cardamom tissues often critically hinder RNA extraction procedure. Hence, to obtain intact mRNA and small RNA from various cardamom tissues, combined protocols involving combination of commercial kits and conventional CTAB methods were developed which yielded RNA with good purity, higher yield and good integrity (Fig. 20). The total RNA isolated through this approach was found amenable for transcriptome and small RNA analysis through next generation sequencing (NGS) platforms.

Development of EST-SSR markers for *Centella asiatica*

Microsatellites or simple sequence repeats (SSRs) are highly reliable and co-dominant markers widely used to study genetic variability, population structure and linkage mapping. For a Department of Biotechnology, Govt. of India funded project, around 27,000 EST sequences of *C. asiatica* and related taxa were used to develop the EST-SSR markers. A total of 464 SSR repeats including mono, di, tri, tetra and hexa

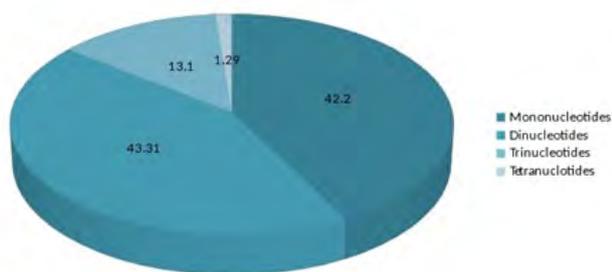


Fig. 21. Percentage distribution of SSR repeats in obtained EST sequences

repeats were obtained (Fig. 21).

Bioinformatics

Bioinformatics programmes are functioning in Sub-Distribution Information Centre (Sub DIC), at Saraswathy Thangavelu Centre in Puthenthope funded by DBT, Govt. of

India. The main objective of the centre is to prepare a comprehensive information system on plant genetic diversity of the country particularly of the Western Ghats and novel discoveries in plant science. In addition, the activities in the Centre are concentrating on beautification of the Centre and extension programmes for income generation.

As part of the ongoing programme supported by DBT on development of Bioinformatics sub Distribution Centre *in silico* and *in vitro* assays were done on selected medicinal plants. A total of 1275 phytochemicals from 20 plant species were screened against HBc protein, 114 phytochemicals were screened against HBx protein and identified potential lead molecules having anti-hepatitis B activity. Based on the *in silico* and *in vitro* assays such as anti-haemolytic, anti-cholinesterase and anti-proteolytic activities tested against Cobra venom showed that *Aristolochia indica* L. and *Acorus calamus* L. have anti-cobra venom activity. In connection with this programme *in silico* screening of 280 phytochemicals from three plants were also completed. Besides, the structures of Russell's viper venom proteins *viz* L-amino-acid oxidase, Cytotoxin drCT-1 and Neutral PLA2 were modeled and screened 722 phytochemicals from nine medicinal plants and identified potential leads. Docking was performed between 1246 chemical molecules from 13 plants with the target molecule Decaprenylphosphoryl-beta-D-ribose epimerase (DprE1) using different software tools and identified potential leads. In addition information on 17 databases, three web sites and two web portal sites were updated.

As part of the DBT sponsored Projects on BTISNET, new web site development and integration/interlinking of bioinformatics resources developed by BTIS Centres, the databases and bioinformatics tools developed by all BTISNET Centres have been collected and evaluated its performance. The databases and tools were categorized discipline wise and

Sl. No.	Name of Plant	No. of phytochemicals docked	Target proteins	Lead molecule (Free energy of binding)	(L.) Corrêa, <i>Andrographis paniculata</i> (Burm. f.) Nees and <i>Aristolochia indica</i> L. It was found that <i>Acorus calamus</i> , <i>Aegle marmelos</i> and <i>Aristolochia indica</i> have potential hemolytic activity. Lead compounds against viper venom activity was identified for which the structure of the target molecule, Acidic phospholipase A2 Drk-1, was created using the tool Swiss Model. Docking was performed using the software application
1	<i>Hemidesmus indicus</i>	22	Basic Phospholipase A2- VRV- PL-VIII a Anticoagulant class II phospholipase A2	Stigmasterol ($\Delta G_{bind} = -11.32$ kcal/mol), Betasitosterol ($\Delta G_{bind} = -10.25$ kcal/mol)	
2	<i>Curcuma aromatica</i>	50	Acidic phospholipase A2 Dr-k1	Stigmasterol ($\Delta G_{bind} = -9.81$ kcal/mol)	
3	<i>Emblica officinalis</i>	58	Acidic phospholipase A2 Dr-k1	Stigmasterol ($\Delta G_{bind} = -9.75$ kcal/mol)	
4	<i>Tamarindus indica</i>	42	Basic Phospholipase A2- VRV- PL-VIII a Anticoagulant class II phospholipase A2 Acidic phospholipase	Beta-amyirin ($\Delta G_{bind} = -12.74$ kcal/mol) Lupeol ($\Delta G_{bind} = -10.34$ kcal/mol) Beta amyirin ($\Delta G_{bind} = -10.02$ kcal/mol)	

Table 5. List of plants with number of phytochemicals screened against Viper venom proteins and potential lead molecules.

linked on BTISNET web site. A total 98 databases and 64 Bioinformatics tools were organized on a common platform. Under the in house Project on *In silico* validation of drug activity in plants A total of 702 phytochemicals from 12 plants viz. *Allamanda cathartica* (29), *Canavalia ensiformis* (31), *Clerodendrum infortunatum* (15), *Emilia sonchifolia* (29), *Evolvulus alsinoides* (138), *Ervatamia coronaria* (22), *Holarrhena antidysenterica* (62), *Lycopersicon esculentum* (141), *Mentha spicata* (132), *Solanum indicum* (21), *Urena lobata* (26) and *Vigna mungo* (56) were docked with the target protein HBc and the results indicated that all plants have anti-hepatitis B activity at various level.

Further *in vitro* studies are in progress. Under in-house Project on Development of computational tools for digitizing JNTBGRI herbarium, about 8000 herbarium specimens were digitized and uploaded data of 2000 herbarium specimens on the database.

As part of the in-house Project on Study of parasitic fungal taxa associated with plants of Sacred groves in Kasaragod districts of Kerala State and organization of a web enabled database, fungal infected specimens were collected from 200 host plants growing in 21 sacred groves in Kasaragod district. Besides 80 fungal herbarium specimens were prepared. Among the samples four were identified and the remaining identification is in progress.

As part of the ongoing programme supported by DBT, validation of the cobra venom detoxification activity was done in selected plants such as *Acorus calamus* L., *Aegle marmelos*

Autodock.

In silico and *in vitro* screening for anti-tuberculosis drugs were done by Docking was performed between 1246 chemical molecules from 13 plants with the target molecule Decaprenylphosphoryl-beta-D-ribose epimerase (DprE1) using different software tools. The results were analysed statistically and selected potential lead molecules. The list of plants screened and selected lead molecules are depicted in Table 5.

Anti-mycobacterial activity of the three plants *Elettaria cardamomum*, *Zingiber officinale* and *Curcuma longa* were evaluated by Luciferase reporter phage (LRP) assay against standard strain of *M. tuberculosis* H37RV at three different concentrations (25, 250 and 500 $\mu\text{g}/\text{mL}$) at National Institute for Research in Tuberculosis, Chennai. The results revealed that all the three plants have potential anti-tubercular activity. Highest percentage of reduction in RLU at 500 $\mu\text{g}/\text{ml}$ was in *Z. officinale* followed by (80.56%) followed by *E. cardamomum* (74.8%) and *C. longa* (71.06%) (Table 6.).

In silico screening of medicinal plants and identification of potential lead compounds in 25 medicinal plants as part of the plan project on *In silico* validation of drug activity in plants. A total 705 phytochemicals from eight plants viz *Azadirachta indica* (332), *Acacia catechu* (36), *Piper longum* (80), *Hordeum vulgare* (41), *Boerhavia diffusa* (25), *Ocimum sanctum* (129), *Carica papaya* (54), and *Pitosporum neelgherrense* (8) were docked with the target HBc protein using Autodock and identified potential lead molecules

Sl. No.	Name of Plant	No. of Phytochemicals Docked	Lead Compound (selected by Rank sum method)	Anti-mycobacterial activity of the three plants <i>Elettaria cardamomum</i> , <i>Zingiber officinale</i> and <i>Curcuma longa</i> were evaluated by Luciferase reporter phage (LRP) assay against standard strain of <i>M. tuberculosis</i> H37RV at three different concentrations (25, 250 and 500 µg/mL) at National Institute for Research in Tuberculosis, Chennai. The results revealed that all the three plants have potential anti-tubercular activity. Highest percentage of
1.	<i>Alstonia scholaris</i>	131	Yohimbine	reduction in RLU at 500µg/ml was in <i>Z. officinale</i> followed by (80.56%) followed by <i>E. cardamomum</i> (74.8%) and <i>C. longa</i> (71.06%).
2.	<i>Acacia catechu</i>	40	Lupenone	
3.	<i>Adathoda vasica</i>	49	Epitaraxerol	
4.	<i>Aloe vera</i>	68	Aloinoid A	
5.	<i>Piper longum</i>	77	Piperundecalidine	
6.	<i>Datura metel</i>	62	Datumelin	
7.	<i>Mimosa pudica</i>	45	Sitosterol	
8.	<i>Ocimum sanctum</i>	122	A-Guaiol	
9.	<i>Tinospora cordifolia</i>	51	Makisterone_A	
10.	<i>Vitex negundo</i>	153	Beta Amyrin	
11.	<i>Curcuma longa</i>	211	2-methoxy-6- 4-hydroxy 3 methylphenyl-2-hepten 4-one	
12.	<i>Zingiber officinale</i>	183	Farnesal	
13.	<i>Elettaria cardamomum</i>	54	Alpha yelangeae	

Table 6. List of plants screened for anti-tuberculosis activity

against hepatitis B. Similarly, 114 phytochemicals from *Andrographis paniculata* were docked with the target HBx protein and identified potential lead molecules. To nullify the errors in lead identification the top ranked hit molecules were again docked using the docking tools Hex server, iGEMDOCK, FireDock and SwissDock. The docked results were statistically analysed following DST and Zhang rule and selected the top ranked molecules.

As part of the plan project on Study of parasitic fungal taxa associated with plants of Sacred groves in Idukki districts of Kerala State and organization of a web enabled database, sacred groves of Idukki district were explored and collected 78 infected specimens. The fungi were identified on the basis of host plant and is given in the following (Table 7).

Fungi

Asteridiella clerodendricola Hosag.
Meliola chandrasekharanii Hosag
Meliola malabarensis Hansf.
Asterina myristicae Hosag. & Sabeena
Meliola dysoxyl-malabarici Hosag.
Meliola patchii Hansf.
Arterolibertia hydnocarpi Hosag. & Abraham
Meliola adenanthericola Hosag., Kamarudeen & Babu
Asterina tetracerae Syd.
Asterina perpusilla Syd.
Asteridiella depokensis Hansf.
Asterina saracae Hosag., Abraham & Crane
Meliola daviesii Hansf. var. *longiseta*
Meliola pongamiae Hosag. & Abraham
Meliola bauhiniiae Hosag.
Amazonia henryi Hosag.
Meliola buteae Hafiz et al.

Host plant

Clerodendrum viscosum
Nothopodytes foetida (Wight) Sleumer
Olea dioica Roxb.
Myristica malabarica Lam.
Dysoxylum malabaricum Bedd. ex Hiern
Strychnos nuxvomica L.
Hydnocarpus pentandrus (Buch. – Ham.) Oken
Adenanthera pavonina L.
Tetracera akara (Burm. f.) Merr.
Alangium salvifolium ssp. *sundanum* (Miq.) Bloemb.
Vitex altissima L. f.
Saraca asoca (Roxb.) W. J. de Wilde
Jasminum sp.
Pongamia pinnata (L.) Pierre
Bauhinia purpurea L.
Combretum indicum (L.) De Filippis
Butea monosperma (Lam.) Taub.

Table 7. Details of fungal species and host plant identified from Idukki district

Andrographis paniculata were docked with the target HBx protein and identified potential lead molecules. To nullify the errors in lead identification the top ranked hit molecules were again docked using the docking tools Hex server, iGEMDOCK, FireDock and SwissDock. The docked results were statistically analysed following DST and Zhang rule and selected the top ranked molecules.

As part of the plan project on Study of parasitic fungal taxa associated with plants of Sacred groves in Idukki districts of Kerala State and organization of a web enabled database, sacred groves of Idukki district were explored and collected 78 infected specimens.

Division of Conservation Biology



Conservation biology is concerned with the causes of the loss of biodiversity and looks for the solutions to reverse this process. The division works on threatened plant species and ecosystems for a deeper understanding on the reproductive process, genetic makeup, gene flow systems, interaction with animals *etc.* to evaluate the reasons of rarity and extinction. The results of these studies will augment the managers and policy makers to take appropriate actions to slow down the loss of biodiversity. Apart from maintaining a pollen herbarium, efforts are also going on in the division to conserve germplasm through Seed Banking.

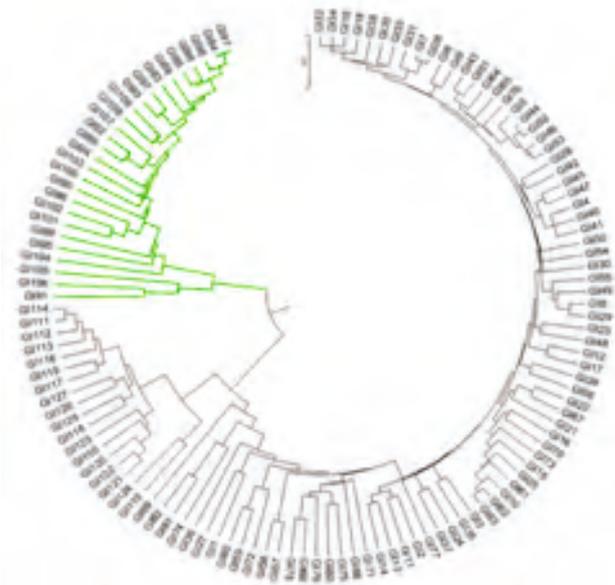
A. Conservation of *Garcinia imberti* Bourd. – An endangered endemic tree of southern Western Ghats through studies on population structure and seed biology

Garcinia imberti Bourd. is an endangered and endemic niche specific dioecious tree species of southern Western Ghats. Phenological observations showed that *G. imberti* fruiting initiated in July and ripened fruits were available during August - October. Along with cessation of fruits, leaf flushing initiates by November. Reproductive biology studies showed that a flower took approximately 43 days from its initiation to withering. Male flowers are smaller than female flowers and produce more than female flowers. A single male flower has 16-20 anthers and produced 6246 ± 245.36 pollen grains. Pollen-ovule ratio was 2167:1. Small stingless bees such as *Trigona* sp. may be the pollinators of this species. Fruit set rate was monitored and showed 56.7 ± 3.34 %. Fruits/seeds suffered high rate of predation especially from arboreal as well as terrestrial rodents. *G. imberti* in Chemunji hills registered density and abundance values of 5.5 each with a total basal area of 23437.3 ($19.56/m^2$) and IVI with a value of 17.37. In Ponmudi hills, the values of density was 2, abundance was 2 and total basal area of the species was 7305.23 ($10.43/m^2$) with an IVI value of 23.19. Comparison of girth class analysis showed that the population in Chemunji was more or less stable.

Genetic diversity analysis

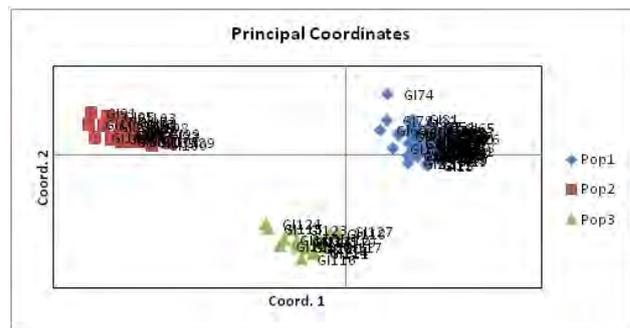
For genetic diversity analysis of *Garcinia imberti*, a total of 127 accessions comprising from 3 different populations viz., Chemunji, Ponmudi and Bonaccord were assayed following ISSR method. Different diversity indices were calculated using the POPGENE software. Genalex and Mega software packages were used to build dendrogram and PCA plots.

The samples of *G. imberti* from different forest ranges of Kerala were grouped into two main clusters. Cluster-I has two major groups comprising of accessions from Chemunji and Bonaccord. Cluster-II has one groups comprising accessions



The samples of 127 accessions of *G. imberti* from different forest ranges of Kerala grouped into two main clusters. The green coloured cluster denotes the population from Ponmudi.

from Ponmudi. The Cluster analysis showed the clustering of samples according to the spatial arrangement of the population. The *Nm* value was relatively less compared to the other population depicting reduced rates of gene flow in the population. This may be due to the fragmentation of Ponmudi



Two-dimensional principal co-ordinate analysis (PCA) plot of 127 accessions of *G. imberti* viz. 3 populations (Pop1-Chemunji; Pop 2- Ponmudi; Pop3- Bonaccord).



Garcinia imberti - a. Male flower; b. Female flower; c. Fruits

population from rest of the two populations which was very evident from the PCA analysis.

The heterozygosity levels in the population is less *i.e.*, around 42% which may be the factor leading to the endemic restriction of the species along with other spatial and ecological constraints. The gene flow levels are also found to be less in the populations, which showed the necessity of conserving the species.

Seed storage and germination studies

Seeds were extracted manually from fruits and thoroughly washed with water after sterilization with 0.5 % sodium hypochlorite solution for disinfection. For storage experiment, fresh mature seeds with moisture content of 62.80 % were stored in polycarbonate bottles under different temperatures (30, 20, 10 and -20°C) and seeds without treatment considered as control. Changes in seed moisture content during different storage conditions were outlined as per the high constant temperature oven method on fresh weight basis (ISTA, 1985). Five seed replicates per each sample were cut and weighed before and after drying at 130 ± 2°C for 1 h and the moisture content was calculated as the percentage of water on fresh weight basis.

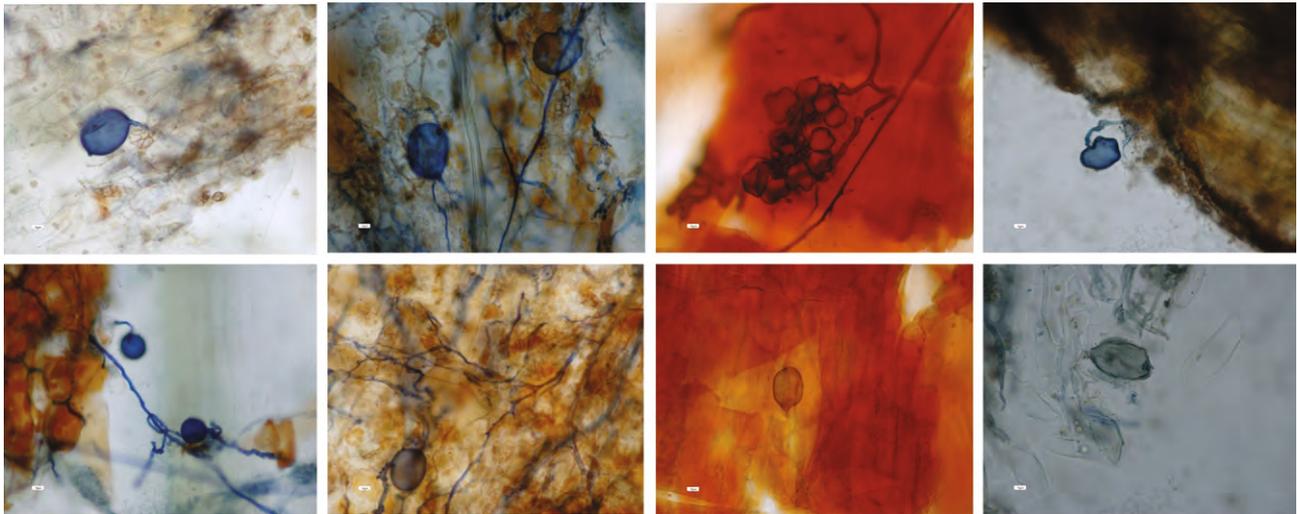
After each period of storage, seeds were de-coated and tested for germination because seed germination studies revealed that de-coating alleviate germination by minimizing the physical dormancy. The viability of seeds was determined on the basis of the percentage of germinated seeds. Germination tests are carried out in six replicates of ten seeds each, rolled in an acid free germination paper kept in a seed

germinator without light (30 ± 2°C, 80 % RH). At ambient temperature hermetic stored seeds registered 62.00 ± 3.74 % germination in 30 days, which was decreased with 60 days stored ones (22.00 ± 3.74). At 20 °C /20 % RH (seed bank condition), both 30 days and 60 days stored seeds showed slightly higher germination percentage *i.e.* 74.00 ± 2.45 and 38.00 ± 3.74 respectively as an optimum storage condition. Seed germination became very low at 10°C of storage in a month and subsequently lost its viability after 60 days of storage. Seeds stored at -20°C showed no germination at all. These observations indicated seed's adaptability to chilling temperature specifically in and round 20°C prevailing at its niche. Confinement of population to the present altitudinal range may be substantiated through reduced seed germination at comparatively higher or lower temperatures at respective lower and higher altitudes.

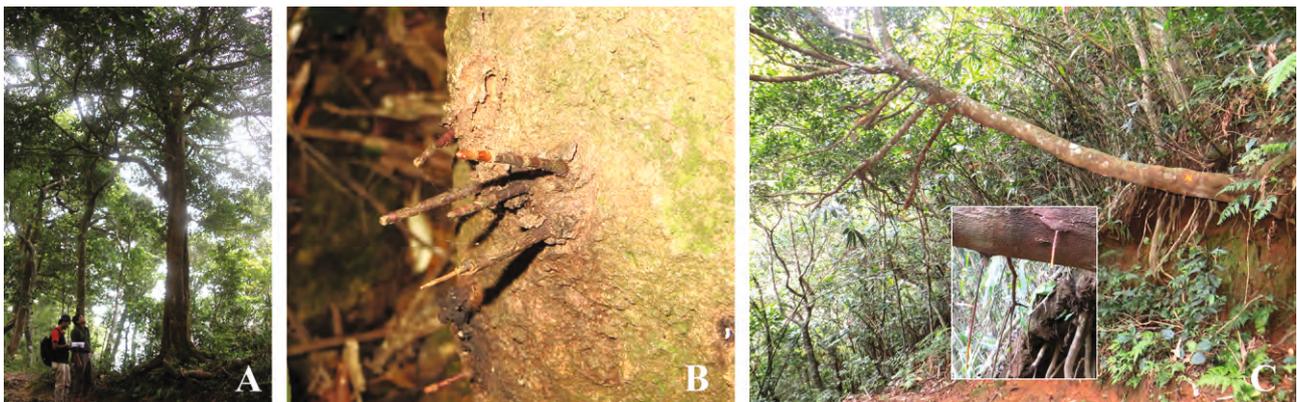
In the natural conditions (*in-situ*), it took more than 4–5 months for the germination of *G. imberti*. As part of *ex situ* germination study, only 5% of the seeds germinated after a period of 136 days in JNTBGRI forest and no seeds were germinated in the nursery condition. Germination treatments (seed germinator) in mature seeds were ranged in four levels of effectiveness according to germination percentage. Maximum percentage of germination was recorded with de-coated seeds on comparison with control. Germination associated parameters MDG, speed of germination, MGT, PV, GV and SVI was higher in de-coated seeds. Germination of seed portions indicated the adaptability for the cause of species perseverance in a niche wherein high rate of predation prevails.



Dormancy breaking and durability tests of *Garcinia imberti* seeds. A-E: Mature seeds; A control, B T1, C T3, D T4, E T5; F-I: Immature seeds; F control, G T3; H. T4; I. T5 (T1: proximal section (PS), T3: Proximal end chipped off (PEC), T4: proximal and distal end chipped off (PDEC) and T5: de-coated seed)



Endomycorrhizal association in *Garcinia imberti*



A. Single tree; B. Adventitious roots C. Fallen female tree of *Garcinia imberti* with adventitious roots

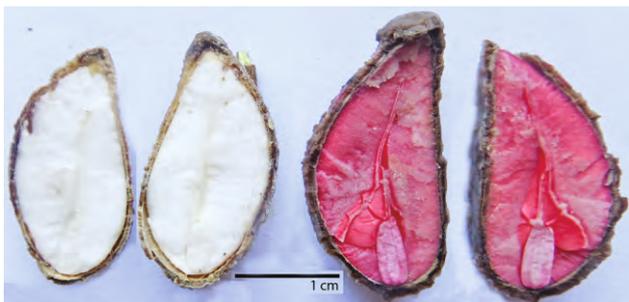
Soil analysis

During this period, the soil characteristics of *G. imberti* populations at Bonaccord, Chemunji and Ponmudi areas were analysed. Altogether 31 soil parameters were tested which include pH, EC, available and exchangeable micro and macro nutrients (P, K, C, Na, Ca, Mg, B, S, Fe, Mn, Zn, Cu, Pb, Cd, Ni & Cr), percentage of sand, silt, clay, water holding capacity and porosity, exchangeable acidity, bulk density and particle density. The values of soil pH range in the three populations of *G. imberti* in between 4.6 to 4.8 indicated an acidic nature while low EC (electrolyte conductivity) values range from 0.11 to 0.18 dS/m may be explained on the basis of high rainfall in these area which washes out soluble cations from the soils. The minimal availability of phosphorous in the respective populations may be compensated by the significant presence of mycorrhizal groups with percentage of association ranges from 54-62 %. Availability of Zinc is significantly high compared to low land soil, which may also help the plants to withstand lower air temperatures. The three parameters like pH, available phosphorous and available zinc are playing pivotal role on species existence while all other parameters are not significant. Among the three *G. imberti*

populations, baring Bonaccord and Ponmudi areas, particularly certain trees of the sloughed slops of Chemunji area produce adventitious from their stem bole. Such adventitious root initiation among those trees which face some constraints as landslides may be the factor for root induction. It was observed that more inclined trees produce more adventitious roots as an adaptive feature of *G. imberti* with narrow distribution, particularly with those individual trees surviving at the slopes of the Agasthyamala Biosphere Reserve.

C. Conservation of seven RET medicinal plants of the Western Ghats through standardization of seed and seedling identification, germination, species restoration, seed and field gene banking

The species selected for the study are *Ensete superbum* (Roxb.) Cheesman, *Hydnocarpus pentandrus* (Ham.) Oken., *Garcinia indica* (Thours) Choisy, *Piper barberi* Gamble, *Rauvolfia hookeri* Srinivas & Chithra, *Rauvolfia micrantha* Hook. f. and *Semecarpus travancorica* Bedd.



Tetrazolium test with *Hydnocarpus pentandrus* seeds

As part of preliminary work, the wild populations of *S. travancorica* and *H. pentandrus* were located along southern Western Ghats regions of Kerala. Fresh fruits were collected and conducted basic germination studies.

H. Pentandrus is an evergreen tree and an endemic to the Western Ghats. Plants are dioecious, flowering starts from November to February and fruits occur on February to June. Male and female flowers are pentamerous, hairy with green sepals and greenish white petals. Fruits are large, brown, and spherical in shape having a diameter of 6-8 cm. Each fruit contain 10-30 numbers of seeds. Seeds are highly polymorphic, endospermic and show viability on Tetrazolium test. The initial moisture content of the seed is 35.49%.

Semecarpus travancorica is also an endemic species scarcely occurring at an altitude of 800-1000 m. Flowering and fruiting are found in the period of January to April. The whole parts of the plant exudates a colourless sap which turns to black on drying and is allergic to skin. Typical panicle inflorescence of female plant bears numerous numbers of false fruit *i.e.* the seeds are seated in a fleshy hypocarp. The young fruits are green in colour and the hypocarp turn to yellow on maturation. The fresh moisture content of the seed is 70.73%. One of the main threats of this plant is the predation of immature and mature fruits. Numerous seeds were found from the faeces of Civet which are easily germinal.

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

Morphological data on the collected fruits and seeds were documented along with photographs. Seedlings of 50 species were raised and their morphological characters up to 2-3 leaf stage were also documented. Data of 50 species has been prepared in bilingual, viz., Malayalam and English. The bilingual field guide is under preparation.

E. Ecology and conservation of fresh water swamp ecosystem

The swampy vegetation is predominant by *Myristica fatua*

var. magnifica, an endemic tree to southern Western Ghats. Profusely bloom and set fruits, the plant is dioecious with distinct flowering and fruiting stages. The male plant flowers in January earlier than female plant's flowering in February. Initiation of fruit development is by March which may mature by June onwards. About 70% of the recalcitrant seeds germinate in a month while the remaining 30% shows delayed germination. Seedlings are adaptive to scanty light with relatively good growth rate.

F. Population biology and gene flow system of endemic plants

Due to high rate of destruction and fragmentation of tropical forests, many endemic plants have dwindling population and some species may be more affected by demographic, stochastic and genetic drift. Altered patterns of gene flow and population structure have implications for mating systems, levels of inbreeding and maintenance of genetic diversity. Hence, it is highly essential to study gene flow mechanisms such as pollination system, seed dispersal system and genetic structure along with population structure of species in order to evolve effective conservation strategies. Such a study was undertaken with respect to *Humboldtia unijuga* var. *trijuga*, *Janakia arayalpathra* and *Ipsea malabarica*, three endemics of the Southern Western Ghats.

Seven field trips were conducted to Chemunji hills in the Agasthyamala Biosphere Reserve in order to study the population structure of *Humboldtia unijuga* var. *trijuga* and established eleven permanent plots of 10 m X 10 m. The trees and saplings in the plots were marked and population characters such as GBH and height of trees and seedlings, number of leaves in the seedlings and vegetative and reproductive phenology etc., were recorded from each plots. Associated plant species were also collected, identified and deposited in JNTBGRI Herbarium. Positions of tagged seedlings and trees of *H. unijuga* var. *trijuga* in each plots were mapped and a total of 55 trees and 148 saplings were recorded. The trees in the sample plot showed height range of 5-15 m and GBH range of 25-80 cm. Most of the saplings are



Humboldtia unijuga var. *trijuga* – flowers and seedlings

below 50 cm height and are classified as non-established seedlings. Further studies such as establishing more plots and other population demographic assessment such as density, relative density, etc. are progressing.

G. Reproductive biology of *Humboldtia decurrens* Bedd. ex Oliv.: An endemic legume of South-Western Ghats

The genus *Humboldtia* Ruiz. & Pav. is a leguminous tree member which comes under the subfamily Caesalpinioideae have 9 taxa in Kerala. Out of this, 8 are endemic to Southern Western Ghats while *Humboldtia laurifolia* is found in Sri Lanka also. The candidate species *Humboldtia decurrens* is endemic to the Southern region of Western Ghats and located in the evergreen forest areas of Sasthanada and Shangili of Kollam and Ponmudi of Thiruvananthapuram districts, between altitudes 250-600 m asl.

The plants start flowering in the month of November and extends up to May with a peak during March. Flowers open in the early morning between 0530-0630 h and anther dehiscence between 0730-0830 h. Stigmas remain receptive at the time of flower opening with maximum receptivity between 0530-1530 h. The plant requires an external agency for effecting fertilization, since the species is in favour of cross pollination. The fertility and viability tests of pollen grains indicated a maximum of 75-80% viability on the day of anthesis and it gradually decreased on successive days.

Floral visitors are attracted by mass blooming of pale pink flowers with mild fragrance. Pollen and nectar constitute the primary floral rewards and visual signals and brooding sites constitute the cues for the visitors. The nectar secretory cells are observed in the inner surface of the corolla tube, below the ovary. Only traces of nectar is present. The concentration of nectar sugar in samples ranged from 16-17%. The floral visitors are honey bees, stingless bees, ants, wasps and butterflies, but only few of them effected pollination. *Apis cerana* and *Trigona iridipennis* are the most frequent visitors, visiting more flowers than any other pollinators for pollen and nectar collection. During foraging, they transfer the viable pollen grains from one flower to another of the same plant or flowers of different plants within and between populations. *Trigona iridipennis* commonly known as "pollen robbers" forage during day time 0700-1100 h for pollen. Butterflies (*Euploea core*, *Ampitta dioscorides*, *Pachliopta aristolochiae* and *Papilio demoleus*) visit the flowers for nectar, spending 2-3 seconds effecting pollination. These butterflies forage for nectar only but simultaneously facilitating the pollination. Butterflies land on the flower, slightly

bend the body and insert the proboscis for collecting the nectar from the flower. While harvesting nectar, the head portion of the butterflies having pollen grains from the previous visits was transferred to the stigma of another flower. It is also observed that, the weaver ants (*Oecophylla smaragdina*) plays a significant role by acting as predator or defender in pollination. They are active for 24 hrs on the flowering branch. So both are mutually benefited but sometimes they behave as notorious nectar robbers effecting no pollination. *Xylocopa* sps was rarely visiting the flower and damage the corolla tube while collecting nectar without facilitating pollination. However, the visits of all the insects are not sufficient to pollinate all the flowers in the populations. This lead to the poor fruit set in the natural condition.

Four breeding experiments were conducted in the field regarding autogamy, geitonogamy, xenogamy and open (natural) pollination. The percentage fruit set were counted and compared with reproductive success under the natural conditions. The pollination experiments were carried out on selected twenty plants at the time of maximum stigma receptivity. There observed no fruit set in autogamous self-pollination, while geitonogamy produced a minimum fruit set of 10% and 4% in natural and *ex-situ* conditions, which considered as a type of self-pollination. The xenogamous pollination conducted within the population produced a high percentage of 46% fruit set.

Fruit initiation was noticed in April-May. Only 42-46% fruit set was observed in the natural habitats. After maturation, the fruit explodes and the seeds get ejected to certain distance from the mother plant. Each pod contains 3-4 seeds. The viability test confirmed that the seeds are viable up to 6 months and thereafter its viability gradually get decreased. The moisture content of the seed was assessed as 29.89%. The seed germination was 60% in both natural habitat and in laboratory conditions. However, freshly harvested seeds in *ex situ* conservation showed only 5% germination. After 12 months, the seeds start germinating and the germination capacity was gradually reduced. About 20% of the seedlings



Fruits and seeds of *Humboldtia decurrens*

were browsed by herbivores, which reduce their establishment.

H. Floral biology of *Humboldtia sanjappae* Sasidh. & Sujanapal (Fabaceae)

Humboldtia sanjappae Sasidh. & Sujanapal is a medium sized tree species strictly endemic to the evergreen forest areas of Neriamangalam. The species flourishes by the commencement of summer phase. Phenological events were noticed among twenty healthy plants from the community and observations were made in natural habitat. The period of flowering to fruit maturity and seed dispersal takes about 6 months. Peak period of flowering was noted during December-January.

Pollen fertility was studied following acetocarmine glycerine staining technique. TTC (2,3,5 Triphenyl Tetrazolium Chloride) and IKI (Iodine Potassium Iodide) tests were conducted to check the viability of pollen grains at three different stages. The acetocarmine staining technique revealed that 84% pollen grains are fertile. Pollen viability by TTC and IKI test confirmed that 70-75% pollen grains were viable on the day of anthesis and its viability gradually decreased on successive days. *In vitro* pollen germination was evaluated by Brewbaker and Kwack's medium supplemented with varied concentration of sucrose (0.25-2 %). Maximum germination was observed at 0.5% sucrose concentration. Stigma receptivity was assessed hourly in 10 flowers from 0500 to 1200 on three consecutive days. Receptivity was determined visually with the help of hand lens and validated by peroxidase activity and revealed that stigma remains receptive only for 6 hrs, soon after anthesis. Maximum receptivity was observed between 0530-1130 h.

I. Distyly in *Ophiorrhiza radicans* Gardner ex Thwaites

Ophiorrhiza radicans is an endangered annual herb of about 10-30 cm height growing in wet, shady places of evergreen forests. Inflorescence is a terminal corymbose cyme with 1-3 flowers. The plant blooms from July to December with a peak between September and October. The anthesis occurs between 0545 and 0830 h, and the flowers lasts 20-24 h. The species was found to exhibit distyly in its natural habitat. Isopleth distribution, reciprocal herkogamy and self-incompatibility are the associated features of a distylous species.

Population studies indicates that *O. radicans* was in isopleth distribution at Rosemala with the morph ratio approximately 1:1. Morphometric analysis of various floral attributes showed that style length was significantly greater in



Ophiorrhiza radicans in bloom

pin morph, while anther length and stamen length are significantly less in pin morph than in thrum morph which is an indication of distyly. No significant difference was found in corolla tube length and corolla lobe width between the morphs, but the corolla lobe length was significantly greater in pin morph than in thrum morph. But the species did not show perfect reciprocal herkogamy; the stamen length of pin morph was significantly greater than the style length of thrum morphs. Results of various breeding experiments showed that the species was self- and intramorph incompatible. The highest rates of fruit set occurred in during open-pollination from thrum morphs to pin morphs (76%) and from pin morphs to thrum morphs (74%). It was also found that the results obtained from cross pollination were close to the results obtained from experiments in the open pollination group. Bees and butterflies are the major pollinators of the species. Bees visit the flower for collecting both pollen and nectar within two hrs after anthesis. Butterflies visited for collecting the nectar from 0900 to 1030 hrs.

J. Community Plant pollinator interactions at landscape level

This study, quantitatively and qualitatively analyses the interference of introduced monoculture plantations on pollination system of native plant species. It focuses on the status and health of pollination services and pollinators in the plantation-evergreen forest matrix. The study will provide clues to understand how pollinators interact with these two habitat elements in such landscapes and the consequences of pollinator behaviour on reproductive biology of native forest species.

The forest located at Kandanchira and Maravanchira of Kollam district, Kerala, India, fragmented by Oil palm (*Elaeis guineensis* Jacq.) plantation was selected for the study.

Quadrates of 20 × 20 M were laid at distances of 100-150 M and 450-500 M range and one at Oil palm plantation. Three transects were taken at Maravanchira (9 quadrates) and five transects were laid at Kandanchira (15 quadrates). Trees above 25 cm girth and shrubs and lianas above 1 m length were identified, tagged and monitored for phenological observations and quantification of floral traits. Common native flora includes *Aporosa lindleyana* (Wight) Baillon, *Terminalia bellirica* (Gaertner) Roxb., *Terminalia paniculata* Roth, *Careya arborea* Roxb., *Tabernaemontana alternifolia* L. and *Calycopteris floribunda* (Roxb.) Poiret. Floral visitors and pollinators of both the forest plants and oil palm were traced by enforcing sticky traps in the field. Preliminary pollinator observations were carried out and they were correlated with the pollinator syndromes in order to analyse the modularity among plant species and pollinators. Common floral visitors of oil palm and forest plants were also sorted out.

K. 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 influence on the seasonal timing of life history events which in turn influences population dynamics of both fauna and flora. The present study funded by DST aims to identify and assess how the climatic and biotic factors affect the life-history and demography of tropical rainforest bulbuls along altitudinal gradients. The field work was continued in the three study sites established along an altitudinal gradient in Silent Valley National Park, Mannarkkad and Nilambur South Forest Divisions. Point count surveys in the study plots recorded 78 bird species and about 120 species were recorded from the general study area. A total of 248 nests of pycnonotids including 90 of Yellow-browed Bulbul (YBB), 53 of Square-tailed Black Bulbul (SBB) and 97 of Red-whiskered Bulbul (RWB) were recorded. Nest construction periods were 3 to 5 days for YBB, 4 to 6 days for RWB and 4 to 6 days for SBB. The plant materials used for the nest construction were identified. Bulbuls used 38 plant species as nesting substrates. The nest substrate and nest habitat characteristics were measured at multiple spatial scales. The nest height preferences of bulbuls ranged 3.0 ± 1.90 m for RWB, 3.21 ± 2.14 m for YBB and 7.32 ± 2.3 m for SBB. Clutch size were determined and was 2-3 eggs for RWB, 1-2 eggs for YBB, 1-2 eggs for GHB and 1-3 eggs for SBB. The developmental periods of bulbuls were determined. The

incubation period ranged between 11 to 14 days and nestling period ranged between 11-13 days in different species. More than 150 hrs. of observations using video cameras and direct observations were made during the incubation and nestling periods to determine the parental care patterns. 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 (23.5%). The phenological patterns of major food plants and abundance of fruits were monitored fortnightly. Bulbuls devoured the fruits of more than 36 plants in the study sites, of which 20 species were fed by GHB and 19, 16 and 12 species by YBB, SBB and RWB, respectively. Five species of mammals, 10 species of reptiles and five species of birds were identified as predators of bulbuls. Both YBB and GHB nested in similar habitats and many competitive interactions between these species were observed during the study period. As a direct response to the irregular rainfalls during the reporting period there was delay in the breeding of the study species and many irregular patterns were observed. Rainfall and wind also caused high mortality of nestlings and loss of eggs in both YBB and SBB.

L. Identification of indicator species for special conservation efforts in the High Range Mountain Landscapes of the Western Ghats

An indicator species or group may reflect the status of a wider community or habitat, act as an early warning system to ecological changes and easy to compile, analyse and interpret. Both plant and animal species have been found to be acting as good biodiversity indicators. This project funded by the GEF-UNDP-Gol aims to describe the potential of indicator species concept as a conservation tool for prioritization and monitoring of biodiversity in the High Range Mountain Landscapes (HRML) of the Western Ghats. The specific objectives were to: a) select the taxa and species for detailed study and b) identify the major habitat types for detailed study. Literature related to the indicator species studies and the biodiversity of the project landscape were collated and analysed to select the potential taxa and species for detailed study in the HRML. In order to identify indicator species/group, extensive literature search were made and observed that mammals, birds, butterflies, beetle and plants either singly or in combination of groups are major indicator species in temperate and tropical regions. Detailed analysis of the literature shows the presence of 79 species of mammals, 305 species of birds, 122 species of reptiles, 50 species of amphibians, 72 species of freshwater fishes, 254 species of butterflies and 111 species of odonates in HRML. Use of taxa such as mammals, birds, beetles, ants and butterflies or a

combination of them as indicator species for studies to represent the overall biodiversity of HRML is suggested. A total of 18 species of mammals, 89 species of birds, 30 species of birds, 18 species of ants and 108 species of butterflies were identified for detailed study. Montane-shola grasslands, Evergreen Forests, Moist Deciduous Forests, Dry-thorn and scrub forests and Plantations (Cardamom, Teak, Tea and Eucalyptus) were identified for detailed study based on vegetation and habitat types. A detailed technical report is submitted to the funding agency.

M. Plant-animal community studies in various landscape elements in High Range Mountain Landscapes in the Western Ghats

The High Range Mountain Landscape (HRML) with multiple land uses has resulted in evolving various landscape elements with specific species assemblages. The predominant forest types in this landscape include high elevation montane grasslands and shola, evergreen forests of high, medium and low elevation and dry forests. There is no information on the plant communities of HRML except for the montane grasslands and sholas of HRML. The present study on the flora and selected faunal groups funded by the GEF-UNDP-Gol will help in evaluating the biodiversity value of different landscape elements and thus contribute to overall management of the landscape. A mini workshop was organised at the Salim Ali Centre for Ornithology and Natural History, Coimbatore, the collaborating institution to finalise the field methodologies and sampling strategies. Preliminary surveys were conducted in HRML covering all landscape elements. About 100 species of plants, 75 species of birds and 30 species of butterflies were recorded. Literature survey also indicate that there are about 305 species of birds recorded from HRML including 15 Western Ghats endemics. This also includes one Endangered, five Vulnerable and 10 Near-threatened bird species. Among the families Accipitridae (25) recorded maximum number of species followed by Sylviinae (23). Based on the available literature there are at least 254 species of butterflies reported in HRML including 27 endemics.

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

The Western Ghats of India is identified as a global biodiversity hotspot due to its rich faunal and floral diversity. Though, the conservation management of the area is largely based on the management/working plans prepared by the forest officials, the custodians of the more than 60 protected

areas and the territorial forest divisions 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 objective of this project funded by INASP is to develop and promote an evidence-based approach to conservation planning and wildlife management in the Western Ghats with focus on the extent of research evidence is used in conservation planning. During the reporting period about 35 management/working plans and more than 600 research papers dealing with the conservation of the flora and fauna of the Western Ghats were collected. The research works cited in each management/working plan and the research papers dealing the conservation and management of the wildlife of Western Ghats are entered in to a database with categories on authors, taxa, management interventions suggested if any, etc. Collation of the information and analysis to unveil the use of research in scientific management is progressing.

O. Integrating ecological and genetic approaches in developing conservation strategies for critically small populations: a case study of the endemic and Critically Endangered cycad, *Cycas annaikalensis* in the Western Ghats



Cycas annaikalensis Rita Singh & P. Radha

Cycads are currently ranked as the most threatened group of organisms on the planet, with 62% of the known species threatened with extinction because of habitat loss/modification and fragmentation, trade of wild-collected plants, traditional use as food/medicine, and reduced regeneration due to competition from introduced invasive

weedy species, etc. Another key issue that cycads suffer from is the critically small populations. India represents about eleven species of *Cycas* with one Critically Endangered, two Endangered, and three Vulnerable species. *Cycas annaikalensis* Rita Singh & P. Radha, classified as Critically Endangered, is currently known from only a single population



with less than 100 individuals over an area of about 250 m² on the Annaikal Hills in Palakkad, Kerala State at an altitude of 940 m. The goal of this project is to develop a conservation strategy for *C. annaikalensis* by integrating ecological and genetic information. During the reporting period, literature related to *C. annaikalensis* and related species were collected.



Preliminary surveys were conducted in Nilambur and Palakkad Forest Divisions and Silent Valley National Park during December - January. Two populations were identified during these surveys. About 250 individuals of *C. annaikalensis* belongs to different size classes were located during the survey in Annaikkal Hills. However, the number of reproductively mature individuals is less than 50, of which, five plants were having the reproductive structures or seeds. The population located at Silent Valley had about 50 individuals with 15 mature individuals. The surveys also indicated small scale collection of the seeds and leaves by the local tribal community. Germination experiments of the seeds collected from the field and tribal collectors are on-going.

P. Study on the faunal communities and their association with plants of JNTBGRI campus with special emphasis on mutualism

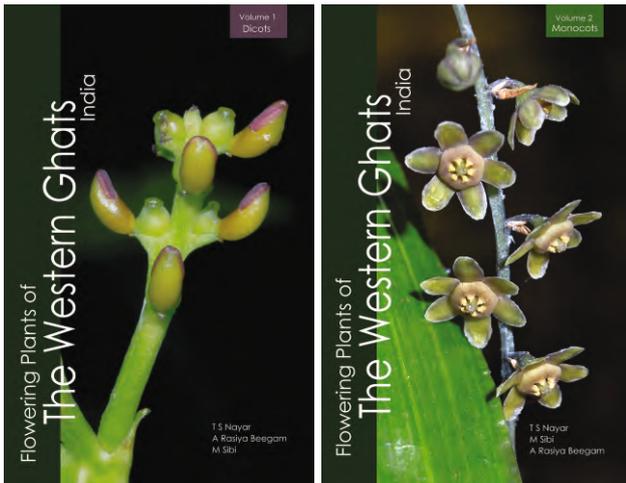
Within the JNTBGRI campus, surveys revealed the presence of 16 species of mammals, 138 species of birds, 32 species of reptiles, 105 species of butterflies and 65 species of odonates. Among butterflies the family Nymphalidae represented maximum number of species (>45). The rare damselfly *Myristica sapphire* (*Calocyphala idlawi*) is also recorded from the campus. More than 200 interactions of birds and butterflies with plants were recorded during this period.

Q. Documenting Plant based information to support practical conservation and Conservation Policies – (i) Kerala (ii) the Western Ghats (iii) India

Flowering plants of the Western Ghats

This work is aimed to bring out 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, phyto-geographical information such as whether these plants are indigenous, endemic or exotic to the Western Ghats, conservation status (IUCN 2012 and Red Data Book), 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.

The Book entitled *Flowering Plants of the Western Ghats, India* having 7402 species in 1700 pages in two volumes was released by Hon' ble Chief Minister of Kerala, Shri Oommen Chandy, on 23rd September 2014 at Thiruvananthapuram by



Flowering Plants of the Western Ghats, India Vol. 1. 934 pp. and Vol. 2. 750 pp.

giving the copy to Dr P Pushpangadan, Former Director, JNTBGRI.

Recorded species in Flowering Plants of the Western Ghats, India

The work records 7402 species of flowering plants in 1480 genera under 210 families. Among them, 5588 species are indigenous, 376 are exotics naturalised and 1438 are cultivated or planted. Cultivated and planted include 1198 exotics. Of the 5588 indigenous species, 2253 species are endemic to India and of the 2253 Indian endemics, 1273 are endemic to the Western Ghats. Apart from the above, there are 593 taxa with subspecies and variety status recorded in this work for the Western Ghats. This brings the total number of taxa to 7995 in the area. The work also records 66 species under 'Doubtful Occurrence'.

Analysis of Flowering Plants of the Western Ghats, India

Different characteristics of plants recorded for the work

from the Western Ghats were analysed. Analysis showed that about 21% flowering plants occurring of the Western Ghats are endemic. About 50% of the species are represented by about 10 families. Naturalised exotics represent about 5% of the flowering plant wealth of the Western Ghats. Analysis of life forms showed that about 60% are shrubs, about 10% are trees and the rest are others. Distribution analysis showed that 19 species distributed only in Gujarat, 317 species in Maharashtra, eight species in Goa, 155 species in Karnataka, 512 species in Tamil Nadu and 423 species in Kerala part of the Western Ghats. It also showed that 680 species occur in Western Ghats area of Maharashtra, Karnataka, Tamil Nadu and Kerala. Out of the 7,402 species, 1380 species used as medicine (19%), 9% used as food and 6% used as fodder, 12% used as dye, 6% as fibre and 3% as oil. Out of the 5,588 indigenous species, 635 species (12%) come under different IUCN threat categories.

Flowering Plants of India

A rough estimate showed that India harbours 18159 species of flowering plants. *Flora of British India* (1872-1897) which contained 14312 species covered the present day India, Pakistan, Afghanistan, Nepal, Tibet, Bangladesh, Myanmar, Sri Lanka and Malayan Peninsula. Even though there are numerous publications dealing with regional, district and local floras appeared after this publication, this Flora has not been revised for the present political boundary of India even after 140-115 years of its publication. As 7402 species are already been worked out for the preparation of *Flowering Plants of the Western Ghats, India* (Nayar et al., 2014), *Flowering Plants of India* is a logical extension of *Flowering Plants of the Western Ghats*. As part of this programme, 256 new species were added to the database from Flora of Tamil Nadu Analysis and updated the bibliography of the work by adding 45 references.



Hon. Chief Minister Shri. Oomman Chandy releasing the book on *Flowering Plants of the Western Ghats, India* by handing over the first copy to Dr. P Pushpangadan, former Director JNTBGRI

R. Interpretation of Flowering Plants of Travancore

The monumental work *Flowering Plants of Travancore* (1914) by Rama Rao (1865-?; Stafloe & Cowen 1983) included 3535 species of flowering plants. Out of these 3535 species, Rama Rao could identify only 1104 plants (marked with an asterisk in the text) and 1138 plant specimens had been sent to the Director of Botanical Survey of India, Calcutta for identification. Rest 1293 plants were included in the work based on the assumption that they are present in Travancore as they occur in the surrounding regions of Travancore. The materials collected by Rama Rao for this work are now spread in various herbaria like TBGT, MH, CAL, FRC and University College, Thiruvananthapuram.

The interpretation of Rama Rao's work aims to assess the present status of the plants mentioned by him. For this purpose, consulted the herbarium of JNTBGRI (TBGT) and studied the specimens of T F Bourdillon, M Rama Rao, K Vencoba Rao, Sankara Iyer and Vythien. A total of 1638 sheets were referred and collected details like plant name, collection number, habit, phenology, altitude, locality, name of collector, date of collection, year, accession number in TBGT, uses mentioned, local names and other special notes of collector. Herbarium Images of 490 species were collected and saved for comparative study. 6005 sheets housed at herbarium of University College, Thiruvananthapuram were referred. Herbarium Images of these sheets were also taken and saved for further reference.

S. Seed Bank

Establishment and Maintenance of Seed Bank

The concepts of JNTBGRI Seed Bank was sowed way back in the year 1987 and since then this sector has become an inevitable part of Institute's plant conservation commitments. As on today, through operating an In house project "*Establishment and Maintenance of Seed Bank*", seed bank is striding towards superior seed storage with 1170 active collection and 4000 seed display as holdings and last year's achievements could be summarised as follows.

New 530 accessions were added to the active collection apart from the seeds of 13 species stored as base collections. Seed accessions (both active and base collection) stored are alphabetically arranged for their easy retrieval for future use.

During this period 80 display bottles of aesthetically and educationally important seed samples were labelled and displayed in the seed bank. Five new species (*Citrus microcarpa*, *Eugenia bractiata*, *Flacourtia inermis*, *Jasminum azoricum* and *Psidium guineense*) collected and added as active collection. Viability was periodically checked to replace



Seed display

non-viable seed samples with new accessions.

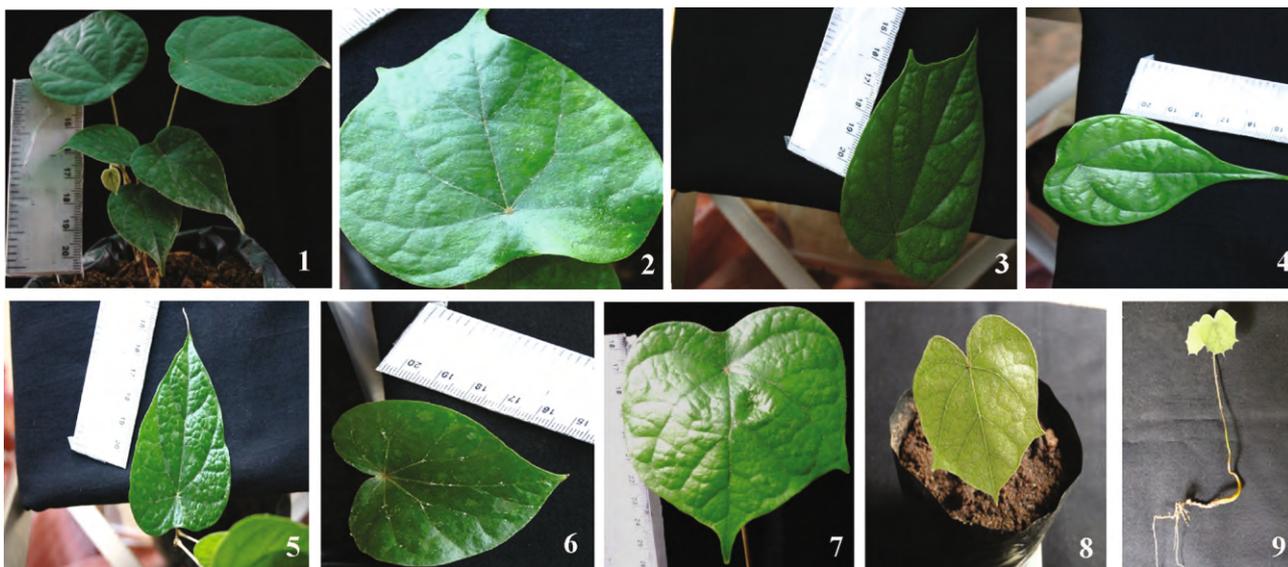
Exchange Programme during this period was involved with 21 Index semina received from other gardens of 14 countries. The seeds received from native research groups were accessed and provided back to the concerned section after a sample being displayed as reference collection.

Carpology studies were carried out in *Myristica fragrans* Houtt and *Eugenia bracteata* (Willd.) Roxb. ex DC., while the seed germination and storage studies were carried out with *Luffa acutangula* (L.) Roxb. (Cucurbitaceae), *Abroma augusta* (L.) L. f. (Sterculiaceae), *Ardisia solanacea* Roxb. (Myrsinaceae) and *Mimusops andamanensis* King & Gamble (Sapotaceae). Seed germination and desiccation studies on six *Sida* sp., *Lagerstroemia speciosa*, *Diploclisia glaucescens*, *Cassia fistula*, *Mucuna pruriens*, *Polyalthia* sp. and *Myristica fragrans* were conducted.

Seeds of 7 medicinal species were supplied to Gujarat Medicinal Plant Board, 300 seeds of *Coscinium fenestratum* were supplied to IIHR, Bangalore and seeds of 10 primitive families were supplied to Calcutta University. 190 seedlings of 9 species were supplied to different sections of JNTBGRI according to field requirements.

Seed biology and seedling studies on *Coscinium fenestratum* (Gaertn.) Colebr.

Coscinium fenestratum, a highly valued medicinal liana is getting endangered due to the extensive depletion from wild. Desiccation studies revealed that the seeds are desiccation



Coscinium fenestratum leaf character - 1. Normal leaf; 2. Type 1; 3. Type 2; 4. Type 3; 5. Type 4; 6. Type 5; 7. Type 6; 8. & 9. Type 7

sensitive to some extent and also sensitive to low temperatures, as they are of intermediate type. Seeds possess physiological dormancy which can be evaded by 24 hours pre-treatment with GA₃ 3000 ppm or by reducing the moisture content by 12-10%. Phytohormonal analysis during different stages of desiccation and storage revealed that GA₃ and IAA were found higher than ABA in seeds desiccated to 12% moisture content as well as in 6-8 months stored seeds. Thus observations proved that the seed germination and dormancy alleviation in *C. fenestratum* seeds are regulated by seed moisture content and phytohormones.

Seedlings raised from seed samples collected from a single mother plant were subjected for morphological characterization. Among the seedlings 5-10% showed remarkable variations on leaf shape at their juvenile stage. Since leaf shape and allied morphological characters are significant for demarcating *C. fenestratum* from similarly looking *Anamirta cocculus* (L.) Wight. & Arn. and *Diploclisia glaucascens* (Blume.) Diels. of the same family Menispermaceae, documenting the leaf characters of seedling and mature plants deserve unique attention.

In *C. fenestratum*, development of first leaf seems to be very slow in the early stages which are covered with minute hairs and is brownish white without green colour. Cotyledonary leaf formation was not seen in the seedlings of *C. fenestratum*. Leaf shape varied from round to caudate long with acute tip (Type 1 & 2) with notch at the base. The gradual changes in leaves were from round, caudate to triangular-elongate, acute or sub-acute leaf tip (Type 3 & 4). The type 5&6 were with broadly ovate to broadly oblong leaves. Some seedlings showed 6-7 sub-acute leaf lobes (Type 7 & 8). The leaf base was up to 1.4 cm in depth; margin entire, sometimes

lobed at one side, either right or left. Apex of the leaf was acute, acuminate or obtuse. Petiole was inflated, thickened and pulvini was included. Normal leaves: Sub-peltate to peltate, broadly elliptic-ovate with acuminate apex, margin entire and rounded or truncate base, 11-17 cm long and 7-13 cm wide.

Carpology, Seed Storage and Germination of South Indian *Rauvolfia* Species

Five species of *Rauvolfia* viz. *R. hookeri* Srinivas. & Chithra, *R. micrantha* Hook. f., *R. serpentina* (L.) Benth. ex Kurz, *R. tetraphylla* L. and *R. verticillata* (Lour.) Baill. were selected for the study. *Rauvolfia* is a group of plants with a high demand for its medicinal value. Seeds of all the selected species were subjected for pre-soaking with different concentrations of GA₃ for 24 hrs., boiling water for 1 to 5 minutes and up to cooling to room temperature, concentrated H₂SO₄ for different durations, distilled water for 24 hrs. and mechanical scarification. Pre-treated seeds were tested for germination in acid-free germination paper in a seed germinator set at 30±2°C/80% RH without light.

Significant increase of germination was found in *R. hookeri* only at 100 ppm GA₃ and with distilled water soaking. In *R. micrantha*, after pre-treatments of 10-200 ppm GA₃ at and mechanical scarification; *R. serpentina* at 300-1000 ppm GA₃ and distilled water; *R. tetraphylla* to 100 ppm GA₃ and mechanical scarification and *R. verticillata* only at 200 ppm GA₃ and mechanical scarification. Concentrated sulphuric acid-soaking was effective only in *R. hookeri* seeds after 1 minute soaking. Boiling water was not effective in breaking dormancy. The dormancy types of *Rauvolfia* species are classified as, *R. hookeri* and *R. serpentina* possess non-deep

physiological dormancy; *R. micrantha* possess combined dormancy of mechanical and physiological dormancy; *R. tetraphylla* and *R. verticillata* possess physical dormancy. Dormancy in *Rauvolfia* seeds could be broken through the application of either GA₃, or distilled water or mechanical scarification.

T. Conservation of *Saraca asoca* (Roxb.) W. J. de Wilde through studies on the interrelation between desiccation sensitiveness and carbohydrate metabolism in seeds

Saraca asoca of the subfamily Caesalpiniaceae is a globally vulnerable (IUCN, 2015) evergreen tree species. It is also enlisted among the 36 threatened and endangered medicinal plants of India. Low seed set, poor natural regeneration and heavy seed pest infection in the wild populations of the Western Ghats intended further studies in relation with seed water physiology.

The indeterminate and continuous reserve accumulation until seed senescence is the characteristic feature of *S. asoca* seeds. Seed sugar content in developmental stages (40 to 120 DAA- Days after Anthesis) as well as desiccated stages (48, 96 and 144 h- Hours) was estimated using a HPTLC system (CAMAG, Switzerland). Glucose, fructose and sucrose are the major sugars and their accumulation at various levels of development was independent. During the initial seed development, fructose act as a prominent soluble reserve compared to glucose and sucrose. Generally, glucose as a hexose sugar decreased with later stages of development except some slight enhancement met with seeds of 80 and 120 DAA. From 80 DAA, the sucrose which was accumulated in *S. asoca* seeds was found to be declined from 35.5- 12.6 mg g⁻¹. When open dried, after 144 h mature seeds lost all the three sugars. The presence of sucrose reserve in the absence of any form of oligosaccharides substantiates the desiccation sensitiveness of the seeds.

Recalcitrant nature of seed instigates to study the level of dehydration tolerance as a prerequisite to maintain viable seeds for extended period with effective germplasm preservation. Seed desiccation responses were investigated with five different treatments such as (a) 30 ± 2°C (b) silica gel (c) 40 ± 2°C (d) 20 ± 2°C and (e) 0 ± 2°C in order to find out the critical moisture content of species and which approximately ranges from 45 to 46%. Storage experiments revealed that

maximum seed viability above four months was observed at both 30 and 20°C which could be suggest as best storage conditions.

U. Plant-insect interactions in *Syzygium travancoricum* Gamble – A critically endangered species

With the studies on the conservation of *Syzygium travancoricum* Gamble., an economically important and Critically Endangered tree of South-Western Ghats region, two species of insects belonging to the order Diptera and Coleoptera were found to be as pests. The first one is the



Syzygium travancoricum Gamble healthy and infested leaves

(oriental fruit fly) *Bactrocera dorsalis* (Hendel), a very destructive pest of fruit and seed belongs to the order Diptera while the second one is the leaf cutting weevil *Deporaus marginatus* (Pascoe) of the order Coleoptera.

Deporaus marginatus (Pascoe) is a weevil attacking young leaves. Main damage is infiltrated by female *D. marginatus*, which cut young leaves and was found to feed in groups causing burns to the tender foliage and curling of leaves. Infested shoots become almost leafless.

Division of Phytochemistry and 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 reported period three in-house projects and six externally-funded research projects from (i) Board of Research in Nuclear Sciences (BRNS), Dept. of Atomic Energy, Govt. of India, (ii) Kerala Forest Department (iii) Department of Biotechnology, Govt. of India (iv) Department of Science and Technology, Govt. of India and (v) KSCSTE, Govt. of Kerala were implemented by the Division.

1. Phytochemical screening and selection of potential species of *Ophiorrhiza* for tissue culture based mass multiplication leading to production of camptothecin - an anticancer compound

In this BRNS project, dried whole plant (1.2 Kg) *Ophiorrhiza shendurunii* was sequentially extracted with hexane, chloroform and methanol. A new pentacyclic

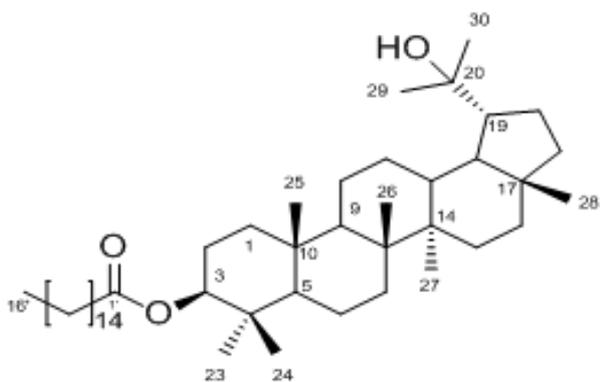


Fig 1: Lupan-20-ol-3(β)-yl hexadecanoate

triterpenoid fatty acid ester, lupan-20-ol-3(β)-yl hexadecanoate, together with lupan-20-ol-3(β)-yl acetate, olean-18-en-3(β)-yl hexadecanoate, dotriacontanoic acid and stigmasterol were isolated from the hexane extract of *O. shendurunii*. Structures of the isolates were determined by ^1H , ^{13}C , ^{13}C DEPT, ^1H - ^1H COSY, HMBC, HSQC, NOESY NMR, FT-IR, DART-MS, ESI-MS, alkaline hydrolysis, derivatization, GC-MS and HPTLC analyses. *O. shendurunii* hexane extract, lupan-20-ol-3(β)-yl hexadecanoate, lupan-20-ol-3(β)-yl acetate and olean-18-en-3(β)-yl hexadecanoate showed moderate activities against *Candida albicans* and *Fusarium oxysporum* on agar well diffusion assay.

2. 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

Piperine content in the fruits and roots of 30 *Piper nigrum* accessions collected from different populations in the Western Ghats region in Kerala were estimated by HPTLC densitometry. In fruits the piperine content ranged from 2.89% to 11.73% (dry wt. of fruit). In *P. nigrum* roots, the highest piperine content was 2.19% (dry wt. of root).

3. Bio prospecting of potential gingers: chemical prospecting, morphological characterization and *ex-situ* conservation

Volatile oils from dry rhizomes and fruit rinds of *Alpinia mutica* were isolated and characterized by GC-FID and GC-MS. *A. mutica* rhizome oil showed 47 components of which 40 (92.75%) were characterized, and the major components were β -pinene (20.23%), camphor (13.33%), 1,8-cineole (8.93%), camphene (7.93%) and α -pinene (6.16%). Fruit rind essential oil showed 69 components of which 63 (97.77%) were identified. Major constituents in *A. mutica* fruit rind oil were with 1,8-cineole (14.80%), camphor (11.69%), β -pinene (7.60%) and camphene (4.83%). Four major constituents in both *A. mutica* rhizome and fruit rind oils (camphene, β -pinene, 1,8-cineole, camphor) were estimated by external standardization. Refractive index, specific rotation and specific gravity of both volatile oils were also determined. Fruit rind oil showed significant antioxidant, cytotoxic and moderate antimicrobial activities. *A. mutica* dry fruit rind oil has a very pleasant smell with potential applications in fragrances.

Volatile oil from fresh rhizomes of *Zingiber anamalayanum* was isolated by hydrodistillation and characterized by GC-FID and GC-MS. Twenty one out of 24 constituents comprising 99.47% of the oil were identified. The major components in *Z. anamalayanum* rhizome oil were δ -2-carene (52.83%), camphene (9.83%) and endo-fenchol (9.42%). Monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpene hydrocarbons in the oil were 65.81%, 23.78% and 9.87%, respectively. *Z. anamalayanum* rhizome oil showed significant anti-DLA activity.

4. Search for potential biologically active constituents from a hitherto uninvestigated, unique bamboo: *Melocanna baccifera*

The fruit of *Melocanna baccifera* (Roxb.) Kurz is rich in amino acids (lysine, glutamic acid), sugars (sucrose, glucose, and fructose) and phenolics (ferulic acid). Protein content (free, bound) in *M. baccifera* fruits is very low. Fruits are rich in

saturated fatty acids (palmitic acid), minerals (potassium), and only B series vitamins (B3) are detected in them. Rat feeding experiments showed that *M. baccifera* fruit alone is not a complete food, but with other protein supplements, it is a valuable food additive. These results could also help in the successful management of rodent outbreaks and other ecological problems associated with *M. baccifera* fruiting. Phytochemical and biological activity studies of *M. baccifera* fruits are in progress.

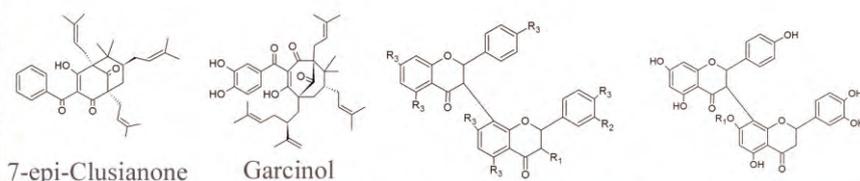
5. Biflavonoids from *Garcinia* species - Chemical, molecular and pharmacological evaluation

The phytochemistry and biological activities of *Garcinia travancorica* Bedd. collected from the Chemunji Hills of Agasthyamala forests were investigated in this project. Phytochemical analysis of *G. travancorica* leaf extract resulted in the isolation and characterisation of the biflavonoids GB-1a, GB-1, GB-2, morelloflavone-7''-O- β -D glycoside and morelloflavone. In addition to the biflavonoids, the benzophenones garcinol and 7-epi-nemorosone were also isolated and characterised from the plant. The compounds were identified using 1D and 2D NMR along with MS techniques. HPTLC estimation revealed the plant leaf as rich source of morelloflavone-7''-O- β -D glycoside (7.12% dry wt).

In this study, the leaf volatile chemical as well as biflavonoid profiles was utilized for the chemosystematics of the new *Garcinia* taxa. The flavonoid profile of the new taxa along with 11 other *Garcinia* species revealed the new taxa is closely associated with *G. xanthochymus* and *G. spicata*. HPTLC profile also revealed characteristic compounds in the new taxa, supporting its species status. Analysis of the biosynthetic pathways revealed that the characteristic volatile compounds, monoterpenoids for the new taxon and diterpenoids for *G. xanthochymus* are formed from two different precursors geranyl pyrophosphate (GPP) and geranyl geranyl pyrophosphate (GGPP) respectively, supporting the distinct species status for the new taxon, as elucidated through morphological studies. Phylogenetic

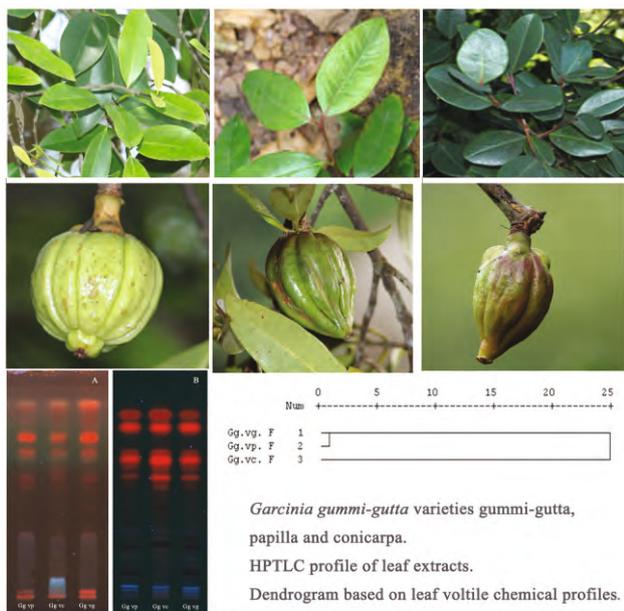


Garcinia travancorica



R1 = R2 = H, R3 = OH (GB-1a) R1 = H (Morelloflavone)
 R2 = H, R1 = R3 = OH (GB-1) R1 = Glucose (Morelloflavone-7''-O- β -D-glycoside)
 R1 = R2 = R3 = OH (GB-2)

evaluation based on biosynthetic pathways revealed that among the three species, *G. spicata* is more advanced, followed by the new taxa and the presence of more complicated diterpenoids in *G. xanthochymus* points to its primitive nature.



6. Economic and bio-geographic evaluation of the *Cinnamomum* species in some selected parts of India through morphological, chemical and molecular biology studies

A new *Cinnamomum* taxon, with campharaceous leaves, has been discovered from the Western Ghats forests of Kerala. The distinguishable status of the new taxon was further confirmed by characteristic phytochemical profile by GC-MS, HPTLC and HPLC. The leaf essential oil yield of the new taxon was 2.4% v/w, compared to 0.6% v/w of *C. camphora*. Camphor content in the leaves of the new taxon was found to be three fold higher (1.01% in fresh leaf), compared to *C. camphora* leaves (0.30% in fresh leaf). Enantiomeric form of camphor was determined as (1R, 4R) - (+) camphor in the new taxon.

7. Search for renewable biomass and biofuel sources in *Euphorbia* plants of the southern Western Ghats

The energy content and thermal stability of seven *Euphorbia* species (*E. pteroneura* A. Berger, *E. lactea* Haw., *E. antiquorum* L., *E. vajravelui* Binojk. & N. P. Balakr., *E. tortilis* Rottler ex Ainslie, *E. trigona* Haw. and *E. tirucalli* L.) were

analyzed by thermal degradation of plant powders by TGA and DSC. TGA experiments showed an initial mass loss of 6-8% below 100°C for all the samples, mainly due to the evaporation of water. Major weight loss of 54-76% by thermal decomposition was observed in the temperature range of 162°C-421°C. The active decomposition temperature that caused the major weight losses were 344.06°C (*E. pteroneura*-75.91%), 309.81°C (*E. lactea*-72.80%), 326.39°C (*E. antiquorum*-72.18%), 346.16°C (*E. vajravelui*-72.26%), 315.03°C (*E. tortilis*-72.27%), 310.47°C (*E. trigona*-65.03%) and 312.43°C (*E. tirucalli*-54.17%). DSC data showed highest enthalpy content in *E. lactea* (38.60J/g) and lowest was in *E. vajravelui* (3.95J/g). Activation energy was least for *E. tirucalli* (13.82kJ/mol), suggesting the species as the most easily combustible.

Hexane extract of *E. tortilis*, a hitherto uninvestigated *Euphorbia* species, on column chromatography using gradient elution of hexane and chloroform yielded three secondary compounds. Structure elucidation of the compounds using NMR (¹H NMR, ¹³C NMR, DEPT, COSY, HMQC and HMBC) and LC-ToF-MS analysis is in progress.

8. Chemical prospecting of plants in Kerala region of Western Ghats for bioactive molecules

Phytochemical studies on *Melicope denhamii* petroleum ether extract resulted in the isolation of five secondary metabolites, MD-1, MD-2, MD-3, MD-4 and MD-5. On repeated column chromatography, MD-6 (m. p. 214-215°C), a yellow solid was isolated from the 78th fraction of petroleum ether extract in 2% methanol-chloroform. With spectral data, MD-6 was identified as ternatin, a flavonoid. MD-7, a white,

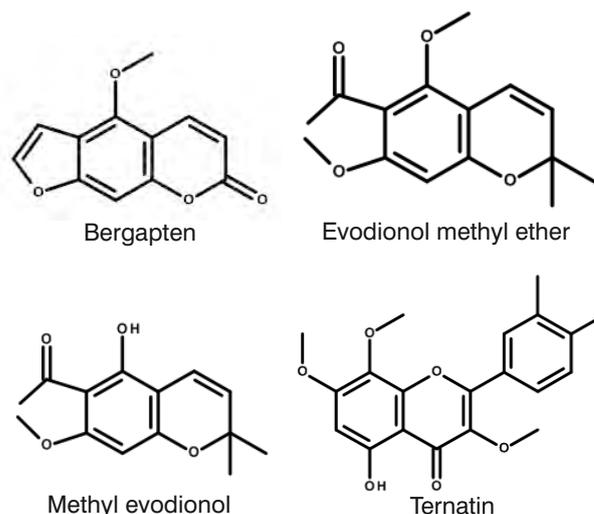


Fig 3. Major compounds isolated from *Melicope denhamii*.

crystalline solid was isolated from the same fraction and its structural identification is in progress. From the petroleum ether extract a hydrocarbon mixture was also obtained in 100% hexane. It was soluble in diethyl ether. GC-MS analysis of this mixture was carried out and data analysis is in progress. Acetone extract (32 g) of *M. denhamii* was subjected to column chromatography to yield a hydrocarbon mixture MDAHc-1 in 100% petroleum ether. GC-MS analysis of this sample was carried out and its data analysis is in progress. At 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). Ethyl acetate (10%) in petroleum ether gave MDAC-2, a white crystalline compound. Spectral data and Co-TLC confirmed this compound same as MD-5. Another compound MDAC-3 was isolated (21 mg) from 65% ethyl acetate in petroleum ether. It was white in colour and the compound charred after 200°C. Its spectral identification is in progress.

Melicope lunu-ankenda leaves are used to treat diabetes in folklore medicinal practices in India and Malaysia. Antidiabetes activity of *O*-prenylated flavonoid (3, 5, 4'-trihydroxy-8, 3'-dimethoxy-7-(3-methylbut-2-enoxy) flavone) isolated from *M. lunu-ankenda* leaves against type-2 diabetes mellitus (T2DM) was investigated. Blood glucose lowering activity of *O*-prenylated flavonoid was tested in normal rats by oral glucose tolerance test and its efficacy was tested in STZ-induced type-2 diabetic rats. SGOT, SGPT, ALP, serum urea, total triglycerides, total cholesterol HDLC, protein and serum insulin levels in STZ-induced type-2 diabetic and control rats were measured. Acute toxicity of OPF was tested at 500 mg/kg dose in mice.

Mechanism of antidiabetes action of *O*-prenylated flavonoid was elucidated by insulin release from RIN 5F cells

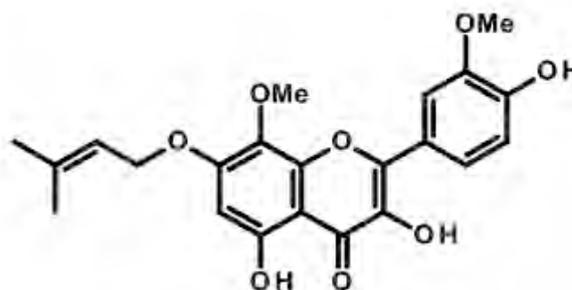


Fig 4: 3, 5, 4'-Trihydroxy-8, 3'-dimethoxy-7-(3-methylbut-2-enoxy) flavone

and human DPP-IV inhibition assays. OPF isolated from *M. lunu-ankenda* showed significant blood glucose lowering activity in oral glucose tolerance test on overnight fasted, glucose loaded normal rats and the optimum activity was observed at a dose of 10 mg/kg body weight. In neonatal streptozotocin (STZ) induced diabetic rats, the *O*-prenylated flavonoid treatment for 20 days significantly ameliorated the derailed blood glucose levels, liver glycogen and serum biological parameters including insulin to normal levels. *O*-prenylated flavonoid on acute toxicity evaluation did not show any conspicuous toxic symptoms even at a higher dose of 500 mg/kg body weight in mice. On evaluating the mechanism of antidiabetes action, it was observed that, *O*-prenylated flavonoid significantly inhibited human dipeptidyl peptidase IV (DPP-IV) enzyme *in vitro* with an IC₅₀ 19.1 µg/ml. *O*-prenylated flavonoid also directly induced insulin release from cultured RIN 5F cells *in vitro*. From these results, it is evident that the *O*-prenylated flavonoid cross talked with the inhibition of DPP-IV and direct induction of insulin release from pancreatic β-cells thereby correcting the derailed blood glucose levels, serum biochemical parameters and ameliorate various diabetic

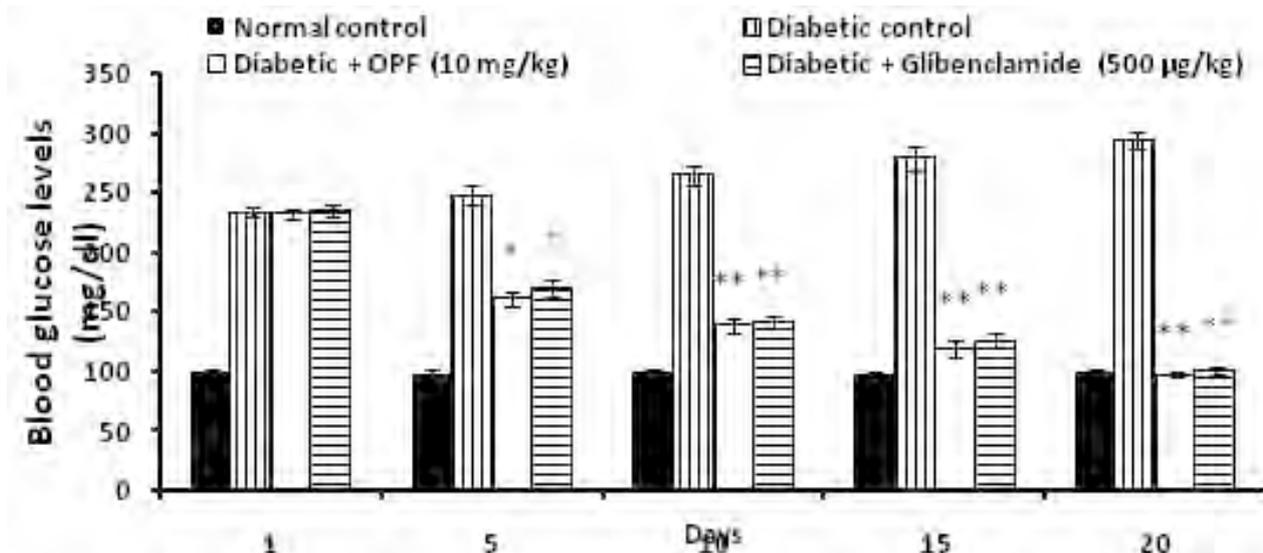


Fig 5: Effect of OPF on blood glucose levels in streptozotocin induced type-2 diabetic rats

complications in STZ-induced diabetic rats. This study shows the potent antidiabetes activity of *O*-prenylated flavonoid and describes its mechanism of action. *O*-prenylated flavonoid is a promising candidate for the development of new generation anti-DM drugs. Isolation of the *O*-prenylated flavonoid justifies the use of *Melicope lunu-ankenda* for diabetic treatments in folklore practices.

Fifty plant species were selected from the genera *Ficus*, *Humboldtia* and *Syzygium* to test their glucose lowering activity. n-Hexane, methanol and water extracts of stem barks of selected species were taken for the glucose lowering activity. Thirty six extracts (n-hexane - 12, methanol - 12, water - 12) from the stem barks of eight *Ficus* species, three *Humboldtia* and one *Syzygium* species were evaluated for their anti-hyperglycemic activity on fasted and glucose loaded normal rats by oral glucose tolerance test. Among the thirty six extracts eight extracts showed promising blood glucose lowering activity.

9. Chemical prospecting of aromatic plants of the Kerala region of Western Ghats

This project is in search of new essential oil sources and potential oil constituents from plants. 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.

Polyscias Forst. are glabrous trees or shrubs distributed in tropical and temperate regions of the world. *Polyscias filicifolia* leaves (257 g) were collected and hydrodistilled (oil yield: 0.15 ml with pale yellow colour, pleasant smell). GC-MS and GC-FID analyses of the essential 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 (300 g) were collected and hydrodistilled (oil yield: 0.15 ml 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 -farnesene (59.64%), δ -cadinene 26.39% and *Z*-falcarinol (6.01%).

Melicope denhamii leaf volatile oil was isolated by hydrodistillation, and twenty six constituents comprising 95.95% of the leaf oil were characterized by gas chromatographic techniques. Sesquiterpenes, zierone (22.49%) and α -gurjunene (19.96%), were identified as the major components. *M. denhamii* leaf oil tested against Gram +ve and Gram -ve bacteria showed significant activity against *Bacillus subtilis* and *Escherichia coli*. Anticancer activity of *M. denhamii* leaf oil against Dalton's Lymphoma Ascites cells was assessed by trypan blue exclusion and MTT assays, and the

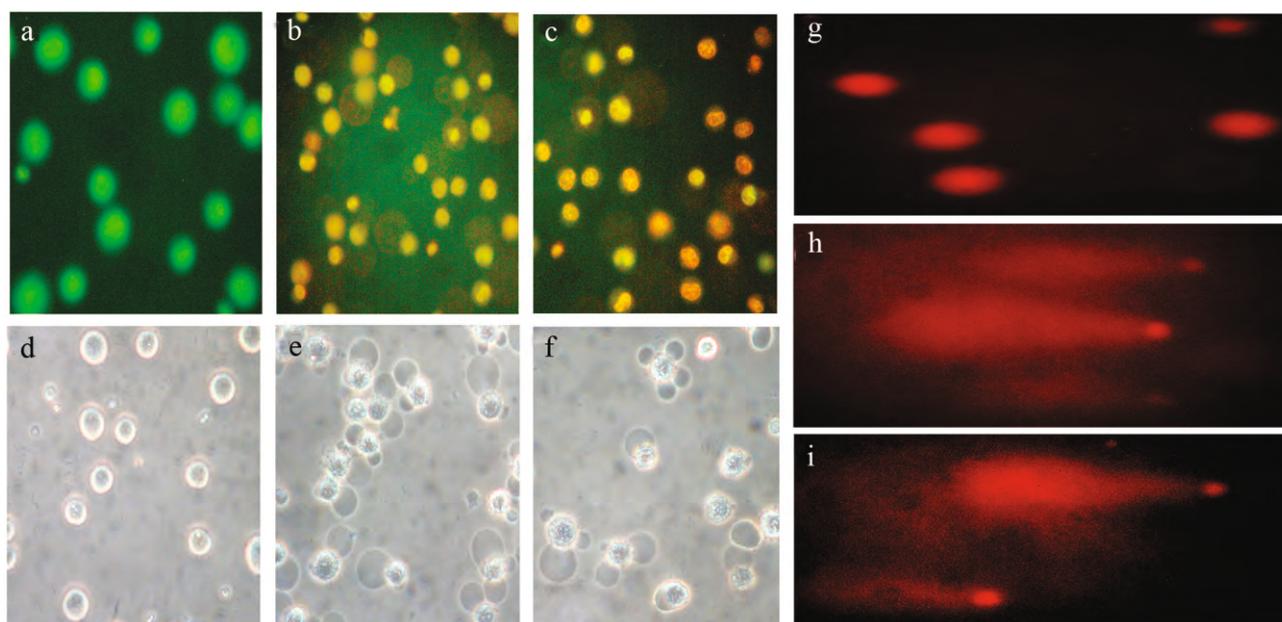


Fig. 6. DLA cells stained with acridine orange-ethidium bromide under fluorescent microscope: (a) DLA cells treated with DMSO (0.01%) appeared in green color (live), (b) DLA cells treated with *M. denhamii* leaf oil (25 μ g/mL) appeared in yellowish red (dead cells), (c) DLA cells treated with vincristine (25 μ g/mL) appeared in yellowish red (dead cells); [ii] Morphological changes under phase contrast microscopy: (d) DLA cells treated with DMSO (0.01%) showed no membrane blebbing and nuclear condensation, (e) DLA cells treated with *M. denhamii* leaf oil (25 μ g/mL) showed membrane blebbing and nuclear condensation, (f) DLA cells treated with vincristine (25 μ g/mL) showed membrane blebbing and nuclear condensation; [iii] DLA cells in comet assay (single cell gel electrophoresis) viewed under fluorescent microscopy: (g) DLA cells treated with DMSO (0.01%) showed nuclear integrity, (h) DLA cells treated with *M. denhamii* leaf oil (25 μ g/mL) showed nuclear DNA damage and comet formation, (i) DLA cells treated with vincristine (25 μ g/mL) showed nuclear DNA damage and comet formation

oil showed significant cytotoxicity at CD_{50} of $12.2\mu\text{g/mL}$. Induction of apoptosis on DLA cells by *M. denhamii* leaf oil was confirmed by morphological observation, nuclear damage and comet assays.

Fresh fruit peels and leaves of five accessions of the three *Citrus* species were collected from various geographical areas in Kerala and Tamil Nadu. Fruit peels and leaves of these *Citrus* accessions were hydro distilled and essential oils were collected. Chemical profiles of *Citrus* fruit peel and leaf essential oils were analyzed by GC-MS. Twenty-two to twenty-five constituents (98.00-99.55%) were identified in *C. maxima* peel oils. Major class of compounds in *C. maxima* peel oils were monoterpene hydrocarbons (78.66-90.09%), oxygenated monoterpenes (3.71-8.83%) and sesquiterpene hydrocarbons (3.86-10.51%). (+)-Limonene (66.85-84.08%), β -pinene (1.57-9.14%), geranyl acetate (1.09-3.58%) and verbenone (0.27-3.00%) were the major constituents in *C. maxima* peel oils. Twenty-nine to thirty-five constituents (97.90-99.15%) were identified in *C. maxima* leaf oils. Monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons and oxygenated sesquiterpenes in *C. maxima* leaf oils were 14.01-84.82%, 6.47-50.41%, 4.25-17.60% and 3.10-30.00%, respectively. (+)-Limonene contents in *C. maxima* leaf oils were 5.29-78.45%, with highest in the Pathanamthitta accession. Other major constituents in *C. maxima* leaf oils were α -pinene (trace-21.09%) and β -pinene (trace-16.93%).

In *C. aurantifolia* peel oils monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpene hydrocarbons were found in the range 71.93-75.05%, 10.44-13.81% and

13.24-17.63%, respectively. Similarly, monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpene hydrocarbons in *C. aurantifolia* leaf oils were 18.66-29.66%, 49.24-66.06% and 10.57-20.00%, respectively. (+)-Limonene (37.8-41.93%), β -pinene (12.78-15.39%) and α -terpinene (8.02-12.36%) were the major constituents in *C. aurantifolia* peel oils. (+)-Limonene (17.33-26.14%), perilla ketone (0-22.54%), citronellyl formate (20.76-25.79%), geranyl acetate (3.65-6.14%) and (E)-caryophyllene (0-9.72%) were the major constituents in *C. aurantifolia* leaf oils. In *C. medica* peel oils, monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpene hydrocarbons were 76.59-86.58%, 7.38-21.11% and 1.45-5.84%, respectively. Similarly, monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpene hydrocarbons in *C. medica* leaf oils were 26.16-37.65%, 49.79-61.82% and 4.72-23.82%, respectively. (+)-Limonene (29.91-68.8%), β -(E)-ocimene (8.14-44.81%) and geraniol (2.07-4.27%) were the major constituents in *C. medica* peel oils. (+)-Limonene (19.48-32.63%), neryl acetate (7.11-25.91%), dihydrolinalool (0.11-3.85%), citronellyl acetate (0.34-6.3%) and nerol (1.45-2.71%) were the major constituents in *C. medica* leaf oils.

Briefly chemical profiling found (+)-limonene as the major constituent in fruit peel and leaf oils of most accessions of *C. maxima*, *C. aurantifolia* and *C. medica*. Other major constituents varied with the *Citrus* species and also with their collection locations. This is the first report of the comparative chemical profiling of *C. maxima*, *C. aurantifolia* and *C. medica* from South India.



a. *Citrus maxima* - fruits; b. *Citrus aurantifolia* - fruits

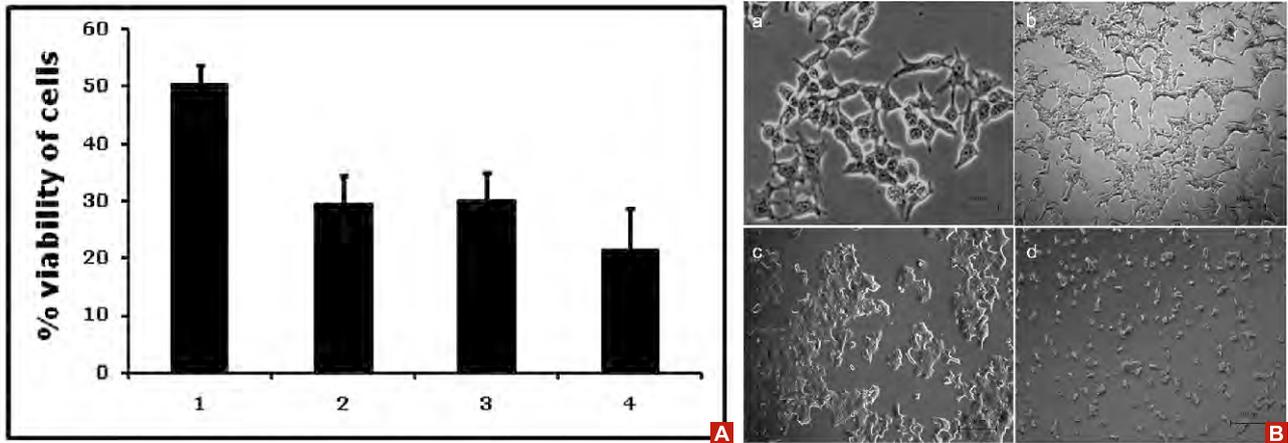


Fig. 8. MTT assay of CMPO on MCF 7 breast cancer cells. (A) CMPO showed growth inhibitory effects on MCF 7 breast cancer cells. X-axis: (1), (2), (3) and (4) CMPO at 10, 20, 30 and 40 $\mu\text{g/ml}$, respectively. (B). Phase contrast pictures of MCF 7 cells at different concentrations of CMPO, a- control, b, c, d,- 10, 30 and 40 $\mu\text{g/ml}$.

Blue fluorescence emission from carnivorous plants

The novel finding of blue fluorescence emission by carnivorous plants was already covered in *Web of Science*, *Super Science Magazine* (New York), *Science VIE Junior Magazine* (French) etc. Now, this finding is included in the Oxford University Press Book authored by Dr. Martin Stevens (Title of the book: *Cheats and Deceits: How Animals and*

Plants Exploit and Mislead) and also in the book *Bio communication* (Gebeshuber I.C. (in press) "Bio communication in the web of life: Theoretical and experimental approaches", in: *Bio-communication*. (Eds. Seckbach J. and Gordon R.), Series: *Astrobiology: Exploring Life on Earth and Beyond*. London, World Scientific Publishing (in press). *Plant Biology* Article level metrics of this article is 68.

Division of Plant Systematics and Evolutionary Science

The PS & ES Division deals with principles and practice of plant classification which is the basis for building other modern branches like cytology, plant breeding, chemo-taxonomy, biotechnology, bioinformatics, environmental sciences etc. At the same time, it has inherent capacity to absorb and synthesize information from other disciplines so that it can be considered as equivalent to any other modern sciences. With this principle, the division is devoted on plant systematics in the broadest sense, encompassing phylogenetic, evolutionary and bio geographical studies at the family, population, specific and higher taxonomic levels. To achieve these objectives, the research activities are focused on theme-wise such as (i) floristic studies (angiosperms and mushrooms) and biodiversity evaluation of ecologically sensitive areas of Western Ghats, (ii) survey, documentation and analysis of useful plant resources for sustainable utilization, (iii) assessment of endemic and RET species, (iv) population/ecology and ecosystem assessment etc. The division also coordinated Lead Garden programmes at national level with financial assistance from MoEF & CC, Govt. of India in recognition of our expertise.

Project wise Detailed Report

Survey, exploration and documentation of floristic wealth of Kerala

During the reporting period 53 collection trips were conducted to different vegetations of Western Ghats and collected a total of 7483 herbarium specimens belonging to 2335 species. The specimens were processed and identified with the help of various floras and compared with the authentic specimens deposited at CAL, MH, CALI and TBGT. The collections include about 60 endemics and 20 RET species of conservation importance. 11 new species were described. 9 species were reported as new records.

New species/varieties published

Memecylon sahyadrica Sivu A. R. *et al.*

Polyalthia malabarica var. *longipedicellata* M. Alister *et al.*

Rhynchospora panduranganii Viji *et al.*



Ardisia stonei Sasidh. & Sivar.



a. *Barleria courtallica* Nees; b. *Begonia albococcinea* Hook.; c. *Humboldtia vahliana* Wight; d. *Thunbergia mysorens* (Wight) Anderson

Rotala dhaneshiana Ratheesh Narayanan *et al.*
Sonerila keralensis Deepthikumari. & Pandur. *et al.*
Sonerila raghaviana Ratheesh Narayanan *et al.*
Sonerila vythiriensis Ratheesh Narayanan *et al.*
Cinnamomum nilagiricum Geethakum. *et al.*
Cyperus coonoorensis Viji *et al.*
Memecylon kurichiarensis A. R. Sivu *et al.*
Impatiens courtallensis Ramasubbu *et al.*
Impatiens mathewiana Ramasubbu *et al.*

Rediscovery after type

Carex walkeri Arn. ex Boott
Ascopholis gamblei Fischer



a. *Cucumis dipsaceus* Ehrenb. & Spach. b. *Sonerila keralensis* Deepthikum. & Pandur.

New Records

Begonia hirtella Link - Tamil Nadu
Ardisia stonei Sasidh. & Sivar. - Tamil Nadu
Carex bilateralis Hayata - India
Eleocharis attenuata (Franch. & Sav.) Palla. - India
Eriophorum comosum (Wall.) Nees. - Peninsular India
Piper hamiltonii C. DC. - Peninsular India
Scleria foliosa Hochst. ex A. Rich - Tamil Nadu
Cucumis dipsaceus Ehrenb. & Spach - Kerala
Friesodielsia sahyadrica N. V. Page & S. Surveswaran - Kerala

Emended Description

Cinnamomum palghatensis Gangop. [floral character]
Antidesma keralense Chakrab. & M. Gangop.

New combination

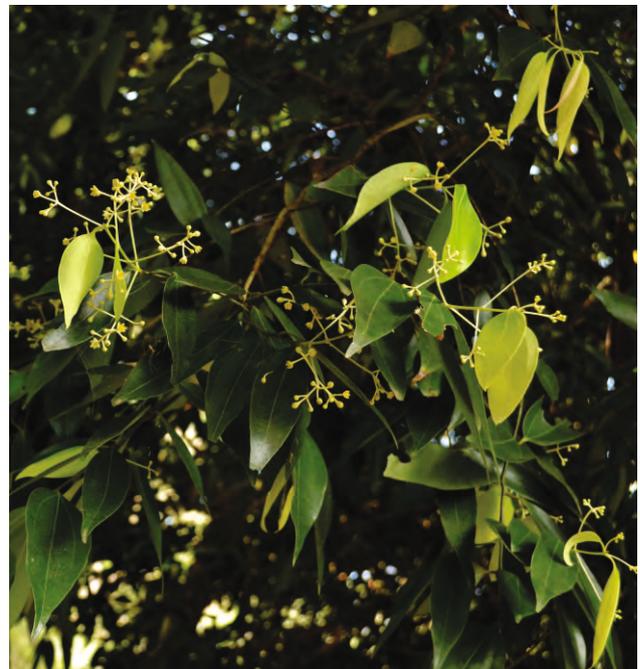
Exacum uniflorum (Henry & Swamin.) Geethakum. *et al.*

Status reinstated

Scleria flaccida Clarke

Taxonomic studies of the genus *Cinnamomum* of Southern Western Ghats

A total of 956 specimens representing 22 species were collected out of the 25 species reported from Southern India. Out of the 25 species, 21 are endemic and 10 are under RET category. A new species namely *Cinnamomum nilagiricum*



Cinnamomum nilagiricum Geethakum. *et al.*



a. *Exacum courtallense* Arn.; b. *Exacum sessile* L.; c. *Trichosanthes tricuspidata* Lour.

was described and lectotypification of *Cinnamomum riparium* Gamble proposed. The important collections are *Cinnamomum chemungianum* Mohan. & Henry, *C. filipedicellatum* Kosterm., *C. litseaefolium* Thw., *C. perrottetii* Meissner, *C. riparium* Gamble, *C. travancoricum* Gamble, *C. walaiwarensense* Kosterm., *C. wightii* Meissner, *C. palghatensis* Gangop., *C. macrocarpum* Meissn., *C. sulphuratum* Nees etc. Efforts are being made to collect the balance 3 species for preparing the taxonomic monograph. In addition to these, 350 seedlings of 5 *Cinnamomum* species namely *C. chemungianum*, *C. filipedicellatum*, *C. palghatensis*, *C. litseaefolium* and *C. malabathrum* were collected and introduced in the the RET species park as well as for its restoration in the natural habitat.

Taxonomic studies of the family Gentianaceae in Southern Western Ghats

The Gentian family represents about 7 genera and 42 species in southern Western Ghats. The present investigation so far collected a total of 523 specimens representing 32 species from southern Western Ghats. The important collections among them include *Canscora diffusa* (Vahl) R. Br. ex Roem. & Schultes, *C. perfoliata* Lam., *Exacum courtallense* Arn., *E. pumilum* Griseb., *E. sessile* L., *Hoppea fastigiata* (Griseb.) C. B. Clarke, *Swertia angustifolia* var. *pulchella* (Buch.-Ham. ex G. Don) Burkill, *Swertia beddomei* C. B. Clarke, *S. lawii* Burkill etc. Based on the present investigation the nomenclature status of *Exacum wightianum* var. *uniiflorum* Henry and Swaminathan and *E. klackenberghii* Gopalan were analysed and a new combination, *E. uniiflorum* was made to stabilize the nomenclature as per ICN. The study proposed three new species, one species for status reinstate, one new combination, two new records for Kerala etc.

Climbing flora of Kerala

Field trips were conducted on various parts of Western Ghats such as Wayanad, Ootty, Meppady, Nadukani, Mulli, Attappady, Palakkad, Silent valley etc. and collected a total of 306 specimens belonging to 52 species representing 22 genera and 12 families during the period. The important among these are *Trichosanthes tricuspidata* Lour., *T. nervifolia* L., *Gymnopetalum tubiflorum* (Wight & Arn.) Cogn., *Zehneria hookeriana* (Wight & Arn.) Arn., *Z. mysorensis* (Wight & Arn.) Arn., *Vitis discolor* (Bl.) Dalz., *Aristolochia grandiflora* Sw., *Argyrea nervosa* (Burm. f.) Bojer, *Passiflora coccinea* Aubl., *P. edulis* var. *hispida* (DC) Killip ex Gleason, *P. incarnata* L., *P. subpeltata* Ortega, *P. vitifolia* Kunth, *P. sublobata* Ortega, *P. mollissima* (H. B. K.) L. H. Bailey, *P. leschenaultia* DC., *P. quadrangularis* L., *Loeseneriella obtusifolia* (Roxb.) Sm., *Gouania microcarpa* DC., *Hiptage benghalensis* (L.) Kurz., *Tinospora sinensis* (Lour.) Merr. *Momordica balsamina* L., *M. subangulata* Bl., *Chonemorpha grandiflora* (Roxb.) M. R. Almeida & S. M. Almeida, *Congea griffithiana* Munier, *Cynanchum callialatum* Buch.-Ham. ex Wight & Arn., *Derris thyrsoiflora* Benth. var. *eualata* (Bedd.) Thoth., *Gymnopetalum wightii* Arn., *Hugonia mystax* L., *Ipomoea alba* L., *Strophanthus hirsutus* H. Hess., *Vallis solanacea* (Roth) Kuntz., etc.

Taxonomic studies of the genus *Sonerila* Roxb. in Western Ghats

The genus *Sonerila* Roxb. belongs to the family *Melastomataceae*. In India, it is represented by 51 species and in Western Ghats by 34 species including 22 endemics and 12 threatened ones. So far 27 species and one variety were collected and these specimens were processed in to herbarium as per the standard procedure. The important collections are *S. nemakadensis* C. Fischer, *S. travancorica*

Bedd., *S. wynadensis* Nayar, *S. elegans* Wight, *S. grandiflora* R. Br. ex Wight & Arn., *S. devicolamensis* Nayar, *S. barnesii* Fischer, *S. pulneyensis* Gamble, *S. pedunculosa* Thwaites, *S. keralensis* Deepthikum. & Pandur. etc.

Taxonomic studies of the genus *Senecio* in India

The genus *Senecio* L. belongs to the family Compositae, commonly known as Daisy family. The members of the genus have great economic value as medicinal, oil yielding, ornamentals etc. Against this back drop, eight field trips were conducted across India and collected 150 herbarium specimens representing 14 species which include *S. belgaumensis* (Wight) C. B. Clarke, *S. bombayensis* Balakr., *S. candolleanus* Wallich ex DC., *S. dalzelli* C. B. Clarke, *S. edgeworthii* Hook. f., *S. graciliflorus* DC., *S. intermedius* Wight, *S. kundiakus* C. Fischer, *S. ludens* C. B. Clarke, *S. rhabdos* C. B. Clarke, *S. vulgaris* L., *S. wightianus* DC. ex Wight, *S. wightii* (DC.) Benth. & Hook., *S. zeylanicus* DC.

During the reporting period, "Floristic Studies of the Coastal Region of Kerala State" was completed. The flora includes 1178 species; belong to 607 genera and 109 families. 852 herbarium specimens were given for incorporation during this period. Artificial key had been prepared for families, genera and species for proper identification. The study identified 34 rare and little known species, 16 true mangroves and 20 mangrove associates, 26 medicinal species, 24 wild ornamentals etc. Rare plants such as *Aglaia elaeagnoidea* (A. Juss.) Benth., *Cissus trilobata* Lam., *Capillipedium assimile* (Steud.) A. Camus and *Pogostemon deccanensis* (Panigrahi) Press; medicinal plants such as *Cyclea peltata* (Lam.) Hook. f. & Thoms., *Asparagus racemosus* Willd., *Calophyllum inophyllum* L., *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G. Don, *Tabernaemontana alternifolia* L., *Strychnos nux-vomica* L., and wild ornamentals such as *Argyreia hirsuta* Wight & Arn., *Pogostemon deccanensis* (Panigrahi) Press, *Chassalia curviflora* (Wall. ex Kurz) Thw. var. *ophioxylodes* (Wall.) Deb & Krishna,

Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don, *Calycopteris floribunda* Lam., *Vitex trifolia* L., *Alstonia scholaris* (L.) R. Br. and *Memecylon umbellatum* formed important among collections.

Inventory, Systematics and Conservation of the family Annonaceae of Southern Western Ghats with emphasis on Endemic, RET Species

The family Annonaceae represented 130 genera and 2,200 species world over is considered as a primitive family which is evolved from the Magnoliaceous line of evolution. In India, the family has 130 species, of which nearly 60% are endemic. The present study is aimed at documenting the species diversity and richness in the Southern Western Ghats with a view to understand their distributional ranges, phyto geography threat status etc. In continuation of last year's study, another 300 specimens representing 12 species and 150 saplings were collected. The important collections include species such as *Friesodielsia sahyadrica* N. V. Page & S. Surveswaran, *Goniothalamus keralensis* E. S. S. Kumar et al., *Miliusa gokhalaei* Ratheesh et al., *M. wayanadica* Sujanapal et al., *Goniothalamus wynaadensis* (Bedd.) Bedd., *Orophea sivarajanii* Sasidh., *O. uniflora* Hook. f. & Thoms. *Polyalthia malabarica* (Bedd.) I. M. Turner and *Uvaria narum* (Dunal) Blume. In addition air layering was carried out in *Cyathocalyx zeylanicus* Champ. ex Hook. f. & Thoms., *Miliusa wayanadica* Sujanapal et al., *M. tomentosa* (Roxb.) J. Sinclair, *M. indica* Lesch. ex DC., *Orophea malabarica* Sasidharan & Sivar etc. for propagation protocol.

The fruiting periodicity was observed from June to December and had a wide range of colour combinations in ripe fruits viz. deep red, yellow, orange and black. These bright colours of ripe fruits contribute much for attracting birds and thereby helping in dispersal. The fruiting materials of *Alphonsea sclerocarpa* Thwaites, *Friesodielsia sahyadrica* N. V. Page & S. Surveswaran, *Goniothalamus cardiopetalus* (Dalz.) Hook. f. & Thomson, *G. wynaadensis* (Bedd.) Bedd.,



a. *Alphonsea sclerocarpa* Thwaites; b. *Popowia beddomeana* Hook. f. & Thomson; c. *Friesodielsia sahyadrica* N. V. Page & S. Surveswaran



a. *Polyalthia malabarica* var. *longipedicellata* M. Alister et al.; b. *Miliusa gokhalaei* Ratheesh et al.

Miliusa eriocarpa Dunn., *M. wayanadica* Sujanapal et al., *M. gokhalaei* Ratheesh et al., *Mitrephora heyneana* (Hook. f. & Thomson) Thwaites, *Orophea malabarica* Sasidh. & Sivar., *Polyalthia malabarica* (Bedd.) I. M. Turner, *P. cerasoides* (Roxb.) Benth. & Hook. f. ex Bedd., *P. korintii* (Dunal) Thwaites, *P. suberosa* (Roxb.) Thwaites, *Popowia beddomeana* Hook. f. & Thomson and *Sageraea dalzellii* Bedd. were collected and photographed. Seeds of *Goniothalamus rhynchantherus* Dunn., *G. wightii* Hook. f. & Thomson, *Popowia beddomeana* Hook. f. & Thomson, *Miliusa nilagirica* Bedd., *Polyalthia malabarica* Bedd. and *Meiogyne pannosa* (Dalz.) J. Sinclair were collected, germinated and planted in the nursery. The seeds of *Friesodielsia sahyadrica* N. V. Page & Surveswaran, *Goniothalamus cardiopetalus* (Dalz.) Hook. f. & Thomson, *G. wynaadensis* (Bedd.) Bedd., and *Sageraea dalzellii* Bedd. were being tested for germination.

Vegetational and Ecological Assessment of Lateritic Zones of North Kerala

A lateritic plateau can be considered as an amphibious ecosystem. It forms a specialized habitat complex that harbour a number of different plant communities. Among these, Ephemeral Flush Vegetation (EFV) is a prominent seasonal plant community characterised by the prevalence of specialized annual species. Throughout the tropics EFV is constituted by taxa that are indicative for nutrient poor and seasonally wet localities. These seasonally wet localities are characterised by presence of Eriocaulaceae, Xyridaceae (Yellow-eyed grasses), Burmanniaceae, Lentibulariaceae (Bladderworts), Droseraceae (Sundews) etc. with the frequent occurrence with Poaceae, Cyperaceae, Commelinaceae etc. Poaceae and Cyperaceae made up of the largest part of biomass of these areas.

The components of herbaceous vegetation in the lateritic

areas possess several adaptive traits for tolerating a wide range of conditions to grow and reproduce in a short time, mostly confined to the wet phase.

Taxonomic study

A total of 10 exploration trips have been conducted to different lateritic zones of northern Kerala comprising the districts of Malappuram, Kozhikode, Kannur and Kasaragod. From each districts, plant communities on 6 representative sites including 2 ecologically important sacred groves were selected for taxonomic and quantitative assessment.

A total number of 487 angiosperm taxa of 64 families were identified and herbarium specimens of each species were collected in quadruplicates. Out of 487 taxa collected from the lateritic zone, 91 (19%) are endemics, of which 21 are exclusively endemics to the lateritic zone of North Kerala. Altogether 740 herbarium sheets were prepared and among that 40 taxa are new additions to TBGT such as *Parasopubia hofmannii* var. *albiflora* Pradeep & Pramod, *Crinum malabaricum* Lekhak & Yadav, *Justicia ekakusuma* Pradeep & Sivar., *Curcuma kannanorensis* Ansari et al., *Eriocaulon madayiparense* Swapna et al., *Antidesma keralense* Chakrab. & Gangop. *Uniyala bourdillonii* (Gamble) H. Rob. & S. K. Varla.

Selected sacred groves of lateritic area: The sacred groves which are unique to these lateritic systems are naturally extent floral centres supporting divers group of plants, including endemics and red list category species. Two ecologically important sacred groves such as Cheemenikavu (60 acres or even more) in Kasaragod district and Vallikattu kavu in Kozhikode district were selected for assessing the species status and distribution.

Richness in endemic and rare species: Endemism among seasonal herbs was exceptionally high, contrary to otherwise bleak and infertile nature of the terrain. These endemics occur



a. *Parasopubia hofmannii* var. *albiflora* Pradeep & Pramod; b. *Uniyala bourdillonii* (Gamble) H. Rob. & Skvarla; c. *Neanotis subtilis* (Miq.) Govaerts; d. *Nymphoides parvifolia* (Griseb.) Kuntze; e. *Rotala malampuzhensis* R. V. Nair & C. D. K. Cook; f. *Striga gesnerioides* (Willd.) Vatke



a. A view of lateritic plains with *Dimeria* spp.; b. *Crinum malabaraicum* Lekkah & S. R. Yadav; c. *Curcuma kannanorensis* R. Ansari et al.; d. *Justicia ekakusuma* Pradeep & Sivar.; e. *Eriocaulon madayiparense* Swapna et al.

in a variety of ephemeral micro-habitats associated with edaphic features of the plateau. The restriction of endemic plant species to nutritionally poor substratum (Laterite, serpentine/ ultramafic) is a wide spread phenomenon in endemic rich areas. There is much evidence to suggest that these nutritionally imbalanced substrata provide a strong selective force for the evolution of endemic plants. Therefore, the patterns of distribution often, correlates, causes of endemism will vary according to the size and location of the geographical area, as well as the taxonomy and phylogenetic relatedness of the assemblage under consideration. Therefore, endemics of laterite may be categorized according to their spatial distribution, inferred evolutionary age and affinity.

Achievements

- 10 exploration trips were conducted to different lateritic regions in four districts of North Kerala covering all seasons.
- Total of 487 taxa were collected from the lateritic area, of which 91 are endemics, including 21 exclusive endemic taxa.
- Family Poaceae dominated by 52 taxa with 28 endemics, in which 8 species are exclusively endemic to the lateritic region of north Kerala.
- 1200 herbarium sheets were prepared for incorporation in TBGT, in which more than 42 species are new accessions
- Identified some adaptive traits, phytogeographical affinities, vicariance, sediment seed banks etc. in lateritic flora.
- Identified a sacred grove housing *Myristica* swamp with IUCN categorized red species in lateritic area.
- Ecological analysis were started in selected sites using different parameters (Quantitative ecological characterization, physical characteristics of soil and assessment of factors for ecosystem degradation).

Adaptive Traits in lateritic flora: To survive in such an ecosystem, an ephemeral species must be able either to tolerate a wide range of conditions or to grow and reproduce in a short time with a variety of ecological adaptations such as Carnivory, succulence, subterranean perennating organs. Poikilohydry, Vegetative propagation, Semi parasitism, N-fixing C4 mechanism etc. Species were categorized based on these adaptations for proper understanding.

Ecological Studies: Analyses of ecological factors responsible for delimiting species distribution in lateritic zones are very essential in the event of climate change and other ecological imbalance. Biomass studies conducted for assessing annual productivity and biomass turnover different lateritic areas. Physical parameters like atmospheric temperature and humidity were periodically observed. Soil

parameters include soil temperature, water holding capacity, hygroscopic coefficient and wilting percentage were calculated. Chemical components of the soil from different study sites were analysed in soil laboratory.

Threats: Commercial mining of laterite stones is common in these zones. Degradation of laterite hills in the midland zone results in simultaneous collapse of at least three ecosystems including hillocks, valleys and wetlands. The uncontrolled degradation of the lateritic zones causes irreparable damage to the ecosystem, and nature's water conservation mechanisms. The disappearance of rare and endemic plants of these peculiar habitats will ultimately lead to depletion of genetic diversity and gene pool.

Conservation: The ecological and cultural values of the laterite hillocks of the northern Kerala have not been given the due weightage it deserves. Majority of the general public is least bothered about its unique and rich biodiversity. The lateritic zones and its environs survived over these years, by supporting its rich cultural and ecological features. However, by changing cultural environment that unique ecological ecosystem may face uncertain future unless we take strong measures to protect it against anthropogenic pressures.

Floristic, ecologic and functional dynamics of selected grasslands of Western Ghats

The Western Ghats, one of the noted hotspots of the world, is widely accepted for its unique biodiversity. The different ecosystems with micro and macro ecological niches of these mountain ranges largely act as an abode of wide array of flora and fauna, which are eco-ecologically very significant from the conservation point of view. The high altitude grasslands with mosaic patches of shola forests are one such example, co-exists in dynamic equilibrium. The floristic and faunistic diversity along with its interdependent association is remarkable in protecting the environmental equilibrium and natural landscape of WGs in general and of State in particular. These grasslands and shola forests together act as a feeding ground for wild herbivores and subsequent dependents carnivore at different tropic levels. They also act as a conservatory and sanctum sanctorum of many novelties and RET species. In addition, areas act as water shed for the rivers and buffer region of carbon sink with high NPP.

The studies were carried out by bimonthly field exploration for floristic survey, and ecological assessment in selected study sites. The ecological and productivity studies in Chemunji, (Agasthyamala) Pettimudi (ENP), Mestrikett (ENP) and Vagamon were conducted through transect method after sampling survey. The study areas are diverse in floristic component having different degree of conservational status. The general ecology and physical edaphology is varying from



Study sites - a. Chemunji; b. Eravikulam National Park; c. Vagamom - domestic grazing

site to site. The main deciding factors are anthropogenic pressure, fire, regional variation and general managements. The type of vegetation and dominant species are varying in different sites which are discussed below.

I. Chemunji hills

It has a vast area of grasslands intermixed with shola forests at an altitude of 1200 – 1500 m. The ecological niches of different sites are very specific and contrasting due to different successional stages of vegetation. The grasslands are dominated by *Ischaemum – Arundinella* spp group along with other associated grasses species of *Cymbopogon* and *Isachne*. There are no reports of fire in the area for the last 10 years. 5 quadrats were laid for studying the biomass in different seasons in a year.

ii. Pettimudi (ENP)

The area is located in Eravikulam National Park and constitutes well established grassland at an altitude of 2000 m and above. The grasslands are intermixed with shola forests and grazing is mainly by Nilgiri Tahr. The dominant grass species combination is *Eulalia –Chrisopogon* spp. Four quadrats were marked for continuous monitoring of biomass production and succession.

iii. Mestrikkett (ENP)

It is also located in Eravikulam National Park at 2100 m from sea level and comparatively less grazing in these grasslands. The dominant grass species belongs to *Eulalia – Andropogon* complex. High wind velocity is a peculiar feature of the grasslands when compared to Pettimudi. Five quadrats were selected for the observation and net primary productivity assessment.

iv. Vagamom

Located on the western fringes of Idukki district, bordering with Kottayam district and lies at 1100 m. above sea level. This area is unique for grasslands with laterite soil type. The Vagamom hills are characterized by typical grassland eco-system and more than 200 varieties

of grasses have been reported here of which 30 are endemic to the high ranges. The dominant grasses are *Cymbopogon – Ischaemum* species and from such 5 quadrats were established for monitoring.

The dominance of grass members in terms of biomass and non-grass members in number wise is yet another important ecological mark which points the ecological succession (Table 1). The general biological, chemical and physical characteristics of soil system are considerably influencing the functional dynamics of the system. The soil analysis indicated that the biological, chemical and physical characters were site specific and vegetation dependent. The

Sl. no.	Sites	Number			Bio mass		
		Grass	Non grass	Ratio	Grass	Non grass	Ratio
1.	Chemunji	3	10	0.30	309.45	188	1.64
2.	Pettimudi	4	16	0.25	218.3	176.9	1.23
3.	Mestrikkett	3	13	0.23	398.2	282	1.41
4.	Vagamom	5	11	0.45	424.4	530.1	0.80

All values are expressed in gm/m²

Table 1. The Species / Biomass Ratio of study sites

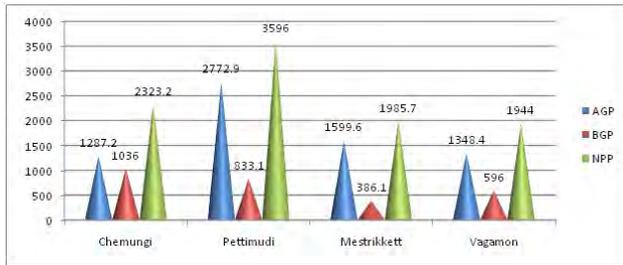


Fig.1. Bar diagram showing the Biomass productivity of study areas (Non Monsoon - 2013)

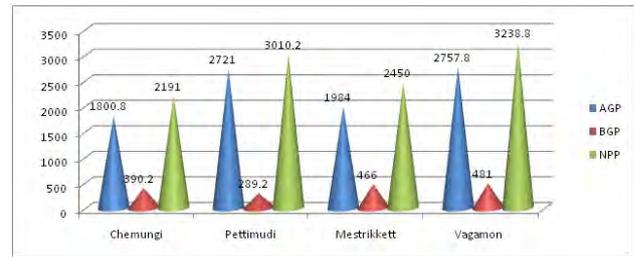


Fig. 2. Bar diagram showing the Biomass productivity of study areas (Monsoon - 2014)

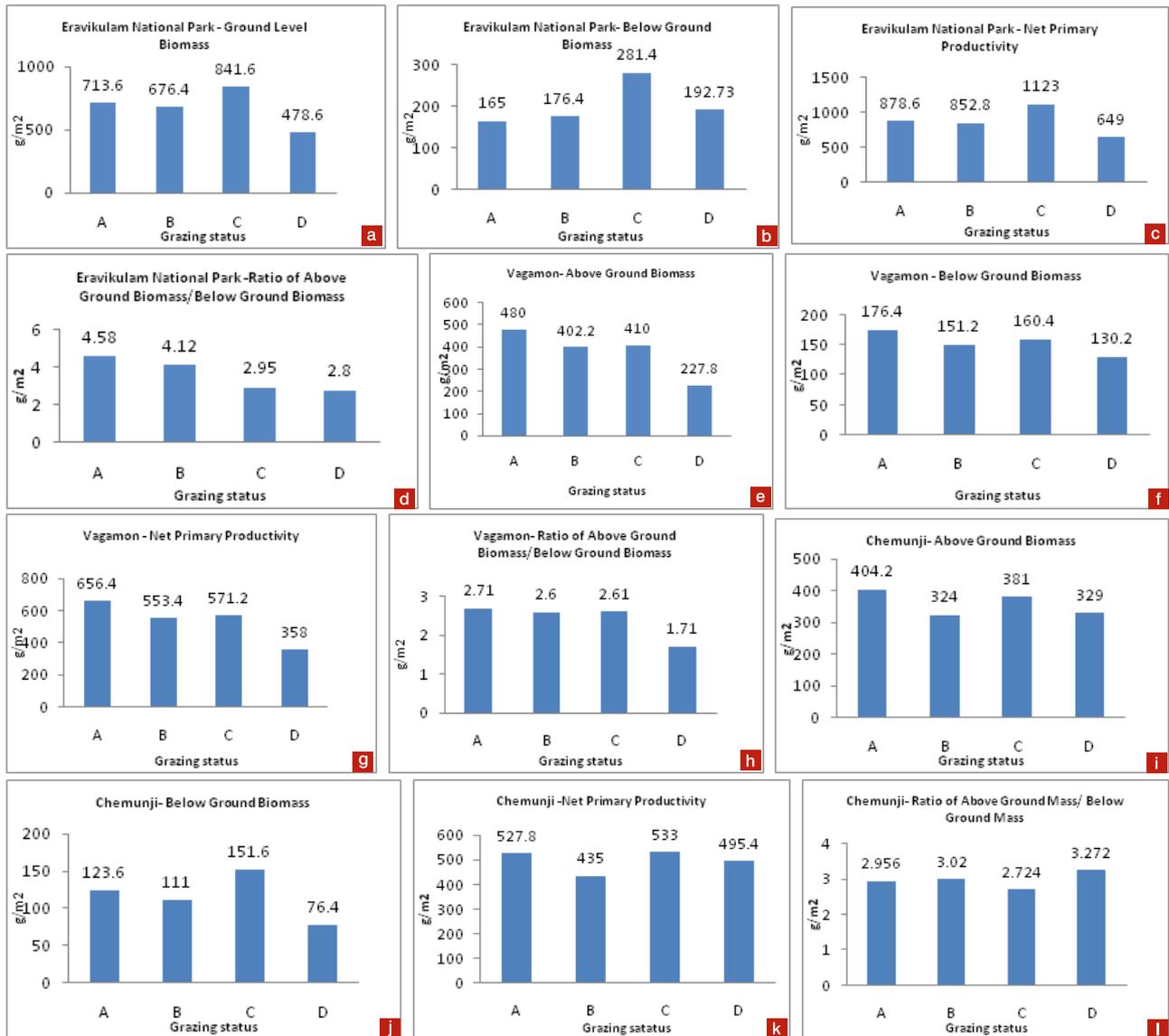


Fig. 3. The productivity status analysis of the different grass lands with different degree of grazing

soil is acidic with high percentage of total soluble salt confirming a high nutrient status. The water regime throughout the year is progressive and positive. Hence, these ecosystems are very vital in protecting wildlife and maintaining water and environmental equilibrium (Table 2). There was a

clear cut seasonal variation in biomass accumulation and distribution. The annual biomass accumulation varies from 1960 gm/m² (Chemunji) to 3238.8 gm/m² (Vagamon) with an average of 2804.8 gm/m². The aerial biomass accumulation showed an increasing trend in monsoon period while in the

No.	Sites	Moisture content	Moisture %	Wilting %	Max. Water holding capacity (%)	Field capacity (%)	Available water (%)
1	ENP	32.6	42.95	5.75	110	67	61.22
2	Chembra	31.8	47.33	7.12	124.7	83.8	76.5
3	Vagamom	15.6	23.94	5.11	71.36	58.8	53.6
4	Chemunji	24.5	33.36	1.95	65.8	46.08	44.12

Table 1. Physical characters

No.	Site	pH	ECmm hos/cm	Available N Kg/Ha	Available P Kg/Ha	Available K Kg/Ha	Ca (ppm)	Mg (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)
1	Vagamom	4.99	0.051	316	8.74	78.4	115.2	7.78	1.19	2.58	7.12	55.9
2	ENP	4.47	0.137	689.92	4.14	358.4	182	7.785	0.99	4.09	28.8	42.9
3	Chemunji	4.75	0.161	329.9	19.78	224	189	7.915	1.3	5.21	31.1	117.1

Table 2. Chemical characters

case of below ground biomass the order is reverse; the peak biomass accumulation was in summer (Fig. 1 & 2).

To understand the ecological and edaphological dynamism with respect to grazing (wild and domestic) the following investigations were carried out in selected grasslands. Through bimonthly survey and inventory comparative accounts of floristic elements, ecological and phytosociological characterization and net primary productivity were assessed. It is noticed that the floristic characteristics such as species composition, distribution pattern, phytosociological status, biomass accumulation, etc. are varying with different ecological niche within the same study site. The soil structure, physical and chemical properties and water regime are correlated with vegetation type, conservation status and grazing status of the study site (Table 1 & 2). The biomass accumulation and turnover rate has changed in accordance with general management of the ecosystems. The energy and matter flow is linked with grazing status, conservation status and functional dynamism of grassland ecosystem. An average of 90% species is palatable and in the case of wild grazing, the fauna is utilizing only 10-12 % of annual productivity while the utilization through domestic grazing is up to 70% of total productivity. The important feature of grasses is the mode of growth and their leafy shoots. The actual stem bearing the nodes from which the tillers originate, is very short and grows upwards only when the plant begins its stage of flowering. So that, in the vegetative stage of the plant, the stem projects only slightly above the soil surface. It is thus escape from damage and continues to produce fresh tillers when the older tillers are removed by grazing. Hence, the moderate grazing enhances the net primary productivity of the grassland. The present status of grasslands is enough to support wild fauna and the impact of grazing in functional dynamism is apparent but not significant. The chemical and physical properties of soil are supportive for healthy

vegetation. The present grazing intensity and pattern directly affect the floristic composition, vegetational structure and productivity of grassland ecosystems but not enough to degrading the system (Fig. 1, 2 & 3).

Ecology and Conservation of Fresh Water Swamps Ecosystems of Western Ghats- Kerala Region

The sample survey and inventory were conducted in 30 swamps of Kulathupuzha range, that led to enumerate 65 plant species. Using line transect method phytosociological analysis were carried out by differentiating swamps in three zone viz. core, transition and edge. The data were assessed and computed to analyse the demographic profile / regeneration status in order to understand if there is any depletion of richness, abundance and diversity of swamp tree species in the smaller and more isolated swamps fragments. During the reporting period the stands were analyzed in order to determine the qualitative and quantitative features of all species and their ecological status. The vitality, periodicity, reproductive capacity and recruitment were assessed for analyzing the conservation status of common and dominant species.

The evergreen vegetation of swamp is Phanerogamous in nature. The other dominant life forms are lianas and geophytes. Vegetation is represented with 4 differentiated storeys; the continuous upper storey is developed with tree members of the primitive family. All other strata including ground vegetation is discontinuous. Swamps are also characterized by high stem density and low floristic diversity. Flora is represented by 29% of endemism. The vegetation is in succession due to both natural and manmade reasons. Survival rate of seedlings and saplings establishment are



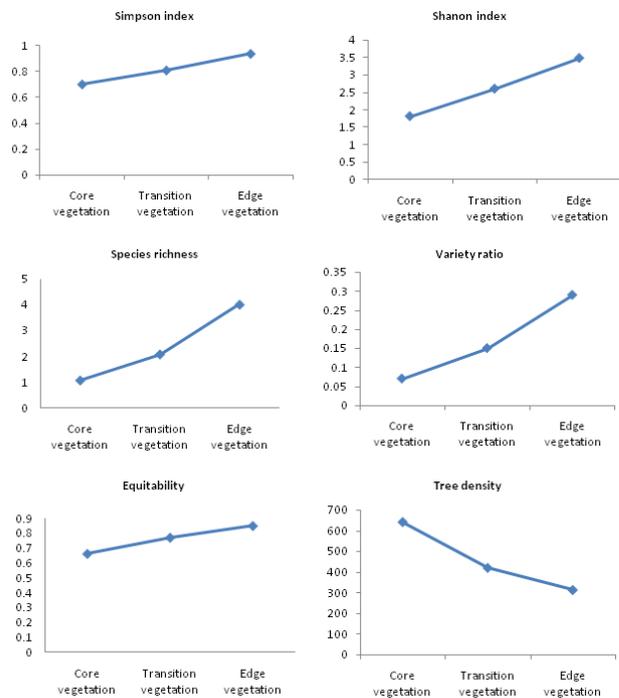
Myristica fatua var. *magnifica* (Bedd.) Sinclair-Flagship species of fresh water swamps at Kulathupuzha

affected by various ecological, edaphological and anthropogenic reasons. During the study, we identified that the isolation and fragmentation of *Myristica* swamps by land use alteration leads to change in edaphological, vegetational and ecological status. This functional changes start with changes in the population dynamics of flagship species and associates. Finally swampy evergreen forest becomes terrestrial evergreen ecosystems.

Survey & Inventory of mushrooms of the Western Ghats and Establishment of a regional reference centre for mushrooms

In Kerala, many people in both urban and rural areas are familiar with mushrooms growing around them, some of which they exploit for food and medicine. But mushroom resource exploration and exploitation is burdened with lack of infrastructure and technical supports from national and international agencies, scarcity of mushroom scientists, poor political and legislative support, poor knowledge of mushroom biodiversity due to dearth of mushroom taxonomists and fast and continuing decline of their habitats due to population explosion and developmental activities. For any meaningful conservation exercise to succeed, the primary emphasize should obviously be on the assessment of the bio-

diversity based on the survey, collection and identification.



Effect of fragmentation and isolation in floristic wealth and diversity of *Myristica* Swamps



a. *Macrocybe lobayensis* (R. Heim) Pegler & Lodge; b. *Macrocybe titans* (H. E. Biglow & Kimbr.) Pegler, Lodge & Nakasone; c. *Macrocybe pachymeres* (Berk. & Broome) Pegler & Lodge; d. *Phylloporus septocystidiatus* C. K. Pradeep & K. B. Vrinda (A new species of *Phylloporus* from Western Ghats); e. *Pleurotus giganteus* (Berk.) Karunarathna & K. D. Hyde

With this view, research programmes were undertaken to evaluate the macro-fungal wealth of Kerala. Main objectives of these programmes were to collect, identify and characterize important indigenous mushrooms of Kerala, conserve specimens in a gene bank and document indigenous technical knowledge about them from the locals.

Achievements

Total collections made during the period : 537
 Collections identified to genera : 537
 Families represented : 17
 Genera represented : 62
 Species represented : 120

New species recognized : 08
 Wild edible species collected : 13
 Toxic species identified : 14
 Medicinal mushrooms collected : 10
 Bioluminescent : 13
 Papers published during the period : 01
 Papers presented : 03
 Papers communicated : 01
 Total accessions maintained in the mushroom herbarium : 16085

Medicinal mushrooms of Kerala

Survey and collection of wild mushrooms from different parts of Kerala was conducted during the period May-



Inocybe carnosibulbosa C. K. Pradeep & K. B. Vrinda

September 2015. Fresh fruiting bodies were collected from different forest areas of Kerala. The most intensive field work was carried out in Thiruvananthapuram and Kollam Districts. Voucher specimens were preserved in the mushrooms herbarium [TBGT(M)] for future reference. Ten mushrooms with medicinal properties were identified consulting literature.

Molecular and phylogenetic studies of *Inocybace* (Basidiomycotina, Agaricales) of Kerala

Altogether 34 collections were made during the period and were macroscopically studied and preserved as herbarium specimens in the mushroom herbarium. Out of the 900 collections available in the mushroom herbarium, about 90 specimens were critically studied. All of them were studied both morphologically and molecularly and recognized as 10 species. Of these, 7 species were new to science while one was a new record for India. 34 DNA sequences (nLSU, ITS, rpb2) were generated for the study. The sequences were deposited in Gene Bank with its accession numbers.

Germplasm Documentation, Evaluation, *Ex-situ* Conservation and Popularization of Local Mango Varieties in Kerala

The main objective of the project is to document and conserve the fast depleting wild mango varieties with a view to tap the potential varieties for future breeding programmes. The project also aims at producing sufficient quantities of planting materials of the promising types for cultivation. In addition, establishing a field gene bank, bringing out an accurate inventory of the local mango varieties and popularization of the promising types are the other objectives envisaged for realization.

As mango varieties are out breeding types, exactly similar characters of the mother plant are reproduced using grafting techniques. This also helps in bringing plus tree characters

Sl. No.	Locality	Shannon index	Shannon evenness	Simpson index
1	Sasthanada	2.697	0.899	0.823
2	Aryankavu	3.593	0.92	0.893
3	Kulathupuzha pop I	1.48	0.64	0.577
4	Kulathupuzha pop II	3.29	0.89	0.86
5	Perumthenaruvi	3.80	0.89	0.91
6	Chaliarmukku	2.09	0.74	0.67
7	Nellikuthu	2.76	0.92	0.83
8	Thalkolli	1.60	0.57	0.50
9	Pattakarimba	3.01	0.87	0.83
10	Mukkali (riparian)	4.04	0.92	0.92

Table 1. Diversity indices of 10 populations of *L. speciosa* across S. W. Ghats, Kerala portion

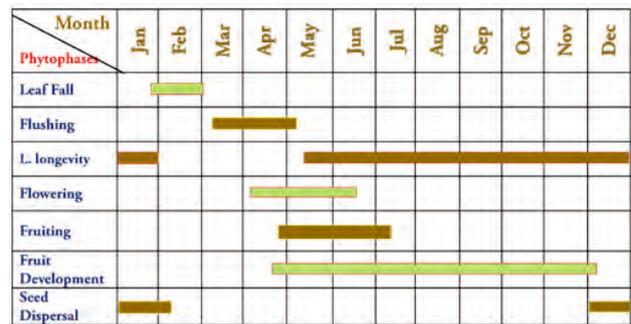


Table 2. Phenophases of *L. speciosa*

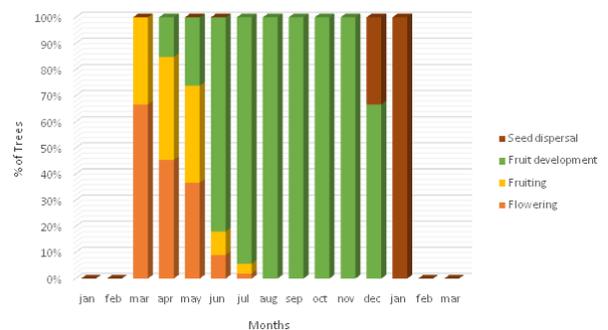


Fig. 1. Reproductive phenological events of *L. speciosa*, expressed by the percentage of trees in a phenophase

such as heavy bearing, early maturing, palatability etc. Sufficient quantity of saplings of the elite varieties are ready for cultivation and popularization. The saplings will be distributed at 'no loss no profit' basis through NGOs, local governments, schools etc. In view of the rapid loss of genetic resources of the species in general and heavy loss of many of the local varieties due to various bio-physical and socio-cultural pressures, the project achieves wide media coverage and enthusiasm from the side of the public as well as from the Forest Department. As we are conserving all the traditional mango types *ex-situ* in our conservatory, the project achieves



Mango varieties : a. Cheruvarikka; b. Chenkavarikka; c. Kalappadi; d. Karpooram; e. Kossery; f. Nattumanga; g. Pulimanga; h. Vellari

the twin objectives of conservation and sustainable utilization in the long run. During the present investigation, we could locate 126 different local mango varieties from the length and breadth of the State and plus trees were marked for future breeding programmes. In spite of the constraints that exist in our system, we could successfully produce thousands of seedlings which are coming up well and are ready for grafting operations for releasing the true-to-type varieties. Since propagation essentially requires humidity controlled chambers, construction of a propagation chamber was been successfully completed in the mango conservatory. Simultaneously the *ex-situ* conservation of the local mango varieties is currently progressing within 5 hectares of area allotted for the purpose in the garden site. We have also conducted market surveys to find out the seasonal influx of diverse varieties in the local market and to analyse the diversity of value added products made out of local mango varieties in the State.

Biotechnological Interventions for Conservation and Utilization of Forest Resources

DBT had sanctioned a five year (2010-2015) multi-institutional project to identify the areas of genetic variability and high yielding genotypes of *Lagerstroemia speciosa* (L.) Pers. for Corosolic acid by analyzing various populations in Kerala and also to study the 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 PS & ES division was entrusted to work on the distribution pattern and reproductive ecology of the species.

As part of accessing the distribution of the species across Western Ghats of Kerala, located 10 viable populations at different sites. The population structures at all the 10 sites were worked out. Analysis of vegetation data of each sites were adopted as per the following methods suggested by Richards (1952), Robins (1959), Harper (1977), Halle *et al.* (1978) and Pascal (1988). Vertical stratification, Horizontal/spatial distribution, Crown projections (Horizontal



Cynanchum callialatum Buch. - Ham. ex Wight & Arn.

& Vertical planes) were worked out for all the 10 population sites. Among the 10 sites, the third site (Kulathupuzha pop. I) showed the lowest values for Shannon and Simpson indices which confirmed that the locality is having low species richness and hence an higher diversity, whereas the tenth population (Mukkali) showed an higher species richness and hence a lower species diversity. The Shannon index shows that the sites – Kulathupuzha pop - I and Thalkolli are highly disturbed whereas Mukkali, Perumthenaravi and Aryankavu are with low disturbance (Table 1).

Vegetative dynamics identified that a leaf took around 20 days to become fully functional. The plant was found to be having a low rate of herbivory. Reproductive phenological events of *Lagerstroemia speciosa*, were closely observed and expressed by the percentage of trees in a phenophase among the marked plants are given in Fig. 1.

The flowering phenology had showed that the total period of flowering was between 90–110 days in a year. 50 % flowering was observed after 19–21 days and full bloom after 65 days. The initiation of flowering was found to be continuous with leaf flushing as it starts afterwards. The flower yield was found to be highly variable parameter which ranged from 1,076 to 6,080 with a coefficient of variation of 42.32 %. Flowers opened with a slit at the top of the bud that widened gradually along the margins of calyx lobes and took 2 hr for complete opening (according to weather conditions it may vary).

The anthesis happens slightly before dawn, between 0530 – 0630 hr. The flower belongs to morning flowering type shows annual flowering frequency (only one major cycle per year), and comes under the subclass intermediate flowering (1 - 5 months), as per Newstrom *et al.* (1994). ANOVA of the effect of time, temperature and relative humidity of the day on anthesis and Pollen production in *L. speciosa* at 10 different sites were worked out. It was observed that anthesis significantly correlated with time, temperature and RH. *L. speciosa* has an Out Crossing Index value of 4 which means, it is partially self-compatible, outcrossing, demand for pollinators. The selfing rate was observed to be 0.2.

The viability of pollen grains had rapidly declined after 36 h of anthesis and by the time the pollen is totally scattered. The stigma remains receptive upto 48h. Different concentrations of sucrose solutions had positive effect on germination of *L. speciosa* pollen grains. However sucrose solution along with different concentrations of Boric acid and Calcium chloride had triggered the germination of pollen grains. A combination of Sucrose (15 gm/100 ml), Boric acid (2 mg/100 ml) and CaCl₂ (1 mg/100 ml) showed the highest percentage of pollen germination of 90 ± 4 %. The PO ratio has been worked out as 605.18 ± 116.85 : 1, indicating the requirement of a vector for effective pollination.

The fruit setting initiated after 3 days of anthesis with visible change in the size of ovary. It took around 180 - 220 days to obtain full maturity and then to dehisce. The fruits were generally six loculed but 4, 5, 7 and 8 loculed conditions were also observed. Being a loculicidal capsule with winged seeds, its dispersal is anemophilous. For understanding the reproductive capacity, the average seed output of the plant was calculated to be 1,75,545.82 ± 11,934.17.

Observations showed that seven ant species interacted with *L. speciosa* seeds at one of the study sites, supporting the generalization that interactions between plants and ants are often not highly specialized or obligate to the particular species as in the case of *L. speciosa* which is non-myrmecophilous. Three ant species removed seeds to distances shorter than 1 m and thus did not act as dispersers. The present observation is a novel report in these parts of tropical forests.

The soil Seed Bank analysis showed that seed density was high in the litter/humus layers and declined with soil depth. Insects and pests associated with the plant during various stages were enumerated and identified 56 species.

Standardized the vegetative propagation of *L. speciosa*. The semi-hard cuttings with the treatment using 1000 ppm IBA provided 55% rooting against the 21% rooting shown by the control. The layering experiments showed that it had taken seventy days for the development of roots and had 90% success rate with semi-hard branches. As part of restoration trials, a continuous monitoring and surveillance on the saplings of *L. speciosa* planted in the field shown different degrees of field performance in the establishment process. The saplings planted at Chaliarmukku forest areas have 70% success rate in field establishment.

Lead garden programme

Establishment of RET Species Park

The proposed programme is a novel and it is an addition to the garden and will serve as a demonstration plot for establishing endemic and RET species of Western Ghats at one place. In short, the RET species park is an *ex-situ* conservation of extinction prone species and such a collection will act as gene sanctuary for future restoration programmes.

For establishing the park, a 5 acre lands had been selected which are under original moist deciduous forest. Subsequently, shade, undergrowth, Lianas and other species were regulated for new planting. Simultaneously, the irrigation system has been established. For the last four years (2009-10 to 2011-14) 1250 seedlings which include 44 RET species and 95 endemics of Western Ghats were introduced. Eminent personalities of National and International importance planted seedlings in the RET species park. Prof. Mabberley,

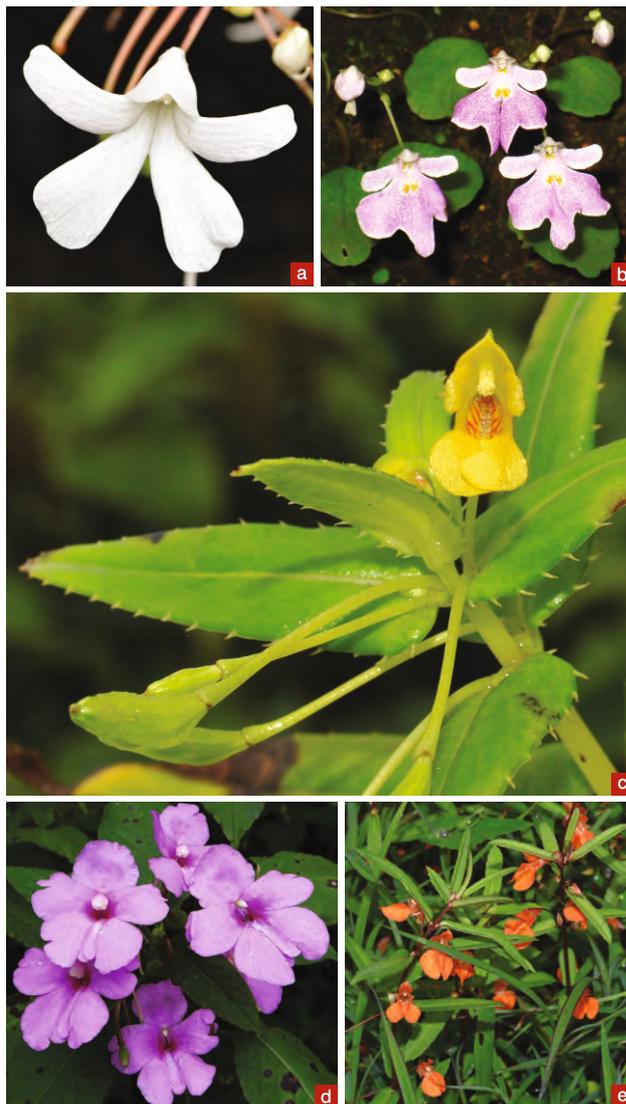
Herbarium in-charge, Kew Gardens and Prof. Hans Fliegner, Curator (Retd.), Kew Gardens, UK planted during their visit to JNTBGRI. Proper after care operations were being taken up and almost all seedlings were established satisfactorily. Now display boards containing all passport details of plants are getting ready and the same will be kept with individual species. College students were encouraged to plant the seedlings during their visit as well as on Environment day observation on June 5th of every year. The establishment of RET species park in the garden will be globally recognized for our conservation efforts.

Construction of climate control Green house and Shade house

The MoEF & CC had sanctioned the construction of climate control Green house for Balsams and a Shade house for acclimatization of plants produced by conventional propagation for the development of RET species park and reintroduction programme. During the period under report, the Green house and the shade house construction had been completed. Both these Shade house and Green house augment the facilities established to overcome for maintenance of balsams and other RET species from throughout Western Ghats and certainly enhance the conservatory value of the Botanic Garden.

Collection of Rare and Endemic Balsams

In India the genus is represented by 200 species and mainly distributed in 3 major centers of diversity. i.e. Western Himalayas, Hills of North Eastern States and Western Ghats. Out of 92 species available in Peninsular India, more than 80 are endemic and confined to Western Ghats. Thirty species of *Impatiens* are already in threatened category including 19 critically endangered. Though, the ideal climatic conditions prevailing in the Western Ghats region provides suitable habitats for the Balsams, the population is rapidly declining due to various factors like habitat degradation, fragmentation of population, lack of specific pollinating agents, poor fruit set, improper seed dispersal and other reproductive problems. Keeping in view of these facts, 25 rare and endangered balsam species were selected for collection and conservation in a specially designed Balsam house. Before establishing the Balsam house, we took explorations to various parts of Western Ghats and collected all the designated species and reintroduced in the garden (Table 1). At present shrubby balsams grow and flowering in the garden. Other species being annual, they will be introduced during monsoon. All these species will be maintained once balsam house construction completed with controlled environmental conditions.



a. *Impatiens acaulis* Arn. (white form); b. *Impatiens dalzellii* Hook. f. & Thomson; c. *Impatiens barberi* Hook. f. d. *Impatiens pulcherrima* Dalzell; e. *Impatiens verticillata* Wight

Standardization of propagation techniques of RET species

Standardization of propagation protocol for the endemic and RET species had been envisaged in the Lead Garden programme for future restoration. 20 Rare and endemic species were selected for the above purpose. Propagation protocols for all the species were standardized. The important species among them are: *Coscinium fenestratum* (Gaertn.) Colebr., *Dysoxylum malabaricum* Bedd. ex Hiern., *Embelia ribes* Burm. f., *Goniothalamus rhynchantherus* Dunn., *G. wightii* Hook. f. & Thoms., *Knema attenuata* (Wall. ex Hook. f. & Thom.) Warb., *Litsea travancorica* Gamble, *Ochreinauclea missionis* (Wall. ex G. Don) Rids., *Poeciloneuron pauciflorum* Bedd.,

Sl. No.	Name of taxa	Sl. No.	Name of taxa
1	<i>Hydrocera triflora</i> Wight & Arn.	21	<i>I. lawii</i> Hook. f. & Thoms.
2	<i>Impatiens acaulis</i> Arn.	22	<i>I. leptura</i> Hook. f.
3	<i>I. anaimudica</i> Fischer	23	<i>I. lucida</i> Heyne
4	<i>I. auriculata</i> Wight	24	<i>I. modesta</i> Wight
5	<i>I. barberi</i> Hook. f.	25	<i>I. munnarensis</i> Barnes
6	<i>I. clavicornu</i> Turz.	26	<i>I. munronii</i> Wight
7	<i>I. coelotropis</i> Fischer	27	<i>I. nataliae</i> Hook. f.
8	<i>I. concinna</i> Hook. f.	28	<i>I. neo-barnesii</i> Fischer
9	<i>I. cuspidata</i> Wight & Arn.	29	<i>I. pandata</i> Barnes
10	<i>I. dalzelli</i> Hook. f. & Thoms.	30	<i>I. parasitica</i> Bedd.
11	<i>I. dasysperma</i> Wight	31	<i>I. parviflora</i> Bedd.
12	<i>I. dendricola</i> Fischer	32	<i>I. phoenicea</i> Bedd.
13	<i>I. densonii</i> Bedd.	33	<i>I. platyadena</i> Fischer
14	<i>I. elegans</i> Bedd.	34	<i>I. pulcherrima</i> Dalz.
15	<i>I. floribunda</i> Wight	35	<i>I. scabriuscula</i> Heyne ex Roxb.
16	<i>I. fruticosa</i> Leschen ex. DC.	36	<i>I. stocksii</i> Hook. f.
17	<i>I. grandis</i> Heyne ex Wall.	37	<i>I. tangachee</i> Bedd.
18	<i>I. jerdoniae</i> Wight	38	<i>I. travancorica</i> Bedd.
19	<i>I. johnii</i> Barnes	39	<i>I. viridiflora</i> Wight
20	<i>I. kulamavuensis</i> Pandur. & Nair	40	<i>I. wightiana</i> Bedd.

Table 1. Collection of Rare and Endemic Balsams of Western Ghats

Vateria indica L. etc.

Herbarium Management and Development

During the period 26 field tours were conducted and collected 3145 specimens representing 960 species. All the specimens were processed, 1390 specimens were mounted for filing and rest kept unmounted for reference. The division staff incorporated 2690 sheets by writing labels and also chemically treated wherever required. As part of maintenance, fumigation has been carried out for 30312 sheets and is now worth for regular examination. In addition, renovation of old specimens, re-poisoning, general indexing etc. were carried out. The current status of herbarium is given.

1	Specimens in the herbarium as on March 2016	: 30312
2	No. of specimens processed	: 3145
3	No. of species collected for the reporting period	: 960
4	Mounted for filing	: 1390
5	Un mounted for reference	: 1755
6	No. of specimens incorporated	: 2690
7	No. of Nomenclature Correction carried out	: 141
8	Specimens received for incorporation	: 2120
9	Identification and labelling	: 380
10	Indexing of General Herbarium specimens	: 2690
11	No. of sheets renovated	: 45
12	No. of enquiries attended	: 520
13	Species additions to herbarium	: 42
14	Genus addition to herbarium	: 7
15	No. of sheets fumigated	30312

Division of **Ethnomedicine and Ethnopharmacology**

The mandate of the division is to conserve, preserve and sustainably utilize the rich traditional herbal wealth and knowledge system of our country, bioprospecting of medicinally important plants based on traditional knowledge and to translate/extend the outcome of the research into action for the benefit of the common people at the grassroots, inter-institutional collaborative research programmes, product development and technology transfer.

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, preparation of database. Ethnopharmacological studies mainly focus on traditional knowledge based preclinical drug discovery that involves identification of active molecule/fraction/formulation through activity guided fractionation, safety evaluation, *in vitro/in vivo* studies and elucidation of cellular/molecular mechanism through molecular pharmacological approach. Preparation and standardisation of novel herbal remedies/neutraceuticals/formulations and other plant based products.

Achievements of Projects

During the reporting period, the division implemented 5 externally funded projects (WGDP, NMPB, DBT and SMPB), 6 in-house projects (KSCSTE), 2 Young scientist programmes (DST-SERB) and 2 Post-doctoral fellow (KSCSTE) programmes. From the division, 2 Ph. Ds were awarded, 1 Ph. D was submitted, 9 Ph. D. programmes are being pursued and 5 dissertation programmes are in progress.

Internal Projects

In the in-house project entitled "Anti-inflammatory, analgesic and anti-arthritis activity of two selected plants of the Western Ghats, Kerala" for the burn wound model study,

ethanolic leaf extract (in the form of ointment) of the coded plant NC 6.5% W/W, showed significant increase in the rate of wound contraction compared with the control animal. The hydroxyproline content was significantly greater than the control group. The histopathological studies also supports the wound contraction (Fig 1). The coded drug NC showed significant phagocytic activity in carbon clearance test. NC (450 mg/kg) significantly ($P < 0.05$) enhanced the phagocytic index (0.1058 ± 0.002) of reticuloendothelial system compared to the normal control (0.0480 ± 0.003). Platelet augmentation study of ethanolic fraction of leaves of coded plant NC (150 mg/kg) was found to significantly increase the platelet count ($2893 \times 10^3 \mu\text{l}$) when compared to standard control *Carica papaya* leaf aqueous extract at 800 mg/kg

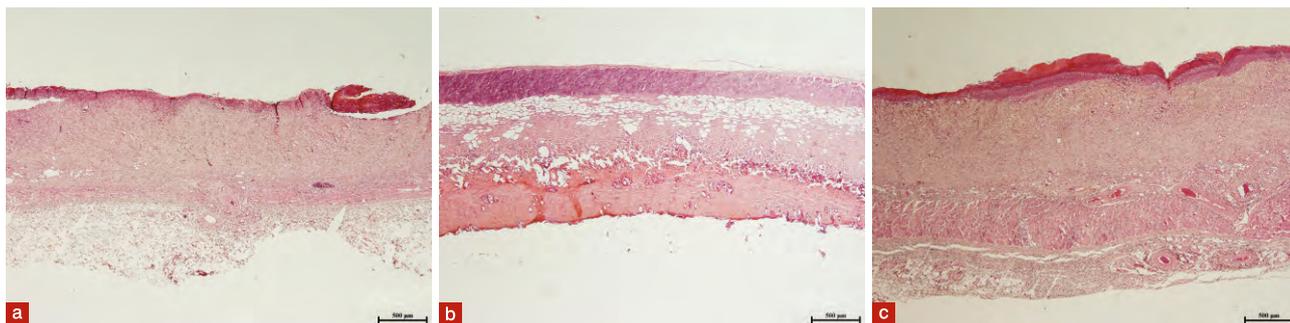


Fig. 1. Histopathology of healed skin at day 12 stained with H & E (4x); a. Skin of control rat showing less epithelisation and moderately proliferate fibroblastic cells and collagen deposition which indicate incomplete healing of wound; b. Silver nitrate gel treated rats showing fibroblastic cells and collagen deposition and blood capillaries; c. Ethanolic leaf extract(ointment)of NC (6.5% W/W) treated rats showing complete epithelisation, fibroblast proliferation, collagen deposition and blood vessel formation.

(2065X10³ μ l). There was a significant reduction in blood clotting time (89.43 \pm 1.52 sec) compared to that of control group (93.57 \pm 2.49 sec). The toxicity analysis of the ethanolic fraction of coded plant NC did not produce any marked variation in hepatic and renal function tests when compared to the normal control. The chronic toxicity study for 90 days also confirmed the non-toxic nature of the extract.

In the in-house project entitled "Clinical trial of coded hepatoprotective herbal formulation in-collaboration with OUSHADHI, Govt. of Kerala", root bark of *Tabernaemontana alternifolia* L. and root of *Thottea siliquosa* (Lam.) Ding Hou were extracted with 98% ethanol (10.6%W/W) and preliminary phytochemical analysis showed the presence of protein, alkaloids, steroids, terpenoids, Phenolic compounds, flavonoids and glycosides. *In vitro* DPPH radical scavenging assay of *Tabernaemontana alternifolia* showed 85% inhibition in 200 μ g/ml.

In the in-house project entitled "Search for anti-diabetic, hepatoprotective, immunomodulatory and wound healing plants from traditional/tribal/folklore medical information of Kerala", ethanolic extract of *Pyrrosia heterophylla* (L.) M. G. was prepared and preliminary phytochemical studies showed the presence of alkaloids, flavanoid, phenols, saponin, carbohydrate, steroid, glycosides, tannins, terpenoids etc. *In vitro* DPPH radical scavenging assay of *P. heterophylla* showed 60% inhibition in 200 μ g/ml. The Coded drug 222 showed significant *in vitro* free radical scavenging activity. The total phenolic, total flavonoid and condensed tannin (Proanthocyanidins) content of the coded drug 222 extract was estimated as 107 mg/g GAE, 132.54 mg/g QE and 187.90 mg/g CE respectively. The coded drug 222 (25 μ g/ml) exhibited significant (87.09%) inhibition of hydrogen peroxide radicals in *in vitro* hydrogen peroxide radical scavenging assay. *In-vitro* antioxidant studies such as super oxide radical scavenging assay and hydroxyl radical scavenging assay were carried out in coded drug 222 ethanolic extract. The extract at 25 μ g/ml (64% inhibition) and 50 μ g/ml (60.94% inhibition) exhibited significant activity against hydroxyl

radicals. Coded drug 222 ethanolic extract at 50 μ g/ml (37.01% inhibition) exhibited maximum free radical scavenging activity against superoxide radicals. The Ferric Reducing Antioxidant Power (FRAP) of coded drug 222 was determined as 26.90 μ M Trolox Equivalents/g.

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 was conducted among the Malavedan tribal community of Naranammoozhi Gramapanchayath, Ulladar and Malavedan tribal communities of Chittar Gramapanchayath and Malapandaram tribal community of Seethathodu Gramapanchayath in Pathanamthitta district and Kadar and Malamalasar tribal communities of Nelliampathy Gramapanchayath of Palakkad district. Interviewed 114 knowledge holders and collected 828 ethnomedical information. Overall, information on 521 single drugs, 213 combination drugs and 94 information on plants used for food were documented. Out of this, 98 plant species are used as single drugs, 58 plant species as combination drugs, 47 plant species for food. Field work at Pathanamthitta district has been completed and Palakkad district is in progress (Table 1), (Fig. 2).

In the in-house project entitled "Ethnobotanical Survey in the coastal areas of three southern districts of Kerala"- Ethnobotanical studies of coastal areas of Kulathoor, Venganoor and Kottukal Gramapanchayaths of Thiruvananthapuram district, Clappana Gramapanchayath of Kollam district and Arattupuzha, Ezhupunna, Pattanakkadu and Mararikulam Gramapanchayaths of Alappuzha district were completed. Interviewed 198 knowledge holders and collected 543 Ethnobotanical information. Overall, information on 241 single drugs, 302 combination drugs, 88 information on plants used for food, 46 information on plants used as tools for fishing and 9 information on plants used for fuel were collected and documented. Survey of Thiruvananthapuram district has been completed and Kollam and Alappuzha districts are in

Description	Seethathodu Gramapanchayath (Malapandaram)	Naranammoozhy Gramapanchayath (Malavedan)	Chittar Gramapanchayath (Ulladar)
Total number of persons interviewed	25	30	22
Total number of informations documented	236	288	162
Single drug informations documented	164	198	93
Combination drug informations documented	18	30	69
Food plant informations documented	54	60	30
Number of plant species used as single drugs	56	62	43
Number of plant species used as combination drugs	25	31	21
Number of plant species used as food	46	58	28

Table 1

progress. Relevant photographs, video clippings and herbarium specimens were collected and documented (Fig.3). The habitats of important medicinal plants like *Excoecaria agallocha* L., *Lanea coromandelica* (Houtt.) Merr., *Quassia indica* (Gaertn.) Nooteb., *Aristolochia indica* L., *Bacopa monnieri* (L.) Pennell., *Morinda citrifolia* L. etc were identified and relevant photographs taken and herbarium specimens collected. Awareness was imparted on conservation and importance of coastal plants among the Panchayath members and local people. The Ethnobotanical survey of Mayyanad (Kollam) Arattupuzha, Purakkad (Alappuzha) Gramapanchayaths were completed and analysed the data

gathered from Mayyanad, Arattupuzha and Purakkad Gramapanchayaths. Collected 323 informations on 181 plant species used for various ethno-medico-botanical purposes by



Fig. 2. Systematic documentation of Traditional Knowledge in Pathanamthitta and Palakad districts - a. *Cullenia exarillata* Robyns – seeds used as food by Kadar tribes of Nellyampathy; b. *Curcuma aromatica* Salisb (kasthurimanhal) - growing in wild; c. Documentation of Traditional Knowledge - Interaction with Malamalasar tribes of Nellyampathy; d. Malapandaram tribal family at Gavi

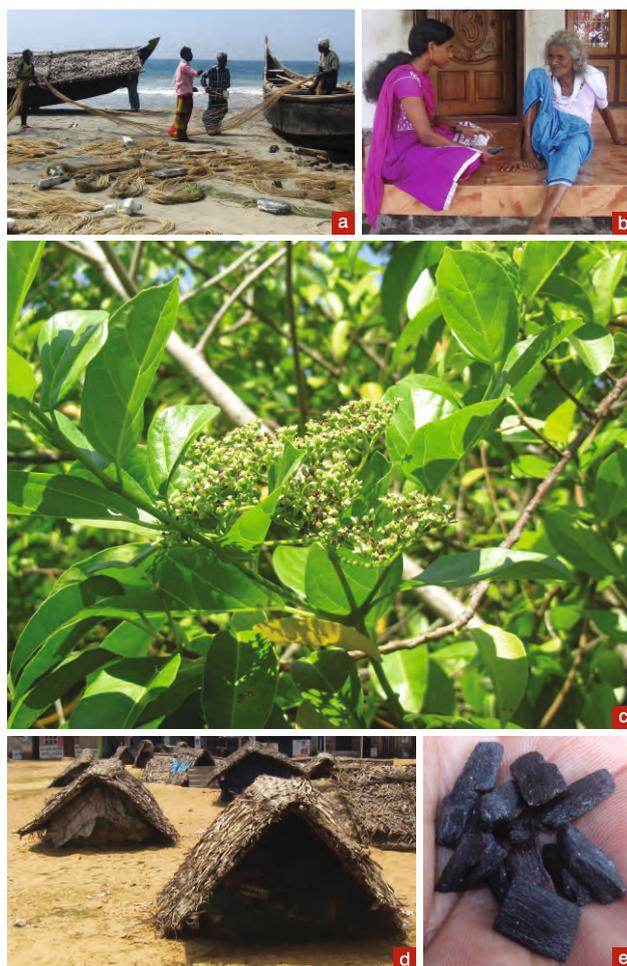


Fig. 3. Ethnobotanical survey in the coastal areas of Thiruvananthapuram, Kollam and Alappuzha districts - a. Fishermen in activity at Venganoor Gramapanchayath; b. Sea of Knowledge – Interaction with 88 year old informant at Clappana Gramapanchayath; c. *Premna serratifolia* L. (Munja) – used as fishing aid; d. Traditional Vallappura at Venganoor Gramapanchayath; e. *Vishakallu* – medicated stone potentiated with anti-poisonous plants for snake bite

Description	Mayyanad	Arattupuzha	Purakkad
	Gramapanchayath	Gramapanchayath	Gramapanchayath
	(No. of species used)	(No. of species used)	(No. of species used)
Total No. of Information documented	161	78	84
No. of Plant species used for making fishing tools	18	10	12
No. of Plant species used in single drugs	37	26	24
No. of Plant species used in combination drugs	63	12	14
Food plant species	26	10	12
Fodder	7	5	7
Fuel	10	5	4
Other uses	23	10	11

the local community including fisher folk (Table. 2).

In the in-house project entitled "Evaluation of Platelet augmentation activity of selected medicinal plants of Western Ghats based on Traditional Knowledge" - The comparative platelet augmentation activity of coded plants VN (200mg/kg) and TA (200mg/kg) were carried out based on the traditional information and all the results were compared with leaves of a reported platelet augmenting plant *Carica papaya* L. All the extracts showed potent platelet augmentation activity and TA showed maximum activity by augmenting the platelet count to $1345 \times 10^3/\mu\text{L}$, whereas Cyclophosphamide (50 mg/kg) treatment reduced the platelet level to $750 \times 10^3/\mu\text{L}$ on 11th day. The clotting time, Prothrombin time and Activated Prothrombin time of all the treatment groups were found to be considerably lower than that of toxicant group. (Fig. 4 & Table 3).

In the external project (WGDP) entitled "A study on the Jasmine varieties of Western Ghats producing high essential oil content with special emphasis on commercialization of essential oil for perfumery by rural women for their empowerment." field trips were conducted for germplasm collection at Pathanamthitta district and Tirunelli Wayanad district. *Jasminum auriculatum*, *J. azoricum*, *J. coarctatum*, *J. grandiflorum*, *J. malabaricum*, *J. multiflorum*, and *J. sambac* were collected from the above places. The Herbarium specimens were prepared. Organized an awareness programme with many rural women at various place in Bharathannur, Thiruvananthapuram district. Selected 10 beneficiaries were given interactive session and training programmes about jasmine cultivation practices, harvesting

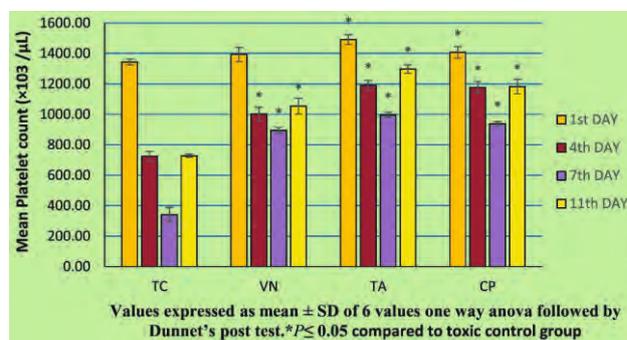


Fig. 4

techniques, extraction of essential oil etc. The Jasmine saplings were distributed along with fertilizers and Bordeaux mixture. Conducted periodical field visits to Bharathannur and evaluated the cultivation progress. The stipends for beneficiaries were distributed at every month. Hydro distillation of *Jasminum sambac* fresh flower were carried out and achieved 0.09 % & 0.05% yield respectively at different times.

In the external project (SMPB) entitled "Assessment of Medicinal Plants Resources of Kerala" (seven southern districts), completed the check list of medicinal plants of Alappuzha, Pathanamthitta and Kottayam districts based on the primary and secondary data. Completed district wise directory of Alappuzha and Pathanamthitta districts. The directory consists of 469 medicinal plants in Alappuzha and 643 medicinal plants in Pathanamthitta districts. During the reporting period, we have conducted 24 field surveys at different physiognomic regions of Alappuzha, Pathanamthitta

Treatment groups	Prothrombin time (sec)	Activated partial thromboplastin time (sec)	Mean clotting time on 15 th day(sec.)
Normal Control	24.25 ± 4.32	57.83 ± 4.54	87.50 ± 2.13
Cyclophosphamide (50 mg/kg)	44.70 ± 3.41*	126.70 ± 6.47*	144.25 ± 6.21*
VN (100 mg/kg)	40.54 ± 3.43	89.20 ± 5.75	101.34 ± 3.15**
TA (100 mg/kg)	28.34 ± 2.86*	61.44 ± 4.34**	92.50 ± 2.03**
<i>Carica papaya</i> (100 mg/kg)	29.47 ± 5.36*	64.49 ± 4.55**	98.43 ± 2.48**

Values expressed as mean ± SEM of 6 values one-way ANOVA followed by Dunnett's multiple comparison test. * $p \leq 0.05$ compared to normal control, ** $p \leq 0.05$ compared to toxic control (Cyclophosphamide) group

Table 3

and Kottayam districts. We had conducted survey in the 140 sacred groves (Cherthala, Ambalappuzha, Karthikapalli, Mavelikkara, Chengannur and Kuttanadu Taluk areas) of Alappuzha district. The sampling surveys was completed in Pathanamthita district. Total, 190 different habitats were surveyed in Evergreen, Semi-evergreen, Moist deciduous and Plantations. Directory and passport script data for Alappuzha and Pathanamthita districts were completed. Kottayam, Idukki and Ernakulam districts are in progress with a view to assess the availability of medicinal plants. Collected base line data and general information for the preparation of Data base of all seven districts (Fig. 5).

In the external project (DBT) entitled "Antivirals from medicinal plants of Western Ghats selected based on Traditional Knowledge (TK)/ethno medicinal information"- Based on literature survey of antiviral plants from various sources, 30 medicinal plants were shortlisted and 27 plants were collected, herbarium specimens were prepared, powdered and processed. From the plants, 31 hydro

alcoholic extracts have been prepared. The 12 extracts were transferred to RGCB for the initial screening of anti-chikungunya activity. According to the results obtained, out of 12 extracts, four extracts (JNTBG VR 01, 04, 08 & 09) possessed significant anti-chikungunya activity and were shortlisted for further studies (Fig. 6).

In the external project (DBT) entitled "Bio-prospecting of two coded anti-diabetic medicinal plants based on ethno medical leads with special reference to diabetic complications-A molecular pharmacological approach"; 15 plants were collected from the Western Ghats, herbarium specimens were prepared. The collected plants were processed, powdered and 15 hydro alcoholic extracts were prepared. 13 extracts have been transferred to NIIST for the screening of *in vitro* anti-diabetic activity and two extracts (JNTBG DN 06 & 07L) got significant anti-diabetic activity in glucose uptake flow cytometry analysis (Fig. 7). *In vitro* HRBC membrane stabilization studies conducted with 13 extracts and two plant extracts (JNTBG DN 05 & 01) possessed



Fig. 5. Assessment of Medicinal Plants Resources of Seven Southern Districts of Kerala. a. Sample collection-Bark of *Pterospermum rubiginosum* Heyne ex Wight & Arn.; b. *Myristica dactyloides* auct. non Gaertn. c. Thamarathu Kavu, an abode of medicinal plants; d. *Morinda citrifolia* L. A vegetation component of coastal sacred groves

significant HRBC membrane stabilization activity. In the case of *in vivo* Glucose Tolerance Test (GTT) with 13 extracts; two extracts (JNTBG DN 05 & 01) showed significant glucose tolerance after high glucose treatment (2gm/kg).

In the external project (NMPB) entitled "Identification of potential Bioactive Chemical Marker Compounds and Biological Studies of *Gloriosa superba* and their Geographical Variations"; Preliminary phytochemical tests showed the presence of alkaloids, flavanoids, phenols, sterols, etc. Nitric oxide scavenging activity of ethanolic extract, *G. superba* (GS) showed 61.32% inhibition at 50 μ L, Ferric reducing antioxidant assay showed 49.72% at GS 80 μ L, Hydrogen peroxide scavenging activity showed 85.14% at GS 100 μ L, Lipid peroxidation assay showed MDA % inhibition of 31.23% at GS 50 μ L. In Carrageenan induced paw oedema study GS (150mg/kg) showed 57.84% inhibition of rat paw volume. Column Chromatography of acetone extract was done and collected six fractions. Different antioxidant assays were carried out to find the most active fraction. Fraction 1, 2 and 4 were found to be effective.

In the external project (DST-YSS) entitled "Pharmacological and molecular expression studies on hepato-protective herbal formulation against liver fibrosis". Herbal formulation (FO) has been prepared using three coded (CP, TL, PL) medicinal plants. Aqueous alcoholic (70%) extract

of FO, CP, TL, PL showed potent *in vitro* hydroxyl and DPPH radical scavenging activity. Among these FO (25 μ g/ml) showed significant radical scavenging activity. *In vitro* primary hepatocyte culture studies showed significant hepatoprotective property of FO (100 μ g/ml) and CP (100 μ g/ml). *In vivo* CCl₄ induced liver fibrosis studies with CP, TL, FO were carried out and FO (500 mg/kg) showed significant anti-liver fibrosis activity. The serum biochemical parameters like AST, ALT, creatinine, SB, albumin, urea, prothrombin time and INR values were elevated after CCl₄ treatment which was reverted after CP, TL and FO treatment. *In vivo* antioxidant defence system (GSH, CAT, and SOD) improved with CP, TL and FO treatment in fibrotic rats. FO (500 mg/kg) and CP (500 mg/kg) treatment reduced the liver TNF- α and COX-II levels. Real Time PCR analysis of CD14, TNF α and NF κ B genes showed the higher expression levels when treated with CCl₄ treatment of FO, CP, TL and Silymarin showed the down regulation of the above said genes involved in inflammatory pathway. Histo-

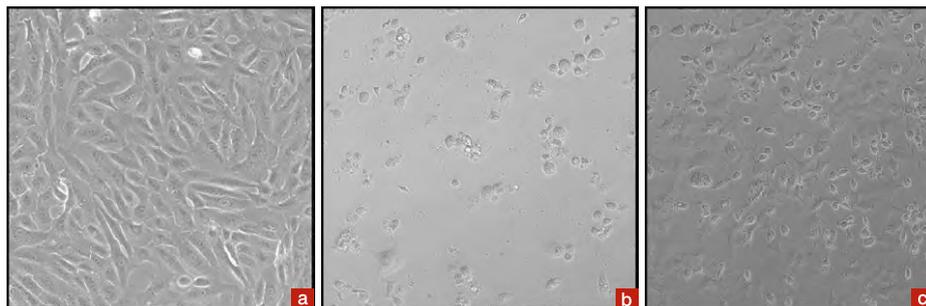


Fig. 6. (a-c) Antiviral activity against Chikungunya virus (CHIKV) clinical strain RGCB355/KL08 on Vero cell. a. Uninfected Vero Cells; b. Vero cells infected with CHIKV; c. CHIKV+50 μ g/ml JNTBGVR04

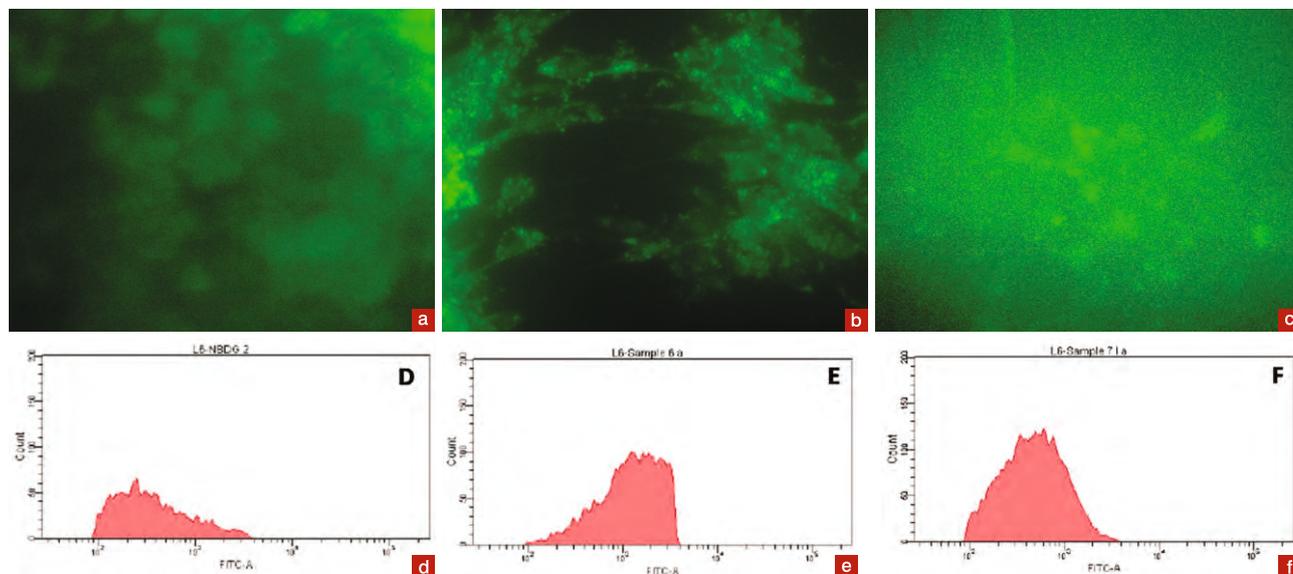


Fig. 7. Glucose uptake study in L6 myotube cells - Confocal microscopy and FACS analysis. a. Confocal microscopy image of L6 myotube cells with Positive control - ROSI.; b. Confocal microscopy image of L6 myotube cells with JNTBGDN06; c. Confocal microscopy image of L6 myotube cells with JNTBGDN 7L.; d. FACS analysis of L6 myotube cells with Positive control - ROSI.; e. FACS analysis of L6 myotube cells with JNTBGDN06.; f. FACS analysis of L6 myotube cells with JNTBGDN 7L

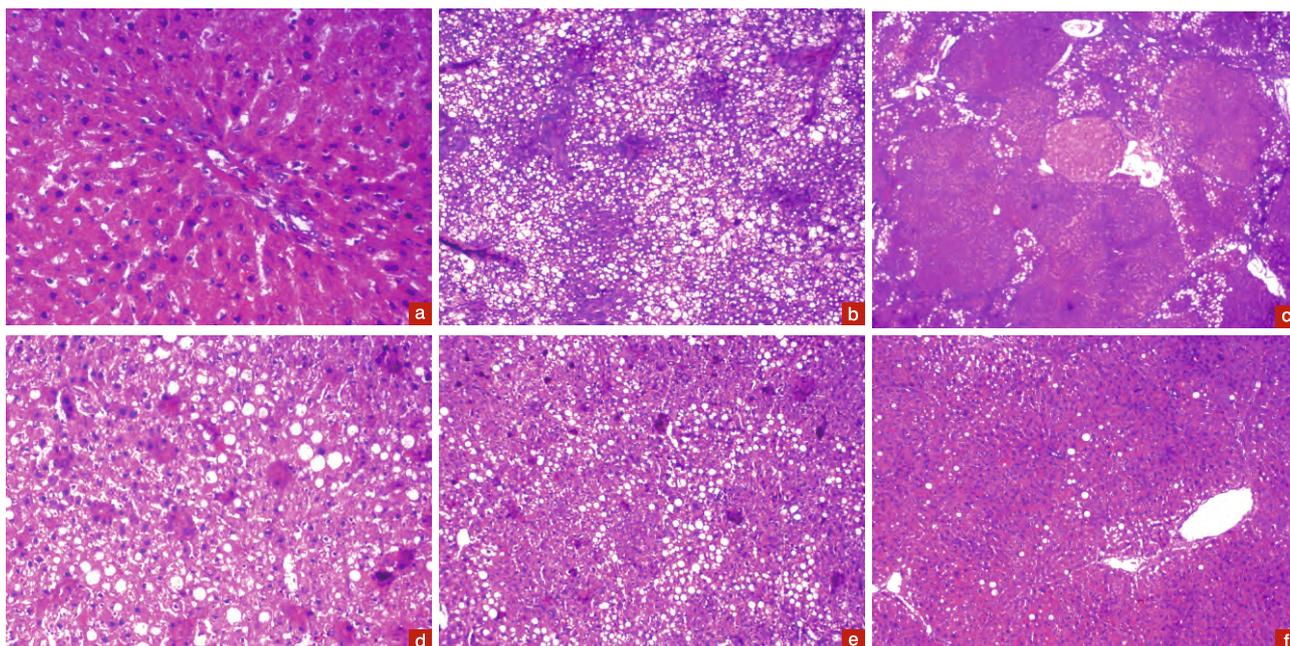


Fig. 8. (a - f). Haematoxylin and Eosin staining of liver section of rat showing liver protection of FO, CP, TL against CCl₄ induced Liver fibrosis; a. Normal liver; b. One month CCl₄ treated rat showing severe diffuse fatty changes, hepatic degeneration & necrosis; c. Three months CCl₄ treated rat showing fibrotic liver with fatty changes, fibrosis, nodule indices; d. Three months CCl₄ treated rats with CP (500 mg/kg) showing fatty degeneration, nuclear pyknosis, focal necrosis but no nodule formation & fibrosis; e. Three months CCl₄ treated rats with TL (500 mg/kg) fatty degeneration, mild fibrosis; f. Three months CCl₄ treated rats with FO (500 mg/kg) minimal degenerative changes among all groups.

pathological studies like H & E staining, Masson trichrome staining and scanning electron microscopic studies also supports the biochemical findings. The present studies revealed FO significantly protect liver from CCl₄ induced liver fibrosis via anti-inflammatory and antioxidant pathway. Tetrandrine (TET) a major alkaloid present in CP was estimated as 3.45% in CP and FO extract contain 2.695% TET. Detection of heavy metal content three plants were estimated using ICP-MS. Heavy metal content was found to be within tolerable levels. (Figs. 8-10)

In the external project (DST- YSS) entitled "A Molecular Approach on Development of a Potent Herbal Drug against Arthritis Based on Tribal/Traditional Knowledge", the main objectives are to develop potent anti-arthritic herbal drug based on traditional knowledge and to elucidate the mechanism of action of the anti-arthritic potency of the herbal drug at molecular level employing *in vivo* and *in vitro* preclinical analysis. Based on the literature survey, 10 promising plants will be collected and subjected to the anti-arthritic study. The most potent plants will be used for the development of herbal drug. The literature survey has been completed. 3 plants (*Drynaria quercifolia* (L.) J Smith (Polypodiaceae) rhizome, *Simaruba glauca* DC (Simarubaceae) *Myxopyrum serratum* A. W. Hill (Oleaceae) root have been collected so far. The plants were subjected to cold extraction (hydroalcoholic extract) as well as hot extraction using soxhlet (serial extraction using hexane, chloroform, ethyl acetate and

methanol). DPPH assay, HRBC membrane study and *in vitro* anti-inflammatory study using RAW 264.7 murine macrophage cell lines are in progress.

In the Post-Doctoral Fellow project (KSCSTE) entitled "Studies on the molecular mechanism of action of anti-inflammatory potential of two traditionally used Pteridophytes in Southern region of Western Ghats"- Identification of naturally occurring phytochemicals that can suppress or downregulate the pro-inflammatory mediators and their upstream transcriptional elements help in the discovery of important anti-inflammatory therapeutics. The folk medicine and traditional herbal remedies and herbal supplements often give miraculous results in treating many dreadful illnesses. The proposed work is aimed to study the anti-inflammatory effect of two ferns present in Western Ghats region which are traditionally used by the tribal people of Kerala. The ferns selected are *Lygodium flexuosum* (L.) Sw. and *Selaginella delicatula* Desv. ex Poir. (Selaginellaceae). *Lygodium flexuosum* (L.) Sw. (Lygodiaceae) was collected from Thiruvananthapuram, Kerala. Ethanol extract of *L. flexuosum* was prepared and the yield was calculated. The antioxidant assays showed that the ethanol extract of *L. flexuosum* possess potent anti-oxidant activity in DPPH radical scavenging and total antioxidant activity. Serial extraction using different solvents is in progress.

In the external project (University of Kerala) entitled

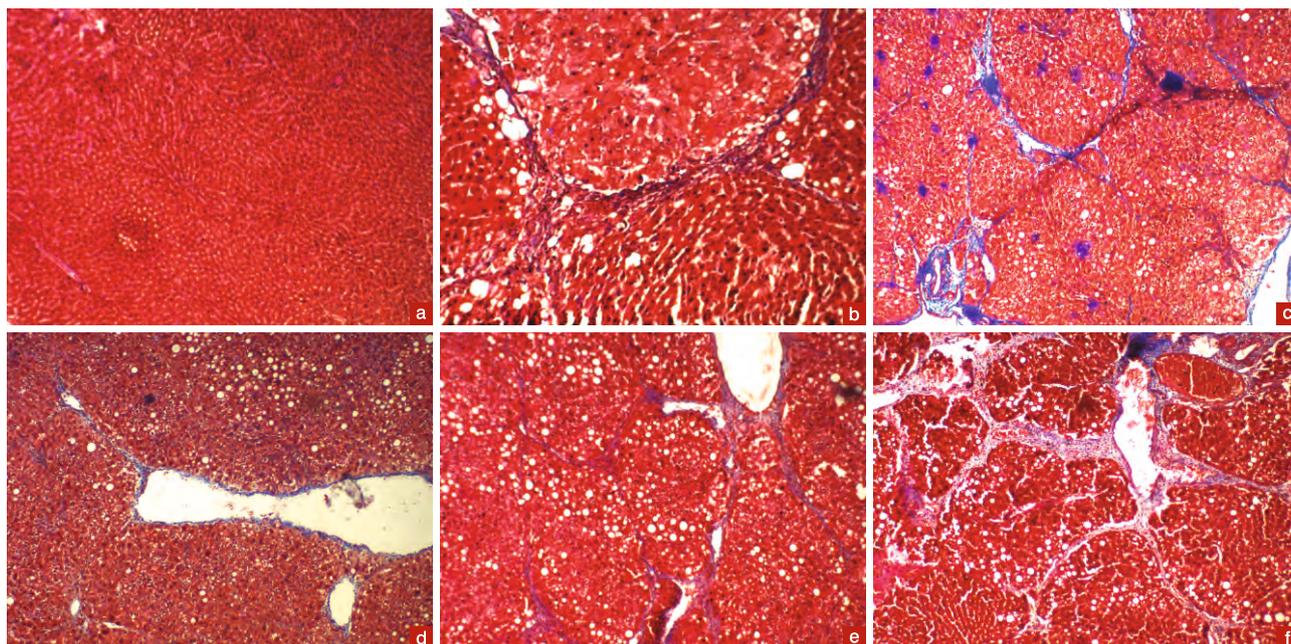


Fig 9. (a - f) Masson Trichrome staining of liver section of rat showing liver protection of FO, CP, TL against CCl_4 induced Liver fibrosis. a Normal liver.; b. One month CCl_4 treated rat showing collagen deposition & necrosis; c. Three months CCl_4 treated rat showing fibrotic liver with collagen; d. Three months CCl_4 treated rats with CP (500 mg/kg) with mild necrosis; e. Three months CCl_4 treated rats with TL (500 mg/kg) mild fibrosis with collagen deposition; f. Three months CCl_4 treated rats with FO (500 mg/kg) minimal necrotic changes

“Mechanism of Immunomodulatory and Antioxidant effects of *Morinda umbellata* L.”; the *in vivo* phagocytic activity of *M. umbellata* (Rubiaceae) leaf ethanolic extract (MU) 200 mg/kg significantly ($P \leq 0.01$) increased the phagocytic index in carbon clearance test, which is a measure of clearance of carbon particles from the blood stream. There was a dose dependent increase ($P \leq 0.05$) in phagocytic index *in vitro* and the maximum percentage of phagocytic stimulation was exhibited by MU (400 $\mu\text{g/ml}$) dose. The total antioxidant capacity of MU was estimated as 56.14 mg AE/gm of the extract.

In the Ph. D. programmes, The LC-MS analysis of *Pellionia heyneana* Wedd. leaf ethanolic fraction (PHEF) was carried out using Xevo G2 Q-ToF. Evaluation of hepato protective activity and antioxidant property of *P. heyneana* ethanolic extract on carbon tetrachloride induced liver damage in Wistar rats showed significant liver protection.

In the external project (ICMR) entitled “Study of the pharmacologically active compounds of *Arenga wightii* Griff”- administration of three graded doses of ethanolic extract of *Arenga wightii* (AW) (125, 250 and 500 mg/kg) showed dose depended decrease in blood glucose level in Alloxan and Streptozotocin induced diabetic rats and was further supported by biochemical serum parameters. In the repeated dose (28 days) oral toxicity study, drug was found to be non-toxic up to 5000 mg/kg.

In the External project (ICMR) entitled “Hepato-protective and Antioxidant Properties of *Oxalis corniculata* L. and

Biochemical/Molecular Characterization of the Relevant Biomolecules.” - Hepatoprotective activity of *Oxalis corniculata* Linn. (OC) against alcohol induced hepatic damage was assessed *in vivo* on Wistar albino rats. The rats were given alcohol and treated with OC 100, 250 & 500 (mg/Kg) respectively for 21 days. The blood serum parameters such as SGOT, SGPT, ALP, glutamate, bilirubin etc were much elevated in the ethanol treated group compared to the drug treated group, the liver histopathology supports the observation. More over the effect of the extract at the molecular level was assessed by checking its effect on the level of expression of $\text{TNF}\alpha$, $\text{NF}\kappa\text{B}$ and CD 14 mRNA levels. The levels of $\text{TNF}\alpha$, $\text{NF}\kappa\text{B}$ and CD 14 were found to be elevated in the toxin treated group, the drug treated group showed a decrease in the expression levels comparable to that of normal control group indicating the protective activity of *Oxalis corniculata*.

In the external project (DST-INSPIRE) entitled “Evaluation of Hepatoprotective, Anti-oxidant and Anti-inflammatory potential of Coded plant TA., an ethnomedicinal plant”; In sub-chronic oral toxicity study (28 days), TA was found to be non-toxic up to 1400 mg/kg (Fig. 11). Short term *in-vitro* cytotoxicity studies were carried out in Dalton Lymphoma Ascites Cells (DLA) and Ehrlich Ascites Carcinoma cells (EAC). In DLA, TA crude extract at 200 μl showed 85% of cytotoxicity and TA ethanol fraction at 200 μl showed 75% cytotoxicity. In EAC, TA Crude extract at 200 μl showed 90% of cytotoxicity and TA ethanol fraction at 200 μl showed 78% cytotoxicity. TA showed

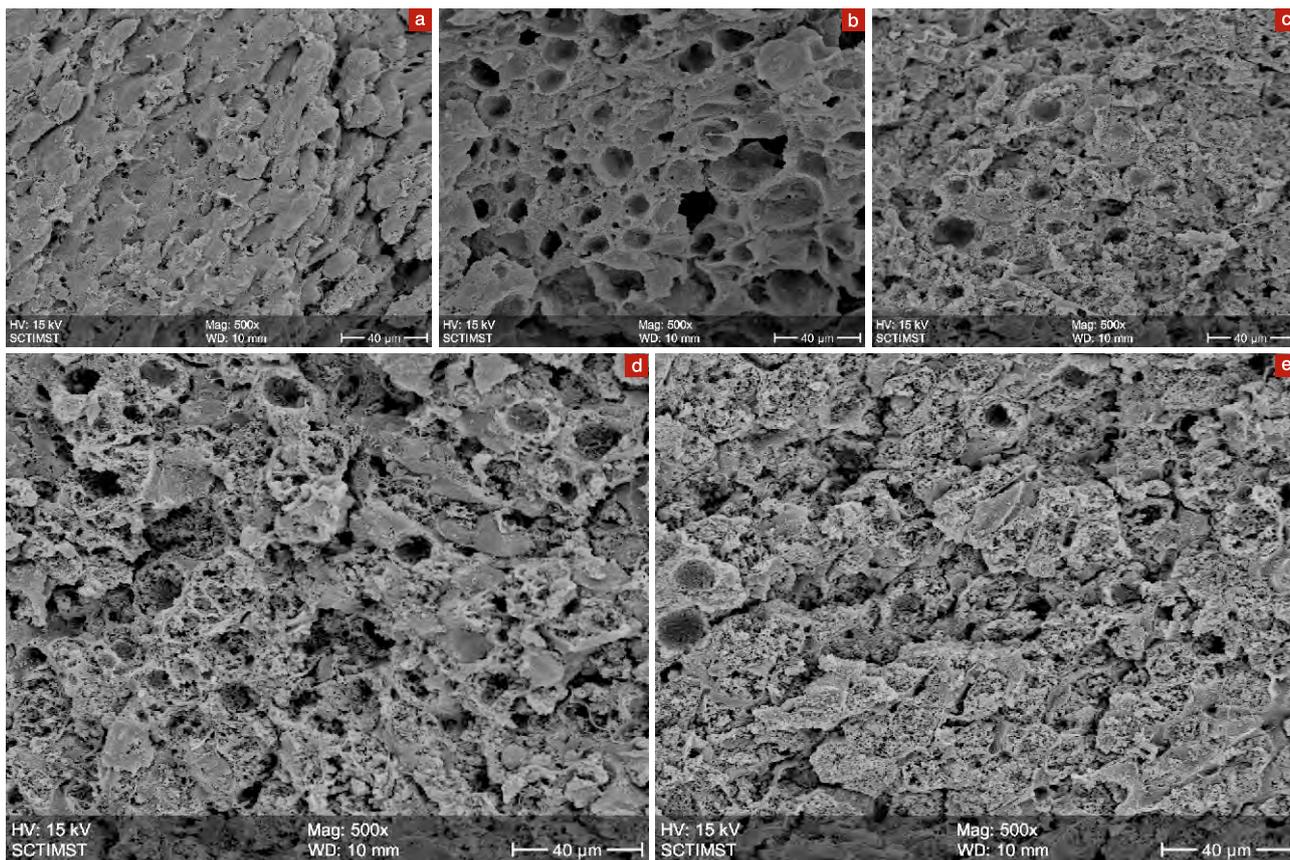


Fig. 10. (a - e) Scanning electron Microscopy of liver section showing liver protection of FO, CP, TL against CCl_4 induced Liver fibrosis; a. Normal liver; b. Three months CCl_4 treated rat showing fibrotic liver with necrosis; c. Three months CCl_4 treated rats with CP (500 mg/kg) showing mild necrosis; d. Three months CCl_4 treated rats with TL(500 mg/kg)with necrosis; e. Three months CCl_4 treated rats with FO (500 mg/kg) minimal necrosis

potent *in vitro* anti-oxidant property, 200 μl of TA crude extract showed $232.29 \pm 2.93 \mu\text{g}$ Trolox equivalent Ferric iron reducing capacity for FRAP assay, $93.41 \pm 2.23 \mu\text{g}$ for Nitric oxide radical scavenging activity and in *in-vitro* lipid peroxidation the IC_{50} value for TA crude extract was $119.4 \pm 3.86 \mu\text{g}$. In the analgesic studies (Hot plate study) TA showed significant dose dependent analgesic activity comparable to standard acetyl salicylic acid. In Cotton pellet induced granuloma studies, TA (50mg/kg, 150mg/kg and 450mg/kg) showed significant dose dependent inhibition of oedema and granuloma formation and the results were comparable to the standard drug Indomethacin (10 mg/kg).

In the Sub- chronic toxicity study of the ethanolic extract of *Schumannianthus virgatus* (Roxb.) Rolfe (SV), SV administration upto 5000 mg/kg body weight did not show any kind of morbidity or mortality. The results of sub chronic toxicity study indicate that SV is fairly nontoxic, upto 5000 mg/kg.

The ethanolic extract of *Asystasia chelonoides* Nees showed significant hepatoprotective effect against alcohol and D-Gal induced liver damage by decreasing levels of serum enzymes, Serum Glutamate Pyruvate Transaminase (SGPT), Serum Glutamate Oxaloacetate Transaminase (SGOT), Alkaline Phosphatase (SAKP) and Bilirubin(SB).

Division of Microbiology

Bio-prospecting and sustainable utilization Microbial wealth of Western Ghats is the mission of Microbiology Division. The other activities includes; Bio-prospecting for Microbial Enzymes of Industrial importance; Small Heat Shock Proteins: Functional analysis; Target based Antimicrobial Screening Studies; Systematic studies of Micro-fungi and Lichens and Extension programmes. The division is hosting two DST-Fast track Scientists Dr. Satheeshkumar and Dr. Asha Poorna, carrying out their research projects. A major extension programme - CARC - is also attached to the division.

Bio-prospecting for Microbial Enzymes of Industrial Importance

Bio catalysis is a favorable alternative to chemical processes and a vital part of green technology. It is an important revenue generating industry due to a global market projected at \$7 billion in 2013 with a growth of 6.7% for enzymes alone. Many microbes particularly bacteria and fungi are currently employed for the production of various industrial enzymes. To meet the increasing demand of robust, high turnover, economical and easily available biocatalysts, research is always channelized for novelty in enzyme or its source or for improvement of existing enzymes by engineering at gene and protein level.

Thermo stable α -amylase production using *Streptomyces griseus* TBG19NRA1

The starch degrading enzyme, α -amylase (endo-1, 4- α -D-glucan-glucanohydrolase EC 3.2.1.1) is widely distributed in nature. This enzyme hydrolyses α -1,4glucosidic linkages randomly and produces oligosaccharides and monosaccharide's, including maltose, glucose and alpha limit dextrin. Amylases are using in the industrial starch conversion process, as in starch liquefaction, maltose production, paper, food, sugar and pharmaceutical industries etc. Microbiology research group of JNTBGRI has isolated and characterised a strain of *Streptomyces griseus* TBG19NRA1 (MTCC 3756) producing a thermo stable α -amylase. Production conditions (submerged) were optimized for the maximum production of the enzyme. Purification of amylase enzyme was attempted and started with ammonium sulphate precipitation, dialysis

and followed by gel filtration chromatography. Among the various ammonium sulphate fractions, 60% fraction showed maximum α -amylase activity and this fractions was subjected for dialyses. The dialyzed product was separated on Sephadex G-100 column chromatography. SDS-PAGE analysis gave a single band of protein with a molecular weight of approximately 60 kDa and the confirmed by zymogram analysis. LC-MS analysis of the purified protein gave 14 prominent ions peaks in the spectrum and was used for protein identification by searching against the Uniprot database using the MASCOT search engine, resulting in one hit. The signal 14.78 was chosen as the target to analyse in the MS mode to identify the precursor ion formed by the ESI ion source. The fragments were analysed further and the results with scores higher than 54 identified the amino acid sequence of 18-mer peptide as GIYGTSGSPGHVTSGADK. The peptide sequences were used for further search in the Uniprot database which showed similarity to α -amylase (Alpha amylase catalytic subunit NCBI A0A059WI) from *Streptomyces albulus*.

Thermo stability is one of the desired industrial factors for amylase and the enzyme resulted maximal activity at 80°C. The thermo stability of purified α -amylase was shown to retain without the addition of CaCl₂ at high temperatures (60, 70 and 80°C). It was observed that the purified enzyme when incubated at 80°C retained (100% activity) and is stable up to 1 h of incubation without the addition of CaCl₂. The enzyme when incubated with CaCl₂ resulted in a decrease of enzymatic activity at 60-80°C from a period of 30 min to 4 h. The study revealed that the purified enzyme was calcium independent in nature. The thermo stability of α -amylase from *S. griseus*

TBGA19NRA1 was compared with that of commercially available α -amylase of *Bacillus licheniformis* (Sigma-Aldrich). Both the enzymes exhibited activity maximum at 80 - 90°C. The activity of purified α -amylase showed slight decline after 80°C, where as in the case of standard α -amylase the thermo stability was retained up to 90°C.

Analysis proved that the effect of enzyme on different substrates, in which the rice starch and potato starch, showed more activity. As calculated from Lineweaver-Burk plots, apparent K_m and V_{max} values were 1.6 mg/ml and 28 mg/ml/min at pH 7 with 0.1 M phosphate buffer. Higher V_{max} and lower K_m had confirmed the efficiency of this enzyme for diverse applications. The enzyme has comparatively high affinity for the substrate.

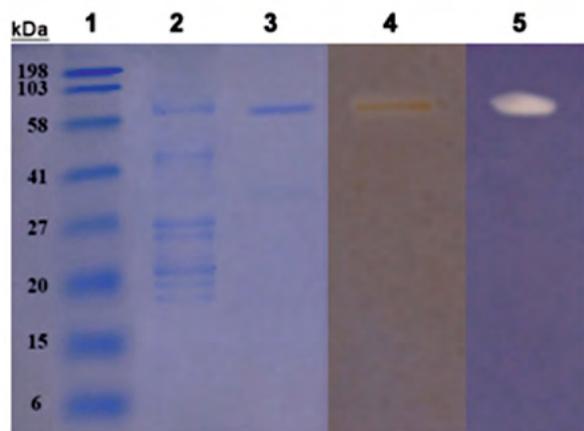


Fig. 1. SDS-PAGE patterns of the purified α - amylase from *Streptomyces griseus*

Lane 1: Molecular weight markers, myosin (198 kDa); α -galactosidase (103 kDa); Bovine serum albumin (58 kDa); Ova albumin (41 kDa) and Carbonic anhydrase (27 kDa); Soybean trypsin inhibitor (20 kDa); Lysozyme (15kDa); Aprotinin (6kDa) Lane 2: Crude enzyme; Lane 3: purified amylase; Lane 4: silver staining; Lane 5 activity staining (zymogram).

Tannase from *Aspergillus* species by Solid State and Submerged Fermentation

Tannin acyl hydrolase is an industrially important enzyme. As the range of applications of this enzyme is very wide there is always a scope for novel tannase with better characteristics, which may be suitable in the diverse fields of applications. Five *Aspergillus* strains *A. niger* AspTBG20(a), *A. japonicus* AspTBG22(d), *A. aculeatus* AspTBG24 (b), *A. niger* AspTBG28(a) and *A. niger* AspTBG30 with potential tannase activity were isolated. Tannase production by solid-state fermentation (SSF) is more advantageous over submerged or liquid surface fermentation and different substrates tried for

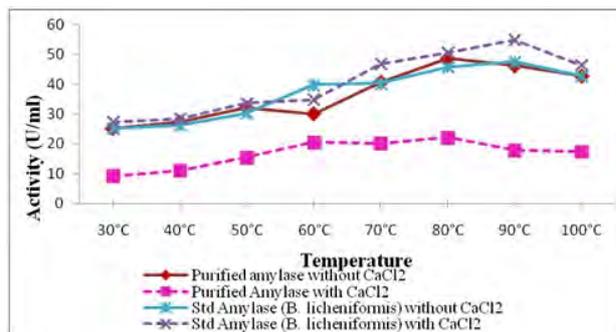


Fig. 2. Effect of Temperature on activity of the purified α -amylase. The activity of enzyme at 80°C was taken as 100%.

tannase production under SSF include rice bran, wheat bran, Jamun leaves, acacia leaves, tamarind seed and coconut kernel cake. 5g each of tannin containing solid substrate were taken in 250-mL Erlenmeyer flasks and moistened with 5 ml of salt solution. The composition of the salt solution was NH_4NO_3 0.5 %, NaCl 0.1 %, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 0.1 % and Tannic acid 1% at pH=5.5. The contents were sterilized by autoclaving. After cooling the sterilized solid substrate was inoculated with 1 ml of the spore inoculum. The contents were mixed properly and incubated at 30 °C for 5 days. Tannase was extracted from the fermented substrate by adding 50 ml of distilled water containing 0.01 % Tween 80. Crude enzyme was separated from the fermented matter by centrifugation at 8000 rpm at 4°C for 20 min. The filtrate was collected in bottles and preserved for further studies. Tannase assay was performed by standard method and enzyme activity was expressed in international units (IU). One unit of tannase activity was defined as the amount of enzyme required to release 1mmol of Gallic acid per minute under standard reaction conditions. From the results it is clear that wheat bran served as good agro-substrate for tannase production by the strains Asp TBG20 (a) and 22 (d).

A screening study was conducted to find out of significant variables for tannase production under solid state fermentation by AspTBG22 (d) using Plackett–Burman design. Design-Expert software (version 10, Stat-Ease Corporation, USA) was used for identifying significant parameters for tannase production. In the present study, effect of 11 physical and nutritional parameters such as incubation time, pH, temperature, inoculums concentration, moisture content, tannic acid concentration, sodium nitrate, ammonium chloride, urea, magnesium sulphate and peptone were investigated as variables using PB design. In this design each selected variable was tested at two levels, low (–1) and high (+1). In Plackett-Burman design, a total of 12 experiments were generated for 11 variables and enzyme activities were measured. The effect of individual variables studied by the PBD was represented in the Pareto chart. From the graph it is clear that four components viz, pH, temperature,

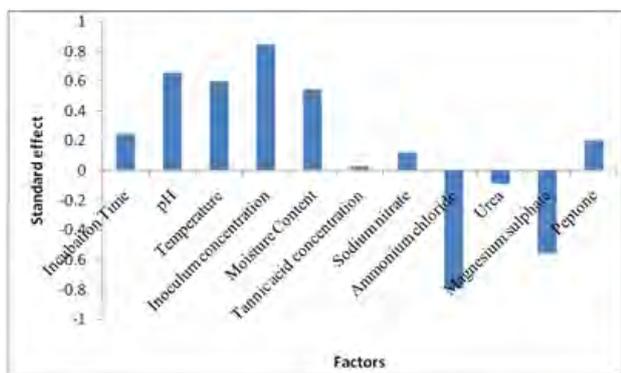


Fig. 3. Pareto chart showing the effects of individual variables on tannase production by *A. japonicus* based on PB experimental results

inoculum concentration and moisture content significantly enhance tannase production. Optimization of production medium using the selected significant variables by Response Surface Methodology is under progress. Simultaneously selection of variables for tannase production by *AspTBG20* (a) using Plackett-Burman Design is also under progress.

Screening and Characterization of Selected chitinase producing *Streptomyces* spp from soil

Chitinases have been receiving an increased attention due to their role in the biocontrol of fungal phytopathogens and harmful insects. A number of bacteria have the ability to produce chitinases, including *Streptomyces*. Fifty strains of *Streptomyces* were isolated from the forest soil samples collected from different locations of Western Ghats of Kerala.

These strains were identified based on morphological, microscopical, biochemical and 16s rDNA sequence similarities. These were further screened for chitinase activities on colloidal chitin agar plates and also using PCR amplification using chitinase gene specific primers. Two isolates TBG 1-A and TBG A-5 were showed promising activity. The isolate TBG A-5 is showing comparatively better production of chitinase in broth media ($560\mu\text{g}/\mu\text{l}$) on 4th day at pH 8.0. The isolate TBG 1-A is identified as *Streptomyces griseus* and TBG A-5 as *S. champavathi*.

β -glucanase from *Streptomyces* spp.

β -glucanase is an industrially important enzyme having application in alcoholic beverages industry. Also have potential role in agriculture like animal feed production and pest controlling. Soil samples were collected from 10 different locations of Western Ghats regions and about 84 pure cultures were isolated and purified. All the 85 isolates were evaluated for qualitative exo- β -1, 4-glucanase production. A total of 81 strains (95% of all strains evaluated) were able to hydrolyze Avicel, specific substrate for assaying exo- β -1,4-glucanase activity, and exhibited obvious growth. The ranges of enzymatic index of evaluated strains were laid between 2.0 to 7.25. 14 strains showed EI values in and above 4.5 are follows: Chi 22 (EI = 4.5); Ana 19 (EI = 6.0); Ner 1 (EI = 4.6); Ner 2 (EI = 4.6); Ner 3 (EI = 7.25); Ner 19 (EI = 4.5); Ner 21 (EI = 4.75); Ner 23 (EI = 4.5); Ner 24 (EI = 4.5); Mun 5 (EI = 4.7); Mar 3 (EI = 4.8); Mar 8 (EI = 5); Mar 9 (EI = 4.7) and Mar 17 (EI = 5). These strains were considered as potent enzyme producers and were selected for secondary screening of exo- β -1, 4-glucanase activity.

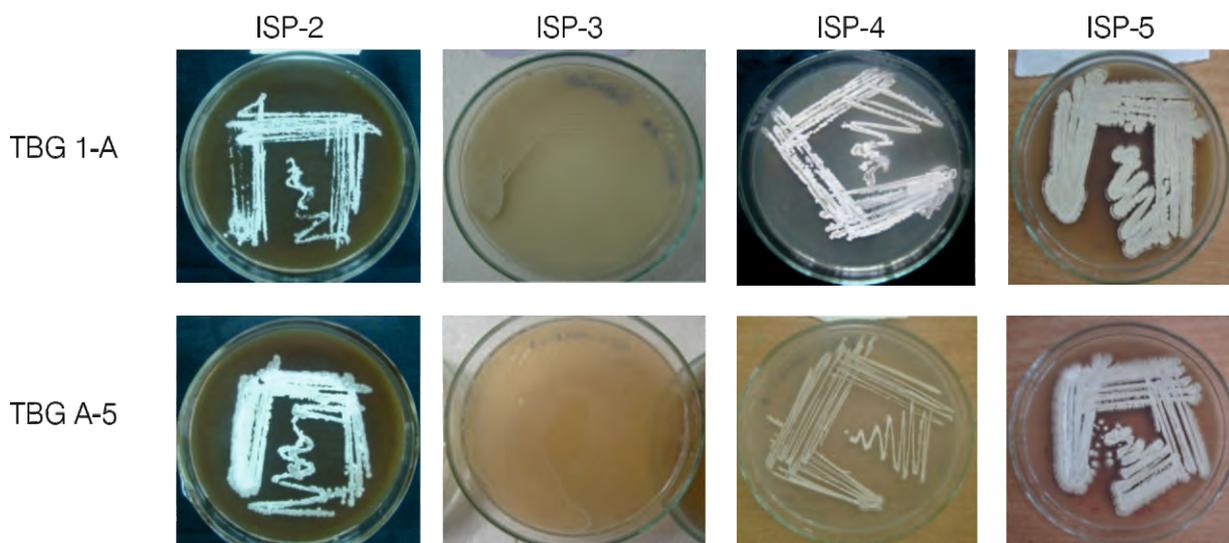


Fig. 4. Colony morphology of TBG 1-A & TBG A-5 on different ISP media. [The growth characters were noted on 14 days old cultures grown on Yeast Malt Agar (ISP-2), Oats meal agar (ISP3), Inorganic salt starch agar (ISP-4), Glycerol asparagine agar (ISP5). The growth pattern and aerial mass colour were noted and photographed]

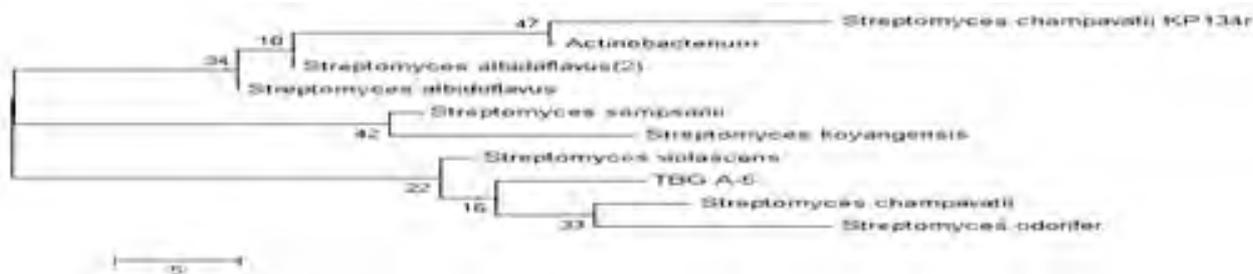


Fig. 5. Phylogenetic tree of 16s rDNA sequence of TBG A-5

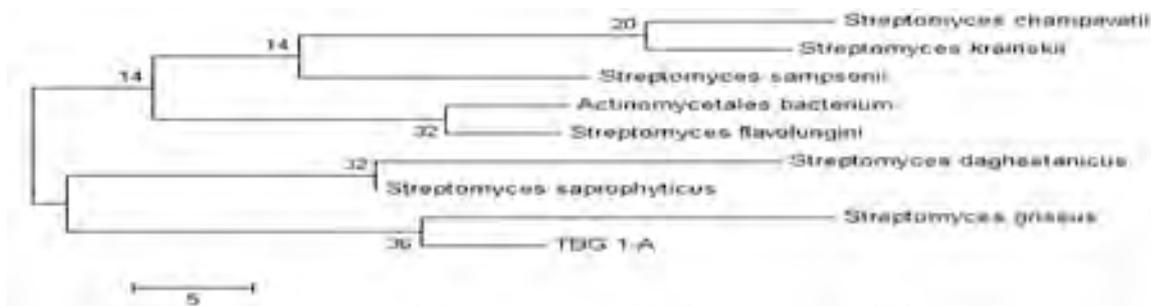


Fig. 6. Phylogenetic tree of 16s rDNA sequence of TBG 1-A

Antifungal Chitinase and pigment from *Streptosporangium nondiastaticum* TBG75A20

Chitin is one of the most abundant natural renewable polysaccharide. Chitin is hydrolyzed by two main enzymes, Chitinase (E: C: 3.1.1.14) and s-N-acetyl hexosaminidase (E.C.3.2.1.52). Chitinases have a wide range of biotechnological applications such as: generation of fungal protoplasts, crustacean chitin waste management, production of single cell protein and bio-control of fungal pathogens. Chitinases so far sequenced are classified in two different families (namely, families 18 and 19) in the classification of glycosyl hydrolases based on amino acid sequence similarities. The family 19 chitinases obtained from actinomycetes have been reported to have antifungal activity. *Streptosporangium nondiastaticum* TBG75A20 is a rare actinomycete isolated from the forest soil of Neyyar Wildlife Sanctuary, Kerala.

The presence of family 19 chitinase specific gene in *S. nondiastaticum* was tested using PCR amplification using family 19 specific primers F19F2 5'-GCCTTCCTCGCC AACGTC-3' and F19R 5'-CCGAGGATCTGGGTGT-3'. Agarose gel electrophoresis of PCR amplification product was carried out and the band obtained was purified by electro elution using dialysis membrane. A homology search was performed with resultant 260 bp sequence using BLAST algorithm. The CLUSTALW programme was used for multiple alignment of *S. nondiastaticum* chitinase gene sequence with similar sequences retrieved from Gene Bank and a phylogenetic analysis was done using MEGA4 software. The

topology of the resultant tree was evaluated by bootstrap analysis of the Neighbour-joining method based on 500 resamples. PCR product having approximately 300bp size was purified using electro elution and sequenced. The 260bp sequence obtained was analysed by NCBI-BLAST and was found to show 89% identity to *Streptomyces plicatus* family 19 chitinase gene. This confirms the presence of family 19 chitinase genes in *S. nondiastaticum*. A phylogenetic tree was constructed from the partial sequence using Neighbour-joining method. The partial sequence show high similarity to family 19 chitinases of numerous *Streptomyces* and

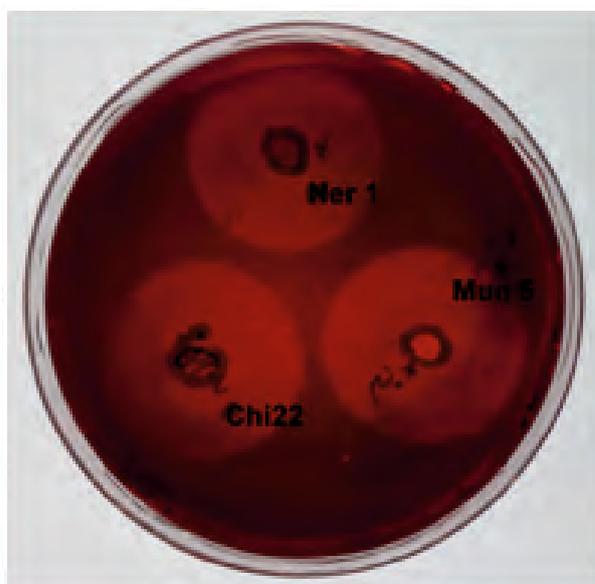


Fig. 7. Plate assay for exo- β -1, 4-glucanase showed clear zones in Avicel agar plate

Kitasatospora setae. Different substrates such as crab shell, shrimp exoskeleton, fungal mycelia were used to produce chitinase enzyme in *S. nondiastaticum*. Further optimization is in progress.

The strain *S. nondiastaticum* TBG-75A20 grown on YEME media was found to produce a pink pigment. The methanol extract of the cell biomass and different solvent extracts of culture filtrate were analyzed for antimicrobial activity. Methanol extract of cell pellet and ethyl acetate and n-butanol extracts of culture filtrate were analyzed for antimicrobial activity. The Methanol and n-butanol extracts showed antifungal activity against *Candida* and mycelia fungi. Further work on the characterization is in progress.

Molecular analysis of Chitinase from *Streptomyces californicus* TBG-201

For the isolation of chitinase producing gene of *S. californicus* TBG-201, genomic DNA library was constructed using pUC18 vector and/KpnI and *E. coli* DH5 α . The nucleotide sequence coding for chitinase in *Streptomyces*

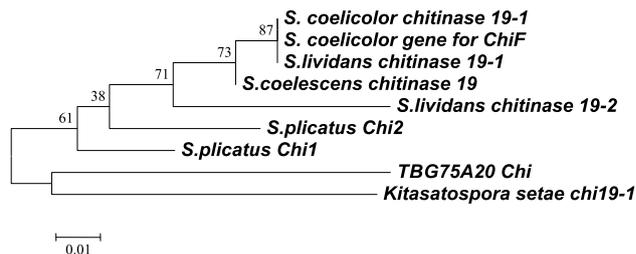


Fig. 8. Neighbour-joining tree of *S. nondiastaticum* TBG75A20 chi gene (partial sequence)

californicus strain NRRLB-2988 contig 9.1, whole genome shotgun (Accession no. NZ_JOFG01000009.1, chitinase sequence region 205660-206544) was retrieved from NCBI. Using NEB cutter, the zero cutters of the coding gene were identified. Plasmid vector pUC18 was used for genomic DNA library construction. The genomic DNA from *S. californicus* TBG201 was isolated by phenol-chloroform extraction method. The isolated genomic DNA and pUC18 plasmid DNA were digested with KpnI at 37°C for 3 h. The opened vector and digested DNA were ligated using T4 ligase. Ligation

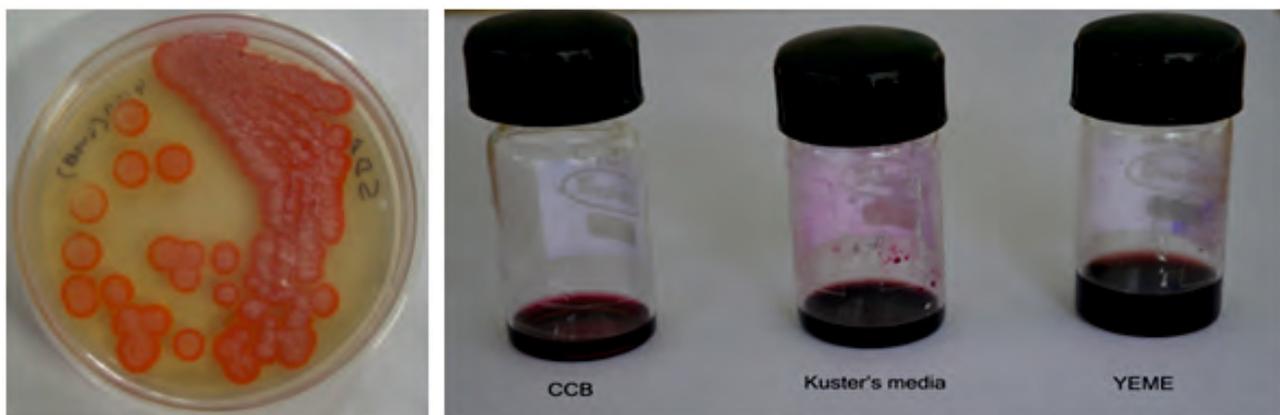


Fig. 9. *S. nondiastaticum* TBG75A20 and culture and Pigment extracted from different media

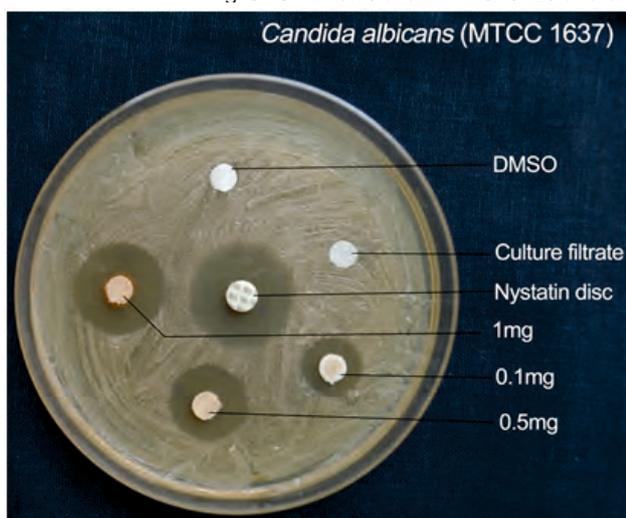


Fig. 10. Anti-*Candida* activity of Methanol extract of Pigment (1, 0.1, 0.5mg)

mixture (10 μ L) was used to transform competent *E. coli* DH5 α (90 μ L). The positive clones (blue-white selection) on LB plates containing ampicillin (100 μ g/ml), IPTG (100mM) and X-gal (100 μ g/ml). The plates were incubated at 37°C overnight and white (recombinant) colonies were picked up and patched on amp⁺ LB plates. The Trans formants were patched on LB agar plates and the screening of chitinase producing clones was accomplished through functional driven analysis. The recombinant clone producing chitinase was picked up and the presence of the insert coding for the enzyme was confirmed by plasmid PCR and restriction analysis. Glycerol stock for positive clones was prepared and stored.

Protease from fungi

Sediments were collected aseptically from six different mangrove localities in Kerala (Payyannur, Thalassery,

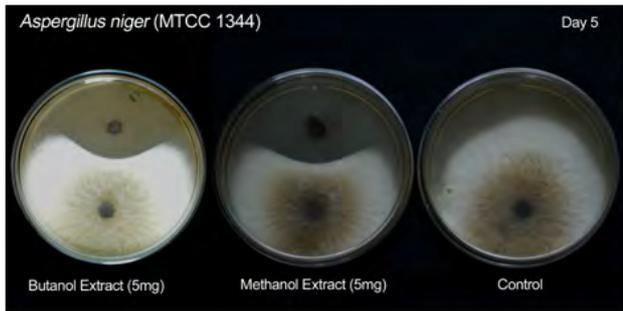


Fig. 11. Antifungal Activity of pigment extracts of Tbg75A20 against *Aspergillus niger*



Fig. 12. Fungal colonies grown on Sabouraud's dextrose agar

Ernakulam, Kasaragod, Azheekkal and Ezhupunna) and soil samples from different low land and high land regions in Kerala (Kainakiri Vayal, Chinnar, Marayoor forest, Neriyananglam forest, Munnar, Anamalai, etc) for the isolation of fungi. Standard dilution plate technique was followed for the isolation technique and the isolates were screened for their ability for protease enzyme production on skimmed milk agar plates and the relative enzyme activity (REA) were measured. 191 isolates were obtained in total and 80 of them (42% of the isolates) were seen as protease enzyme producers. The REA for all the positive isolates ranged from value of 1-2. The strain showing maximum enzyme activity is Tly 8 (REA: 2.115).

Heat Shock Proteins perform an important function in the

folding and unfolding or translocation of cellular 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. Increased expression of sHSPs under heat shock conditions and their protective effect on cell viability at elevated temperatures suggest that they may have a function in the formation or maintenance of the native conformation of cytosolic proteins. The chaperone activities of sHSPs have been demonstrated in *in-vitro* conditions, to prevent of thermal degradation of restriction enzymes with bovine alpha crystalline and 18HSP of *Mycobacterium leprae*. These studies open a possibility of utilizing sHSPs for preserving heat sensitive enzymes. The major objective of this programme is the exploration of its industrial applications as stabilizer to thermo liable enzymes of commercial value.

Functional analysis of sHSP18 of *Mycobacterium leprae* by site directed mutagenesis: To discrete structural elements composed of single residues, peptides and three-dimensional motifs that influence sHSPs in chaperon activity, focused on the structure and functional analysis of small heat shock protein of *M. leprae* through site directed mutagenesis. The recombinant protein was assayed for their chaperone activity. Site directed mutagenesis of the wild sHSP18 gene was done using the quick change mutagenesis kit (Stratagene®, La Jolla, U. S. A.) with predesigned mutated primers. A single nucleotide mutation in the 13th amino acid position, changing Arginine to Cysteine (R13C) was induced. The mutated protein was expressed and purified and analysed for chaperone activity. The sHSP18 R13C showed more chaperone activity comparing to the wild strain. More over the *E. coli* cells expressing the mutated protein showed more cell viability at 48°C than that expressing wild protein.

Genomic and Proteomic Studies on Small Heat Shock Proteins from *Artemia* spp.: *Artemia* is an aquatic crustacean widely used as live feed in aquaculture. During conditions of stress, they produce diapause cysts. Diapause is a genetically programmed reversible state of dormancy characterized by developmental arrest, decreased metabolic activity and



Fig. 13. Plate assay for protease showing clear zones in Skimmed milk agar plate Small Heat Shock Proteins: Functional analysis

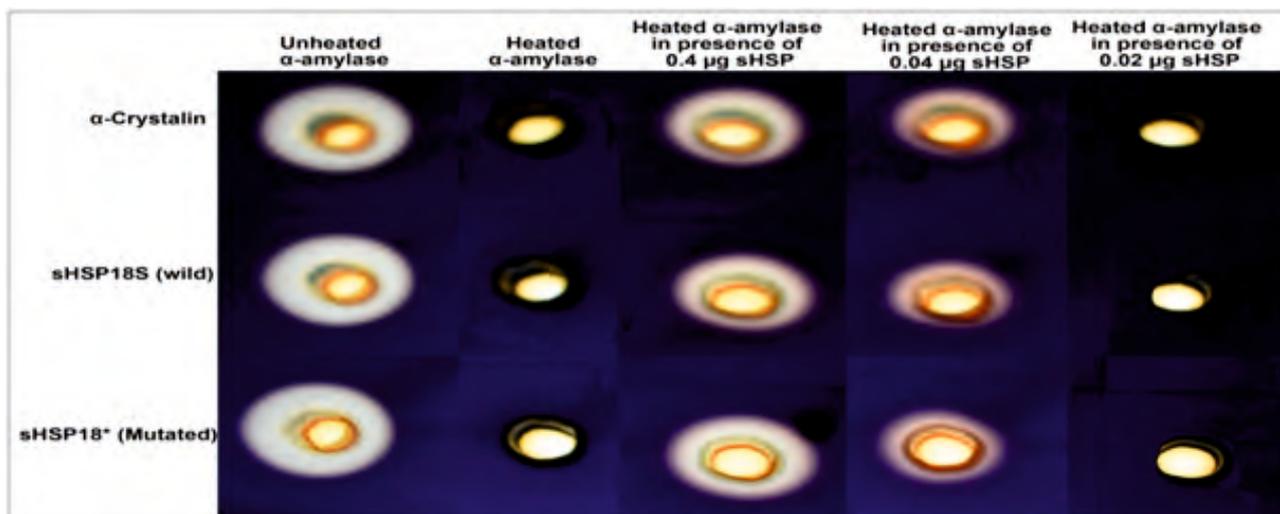


Fig. 14. Starch agar plates demonstrating Chaperone activity of wild and mutated sHSP18 - Protecting thermal inactivation of α - amylase

resistance to severe physiological stress. The molecular mechanisms of diapause induction, maintenance and termination are poorly understood. Previous work in *Artemia franciscana* has demonstrated that molecular chaperones particularly sHSPs make up a significant proportion of proteins up regulated during diapause. Total RNA was isolated from 100 mg *A. franciscana* cyst samples using TRIzol reagent (Life Technologies Invitrogen, USA). cDNA was prepared using SuperScript® III Reverse Transcriptase kit (Invitrogen, USA) using oligo(dT) primers. Gene specific primers were designed for three different sHSP genes namely, P26, ArHsp21 and ArHsp22 from nucleotide sequences available in GeneBank. Recombinant *E. coli*/M15/pREP4/pQE31/ArHsp21 was grown in LB broth containing 100 μ g/ml ampicillin and 25 μ g/ml kanamycin at 37°C in an incubated shaker until OD₆₀₀ and was induced with the addition of IPTG (Isopropyl β -D-1-thiogalactopyranoside) to a final concentration of 0.6 mM. After 3hrs of incubation, the cells harvested, lysed and the histidine tagged protein was purified by Ni-affinity chromatography. Further analysis is in progress.

Functional Analysis of sHSPs from *Streptomyces venezuelae*

Streptomyces albus, *S. venezuelae* and *S. avermitilis* were found to have putative heat shock protein genes in their genome. The restriction sites were incorporated into the primer sequence so as to clone the gene into the multiple cloning site of the expression vector PQE30. The DNA of *S. venezuelae* was isolated using standard protocol. The PCR amplified gene was restriction digested, cloned into PQE30 vector and the transformed into *E. coli* M15. The transformants were then screened in LB Amp+Kan+ plates. The protein was then over-expressed in LB broth (IPTG 0.04mM)

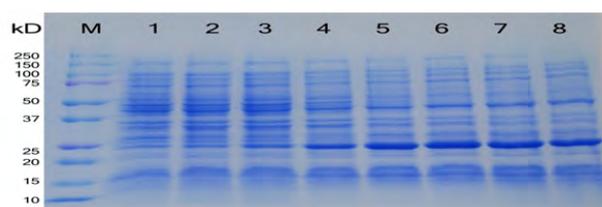


Fig. 15. SDS-PAGE of IPTG concentration optimization of ArHsp21

The lanes represent, M- Marker, 1 - uninduced, 2 - 0.001mM IPTG, 3 - 0.004mM IPTG, 4 - 0.02mM IPTG, 5 - 0.04mM IPTG, 6 - 0.06mM IPTG, 7 - 0.08mM IPTG and 8 - 0.1mM IPTG

and purified using Ni affinity chromatography and checked in the SDS PAGE.

Thermo-tolerance of the *E. coli* cells over expressing the sHSP protein was studied. The protein was over-expressed for 6h at different temperatures: 37 C, 48 C and 55 C. 200 μ l of the cells grown in these temperatures were plated in LB Amp+Kan+ plates in triplets at 0h, 3h and 6h time intervals and incubated overnight and analysed for the thermal tolerance. The cells expressing sHSP were shown to exhibit resistance to temperatures up to 48 C as compared to control *E. coli* M15 cells. The purified sHSP protein also showed chaperone activity *in-vitro*. The homology model of sHSP from *S. venezuelae* was predicted using Schrodinger software.

Target based Antimicrobial Screening Studies (FtsZ as drug target)

Antibiotic resistance is an alarming health problem worldwide. Thus, there is an urgent need for new antibacterial agents with innovative mechanisms of action. Filamenting temperature-sensitive mutant Z (FtsZ), an analogue of eukaryotic tubulin, is an essential and highly conserved bacterial cytokinesis protein. During bacterial cell division,

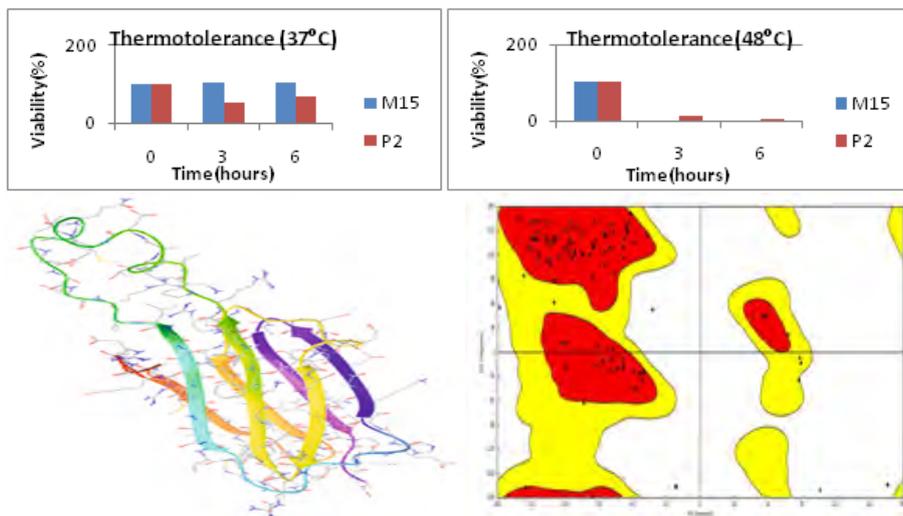


Fig. 16. The predicted structure of sHSP from *S. venezuelae*

FtsZ monomers self-assemble into a Z-ring, a highly dynamic cytoskeleton scaffold generated at the site of septum formation. The mechanism regulating assembly and organization of FtsZ into a ring-like structure involves GTP binding and hydrolysis, modulated by the interaction of the N-terminal nucleotide binding domain of one FtsZ monomer with the C-terminal GTPase activating domain (T7-loop) on the adjacent FtsZ monomer. The inhibition of bacterial cell division proteins with an essential role in bacterial cytokinesis, such as FtsZ, is a promising approach against antibiotic-resistant bacterial infections.

FtsZ inhibitor molecules from Wild Medicinal and aromatic Plants

The screening studies were conducted through *in-vitro* and *in-silico* experimental approach. Three plants namely *Garcinia travancorica*, *Cinnamomum malabathrum* and *Piper sarmentosum* were selected after screening. The active fraction from *G. travancorica* was identified as a flavonoid on GC-MS analysis and coded as GTMM. This purified compound was analysed for FtsZ inhibition assay and

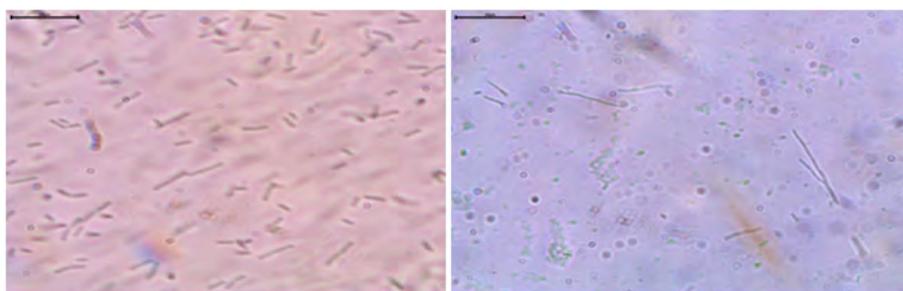


Fig. 18. Effect of GTMM on bacterial cell morphology

Untreated Bacterial cell
(Mean length 3.61 ± 0.35)

Treated bacterial cell
(Mean length 30.42 ± 3.36)

showed 82% inhibition which is higher than the positive control berberine hemisulphate (a known FtsZ inhibitor purchased from Sigma). Myristicin, a major compound of *Piper sarmentosum*, showed FtsZ GTPase inhibition activity, but its activity is less than that of the positive control, berberine. Essential oil from *C. malabathrum* also showed promising activity.

The *Bacillus subtilis* 168 strain usually used to demonstrate the effect of FtsZ inhibitors as it results elongation of bacterial cell. Morphological changes in *B. subtilis* 168 were observed after

GTMM treatment. GTMM treated cells were strikingly longer than the control suggests that the compound inhibited cell division *in-vivo* and induced cell elongation by interfering with septum formation.

For the *in-silico* analysis, the homology modeling *E. coli* FtsZ was done based on the available crystal structure of *Pseudomonas aeruginosa* FtsZ (PDB code: 2VAW, 2.8 Å). The primary amino acid sequence of *E. coli* (Target protein) compared against sequence crystal structure of *P. aeruginosa* FtsZ (Template protein). The sequence of template protein aligned with primary amino acid sequence of *E. coli* FtsZ. Backbone of protein structure was generated and side chains were modelled. The predicted Homology model of *E. coli* FtsZ was docking template. The best docked representation of the ligand was chosen based on the conformation with lowest docking score. Hydrogen bonding and hydrophobic interactions of the ligand with the protein were analyzed using Maestro software. The Coded compound GTMM from *Garcinia* spp. showed good binding affinity to putative binding site in *in silico* analysis. Molecular docking analysis showed that GTMM forms Hydrogen bonds with Asn 24, Glu 138, Asn 165, Gly 19, Thr 109, Asp 145 with docking score -12.62.

Anti-bacterial (anti-Vibrio) activities of Zingiberaceous Plants targeting FtsZ

Vibrio cholerae is one of the notorious agents, causing cholera worldwide. Antibacterial activities of Zingiberaceous plants like

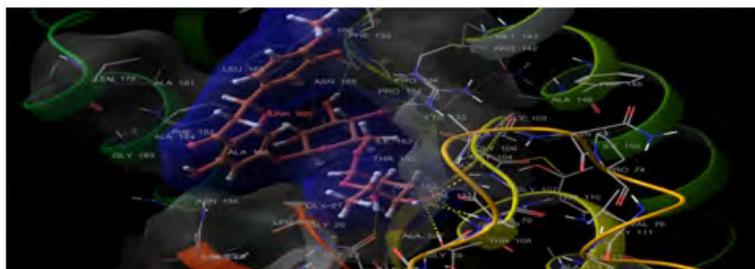


Fig. 19. Docking conformation of GTMM into GDP binding pocket of *E. coli* FtsZ

Zingiber officinale, *Alpinia galanga*, *Curcuma longa*, *Kaempferia galanga* and *K. rotunda* against different *Vibrio* spp. has been screened. Antimicrobial susceptibility testing of the selected Zingiberaceous plants has revealed that most of the essential oils as well as methanolic extracts possess significant antibacterial potential. Since some of the plant extracts showed FtsZ inhibitory activity on Malachite green assay method, docking studies were performed for the major bioactive compounds. The major compounds like Limonene and Terpinen-4-ol resulted in agreeable docking scores and its further studies are to be carried out using high throughput strategies.

Systematic studies of Micro-fungi and Lichens

Lichens are complex organisms involving a symbiotic relationship between a photobiont (a green alga or a cyanobacterium or both) and a mycobiont (a fungus), and have attracted considerable attention because of their perceived position on the ladder of evolution to land plants. They are dominant in some parts of the planet's landscape and have been estimated to cover up to 8% of the total land surface.

Collection, Identification and Documentation of Lichens in the Shendurney Wildlife Sanctuary, Kollam, Kerala

The prime objective of the project was to understand the lichen flora of this region and to bring in awareness of this fascinating group of lichens to the people. Collection trips were conducted to different regions of Shendurney Wildlife

Sanctuary. In addition to this, various forest localities of Idukki and Wayanad districts were also surveyed for lichens during the period. Lichen herbarium holds 3600 exsiccates deposited under TBGT.

Diversity of Foliar Mycobionts in the Botanic Gardens of Kerala

Follicolous fungi are ectophytic obligate biotrophs infecting wide range of flowering plants and produce black colonies on the leaf surface.

Botanical gardens are often run by universities or other scientific research organizations and often have associated herbaria and research programmes in taxonomy or some other aspect of botanical science. In principle, their role is to maintain documented collections of living plants for the purposes of scientific research, conservation, display and education, although this will depend on the resources available and the special interests pursued at each particular garden.

More than 150 collections are made from the study area and pressed them in between blotters till completed dryness. Additional collection trip conducted to Rosemala and Wayanad district. Prepared permanent slides and confirmed the identity of 80 foliicolous fungal samples collected from various gardens and also from Andaman Islands. Identified materials have been accessioned in the herbarium. Over 6800 exsiccates are maintaining under TBGT - Fungal herbarium.

Molecular phylogeny of Follicolous fungi

Members of Meliolaceae are commonly known as black or dark mildews and are obligate parasites. Although the Meliolales contain numerous species, DNA sequences have been published only for few species. Infected plant parts of *Vallis solanacea*, *Milletia ovalifolia*, *Gmelina asiatica*, *Jasminum nitidum*, *Butea monosperma*, *Pterocarpus marsupium*, *P. santalinus*, *Jasminum multiflorum*, *Jasminum* sp. etc were collected.

Fungal mycelia were collected in micro centrifuge tube and stored at -20°C for later use. Fungal samples were

processed by freezing with liquid nitrogen and grinded it into a micro centrifuge tube pestle by using washing buffer. After incubation the solution was cooled at -20°C for 5 min and thereafter, the samples were vortexed in equal volume of chloroform and iso amyl alcohol. After centrifugation DNA was precipitated by using ethanol -20°C

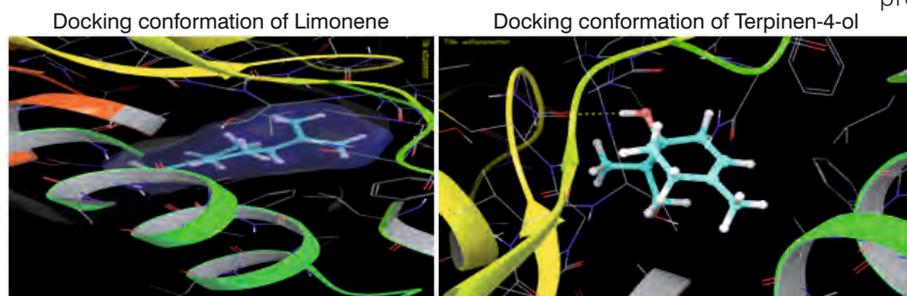


Fig. 20. Docking conformation of Limonene and Terpinen-4-ol



Fig. 21. *Lemna gibba* plants growing in aseptic condition; Fig. 22. Callus induction in *Lemna gibba*.

for 30 min. The DNA was pelleted and washed with 80% ethanol at 10000rpm for 10 min at 4°C. The pellet was suspended with 50µl TE buffer.

The primers LR0R (5'-accgctgaacttaagc-3') and LR5 (5'-tcctgagggaaactcg-3') and ITS1 (5'-tccgtaggtgaacctgcgg-3') and ITS4 (5'-tcctccgctattgatatgc-3') were used to amplify the partial 28S rDNA and ITS, respectively. The phylogenetic analysis of 28S rDNA sequences, the consensus regions were compared against database using BLAST program. The closest hit sequences and representatives of selected fungal families were obtained from Gene bank to help clarify the phylogenetic relationship of meliolales within the class. Multiple alignments were carried out using CLUSTALW. The pair-wise alignment was used to construct the phylogenetic tree using mega4.

In *Gmelina asiatica*, *Jasminum nitidum*, *Vallis solanacea* and *Milletia ovalifolia* the Meliolaceous fungus reported were *Meliola clerodendricola*, *M. jasmini*, *M. vallaridis* and *M. milletiae* respectively. ITS and 28S rDNA sequences data were generated for the species.

DST Fast-track schemes hosted

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

Rhizo secretion 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 project is aimed to;

1. Development of transgenic *Lemna gibba* expressing recombinant hCAP-18 3.
2. Analysis of transgenic plants and culture media for the presence of recombinant protein/ peptide
3. Purification and characterization of recombinant protein/peptide
4. Biological activity studies with hCAP-18

Reamplification of signal+hCAP-18 from the pXcmkn12 vector and cloning in pCAMBIA 2301 and pCAMBIA 1301: In

order to generate the plant expression vector, the fragment cloned in the pXcm kn12 vector has to be either released or re amplified to clone in pCAMBIA vectors. Upon sequencing of the pXcm clone it was evident that there was a frame shift in the insert and cannot be released directly to clone in the plant expression vector. Therefore, new primers were designed to amplify the signal+hCAP-18

fragment from pXcmkn12 with specific sites integrated to it to facilitate the cloning in pCAMBIA vectors.

Cloning in pCAMBIA 2301 plant expression vector: The fragment of signal+hCAP-18 was amplified, digested with restriction enzymes Bam HI and Hind III and ligated. The colonies developed after transformation was used to extract plasmid DNA and the sequencing confirmed the presence of signal+hCAP-18 in the pCAMBIA vector. The clones were further confirmed by restriction digestion.

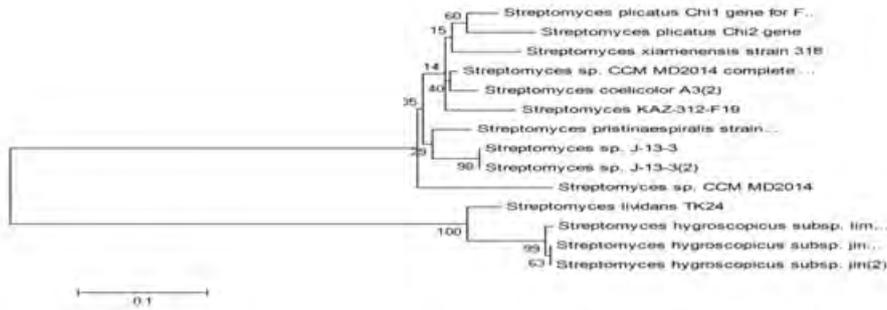
Collection of *Lemna gibba* and surface sterilization: The experimental plants *Lemna gibba* were collected and surface sterilized for in vitro multiplication. The plants were then rinsed with 0.1% mercuric chloride for 5 minutes followed by sterile distilled water for three times of 5 minutes each. The plants were then inoculated in half Hog lands medium.

Callus induction and transformation of *Lemna gibba* : Gamborg B-5 medium (half strength) with the phytohormones BAP (6-benzile amino purine) and 2, 4-D (2, 4 Dichloro phenoxyacetic acid) produced green calli at the tip of the parent fronts cultured.

Transformation of *Lemna gibba* using pCAMBIA 2301-Cal-hCAP construct: To generate the *Lemna gibba* transgenic plants expressing Cal-hCAP recombinant protein, *Agrobacterium* mediated transformation was performed. The experiments are continuing to generate transgenic *Lemna gibba*.

Bio-prospecting of actinobacteria from the sacred groves of Kerala for biocatalysts of commercial applications

Sacred groves are small patches of forest land preserved for centuries without any human intervention. Due to these reason soil samples from this region where taken into consideration for bio-prospecting studies of actinobacteria. Actinomycetes produce a large number of enzymes that help in the degradation of organic plant materials like lignin and chitin and their occurrence is significant in composting. There is growing need for enzymes that work on a specialized environment like chitinases that will inhibit fungi infecting crop plants.



Evolutionary relationships of Family 19 chitinase gene of *Streptomyces* KAZ -312 Extension projects 7.1 CARC

Lipases, particularly cold active, are today the enzymes of choice for various industrial processes. So a detailed study is proposed for the exploration of *Streptomyces* and related organisms from sacred groves of Kerala: an exotic environment for these industrial enzymes like amylases, chitinases and lipases.

Soil sample collected from Kulathupuzha Sastha Temple reserve forest - 2acres. Primary screening for chitinase, lipase and amylase production were done. Secondary screening for lipase in olive oil medium is estimated by DNS method. Primary screening for Antagonistic Activity-dual plate method (% of inhibition = $(A1-A2)/A1 \times 100$, {measurement of diameter of fungal colony -A1- control plate and A2- dual culture plate}. Morphological character identification in different media ISP-2: YEME agar, ISP-3: OM agar, ISP-4: ISS agar and ISP-5: GA agar, plates incubated at 28°C and observed after 7 days. Micro-morphological characters were studied following slide culturing and observing under phase contrast microscopy. Extraction of genomic DNA by standard method and PCR amplification using 16SrDNA FwPrimer 8-27 F5'-AGATTTGATCCTGGCTCAG-3', Rev Primer 1495R 5'-CTACGGCTACCTTGTTACGA-3' . Sequence searched in

NCBI blast and Phylogeny tree constructed in MEGA4. Fungal chitinase (F-19) amplified using F-19 F₂ primers. PCR Programme - 94°C-3min 1 cycle, Denaturation-94°C-30sec, Annealing 58°C-30sec (for 16SrDNA), extension 72°C-1min.30sec 35 cycle, Final extension- 72°C-7min, 1cycle and hold at 4 °C and annealing temperature for Chi is 55°C

Different training programmes were organized for the rural folks and products viz. Hair oil. Soap, Mosquito repellent Agarbates, Herbal tea, Herbal mix, Fish amino acid, Enriched vermin Compost, Bio fertilizers etc were developed. The construction of the building for CARC is in progress. A compilation of 101 Banana recipes was also published.

Model Waste management programme

A model waste management programme was implemented at Sasthamangalam ward, Thiruvananthapuram covering about 4000 houses spreads in 22 residents associations, commercial establishments, flats etc aiming at a zero waste ward. The programme was implemented in such a way so as to enable the residents to process the degradable waste generated at source itself and a Material recovery facility was created for the non-degradable wastes. Forward linkage was created for e-wastes and plastic wastes. Considering the success of the programme the Thiruvananthapuram Corporation was replicated the same model in many other wards. The facility created through this project was handed over to 'Suchitwa Mission' for continuing the programme.

Library

The Library and Information Centre (LIC) of JNTBGRI firmly adhered to the principle of “Right information to right user at right time in right format”. The library team is putting its best effort to reach this objective. Our endeavor is to provide relevant and latest information to the scientific family of JNTBGRI in their respective area of research. As an integral part of the organization our aim is to support the research objectives of JNTBGRI and its dissemination.

Collection Development

The collection development of LIC ought to keep up with the developments in the scientific subject field of the organization. In order to fulfill this objective library used to follow demand-driven acquisition of books. The major advantage of this policy is that it will ensure the maximum utility of books. Journals (both International and National) form the bed-rock of the total collection of library. The library now subscribes 40 International Journals (includes both print and online) and 60 Indian Journals. The statistics of collection development for the previous financial year has been given below:

◆ Creation of mailing list

In collaboration with the System Administrator, a mailing list has been created. All the official communications of library are mailed through the mailing list. The principle of LIC is to “Go Green” as far as possible to minimize the use of paper.

◆ e- Newspaper clipping service (e-NCS)

JNTBGRI library has been providing newspaper clipping service to its user community since its inception. However e-Newspaper service aims to reach out news to the user rather than user coming to the library. As a pilot project currently news digest related to the field of Agriculture, Science and Technology, Environment and Ecology, Education are mailed on per day basis. However, LIC aims to create a database of these news digests in future.

◆ e- Current Awareness Service (e-CAS)

All new additions into the library are alerted to the users in weekly basis. More over, the content pages of all journals and books are scanned and send through mailing list. The purpose is to alert the users on availability of any new information in the library in his/her area of research interest.

◆ e- Document Delivery Services (e-DDS)

Broadly it is an extension of e-CAS. This service is mainly intended to cater the information needs of the scientific community of Bio Informatics Extension Centre in Puthenthoppe, Thiruvananthpuram. Through e-DDS required articles of print journals are scanned and mailed through mailing list on demand.

◆ Reference Management Services (RMS)

Reference Management is one of the most vital and tedious job of a researcher. By Reference Management Service (RMS) the library aims to support its users for developing error free referencing in their research publication. This is ensured by using open-source RMS software's and other online tools.

◆ Plagiarism Detection Services (PDS)

Online tools in Open source platforms are currently used for providing Plagiarism Detection Services. This analytical study will provide a quantitative statement on amount of adapted content in a research paper or thesis. This insight is essential for a researcher to be novel in his research output.

Sharing the Research Output

JNTBGRI LIC is keen to share the research output of the organization. The library department has taken various initiatives to market JNTBGRI publications through various online portals. The sales of these publications are currently handled by the library department. As part of social responsibility, a fixed number of copies of JNTBGRI publications are given as complimentary copy every year to the government colleges across the country.

To ease the procedure of publication, library holds the responsibility of obtaining ISBN number on behalf of the institution. Library department is currently engaged in compiling the bibliography of scientific contributions of JNTBGRI from 1980 to 2015. Mrs. Sujatha of library department is instrumental in collating, crosschecking and error proofing the bibliographic data and manages referencing according to International Standards.

Targets

JNTBGRI-LIC is not only vision oriented, it is mission

oriented too. The following targets have been set to motivate and direct ourselves.

◆ **Migration to Open Source**

The library operations are automated using the proprietary software LIBSOFT. The disadvantage of proprietary software's are, only the supplying company can add new feature and the cost of maintenance. Hence migration to Open Source Software, most preferably KOHA is the need of the hour.

◆ **Design and development of Institutional Repositories**

Institutional repositories are digital collections of the research outputs created within an institution viz., Thesis, technical reports, project reports etc. Developing an Institutional Repository will provide a one stop platform to access all such resources.

◆ **Collaboration and dissemination of research output**

Library team aims to collaborate with the other divisions in disseminating knowledge. This can be done through various platforms like development of databases of flora.

Happy to Help Always- Together we grow

'Happy to Help Always' is the motto of LIC. We are happy to hear their grievances, suggestions and feedbacks of our esteemed users. It is the duty of the users to customize the library centre according to their needs. One such example is the minimizing of stamping and labeling in books on popular demand to keep document intact. We strongly believe in empowering our users which is vital for the growth of our division.

Extension Activities

Twenty six thousand students and public visited the Garden during the period. The visitors were well attended by guided tour within the Garden and with audiovisual aids. Regular sale of plants was done through the Sales Unit. ₹ 6,11,265/- (Six lakhs eleven thousand two hundred and Sixty five only) has been generated during the report period through the sale of plants. Other than students and general public about 25 Governmental and non governmental Agencies received plants from the Institute during this report period, to name a few viz. Kerala Forest Department; Planning Board, Govt. of Kerala. Agriculture Department, Govt. of Kerala. Vikram Sarabhai Space Centre, Various Colleges and Schools of the State. etc

JNTBGRI conducted the Children's Day Celebrations 2014 on 14th November 2014. 100 students and 10 teachers from the four nearby schools Govt. School Jawahar Colony, U. P School, Karimancode, Crescent Central School, Palode and SKV School, Nanniyode participated in the programme. Garden visit, Painting competition, Plant identification and Quiz programme were conducted. A free entry was given to all the schools who visited the Garden on Children's Day.

Central Nursery organized training programmes in Plant Propagation and Nursery practices to the Farmers in collaboration with the Agricultural Department, Government of Kerala. Three batches of farmers were given training during the reporting period. Organized training programme on nursery practices to 100 students of SKV High School, Nanniyode as part of their curriculum.

A project on the greening works of the Games Village at Menamkulam, Thiruvananthapuram and 6 stadiums were undertaken by VMC staff along with the staff of Puthenthope extension centre, in connection with the National Games 2015. A near natural landscaping of areas with lawns, ornamental gardens, homestead plantings, theme based gardens such as medicinal garden, water gardens etc were created in record time. ₹ 95 lakhs worth work was well received by the guests and Government of Kerala has appreciated the excellent work done by JNTBGRI.

World Bamboo Day was observed on 18th September 2014. To mark the occasion the species *Neololaba atra* was planted in the Bambusetum which was a new addition to the bambusetum. Also, distribution of an economically important species, *Bambusa tulda* was inaugurated by Dr. K. C. Koshy, by handing over saplings to Dr. A. Salim.

Dr S. Bhupathy, noted herpetologist and Head of the Conservation Ecology division of the Salim Ali Centre for Ornithology and Natural History (SACON), met with a tragic end while on a research trip on the Agasthyamala on Monday, 28 April 2014. Dr. Bhupathy, 51, had slipped while coming

down a rocky terrain deep inside the forest around 2 pm and fell into a bamboo cluster beneath, with a sharp bamboo stalk piercing his left eye. The team carrying him could reach the Thiruvananthapuram Medical College Hospital only by Tuesday early morning where he was declared brought dead. Dr Sivasuthan, HoD, Forensic medicine GMCT referred the photographs to us for identification of the bamboo. We identified the material as a portion of culm, i.e. one and half portion of top internode of the reed bamboo *Arundinaria walkeriaana* Munro.

As part of a joint expedition with Royal Botanical Gardens, Edinburgh, a field trip was conducted to Nilgiris during 6-26 October 2014. The main objective was to show Dr Michael Moeller, Principal Scientific Officer, RBGE the native species of Gesneriaceae of Western Ghats. We visited Calicut University and Gurukula Botanical Sanctuary *en route* Nilgiris. At Calicut University Dr C. Sathish Kumar delivered two lectures and at Gurukula orchid collections were studied.

Technical Consultancy has been rendered for tissue culture production of Anthurium and Banana to Finura Bioteks, Nagercoil, Tamil Nadu based on mutually agreed terms w.e.f.10.7.2012. This programme has been extended further up to 10.7.2014.

A tissue culture laboratory was setup in the Botany Department, Iqbal College, Peringamala and provided technical support for the successful completion of the programme.

A three day workshop on 'Bamboo Technology' was organized by the Govt. Engineering College (GEC) Barton Hill with the objective to explore the industrial applications of Bamboo and develop GEC as a major R&D center. In connection with this, the Bamboo Biology Group, JNTBGRI have arranged a one day Species Familiarization Workshop for the participants on 4.12.2015. A team of 25 members, mainly teachers of Civil, Mechanical, Electrical and Electronics backgrounds from various Engineering Colleges in Kerala participated in the event.

The Bamboo Biology group observed the World Bamboo Day (Sep. 18th) by a mass planting of 9500 *Dendrocalamus brandisii* seedlings (to polybags). In addition, we distributed 5000 bamboo seedlings to Ranni FDA (on 11th). News regarding this was appeared in JNTBGRI website and *Malayala Manorama* daily dated 21.9.2015.

Under Community Agri biotechnology Resource Center (CARC) at Puthenthope several training programme such as Medicinal plants cultivation, Banana fibre extraction process were organized for the rural folks. Products such as Hair oil, Soap, Mosquito repellent Agarbatis, Herbal tea, Herbal mix, Fish amino acid, Enriched vermin Compost and Biofertilizers were developed with the participation of the rural people. A

compilation of 101 Banana recipes was published. Training on Banana fibre extraction process was also done at external agencies such as Pallichal Sangamithri Banana Cultivators Society.

A model waste management programme was implemented at Sasthamangalam ward of Thiruvananthapuram Corporation, covering about 4000 houses spreads in 22 residents associations, commercial establishments, flats etc aiming at a zero waste ward. The programme was implemented in such a way so as to enable the residents to process the degradable waste generated at source itself and a Material recovery facility was created for the non degradable wastes. Forward linkage was created for e-wastes and plastic wastes. The facility created through this project was handed over to Suchitwa Mission for continuing the programme. On the successful implementation of this programme, Thiruvananthapuram Corporation has replicated the same model in many other wards also.

Observance of Technology Day - 2015 was organized on 11th May 2015. A series of three lectures on the theme "Bio-based Technologies for Future Generation" was done by invited speakers Prof. Dr. G. M. Nair, Advisor, Inter-University Centre for Genomics and Gene Technology, University of Kerala. Dr. C. K. Peethambaran, Former Director of Research, Kerala Agriculture University, and Dr. Rajeev K. Sukumaran, Scientist, Center for Biofuels, CSIR-NIIST, Thiruvananthapuram. Besides Research Scholars of institute, 70 college students (NSS College - Nilamel, M.G College - Thiruvananthapuram, Iqbal College - Peringamala) also participated in this programme. The programme was coordinated by Dr. S. Shiburaj.

A team of scientists from Autonomous University of Coahuila, Saltillo, Coahuila, MEXICO visited JNTBGRI on 24 November, 2015. The team included Dr. Cristóbal Noé Aguilar Gonzalez, Professor and Dean-School of Chemistry, Group of Bioprocesses, Dr. Jose Luis Martinez Hernandez, Professor of the Group of Nano Bioscience of University of Coahuila and Dr. A. Sabu, Assistant Professor, Kannur University (Visiting professor to University of Coahuila). Dr. Cristóbal Noé Aguilar delivered a lecture and also addressed Scientists and Research students of JNTBGRI. The Scientists from Division of Microbiology submitted a collaborative project with this group under India-Mexico inter-governmental programme of Cooperation in science and technology of DST, Govt of India.

World Environment Day was observed on June 5th 2015 by introducing a new species, *Schizostachyum brachycladum* to the Bambusetum. The planting was done by Dr. K.C. Koshy.

Two short term training named plant festival was imparted to students of students of PSGR Krishnammal College, Coimbatore and Madras Christian College, Chennai

As part of centenary celebrations of J. S. Gamble's *Flora of*

the Presidency of Madras, the first part of which was published in 1915, a one-day seminar was organized on 18th Dec. 2015 with ten themes as topics of presentation. This was attended by JNTBGRI staff and researchers and scholars and students and teachers from Botany Departments of Iqbal College, Peringammala; University College, Palayam; Women's College, Thiruvananthapuram; N. S. S. College, Nilamel and M. G. College, Thiruvananthapuram. Altogether about 90 delegates participated. The exhibition of Gamble memorabilia and novelties described by Gamble and his associates attracted a lot of researchers and students.

A programme "Opening of a sanctuary for 'Maramanjala'" was organised by Medicinal, Aromatic and Spice Plants Unit in connection with the 'Biodiversity Day' celebrations on 22/05/2015 by planting 30 saplings of *Coscinium fenestratum* in a forest patch near Field Gene Bank. Eighty students and five teachers of Government Ayurveda College, Thiruvananthapuram participated in the function and His Grace Joseph Mar Dionacius, an environmentalist, delivered the Biodiversity Day message. Seedlings of *Coscinium fenestratum* and publications of JNTBGRI were given to the Govt. Ayurveda College.

Shri. Jiji Thomson IAS, Hon. Chief Secretary of Kerala released the book titled 'Bee's Herbal Garden – A Garden in the Forest @ JNTBGRI' authored by Dr. P. J. Mathew, Dr. Mathew Dan, C. Muraleedharan Unnithan, V. Premkumar, Dr. P. A. Jose and Thomson Davis at a function organised on 07-05-2015 at KSCSTE, Pattom. Dr. Suresh Das, EVP, KSCSTE presided over the function and Dr. C. A. Ninan, Dr. P. M. Mathew, Prof. K. P. Vijayakumar offered the felicitations. Mr. P. Pratheep Kumar, Headmaster, Govt. Girls' Higher Secondary School, Pattom received the first copy of the book.

Conducted a training programme on herbal gardening and medicinal plant cultivation to 16 tribal farmers, on behalf of WEEDS, Nagercoil on 25-11-2015.

Based on the results obtained with the research project on Screw pine funded by Kerala State Industrial Development Corporation (KSIDC), Govt. of Kerala, the project was revised to develop an Integrated R&D Centre (JNTBGRI) for the Establishment of Green Industry at Kodungallur to the tune of Rs 18.99 crores, supported by KSIDC. To implement this mega programme 1.27 acres of land was obtained on lease basis for a period of 99 years from Kuzhur Grama Panchayath and financial support of Rs 3.90 crores as first installment was received from KSIDC. Design and construction of the laboratory complex has been entrusted to Hindustan Lifecare Limited, Govt. of Kerala. Foundation stone of the proposed laboratory complex named as Prof. A. Abraham R & D Sub Centre, JNTBGRI, Kuzhur, Thrissur Dist. was laid by Shri Oommen Chandy, Hon'ble Chief Minister of Kerala on 18th August 2015.

For the smooth functioning of the Institute, a System Administration Unit was established for maintaining the internet connection provided by National Knowledge Network (NKN), Govt. of India, to develop and update Institute's Web page and suitable software packages for facilitating the R&D activities of the Institute.

Exhibitions

Participated in Mallappally Fest -2014, a festival of Agriculture, Education, Industry, Science and Technology from 8/1/2014 to 14/1/2014 at CMS HSS Ground, Mallappally, Pathanamthitta organised by Mallappally Block Panchayat.

Participated Sasthra Jalakam National Science Expo 2014, in connection with 26th Kerala Science Congress at Chandragiri Auditorium, Kalpetta, Waynad from 27/1/2014 to 31/1/2014.

Participated in Pride of India Exhibition at Jammu University in connection with the 101th Indian Science Congress from 2/2/2014 to 9/2/2014.

Participated in Palode Mela 2014 organized by Palode Pourasamithi from 7/2/2014 to 18/2/2014 .

Participated in Coir Fest 2014', an exhibition organized by Kerala State Coir Board at Konni, Pathanamthitta from 20/2/2014 to 26/2/2014.

Put a stall at the NSS college, Nilamel in connection with the Exhibition of Medicinal plants and plants with special importance from 25/2/2014 to 26/2/2014.

Participated in Agri-Horti Mela in connection with Uzhamalakkal Thiruvathira Fest from 4/3/2014 to 11/3/2014 at Uzhamalakkal, Nedumangad.

Participated the exhibition organized by the Kadakkal Thiruvathira Fest at Kadakkal from 11/3/2014 to 18/3/2014.

Participated the Karshakasree Farm Fair 2014 at Putharikandam, Thiruvananthapuram. Organized by Malayala Manorama, from 23/9/2014 to 29/9/2014.

Participated the National Biodiversity Expo 2015 held at Kanakakkunnu Palace, Thiruvananthapuram during 23/2/2015 to 27/2/2015

Setting up a stall at the venue of "Jignjassa 2015" National Seminar on Ayurveda Sidha and Health Expo at Kanakakkunnu Palace Thiruvananthapuram, organized by Vidarthi Seva Trust from 8/4/2015 to 15/4/2015.

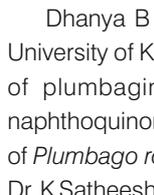
Ph. D. awarded



Anilkumar E S was awarded Ph. D. by Kannur University for the thesis "Pharmacognostical Characterisation and crude drug standardisation of selected ethnomedicinal plants of Kerala" under the guidance of Dr. P G Latha and Dr. Mathew Dan.



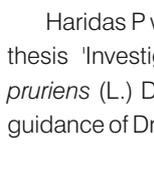
Deepu Sivadas was awarded Ph. D. by Kannur University for the thesis 'Population structure, dynamics and conservation of *Lagerstroemia speciosa* (L.) Pers. from Western Ghats of Kerala' under the guidance of Dr. A G Pandurangan.



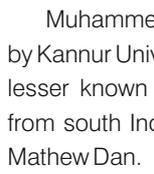
Dhanya B Pillai was awarded Ph. D. by University of Kerala for the thesis 'Production of plumbagin (5- hydroxy-2-methyl-1,4-naphthoquinone) through hairy root cultures of *Plumbago rosea* L.' under the guidance of Dr. K Satheeshkumar and Dr P N Krishnan



Gopakumar B was awarded Ph. D. by University of Mumbai for the thesis 'Ecology and Conservation of *Ochlandra travancorica* and *Ochlandra wightii*' under the guidance of Dr. Bhabna Motwani.



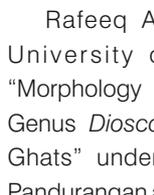
Haridas P was awarded Ph. D. by Kannur University for the thesis 'Investigation on intraspecific variability in *Mucuna pruriens* (L.) DC. With special reference to Kerala' under the guidance of Dr. P J Mathew



Muhammed Thaha A was awarded Ph. D. by Kannur University for the thesis 'Studies on lesser known edible plants of Zingiberales from south India' under the guidance of Dr. Mathew Dan.



Navas M was awarded Ph. D. by University of Kerala for the thesis "Anatomical and histological studies on the genus *Sida*. L. (Malvaceae) of peninsular India, with special focus on the botanical source of the drug, Bala" under the guidance of Dr. P G Latha and Dr. Mathew Dan.



Rafeeq A was awarded Ph. D. by University of Kerala for the thesis "Morphology and DNA bar-coding of the Genus *Dioscorea* L. in Southern Western Ghats" under the guidance of Dr. A G Pandurangan and Dr. N S Pradeep.



Rajith N P was awarded Ph. D. by Kannur University for the thesis, 'Ethnobotanical studies of Kasaragod District of Kerala State with special reference to Koraga and Mavilan tribes', under the guidance of Dr. N Mohanan.



Shrishail K Kullooli was awarded Ph. D. by Kannur University for the thesis "Studies on reproductive dynamics and conservation strategies of three rare and endemic balsams of Western Ghats" under the guidance of Dr. A G Pandurangan and Dr. A K

Sreekala.

Thankachan K V was awarded Ph. D. by University of Kerala for the thesis: 'Chemical Profiling and Biological Activity Studies of *Citrus* Volatile Oils from South India' under the guidance of Dr. B Sabulal.



Viji A R was awarded Ph. D. by Kannur University for the thesis 'Taxonomic studies of the family Cyperaceae in Nilgiri Biosphere Reserve, India' under the guidance of Dr. A G Pandurangan.

Vimalkumar C S was awarded Ph. D. by Kannur University "Systematic documentation of traditional knowledge on fungus infected ethnobotanically important plants with special reference to scientific validation of anti-infertility property of *Olea dioica* Roxb. infected with *Zaghouania oleae* (E. J. Butler) Cummins" under supervision of Dr. P G Latha, Dr. VB Hosagowdar.



Vipinlal V was awarded Ph. D. by University of Kerala for the thesis: 'Phytochemical and Bioactivity Studies of Some *Bauhinia* Species from Kerala' under the guidance of Dr. B Sabulal.

Honours and Memberships in Professional Bodies

Anilkumar C. Member, International Society of Plant Morphologist.

Anilkumar C. Member Children's Science Congress Committee, 26th Kerala Science Congress, 2014.

Anilkumar C. Member, Board of Studies, Botany, Kannur University.

Balakrishnan P. Member, Board of Studies in Forestry and Wood Technology, Kannur University.

Balakrishnan P. Member, Executive Board, Wildlife Research and Conservation Trust, Nilambur.

Balakrishnan P. Member, International Association for Ecology; Member, Indian Bird Conservation Network and Member, International Network of Next Generation Ecologists.

Bindu S. Member, International Society of Plant Morphologist.

Koshy KC. Life member, Indian Association for Angiosperm Taxonomy; Member, Association for Tropical Biology and Conservation (ATBC) and Member, Association for Plant Taxonomy, Dehra Dun.

Koshy KC. Reviewer for journals Plant Systematics and Evolution; Biodiversity and Conservation; Current Science; Bulletin of Botanical Survey of India and Rheedeia.

Koshy KC. Member, Sub-committee on 'Propagation of Bamboo', Kerala State Bamboo Mission.

Latha PG and Suja SR. Reviewers for Journal of Clinical Medicine and Research; African Journal of Pharmacy and Pharmacology; BMC Complementary and Alternative Medicine; Indian Journal of Experimental Biology and Sky Journal of Biochemistry Research.

Mathew Dan, chaired a session in the National Seminar on 'Biodiversity of Microbes and Climate Change Mitigation' at Catholicate College, Pathanamthitta on 4th February 2016.

Mathew Dan. Editorial Team member of the Abstract Book for the Silver Jubilee Conference of IAAT and Council Meeting of IAAT.

Mathew Dan. Reviewer, Nordic Journal of Botany.

Mohan N. Member, Vanamithra Award Committee, Kerala Forest Department 2014-16

Mohan N. Reviewer, Bangladesh Journal of Plant Taxonomy.

Muraleedharan Unnithan C, served as resource person for the raining to farmers on Medicinal Plant Cultivation, CARC Project, Saraswathi Thankavelu Extension Centre, Puthenthope 2104.

Navas M. Awarded FNSE (Fellow of National Society of Ethnopharmacology) by National Society of Ethnopharmacology, India.

Pandurangan AG has been awarded IAAT Prof. V V Sivarajan Gold Medal 2015

Pandurangan AG has been nominated as Committee Member of SRS and SSW Programme, KSCSTE

Pandurangan AG nominated as Member, Expert Committee on Ecosystem Research Programme, MoEFCC, 2015-18

Pandurangan AG, Member, Task Force, State level Steering Committee on Medicinal Plants, Govt. of Kerala.

Pandurangan AG, Co-ordinator, Lead Garden Programme, and BR Co-ordinator, Lead Institution for Biosphere, Programme, MoEFCC, Govt. of India.

Pandurangan AG. Elected as Executive Member, IAAT, Calicut, 2014-17.

Pandurangan AG. Recognized as Research Guide, M. S. University, Tirunelveli, Tamil Nadu.

Pradeep NS, Life Member of Association of Microbiologists India (AMI) in 2015.

Radha RK. Member, Indian Science Congress Association (ISCA); Life Member of Kerala Academy Sciences and Member, Asian and Mideast Institute of Chemists (USA).

Radha RK. Reviewer, African Journal of Biotechnology.

Rameshkumar KB. Member, Executive Council, Kerala Academy of Sciences, 2015-2016.

Rameshkumar KB. Member, Royal Society of Chemistry, Cambridge, UK.

Rameshkumar KB. Member, Royal Society of Chemistry, Cambridge, UK.

Rameshkumar KB. Organizing Secretary, International Symposium on Phytochemistry and Prof. Dr. A. Hisham Endowment Award Ceremony-2015

Sabu KK. Member, Indian Science Congress Association (ISCA); Life Member, Indian Society of Spices, Calicut; Member, International Society of Plant Morphologists, Delhi and Member of International Union of Forest Research Organizations (IUFRO), Vienna, Austria.

Sabu KK. Reviewer, Bioinformatics and Biology Insights, Genomics Insights and Evolutionary Bioinformatics.

Sam P. Mathew and Dr. Santhosh Kumar ES. served as Judges in the Kerala Sastholsavam 2015, conducted at Kollam from 25-26 November 2015.

Sam P. Mathew served as a judge for the evaluation of District level Inspire Science of three districts viz Kollam, Pathanamthitta and Alappuzha.

Santhoshkumar E S. Reviewer, Bangladesh Journal of Plant Taxonomy, Rheedeia.

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

Sathish Kumar C. Invited to the Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur as an expert to evaluate an orchid project and also to serve as a special invitee to the Research Advisory Council during 1-4 August 2015.

Sathish Kumar C. Selected as the Chief Editor of *Journal of Economic and Taxonomic Botany*, Jodhpur, Rajasthan.

Sathish Kumar C. Selected as the Vice President of the Alumni Association of the Botany Department of University College, Thiruvananthapuram.

Sathishkumar C. Reviewer, Current Science and BSI Publications.

Shiburaj S. Life Member of Association of Microbiologists India (AMI) in 2015.

Sreekala AK. Reviewer, Journal of Threatened Taxa.

Sreekala AK. chaired a technical session in the National Seminar on "Flowering plant reproduction and diversity"

2015, organized Fathima Matha National College, Kollam.

Sreekala AK. served as an external examiner for the Doctoral Committee meeting of two full time Ph. D. Research Scholars, Department of Biology, Gandhigram Rural University.

Sreekala AK. served as an External Examiner/ Chairperson of the Ph. D. Open Defense, Department of Biology, Gandhigram Rural University, Tamilnadu.

Sreekala AK. Life Member, Society of Plant Reproductive Biologists.

Sreekala AK. Member Research Advisory Committee, Department of Plantation Crops and Spices, College of Agriculture, Vellayani.

Sreekala AK. served as external member for the FRC meeting of the Ph. D. at Department of Plantation Crops and Spices, College of Agriculture, Vellayani.

Sudha CG. Life member, Society for Conservation and Resource Development of Medicinal Plants, India

Sudha CG. Member, P G Board of Studies, MG University.

Sudha CG. Reviewer, Brazilian Journal of Botany; Acta Physiologia Plantarum and British Biotechnology Journal.

Suja SR. Member, Research Advisory Committee, M. Sc. Biotechnology, Kerala Agricultural University.

Suja SR. Editorial Board Member of American Journal of Experimental Biology

Suja SR. Reviewer, Indian journal of Experimental Biology; British Journal of Pharmaceutical Research; Evidence-Based Complementary and Alternative Medicine; Biomed Research International; American Journal of Experimental Biology; European Journal of Medicinal Plants and International Journal of Pharmacy and Biosciences.

Vrinda KB. conferred Honorary Fellow, Indian Mycological Society (FIMS), 2016.

Awards

Anju Sudhakaran received best poster award 'Repellency and electrophysiological response of essential oil from the leaves of *Etilingera fenzlii* (Kurz) K. Schum., the honey bee repellent endemic plant species of the Andaman Nicobar Islands" (Anju Sudhakaran, Ramesh Kumar KB and Radha RK) in the International Symposium on Phytochemistry (ISP-2016) & Prof. Dr. A. Hisham Endowment Award Ceremony at Malabar Botanic Garden and Institute for Plant Sciences, Kozhikode on 27th February 2016.

Anu Aravind received Best Poster Award in International Conference on Medicinal Plants and Herbal Drugs for Human Welfare, University of Madras, 2015.

Binoy Kurian received Aspire Fellowship from University of Kerala to conduct a short-term research work on "Analysis of genetic diversity of *Calamus* sp from north-east India" at

Assam Agricultural University (AAU), Jorhat, Assam from July – November 2015.

Divya Balakrishnan received Prof. Abraham Memorial award (2nd prize) May 2015 conducted at JNTBGRI.

Nadiya F received Prof. Abraham Memorial award (3rd prize) May 2015 conducted at JNTBGRI.

Navas M received Best Paper Award in the National Seminar on 'Flowering Plant Diversity and Reproductive Biology' held at Fathima Mata National College, Kollam in August 2015.

Rameshkumar KB received Fr. Anthony Mukhath-K.S.Manilal Award, for the best presentation in 'Modern Techniques in Plant Taxonomy'. Indian Association for Angiosperm Taxonomy (IAAT), 2014.

Rameshkumar KB received Dr P D Sethi Award 2015, Instituted by Kong Posh Publications Pvt. Ltd., New Delhi, for the best paper in HPTLC related works published in 2014.

Reshmi S received first prize for oral presentation for the paper entitled "Development of *in vitro* strategies for the *ex situ* conservation and sustainable utilization of *Rauvolfia micrantha* Hook.f., a rare and endemic medicinal plant in Southern Western Ghats (Reshmi S and Sudha CG) in Botanica 2015 organized by Department of Botany, Sree Narayana College, Chempazhanthy during 12th 13th February 2016.

Shameer P S received Prof. Abraham Memorial award (3rd prize) May 2015 conducted at JNTBGRI.

Sony George received Prof. Abraham Memorial award (1st prize) May 2015 conducted at JNTBGRI.

Evaluation of Examination, Thesis, Designs, etc.

Koshy K C evaluated 177 essays for an Essay Competition conducted for +2 students by Kerala Bamboo Mission in connection with Kerala Bamboo Fest 2014.

Mathew Dan evaluated a Ph. D. Thesis for Bharatidasan University, Tiruchirappally, Tamil Nadu, 2014.

Mathew Dan evaluated a project proposal for Women Scientist Division, KSCSTE, 2014.

Mathew Dan evaluated the Ph. D. thesis Bharathiar University, Coimbatore, 2015.

Mathew Dan served as an evaluator for Ph. D. Pre-submission Seminar, Department of Botany, University of Kerala, 2016.

Mohan N evaluated Ph. D. Thesis entitled "Pharmacognostic, Phytochemical and Tissue Culture studies of *Tylophora indica* (Burm.f) Merrill" submitted to M. G. University, Kottayam.

Pandurangan AG evaluated Ph. D. thesis entitled "Experimental taxonomic studies of the genus *Terminalia* L." submitted to Dr Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra

Pandurangan AG evaluated Ph. D. thesis entitled "Experimental taxonomic studies of the Family Tiliaceae" submitted to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra

Pandurangan AG evaluated Ph. D. thesis entitled "Pharmacognostical studies on *Passiflora incarnate* Linn. (Passifloraceae)" submitted to Tamil University, Thanjavur, Tamil Nadu

Pandurangan AG evaluated Ph. D. thesis entitled "Studies on the predation and evaluation of the impacts of biomass based power plant in Tamil Nadu" submitted to Madurai Kamaraj University, Madurai, Tamil Nadu

Sabu KK served as examiner for M. Sc. Biotechnology Viva-Voce (Semester 4), SN College, Kollam, 2015.

Sabu KK served as examiner for Practical and Viva exam for M. Sc. Biotechnology, SN College of Technology, Kollam, 2015.

Sabu KK served as examiner for practical examination and viva voce of 3rd Semester M. Sc. Biotechnology, Department of Biotechnology, University of Kerala. 2016

Santhoshkumar ES evaluated the Ph. D. thesis titled "Floristic Diversity of Dangs, Gujarat" for M. S. University of Baroda.

Sathishkumar C designed the cover of Fascicles of Flora of India Vol. 25 Ericaceae, BSI Kolkatta.

Sathishkumar C evaluated a thesis on Ethnobotany from M.G.University, 2014.

Sathishkumar C done Review of species assessments of 4 species: *Bulbophyllum cauliflorum*, *Cymbidium tracyanum*, *Vanda spathulata* and *Vanda tessellata* done for Maiko Lutz of IUCN (RBG, Kew).

Sathishkumar C evaluated a thesis from University of Agricultural Science, Bangalore. 2014.

Sathishkumar C evaluated thesis from Delhi University, 2015.

Sathishkumar C reviewed a project proposal on Idukki Flora submitted by Dr Santhosh Nampy and Dr AK Pradeep of Calicut University for KSCSTE.

Sreekala AK evaluated Ph. D. thesis entitled "An ecological study of pollination in some mangrove associates" submitted to Andhra University, Visakhapatnam.

Sreekala AK evaluated Ph. D. thesis entitled "Biodiversity and Biomass of Tropical Evergreen Forest at Uppangala, Western Ghats, India: Spatial Patterns And Residual Impacts of Selective Logging" submitted to Madurai Kamaraj University, Madurai, Tamil Nadu.

Sreekala A K evaluated Ph. D. theses entitled "Environment friendly and cost effective ultra high performance liquid chromatography for the characterization of three active pharmaceutical ingredients" submitted to Andhra University, Visakhapatnam.

Sreekala AK evaluated Ph. D. theses entitled

“Ethnobotanical studies of the tribes in Idukki district, Kerala” submitted to Gandhigram Rural Institute, Dindigul, Tamil Nadu.

Sreekala AK evaluated Ph. D. theses entitled “Floral biology, pollination, fruiting aspects and importance of some herbaceous weeds of Amaranthaceae family” submitted to Andhra University, Visakhapatnam.

Sreekala A K evaluated Ph. D. theses entitled “*In Vitro* Anti Bacterial and Cytotoxic Studies of Fabricated Silver Nano Particles” submitted to Madurai Kamaraj University, Madurai, Tamil Nadu.

Sreekumar S evaluated M. Phil. thesis on Computer Aided Drug Design of University of Kerala, 2015

Sreekumar S served as Examiner M. Sc. Biotechnology and conducted viva voce examination, University of Kerala 2016

William Decruse S served as examiner for M. Sc. Biotechnology practical examinations of Kerala University, 2014.

Visitors

Shri O. Rajagopal, Former Union Minister

Prof. Richard Hay M P, Hon'ble Member of Parliament

His Excellency Waven W. William, High Commissioner of the Republic of Seychelles

Shri Sangay Wangchur, Hon'ble Minister, Bhutan

Dr. Girish Sahni, Director General, CSIR, India

His Grace Joseph Mar Dionacious, Metropolitan of Kolkata Diocese

Shri B. L. Jain, Vice Chairman, Planning Commission, Madhya Pradesh

Richard Moller, Royal Botanic Garden, Edinburgh

Agui Mitra IFS, Deputy Conservator of Forests, Port Blair

Dr. Suresh Das, Executive Vice President, KSCSTE

Prof. Vikram Singh, Hisar, Haryana

Dr. K. P. Madhusudhanan, CDRI, Lucknow

Dr. K. P. Sri Vasuki, Director General, CEFNRAM, Forest Dept. Telangana, Hyderabad

Prof. R. S. Tripathi, INSA Honorary Scientist, NBRI, Lucknow

Dr. J.K. Sharma, Former Director, KFRI

Dr. B. S. Dandin, Liaison Officer, Biodiversity International

Dr. M. R. Thampan, Director, Kerala Bhasha Institute

Dr. Sandra Malaval, Conservatoire Botanique Pyrenes, France

Patents Filed

A Single herbal drug possessing multiple therapeutic effects as wound healing, anti-cancer, anti-inflammatory, immunoenhancing and antioxidant. Provisional patent filed No. 5667/CHE/2014 Inventors: S Rajasekharan, PG Latha, SR

Suja, EA Siril and AL Aneesh Kumar.

A Single herbal drug possessing diverse therapeutic potential as Immunomodulatory, platelet augmentation, anticancer and antioxidant. Provisional patent filed. No.6263/CHE/2014 Inventors: S Rajasekharan, PG Latha, SR Suja and V Vilash.

A single Herbal Drug possessing Multiple Therapeutic Effect as Hepatoprotective, Anti-inflammatory and Antioxidant” Provisional patent filed. No: 700/CHE/2015 dated 13-02-2015. Inventors: S Rajasekharan, PG Latha, SR Suja and Ragesh R Nair.

Novel poly herbal formulation against liver fibrosis. Provisional Patent filed no. 699/CHE/2015. Inventors: VJ Shine, PG Latha, SR Suja, S Rajasekharan, Vinodkumar T G Nair and GI Anuja.

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Vilash V, Suja SR, Latha PG and Rajasekharan S (2015). Evaluation of hepatoprotective and antioxidant activity of *Pellionia heyneana* Wedd. leaf ethanolic extract on carbon tetrachloride induced liver damage in Wistar rats. *Int. J. Pharm. Pharm. Sci.* 7(3): 374-378.

Vimalkumar CS, Hosagaudar VB, Suja SR, Vilash V, Krishnakumar NM, Latha PG (2015). Comparative preliminary phytochemical analysis of ethanolic extracts of leaves of *Olea dioica* Roxb., infected with the rust fungus *Zaghouania oleae* (E.J. Butler) Cummins and non-infected plant. *J. Pharmacognosy and Phytochemistry* 3 (4) 69-72.

Vineesh PS, Skaria R, Mukunthakumar S, Padmesh P and Decruze SW (2015). Seed germination and cryostorage of *Musa acuminata* sub sp. *burmanica* from Western Ghats. *South African Journal of Botany*. 100: 158-163.

William Decruze S (2014). Extended distribution of *Vanda wightii* Rchb. f., an endangered orchid of Western Ghats revealed by ecological niche modeling. *The J. Orchid Soc. India* 28: 15-21.

Seminars, Symposia, Workshops

Ajitha J Chandrapal (2016). Participated in 9th National Seminar On Medicinal Plants Organized by ARI Thiruvananthapuram at RGCB Thiruvananthapuram.

Akshaya Vijayan P, Padmesh AS, Hemanthakumar and Krishnan PN (2014). *In Vitro* propagation of a multipurpose tree, *Lagerstroemia speciosa* (L.) Pers. for *ex-situ* conservation. Paper presented in Third Indian Biodiversity Congress, SRM University Chennai.

Alister M, Rajkumar G, Nazarudeen A and Pandurangan AG (2014). Studies on the epidermal characters and its taxonomic significance in the genus *Goniothalamus* (Blume) Hook. f. & Thoms. in Western Ghats. Paper presented in 24th IAAT conference held at Bharathidasan University, Tiruchirappalli.

Alister M, Rajkumar G, Nazarudeen A and Pandurangan AG (2015). Status of Annonaceous endemics in Western Ghats and its conservation. Paper presented in International Seminar on Advancements in Angiosperm Systematics & Conservation, University of Calicut, Kerala.

Alister M, Rajkumar G, Nazarudeen A and Pandurangan AG (2015). Systematics and distribution of the family Annonaceae: Kerala Scenario. Paper presented in National Seminar on Advancement of Biosystematics on Biodiversity Conservation at Department of Botany, SN College, Varkala.

Aneesh kumar AL (2015). Attended the National Workshop on Flow cytometry and Cell Sorting, at the Inter University Centre for Genomics and Gene Technology, University of Kerala, Karyavattom, Thiruvananthapuram.

Aneesh kumar AL, Siril EA, Suja SR, Latha PG, Rajasekharan S (2015). Evaluation of pharmacognostic, physicochemical and preliminary phytochemical aspects of *Neurocalyx calycinus* (R. Br. ex Benn.) Rob. Poster presented in the national seminar on "Recent advances in medicinal plant research" at BharathMatha college, Thrikkakara, Kochi.

Angala Mathew (2016). Ethnomedical Investigation of Antipyretic Plants Used by Paliya Tribes in Idukki District of Kerala. Paper presented in 28th Kerala Science Congress held at Calicut University.

Anilkumar ES, Mathew Dan, Latha PG (2015). Taxonomic significance of root anatomy in *Aristolochia* (Aristolochiaceae) species from Western Ghats. Paper presented in International Seminar on Advances in Angiosperm Systematics and Conservation. IAAT, University of Calicut.

Anilkumar C, Chitra CR, Bindu S and Abdul Jabbar (2014). An account on some wild edible underutilized fruits of Kerala, Poster presented at in the National Symposium on Underutilized and wild edible plants of India- "Future crops" at University of Kerala, Karyavattom, Thiruvananthapuram.

Anjali A and William Decruse S (2016) A comparative study of symbiotic and asymbiotic seed germination of *Vanda wightii* Rch.f., an endangered orchid of Western Ghats. Paper presented in National Conference of the Orchid Society of India, YSR Horticultural University, Venkataramannaguddem.

Anjali N and Sabu KK (2016). Identification of conserved and novel micro RNAs from cardamom under drought stress by next generation sequencing. Paper presented in 28th Kerala Science Congress, Kozhikkode.

Anju V, Rameshkumar KB and Sabulal B (2014). Biofuel evaluation of selected *Euphorbia* species. Paper presented in

National seminar on hydrogen energy and other renewable energy sources at Department of Chemistry, University of Kerala, Karyavattom, Thiruvananthapuram.

Anju Sudhakaran, Ramesh Kumar KB and Radha RK (2016). Repellency and electrophysiological response of essential oil from the leaves of *Etilingera fenzlii* (Kurz) K. Schum., the honey bee repellent endemic plant species of the Andaman Nicobar Islands" Paper presented in International Symposium on Phytochemistry (ISP-2016) & Prof. Dr. A. Hisham Endowment Award Ceremony organised by Kerala academy of Sciences, DBT, Govt. Of India, JNTBGRI and KSCSTE

Anoosh Varghese, Nazarudeen A and Pandurangan AG (2015). Varietal wealth of Mango in Kerala – A case study. Paper presented in National Seminar on New Frontiers in Plant Science and Biotechnology. Department of Botany, Goa University, Goa.

Anto M, Prajith TM, Jothish PS and Anilkumar C (2016). An overview of floral and fruit variants among the populations of the endangered tree species '*Garcinia imberti* (Clusiaceae). Paper presented in National Seminar on Biodiversity of Microbes and Climate Change Mitigation' at Department of Botany, Catholicate College, Pathanamthitta- Kerala.

Anto M, Prajith TM, Jothish PS and Anilkumar C (2015). Population studies of *Garcinia imberti* – an endangered endemic tree of the southern Western Ghats. Paper presented in the National Conference Plants Reproductive Ecology and Diversity held at Department of Botany, FMN College, Kollam.

Anu S and Shiburaj S (2015). Isolation and molecular screening of Chitinase producing Actinomycetes from Western Ghats of Kerala and their taxonomic classification. Paper presented in the 56th Annual conference of Association of Microbiologists India (AMI) to be held at JNU, New Delhi.

Anu Aravind P and Rameshkumar KB (2014). Chemotaxonomy of *Garcinia* species based on leaf volatile chemical profiles. Paper or poster presented at 24 IAAT conference held at Bharathidasan University, Tiruchirappalli.

Anu Aravind P, Asha KRT and Rameshkumar KB (2014). Bioactive biflavonoids from *Garcinia travancorica*. Paper presented in the Joint Malaysia-UK Symposium on Natural Product Chemistry and Drug Discovery, organized by the Royal Society of Chemistry, at International Medical University, Kuala Lumpur, Malaysia.

Asha Poorna C, Anu S, Shiburaj S and Pradeep NS (2014). Isolation and screening of chitinolytic actinomycetes from sacred grooves of Kerala and their taxonomic classification. Paper presented at 3rd Indian Biodiversity Congress (IBC), Chennai.

Asha Poorna C, Shiburaj S and Pradeep NS (2015). Molecular screening of actinomycetes from soil of Kulathupuzha sacred grove for Lipase production and its

application. Paper presented in National Seminar on Plant Breeding, Biotechnology and Conservation at Malabar Botanic Garden and Institute for Plant Science, Kozhikode.

Asha Poorna C, Reshma. AK, Shiburaj S and Pradeep NS (2015). Thermostable amylase from *Streptomyces* sp by submerged fermentation and its characterization. Paper presented in National seminar on Insight into recent trends in Biological Science and Technology at University College, Kerala.

Asha Poorna C, Sruthi G, and Pradeep NS (2015). Studies on bioprospecting of lipolytic microbes from soil degrading soil and its identification and production optimization. Paper presented in National Seminar on Insight into recent trends in Biological Science and Technology at University College, Thiruvananthapuram.

Balakrishnan P (2014). Attended a training workshop on Forest health surveillance and early detection, monitoring and reporting of forest invasive species organized by the Asia Pacific Forest Invasive Species Network and Kerala Forest Research Institute, Peechi.

Balakrishnan P (2014). Attended the group monitoring workshop for the principal investigators of the projects funded by the SERB, Department of Science and Technology, Govt. of India at Gitam University, Vishakapattanam .

Balakrishnan P (2015). Attended the GEF-UNDP-Gol India High Range Mountain Landscape Project review meeting held at Ministry of Environment, Forests and Climate Change, New Delhi.

Balakrishnan P (2015). Attended the World Environment Day Celebrations, Community Development Society, Kondazhy, Thrissur.

Balakrishnan P (2016). Attended a three day workshop Entomology at Kerala Forest Research Institute, Peechi.

Balakrishnan P (2016). *Citizen Science in Entomology: state of field and future perspectives*. Presented paper in the three day workshop on Entomology. Kerala Forest Research Institute, Peechi, Thrissur.

Bijeesh C, Vrinda KB and Pradeep CK (2016). Presented a paper entitled "*Inocybe* poisoning in Kerala- a case study" in the National Conference on *Emerging Trends in Fungal Biology and Plant Protection- ETFPP-2016*, Mycological Society of India at Banaras Hindu University, Varanasi.

Bindu S and Anilkumar C (2016). Effect of pre-treatments in the seed germination of *Rauvolfia* species. Paper presented in the 28th Kerala Science Congress, University of Calicut, Thenhipalam, Malappuram.

Binoy Kurian, Vishnu V Nair, and Sabu KK (2015). Paucity of genetic diversity in an important non-wood forest produce: *Calamus brandisii* Becc. - A dwindling species? Paper presented in the 27th Kerala Science Congress held at

Alappuzha. .

Chitra CR, Anilkumar C, Upreti KK and Yogeesh HS (2015). Conservation of *Coscinium fenestratum* (Gaertn.) Colebr. through seed studies. Poster presented in the second National Biodiversity Congress, Kanakakunnu palace, Thiruvananthapuram.

Deepthi Kumary and Sreekala AK (2015). Phenology and floral biology of *Embelia ribes* Burm. f. (Myrsinaceae): An important medicinal plant of Western Ghats. Paper presented in 25th annual conference of IAAT and Advancements in Angiosperm Systematics and Conservation, held at Department of Botany, University of Calicut, Kerala.

Deepthi kumary KP and Pandurangan AG (2015). Taxonomic studies of the genus *Sonerila* in Western Ghats" Paper presented at National Seminar on: "Plant Genetic Resources Utilization And Conservation" held at V. O. Chidambaram College Thoothukudi.

Deepu Sivadas and Pandurangan AG (2014). Ants as seed predators and dispersers of a non-myrmecochorous tree *Lagerstroemia speciosa* in Tropical deciduous forest" Paper presented in National workshop on Concepts and Practices in Ecology of Plant-Animal interactions.

Deepu Sivadas and Pandurangan AG (2016) Studies on the Reproductive Ecology and Conservation of *Lagerstroemia speciosa* (L.) Pers. – A High Value Medicinal Plant from Western Ghats, Kerala. paper presented in 28th Kerala Science Congress. Malappuram.

Dhanusha S, Sabeena A, Shiburaj S and Pradeep NS (2014). Phylloplane fungi collected from Shenduruney Wild Life Sanctuary, Kerala and evaluation of its taxonomic position using molecular taxonomic tools. Paper presented at 3rd Indian Biodiversity Congress (IBC), Chennai.

Dhanusha S, Shiburaj S and Pradeep NS (2015). Diversity of phylloplane fungi affecting selected plants and evaluation of its taxonomic position using molecular tools. Paper presented in the National seminar on Patents, Plant Breeding & Biotechnology Conservation held at Malabar Botanic Garden.

Dhanusha S, Shiburaj S and Pradeep NS (2015). Foliicolous Fungi Inhabiting Tropical Forest Plants – Analyzing Diversity Using Molecular Tools" received award for best poster in the National seminar on Advancement of Biosystematics on Biodiversity Conservation held at SN College, Varkala.

Dhanya CS, William Decruse S, and Reghunath BR Sudha CG (2015). Cryopreservation of hairy root culture of *Decalepis arayalpathra*, a critically endangered ethnomedicinal plant in southern Western Ghats. Paper presented in International Conference, Medicinal Plants and Herbal Drugs for Human Welfare.

- Divya Balakrishnan, Shiburaj S and Pradeep NS (2014). Production, purification and characterization of a thermostable α -amylase from *Streptomyces griseus* TBG19NRAI. Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.
- Divya Balakrishnan, Shiburaj S and Pradeep NS (2014). Studies on a thermo stable calcium independent α -amylase from *Streptomyces griseus* TBG19NRAI. Paper presented at 3rd Indian Biodiversity Congress (IBC), Chennai.
- Elsamma Joseph Arackal and Pandurangan AG (2014). Studies on the cell inclusions and their taxonomic diagnostic values in the Genus *Dioscorea* L. in the Western Ghats. Paper presented in 24th IAAT conference at Bharathidasan University, Tiruchirappalli.
- Gayathri V and Shiburaj S (2014). Studies on family 19 chitinase from *Streptosporangium nondiastaticum* TBG75A20. Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.
- Gayathri V and Shiburaj S (2015). Antifungal Activity of Pigment Extracts from *Streptosporangium nondiastaticum* TBG-75A20. Paper presented in 56th Annual Conference of Association of Microbiologists of India, Delhi.
- Gayathri V, Hari B and Shiburaj S (2015). DNA barcoding of *Artemia* population at Thamaraiikulam Saltpan, Kanyakumari District, Tamil Nadu. Paper presented in the National Seminar on Biosciences in the Genomic Era, Dept. of Zoology, Sree Narayana College, Cherthala.
- Geethakumary MP and Pandurangan AG (2014). Taxonomy, diversity and distribution of the genus *Cinnamomum* Schaeffer in Peninsular India. Paper presented in 24th IAAT conference at Bharathidasan University, Tiruchirappalli.
- Geethakumary MP (2016). Attended the 28th Kerala Science Congress held at University of Calicut, Malappuram.
- Hima S, Dhanya BP, Binoy Jose, Satheeshkumar K (2016). Effect of varying ammonium/nitrate concentration on growth and plumbagin production in hairy root cultures of *Plumbago rosea* L, paper presented in the 28th Kerala Science Congress, Malapuram.
- Ijnu TP, Latha, PG, George V and Pushpangadan P (2015). Phytochemical screening and HPTLC fingerprinting of *Blepharis maderaspatensis* (L.) Heyne ex Roth – an ethnomedicinal plant. Paper presented in National Conference on Bio-prospecting – Initiatives and Challenges, Organized by Department of Biotechnology, Dr N.G.P. Arts and Science College, Coimbatore.
- Ijnu TP, Latha, PG, George V and Pushpangadan P (2016). Antioxidant potential of methanol extract of *Blepharis maderaspatensis* (L.) Heyne ex Roth whole plant. Paper presented in International Seminar on New Frontiers and Challenges in Environmental Sciences (BIOENVIRON-16), School of Biosciences, Marudupandiyar College, Thanjavur.
- Jagadeesan R, Gangaprasad A and Mathew SP (2015). Wild ornamental plants of Agasthyamalai Biosphere Reserve endemic to the Western Ghats of the Peninsular India. Paper presented in National Seminar on Flowering plant reproduction and diversity, Fatima College, Kollam.
- Jagadeesan R, Suresh Kumar P, Gangaprasad A, Sam P Mathew and Santhosh Kumar ES (2015). Natural History of *Dalbergia travancorica* (Fabaceae). Paper presented in International Seminar on Advances in Angiosperm Systematics and Conservation, IAAT, University of Calicut, Calicut.
- Jayalakshmi M, Sreekala AK and Maria Theresa (2014). Phenology and floral biology of *Humboldtia decurrens* Bedd. ex Oliver (Fabaceae)- An endemic legume of Southern Western Ghats. Poster presented in 24th annual conference of IAAT Thiruchirappally.
- Jayalakshmi M, Sreekala AK and Maria Theresa (2015). Morphology and flowering phenology of *Humboldtia decurrens* Bedd. ex Oliver (Fabaceae). Poster presented in National Seminar on Flowering Plant Reproduction and Diversity organized by Fathima Matha National College, Kollam.
- Jayalakshmi M, Sreekala AK and Theresa M (2015). Phenology, breeding system and reproductive success of *Humboldtia decurrens* Bedd. ex Oliver (Fabaceae). Paper presented in 25th annual conference of IAAT and Advancements in Angiosperm systematic and Conservation, University of Calicut, Kerala.
- Jayalakshmi M, Maria Theresa, Anoosh Vargeesh and Prabhu A (2016). Attended the workshop on Pollination of Flowers by Insects from Ecology to Chemistry and Behaviour on 09 to 13 January, 2016 organized by University of Exeter, United Kingdom, Royal Botanic Garden, Kew, London, U. K., IISER, Pune and IISER, Thiruvananthapuram at IISER, Thiruvananthapuram.
- Jeeshma NP, Shiburaj S and Pradeep NS (2014). Recombinant Molecular chaperone HSP 18 from *Mycobacterium leprae* confer heat stabilization of alpha amylase from *Bacillus licheniformis*. Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.
- Jeeshma NP, Shiburaj S and Pradeep NS (2015). Comparative studies on the chaperonic activity of HSP 18 antigen of *Mycobacterium leprae* with its mutant (C193T) Paper presented at 56th Annual Conference of Association of Microbiologists of India (AMI) JNU, New Delhi.
- Jeeshma NP, Karthik Menon, Pradeep NS and Shiburaj S (2015). In-vitro chaperone activity of 18 kDa HSP of

Mycobacterium leprae on heat inactivated amylase” Paper presented at UGC sponsored National Seminar on Biociences in the genomic era held at SN College, Cherthala.

Jeeshma NP, Pradeep NS and Shiburaj Sugathan (2016). Functional analysis of small heat shock protein by site directed mutagenesis. Paper presented at 28th Kerala science congress held at University of Calicut January 2016.

Jero Mathu A (2015). History of cytology of bamboos. Paper presented in the National Seminar on Plant Breeding, Biotechnology and Conservation, held at Malabar Botanical Garden, Kozhikode.

Jero Mathu A (2016). Highest chromosome number in bamboos. Paper presented in the 28th Kerala Science Congress, Calicut.

Jinu Krishnan Unnithan G, Chandralekha CT, Suja SR, Latha PG, Suresh Kumar KV (2015). A Comparative study on Biosorption of Methylene Blue with bark of three plants-An application to waste water treatment. Poster presented at the National Seminar on Recent Advances in Medicinal Plant Research held at Bharath Matha College, Thrikkakkara.

Joemon Jacob and William Decruse S (2014). Cryopreservation of *Calamus vattayila* Renuka embryos by encapsulation-dehydration. Paper presented in National seminar “New horizons and challenges in biotechnology and bioinformatics”, CPCRI, Kasaragod.

Joemon Jacob and William Decruse S (2014). Effect of desiccation on seed storage of *Calamus hookerianus*, *C. nagabettai* and *C. vattayila* three underutilized rattans of Western Ghats. Paper presented in National Seminar on underutilized and wild edible plants of India-Future crops, Department of Botany, University of Kerala, Thiruvananthapuram.

Jomon Jacob and William Decruse S (2015). Zygotic embryo cryopreservation of *Calamus vattayila* an endemic rattan of Western Ghats- a comparative study of different techniques. Paper presented in International Conference on Low Temperature Sciences and Biotechnological Advances, NBPGR, New Delhi.

Jothish PS and Anilkumar C (2014). *Cassine kedarnathii* Sasi. & Swarup. – an endemic tree species in Silent Valley need conservation efforts for its survival. Paper presented in the Third Indian Biodiversity Congress (IBC 2014) held at SRM University, Chennai.

Jothish PS and Anilkumar C (2015). Pollination ecology of *Palaquium ellipticum* (Daltz.) Baillon – a key ecological species in tropical evergreen forests of the Western Ghats. Paper presented in the National Conference on Flowering Plants Reproductive Ecology and Diversity held at Department of Botany, FMN College, Kollam.

Karthik Menon, Shiburaj S, Pradeep NS (2014). Analysis of small heat shock protein in *Streptomyces venezuelae* (MTCC

327). Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.

Karthik Menon, Shiburaj S and Pradeep NS (2015). Functional analysis of small heat shock protein. Paper presented in 5th IPS Symposium at JNC SAR, Bangalore.

Karthik Menon, Shiburaj S and Pradeep NS (2015). Study of Small Heat Shock from *Streptomyces*. Paper presented at 56th Annual Conference of Association of Microbiologists of India (AMI) held at JNU, New Delhi.

Krishnakumar NM, Latha PG, Suja SR (2016). Evaluation of *in vivo* and *in vitro* phagocytic activity of *Morinda umbellata* L. leaf extract. Poster presented in the 28th Kerala Science Congress, University of Calicut, Malapuram.

Latha PG (2014) delivered invited talk on 'Phytocueticals in Diabetic Research' in the National Seminar on Phytocueticals in Diabetic Research at Pushpagiri Medical College, Thiruvella, Kerala.

Latha PG (2015). Presented an invited talk on 'Ethnopharmacology Research at JNTBGRI' in National Seminar on “Recent Advances in Medicinal Plant Research” at Bharath Matha college, Thrikkakara, Kochi.

Lekshmi KE, Pradeep NS and Shiburaj S (2015). Microbial β – glucanase - a look for interest in Western Ghats regions. Paper presented in the National seminar on Insight into Recent Trends in Biological Sciences and Technology, Thiruvananthapuram.

Lekshmi K E, Pradeep NS and Shiburaj S (2015). Beta glucanase- Microbes are the potential source of production considered unusual as of cellulases. Paper presented in National seminar on Patents, Plant Breeding, Biotechnology and Conservation, Kozhikode

Lekshmi K E, Shiburaj S and Pradeep NS (2016). Molecular biology of exocellular microbial Beta glucanases-illustrated different from cellulases. Paper presented in National conference on Genomics and Society – Prospects, Challenges and Concerns, Inter University Centre for Genomics and Gene Technology (IU-CGGT), Dept of Biotechnology, University of Kerala, Thiruvananthapuram.

Lekshmi NM, Anto M, Anilkumar C and Rameshkumar KB (2016). *Garcinia imberti* – A rich source of the triterpenoid friedelin. Paper presented in International Symposium on Phytochemistry & Prof. Dr. A. Hisham Endowment Award Ceremony, Malabar Botanical Garden and Institute for Plant Science, Kozhikode, Kerala.

Maria Theresa, Sreekala AK and Jayalakshmi M (2015). Flowering phenology and breeding system of *Ophiorrhiza radicans* Gardner ex Thwaites: - A distylous herb of Western Ghats Paper presented in National Seminar of Insight into Recent Trends in Biological Sciences and Technology,

University College, Thiruvananthapuram.

Maria Theresa, Sreekala AK and Jayalakshmi M (2015). Floral biology and distyli of *Ophiorrhiza radicans* Gardner ex Thwaites (Rubiaceae): An endangered herb of Southern Western Ghats. Paper presented in National Seminar on Flowering Plant Reproduction, and Diversity organized by Fathima Matha National College, Kollam.

Mathew Dan and Thaha AM (2015). Scope for *Curcuma* starch– an under exploited resource. Paper presented in the 7th International Symposium on the Family Zingiberaceae, The Botanical Garden Organisation, Ministry of Natural resources and Environment, Thailand.

Mathew Dan, Navas M, Latha PG (2015). Characterisation of the raw drug 'bala' from south Indian market and comparison with genuine drug. Paper presented in International Seminar on Advances in Angiosperm Systematics and Conservation. IAAT, University of Calicut.

Mathew Dan (2016), delivered an invited talk on 'Chemotaxonomy – a tool for systematics' in National Science day Celebrations, St. Stephen's College, Pathanapuram on 29 February 2016.

Mathew Dan (2016), delivered an invited talk on 'Conservation and Characterisation of Medicinal Plants in Kerala' in 9th National Seminar on Medicinal Plants, Govt. Ayurveda College, Thiruvananthapuram on 15 January 2016.

Mathew Dan (2016), delivered an invited talk on 'Conservation, Characterisation and Utilization of the Genetic Resource of Medicinal and Aromatic Plants' in the International Symposium on Medicinal Plants and Herbal Drugs in Human and Livestock Wealth : A Global Perspective, Pachaiyappa's College, Chennai on 31 January 2016.

Mathew Dan(2016), delivered an invited talk on 'Relevance on Conservation and Characterisation of Medicinal Plants' in the National Seminar on Medicinal Plant Biodiversity and Local Health Care, Sri Parasakthi College for Women, Courtallum on 22 January 2016.

Mathew SP (2015). Floristic history of Andaman-Nicobar Islands with special reference to contribution of J S Gamble. Paper presented in Seminar on Centenary Celebration of Gamble's Flora of the Presidency of Madras at JNTBGRI, Trivandrum.

Midhu CK, Sibi C, Varghese, Hima S, Binoy Jose and Satheshkumar K (2016). High frequency plant regeneration in *Ophiorrhiza pectinata* Arn. through somatic embryogenesis. Paper presented in the 28th Kerala Science Congress, Malapuram.

Murugesan K, Mathew Dan, SP Mathew, Kumar ESS (2015). Leaf morphology and stomatal studies of *Plumbago* L. species from India. Paper presented in National Seminar on Plant Breeding, Biotechnology and Conservation at Malabar Botanic Garden, Kozhikode .

Muthulakshmi E (2015). Attended the National Workshop on "Flow cytometry and Cell Sorting at the Inter University Centre for Genomics and Gene Technology, University of Kerala, Kariavattom, Trivandrum.

Nandu TG, Shiburaj S, Reshma Reghu S and Rameshkumar KB (2014) . In silico screening for inhibitors of bacterial cell division protein (FtsZ) from natural compounds. Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.

Nandu TG, Reshma Reghu, Shiburaj S, Rameshkumar KB and Pradeep NS (2015). Myristicin: a potential FtsZ inhibitor from *Piper sarmentosum*. Paper presented at International Symposium on Phytochemistry and Prof. Dr. Hisham Endowment Award Ceremony - State Science and Technology Museum, Trivandrum.

Nandu TG, Reshma Reghu, Shiburaj S, Rameshkumar KB (2016). In-silico screening for inhibitors of Bacterial cell division protein (FtsZ) from Herbal compounds. Paper presented at 28th Kerala Science Congress, Calicut University, Malapuram (Best Paper contest)

Nandu TG, Reshma Reghu, Shiburaj S, Rameshkumar KB (2016). Bacterial cell division protein (FtsZ) inhibition activity of essential oil of *Cinnamomum verum*. Paper presented at the International Symposium on Phytochemistry and Prof. Dr. Hisham Endowment Award Ceremony. Malabar Botanical Garden and Institute for Plant Sciences, Kozhikode.

Navas M (2015) Attended as a faculty member in the field study organized at Kottur and JNTBGRI, Thiruvananthapuram in connection with the workshop on "Community-to-Community Exchange and Capacity Development Workshop for Traditional Knowledge Holders" organized by United Nations University – Institute for the Advanced Study of Sustainability (UNU-IAS), GIZ, UNDP Equator Initiative, ABS Capacity Development Initiative, Biodiversity International, FLEDGE and TDU with participants from Africa, Central Asia and India.

Navas M (2015). Attended a meeting at All India Radio, Thiruvananthapuram.

Navas M (2015). Attended the advisory committee meeting of Farm and Home programme of AIR at Regional Academy of Broadcasting and Multimedia Training Hall, Thiruvananthapuram.

Navas M, Angala Mathew and Ajitha J Chandrapal (2016). Conducted awareness classes on the importance of traditional knowledge and its conservation at Nelliampathy Gramapanchayath of Palakkad.

Navas M (2015). Diversity, Distribution and Status of genus *Sida* L. (Malvaceae) in South India. Paper presented the National Seminar on 'Flowering Plant Diversity and Reproductive Biology' held at Fathima Mata National College, Kollam.

Navas M (2015). Attended the K M Basheer Memorial Lecture titled "The Social Audit of Scientific Research" organized by Vakkom Moulavi Foundation Trust, Thiruvananthapuram.

Navas M (2015). Delivered an invited talk on Medicinal Plant– Diversity and traditional Knowledge in connection with Gregor Mendel birth day celebrations held at G H S S Puthiyakavu, Ernakulam District.

Navas M and Anooj SL (2015). Attended the Review meeting and progress report presentation of the project entitled "Assessment of medicinal plant resources in seven southern districts of Kerala" Project A-146 at State Medicinal Plants Board Regional Office, Poojappura.

Navas M, Mathew Dan and Latha PG (2015). Diversity, distribution and status of the genus *Sida* L. (Malvaceae) in south India. Paper presented in National Seminar on Flowering Plant Diversity and Reproductive Biology, Fatima Mata National College, Kollam.

Navas M (2016). Conducted a meeting with President, Ward members and Local communities at Kottukal (02/03/2016) and Kulathur (14/03/2016) Gramapanchayaths of Thiruvananthapuram district and Clappana (21/03/2016) Gramapanchayath of Kollam District.

Navas M, Renju VS and Midhun Krishna M (2016). Conducted awareness classes on the importance of Conservation of coastal Ethnobotany at Ezhupunna Gramapanchayath of Alapuzha.

Nazarudeen (2014). Delivered lecture on "Analyzing and documenting biodiversity" for the Integrated M. Sc. students at Kerala Agricultural University, Trivandrum.

Nazarudeen (2014). Served as resource person at National Workshop cum Training Programme on Conventional and Modern Aspects of Plant Taxonomy held at the Dept. of Biology, Gandhigram Rural University, Dindigul (Tamil Nadu).

Nazarudeen (2014). Served as resource person on "Biodiversity: Historical and Geographical Causes, Hotspots and Centers of Origin" at the Kerala Agricultural University, Trivandrum.

Neethu RS, Shiburaj S and Pradeep NS (2014). Studies on tannase producing abilities of *Aspergillus* strains isolated from mangrove soils and tannery effluents. Paper presented at 3rd Indian Biodiversity Congress (IBC), Chennai.

Neethu RS, Shiburaj S, Pradeep NS (2014). Screening of potential tannase producing *Aspergillus* isolates and optimization of various cultural parameters for maximum tannase production. Paper presented at 55th Annual Conference of Association of Microbiologists of India (AMI) held at TNAU, Coimbatore.

Nisha NC, Sreekumar S and Biju CK (2015). Identification of lead molecules against Cobra venom in *Andrographis paniculata*". Paper presented in the 5th Annual Conference of

the Toxicology Society of India, TSICON 2015, organized by Little Flower Hospital, Angamaly.

Pandurangan AG (2014). Lead lecture on "Endemism and its phytogeographic significance of Angiosperms in the Western Ghats" delivered at 24th IAAT conference, Bharathidasan University, Tiruchirappalli.

Pandurangan AG (2015). Lesser known vegetables and pulses of Southern Western Ghats – Potential future crops for food security. Paper presented in National seminar on plant Genetics Resource: Utilization and conservation. Chidambaram College Thoothukudi

Prabalee Sarmah, Sabu KK, Borpatra Gohain P, Nath J and Barua VJ (2015). Genetic characterization and gender identification of some rattan species and Northeast and South India with molecular markers. Paper presented in the DST sponsored National Symposium on Sustainable Conservation Strategies for Bio-resources of North East India.

Pradeep CK and Vrinda KB (2016). "Inocybaceae (Agaricales) in Kerala state" Paper presented in the National Conference on *Emerging Trends in Fungal Biology and Plant Protection- ETFP-2016* Mycological Society of India at Banaras Hindu University, Varanasi.

Prajith T M, Anilkumar C, Jothish P S, Chitra CR and Anto Mathew (2015). Conservation of an endangered endemic tree- *Garcinia imberti* Bourd through seed studies. Poster presented in the 2nd National Biodiversity Congress, held at Kanakakunnu Palace, Thiruvananthapuram.

Radhika BJ, Ravichandran P, Bejoy M, Satheeshkumar K (2016). *In vitro* regeneration via callus cultures of *Musa paradisiaca* L. cv. Nendran. Paper presented in the 28th Kerala Science Congress, Malappuram.

Ragesh R Nair, Suja SR, Latha PG, Rajasekharan S (2015). Toxicity evaluation and preliminary phytochemical screening of *Tetracera akara* (Burm.f.) Merr., an important ethnomedicinal plant. Poster presented in the National Seminar on "Recent advances in medicinal plant research" at BharathMatha college, Thrikkakara, Kochi.

Rajasekharan S (2014). Traditional Medicine in Healthcare Management in Kerala. Paper presented in the National Workshop on Importance of Traditional Medicine in the Healthcare Management, organized by State Medicinal Plant Board, Tripura.

Rajkumar G (2015). Participated in Kerala Environment Congress (KEC 2015) with focal theme 'Climate Change and Sustainable Development' Kottayam, Kerala.

Rajkumar G (2016). Participated at Kerala State Land use Board- National Seminar 2016 with focal theme 'Emerging Approaches in Land Use Planning' Thiruvananthapuram, Kerala.

Rameshkumar KB, Bindu S, Awantika Singh and Brijesh Kumar (2014). Distribution of indole alkaloids in Indian

Rauvolfia species. Paper presented in Joint Malaysia-UK Symposium on Natural Product Chemistry and Drug Discovery, held at International Medical University, Kuala Lumpur, Malaysia.

Rameshkumar KB, Ananthkrishnan R and Santhoshkumar ES (2014). Volatile chemical profiling of *Cinnamomum* species of south India and its applications. Paper presented in National Seminar on 'Metabolomics- A New Frontier in Natural Products Research'. North East Hill University, Shillong.

Reby S, Vineesh PS, Arya Das J, Padmesh P, Decruse SW, Mukunthakumar S (2015). Genomic DNA content estimation and phytochemical screening of two indigenous *Musa acuminata* (AA) cultivars viz. 'Matti' and 'Chematti'. Paper presented in 'International Symposium on New Perspectives in Modern Biotechnology', held at Pondicherry

Remya J and Pandurangan AG (2014). Taxonomic studies on the family Poaceae of the Nilgiri Biosphere Reserve" Paper presented in 24th IAAT conference. Bharathidasan University, Tiruchirappalli.

Remya Krishnan, Santhosh Kumar ES, Radhamany PM and Valsaladevi G (2015). Morphometric studies on south Indian species of *Cinnamomum* (Lauraceae). Paper presented in International Seminar on Advances in Angiosperm Systematics and Conservation, IAAT, Calicut University.

Reshma Reghu S, Ramesh Kumar KB, Pradeep NS and Shiburaj S (2014). Analysis of different Zingiberaceous plants for Anti-vibrio activities. Paper presented at 3rd Indian Biodiversity Congress (IBC), Chennai.

Reshma RS, Shiburaj S, Nandu TG, Ramesh Kumar KB and Dan M (2015). Zingiberaceous plants as a source of anti-bacterial activity: targeting bacterial cell division protein (FtsZ). International Science Index Vol:2 No.5,2015.

Reshma Reghu S, Mathew Dan and Shiburaj S (2015). Sustainable utilisation of zingiberaceous plant diversity for antimicrobial properties. Paper presented in National Seminar on "Advancement of Biosystematics on Biodiversity Conservation" held at SN College, Varkala .

Reshma Reghu S, Nandu TG, Ramesh Kumar KB, Mathew Dan and Shiburaj S (2015). Zingiberaceous plants as a source of anti-bacterial activity: Targeting bacterial Cell division protein (FtsZ). Paper presented International Conference on Emerging Biosensors and Biotechnology to be held in Montreal, Canada.

Reshmi S and Sudha CG (2015). Establishment of *in vitro* seed germination protocol of *Rauvolfia hookeri* Sriniv. & Chitra., a rare and endemic medicinal plant in Southern Western Ghats . Paper presented in International Conference on Medicinal Plants and Herbal Drugs for Human Welfare (ICMP-2015).

Reshma Reghu S, Nandu T G, Mathew Dan and Shiburaj S (2016). Analysis of anti-bacterial potential of *A. galanga* and *Z. officinale* by targeting the bacterial protein, FtsZ" presented at the International Symposium on Phytochemistry and Prof. Dr. Hisham Endowment Award Ceremony, Malabar Botanical Garden and Institute for Plant Sciences, Kozhikode.

Reshma Reghu S, Nandu TG, Mathew Dan and Shiburaj S (2016). Efficacy of zingiberaceous plant extracts against the fish pathogens belonging to the genus *Vibrio*". Paper presented at 28th Kerala Science Congress, Calicut University.

Reshmi S and Sudha CG (2016). Production of indole alkaloids in callus and normal root culture of *Rauvolfia micrantha* Hook. f., a rare and endemic medicinal plant. Paper presented in the 28th Kerala Science Congress, Malappuram.

Riju Raj, Shaju T, Rajendraprasad M and Pandurangan AG (2014). "Perspectives of Endemism in lateritic Zones of Northern Kerala. Paper presented in 24th IAAT Conference, Bharathidasan University, Tiruchirappalli.

Santhosh Kumar ES (2015) delivered a lecture on 'J S Gamble's novelties in Flora of the Presidency of Madras' at the one day seminar on the 'Centenary celebration of Gamble's Flora Presidency of Madras' conducted by JNTBGRI, Trivandrum

Shameer PS, Sabu T, Rameshkumar KB, and Mohanan N (2014). Genus *Garcinia* L. diversity and potential utility as fruit crops. Paper or poster presented in National Symposium on underutilized and wild edible plants of India- Future crops. Department of Botany, University of Kerala, Karyavattom.

Shameer PS, Rameshkumar KB, Sabu T and Mohanan N (2014). Diversity of *Garcinia gummi-gutta* (L.) Robs. - Morphological and chemical evaluation. Paper presented in the 24th IAAT conference held at Bharathidasan University, Tiruchirappalli.

Shamnad J and Mathew Dan (2015). Preliminary intraspecific variability studies in *Clitoria ternatea* (Fabaceae), a potential medicinal plant. Paper presented in International Seminar on Advancecs in Angiosperm Systematics and Conservation. IAAT, University of Calicut.

Sharmila A, Anoosh Varghese, Nazarudeen A and Pandurangan AG (2015). Native mango varieties of Thiruvananthapuram district, Kerala (India), a case study. Paper presented in National Seminar on Advancement of Biosystematics on Biodiversity Conservation, Department of Botany, SN College, Varkala, Kerala.

Sharmila S, Anoosh Varghese, Nazarudeen A, and Pandurangan AG (2015). An assessment of native mango diversity in Kerala: A practical approach for conservation. Paper presented in International Seminar on Advancements in Angiosperm Systematics & Conservation, pp 67-68. University of Calicut, Kerala.

- Shiburaj S, Neethu RS and Pradeep NS (2016). Production of Carboxymethyl cellulase using *Trichoderma atroviride* TBG-01(NFCCI 3763) isolated from forest soils of Western Ghats, Kerala. Paper presented at National Conference on 'Emerging Trends in Fungal Biology and Plant Protection (by Mycological Society of India) held at Banaras Hindu University, Varanasi.
- Shikha P, Latha PG, Suja SR (2016). Sub-chronic toxicity and antidiabetic study of *Arenga wightii* Griff. Paper presented at 28th Kerala Science Congress held at University of Calicut , Malappuram.
- Shine VJ (2015). Attended National Workshop in "Animal Cell Culture and Cytogenetics" scheduled at Mar Ivanios College, Thiruvananthapuram.
- Soorya Vijayan (2015). Attended the National Workshop on "Flow cytometry and Cell Sorting at the Inter University Centre for Genomics and Gene Technology, University of Kerala, Kariavattom, Trivandrum.
- Soorya Vijayan , Suja SR, Latha PG, Showmya S, Sabulal B (2015). Role of bioactive compounds from a therapeutically important endangered medicinal plant - *Gloriosa Superba* Linn." Paper presented at the 9th National Seminar on medicinal plants held at Rajiv Gandhi centre for Biotechnology, Thiruvananthapuram.
- Sowmya SD, Anjali N, Nadiya F and Sabu KK (2014). Variation in lignin content and genetic diversity in *Elettaria cardamomum* Maton. *Proc. of International Symposium on Plantation Crops – PLACROSYM XXI*, Kozhikkode.
- Sreejith G (2015). Attended the National Workshop on "Flow cytometry and Cell Sorting at the Inter University Centre for Genomics and Gene Technology, University of Kerala, Karyavattom, Thiruvananthapuram.
- Sreekala AK and Kulloli SK (2014). Pollination Biology of *Impatiens pulcherrima* Dalzell. (Balsaminaceae) - An endemic balsam of Western Ghats. Paper presented at the 3rd international global congress in Plant Reproductive Biology, Conservation and Crop Improvement. Agra.
- Sreekala AK (2016). Floral structure in relation to pollination and breeding system of selected endemic *Impatiens* of Western Ghats. Paper presented in fifth International conference on Biodiversity, Organised by OMICS international, Madrid, Spain.
- Sreekumar S and Biju CK (2015). Secondary metabolite production in plants through biotechnological intervention. Paper presented in 'Biotrends– 2015', National Seminar on Bio-innovations for Global Prosperity, organized by Malankara Catholic College, Kanyakumari.
- Stephin S, Gangaprasad A and Mathew SP (2015). Preliminary phytochemical analysis and antioxidant activity of crude methanolic extracts of *Piper ribesoides* Wall – a lesser known wild relative of pepper from Andaman Islands, Paper presented in 9th National seminar on Medicinal plants, held at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram.
- Suja SR and Latha PG (2014). A Glance in to the Bioprospecting, Ethnopharmacological and Therapeutical potential of *Spilanthes* genus- A Repository of Traditional Medicine" Paper presented in the 2nd International conference on Advances in Plant sciences , Kuching, Sarawak, Malaysia.
- Suja SR and Shine VJ (2014) Attended three days National colloquium on NMR and MS -Biological Applications, organised by SRIBS, Kottayam.
- Suja SR (2015). Attended investigators meeting of DBT Project at Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram.
- Suja SR (2015). Attended investigators meeting of DBT Project at JNTBGRI, with NIIST regarding the DBT funded project, Palode .
- Suja SR (2015). Attended the Election Training programme at Vanashree Auditorium, Thiruvananthapuram .
- Suja SR, Binu S and Jinu Krishnan (2015) organized an awareness programme for rural Women on Jasmine Cultivation and Practices at Bharathanoor Gramapanchayath of Thiruvananthapuram district.
- Suja SR, Shine VJ, Aneeshkumar AL, Soorya Vijayan, Aruna, Geethu, Sagna and Muthulekshmi (2015). Attended Workshop on "Intellectual Property Rights" at Department of Zoology, M.G. College, Thiruvananthapuram.
- Suja SR, Vinodkumar TG Nair, Navas M, Shine VJ, Krishnakumar NM (2015). Attended the Monograph releasing ceremony of clinical studies conducted based on the ethnomedical lead given by Mr. Shahul Hameed at Honourable Chief Minister's Chamber, Thiruvananthapuram .
- Sunilkumar S, Vrinda KB & Pradeep CK (2016). Presented a paper entitled "Notes on *Amanita* section *Caesarea* from Western Ghats of Kerala" in the National Conference on *Emerging Trends in Fungal Biology and Plant Protection-ETFPP-2016*, Mycological Society of India at Banaras Hindu University, Varanasi.
- Unnithan CM, Mathew Dan, Mathew PJ (2015). Conservation of *Cosciniium fenestratum*, a red listed medicinal plant – a success story at JNTBGRI. Paper presented in the National Conference on Indian Botanic Gardens, NBRI, Lucknow.
- Usha VS and Pandurangan AG (2015). Systematics studies of the genus *Passiflora* L. *Western Ghats*". Paper presented in National Seminar on "Plant Genetic Resources Utilization and Conservation", held at V. O. Chidambaram College, Thoothukudi.
- Viji AR and Pandurangan AG (2014). The status of the genus *Cyperus* L. (Cyperaceae) in Nilgiri Biosphere Reserve, Western Ghats of India. Paper presented in 24th IAAT conference, Bharathidasan University, Tiruchirappalli.

Viji AR and Pandurangan AG (2016) Systematic studies of the family Cyperaceae in Nilgiri Biosphere Reserve, India. Paper presented in the 28th Kerala Science Congress. Malappuram.

Vinodkumar TG Nair conducted awareness programme on ethno botanical survey in the coastal areas at Pattanakkadu Gramapanchayath of Alappuzha district.

Vinodkumar TG Nair and Navas M (2014) conducted awareness programme on systematic documentation of traditional knowledge, its importance and conservation at Seethathodu Gramapanchayath of Pathanamthitta district.

Vinodkumar TG Nair (2015). Delivered a talk on "Ethnomedical Traditions of Kerala" in National Seminar on Traditional Medical Practises in Kerala conducted by International Centre for Kerala Studies, University of Kerala, Thiruvananthapuram.

Vinodkumar TG Nair (2015). Participated as a Panellist at the "Community-to-Community Exchange and Capacity Development Workshop for Traditional Knowledge Holders" organized by United Nations University – Institute for the Advanced Study of Sustainability (UNU-IAS), GIZ, UNDP Equator Initiative, ABS Capacity Development Initiative, Biodiversity International, FLEDGE and TDU with participants from Africa, Central Asia and India at Bangalore.

Vinodkumar TG Nair and Navas M (2015). Attended a meeting conducted in connection with the implementation of project at Mararikkulam Gramapanchayath of Alappuzha.

Vinodkumar TG Nair and Navas M (2015). Attended a meeting conducted in connection with the implementation of Project P124 at Ranni-Perunnadu Gramapanchayath of Pathanamthitta.

Vinodkumar TG Nair and Navas M (2015). Attended a national workshop on "Vrikshayurveda in Plant Health Management" organized by Kerala State Planning Board and Kerala State Biodiversity Board at Mascot Hotel, Thiruvananthapuram.

Vinodkumar TG Nair and Navas M (2015). Attended meeting organized by Kerala Forest Department in collaboration with OUSHADHI, Thrissur and JNTBGRI at Kottur Tribal area.

Vinodkumar T.G Nair (2016). Indigenous Knowledge of Kani Tribe Relating to Medicinal Herb *Trichopous zeylanicus* subsp. *travancoricus*- 'Arogyapacha' Benefit Sharing with the community' Paper presented as part of SFDA Kerala- 10th Executive Committee Meeting at Forest Head Quarters, Thiruvananthapuram.

Vinodkumar TG Nair (2016). Organized a meeting with President, Ward members and Local communities of Kottukal and Kulathur Gramapanchayaths of Thiruvananthapuram district and Clappana Gramapanchayath of Kollam District.

Vinodkumar TG Nair (2016). Attended as Invited

participant at the Preparatory Meeting of UN-NITI AYOGRIS National Consultation on the Road to Sustainable Development Goals at RIS, New Delhi

Vinodkumar TG Nair (2016). Attended the conference on 'Revitalization of Local Health Tradition' Organized by AzimPremji University.

Vinodkumar TG Nair (2016). Invited as a Discussant at the UN – NITI AaYogRIS 'Nation of Consultation on the Road to Sustainable Development Goals' at India, International Centre, Lodhi Road, New Delhi.

Vinodkumar TG Nair (2016). Official meeting with Dr. Harshwardhan, Hon'ble Minister for Health and Family Welfare regarding the takeover of JNTBGRI by CSIR.

Vinodkumar TG Nair (2016). Participated in the '7thAshtanga Hridaya Satram' organized by Vagbhatarani as Academic Committee Convener on 25th January, 2016.

Vinodkumar TG Nair and Angala Mathew (2016). Met Smt. P. K. Jayalekshmi The Hon'ble Minister for Welfare of Scheduled Tribes, Youth Affairs, Museum & Zoo's Govt. Secretariat, Thiruvananthapuram.

Vinodkumar TG Nair, Navas M, Renju VS and Midhun Krishna M (2016). Conducted awareness classes on the importance of Conservation of costal Ethanobotany at Venganoor and Kottukal Gramapanchayath of Thiruvananthapuram.

Vinodkumar TG Nair, Navas M, Renju VS and Midhun Krishna M (2016). Ethnobotanical Survey in the Coastal Areas of Thiruvananthapuram District, Kerala. Poster presented In 9th National Seminar on Medicinal Plants Organized by ARI Thiruvananthapuram at RGCB Thiruvananthapuram.

Vinodkumar TG. Nair, Navas M, Cheshaga GU and Angala Mathew (2016). Digitization of Ethnomedical Information by Different Tribal Communities of Idukki District, Kerala'. Paper presented at 9th National Seminar On Medicinal Plants Organized by ARI Thiruvananthapuram at RGCB, Thiruvananthapuram.

Vrinda KB and Pradeep CK (2016). Attended the National Conference on *Emerging Trends in Fungal Biology and Plant Protection-ETFP-2016*, organized by the Mycological Society of India at Banaras Hindu University, Varanasi.

William Decruse (2015). Ecological niche modeling to trace unknown populations and restoration planning of endangered plant species: A case study in *Vanda wightii* Rchb.f., an endangered orchid species of Western Ghats. Paper presented in National Seminar on Flowering Plant Reproduction and Diversity, FMN College, Kollam.

William Decruse S, Ajeesh Kumar S and Sayoogia SV (2015). Seed and protocorm cryopreservation of orchids of Western Ghats for their effective conservation in gene banks.

Poster presented in National Seminar of the Orchid Society of India, SVD University, Katra, Jammu.

William Decruse S, Sayoogia S, Vargheese and Ajeeshkumar S (2015). Cryopreservation and utilization of pollinia of the orchids of Western Ghats. Paper presented in International Conference on Low Temperature Sciences and

Biotechnological Advances, NBPGR, New Delhi .

William Decruse S, Shailajakumary S, Seeni S and Latha PG (2016). Conservation of notified endangered orchids of Western Ghats: *Paphiopedilum druryii*, *Vanda thwaitesii* and *V. wightii*. Paper presented in National Conference of the Orchid Society of India, YSR Horticultural University.

Events



DBT Brainstorming Session at JNTBGRI on 13.06.2014



Ailing cancer victims spent a day relaxing at JNTBGRI on 04.07.2014. They were attended carefully by the staff and gifted packets of food grains, lentils, soaps, antiseptics etc.



Onam 2014 celebrations with Smt. Nalini Netto IAS



Shri O. Rajagopal visited JNTBGRI on 10. 09. 2014 and planted a sapling



Shri B. L. Jain, Vice Chairman, Planning Commission visited JNTBGRI on 25. 09. 2014



Michael Moller, Royal Botanic Garden, Edinburgh visited JNTBGRI on 08. 10. 2014



MGNREGA volunteers agreed to garden activities on 20. 10. 2014



Children's day celebrations 2014



Austrian guests, Ingrid and Josef Mayer and Hedwig Peter visited JNTBGR on 24. 11. 2014



Farewell to Shri S S Dayal, PRO and Shri Gangadhara Pillai on 28. 11. 2014



Director Dr P. G. Latha received the Job Day Award from Shri Shashi Tharoor, Hon'ble M.P. on 29. 11. 2014



Dr P. Pushpangadan, Former Director, JNTBGRI switches on the newly installed 25 KV generator on 06. 1. 2015



Former Minister of Tourism, GoK, Shri A. P. Anilkumar visiting the garden on 13. 01. 2015



The first crop of the leafy vegetable, Amaranthus of JNTBGRI handed over to Shri Anilkumar, Canteen Manager on 19. 01. 2015



JNTBGRI took part in the Run Kerala Run on 20. 01. 2015



Send-off to Security Guards Shri Viswambaran and Shri Sukumaran on 31. 03. 2015



Dr Sri Vasuki, PCCF, Telengana addressing the staff on 16. 04. 2015



The former Chief Secretary of Kerala, Shri Jiji Thomson IAS releases the JNTBGRI publication "Bee's Herbal Garden" on 07. 05. 2015



With Dr. G. M. Nair, University of Kerala, Dr. Peethambaran (Agri. University) and Dr. Rajeev (NIIST) National Technology Day Celebrations at JNTBGRI on 11. 05. 2015



Smt Jaya Chandrasekhar addressing the staff during a 'Interpersonal relationship' training programme on 12. 05. 2015



Shri Dr. Harshvardhan, Hon'ble Union Minister for Science and Technology at the presentation of JNTBGRI by Director on 17. 05. 2015 flanked by Dr Suresh Das, EVP, KSCSTE and Shri A. Sampath Hon'ble M.P. and Shri K. M. Chandrasekhar, Kerala State Planning Board



The "Chakshumukhi" differently abled group with Dr U. K. Damodaran and Smt Sobha Koshy IAS at JNTBGRI on 18. 05. 2015



Hon'ble Chief Minister, Shri Oomen Chandy distributing the special award to JNTBGRI at International Biodiversity Day Celebrations on 22. 05. 2015



His grace, Dr Joseph Mar Dionysius Metropolitan of Calcutta Diocese addressing JNTBGRI staff on 22. 05. 2015 in connection with Biodiversity Day 2015



JNTBGRI organised Centenary celebrations of J. S. Gamble' Flora of Presidency of Madras on 18. 12. 2015



Dr Suresh Das, Executive Vice President visited JNTBGRI on 31. 12. 2015



Officials from CSIR visited JNTBGRI on 17. 02. 2016



Dr K. P. Mohanakumar, Chief Scientist, CSIR-IICB, Kolkata presenting Professor A. Abraham Centenary Lecture on 29. 04. 2016 at JNTBGRI



DBT team monitoring the progress of the Programme Support Mode Project in January 2016

Plan Funded Research and Infrastructure Programmes

Budget Allotment 2014 -'16

Sl. No & Project Code	Project Title	Principal Investigator
1 (P 102)	Phytochemical screening and selection of potential accession of <i>Ophiorrhiza mungos</i> L. for the development of suitable <i>in vitro</i> cultures including multiple shoots leading to the production of camptothecin - and production of plumbagin through hairy root cultures of <i>Plumbago rosea</i> L.	Dr K Satheeshkumar
2 (P 103)	Propagation of <i>Phaius luridus</i> and expansion of pollinia and seed cryobank of orchids of Western Ghats	Dr S William Decruse
3 (P 104)	Genetic conservation and chemical characterization of ethnobotanical insect repellent plant species of Andaman Islands	Dr R K Radha
4 (P 106)	Establishment of normal and hairy root cultures of <i>Trichosanthes cucumerina</i> , a high value medicinal plant	D C G Sudha
5 (P 107)	Study of parasitic fungal taxa associated with plants of sacred groves of Kerala (Alappuzha and Ernakulam districts)	Mr M Raveendran
6 (P 108)	Digitizing of JNTBGRI herbarium specimens	Dr C K Biju
7 (P 109)	Development and maintenance of Puthenthope Centre	Mr M Raveendran
8 (P 110)	Cultivation of high value ornamental plants and income generation	Dr S Sreekumar
9 (P 111)	Development of Conservation strategies for Seedless diploid (AA) members of <i>Musa</i> family through biotechnology	Dr S Mukunthakumar
10 (P 112)	<i>In vitro</i> propagation and ecorestoration of threatened medicinal plant <i>Myristica malabarica</i> Lam.	Dr R K Radha
11 (P 113)	Selection of elite genotype of <i>Curculigo orchioides</i> Gaertn. an endangered and commercially important medicinal plant from southern Western Ghats by morphological, molecular and phytochemical characterization for its sustainable utilization and <i>ex situ</i> conservation through biotechnological interventions	Dr CG Sudha
12 (P 114)	Analysis of genetic variability and bioprospecting of wild Cardamom populations	Dr K K Sabu
13 (P 115)	<i>In silico</i> validation of drug activity in plants	Dr S Sreekumar
14 (P 116)	Population studies and gene flow system in plant species of critically endangered and endemic species	Mr P S Jothish
15 (P 117)	Tree pollen of the Western Ghats + airborne pollen atlas	Mr P S Jothish
16 (P 118)	Documenting plant based information to support practical conservation and conservation policies – (i) Kerala (ii) the Western Ghats (iii) India	Mrs A Rasiya Beagam
17 (P 141)	Establishment and maintenance of JNTBGRI Seed Bank	Dr C Anilkumar
18 (P 150)	Studies on reproductive biology and conservation of selected RET species of W. Ghats	Dr A K Sreekala
19 (P NEW 005)	Integrating ecological and genetic approaches in developing conservation strategies for critically small populations: a case study of the endemic and critically endangered cycad, <i>Cycas annaikalensis</i> in the Western Ghats	Dr P Balakrishnan
20 (P 120)	Anti-inflammatory, analgesic and anti-arthritis activity of two selected plants of Western Ghats	Dr P G Latha
21 (P 121)	Clinical trial of coded hepatoprotective herbal formulation in collaboration with OUSHADHI, Govt. of Kerala	Dr S R Suja
22 (P 122)	Search for anti-diabetic/hepato-protective, immuno-modulatory and wound healing plants from traditional/folklore medical information of Kerala	Dr P G Latha
23 (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 Nair
24 (P 125)	Ethnobotanical survey in the coastal areas of three southern districts of Kerala	Dr K Radhakrishnan
25 (P NEW 004)	Evaluation of platelet augmentation activity of selected medicinal plants of Western Ghats based on traditional knowledge	Dr S R Suja
26 (P 126)	Development and maintenance of conservatories: Arboretum, Palmetum and Aquatic Plants	Dr N Mohanan
27 (P 127)	Development and maintenance of conservatories: Ferns and Gymnosperms	Mr Cheriyan P Koshy
28 (P 128)	Development and maintenance of conservatories: Wild Fruit Plants	Mr Cheriyan P Koshy
29 (P 129)	Landscaping and garden development	Dr R Raj Vikraman
30 (P 130)	Management, research and development of Central Nursery of the Garden and Sales unit	Dr N Mohanan
31 (P NEW 006)	Development of a conservatory for aquatic macrophytes in JNTBGRI	Dr A A Prasannakumari
32 (P NEW 007)	Organic farming through terrace cultivation – A demonstration at JNTBGRI	Dr A A Prasannakumari

SI. No & Project Code	Project Title	Principal Investigator
33 (P 131)	Search for renewable biomass and biofuel sources in <i>Euphorbia</i> plants of the southern Western Ghats	Dr K B Rameshkumar
34 (P 132)	Chemical prospecting of plants in the Kerala region of Western Ghats for bioactive molecules	Dr B Sabulal
35 (P 133)	Chemical prospecting of the aromatic plants of the Kerala region of the Western Ghats	Dr B Sabulal
36 (P 135)	Establishment of National Collection and Conservation – Education Centre of medicinal, aromatic and spice plants	Dr Mathew Dan
37 (P 136)	<i>Ex-situ</i> conservation genetic resources of selected medicinal, aromatic and spice plants and assessment of intraspecific variability	Dr Mathew Dan
38 (P 137)	Field gene bank development of selected medicinal and aromatic plants and characterization of germplasm	Dr Mathew Dan
39 (P 138)	Development of a systematic garden of herbals	Dr E S Santhoshkumar
40 (P 139)	Standardisation of tissue culture techniques and mass production of ornamentals	Dr Bejoy Mathew
41 (P 140)	Micropropagation of commercially important banana and other taxa	Dr Bejoy Mathew
42 (P 142)	Cyto-taxonomic investigations on bamboos of the Western Ghats	Dr K C Koshy
43 (P 143)	Conservation of bamboos of TBGRI	Dr K C Koshy
44 (P 144)	National Collection of Orchids	Dr C Sathishkumar
45 (P 145)	Building up a conservatory for carnivorous plants	Dr C Sathishkumar
46 (P 146)	Survey, exploration and documentation of floristic wealth of Kerala	Dr A G Pandurangan
47 (P 147)	Inventory, documentation and phylogenetic studies of mushrooms of Western Ghats & Establishment of a regional herbarium for mushrooms	Dr KB Vrinda
48 (P 149)	Development and management of Regional Herbarium for Kerala	Dr A G Pandurangan
49 (P 151)	Floristic, ecologic and functional dynamics of selected grasslands of Western Ghats	Dr M Rajendraprasad
50 (P NEW 001)	Molecular and phylogenetic studies on <i>Inocybaceae</i> (Basidiomycotina, Agaricales) of Kerala	Dr C K Pradeep
51 (P NEW 002)	Vegetational and ecological assessment of lateritic zones of North Kerala	Dr T Shaju
52 (P NEW 003)	Inventory, systematics and Conservation of the family Annonaceae of Southern Western Ghats with emphasis on Endemic and RET species	Dr G Rajkumar
53 (P 148)	Molecular taxonomy and establishment of microbial culture collections for bioprospecting	Dr N S Pradeep
54 (P 153)	Collection, identification and documentation of Lichens in the Shendurney Wildlife Sanctuary, Kollam, Kerala	Dr N S Pradeep
55 (P 154)	Diversity of foliar mycobionts in the Botanic Gardens in Kerala	Dr S Shiburaj
56 (P NEW 008)	Establishment of a souvenir shop at JNTBGRI	Dr S Binu
57 (P 155)	Infrastructure Programmes	
A	Compound wall forest side	
B	Upgradation of office buildings: (DBT, Herbarium, Jubilee Complex, Roofing of Main Building, Staff Quarters; Microbiology Division)	
C	Extension and up gradation of roads, electrification and irrigation	
D	Cost of electricity, diesel, telephone, vehicles	
E	Upgradation of toilet blocks	
F	Central Plant Production Unit (Micro propagation)	
G	Infrastructure development and up gradation (Puthenthope Centre)	
H	Library and Information Services	
I	System Administration Unit	
J	Upgradation of Biometrics	
K	Vehicles	
L	Instrumentation facilities – AMC s, repairs , servicing	
M	Garden renovation (Garden Management Division, Mist house, Green House etc.)	
N	Live plant up gradation and emergency medical assistance for casual labourers	
O	Audio visual aids (laptop, projector etc.) for Seminar Club	
P	Art and photography	

SI. No & Project Code	Project Title
Q	VMC - exhibition (LED TV, Slide units etc.)
R	Auditing & printing
S	Organization of national/international conferences
T	Contingency

List of Ongoing Externally Funded Projects of JNTBGRI

Sl. No.	Code	Project title	Name of PI	Funding Agency
1	A-19	"Establishment of Sub-Distributed Information Centre at TBGRI under Bio informatics Programme"	Director	Department of Biotechnology, Govt. of India
2	A-94	Improvement of infrastructural facilities in TBGRI, Palode, Kerala under Recognition of Lead Garden to facilitate <i>ex situ</i> conservation of Indigenous, particularly Rare, Endangered and Threatened (RET) Plants	Dr A. G. Pandurangan	MoEF, Govt. of India
3	A-106	Conservation and restoration of two endemic and critically endangered tree species (<i>Syzygium gampleanum</i> Rather & Chithra and <i>Syzygium rama-varma</i> (Bourd.) Chithra from Agasthyamalai Biosphere Reserve through Conventional and Non-Conventional propagation	Dr P. Padmesh	DBT, Govt. of India
4	A-108	Establishment of Seed Bank and Field Gene Bank of <i>Saraca asoca</i> – A vulnerable medicinal species of the Indian subcontinent	Dr C. Anilkumar	Kerala Forest Dept. , Govt. of Kerala
5	A-109	Training and technical consultancy service for Marari Mushroom project	Dr NS Pradeep	State Poverty Eradication Mission, Kudumbashree
6	A-110	Identification of nuclear tree species and assessment – A case study with reference to the tropical rain forests in Silent Valley in the W. Ghats	Dr TS Nayar	MoEF, Govt. of India
7	A-113	Development of tissue culture protocol for mass propagation of selected Screwpine (<i>Pandanus</i> spp.) plants leading to technology transfer and establishment of tissue culture facility at KIDS	Dr PN Krishnan	KSIDC, Govt. of Kerala
8	A-114	Systematic documentation of Traditional Knowledge related to plants used for food and medicine from the Oral Tradition	Dr S. Rajasekharan	Department of AYUSH, Ministry of Health & Family Welfare, Govt. of India
9	A-115	Biotechnological interventions for conservation and utilization of forest resources	Dr Padmesh P.	Dept. of Biotechnology, Govt. of India
10	A-117	Conservation of <i>Vanda thwaitisii</i> , <i>V. wightii</i> and <i>Eulophia cullenii</i> three endangered orchids of Western Ghats through micropropagation and restoration with tribal participation	Dr William Decruse	Dept. of Biotechnology, Govt. of India
11	A-118	Phytochemical screening and selection of potential species of <i>Picrorhiza</i> for tissue culture based mass multiplication leading to production of camptothecin – an anticancer compound	Dr K. Satheshkumar	Department of Atomic Energy (DAE), Board of Research in Nuclear Sciences (BRNS), Govt. of India
12	A-119	Preparation of Detailed Project Report for the conservation and preservation package for the cliff area of Varkala	Dr C Sathish Kumar	Dept. of Tourism, Govt. of Kerala
13	A-122	CSIR Fellowship	Silja PK	CSIR, Govt. of India
14	A-123	Wild edible mushrooms from Kerala forests – a source of food and income	Dr KB Vrinda	WGDP, Govt. of Kerala
15	A124	Hepatoprotective properties of <i>Saraca asoca</i> stem bark (Fabaceae), an important medicinal plant	Dr PG Latha	WGDP, Govt. of Kerala
16	A125	Analysis of genetic diversity in selected rattan palms (<i>Calamus</i> sp.) using microsatellite markers	Dr K.K. Sabu	KSCSTE, Govt. of Kerala
17	A126	UGC Fellowship UGC	Akshaya Vijayan	UGC, Govt. of India
18	A128	BTISNET New website development and integration / interlinking of bioinformatics resources developed by BTIS Centres	Dr Sreekumar S	DBT, Govt. of India

Sl. No.	Code	Project title	Name of PI	Funding Agency
19	A129	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
20	A132	KSCSTE Studentship	Neethu RS	KSCSTE, Govt. of Kerala
21	A133	Conservation of <i>Calamus shendurnii</i> Anto, Renuka and Sreekumar and <i>C. wightii</i> Griff., two endangered and endemic rattans of Western Ghats through micropropagation, reintroduction and cryobanking	Dr William Decruse	Kerala Forest Department
22	A134	Conservation and sustainable utilization of <i>Garcinia</i> species of the southern western Ghats	Dr N Mohanan	Kerala Forest Department
23	A137	Bioprospecting of potential gingers : chemical prospecting, morphological characterization and <i>ex situ</i> conservation	Dr Mathew Dan	DBT, Govt. of India
24	A138	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
25	A139	INSPIRE Fellowship	INSPIRE Fellowship NC Nisha	DST, Govt. of India
26	A140	Search for potential biologically active constituents from a Hitherto Uninvestigated unique bamboo, <i>Melocanna baccifera</i>	Dr B. Sabulal	SERB, Govt. of India
27	A141	CSIR Studentship programme	Deepthi S	CSIR, Govt. of India
28	A143	<i>Ex situ</i> and <i>in situ</i> conservation of <i>Garcinia imbertii</i> Bourd, an endangered and endemic tree of the southern W.Ghats	Dr Anil Kumar	KSCSTE, Thiruvananthapuram
29	A144	Biflavonoids from <i>Garcinia</i> species-chemical, molecular and pharmacological evaluation.	Dr KB Ramesh Kumar	KSCSTE, Thiruvananthapuram
30	A145	Preparation of an illustrated bilingual field guide on medicinal fruits, seeds and their seedlings occurring in Kerala forest.	Dr C Anilkumar	Forest Department, Govt. of Kerala
31	A 146	Assessment of medicinal plants resources in seven southern district of Kerala.	Dr PG Latha	State Medicinal Plants Board, Kerala
32	A147	Studentship from KSCSTE	Smt. Anjali N.	KSCSTE, Govt. of Kerala
33	A148	Germplasm documentation, evaluation, ex-situ conservation and popularization of local mango varieties in Kerala.	Dr Nazarudeen A.	Forest Department, Govt. of Kerala
34	A150	High-tech micropropagation unit for mass production of economically important Plants	Dr Bejoy Mathew	Agriculture department, Govt of Kerala
35	A151	Cloning and expression of small heat shock proteins from <i>Streptomyces</i> spp. and exploration of its industrial applications.	Dr S Shiburaj	KSCSTE, Govt of Kerala
36	A152	Studies on bacterial plants of WGs of Kerala for the development of novel antibacterial drugs	Dr S Shiburaj	KSCSTE, Govt of Kerala
37	A153	Establishment of a community agro-biotech resource centre	Dr P G Latha	KSCSTE, Govt of Kerala
38	A154	Development of a rhizosecretion system for recombinant protein expression in <i>Lemna gibba.</i> , <i>L</i> using the candidate molecule, hCAP-18	Dr P K Satheeshkumar	SERB, Govt of India
39	A155	Printing of poster on birds of JNTBGRI	Dr S Anilkumar	KSCSTE, Govt of Kerala
40	A156	KSCSTE Studentship programme	Smt Nadiya	KSCSTE, Govt of Kerala
41	A158	Studentship from CSIR	Mr Karthik Menon	CSIR, Govt. of India
42	A159	Economic and bio geographic evaluation of the <i>Cinnamomum</i> species in some selected parts of India through morphological, chemical and molecular biology studies.	Dr K B Rameshkumar	DBT, Govt. of India

Sl. No.	Code	Project title	Name of PI	Funding Agency
43	A160	Conservation of <i>Garcinia imberti</i> Bourd-An endangered endemic tree of Southern Western Ghats through population studies and Seed Biology	Dr C Anilkumar	SERB, Govt. of India
44	A161	Bio prospecting of actino bacteria from the Sacred Groves of Kerala for bio catalysts of commercial applications	Dr Asha Poorna	DST, Govt. of India
45	A162	Studentship from DST	Ms Nimmi Haridas	DST, Govt. of India
46	A163	Assessing the Influence of environmental and biotic factors on life history variation and demography of tropical rainforest bulbuls	Dr P Balakrishnan	DST, Govt. of India
47	A164	Studentship from ICMR, Govt. of India	Ms Sika P	ICMR, Govt. of India
48	A165	MSc Integrated Biotechnology Course Batch for 10 students undergoing thesis research work at JNTBGRI.	Director	Kerala Agriculture University, Govt. of Kerala
49	A166	Molecular analysis of the alpha-amylase production in <i>Streptomyces griseus</i> (MTCC 3756)	Smt. Divya Balakrishnan	KSCSTE, Govt. of Kerala
50	A167	Studentship from KSCSTE	Ms Jeeshma N P	KSCSTE, Govt. of Kerala
51	A168	Production and supply of quality seedlings of selected 10 Medicinal Plants	Dr Mathew Dan	State Medicinal Plants Board, Govt. of Kerala
52	A169	Studentship from KSCSTE	Ms Subin Mathew	KSCSTE, Govt. of Kerala
53	A170	Pharmacological and molecular expression studies on hepatoprotective herbal formulation against liver fibrosis	Dr V J Shine	SERB, Govt. of India
54	A171	Studentship from CSIR	Smt. Gayathri V	CSIR, Govt. of India
55	A172	Genomic characterization of wild <i>Musa</i> spp. using microsatellites and its pollen cryobank development.	Dr S Mukunthakumar	DBT, Govt. of India
56	A173	Studentship from DST	Mr. Ragesh R Nair	DST, Govt. of India
57	A174	Gardening and landscaping at 35 th National Game's Village	Dr S Sreekumar	NGS, Govt. of India
58	A175	Setting up a small bamboo nursery in public sector at JNTBGRI	Dr K C Koshy	Kerala Bureau of Industrial Promotion, Govt. of Kerala
59	A176	Identification of potential chemical marker compounds and biological studies of <i>Gloriosa superba</i> and their geographical variations	Dr P G Latha	National Medicinal Plant Board, Govt. of India
60	A177	Beautification of Tennis Complex at Kumarapuram.	Dr S Sreekumar	NGS, Govt. of India
61	A178	Beautification of Squash Court Building at Chandrasekharan Nair Stadium, Thiruvananthapuram	Dr S Sreekumar	NGS, Govt. of India
62	A179	Genomics and metabolomics of wild medicinal plants - training programme	Dr P Padmesh	DBT, Govt. of India
63	A180	Identification of indicator species for special conservation efforts	Dr P Balakrishnan	UNDP, Govt. of India
64	A181	Studentship from ICMR	Mr. Sreejith V	ICMR, Govt. of India
65	A182	Conducting study for establishment of Orchidarium in Infosys Mangalore SEZ Campus	Dr C Sathish Kumar	INFOSYS, Bangalore
66	A183	Beautification of Shooting Range, Vattiyoorkavu	Dr S Sreekumar	NGS, Govt. of India
67	A184	Gardening and landscaping at Indoor Stadium, Kannur	Dr S Sreekumar	NGS, Govt. of India
68	A185	Beautification of Medical College Stadium, Kozhikode	Dr S Sreekumar	NGS, Govt. of India
69	A186	Medical Mushrooms of Kerala	Dr K B Vrinda	WGDP, Govt. of Kerala
70	A187	A study on the Jasmine varieties of Western Ghats producing high essential oil content with special emphasis on commercialization of essential oil for perfumery by rural women for their empowerment.	Dr Suja S R	WGDP, Govt. of Kerala
71	A188	One-time assistance for the establishment of green belt in the premises of Vellayani Lake	Dr Mathew Dan	Kerala State Biodiversity Board, Govt. of Kerala

Sl. No.	Code	Project title	Name of PI	Funding Agency
72	A189	Stakeholders consultative workshops for integrated waste management plan.	Dr N S Pradeep	Department of Environment and Climate Change, Govt. of Kerala
73	A190	Mapping environmental issues and developing management plan for Vamanapuram river basin	Director	Department of Environment and Climate Change, Govt. of Kerala
74	A191	Waste management and recycling, waste to garden-Proposal with recycling (Non-Biodegradable) waste processing programme (Zero Waste Ward)	Dr N S Pradeep	Department of Environment and Climate Change, Govt. of Kerala
75	A192	KSCSTE Studentship Programme	Ms Hima S	KSCSTE, Govt. of Kerala
76	A193A1	Community plant-pollinator interactions at the landscape level	Dr A K Sreekala	DBT, Govt. of India
77	A193A2	Ecology and conservation of fresh water swamp ecosystems of the Western Ghats-Kerala region	Dr Rajendra Prasad	DBT, Govt. of India
78	A193 (A3)	Comparative biogeography of plants of the Western Ghats	Dr N Mohanan	DBT, Govt. of India
79	A193 (B1)	Identification of elite lines of <i>Centella asiatica</i> and <i>Bacopa monnieri</i> for commercially significant constituents for standardization of their extracts.	Dr B Sabulal	DBT, Govt. of India
80	A193B2	Bio-prospecting of two coded anti-diabetic medicinal plants based on ethnomedical leads with special reference to diabetic complications- A molecular pharmacological approach.	Dr S R Suja	DBT, Govt. of India
81	A193B3	Metabolic pathway analysis of L-dopa synthesis in <i>Mucuna pruriens</i> L. by characterization of catecholamine pathway with emphasis on modulation of tyrosine hydroxylase genes	Dr P Padmesh	DBT, Govt. of India
82	A193B4	Antiviral from medicinal plants of Western Ghats selected based on traditional knowledge/ethnomedical information	Dr S R Suja	DBT, Govt. of India
83	A193(B5)	Characterization, recombinant expression process scale up and validation of selected hydrolases from native action-bacteria for commercial exploitation	Dr S Shiburaj	DBT, Govt. of India
84	A194	Award for Plant Biodiversity Conservation	Dr P G Latha	Kerala State Biodiversity Board, Govt. of Kerala
85	A195	National Technology Day Celebrations 2015	Dr S Shiburaj	KSCSTE, Govt. of Kerala
86	A196	Floristic Studies of VSSC Campus, Thiruvananthapuram	Dr N Mohanan	VSSC, Govt. of India
87	A197	Fresh water fish farming	Director	FFDA, Govt. of Kerala
88	A198	Landscaping works at the premises of the proposed Green Building under construction in EMC campus at Sreekariyam.	Dr S Sreekumar	Energy Management Centre, Govt. of Kerala
89	A199	Conservation of seven RET medicinal plants of the Western Ghats through standardization of seed and seedling identification, germination, species restoration, seed and field gene banking	Dr C Anilkumar	MoEF, Govt. of India
90	A200	A molecular approach on development of a potent herbal drug against arthritis based on tribal/ traditional knowledge.	Dr Anuja G I	SERB, Govt. of India
91	A201	Production and Characterization of β -Glucanase from <i>Streptomyces</i> sp.	Lekshmi K Edison	KSCSTE, Govt. of Kerala
92	A202	Inspire Fellowship Programme	Smt. Sakthipriya M	DST, Govt. of India
93	A203	Genetic diversity conservation and population study of selected notified endangered plant species of Western Ghats region of Kerala	Dr S William Decruse	Kerala State Biodiversity Board, Govt. of Kerala
94	A204	KSCSTE Fellowship	Ms Lekshmi N Menon	KSCSTE, Govt. of Kerala
95	A205	KSCSTE Fellowship	Ms Reshma Anilkumar	KSCSTE, Govt. of Kerala
96	A206	Studies on the molecular mechanism of action of anti-inflammatory potential of two traditionally used pteridophytes in southern	Dr Sobha Bhaskar	KSCSTE, Govt. of Kerala

Sl. No.	Code	Project title	Name of PI	Funding Agency
		region of Western Ghats		
97	A207	Investigation of the potential anti-inflammatory properties of <i>Pyrrrosia heterophylla</i> . L on inhibiting and reversing alcoholic hepatitis.	Dr Ratheesh R	KSCSTE, Govt. of Kerala
98	A208	Publication of the Journal of Traditional and Folk Practices	Director	KSCSTE, Govt. of Kerala
99	A209	Studentship programme	Ms Gouri Priya Ranjith	KSCSTE, Govt. of Kerala
100	A210	Organisation of third Meeting of Programme Advisory Committee on Plant Sciences under SERB	Dr C Anilkumar	SERB, Govt. of India

JNTBGRI Research Council

Dr M Sanjappa, Bangalore	Chairman
Dr M P Nayar, Thiruvananthapuram	Member
Dr R R Rao, Bangalore	Member
Dr Nabeesa Salim, Kollam	Member
Dr C H V Rao, Lucknow	Member
Dr V S Ramachandran, Coimbatore	Member
Director, JNTBGRI	Member Secretary

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
Mr A K Azeem	Gardener

JNTBGRI Management Committee

Director, JNTBGRI	Chairperson
Member Secretary, KSCSTE	Member
Director, KFRI	Member
Dr N Mohanan, Scientist F, JNTBGRI	Member
K S Sheela, Addl. Secretary, Govt. Kerala	Member
Registrar, JNTBGRI	Member Convener

Plant Genetic Resources Division

Dr P J Mathew	Scientist EII, Head (Retired on 31/05/2015)
Dr K C Koshy	Scientist EII, Head (Retired on 31/01/2016)

JNTBGRI Staff 2014 - 2016

Director	Dr P G Latha
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Garden Management, Education, Information and Training Division

Dr N Mohanan	Scientist F, Head
Dr R Rajvikraman	Scientist E1
Mr Cheriyen P Koshy	Scientist E1
Dr Thania Sara Varghese	Scientist C (Joined on 28/03/2016)
Dr A APrasannakumari	Scientist B
Mr S S Dayal	Public Relations Officer (Retired on 30/11/2014)
Mr V Premkumar	Asst. Public Relations Officer
Dr Raju Antony	Technical Officer
Mr Joemon Jacob	Technical Officer
Mr Muhammed Shareef	Technical Officer
Dr T Sabu	Technical Officer
Mr K J Lathan Kumar	Technical Officer
Mr G Thulasidas	Technical Officer
Mr A Hussain	Technical Officer
Mr K S Kalesh	Technical Officer
Mr S Suresh Kumar	Assistant Artist
Mr B Jayakumar	Labour Supervisor
Mr S Baburaj	Garden Maistry
Mr P Manikantan Nair	Garden Maistry
Mr C Sudarsanan	Gardener
Mr G Vijayakumaran	Gardener
Mr B Harilalkumar	Gardener
Mr K Vijayakumar	Gardener
Mr K Anilkumar	Gardener
Mr M Varghese	Gardener
Mr J Rajan	Gardener
Mr V Satheesan	Gardener

Dr C Sathishkumar	Scientist EII
Dr P K Suresh Kumar	Scientist EII, Head
Dr Bejoy Mathew	Scientist EII
Dr Mathew Dan	Scientist EI
Dr Sam P Mathew	Scientist EI
Mr C Muraleedharan Unnithan	Technical Officer
Dr E S Santhosh Kumar	Technical Officer
Dr M Abdul Jabbar	Technical Officer
Dr M Saleem	Technical Officer
Mr B Gopakumar	Technical Officer
Smt B J Radhika	Technical Officer
Mr M K Sreekumaran	Technical Officer
Dr S Anilkumar	Technical Officer
Mr G Manoharan	Garden Maistry
Mr N Salahudeen	Garden Maistry
Mr V Venugopalan Nair	Garden Maistry
Mr S Ajayakumar	Gardener
Mr K Asok Kumar	Gardener
Mr B Jayalalkumar	Gardener
Mr S R Kamaleshkumar	Gardener
Mr P Shaji	Gardener
Mr S Thulaseedharan	Gardener
Mr K Asokachandran Nair	Gardener
Mr G Sudarsana Kurup	Gardener
Mr V Renjan	Gardener
Mr A Ullas	Gardener
Mr R Lalan	Gardener
Smt T Mini Thomas	Gardener
Mr J Jose	Laboratory Assistant
Smt A Manjuladevi	Laboratory Assistant
Smt S Kanakasundaram	Laboratory Assistant

Biotechnology and Bioinformatics Division

Dr P N Krishnan	Scientist F, Head (Retired on 30/06/20140)
Dr C G Sudha	Scientist EII, Head

Dr K Satheeshkumar	Scientist EII	Smt S R Rajani Kurup	Technical Officer
Dr S Mukunthakumar	Scientist EII	Mr G Santhoshkumar	Animal House Technician
Dr P Padmesh	Scientist EII	Smt P Sasikala	Lab Attendant
Dr S Sreekumar	Scientist EI	Smt A Leela	Office Attendant
Dr William Decruze	Scientist EI		
Dr K K Sabu	Scientist EI	Plant Systematics and Evolutionary Science Division	
Dr C K Biju	Scientist C	Dr A G Pandurangan	Scientist F, Head
Dr R K Radha	Scientist B	Dr K B Vrinda	Scientist EII
Mr M Raveendran	Scientist B	Dr G Rajkumar	Scientist C
Mr K Gopakumar	Technical Officer	Dr M Rajendraprasad	Scientist C
Smt S Shailaja Kumary	Technical Officer	Dr C K Pradeep	Scientist C
Dr A S Hemanthakumar	Technical Officer	Dr A Nazarudeen	Scientist B
Dr C Sunil Chandran	Estate Supervisor	Dr T Shaju	Scientist B
Smt V S Sindhu	Lab Assistant	Mr Dhruvan Thandyekkal	Scientist B
Smt S Syamala Kumary	Lab Attendant	Dr V S Usha	Herbarium Asst
Mr B Chandran	Gardener	Smt M P Geethakumary	Technical Officer
Mr M Vijayan	Gardener	Smt K P Deepthy Kumary	Technical Officer
Mr R Anil Kumar	Gardener	Mr R Thulaseedharan	Gardener

Conservation Biology Division

Dr C Anilkumar	Scientist EI, Head
Dr A K Sreekala	Scientist EI
Dr P Balakrishnan	Scientist C
Dr P S Jyothish	Scientist C
Dr Anurag Dhyani	Scientist C (Joined on 04/03/2016)
Smt A Rasiya Beegam	Scientist B
Smt C R Chitra	Technical Officer
Mr M Sibi	Technical Officer
Mr S Suresh	Technical Officer
Smt S Bindu	Technical Officer
Mr P Shaji	Gardener
Sri G Madhu	Gardener

Ethnomedicine and Ethnopharmacology Division

Dr Vinodkumar T G Nair	Scientist EI
Mr K Radhakrishnan	Scientist E1 (Deputation to State Medicinal Plant Board)
Dr S R Suja	Scientist C, Head i/c
Dr Navas M	Technical Officer
Mr S Radhakrishna Pillai	Animal House Technician
Mr G Anikumar	Lab Assistant

Phytochemistry and Phytopharmacology Division

Dr B Sabulal	Scientist EII, Head
Dr V Gayathri	Scientist EI (Joined on 12/02/2016)
Dr K B Rameshkumar	Scientist C
Dr Anil John	Technical Officer
Dr S Ajikumaran Nair	Technical Officer

Microbiology Division

Dr N S Pradeep	Scientist EI
Dr S Shiburaj	Scientist EI
Dr S Binu	Scientist EI
Dr Vipin Mohan Dan	Scientist C (Joined on 12/02/2016)
Dr H Biju	Technical Officer
Smt A Sabeena	Technical Officer
Smt Kumari Girija	Sweeper (Retired on 31/03/2015)

Library and Information Services

Smt A Syamalakumary	Librarian (Retired on 31/05/2015)
Dr S Ajeemsha	Librarian (Joined on 15/02/2016)
Mr K P Pradeep Kumar	Technical Officer Gr. V (Photography)
Smt V Sujatha	Library Assistant
Smt V Leena Kumary	Clerical Assistant
Mr C R Vinu Krishnan	Clerical Assistant

Administrative Staff

Mr P S Pradeep Kumar	Deputy Controller (Purchase)
Smt S Meenakumary	Section Officer Gr. I
Mr K Vijayan	Section Officer Gr. I
Mr M Anilkumar	Section Officer Gr. I
Smt B S Ajanthakumary	Assistant Gr. III
Smt R Subha Sankar	Computer Operator Gr. II
Mr T S Sunil Kumar	Assistant Gr. I
Smt R Sofia	Assistant Gr. I
Smt T Ajithakumary	Assistant Gr. I
Smt S Sudha	Assistant Gr. I
Mr Vishnu P S	Assistant Gr. I
Smt Seema Viswanath	Assistant

Smt R Chithra	Assistant	Smt Baby Girija	Sweeper Gr. II
Smt S Jishi	Assistant	Mr V Gangadhara Pillai	Sweeper/Cleaner (Retired on 30/11/2014)
Smt R Anuradha	Assistant		
Smt P S Prathibha Rani	Assistant		
Smt R S Athira Nair	Assistant	Security Section	
Smt R Prasannakumary	Stenographer Gr. III	Mr A P Sukumaran Nair	Security Officer
Smt P S Shyladevi	Typist Gr. II	Mr P Jain	Security Guard Gr. IV
Mr K Mohammed Habeebulla	Typist/Data Entry Operator Gr. II (on deputation to KFRI)	Mr G Somasekharan Nair	Security Guard Gr. IV
Mr K P Elias	Store Assistant Gr. II	Mr C Stanly	Security Guard Gr. IV (Retired on 31/05/2014)
Mr B R Dinesh	Record Keeper Gr. I	Mr K Ramachandran Nair	Security Guard Gr. IV
Mr S Shaferkhan	Photocopy Operator Gr. I	Mr K Mohanan	Security Guard Gr. IV (Retired on 31/08/2015)
Mr D Mohanachandrakumar	Driver Gr. III	Mr S Venugopalan Nair	Security Guard Gr. III (Retired on 31/10/2015)
Mr T Mohanakumar	Driver Gr. III	Mr T Sukumaran Nair	Security Guard Gr. III (Retired on 31/03/2015)
Mr V Sudheeshkumar	Driver Gr. III	Mr G Viswambharan Nair	Security Guard Gr. III (Retired on 31/03/2015)
Mr G Murukesan Nair	Driver Gr. I	Mr A Subairkunju	Security Guard Gr. III (Retired on 30/04/2015)
Mr S Sanalkumar	Driver Gr. I	Mr K Surendran Nair	Security Guard Gr. III
Mr N Hariprasad	Driver Gr. I	Mr B Venukrishnan Nair	Security Guard Gr. III
Mr Balachandran	Driver Gr. I	Mr P Vijayakumar	Security Guard Gr. III
Smt K S Bindhu	Office Attendant	Mr R Rajan	Security Guard Gr. III
Mr G S Madhusoodhanan Asary	Office Attendant	Mr A Vijayan	Security Guard Gr. I
Smt J Anithakumari	Office Attendant	Mr P Devaraj	Security Guard Gr. I
Smt S Sheeja	Office Attendant	Mr C Jayakumar	Security Guard Gr. I
Smt R Sreemukari	Gardener Gr. I	Mr S Vikraman Nair	Security Guard Gr. I
		Mr G Ashokkumar	Security Guard Gr. I
Engineering Section		Mr K Suresan	Security Guard Gr. I
Mr P P Markose	Tech. Officer (Engineering)	Mr C Sureshkumaran Asari	Security Guard
Mr S Ajith	Assistant Work Supervisor Gr. III	Mr S Rajan	Security Guard
Mr V S Suresh Kumar	Technical Assistant Gr. III	Mr R Prasannakumar	Security Guard
Mr P Ajith Kumar	Supervisor (Electrical)	Mr R Nagappan	Security Guard
Smt M R Geetha	Overseer Gr. II	Mr G Anilkumar	Security Guard
Mr G Ajayakumar	PABX Operator Gr. II		
Mr M Madhusoodhanan Nair	Pump Operator Gr. III		
Mr R Prabhakaran Nair	Plumber (Retired on 30/09/2014)		
Mr P S Hanikumar	Label Writer		
Smt K Lali Kutty	Sweeper Gr. II		

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN & RESEARCH INSTITUTE
PALODE, THIRUVANANTHAPURAM

(A Unit of Kerala State Council for Science, Technology and Environment of Govt. of Kerala)

BALANCE SHEET AS ON 31ST MARCH 2015

Liabilities	Sch No	As on 31-03-2015	As on 31-03-2014	Assets	Sch No	As on 31-03-2015	As on 31-03-2014
Capital Reserve				Fixed Assets			
Institute	I A	5,29,99,983	4,57,90,693	Institute	V A	5,29,99,983	4,57,90,693
Grant in Aid Projects	I B	2,32,97,384	2,21,74,575	Grant in Aid Projects	V B	2,32,97,385	2,21,74,576
Current Liabilities & Provisions				Current Assets			
Institute	II A	2,02,70,207	3,74,17,082	Institute	VI A	4,55,77,181	4,71,00,051
Grant in Aid Projects	II B	1,65,877	3,33,822	Grant in Aid Projects	VI B	3,48,01,456	3,21,29,194
Other Unreconciled Balances	III	5,32,07,035	5,32,07,035	Loans & Advances			
				Institute	VII A	1,64,45,750	1,55,06,552
Unspent Balance				Grant in Aid Projects	VII B	35,62,762	35,75,648
Institute	IV A	(2,39,17,162)	(3,83,14,074)				
Grant in Aid Projects	IV B	3,81,98,340	3,53,71,019				
Corpus Fund	IV C	1,24,62,852	1,02,96,561				
TOTAL		17,66,84,517	16,62,76,714	TOTAL		17,66,84,517	16,62,76,714

For Mohan & Mohan Associates
Chartered Accountants

R. Suresh Mohan
Partner

Membership No. : 013398
Firm Reg. No.: 0020925

Place : Thiruvananthapuram
Dated :



For JNTBGRI
Palode Thiruvananthapuram

Sathya
Director

Jawaharlal Nehru Tropical Botanic
Garden and Research Institute
Karinancode P.O., Pacha - Palode
Thiruvananthapuram - 695 562
Kerala, India

Sathya
(Registrar)

REGISTRAR
TROPICAL BOTANIC GARDEN
AND RESEARCH INSTITUTE
KARINANCODE, PACHA, PALODE
THIRUVANANTHAPURAM - 695 562
KERALA, INDIA

Sathya
(Dy Registrar)

Finance Officer
Jawaharlal Nehru Tropical Botanic
Garden and Research Institute
Thiruvananthapuram - 695 562
KERALA, INDIA

Dated:

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN & RESEARCH INSTITUTE
PALODE, THIRUVANANTHAPURAM
 (A Unit of Kerala Council For Science, Technology and Environment of Govt of Kerala)

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH, 2015

Expenditure	Sch No	Year ended 31.03.2015	Year ended 31.03.2014	Income	Sch No	Year ended 31.03.2015	Year ended 31.03.2014
To Research & Development Expenses	IX	5,38,92,196	4,56,50,857	By Grant From Govt Of Kerala	XV	15,74,00,513	14,80,07,841
To Employee Benefits	X	10,72,62,539	9,10,02,139	By Other Receipts	XVI	12,79,423	9,80,554
To Administrative Expenses	XI	29,93,512	1,27,21,885	By Open House		-	-
To Repairs and Maintenance	XII	1,900	2,400	By interest from Banks		4,70,933	3,95,885
To Prior Period Expenses	XIII	-	-	By Prior Period Income		-	-
To Other Expenses	XIV	722	6,999	By Income from Training		-	-
To Depreciation		1,21,74,570	1,03,74,907	By Depreciation on Asset Acquired out		1,21,74,570	1,03,74,907
TOTAL		17,13,25,439	15,97,59,187	TOTAL		17,13,25,439	15,97,59,187

For Mohan & Mohan Associates
Chartered Accountants



R. Suresh Mohan

Partner

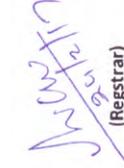
Membership No. : 013398

Firm Reg. No.: 002092S

Place : Thiruvananthapuram

Dated :

For JNTBGRI
Palode Thiruvananthapuram



(Registrar)

(Dy Registrar)

Finance Officer

Jawaharlal Nehru Tropical Botanic
Garden and Research Institute
Thiruvananthapuram - 695 562

(Director)
Director

Jawaharlal Nehru Tropical Botanic
Garden and Research Institute
Karimancode P.O., Pacha - Palode
Thiruvananthapuram - 695 562
Kerala, India

Place : Palode
Dated:





Jawaharlal Nehru Tropical Botanic Garden and Research Institute
www.jntbgri.res.in