JNTBGRI

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2018-2019
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KSCSTE - JNTBGRI

KERALA STATE COUNCIL FOR SCIENCE TECHNOLOGY AND ENVIRONMENT - JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE

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Front Cover: *Strobilanthes luridus* Wight var. *bourneae* Gamble (Photo by Dr A. Nazarudeen)

Back Cover: JNTBGRI (Photo by C. Suseendran)

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Director's Desk

With great pleasure and privilege, I am presenting the Annual Report of Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE-JNTBGRI) for the period 2018-2019 and 2019-2020. JNTBGRI, a garden based R&D institution established in 1979, is presently governed by the Kerala State Council for Science, Technology and Environment (KSCSTE). This Institute is established with the objective of setting up a conservatory botanical garden of tropical plant resources in general and of Western Ghats in particular. The institute mainly focuses on R&D efforts in plant biology with continued support from the State Government and project based supports from the Central Government, public and private sector, industries and academia. Programmes under various themes, meeting the mission and vision of JNTBGRI are being carried out by the Institute maintaining a uniform balance between knowledge generation and translational research. The Institute is also operating prestigious Global Genome Biodiversity Network project, Global Genome Initiative (GGI), Orchid propagation and commercialization programmes through cluster formation for the benefit of the people, ecotourism initiatives at JNTBGRI and several other bilateral programmes are under various stages of execution. The steady upsurge in the number of projects continued during the reporting period and JNTBGRI bagged honours and awards in the field of research and development, conservation, technology transfer and patent licensing. The Institute has conducted various skill development programmes and received overwhelming response from public and private sector, academic circles and industries. Dr. R. Prakashkumar served as the Director of the Institute during this report period. JNTBGRI has performed well as a team and I take this opportunity to thank all the staff members of JNTBGRI who had contributed immensely to the progress of the Institute through their dedicated support. I thank the State Government and also Government of India, various collaborators, agencies, well-wishers, media and all who have contributed in maintaining the vibrance of JNTBGRI and look forward for consistent support in the future also.

Dr. B. Sabulal
Director
JNTBGRI

Message

It gives me a great pleasure to be writing this note to congratulate the Jawaharlal Nehru Tropical Botanic Gardens and Research Institute (JNTBGRI), Kerala for their impressive progress and achievements made during the reporting years in support of conservation, sustainable management and use of the genetic resources. These years also saw strengthening of the work being undertaken by the Institute to reach out to the society at large and make the work socially-relevant as well.

The Institute boasts having an uncommon combination of basic and applied research and development programmes in the area of genetic resources and stands out as a premier institute in the country focusing on transdisciplinary research teams.

The reach and impact of the programmes during the years, including the results and partnerships established indicate the relevance of the work being undertaken by the Institute.

I am grateful to the staff and Director of the Institute for their commitment to making the Institute reach new heights as well as member of the Research Council for their support in advising and guiding the Institute in their activities and plans.

Dr. Balakrishna Pisupati
Chairman, RAC

INTRODUCTION

KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE - JNTBGRI) is a leading R&D Centre in Kerala for the conservation of tropical plant resources of India and to develop scientific methods for their sustainable utilization for human welfare. This was started as an autonomous R&D organization by the Government of Kerala in 1979 by the Founder Director Professor A. Abraham, following the first United Nations Conference on Human Environment held in Stockholm in 1972. Currently JNTBGRI maintains a 300 acre Conservatory Botanic Garden with a well-integrated multidisciplinary research in the most innovative and challenging areas, under eight R&D Divisions.

During the past 40 years, the Institute has flourished into one of the premier R&D organizations and one of the biggest conservatory botanic gardens in Asia. The Institute is recognized as a 'National Centre of Excellence in *ex-situ* conservation and sustainable utilization of tropical plants diversity' by the Ministery of Environment and Forests and climate change, Government of India and a lead Garden in RET species of the Ministry. JNTBGRI enjoys the membership of Botanic Gardens Conservation International (BGCI), Global Genome Biodiversiy Network (GGBN) and part of Global Genome Initiative (GGI), Climate Change Alliance of Botanic Gardens (CCABG) during the reporting period. JNTBGRI is a recognized centre of research for Post Graduate and Doctoral research of several universities, within the country.

DIVISION OF GARDEN MANAGEMENT, EDUCATION INFORMATION AND TRAINING

The Division of Garden Management, Education, Extension and Training of JNTBGRI, deals with the development and maintenance of plant conservatories, aesthetic landscapes and the live educational displays disseminating botanical knowledge. The *ex-situ* conservatories comprises both of open landscape gardens and closed greenhouses provided with controlled climatic conditions. Conservatory gardens mainly focus on indigenous plants especially endemics and species having IUCN conservation status, while the aesthetic and educational collections include many curious exotic species also. Plant propagules for developing the collections are mainly procured through field explorations without harming the natural population. Curious exotic species of educational and aesthetic interests are procured through purchase or exchange from other public or private agencies. Besides propagating for the different garden sections, plants are multiplied for sales and distribution to the public also. It is also developed conventional propagation protocols for species facing population threats and multiplies for eco-restoration programmes. Guided tours for visitors and outreach programmes like exhibitions, consultancy in developing Bio-parks/ Eco-gardens for schools and other government organization are also arranged. There are ten different group/function based units in the division viz. (i) Aquatic plants conservatory, (ii) Arboretum, (iii) Palmetum, (iv) Ferns & Gymnosperms, (v) Fruit Plants including lesser exploited indigenous species, (vi) Ornamental plants and landscapes (vii) Central nursery, sales and distribution, (viii) Compost management (ix) Public relations and visitors management and Extension activities (x) Labour management.

Aquatic Plants Conservatory

The Aquatic plant conservatory, started as a group collection in 2015, now holds 115 species with conservation, ornamental and educational interests. Plants are kept in ponds, tanks and bottom sealed pots as well as in the surroundings of the dam catchment area. The 5 endemic species and 12 *Nymphaea* species/varieties turn to be the collection attractions. Plant with largest simple leaf *Victoria amazonica* (Giant water lily), the smallest angiosperm *Wolffia arrhiza* and plants variously adapted for the aquatic life are the educational attractions. During the report period 26 new accessions were added, out of which *Nymphaea colorata*, *Nymphaea malabarica* and *Coix lacryma* -jobi are new in the collection. Nearly 60 labels in prescribed format were made for the display plants and 15 herbarium specimens of water plants were mounted and labelled for depositing in the Herbarium. The unit also do the eco-remediation studies on water plants.

Arboretum

Arboretum is one of the beginning conservatory gardens of JNTBGRI started in 1985, spread over about 50 acres of land. At present it comprises more than 3500 plantings belong to about 780 species, out of which around 600 are indigenous with about 140 endemics and threatened. Special groups viz. *Humboldtia* (5 species) *Terminalia* (7 species), *Ficus* (71 species) *Garcinia* (14 species), *Goniothalamus* (6 species) *Cynometra* (4 species), *Symplocos* (5 species), *Diospyros* (6 species) and the 'Star tree garden' of the 27 birth star trees are the collection attractions. During the report period 20 new accessions were made, out of which *Antidesma montana, Cynometra iripa, Diospyros marmorata, Garcinia andamanica, Garcinia cymosa, Garcinia intermedia, Hopea racophloea, Madhuca andamanica, Madhuca bourdillonii, Mangifera andamanica* and *Symplocos macrocarpa* are new additions to the collection. The section raised about 4200 tree saplings belonging to 27 species, of which around 931 plants were sold out through the sales unit. The rainwater harvesting and recharge ground water programme making use of the manpower from the Mahatma Gandhi National Rural Employment Guarantee (MGNREG) Scheme of local bodies was one of the major activities of the unit. Rubble arranged weirs and small ponds were constructed focussing the rivulet leading to the dam catchment area of the garden. The Executive Vice President (KSCSTE) Dr KP Sudheer and Dr N Mohanan, Head, Garden Division on his retirement, planted the endemic species *Garcinia talbotii* and *Garcinia assamica* respectively in the Arboretum.

Palmetum

The Palmetum initiated in 1988, now spreads over 5 acre land comprises of more than 180 species of Palms and Rattans with about 28% indigenous species representation and many exotic palms of ornamental interest. During the reporting period, 21 species were accessioned newly, out of which *Trachycarpus martianus*, *Coccothrinax argentata*, *Pinanga gracilis*, *Caryota obtusa*, *Wallichia oblongifolia, Wallichia disticha, Syagrus romanzoffiana, Kerriodoxa elegans, Daemonorops kurziana* and *Dictyosperma album* are new additions to the collection. During the report period, a major landscape alteration is made in the Palmetum by providing a straight entry from the Rose garden area. The new entrance garden comprises of 513 square feet front-yard paved with rough granite, leaving two rows of square shaped planting areas planted with Fan palms and Champagne palms on either side. An arch made of unbroken Palmyra palm (*Borassus flabellifer*) timbers with the hanging wooden board at beginning of the foot path to the interior, gave a new look to the Palmetum. The existing stone paved foot path was rearranged in new design to connect with the reservoir premises. Fifteen display boards illustrating traditional uses and curiosities regarding Palms were provided on the pathway sides. An endemic palm display of about 50 species was arranged near the new entrance. Thirty three numbers of field plantings, 850 seed germinations and about 2110 pot transplantations were done in the period. A collection of about 2500 Palm seedlings were developed for sales, of which 350 were sold out through the sales counter.

Fernery

The Fernery with 265 species of Pteridophytes, out of which 62 species comes under IUCN threatened category, turns to be the best of its kind in the country. During the reporting period, *Asplenium scalare*, *Asplenium* sp. *Dryopteris juxtaposita*, *Phelbodium* sp., *Platycerium hillii*, *Polypodium* sp. and *Polystichum* sp. were newly added to the collection through field explorations. Nearly fifty accessions in the report period were got established. *Asplenium* and *Dryopteris* species collected from Agasthyamala Biosphere Reserve were critically studied and identified as *Asplenium scalare* and *Dryopteris juxtaposita* respectively. So far, both these species are rarely reported from Kerala. Forty five digital images of ferns were identified on request for researchers from different Universities and colleges of Kerala and Tamil Nadu.

Gymnosperms

The Gymnosperm collection holding 42 species belonging to 15 genera are also maintained in the same unit. A Cycad collection with 20 species representing 6 out of the total 10 genera is the highlight of Gymnosperm collection. The New addition of threatened species *Cycas orixensis* (endemic from Odhisha) and *Cycas wadei* (endemic from Philippines) is an important achievement during the period of report. The endangered Cycad in the collection, *Encephalartos barteri*, produced cone for the first time during the report period was found female.

Lesser-known Fruit Plants

The fruit plants collection maintain 179 species/variants including indigenous fruits used by local and ethnic people lesser known to the public. Besides propagating and popularizing the indigenous fruit plants, saplings of demanded fruit plants of both exotic and indigenous are also multiplied and sold. It is also keen on producing pure breed vegetative, layer, bud and grafts of top quality variants for sales. During the report period 60 new accessions were added to the mother stock, out of which 21 species/variants are new to the collection. During the period 2670 vegetative saplings through budding, grafting, layering or hormone treated cuttings and 7753 seed raised plants were produced for sales and distribution. Developed 220 desirable quality graft mother plants of different fruit trees/shrubs in large cement pots.

Ornamental Garden

Development and maintenance of ornamental plants and landscapes is one of the major units of the Garden Management Division. The aesthetic gardens focussing the main entrance, major roads and buildings are spread over a good area including the frontage garden, meteorological station premises, main office garden, woodland garden, rockery and A N Namboodiri Glass House, biotech lab premises, wild Ornamental garden etc. The unit also maintains special/ curious group collections of conservational, educational and aesthetic interests. There were about 255 new accessions including 41 newly added species/variants during the report period through field explorations and purchase. Extending the QR labels, started in the previous year, to about 200 plants in the front garden is one of the major achievements during the period. The 4×6 inch field boards display the name, family, natural distribution and code, while the QR links give the detailed description of the particular plant. Field plantings: *Tibouchina urvilleana*, *Schefflera actinophylla* and *Phyllodium longipes* were newly planted in the Shrubbery. Twenty eight different Croton (*Codiaeum variegatum*) colour variants were planted along the drive way to guest house. Groups of Miniature *Ixora*, *Tabernaemontana*, *Dracaena* and *Cordyline* in island beds, *Bougainvillea* in the narrow terrace of Guest house front slop, and two Canna beds were also made during the period. The Gandhi carpet bed was refreshed by planting the worn out portions with new saplings of *Phyllanthus myrtifolius* and replanting the bed at the lower side with *Melampodium divaricatum*. Many field additions of succulents were made in the Rock garden also. In addition to the supply from the Central Nursery about 300 pots of Roses and 1500 pots of *Bougainvillea, Canna, Codyline, Coleus, Dahlia, Dracaena, Hibiscus, Hydrangia, Ixora, Kopsia, Ophiopogon, Pentas, Poinsettia, Tabernaemontana* were prepared and displayed both indoor and outdoor.

Wild Ornamental Garden

The unit explores out, conserve and popularise the underutilized indigenous wild ornamental plants. During the report period 6 plant collection trips in the Western Ghats were conducted and 85 accessions of wild ornamentals were made. Fifteen taxa viz. *Alphonsea zeylanica, Argyreia fulgens, Elatostema lineolatum, Erythroxylum acuminatum, Gomphostemma eriocarpon, Gordonia obtusa, Gyrinops walla, Henckelia gambleana, Lobelia nicotianifolia, Memecylon gracile, Osbeckia lawsonii, Phyllocephalum rangacharii* var. *agastyamalayanum,*

Psydrax sp., *Spondias acuminata, Stylocoryne lucens,* are new additions. Dr E S Santhosh Kumar has also deposited 24 numbers of herbarium specimens collected during the explorations at TBGT Herbarium. Routine maintenance like watering, weeding, feeding fertilizers, applying insecticide/ pesticide, trimming hedges, clipping topiaries, cutting wild grown grasses and bushes, mowing lawns, pruning Roses, shrubs and trees, collection and germination of next generation annuals *etc*. is the major time and labour consuming work for ornamental plants and landscapes.

Central Nursery and Sales unit

The Central Nursery unit of the Division deals with the propagation of plants for other garden units as well as for sales and distribution. It also standardises propagation protocol for endemic/ threatened species for their eco-restoration programmes. Collaborative programmes with Phytochemistry and Biotechnology divisions are also involved. During the report period nearly 4000 container plants were supplied for outdoor and indoor display for the ornamental plants unit. About 2500 rooted saplings including *Phyllanthus myrtifolius* for carpet beds were supplied to the ornamental plants unit for field planting. About 2000 display changes of plants in pots and in field flower beds were made in the Visitors Management Centre garden looked after by the Central Nursery unit. The Sales and Distribution section is also managed by the Central Nursery unit. During the report period, a total of Rs.10,15,997 (Rupees Ten lakhs fifteen thousand nine hundred and ninety seven only) was generated through sales of plants from all field units and compost.

Compost unit

The compost unit was established with the intention of managing the garden generated waste as well as producing potting ingredient and manure for garden plants. The excess product is selling out as an income generation. During the report period, twelve tons of processed compost was supplied to different units apart from sales outside.

Public Relations and Visitor's Management

Public Relations and Visitors Management is another important component of the Garden Division. Along with arranging visits lead by qualified guides in garden conservatories and demonstrations by scientists in laboratories, the Information, Education and Communication (IEC) is supported by direction boards, general explanatory boards, and individual plant labels including QR labels. Conservation awareness is extended to the public by participating in exhibitions conducted at educational events also. During the report period specially designed directional boards at junctions and name boards in front of garden units and group collections were provided. Total gate collection through entry fee in this period was Rs.4,73,380/- (Four Lakh seventy three thousand three hundred and eighty only). Seven theme based exhibition stalls of JNTBGRI were installed at celebrated public ceremonies in different parts of Kerala, viz. (i) Golden Jubilee Celebration of Thiruvananthapuram Press Club from 05.04.2019 to 16.04.2019, (ii) All India Agri-Industrial Science Exhibition in Varkala Sivagiri pilgrimage from 24.12.2019 to 03.01.2020, (iii) National Children's Science Congress 2019 (NCSC) at Thiruvanthapuram from 27.12.2019 to 31.12.2019, (iv) Kerala Agriculture Department exhibition (VAIGA) from 02.01.2020 to 10.01.2020 at Thrissur,(v) Kerala Science Congress EXPO by KSCSTE from 23.01.2020 to 28.01.2020 at Palghat, (vi) Palode Karshika Mela 2020 in Thiruvananthapuram from 06.02.2020 to 17.02.2020 and (vii) Kerala State Karshaka Sangham Conference 2020 at Kollam from 13.02.2020 to 03.03.2020. Besides these Mr V Premkumar, Public Relations Officer and architect of the garden division designed and constructed the theme based float and participated in the Onam Pageantry 2019 procession of Kerala Tourism Department. An initiative of the Visitors Management Centre, one KTDC funded project, "Eco tourism initiatives at Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode" was sanctioned. Administrative Sanction (AS) for components (i) Entrance Arch, (ii) Viewing

Tower, (iii) Garden area upgradation, (iv) Birds' corner, (v) Parking area, (vi) Electrical work, (vii) Light fixtures and (viii) Interpretation centre. On request from different government organizations the Public Relations Officer Mr V Premkumar has extended his service for (i) Sculpturing of Mahatma Gandhi statue in Thiruvananthapuram Flower show (Vasantholsavam), organized by KTDC and KSCSTE, (ii) constructing the theme based entrance arch for the 32nd Kerala Science Congress at Palakkad (January 2020), (iii) constructing Onam Pageantry 2019 procession floats for the sister institution NATPAC as well as for JNTBGRI and (iv) for preparing project proposal for 'Bonacaud Bio-resource Park' (KSCSTE). Landscape gardening at official Residence of Chief Secretary of Kerala and Cliff House premises were also done. Submitted projects jointly with Puthenthope extension centre on landscaping at GV Raja Sports School and Gymmy George Indoor Stadium at Thiruvananthapuram.

The garden works management engaging casual labourers is also initiated by the division. Recruiting and managing labourers as per requirement from garden units every day is the responsibility of the unit.

Exhibitions

Different units of the division has participated in the Thiruvananthapuram Flower show (Vasantholsavam, 19/12/19 to 5/1/2020) jointly organized by KTDC and KSCSTE and won prizes for flowering and foliage group collections like Aglaonema, Bonsai, Bromeliads, Cacti & other succulents, Caladium, Coleus, Dieffenbachia,

1. Exhibition of Endemic trees in connection with IAAT Conference 2020, 2. Newly lqandscaped Palmetum entrance, 3. Story boards in Palmetum, 4. Small ponds harvesting rain water in the Palmetum valley.

1. Children's Day Celebration 2019, 2. Exhibition of New species from JNTBGRI in connecting with IAAT Conference 2020, 3 Contact and awareness programme at Koovappady Gramapanchayath, 4. Quize competition winners Children's Day 2019

Dracaena, Ficus, Garcinia, Maranta, Peperomia *etc*. The garden division had taken the responsibility of the Exhibition arranged in connection with the 29th IAAT National Conference conducted at JNTBGRI, 11- 13 November 2019. The division has arranged photo/live plant display of taxa published by scientists of the Institute titled "Novelties of JNTBGRI". In connection with this event, live displays of endemic trees (100 spp.) and special groups viz. *Humboldtia* (6 spp.), *Goniothalamus* (6 spp.), *Garcinia* (13 spp.) *Ficus* (25 spp.) and *Cynometra* (4 spp.) were arranged by the Arboretum unit. Another important event was the self-employment training on Quality Planting Material Production (QPMP), sponsored by Environmental Information System (ENVIS Hub) Kerala- Green Skill Development Programme (GSDP). During the one month programme theory and demonstration classes were arranged with all scientists and technical officers with the faculties of their concerned areas viz. Aquatic plants, Compost, Ferns and Cycads, Fruit plants, Wild ornamental plants, Indoor plants, Nursery practices, Palms and Trees. The Children's Day that is also the Birth day of Jawaharlal Nehru after whom the Institute is christened was celebrated on November 14th by arranging free entry and Quiz programme on medicinal plants for school children.

Rediscovery of Threatened Species

During the plant explorations Dr E S Santhosh Kumar through taxonomic studies could rediscover three critically endangered species after more than 100 years of their previous reports. *Madhuca diplostemon* (C.B.Clarke) P. Royen of Sapotaceae

is a lone tree species originally described by Robert Wight in 1835 (as *Diospyros obovata* and later corrected by C.B. Clarke as *Isonandra diplostemon*). The present collection from a sacred grove near Paravur, Kollam, forms a rediscovery after 184 years. Like this, *Drypetes travancorica* (Bourd.) Santapau & S.K. Jain (Euphorbiaceae), small evergreen tree, known only by a single gathering in 1895 from Aryankavu forests is rediscovered after 125 years. *Dialium travancoricum* Bourd. (Fabaceae –Diallioideae), a species treated as Critically Endangered has also been relocated from the Kallar-Ponmudi region.

DIVISION OF PLANT GENETIC RESOURCES

The PGR Division undertakes diverse activities on taxonomic, biosystematic and phytochemical studies, breeding experiments to produce new hybrids, studies to utilize the resources in a sustainable manner and extension/awareness activities along with its chief mandate on enrichment of the genetic resources of Medicinal and Aromatic plants, Bamboos, Orchids, Carnivorous plants *etc* and maintaining of the existing resources in the garden. For effective management, activities of the Division are organized under four Units.

Medicinal, Aromatic and Spice Plants Unit

As part of the development of living collections of medicinal, aromatic and spice plants, following activities were carried out. The plants in the special group display were replanted and new educational labels were displayed. Stone benches were constructed in front of the Itty Achuthan Vaidhyan Garden so as to facilitate the visitors to enjoy the view of natural water falls in the Chittar River. Fencing with bamboo was erected to block the direct access to the river. The roof for Dhanwanthari image was thatched with the Umbrella palm leaves, which gave a better ambience.

Ex-situ conservation of genetic resource of selected medicinal plants and assessment of intraspecific variability is an on-going programme through which characterization of selected medicinal plants are being carried out. Morphological and anatomical characterization of 34 accessions of *Pellionia heyneana,* an ethnomedicinal plant was carried out. Molecular studies on these accessions were carried out in association with the Biotechnology Division and palynological studies in collaboration with the Conservation Biology Division. As part of a revisionary work on Aristolochiaceae from Western Ghats, morphological characterization of 7 accessions of 4 *Aristolochia* spp.were completed. Characterisation of south Indian *Curcuma* species was another on-going study. Carried out the morphological, anatomical and histochemical characterization of rhizomes from ten *Curcuma* spp. Total sugar and phytic acid of starch powder from 5 *Curcuma* spp. were analysed and carried out cooking trials of the isolated starch to assess its edible value. Introduced and planted *Curcuma caesia* from Mylamoodu, Thiruvananthapuram and *Curcuma decipiens* from Palakkad. Observations on macro-microscopic characters of leaves and petiole of 6 *Curcuma* spp. were carried out. Chemotaxonomic studies on Myristicaceae from the Western Ghats were another on-going research programme. Field study was conducted in the *Myristica* swamps at Goa and Maharashtra during the reporting period. Completed HPTLC studies of essential oils from the leaves of 4 species in Myristicaceae, and compound malabaricin-c was isolated and submitted for NMR in collaboration with the Phytochemistry and

Phytopharmacology Division. Carried out the HPTLC profiling and quantification of methanolic extracts of arils of 9 taxa of Myristicaceae.

Field Gene Bank

The in-house programme on upkeep and maintenance of Field Gene Bank of selected medicinal and aromatic plants and characterization of Germplasm has examined and documented 10 vegetative characters of 12 accessions of *Cissus quadrangularis*. *Murraya koenigii* and *Piper* sp. were multiplied through layering. The RET Plant Conservatory which was damaged due to strong wind was renovated. Herbarium specimens of 11 species were prepared. In connection with the study on wild ornamentals, carried out the propagation of *Impatiens maculata, Begonia malabarica, Exacum travancoricum, Withania somnifera, Indigofera tinctoria, Thysanolaena latifolia*, *Laportea crenulata*, *Cinnamomum* sp. *etc*. Standardization of micropropagation protocol for 2 wild ornamental plants, *Jerdonia indica* and *Ixora johnsonii,* were completed in collaboration with the Department of Botany, University of Kerala.

Conservatory Garden for Andaman flora

As part of the enrichment of the field conservatory for Andaman flora, a plant exploration trip was conducted to Andaman Islands and introduced 52 species and seeds of 9 species are being established in the nursery. Propagation of 14 species was carried out and raised 1158 plants, including *Endocomia macrocoma*, *Calamus andamanicus*, *Mangifera andamanica*, *Adhatoda vasica, Adhatoda beddomei* and *Piper* spp. The unit also handles a number of projects which are externally funded in collaboration with other divisions.

'Identification of elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardisation of their extracts' is an ongoing DBT funded programme in association with the Phytochemistry and Phytopharmacology Division. Conducted multi-locational trials of selected accessions *Centella asiatica* and *Bacopa monnieri* in the campus of Malabar Botanical Garden, a farm in Munnar, site of Saraswathi Thankavelu Extension Centre, Puthenthope and in JNTBGRI, so as to assess the growth performance in different agro-climatic conditions. Harvested samples were given to the Phytochemistry Lab and Biotechnology Lab for phytochemical screening and DNA Analysis respectively. Following guidelines of experts from Govt. Agricultural College, Vellayani, large scale cultivation of selected accessions of both *C. asiatica* and *B. monnieri* was attempted. The agro-techniques of both the species were standardized and a dossier was prepared.

'Establishment of a herbal garden in the Kerala Raj Bhavan, Thiruvananthapuram' is an ongoing project funded by National Medicinal Plant Board through State Medicinal Plant Board. A collection trip was conducted to Parassala and Cheruvarakkonam during the report period and procured 556 plants belongs to 16 spp. including *Clitoria arborea, Gardenia gummifera, Mentha arvensis, Ruta graveolens, Ehretia microphylla etc*. During the period 1372 plants belong to 54 spp. were transferred to Raj Bhavan from JNTBGRI towards the establishment of the Herbal Garden. An elegant entrance with granite pillars was designed and erected in the Herbal Garden at Raj Bhavan. Plant labels depicting different names and the uses of plants were displayed. 'HANDBOOK ON MEDICINAL PLANTS IN THE HERBAL GARDEN AT RAJ BHAVAN, KERALA' was published and the copies were submitted to the then Hon. Governor, Justice P. Sathasivam.

'Production and supply of quality seedlings of selected medicinal plants' is an annual on-going programme supported by Kerala State Medicinal Plants Board for the last four years. The objective of the programme is production of quality seedlings of selected medicinal plants, supply of seedlings to different target groups and their popularization. Seedlings were also procured from authentic nursery men from Kerala and Tamil Nadu. During

1. Herbal Garden established at Kerala Raj Bhavan with funding from NMPB through SMPB, 2. Medicinal plant conservatory constructed with funding from the State Horticulture Mission, 3. New species of wild nutmeg *Myristica trobogarii* Govind et Dan, published in Nordic Journal of Botany

the period 9578 seedlings of 50 species were raised and 2875 seedlings were distributed to various beneficiaries including Educational Institutions, Govt. Institutions/Departments. This is a successful activity since the botanic garden has an important role in popularization of economically important plants of the Western Ghats, which in turn promotes the *ex-situ* conservation of the species.

'Taxonomic revision and phylogeny of genus *Piper* L. (Piperaceae) in India with its Biogeography' is a new project with the financial support of SERB-DST. It is a multi-institutional project in which the taxonomic and systematic studies on *Piper* species from the Western Ghats and Andaman region were assigned to JNTBGRI. Three plant exploration trips were conducted covering Agumbe and Kollur,

Karnataka, Mekkarai, Cheenikkala and introduced 14 accessions of *Piper* species including the RET species *P. barberi* and *P. mullesua* was planted near the Hexagonal Conservatory. Rooted cuttings of *Piper peepuloides* were introduced and potted. The Conservatory House of Piperaceae comprising 24 species is being maintained. Five samples for molecular characterization were given to ATREE, Bangalore.

Bamboo Biology Unit

'Conservation of Bamboos at JNTBGRI' is an on-going plan funded project through which the Bambusetum of the Institute is being developed and maintained. Plant explorations were carried out to various parts of Kerala, Tamil Nadu, Karnataka, and collected seedlings of *Dendrocalamus sikkimensis, Bambusa teres, Gigantochloa rostrata* and planted in the experimental plot. Flowering offsets of *Bambusa bambos* and *Bambusa vulgaris* var. *vittata* were also collected. A total of 110 seeds of *Ochlandra travancorica* and 3000 seeds of *Ochlandra setigera* were collected and sown in the nursery beds. Pollen viability of eight species were tested using Brewbaker and Kwack's Medium. Floral biology, abnormal flower opening, pollen germination and seed set of *Dendrocalamus* sp. were observed and recorded. Breeding trials (452 nos.) in seven combinations were carried out, in continuation to the Hybridisation programme of the bamboos and 26 seed settings were observed. The hut in the Bambusetum was renovated. The Bamboo Biology Unit participated in the 16th edition of Kerala Bamboo Fest, organized by the Kerala State Bamboo Mission, at the Marine Drive, Eranakulam, during 6th to 10th December 2019. Bamboo saplings (14 species), bamboo seeds, the book 'Bamboos at TBGRI', pots and flower vases made of bamboo wood were exhibited. During the period 14321 seedlings of bamboo varieties were raised and 9922 seedlings were distributed to various beneficiaries.

As usual, the World Bamboo Day was observed on 18th September by distributing Walking Bamboo (*Melocanna baccifera*) seedlings to the Kerala Forest Development Corporation, Palode Sub-Unit, for planting at the Chittoor Block. First time planting of hardened offsets of six bamboo species (*Bambusa assamica*, *B. garuchokua*, *B. pseudopallida*, *Cephalostachyum fuchsianum*, *Gigantochloa auriculata* and *Gigantochloa* sp.), collected from Nagaland and Assam was made in the suitable locations at Bambusetum.

Orchid Biology Unit

'Establishment and upkeep of a National Collection of Orchids' is an on-going plan funded programme through which daily maintenance and upkeep of the Orchidaria are continued. *Vanda* 'John Clubb' was planted as an avenue border along the path near VMC building. This year also the 'Tiger Orchid' *Grammatophyllum speciosum* was in full bloom in the Orchidarium which attracts lot of public and media. One of the *Vanda* hybrids which were gifted by Martin Motes, a well-known Vanda breeder from Florida, was bloomed for the first time. Hybridisation of Orchids is an important activity of the Unit. Forty crosses aiming intergeneric hybridization were carried out. Three hybrid capsules (101/18, 110/18 111/18) were harvested and establishment of cultures is in progress in the Biotechnology Division. Two of *Phalaenopsis* hybrids raised by JNTBGRI were flowered and are under observation. Other than routine maintenance, fertilizer application and pest management were carried out. Due to water shortage, alternative measures were adopted for irrigation from the check dam. Partial roofing for two Orchidaria using poly carbonate sheets were done in order to protect the plants from over rain. Nine different categories of Orchids and Anthuriums were exhibited at Vasantholsavam 19-20 and secured six first prizes and two second prizes. About 630 plants purchased towards the display were planted and being maintained in different Orchidaria. During the report period 480 Orchid plants/cuttings were sold.

Carnivorous Plants

'Building up of a Conservatory for Carnivorous Plants' is another notable on-going

programme. The conservatory holding Carnivorous plants is one of the most appreciated centres in JNTBGRI, where an array of insectivorous plants are being maintained and displayed. Towards the hybridization of *Nepenthes,* the Pitcher Plant, two crosses (*Nepenthes alata* X *N. mirabilis* and *N. alata* X *N. khasiana*) were done during the report period. Fruits and seeds were collected from the crosses *viz N. mirabilis* with *N. rafflesiana* and sown. Flowering was observed in Nepenthes hybrids *N. mirabilis* X *N. khasiana*, *N. mirabilis* and *N. rafflesiana*. Pollen was collected from *N. mirabilis* and *N. khasiana* and preserved for breeding purpose. One female plant of *Nepenthes khasiana* was newly introduced. About 30 Nepenthes hybrid seedlings were planted in the conservatory.

Butterfly Garden

Establishment of a Butterfly Garden at JNTBGRI was a one year project funded by KSCSTE. The landscaping was completed so as to facilitate access to the visitors. In addition to the upkeeping of plants, an endemic species *Heliotropium keralense*, a host plant introduced from Wayanad was planted. A total of 62 nectar plant species are being maintained. Dwarf variety of ornamental *Ixora* (684 nos.) was planted not only as a nectar source but also to improve the aesthetics of the site. Six Higher Secondary students (+2, CBSE curriculum) from Loyola School, Thiruvananthapuram had successfully completed a fortnight project on "Biological awareness through setting up a Butterfly Garden in the School".

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-Lab Programme and generating income for the Institute. As part of multiplication and distribution of commercially potential plants, 13 Orchid hybrids were tissue cultured for mass production during the report period. Multiplication of protocorm like bodies (PLB) followed by seed cultures of Dendrobium 'Earsakul' was in progress, and the cultures of other 9 hybrids of *Dendrobium* and three varieties of *Phalaenopsis* are in different stages. Embryo cultures of three *Dendrobium* hybrids were initiated, of which one showed response. As part of contract multiplication programme, regenerated plants were transferred to rooting medium for root induction and other PLBs are under multiplication. Rooted culture bottles were transferred to Green Houses for hardening. There are about 20000 Bottles containing PLBs/ young plants of various orchid hybrids are being maintained during the report period. In addition, 1000 cultures are at rooting stage.

Micropropagation of 11 banana varieties such as Nendran, Red Banana, Swarnamukhi, Poovan, Charapoovan, Rasakadali, Palayamcodan, Grand Nain, Nagapoovan, Padathi and Udayam were also carried out which are at different stages of establishment. In addition, culture initiation of one variety 'Monthan' and 'Big Ebang' started which responded positively through shoot bud formation. *Rauvolfia serpentina* cultures maintaining at different stages. Black Pepper cv. 'Karimunda' first section was completed. New one started as fresh culture during the report period. Total bottles subcultured during the reported period include 13650 Banana, 10500 Orchids, 3750 Anthuriums and 1400 *Rauvolfia serpentina*. During the period 13956 seedlings were distributed to various beneficiaries.

DIVISION OF BIOTECHNOLOGY AND BIOINFORMATICS

1. Main Centre, JNTBGRI

Biotechnology and Bioinformatics Division is established for the development of suitable technologies for the conservation and sustainable utilization of wild genetic resources of the nation with special reference to Western Ghats and translating the outcome for practical conservation and public utilities. The Division is equipped with basic laboratory facilities for micro propagation, cryo-banking, molecular biology and bio production work. Bioinformatics facilities include web-server, database server, workstations, desktops and application package Schrodinger maestro glide. The Division also has mist house facility and green houses for hardening and rearing of micropropagated plants. The division also have training and extension services including project work to graduate and postgraduate students.

Major R & D programmes

- *In vitro* propagation leading to restoration and/or cultivation of prospective medicinal plants, insect repellent plants, orchids, wild musa, cardamom and bamboos.
- Isolation, characterization, evaluation and utilization of endomycorrhiza for conservation and cultivation of orchids.
- *In vitro*/cryo-banking of endangered and endemic orchids and medicinal plants of Western Ghats.
- Bio-production and metabolic profiling of plant-specific compounds such as asiaticoside, anthocyanin *etc*.
- *Ex situ* conservation, chemical and molecular profiling of 'sweet flag' (*Acorus calamus* L.) germplasm from the Western Ghats.
- Utility of Semiochemicals and screening of ethno botanical insect repellent plant species of the Andaman Nicobar Islands in pest/insect management and its popularization as an eco-friendly products.
- Functional Genomics and Population Genetics of *Musa* spp., *Elettaria cardamomum*, *Borassus flabellifer*, *Centella asiatica etc*.
- Mechanism of sex determination in dioecious plants; role of microRNAs in the biosynthesis of secondary metabolites.
- Transcriptome analysis to understand gene expression in plant systems.

1. Dr. Prakashkumar and Dr. A.B. Rema Shree, Dirctor (Research), ICRI exchanged the MoU on January 2019, 2. GSDP Plant Tissue Culture course was inaugurated by Dr. R. Prakashkumar, Director of JNTBGRI on Ist January 2020, 3. Trainees working on Laminar air flow - GSDP PTC course at JNTBGRI

- Bioinformatics research focussing on validation of the efficacy of medicinal properties of selected plants through *in silico, in vitro* and *in vivo* screening and identification of lead molecules; development of biodiversity databases.
- Training and extension services extended to BSc, BTech and M Sc students for project work as part of their curriculum in the field of micropropagtion, bioinformatics and molecular biology on payment basis.

Dr K K Sabu conducted a Certificate course on Plant Tissue Culture Techniques and Applications from 1 Jan to 29 Feb 2020. Sixteen graduates from various districts of Kerala attended the course. The course was aimed to develop trained manpower in the area of plant tissue culture and also equip them with advanced theoretical and practical knowledge. It has been organized under Green Skill Development Programme of Ministry of Environment, Forest and Climate Change, Govt. of India through ENVIS Hub, KSCSTE.

Restoration of endangered orchids of Western Ghats

Two endomycorrhiza strains having close resemblance with the genus *Ceratobasidium* isolated from *Vanda thwaitesii* and was evaluated to possess symbiotic activity in a series of vandaceous orchids. Seedlings of *V. thwaitesii* and *V. wightii* infected with the effective symbiotic fungus was utilized for restoration and about 600 seedlings of *V. thwaitesii* and 357 seedlings of *V. wightii* reinforced in to its native locality in Idukki WLS and Wayanad. *V. thwaitesii* seedlings exhibited 68-95% survival and establishment while *V. wightii* exhibited only 42% survival after one year. Conservation introduction of *V. wightii* at JNTBGRI showed 64.7% establishment after 5 years and 219 seedlings representing different populations were established at JNTBGRI campus. Only 25% of the 320 seedlings of *Paphiopedilum druryii* restored at Agasthyamala survived after one year due to long dry period of about 6 months.

***Study on the populations of Decalepis arayalpathra*:**

Survey and estimation of population in 9 localities completed. The locations were mapped and population estimated through quadrate studies and project population strength of over 22,000 mature individuals and thus the species is evaluated as vulnerable as per IUCN guidelines version 3.1. A distribution model was also prepared using Maxent software and revealed precipitation seasonality and temperature diurnal range as the decisive factors that support sustenance of *D. arayalpathra* popultions.

Utility of Semiochemicals and exploitation through in vitro technology of Etlingera fenzlii

Developed very efficient in vitro regeneration protocol through direct regeneration and microrhizome induction for *E. fenzlii*; comprises multiplication of high quality and disease free plantlets independent of seasons in a pace unattainable through conventional means. The study also emphasised on GC/MS analysis to confer its constituents in leaf/pseudostem/rhiome/seed capsule/flower. A total of thirty five compounds were identified from the essential oil of flower which was identified using Retention Index (Ri) and Mass Spectral Data. Major constituents of the oil were 1-dodecanol, followed by dodecanal and naphthalenol. A total of forty compounds were characterised in rhizome oil. The most abundant components include n-dodecanol, dodecanal and dodecanoic acid. Out of the fifty compounds characterized in essential oil of pseudostem, dodecanal predominated followed by dodecanol and dodecanoic acid. Essential oil of leaf characterized the presence of fifty constituents of which the major compounds are dodecanal, dodecanol and alpha humulene whereas seed capsule essential oil was determined to possess dodecanoic acid as the leading compound followed by dodecanal and 1-dodecanol. Among the compounds identified in all the five parts of the plant, 1-dodecanol plays as a major component which can substantiate the use of all parts of the plant as an insect repellent. n-dodocanol, n-dodecanol, humulene epoxide, n-undecanol and caryophyllene oxide of the essential oil showed high repellent property against *Anopheles stephensi and Culex quinquefasciatus*. Activity displayed was concentration dependent and comparable to DEET, a synthetic insecticide without any toxicity (safe up to 200mg/kg *in vivo* concentration.

Study was also focussed on the role of larvicidal activities of the essential oil of *Etlingera fenzlii* against *Aedes albopictus*. Results obtained on larvicidal effects of essential oil of *Etlingera fenzlii* could be considered a contribution to the search of new biodegradable larvicides of natural origin, signifying an ecofriendly method for the control of mosquito vectors. Present results substantiate the role of *E. fenzlii* oil as an effective eco-friendly larvicide, since the promising effect was rendered by the active components of the essential oil, further studies on their effect against insects/pests at mass level may provide futuristic lead products.

Ex situ conservation, chemical and molecular profiling of sweet flag (*Acorus calamus* L.)

Molecular and chemical evaluation of diverse germplasm of potential species *A. Calamus* will confirm the pre-requisite procedures for commercial utilization because the plants exhibit tremendous variations in the chromosome numbers and chemical constitution of the essential oil (WHO suggested that only the plants of *A. calamus* with no β-asarone or having very low quantity of this compound should be used in the food as well as in the medicines due to the highly carcinogenic and toxic properties of the β-asarone compounds). Accomplished chemical profiling of 12 accessions of 'sweet flag' (*Acorus calamus* L.) germplasm from the Western Ghats will confirm the pre-requisite procedures for commercial utilization. Different accessions of *A. calamus* collected from the Western Ghats of Kerala and Tamil Nadu are maintained in the *in vitro* bank. Chemical analyses revealed that both the triploid and diploid accessions showed rather lower concentration of β-asarone and no significant correlation existed between the ploidy level and the asarone content in the rhizome samples

Enhancement of anthocyanin production in suitable *in vitro* culture system (cell/root) of *Ipomoea batatas* (L.) Lam.

Standardized the protocol for micropropagation of *I. batatas* using nodal and *in vitro* root as the explants. Four weeks old *in vitro* derived micro shoots maintained in MS medium containing 1mg/lBAP were used as the explant for raising callus and cell suspension culture. Optimised best auxin for the root induction and biomass production in *I. batatas*.

Functional Genomics studies

The Next Generation Sequencing (NGS) technologies led to significant advances in whole genome sequencing, which provide ultra-throughput sequences to revolutionize plant genotyping and breeding. To further broaden NGS usages to plant genomes, genotyping-by-sequencing (GBS) has been developed and applied in sequencing multiplexed samples of *Centella asiatica* (Kudangal) that combine molecular marker discovery and genotyping. GBS is a novel application of NGS protocols for discovering and genotyping single nucleotide polymorphisms (SNPs) in genomes and populations. GBS sequencing has been carried out at James Hutton Institute (JHI), Scotland by Ms. Sakthipriya M (supervisor: Dr K K Sabu) through DBT Newton Bhaba Fellowship during October 2019 – January 2020.

2. Saraswathi Thangavelu Extension Centre

Saraswathi Thangavelu Extension Centre of JNTBGRI was established in 1996 at Puthenthope, Thiruvananthapuram. This centre was established in the land donated to JNTBGRI by Late Dr. M. Thangavelu, former Principal, Medical College,Thiruvananthapuram in memory of his wife late Saraswathy Thangavelu. Currently, the centre is functioning as a unit of Biotechnology and Bioinformatics Division of JNTBGRI. The centre is equipped with major facilities for research in bioinformatics. In addition, cultivation of vegetables for seed production, cultivation of arid zone medicinal plants, cultivation of orchids and foliage plants are undertaken. Manpower development through training is an integral component of the centre.

Major activities include

A. Research and Development

- Development of software application tools and organisation of biodiversity databases.
- Validation of the efficacy of anti-snake venom, anti-tuberculosis, anti-hepatitis B, anti-dengue virus activity of selected plants through *in silico, in vitro* and *in vivo* methods and identification of lead molecules.
- Genetic improvement of orchids through distant hybridisation and embryo rescue.
- Human resource development by imparting training in Bioinformatics.

B. Garden related activities (Society benefited and income generation)

- Vegetable seed production and sale.
- Production and sale of planting materials (saplings) of orchids, *Spathiphyllum, Heliconia etc*.
- Maintenances of coconut plantation and other economic crops like mango and cashew.
- Maintenance of about 600 plant species as part of the garden in the campus.
- Cultivation of endangered high value medicinal plant *Plectranthus vettiveroides*.

C. Income generation

Income generation through product sale, training and consultancy projects

D. Human Resource Development

- Academic programmes like Ph.D., M.Phil., M.Tech, M.Sc. Biotechnology and Bioinformatics thesis research work.
- Six months training to M.Sc. degree holders with fellowship.
- Conducting national level workshops/ trainings (7-21 days) in Bioinformatics for college teachers/scientists/research scholars.
- Curriculum based training in Bioinformatics to M.Sc. students.

Key events/ achievements/ discoveries

Validation of the efficacy of plant-derived molecules and identification of lead molecules

Evaluated anti-cobra venom activity of 1183 phytochemicals derived from 13 medicinal plants (*Alternanthera sessilis, Anacardium occidentale, Acanthus ilicifolius, Allium sativum, Areca catechu, Anisomeles malabarica, Biophytum sensitivum*, *Bixa orellana, Blepharis maderaspatensis, Acalypha hispida, Alangium salvi folium, Albizia amara* and *Alysicarpus monilifer*) against 14 cobra venom proteins such as phospholipase A2 (PLA2), long neurotoxin 1 (LN1), long neurotoxin 2 (LN2), long neurotoxin 3 (LN3), long neurotoxin 4 (LN4), long neurotoxin 5 (LN5), acetylcholinesterase (Ach-E), L-aminoacid oxidase (L-AAO), cobramin A (CA), cobramin B (CB), cytotoxin 3 (CYT3), cobrotoxin (COT), serine protease (SP) and proteolase (PL) through docking and further drug-likeness property and ADMET property analysis potential lead compounds were identified.

Anti-tuberculosis activity

Anti-tuberculosis activity of *Plectranthus vettiveroides* root-derived essential oil was determined by *in vitro* assays such as Luciferase reporter phage and Broth dilution and the results showed that the essential oil has anti-tuberculosis activity. To find out the active compound against tuberculosis, the essential oil was analysed in GC-MS and identified 40 compounds. They were docked with four target proteins such as FtsZ, DprE1, PanK and Ag85C each have pivotal role in *Mycobacterium* cell wall formation or virulence. The top ranked hit molecules were further analysed based on binding properties, toxicity and ADMET properties. Molecules having significant properties as drug against cobra venom are suggested as the best lead.

In silico evaluation of anti-tuberculosis activity in ten nutraceutical plants *viz*. *Ananas comosus* (L.) Merr., *Annona muricata* L., *Annona reticulata* L., *Annona squamosa* L., *Manilkara zapota* (L.) P. Royen, *Carica papaya* L., *Phyllanthus emblica* L., *Garcinia mangostana* L., *Psidium guajava* L., and *Punica granatum* L. was completed. The four promising target proteins of *Mtb* selected for the study include mycolyltransferase antigen protein 85C (Ag85C/FbpC) involved in cord factor synthesis, filamentous temperature sensitive protein Z (FtsZ) involved in bacterial cell division, pantothenate kinase (PanK) involved in co-enzyme A pathway and decaprenylphosphoryl β-D-ribofuranose-2 epimerase (DprE1) involved in the synthesis of virulent factor arabinan. A total of 1154 phytochemicals derived from the forgoing selected plants were docked with the target proteins using the tool, Autodock Vina. Docked results were analysed based on free energy of binding (ΔG),

hydrogen bond anaylsis and ADMET properties. The top hit molecules were subjected to Extra Precision (XP) Glide Docking and Quikprop analysis. Results revealed the best lead molecules against *Mtb* in the order of merit as emblicanin A, rutin and homoorientin. Isolating the best lead compounds is in progress.

In silico analysis of essential oil of Plectranthus vettiveroides for antidiabetic activity

Phytochemical profiling of the essential oil derived from the roots of *Plectranthus vettiveroides* was carried out by GC-MS analysis and identified the presence of 112 chemical components from the fresh roots derived oil while the dried roots derived only 70 chemical components. In order to study its antidiabetic property, four potential targets such as ATP sensitive potassium channel, SGLT 2, DPP IV and Alpha amylase were selected and *in silico* analysis is in progress.

Anti-dengue fever compounds

To find out the best compounds to inhibit the growth and multiplication of the dengue virus, a total of 352 phytochemicals obtained from 5 common medicinal plants viz. *Cissampelos pareira* L. (40), *Cymbopogon citratus* (DC.) Stapf. (137), *Phyllanthus amarus* Schumach.&Thonn. (87), *Solanum nigrum* L. (41) and *Silybum marianum* (L.) Gaertn. (47) were docked against the Dengue virus crucial enzyme Non-structural protein five (NS5) protease which is responsible for the replication of the viral genome and Human Inosine-5'-Monophosphate Dehydrogenase-2 (IMPDH-2), a rate limiting enzyme in the synthesis of guanine nucleotides during replication of virus genome. The result showed that 41 active compounds against the targets. Further analysis of the *in silico* results followed by bioactivity and ADMET property analysis, 5 most promising leads were identified.

Anti-Hepatitis-C Compounds:

Non-structural protein 3-with 4A (NS3-4A) Serine protease, an enzyme crucial to cleave the polyprotein precursor produced by the HEPAC-RNA viral genome was selected here as the target for the *in silico* screening of phytochemicals. A number of 445 compounds derived from 5 different medicinal herbs *viz*. *Solanum nigrum* L. (41), *Curcuma longa* L. (140), *Silybum marianum* (L.) Gaertn. (47), *Phyllanthus amarus* Schumach. &Thonn. (87) and *Ocimum sanctum* L. (130) were subjected to screen between the target protein and resulted 22 active compounds after the analysis of the *in silico* results including free energy of binding, hydrogen bond and other molecular interactions. After the ADMET and bioactivity property analysis of the active compounds, five compounds were selected as leads.

Development of software tools and database organisation

- Developed a software tool 'plant chemicals and therapeutics' for the documentation of medicinal plants and their phytochemical details. Currently it provides details of 150 phytochemicals and its source plants. URL www.jntbgri.in/plantchemistry.
- Database on Anti-snake venom plants: Currently it provides details of 100 herbs commonly used as antidote against snakes in Kerala. URL. www.jntbgri.in/antisnake.
- Developed Visitors' Management and Billing tool-Version-1.5 for the management of visitors' details and entry fee billing for JNTBGRI.

Product development

As part of Herbarium digitization of the University of Kerala, a software application was developed, tested its performance and incorporated over 6000 herbarium specimen's image with data and made available on the web. URL www.jntbgri.in/herbariumku

Hybrid registered

A primary hybrid Acampostylis tropgarden fragrance (*Acampe praemorsa x Rhynchostylis retusa*) registered with RHS, London. The hybrid is intermediate between the parents and exhibited

sweet fragrance. It flowers more than twice in a year and overcome seasonal dominance of parents with regard to flowering.

3. JNTBGRI Sub-Centre, Kuzhur

A sub-centre of KSCSTE-JNTBGRI is functioning at Kuzhur Panchayath of Kodungallur Assembly Constituency since January 2019. The centre was established through financial assistance from KSIDC for the development of green industry at Kodungallur as part of Constituency development programme. The centre inaugurated in 2019 possesses exclusively a plant tissue culture laboratory of Class 10000 standard for the production of highly demanded agricultural and ornamental plants.

Main areas of research activities include

- Development of tissue culture protocol for the propagation of different species of *Pandanus* to enrich resource base for screw-pine craft and water body protection.
- Development of protocol and propagation of different varieties of banana to meet the requirements of farmers and industry through the supply of quality planting materials
- Development of protocol and propagation of demanding ornamental plants such as orchids, *Calathea, Agleonema etc*. for the growth and development of green industry.

Major outcomes

Different varieties of *Pandanus*, Banana, ornamental plants *etc*. have been collected and are propagated conventionally inside the campus. A total of 170 species of different plants are maintained in the sub-centre for developing tissue culture protocol for future sale as well as research. As part of germplasm conservation, the centre is maintaining different species and verities of *Pandanus* such as *P. leram*, *P. furcatus*, *P. tectorius* (thornless) *P. amaryllifolius, P. baptisti, P. pygmaeus* – green striped, *P. pygmaeus* - white striped, *P. dubius, P. odorifer* (Alappuzha metha verity, poyya variety) *etc*. This collection includes Pandanus species used in cottage industries, river side protection and ornamental purpose.

Development of tissue culture protocol and mass production of selected plants

Screw Pine

Pandanus (Screw pine, locally known as Kaitha, Thazha in Malayalam) is a monocot with about 600 known species in the world. The screw pine plant was used to craft a range of products such as mats, bags, baskets *etc*. which provided a meaningful income especially for women associated with the trade. Recent urbanization and habitat destruction has lead to decline in the availability of plant material which seriously affected this traditional industry.

A successful protocol for large scale production of Pandanus species of Kerala (*P. fascicularis*) has been developed at the centre. Another prospective species with long leaves (6 m) from Andaman Island and thornless varieties of screwpine has been planted. Tissue culture protocol has been standardized in Pandanus 'Thazhava' variety. Multiplication and rooting achieved in *Pandanus* (Thornless variety). 5000 Tissue culture plants of *Pandanus* were supplied to MSSRF for water body protection program prepared. 6000 Screwpine plants for sale, 2000 plants at rooting stage and 1000 shoots at multiplication stage. Culture was also initiated in thorn less variety of *Pandanus*.

Banana

Different varieties of Banana (*Musa* sp.) were produced in culture to meet the demand of farmers. This Include Nendran, Pooan and Robusta. Sold 2000 banana plants and another 200 numbers provided to local farmers for demonstration plots.

Medicinal Plants

Propagation of a few medicinal plants has been carried out through tissue culture. This includes *Withania somnifera, Plumbago rosea* and *Piper nigrum*. Five hundred plants of *W. somnifera*

were prepared ready for rooting and 1000 *Plumbago rosea* plants has completed rooting and are ready for hardening.

Conventional propagation of selected plants

In addition to micropropagtion, a few Ornamentals (*Aglaonema, Ixora, Tradescantia, Hibiscus, Pandanus* (ornamental), *Calathea*), medicinal plants (*Alpinia*, Kacholam, *Asparagus*) and selected spices (*Cinnamomum, Murraya*, Pepper) were also propagated conventionally at the Centre.

Income generation:

The Centre has generated a total income of ₹ 1,70,063 through plant sale and training during the period.

DIVISION OF CONSERVATION BIOLOGY

Recent studies showed that many higher plants of Kerala are listed under any one of the Red Listed category of IUCN mainly due to endemicity, small population size and habitat loss. Receding species occupancy space, quality of habitat, number of mature individuals and their co-habitants are the major criteria of being listed in an endangered category. The status and the ratio of various age groups in a population determine the reproductive and regenerative capacity of the population and indicate their future course of survival. Knowledge on sexual system, pollination, mode of reproduction, seed dispersal, seed germination and genetic structure of a species is essential to understand the survival capacity of populations.

Key-areas of research groups in the Division are on plant population and reproductive biology for the conservation of selected species having socio-ecological relevance. Based on data collected on species auto ecology, life histories of selected species are documented for augmenting *ex-situ* (Seed Bank) and *in-situ* conservation through operational in house and externally funded projects.

In line with Global Strategy for Plant Conservation (GSPC), ecological restoration and species recovery programmes are being implemented in collaboration with Central and State Government agencies like SERB, DST and Kerala Forest Department.

Objectives:

- Study the population structure and gene flow system of selected endemic and endangered species of the southern Western Ghats.
- Study the reproductive dynamics with reference to floral biology, pollination, development of a pollen herbarium, reproductive success and identification of causal factors for rarity.
- *Ex-situ* conservation of native flora through seed banking with special emphasis on endemic flora and documenting seed biology, seedling ecology and species restoration programmes.
- Documentation of flowering plant wealth of India to support conservation.

Data documented with SERB, DST funded project on Conservation of *Garcinia imberti* Bourd

Garcinia imberti is an endangered tree of the southern Western Ghats distributed in Chemunji, Bonacuad, Ponmudi, Cheenikala, Sankhili and Poonkulam forests of Agasthyamala Biosphere Reserve. As part of developing its conservation strategies, some of the following life history traits were documented.

Vegetative dynamism

Flushing of new leaves usually occur between November-January which may extend up to February. Leaf development period spreads for 80 days to attain 10.78 ± 3.3 cm length and 3.68 ± 1.5 cm breadth. Mature leaves are simple, opposite, elliptic to lanceolate in shape and are dark green coloured. The leaf senescence occurs during the months of November to December along with a colour change from brown to dark brown. Annual bole growth rate in terms of girth diameter was observed to be 2.2 to 3.1 cm year^{-1}. The seedling and tree growth rates recorded maximum in Chemunji population (0.5 and 3.1 cm year^{-1}) compared to less percentage of seedlings in Sankhili and trees in Cheenikkala (0.3 cm year^{-1} each).

Reproductive dynamism

G. imberti as a dioecious tree, male and female tetramerous flowers occur in different individuals with sex ratio nearly 1:1.2. The pale green sepals persist up to fruit setting and the petals are yellowish-creamy in colour. Usually petals are four, rarely up to six in female flowers. Male flowers initiate from January followed by female flowers from the last week of January that extends up to May. Peak flowering period was observed throughout the month of April with ⩾ 90% as male flowers. A maximum of 50-60 days were taken for complete development. A single male flower consists of 28 ± 5 anthers. Anthesis was initiated at early morning. Pollen grains are spherical and tetracolporate and with 59698 ± 945 per flower. The rate of flowering was found to be decreased rapidly by the month of June onwards. The female flowers borne on tip of branchlets and are usually solitary, however rarely 3-4 flowers was also observed. Usually the floral buds of January mature to the tune of ⩾ 90% by the month of May. The female flower slightly larger than male flower took 50-70 days for maturity (⩾46 mg weight) and the number of ovules per ovary was observed as 2-3. The pollen-ovule ratio was 85:45.

Fruit/seed phenology

Fruiting primordia initiated by July mature into ripened fruits in October. Fruit set is very less and produce only an average of 35.5 ± 3.9% mature fruits (160 days after pollination) per year. Massive fruit predation by arboreal mammals was observed.

Fruit variations

Usually, *G. imberti* fruits bear 1 or 2 seeds at the rate of 53.5 and 42.1% respectively while certain accessions carry 3 or 4 seeded fruits. The occurrence rate of three seeded fruits (TSF) was 3.34% and four seeded fruits (TtSF) 1.05%. Each fruit has distinct shape and dimensions from narrow elliptic to elliptic-obovate to wide elliptic shapes according to the number of seeds.

Fruit/seed development

The bud shaped fruit primordium attains different shapes depending up on the number of seeds in a fruit. The mature fruit is a berry with hesperidiform morph D 65 and morph D 67 (Clopton, 2004) for single and double seeded fruit respectively. Immature fruits of *G. imberti* appear in strong yellowish green colour which changes to brilliant yellowish green at maturation. Fruit dimensions (length and width) were significantly increased since 100 DAA while seed breadth was significantly increased from 120 DAA onwards. The fresh weight of fruit gradually increased from immature to mature stages and the rind moisture became peak by 80-120 DAA which was reduced subsequently. There was a positive correlation between fruit size and number of seeds per fruit.

During seed development, significant increases of seed dimensions (length, width and breadth) were noticed since 120 days after anthesis (DAA) and the maximum seed size (length; 3.05 ± 0.92, width; 1.6 ± 0.01 and breadth; 1.90 ± 0.02 cm) was achieved in seeds of 160 DAA. During seed maturation, the moisture content gradually increased up to 100 DAA and rapidly decreased to attain a final stable value of 62.80 ± 3.7% (160 DAA) and registered a higher nutrient content of lipids (127.7 ± 6.2 mg/g) which may attract more predatory mammals. G. *imberti* seeds harvested with high moisture content at 100 DAA showed speedy germination, though they are prone to decay due to physiological immaturity. It was observed that the physiologically mature 160 DAA seeds are better for banking and producing sound seedlings.

Fruit predation

Field observations revealed that major portion of fruits/seeds were affected with high level of predation from immature stage onwards mainly by arboreal mammals like Malabar Giant Squirrel (*Ratufa indica*) and Nilgiri Langur (*Trachypithecus johnii*). The behavioural pattern particularly of squirrels was observed as a group foraging on immature fruits over a period of two weeks. Majority of the associated species surpass the fruiting span of *G. imberti* (July-October) so that the predators depend more on *G. imberti* fruits on these months.

The pooled data from the seed traps also confined a similar tendency of only ⩽8% of seeds escaped from predation (2.4 ± 0.2 to 6.4 ± 0.3). Nevertheless, majority of fruits or seeds (74 to 85%) were incompletely predated which means skipped from complete predation with varying percentages of seed kernels. Above 40% of seed remains were with less amount of seed tissue (⩾66% predation) that might be of the scraped tissues skipped while feeding. The Malabar Giant Squirrel predated about 71.23% of fruits followed by *Rattus rattus* (2.04%) and the *Trachypithecus johnii* (1.21%). These predators feed only on seeds leaving the pericarp unlike that of the other *Garcinia* fruits. The nutrient analysis of the seeds revealed richness in proteins (16.2 ± 0.5 mg/g) and lipids (127.7 ± 6.2 mg/g) which may be the palatable attractants for mammals.

Seedling recruitment

The population dynamics of *G. imberti* revealed that, Cheenikkala, Poonkulam and Sankhili have seedling recruitment of 11.3%, 13.6% and 14.9% respectively; however in Chemunji and Ponmudi populations recruited higher percentage *i.e.*, 24.7% and 24.4% respectively. Seedling mortality rate is also higher in Sankhili (17.5%) and Cheenikkala (16.9%). Less rate of seedling mortality was recorded in Bonacaud population (4.7%). Tree mortality rate in all populations showed almost equal range of 1.9 to 2.6%.

Population dynamics and agroecology of *Trichopus zeylanicus* Gaertn. subsp. *travancoricus* (Bedd.) Burkill *ex* K. Narayanan – *Arogyapacha*

Trichopus zeylanicus Gaertn. subsp. *travancoricus* (Bedd.) Burkill ex K. Narayanan (Dioscoreaceae) is an endemic medicinal herb of the southern Western Ghats, commonly known as 'Arogyapacha'. It is a small perennial rhizomatous herb, the distribution of which is restricted to the Peppara and Shendurney Wildlife Sanctuaries and Kalakad – Mundanthurai Tiger Reserve of Agasthyamala Biosphere Reserve. A total of 29 field trips were conducted to Kulathupuzha, Aryankavu, Rosemala, Thenmala, Bonacaud, Kallar and Kottur hills to study the population structure, phenology, agroecology and cultivation aspects for *ex situ* conservation. Through People Participatory Programme at Kulathupuzha Forest Range, a nursery was developed for comparative growth studies. For agroecolgical standardisation, we planted 1000 seedlings in homestead soil, 1000 in forest fringe area soil and 1000 seedlings growing in forest soil. All the planted seedlings were transferred to JNTBGRI conservatory for continued observation and seedling growth.

Distributional maps of the candidate species from the study sites were prepared using Garmin eTrex GPS and draw with the help of MaxEnt (version 3.4.1) and DIVA-GIS (version 7.5) software. From the basic data six main study sites were selected for month wise analysis. In these areas five permanent plots (5x5 m^2) each were established for further studies. Quantitative parameters like abundance, density and frequency also were calculated. Age class structure was recorded in all study sites including number of seedlings, saplings and mature plants. Emergence and decline of plants in a plot were also recorded. Average annual vegetative and reproductive productions were documented to identify elite population.

Month wise phenological changes were documented in the selected study sites. Vegetative dynamism such as leaf flushing, initiation, maturation, senescence and reproductive dynamism like bud initiation, flowering, fruit initiation, maturation, dehiscence, dispersal, predation, seed germination and seedlings establishment were recorded. The individuals were randomly selected, tagged with metal tags for the above study. Morphological parameters like leaf/fruit/seed dimensions and leaf/fruit/seed colour were also recorded. Reproductive phenology was documented

through flowers tagged on the day of anthesis and subsequent sequential growth was analysed. Month wise data of edaphic factors (temperature, RH, pH), climatology (Day and Night atmospheric temperature, Day and Night atmospheric RH, Day light intensity) and phenology (vegetative and reproductive) were recorded in these areas at regular intervals.

Seed germination studies were carried out in natural as well as laboratory conditions. Natural seed germination happens 6-7 months after dehiscence. In the forest areas seed germination percentage observed as 45-60 %. Heavy rain washes out the dehisced seeds from the plant distributed area. Predation is high in the stage of mature fruit. Anthropogenic activity (excessive collection of plants, leaves and fruits) also leads to decrease in seed germination. Seed germination trials were carried out with different soil samples (a. Forest condition: Forest soil – control & Nursery soil, b. Nursery condition: Nursery soil – control & Forest soil) and found that forest soil was better for the growth of *T. zeylanicus*.

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

As part of this MoEF&CC sponsored project, seed germination and seedling studies of seven species *viz*. *Ensete superbum*, *Garcinia indica, Piper barberi*, *Rauvolfia hookeri, R. micrantha, Semecarpus travancoricus* and *Hydnocarpus pentandrus* were carried out to standardise seedling production and maintenance.

Fruits of all the species were hand harvested except that of *Semecarpus travancoricus* as it is allergic at fully ripened stage. Fresh seed samples were depulped and washed under tap water and floated ones were discarded. Remaining seeds were surface dried at the lab conditions (28±30ºC) until no seeds adhered to palm when pressed. Such surface dried seeds were stored in polyethylene bags for an interim period of germination studies.

***1. Ensete superbum* (Roxb.) Cheesman**

Seeds are orthodox with 17.9% initial moisture content having dormancy for a period of 4 to 6 months. Observations showed that drying the seeds under sunlight enhanced germination both at laboratory conditions and natural habitat. Different pre-treatments were carried out to overcome the seed dormancy out of which sun drying for 3 days or chemical scarification with conc. H_2SO_4 treatment for 15 min enhanced germination up to 75% in three weeks period. Differential drying (or acid leaching) of tissues around the monocotyledonous embryonic plug area at the black testa operculum face facilitates the water entry. Ninety to cent percent germination was registered and seedlings are grown in black polyethylene bags in medium comprising 1:1:1 ratio of sand, cow dung and garden soil. Almost 400 seedlings were kept for six months beyond which planting became inevitable. Apart from the supply of 200 seedlings to public and students participants of various science day celebrations, as part of field establishment, 200 seedlings were planted around a water reservoir of the campus and 10 plants were planted at Kerala Raj Bhavan campus.

***2. Garcinia indica* (Thouars) Choisy**

Fresh seeds with initial moisture content of 42.81% registered 100 percentage germination and lack dormancy. Seeds are highly recalcitrant in nature. Seeds lost viability within ten days. Earthen pot storage is a traditional method which was also effective in the short term storage of *G. indica* seeds. In earthen pot, seeds stored in open condition failed to germinate after 30 days. Seeds stored in earthen pots at 20°C registered 57% germination after 90 days. More than 360 seedlings were produced and as part of field establishment programme, 50 seedlings were supplied to Ranipuram hill station at Kannoor district of Kerala. Ten seedlings were planted in JNTBGRI campus while remaining 300 seedlings were supplied to public homesteads.

***3. Piper barberi* Gamble**

The average initial moisture content of the seeds was 33.21% with 96% germination within 12 days. Seeds are recalcitrant in nature loosing viability within one week at open laboratory condition. Results showed that seeds stored in polycarbonate bottles kept at 20°C for 90 days registered 60% germination. About 461 seedlings were raised which were accessioned to the

'Piperatum' of the Plant Genetic Resource Division for continued observations.

***4. Rauvolfia micrantha* Hook. f.**

The initial moisture content was 20.14% with an average germination of 60%. Seeds are orthodox in nature and when stored with 5 to 10% MC in liquid nitrogen (-196°C), 100% germinated after one week storage. As an accepted seed storage procedure, the standardised seed condition with more than 60 % germination was found at -4°C with 5% MC. Seedlings (24 numbers) were kept in polyethelene grow bags up to four leafed stage before planted in the field.

5 . *Rauvolfia hookeri* S.R.Sriniv. & Chithra

Seeds are orthodox and have dormancy. The initial moisture content was 20% with an average germination of 10%. Among the many trials tested, seeds pre-treated with 100 ppm GA_3 or soaked for 24 hours in distilled water registered 80 to 90% germination, but mean germination time value for GA_3 was significantly less as an advantage. When stored at 20°C for a week, seeds showed maximum germination percentage of 80±6.3. Nevertheless, seeds upon losing moisture to 5%, germination percentage were reduced considerably to 30 to 55% accordingly with the storage temperatures. Only few individual plants with fruits were located in the wild and that too with more than 70 % chaffy seeds. We could arise only 10 seedlings which were planted in the field gene bank area.

***6. Hydnocarpus pentandrus* (Buch.-Ham.) Oken**

In the laboratory condition, decoated seeds registered 90% germination over a period of 78 days of incubation in between paper method. With reference to various combinations of the tested pre-treatments, 250 ppm GA_3 registered 100% germination in two weeks is found worthy. Seedlings produced to the tune of 255 numbers were kept in grow bags for a period of 6 months in semi shade and seedling morphology was noted, especially the leaf polymorphism, and 50 seedlings were planted at the riparian vegetation stretches.

***7. Semecarpus travancoricus* Bedd.**

It bears recalcitrant seeds. Initial moisture content of the seeds was 32% with 38.36% germination initiated in 13 days of incubation and in a month 70 to 80 % germinated. It was found that a ten percent decrease from the initial seed moisture content was deleterious in sense the decrease of germination to below 40 % as a mark of recalcitrant nature. Germination is epigeal type and seedlings were planted in grow bags with potting soil with humus simulated to natural habitat. Seedlings (25 nos.) were planted along the evergreen patches of the JNTBGRI campus.

Seed bank

According to CBD report on Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), more than one million species of plants and animals are at risk of extinction. JNTBGRI Seed bank was started during 1984 with an initial collection of seeds from the provincial Palode flora. Growing concern of many international agencies like IUCN and BGCI over climate shifts and gene erosion surged the importance of seed storage. Over the years of changes in agricultural preference that lead to loss of landrace paved the way for the ever increasing importance of regional seed banks. Since no place is a safe haven for the seeds to be stored for the posterity, seed holdings are insurance for the present plant genetic diversity. This seed bank has network of partners with 35 centres globally spread over 20 countries for sharing concepts of species conservation.

During the period 106 accessions of 99 species in 94 genera were collected and added to the active collection of the JNTBGRI seed bank, of which 11 species are Western Ghats endemic. Prepared 35 display bottles and labelled them. Viability of the seed samples were periodically checked and replaced non-viable seed samples with new accessions according to availability. A total of 111 seedlings of 3 species developed from seed bank were supplied to different sections of JNTBGRI for planting.

Seed germination and storage studies on selected species

***Julostylis polyandra* Ravi & Anil Kumar**

Julostylis polyandra is an endemic and endangered tree of southern Western Ghats.

1. Reintroduction of *Garcinia imberti*, 2. *Salacia* spp. Seed morphology, 3. *Garcinia imberti*-population depletion over a period of four years

Moisture content of the seed determined as 22.53% showed 30% germination. The germination was improved to 90% with seeds stored in polycarbonate bottles in 30°C for 10 days. When MC reduced to 18% the seeds at 30°C germination reduced to 40%. Seeds retained viability only up to one month in room condition.

***Garcinia pushpangadaniana* T. Sabu, N. Mohanan, Krishnaraj and Shareef**

It is an endemic to the semi-evergreen forest of the Southern Western Ghats of Kerala and Tamil Nadu. Seeds are brownish and ovoid with a dry thin layer seed coat with 32.02±4.32mm x 19.80±3.65 weighing 6.89±2.32gm. Seed with moisture content of 49% registered 90% germination.

***Symplocos cochinchinensis* var. *laurina* (Retz.) Raizada**

This tree has high medicinal value and can be used effectively for restoration of degraded lands. Initial seed moisture content (MC) and viability of seeds were used to determine the seed storage behaviour. Germination of mature intact seeds at 25°C in light/dark (14h/10h) and imbibition

of nonscarified (NS) and manually scarified (MS) seeds was assessed to determine the presence of physiological and/or physical dormancy. Manual scarification, gibberellic acid (GA_3) treatment and hot water treatments were conducted to determine the level of dormancy. Effect of temperature (at 15, 25 and 35°C) and complete darkness on seed germination was studied. Time taken for shoot emergence and radicle emergence was monitored to evaluate the presence of epicotyl dormancy. Initial MC was 24.86 %. Those seeds with cutting of mycropylar ends showed quick germination. GA_3 2000 ppm treated seeds gave the highest germination with 18 days. Also the cut micropylar end with GA_3 further reduces the days required for germination. The embryo was fully developed. Shoot emergence delayed significantly after radicle emergence. Further work such as insecticide treatment and normal germination treatments are in progress

***Syzygium myhendrae* (Bedd. ex Brandis) Gamble**

Syzygium myhendrae is an endemic and endangered tree species. The average seed weight is 0.92g. Seeds showed considerable reduction in moisture content during storage. Initial viability tests revealed 50 % germination. Tetrazolium test revealed the seed viability which indicated that cotyledons and embryonic axis were lightly stained with tetrazolium, confirmed the seeds are less viable. Fresh seeds hold 48% moisture content. Desiccation studies revealed that seeds are moderately recalcitrant. Seeds showed hypogeal germination. Seeds with highest moisture content germinated 52% in the seed germinator, which on further open natural drying for a period of 104 days became moisture content 23.11% with a germination of 10%. Seed germination studies conducted in mist house did not give a positive result. Eighteen percentages of seeds only developed as seedlings and 2% of them showed multiple shoots. The low seed germination percentage could be the reason for the narrow distribution of the plant in the wild.

Seed characterisation of four species of *Salacia* L.

As part of *ex-situ* conservation, seed studies were carried out on four highly sought *Salacia* species, viz, *Salacia brunoniana* Wight & Arn., *S. malabarica* Gamble, *S. fruticosa* Wall. ex M.A. Lawson and *S. oblonga* Wall. ex Wight & Arn. Among the four selected species, *S. malabarica* and *S. fruticosa* are endemic to the Western Ghats, while *S. brunoniana* is endemic to Peninsular India and is a vulnerable species. *S. oblonga* is native of India and Sri Lanka and is also become vulnerable. Among the endemic species, *S. malabarica* is becoming endangered due to over exploitation and habitat destruction.

The morphological data of fruits and seeds were documented. The seeds of *Salacia fruticosa* recorded highest moisture content, followed by *S. brunoniana*, *S. malabarica* and *S. oblonga*. Germination percentages were high in *S. malabarica*, followed by *S. fruticosa, S. brunoniana* and *S. oblonga*. The two vulnerable species have lowest germination percentage (*S. brunoniana* and *S. oblonga)*, which can be a reason for their extinction. Purity of seeds was high in *S. malabarica*, followed by *S. brunoniana*, *S. fruticosa* and lowest in *S. oblonga*. *S. malabarica* has highest germination percentage and highest germination speed. Germination speed is lowest in *S. oblonga* where germination percentage was also low. *S. malabarica* has highest germination value, followed by *S. fruticosa, S. brunoniana* and *S. oblonga* which are in accordance with the initial germination percentage of the respective species. Species having higher germination percentage has higher germination value and vice versa.

Fruit and seed polymorphism was observed in all the species. But more variation was found in *S. fruticosa*, especially within seeds. When fruits of S. *fruticosa* were collected in bulk and seeds were extracted, 6 classes were differentiated according to their size. Here the largest number of seeds belongs to the class 4 (66 seeds) followed by class 5 (38 seeds), class 3 (34 seeds), class 2 (32 seeds) and class 1 (9 seeds). When the seeds were tested for germination, there was no marked difference in germination percentage.

Fruit and seed weight were highest in *S. brunoniana* with 1-6 seeds per fruit. *S. malabarica* fruits also enclose 1-6 seeds, and have seed weight greater than *S. oblonga* which has more fruit weight than *S. malabarica* with 3-4 seeds per fruit. *S. fruticosa* has the lowest fruit and seed weight that hold 1-3 seeds per fruit.

Desiccation details revealed that all the four species do not retain viability more than 30 days. *S. fruticosa* has the highest critical moisture content that 9% reduction of moisture content reduces viability considerably. In *S. oblonga* 6% reduction of moisture content within 17 days was found lethal. *S. malabarica* seeds lose viability in 29 days while in *S. brunoniana,* it occurs within 19 days. So the seeds are found to be desiccation sensitive and cannot be dried below 30-33% as a recalcitrant nature.

In all the species germination is of epigeal type. Field establishment in *S. oblonga* seems to be poor. Seedling characters of selected species up to six leaf stage were documented. Seedling vigour is found high in *S. malabarica* where germination percentage was high and low in *S. oblonga* where germination percentage was also low. A key for the identification of selected species were also prepared for identifying the species in seedlings stage.

Development aspects of *Bentinckia condapanna* Berry ex Roxb. seeds

Bentinckia condapanna Berry ex Roxb. (Arecaceae), commonly known as "Bentinckia palm", or "Kantha Kamung" is an altitude specific endemic palm species of the southern Western Ghats. This palm confined to its niche has been categorized as vulnerable. The recalcitrant nature of seed along with a shift in the climate has reduced its propagation rate during the past decades. Factors like habitat destruction, low levels of natural regeneration, lack of research on the improvement of existing genetic stock are the other major hindrances for the establishment of this species.

Seven development stages of fruits were collected and the matured stage was available only in scarce amount. Moisture content, morphological parameters, biochemical parameters and antioxidant enzyme activity were analysed for all the development stages. The study of seeds during developmental stage depicts the suspected recalcitrant nature of the seeds with peculiarities. Germination percentage and conductivity has been recorded in the physiologically mature seeds. Moisture content, conductivity and germination percentage of the premature seed's three desiccant stages up to 13% moisture has been tracked. Moreover it has been found that the seeds possess dormancy and the germination percentage is found to be alarmingly low (20%). Viability study conducted till now indicates that the seeds could retain viability for a period of 8 months. The rapid reduction in the moisture content during desiccation of the physiologically mature seeds and its dormancy of 2 months or more indicates that the seeds are not typical recalcitrant ones, but is recalcitrant with peculiar behaviour.

Seed desiccation studies on two *Myristica* swamp trees

Myristica swamps are highly fragmented fresh water ecosystem of the Western Ghats. Correlation between desiccation, viability and bio molecule status are reported to augment species reclamation.

Gymnacranthera canarica (Bedd. ex King) Warb. (Myristicaceae, nutmeg family) is the most dominating tree species of myristica swamp ecosystem. Mature seeds normally possess 28.6% moisture content (MC). Moisture content gradually decreases and seed lose its complete viability within 12 days of desiccation depicting recalcitrant behaviour. Seed critical moisture content (CMC) was found as 19%. Germination studies conducted with fresh seeds registered only 35% germination percentage in 50 days but seed samples exposed to 5 days continuous desiccation with moisture content decreased to 19.39% registered 80% germination.

Changes in phytochemicals during the desiccation of the recalcitrant embryos of *Myristica malabarica*

FTIR spectroscopic analysis of the mature embryonic tissue at the time of germination, showed the presence of all phytochemicals which were present in the mature embryo except alkenes. The presence of primary and secondary amines in the germinated embryos indicates the appearance of alkaloids during germination. Desiccated embryos showed the presence of all phytochemicals except ketones, amides, primary and secondary amines and polysulphides. It can be assumed that the drop in moisture content during desiccation was

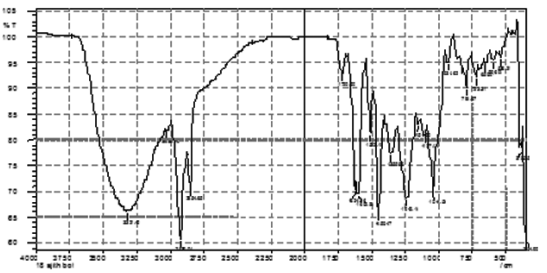


Fig. 1. FTIR analysis of mature embryo of *Myristica malabarica* (methanol extract)

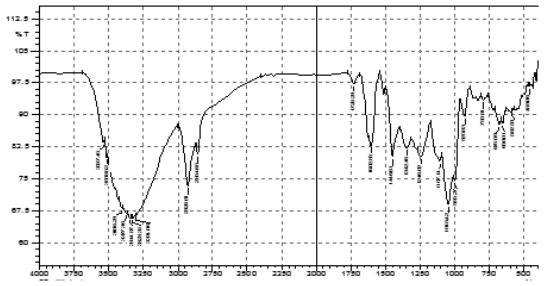


Fig 2. FTIR analysis of severely desiccated embryos of *Myristica malabarica* (methanol extract).

accompanied by lack of production of these chemicals and it might be a reason for their loss of viability.

Propagation and conservation of *Lilium neilgherrense* Wight; a perennial herb from South Western Ghats, India

Lilium neilgherrense (Liliaceae) also known as the Nilgiri lily is a perennial bulbous herb, endemic to Southern Western Ghats. The species is an erect unbranched herb and grows to 1m in height, generally flowers from September to October. The lily was very common along the grassy slopes of Nilgiris during 1900. Now due to habitat destruction, over exploitation and human interference the lily is restricted to steep stony fragments of land. The study focus on habitat analysis, status assessment, phenology, morphological variability, seed collection and storage and to develop propagation protocols for *L. neilgherrense*.

During the survey, one population is reported from Eravikulam National Park, Munnar in Idukki district of Kerala and phytosociological parameters of the population was recorded. To assess the conservation status, number of mature individuals was counted. Morphological features such as plant height, number of leaves, leaf size, and bulb morphology were also measured in the natural habitat.

Conservation of endemic and critically endangered *Buchanania barberi* in India

Buchanania barberi Gamble belongs to family Anacardiaceae, is a small evergreen tree (15 meter) endemic to Southern Western Ghats of Kerala, India. Our recent survey of the Palode region (Thiruvananthapuram district) where the species was last reported, found just four trees. Two of the individuals are mature and two juveniles. The species has very small area of occupancy and population size and globally assessed as Critically Endangered on IUCN Red List. An *ex situ* conservation project funded by The Mohamed Bin Zayed Species Conservation Fund; UAE initiated to conserve the species.

Mature fruits were collected in cotton bags and brought to the laboratory. Seed pulp was removed manually and the seeds dried for a day in ambient room conditions. Later 300 seeds were incubated at ambient temperature for germination in the laboratory. *B. barberi* seeds take *circa* 15 days to start germination and then are transferred to black polybags with a sterilized mixture of sand and cow dung as a growing medium. These seedlings were placed in the JNTBGRI nursery for adaptation. After few months, the seedlings attained a good height and ample number of leaves. Community awareness campaign was conducted in nearby schools in Palode region and campaign materials like posters, mugs and bags were disseminated. Seedlings were

Community awareness programme of *Buchanania barberi* Gamble

also transplanted in these schools and JNTBGRI campus and their survival will be monitored. Hope these steps will ensure the *ex-situ* conservation of this rare tree species.

Conservation of vulnerable sandalwood (*Santalum album* L.) through propagation and reintroduction

Santalum album is the second most expensive wood in the world (₹ 300,000/kg). Major causes of decline in populations of sandalwood has been smuggling of the wood. Forest fire, grazing, exploitation of the wood for fine furniture, carving, absence of adequate number of seed-bearing trees, lack of established plantations and heavy demand by the sandalwood oil factory are other threats. All these factors are responsible for the inclusion of *S. album* under vulnerable status by IUCN Red List (IUCN 2018). The study involves seed storage and germination experiments with raising quality planting material and transplantation in natural habitat.

Based on previous trails all seeds were pre-treated with GA_3 to improve germination. Among three germination medium selected, petridishes lined with Whatman no.1 filter paper shows maximum seed germination (> 60%) compared to paper and sand medium at 30°C. During the experiments we observed emergence of two radicles from one seed (bi-embryonic). These germinated seeds were transferred to small pots and observed for growth. Later, these seedlings were planted in polythene bags along with *Mimosa pudica* or *Crotalaria retusa* seedlings. The potting media consist of sand:cowdung:cocopeat (1:1:1). For storage study, seed were stored in polythene and cotton bags at different temperature conditions. The present work will help in conservation of this valuable tree species and in augmenting the economy of the state.

Population Biology of *Humboldtia unijuga* var. *trijuga*, an endangered tree species of the southern Western Ghats and its conservation

Humboldtia unijuga Bedd. var. *trijuga* Joseph & Chandras. is a small tree of Leguminosae (Ceasalpinioidea), restricted to the southern Western Ghats. Preliminary observations showed that *H. unijuga var. trijuga* is surviving only with distracted populations of few individual trees. An enquiry on metapopulations of this plant in other spatially separated niche is essential for the future conservation of this species. Knowledge on the present population, species specific adaptive ecology especially recruitment failure and genetic structure may provide clue for its limited distribution. The study envisages devising a conservation protocol of this species through studies on population, genetic structure and seed biology.

During the period, literature on *Humboldtia* and allied species were scanned from the journals and a total of 63 references were collected. Exploration trips/field trips were conducted (21 numbers) to forest areas of Agasthyamala Biosphere Reserve (ABR) such as Chemmunji hills, Attayar, Koviltherimala, Bonacuad and Ponmudi in order to locate the distribution of the species, for identifying study sites and for population study. Population at Koviltherimala, was located after 30 years from its type collection. Phenology was observed from 25 trees marked at Chemunji hills. Leaf flushing was observed in all months but major flushing event in August-October. Flowering is initiated in October and extended up to March and fruiting from January to June. During the one year tenure, fruit set was not yet observed barring an instance a single fruit of open pollination (1%) but that too predated by some animals/insects prematurely. Hence, flower to fruit set ratio was very less *ie,* 0.03.

In order to study the population structure and dynamics, 6 permanent plots (20 X 20m) were established in Chemmunji and 1 plot in Koviltherimala. A total of 54 trees and 236 seedlings are observed from the 6 studied plots of Chemmunji. Most of these trees are in lower girth class, 47 trees are < 50 cm gbh and the largest individual measured 82cm gbh. This species is well represented in all girth classes and exhibited a negative exponential curve with more individuals in lower girth class. Among the saplings, 174 are less than 1m height (72.73%) which is considered as unestablished seedlings while the rest as established saplings (> 1m height, 62 saplings, 26.27%). This preliminary study showed that *H. unijuga* var. *trijuga* has a

Fig. 3. Girth class structure of *Humboldtia unijuga* var. *trijuga*

healthy population structure in Chemmunji with greater number of individuals in lower girth classes. The height class also exhibited a more or less similar pattern with the highest individual tree attained a height of 16m.

The sampled area of 0.16ha had 78 species with total basal area of 101.26 m^2 ha^{-1} and *H. unijuga* var. *trijuga* have basal area of 2.52 m^2 ha^{-1}. Also they have relative density of 14.05 and relative frequency of 2.04. They have an important value index of 16.28.

Observations made on the canopy condition and stature of the trees showed that many trees are with unhealthy canopy structure and hollow trunk. This condition may be a threat to the population as they may uproot in harsh wind which is frequent

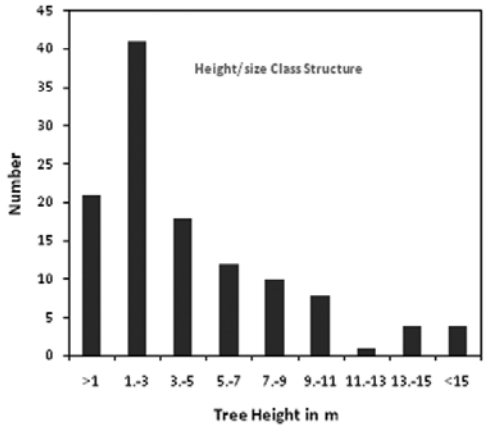


Fig. 4. Height / Size structure of population

phenomenon at Chemmunji. Even though, the species have fairly good population structure and girth class distribution, low area of occupancy and unhealthy individuals pose problems of their existence in the near future.

Reproductive Biology

Reproductive biological studies are very essential part of conservation studies. The Division has a well-established reproductive biology lab, where following reproductive biological works were carried out during the period under report.

Humboldtia bourdillonii **Prain**

Humboldtia bourdillonii inhabits the wet evergreen forests at an altitude range 450-800m asl, growing in flood area of streams as well as areas between streamlets. This species included under critically endangered category by IUCN. Field trips were conducted in the Sabarimala forest areas and located *H. bourdilloni* in the wet evergreen forest of Arjunan Kotta and Poonkavanam forest (9^0 28'11.5" N latitude and $77^0$4'28.1" E longitude) of Southern Western Ghats.

The tree flushes throughout the year. They flower profusely during November to February. Inflorescences arise mainly from the tree trunk (Cauliflorous) and to a lesser extent on the branches. Buds takes about 25-30 days to

1. Seed germination - Syzygium myhendre, 2. Syzygium occidentale - vivipary, 3. Humboldtia bourdillonii - Flower

produce mature flowers. Reproductive cycle is 2 to 4 months from flower buds to mature pod. Pods are reddish- pubescent when young, turning to brown-pubescent at maturity. Viable seeds are available from March to May.

The flowers open gradually, starting from late morning to early evening. Complete opening of the flowers take place in between 4.00 pm to 6.00 pm, and the style and filaments get uncoiled. Style and stigma show a spatial separation among themselves before anther dehiscence. Pistils are shorter than stamens. Anthers dehisce longitudinally around 8 pm; on dehiscence they change from dark pink to black, liberating creamy white powdery pollen. Pollen grains are non-sticky, tricolpate and are carried away by wind. Pollen grains are viable from the time of anther dehiscence up to 40 hrs after flower opening. The Pollen fertility and viability tests indicated that 78% of pollen grains are fertile and 72.15% are viable. Ovary is superior, monocarpellary, unilocular and is covered by tuft of hairs. The style is long and pubescent and has a capitate stigma. Stigma secretes a thin layer of exudate at the time of anthesis indicating receptivity. The stigma was found receptive from flower opening to 24 hrs post opening. Petals fall off one day after anthesis. Sepals remain few more days and the stamens and the style dry out after a week. This plant favours both anemophilous and entomophilous pollination. Only few insects such as *Apis cerana, A. mellifera* and *Trigona iridipennis* were seen in peak flowering period. They visit the flowers for pollen and nectar, their inter-plant movement facilitates pollination. Natural fruit set rate was nearly 23%.

***Humboldtia brunonis* var. *raktapushpa* Udayan, Tushar & S. George**

It is distributed in the semi evergreen forest areas of Kakkayam with an altitude between 700-800 m asl. It is a small tree up to 3-4 m height and produce red flowers, which have high ornamental potential. The flowering starts in the month of December, reaches a peak during January and extends up to February. Most of the floral characters of the plant are similar to that of *Humboldtia brunonis* except in flower colour (red) and densely pubescent gynoecium. Fruit initiation was observed during February and maturation during May.

***Humboldtia vahliana* Wight**

Humboldtia vahliana is an endemic medicinal tree species with 5-30 m in height. The pollen germination percentage showed a declined rate with malfunctioning ones ensuing in the reduction of flower-fruit ratio. During fruit development stage, some unidentified insects and beetles infect the tender fruits which adversely affected the fruit production. These factors clearly indicate that gene flow between the natural population is restricted within that area gradually leads to less reproductive success

***Embelia ribes* Burm.f.**

Embelia ribes is a highly sought medicinal plant included in the red data book. It is a polygamo-dioecious species with male and female flower ratio was calculated as 5:1. Male flowers are short lived compared to females. Fruit to flower ratio is low, but the seed - ovule ratio is very high. *In-vivo* pollen germination studies indicated that only small quantity of pollen grains are loaded on the stigmatic surface of the flower. Percentage of fruit set was 40-45%, during the developmental stage they abort up to 12%. Fruits are eaten by birds and insects. Natural regeneration is poor due to overharvesting, exploitation, habitat destruction, slow germination of seeds, low seed viability and germination percentage. Pre-treatment was done to alleviate physiological dormancy by using GA_3. Maximum germination of 75% was recorded with GA_3 1000 ppm. Plants were transferred to field after they reach four leaf stages. More vigorous growth was observed in plants treated with 1000ppm GA_3.

***Elaeocarpus munroii* (Wight) Mast.**

Elaeocarpus munroii is a tall tree endemic to Western Ghats and included in IUCN red list (2018) as near threatened. The present study was conducted in Ponmudi hills of Agasthyamala Biosphere Reserve and Kochupamba. The plant flowers twice in a year. By comparing both flowering season peak flowering can be observed in August to October. Flies, wasp, bees, ants, beetles and moths are the pollinating agents but flies are the major

pollinators. The activity of floral visitors helps the anther to dehisce. The seed took 6 month duration for maturation. The stony endocarp started to develop only from the fourth month onwards. Purity analysis showed that seeds are 99% pure. The seeds coat is least permeable to water. The mature seed have the moisture content of 25±1.46%. The TTC test resulted in 95% of initial viability. After shedding, the embryo slowly reaches more active stage and ready to germinate. Measuring the DHA activity and conductivity indicated the same. Nearly 20 percentages of seeds germinated. Mean time taken for germination is about 61.5 days. Poor seed germination in the natural habitat could be the reason for the narrow distribution of this species in the wild.

Reproductive biology and Genetic structure of *Xanthophyllum arnottianum* Wight., an endemic tree species of the Western Ghats

Xanthophyllum arnottianum (Polygalaceae) shows morphological variations within as well as among populations. The flowering and fruiting phenology, fruit predation *etc*. were observed and found interestingly varying at different degrees. Different pollen viability tests such as Fluorochromatic reaction test (FCR) and 3-3'diaminobenzidine (DAB) tests confirmed that more than 85% pollen grains were viable on the day of anthesis. Fertility and viability gradually decreased on successive days after anthesis. The pollination mechanism was studied by regular field visits to check for the pollinator behaviors. Pollinators were traced and identified with the help of insect manual and expert consultation and their foraging behavior was recorded periodically. Cross pollination is effected by pollinators of insect Orders *viz*. *Hymenoptera* and *Lepidoptera* especially, *Apis cerana, Apis mellifera*, *Trigona iridipennis, Euploea core* and Moth spp. Certain *Xylocopa* sp. found to be nectar robbers. Different manual pollination techniques such as autogamy, geitenogamy and xenogamy were conducted in the field along with open pollination. Maximum percentage of fruit set (86.47%) was observed in xenogamy.

Since the plant is an endemic species showing a lot of morphological variations, the genetic structure of the plant was intended to study using ISSR markers. For that, three populations of 15 trees each were selected, in three geographically distant areas of the endemic locality of the plant. Fresh collections of leaf samples were used for yielding whole genomic DNA of the plant using Plant DNA isolation kits. The eluted DNA was diluted to desirable concentrations for further analysis. Sixty ISSR primers were designed after a good literature survey. The designed primers were used for initial screening using two representatives from each population and tested for allelic combinations. After this screening the selected primers were used for the remaining samples of each population and the alleles were scored and analyzed for comparison. The work is in progress for further sequencing analysis.

Vivipary in *Syzygium occidentale* (Bourd.) Gandhi

It is a vulnerable riparian tree species, endemic to the southern Western Ghats of Kerala and is distributed up to an altitude of 700 m MSL. While studying the reproductive biology of the species, observed an instance of vivipary in *Syzygium occidentale*. This is the first report of vivipary in this species as well as the family Myrtaceae. Viviparous germination is often regarded as an adaptive strategy developed by riparian/marshy/halophytic plants to ensure the establishment of seedlings in the altered habitat.

Gynostemium morphology and its implications in the reproductive biology of the genus *Thottea* Rottb. (Aristolochiaceae) from the Western Ghats

The presence of gynostemium is a very significant and interesting feature in *Thottea*. Here the gynostemium formed by the fusion of basal region of the style and filaments of stamens rather than the primitive type of complete fusion. So, there are a lot of confusions regarding the structure and function of gynostemium in *Thottea* and hence, it is necessary to reveal the role of gynostemium in the reproductive potential of the *Thottea* flower.

SEM analysis of gynostemium was conducted using mature flowers. Histological studies of gynostemium of *T. duchartrei* were carried out by taking hand sections and microtome sections.

Floral buds at different developmental stages were analysed by taking SEM and hand sections for studying gynostemium development. It was seen as a partial fusion product of basal portion of the style and filaments of the stamens. Field observations and the subsequent microscopic analyses on the flowers of the two accessions confirmed three types of gynostemium on the basis of colour of the stylar lobes. The first type of gynostemium was the one where the entire stylar lobes were red or reddish brown. The second type is with pale yellow stylar lobes and the third type with stylar lobes having either red or reddish brown and pale yellow colours. Pollen viability by FCR test indicated that maximum percentage of pollen viability (95.55%) was noticed on the day of anthesis. Stigma receptivity was maximum between 11 am and 3 pm. Stigma surface esterases were localized on the stylar lobes to identify the receptive area on it. Artificial pollination was conducted under field conditions and the stylar lobes were observed. The fluorescent photomicrographs of artificially pollinated gynostemium, it was clear that the pollen grains showed germination on all the area on the surface of stylar lobe, regardless of the presence or distribution of red patches and uncinate hairs. Pollen germination was not observed on the appendages.

Floristic studies on the Sacred Groves of Kollam district, Kerala, India.

Floristic studies on the sacred groves of Kollam district in Kerala, resulted in the discovery of 1126 sacred groves distributed in six Taluks, *viz*. Kottarakkara, Karunagappally, Kunnathur, Kollam, Pathanapuram and Punalur. The largest sacred grove in the study area is the Thiravoor Kavu with an area of 2.5 acre land located in Karunagappally taluk. The present study reveals that the sacred groves in Kollam district has 420 species, 5 subspecies and 12 varieties of flowering plants, belonging to 304 genera in 89 families and 3 subfamilies. Gymnosperms are represented by 2 species and 2 genera in 2 families. The present study resulted in the discovery of four species new to science *viz*. *Eugenia kollamensis* Shailaja *et al*., *Mallotus kollamensis* Shailaja *et al*., *Millettia sanjappae* Shailaja *et al*. and *Sida travancorensis* Shailaja *et al*. The rediscovery of *Madhuca diplostemon* (C.B.Clarke) P. Royen, a thought to be extinct species after a period of 183 years of its original collection, is another highlight of the study. New locations were also reported for *Buchanania barberi* Gamble, *Grewia palodensis* E.S.S.Kumar *et al*., *Strobilanthes barbata* var *bonaccordensis* E.S.S. Kumar & Rajvikraman as they were known only from a single locality.

Flowering Plants of India

It is estimated that India harbours 18,800 species of flowering plants (Plant Discoveries 2019). Even though numerous publications dealing with regional, district and local Floras appeared, a comprehensive account on the flowering plants of India has yet to come out. As 7,402 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.

During the period, one genus and 724 species were newly added to the database and updated relevant characteristics of 5,251 species referring to states, districts and regional Floras. Collected 1,065 scientific papers, by online, related to new species, new records, rediscoveries, revisionary studies and nomenclature from 62 plant taxonomic journals. Updated the Bibliography of the work by adding 192 references and modified the red list status of 1,087 species by referring to Red list plants of India based on IUCN website.

Pharmacopalynology of Ayurvedic drugs

Pharmacopalynology, the study of pollen grains in drugs, is helpful for identifying the source of drugs, fixing the correct identity of drugs and identifying the adulterants in both raw drugs and medicinal preparations.

Bala is one of the most frequently used drugs in Ayurveda, Sidha, Unani and Folk medicines with an annual demand of about 9339 tons/year in India. The roots of *Sida alnifolia* and *Sida cordifolia* are widely accepted as *bala*. But the availability of true *bala* is much less than what is required as the source of original drug and is getting diminished in the wild due to over collection. So, *bala* available

in the market is adulterated with *Abutilon indicum, Malvastrum coromandalianum, S. rhomboidea, S. rhombifolia, S. acuta,* and *S. fryxellii, Urena lobata,* and *Triumfetta*. *Bala* is sold in market as choppings or crushed form of whole plant to increase the weight. By analyzing the pollen, it is possible to find out the identity of species in the sample if the pollen morphology of true bala and the adulterants are known. A study is initiated on *Bala* to identify the adulterants. The major objective of this study is to document the pollen morphology of *Sida* species used as the drug *Bala* and its adulterants and analyse the pollen morphology of the market samples of *bala* for its purity.

Pollen morphology of ten species, *S. alnifolia* and *S. cordifolia* used as *bala* and *S. acuta, S. fryxellii, S. rhombifolia, S. rhomboidea*, *Abutilon indicum, Malvastrum coromandelianum, Urena lobata* and *Triumfetta rhomboidea* used as adulterants of *bala* were studied using acetolysed pollen grains prepared from authentically identified species. Pollen descriptions were prepared based on light microscopic observations. Pollen analysis of seven samples of *bala* from the market was carried out. The pollen grains recovered were identified using the pollen key prepared and the reference pollen slides of *bala* and its adulterant species.

Pollen morphology of all the species observed in the present study agrees with the observations of previous workers cited in Thaniakaimoni (1972-1980) except for Cheema (2018). Two aperture types were observed, colporate and porate. *Abutilon indicum* and *T. rhomboidea* were tricolporate and the other eight species were polyporate. Two ornamentation types were observed, reticulate in *T. rhomboidea* and echinate in other nine species. A clear morphological distinction in the pollen grains is observed in size, aperture, exine ornamentation and characters of spines among the 10 species studied. Out of the ten market samples subjected to pollen analysis in this study, sample from Neumangadu belonged to *Malvastrum coromandelianum*, an adulterant species used as *bala*. The other five samples did not yield any pollen grains. Pollen analysis of more market samples are in progress. This study provides indications that pollen morphology is a cost effective method to authenticate the identity of the drug *bala* when pollen grains are recoverable from the market samples.

DIVISION OF PHYTOCHEMISTRY AND PHYTOPHARMACOLOGY

Phytochemistry and Phytopharmacology Division of JNTBGRI is a lead centre in natural product research with the objectives to carry out chemical and pharmacological studies of potential medicinal and aromatic plants and to carry out chemical research for plant improvement and utilization.

Major Areas of Research

- Search for new secondary metabolites
- Search for biologically active molecules
- Discovery of antiviral, antidiabetic molecules
- Elite accessions of medicinal (industrially important) plants
- New essential oil sources with potential applications as flavors, cosmetics, biopesticides
- Plant secondary metabolites-based nanoparticles, their biology
- New prey capture mechanisms in carnivorous plants
- Chemical ecology

Major Accomplishments

Discovery of antidiabetic molecules from a *Ficus* species

Ficus krishnae stem bark and leaves are used for diabetes treatment in traditional medicines. Stem bark of *F. krishnae* was sequentially extracted with hexane, methanol and water, and these extracts were tested for their anti-hyperglycemic activity by oral glucose tolerance test (OGTT) in overnight fasted glucose loaded normal rats. Hexane extract showed significant glucose lowering activity in OGTT, and the triterpene alcohols (cycloartenol+24-methylenecycloartanol) (CA+24-MCA) were isolated together from it by activity guided isolation and characterized by NMR and mass spectroscopy. The ratio of the chemical constituents CA and 24-MCA in (CA+24-MCA) was determined as 2.27:1.00 by chemical derivatization and gas chromatographic quantification.(CA+24-MCA) in high fat diet-streptozotocin induced type II diabetic rats showed significant antidiabetes activity at 1 mg/kg and ameliorated derailed blood glucose and other serum biochemical parameters. Cytoprotective activity of (CA+24-MCA) from glucose toxicity was evaluated in cultured RIN 5F cells by MTT assay and fluorescent microscopy. (CA+24-MCA) in *in vitro* studies showed enhanced cell viability in RIN 5F cells and

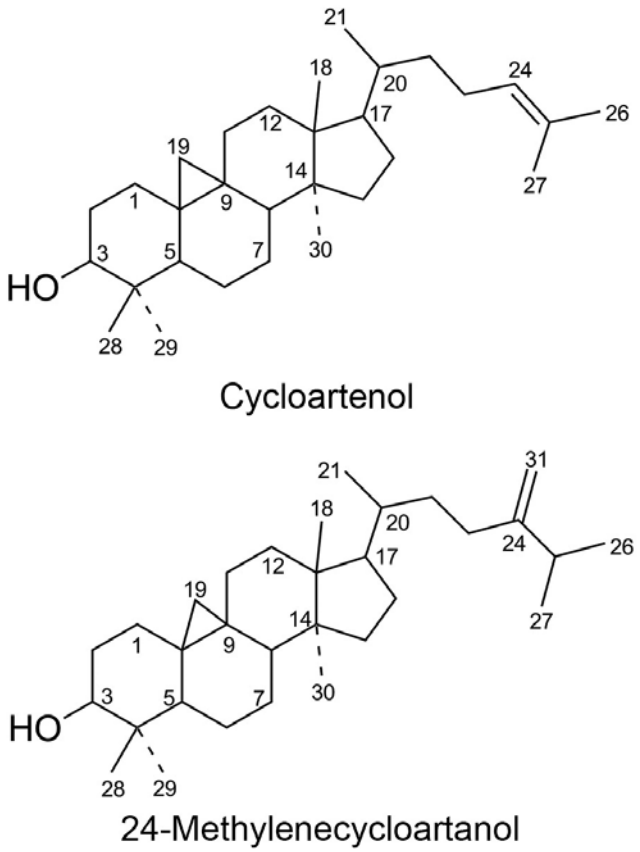


Fig.1. Cycloartenol (CA) and 24-methylene cycloartanol (24-MCA), antidiabetic molecules from *Ficuskrishnae*

significant protection of beta cells from glucose toxicity. Both in *in vivo* and *in vitro* studies (CA+24-MCA) showed enhancement in insulin release from the beta cells. In short term toxicity studies in mice (CA+24-MCA) did not show any conspicuous toxic symptoms. The combination of the phytosterols (CA+24-MCA) obtained through activity guided isolation of the stem bark of *F. krishnae* showed significant activity, and therefore is a promising candidate for new generation antidiabetes drug development.

Discovery of antiviral molecule from medicinal plants

As part of a DBT Programme Support Project, in collaboration with the Ethnomedicine and Ethnopharmacology Division, an antiviral molecule with significant activity against Chikungunya was discovered from a coded plant. One of the derivatives of the isolated active molecule showed significant activity against Dengue virus. Antiviral testing was carried out at the partner Institute, RGCB, Thiruvananthapuram. A provisional product patent has been filed on the discovery of this anti-CHIKV molecule from the coded plant chosen based on traditional/ethnomedical information.

Discovery of elite lines of high value medicinal plants, *Centella asiatica* and *Bacopa monnieri*

C. asiatica and *B. monnieri* are two high value medicinal plants. As part of a five year (2015-20) DBT Programme Support project entitled, 'Identification of elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardization of their extracts' field explorations were conducted to various agro-climatic regions of Kerala, Tamil Nadu and Karnataka, and *C. asiatica* and *B. monnieri* accessions were collected. One hundred and twenty four *C. asiatica* and 119 *B. monnieri* accessions representing 14 districts of Kerala, 7 districts of Tamil Nadu and 2 districts of Karnataka were collected, introduced and documented. Whole plant specimens of 106 *C. asiatica* and 103 *B. monnieri* accessions collected from the wild were systematically analyzed for the contents of their bioactive principles (*C. asiatica*: asiaticoside, madecassoside; *B. monnieri*: bacoside A, bacopaside I). The industrial benchmark(s) for elite lines were defined as: *C. asiatica* (whole plant) asiaticoside + madecassoside, not less than (NLT) 4% (%, w/w) or asiaticoside NLT 2.0% (%, w/w); *B. monnieri* (whole plant) bacoside A + bacopaside I, NLT 5.5% (%, w/w).

C. asiatica and *B. monnieri* samples (whole plants) were washed, cut into small pieces, oven dried at 50°C and powdered. Dried finely powdered materials (1 g each) were repeatedly extracted with methanol and used for HPTLC analysis. Asiaticoside and madecassoside in *C. asiatica* and bacoside A and bacopaside I in *B. monnieri* were quantified using standardized HPTLC-densitometry protocols. Asiaticoside and madecassoside in *C. asiatica* (106 accessions) ranged from 0.04-1.98%, w/w and 0.13-5.54%, w/w, respectively, and (asiaticoside +

madecassoside) ranged from 0.19-6.94%, w/w. Similarly, bacoside A and bacopaside I in *B. monnieri* (103 accessions) ranged from 0.36-5.68%, w/w and 0.05-1.53%, w/w, respectively, and (bacoside A + bacopaside I) ranged from 0.41-7.17%, w/w. These data show significant variations in the bioactives in wild accessions of these medicinal plants, and emphasize the significance of choosing elite lines for commercial purposes. Based on these assays, we found six 'elites lines' (each) of *C. asiatica* and *B. monnieri*.

These elite lines of *C. asiatica* and *B. monnieri* were subjected to multilocation trials at four agroclimatic locations in Kerala. We found the best biomass yield and bioactive contents for *C. asiatica* and *B. monnieri* elites at one of these four locations. Agricultural parameters (NPK, cow dung, cocopeat, water; soil parameters, pesticide contents *etc*.) of these *C. asiatica* and *B. monnieri* elite lines were standardized. The biomass yield, content of bioactives and other parameters were also evaluated.

Phytochemical investigation of *Garcinia* species

Two new caged xanthones, wightiic acid and 16-methoxy wightiic acid, along with eight known compounds, gaudichaudic acid E, isogaudichaudic acid E, ursolic acid stigmasterol, lupeol, glutinol, lupenone and stigmasteryl linoleate were isolated from *Garcinia wightii*, a species endemic to the Western Ghats.

Anti-proliferation activities of the four caged xanthones were evaluated by MTT assay on MCF-7 and SKBR-3 human breast cancer cells and A-375 human melanoma cells by MTT assay. All the tested compounds exhibited dose dependent

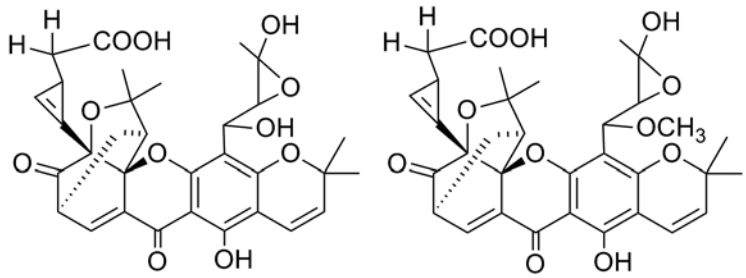


Fig. 2. Wightiic acid and 16-methoxy wightiic acidisolated from *Garciniawightii*

antiproliferative activity. Wightiic acid showed remarkable activity with IC_{50} value of 4.7 µM and 5.2 µM respectively in A-375 and MCF-7 cells. The compound isogaudichaudic acid E induced potent antiproliferation against SKBR-3 cell with an IC_{50} value of 6.1 µM.

G. gummi-gutta seeds are treated as waste products in fruit processing, but our studies revealed the seeds as rich source of fixed oils that can be used in food, cosmetic and fuel sectors.

LC-MS/MS profiling of *G. wightii* bark methanol extract

Five bioflavonoids (fukugiside, madrunoudeaside, morelloflavone, volkensiflavone, amentoflavone) and isomorellin (xanthone) were detected in the bark methanol extract of *G. wightii* through UHPLC-QqQ-MS analysis.

Chemical profiling of essential oil of *G. wightii*

Total 26 components were identified from the leaves, stem bark and fruit oils (Leaves: α-bulnesene (23.3%), δ-amorphene (11.9%) and zonarene (11.4%); Stem bark: α-Bulnesene (16.1%), zonarene (15.5%) and β-caryophyllene (14.2%) and Fruits: α-Bulnesene (22.2%), δ-amorphene (11.0%) and trans-cadina-1(6),4-diene (9.0%)).

Sustainable utilization of nanoparticles synthesised from bioactive plant secondary metabolites for bio medical applications

Asiaticoside and madecassoside are pentacyclic triterpenoid saponins in *Centella asiatica*. Bacopaside II (a triterpenoid saponin), one of the four components of bacoside A, is a major bioactive constituent in *Bacopa monnieri*. These saponins from *C. asiatica* and *B. monnieri* possess numerous biological activities. However, their therapeutic potential in a sustainable way is not well established. We prepared

and characterized asiaticoside, madecassoside and bacopaside II encapsulated nano conjugates in polymeric matrices. Subsequently, their therapeutic potentials on glioma tumour cells were evaluated. Synthesized nanoparticles were physicochemically characterized by dynamic light scattering (DLS), transmission electron microscopy (TEM), scanning electron microscopy (SEM), Zeta potential and FT-IR. Thermogravimetric analysis (DTA, DSC, TGA) were carried out to assess the degradation profiles of the molecules in the biopolymer matrix for their effective action in the physiological brain micro environment and across the BBB (Blood Brain Barrier). Asiaticoside and madecassoside-based nanoparticles showed encapsulation efficiency (EE) greater than 90% with 10% drug release in 24 hr. Their cytotoxicity and anti-proliferative effects were studied on C6 glioma cell line using MTT and Edu-assays. Annexin V staining followed by flow cytometry analysis revealed that these nanoparticles induced necrosis/apoptosis in C6 glioma cells. Lysosomal membrane integrity was also detected using Acridine orange staining method. DCFDA assay by flow cytometry showed an increase in reactive oxygen species (ROS) production in these nanoparticles-treated C6 glioma cells. Asiaticoside and madecassoside-based nanoparticles inhibited the proliferation of C6 glioma cells *via* increased intracellular ROS production. Cell cytotoxicity of bacopaside II nanoparticles on C6 glioma cells was examined by MTT assay in the range of 300-450 µg/mL (322-484 µM) and obtained 40-50% cytotoxicity.The apoptosis-inducing property was evaluated by annexin V Alexa fluor 488 staining. EdU (5-ethynyl-2'-deoxyuridine) assay on C6 glioma cells confirmed their antiproliferative potential. Cell cycle analysis by quantitation of DNA content showed the appearance of Sub-G1 peak and confirmed the occurrence of apoptosis. Our findings suggest that asiaticoside, madecassoside and bacopaside II nanoparticles are promising drug delivery carriers for the management of glioma and shed a new insight to the brain maladies.

The therapeutic potentials of asiaticoside and madecassoside encapsulated alginate chitosan nanoparticles against pilocarpine (PC) rodent seizure model were also studied. Both the nano conjugates significantly reduced the number of animals experiencing the most severe seizures, showed enhanced bioavailability and membrane integrity. Protection of tissues by asiaticoside and madecassoside nanoparticles on PC toxicity in mice was assessed by histopathology on challenged mice brain. mRNA overexpression of MAPK1, MAPK14 genes together with bcl2, caspase 3 and hspa1b for oxidative stress and inflammation was observed. Our results describing the anti-seizure profile, combined with its observed mRNA expression and biodistribution, strongly support asiaticoside and madecassoside nanoparticles as therapeutic candidates for a diverse range of epilepsies and related stress-inflammation.

Sustainable utilization of nanoparticles synthesised from essential oils for biomaterial applications

Volatile oils from fresh leaves of *Thottea siliquosa, T. ponmudiana* and *Clausena indica* were isolated by hydrodistillation and characterized by GC-FID and GC-MS. *T. siliquosa* leaf oil showed 50 components of which 49 were characterized, and the major compounds were bicyclogermacrene (29.33%) and (E)-β-ocimene (18.41%). *T. ponmudiana* leaf oil showed 41 compounds of which 35 compounds were characterized and the major compounds were α-costol (25.04%) and pregeijerene-B (14.39%). Refractive index, specific rotation and specific gravity of volatile oils were also determined. Nanoemulsions of volatile oils were synthesised by ionic gelation method using chitosan and alginate. DLS and Zeta potential of nanoemulsion indicated minimum sized particles with good stability. The oil release profile showed slow and sustained release at neutral pH for 48 hours. Biological activity of *T. siliquosa* and *T. ponmudiana* oils and their nanoemulsions were studied *in vitro* keratinocyte culture as well as on Zebra Fish regeneration and wound healing models.

Development of controlled release formulations of eco-friendly pesticides in stored pest management

The biopesticidal activity of basil, eucalyptus, orange and citronella essential oils were tested against the two stored grain pests *viz*., Pulse beetle (*Callosobruchus* sp.) and Red flour beetle (*Tribolium castaneum*).

Synthesis of plant secondary metabolites for seizure models in mice and to assess neurotoxicity

Verbacine, a polyamine isolated from the unique bamboo *Melocanna baccifera* and its effect on pilocarpine (PC) induced excitotoxicity on mouse brain was investigated. Live/dead flow cytometry analysis, when treated with verbacine/pilocarpine, confirmed the necrosis of cells protecting the hemostasis of the excitotoxicity-induced brain. This was further confirmed with fluorescent imaging techniques which showed apoptotic bodies after 24 h post-treatment. Substantial decrease in the m-RNA expression of cell signalling mediators (bcl2, hspa1b, caspase3) in verbacine/pilocarpine administered mouse brain tissues was evident in RT-PCR. Verbacine/pilocarpine treated brain tissues were also assessed for gross and histopathology. Isolated mouse brain astrocyte (*mBA*) cells treated with verbacine alone (at 100, 300 and 600 mg/kg b. wt.) showed viability above 60% in MTT assay. Overall results indicated that verbacine/pilocarpine treatment in mice markedly inhibited inflammation induced during toxicity and promoted cell apoptosis in mice brain, furthermore verbacine did not attribute any toxicity on normal cell, mBAS. Our results point out the scope of verbacine as a protective agent against inflammation.

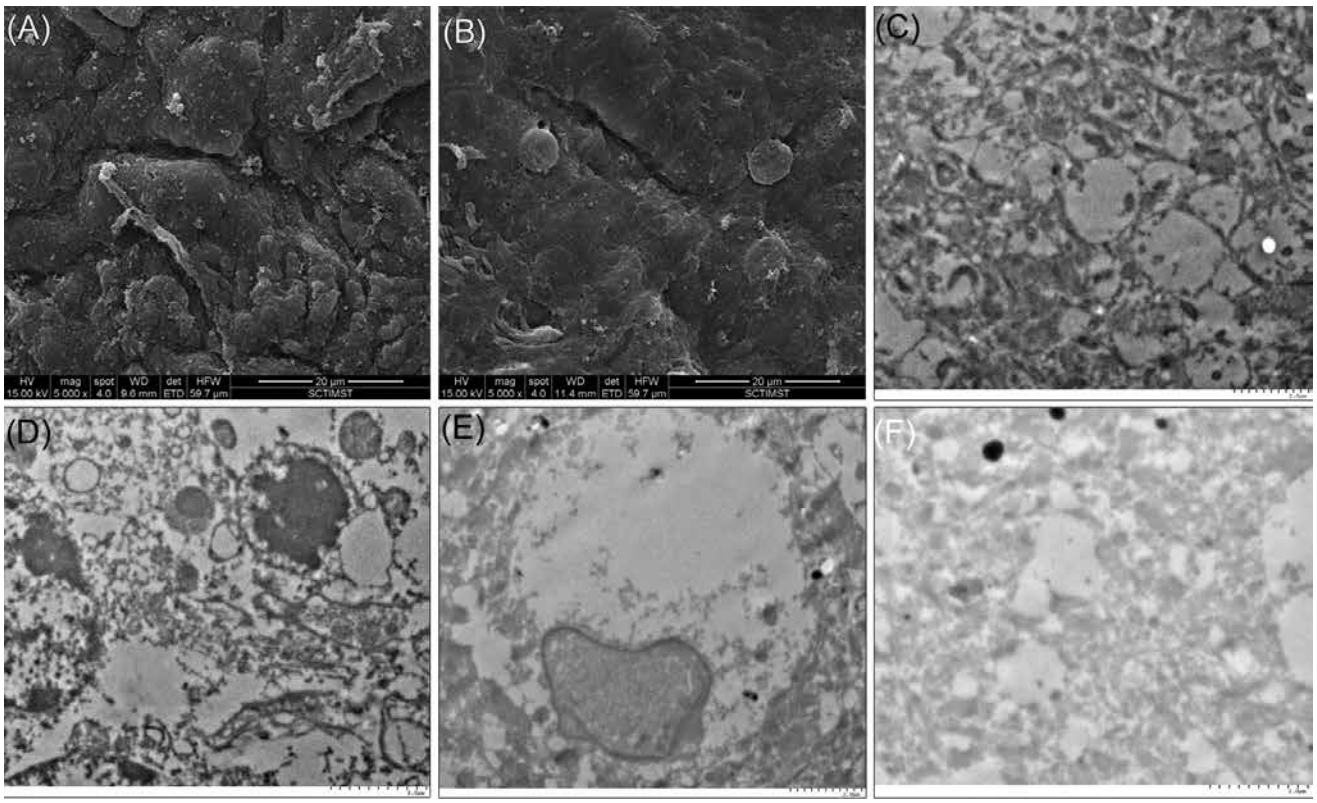


Fig. 3. Particle distribution analysis using SEM and TEM. SEM images of (A) control and (B) MACNP+PC treated mice brain. TEM images of (C) control, (D) PC treated, (E) MAD+PC treated and (F) MACNP+PC treated mice brain.

DIVISION OF PLANT SYSTEMATICS AND EVOLUTIONARY SCIENCE

Plant Systematics and Evolutionary Science Division is engaged in survey, exploration and documentation of floristic wealth development of State-of-the art of Herbarium and act as referral centre of Taxonomy, structure, dynamics and evaluation of different eco-systems in the Western Ghats; ecology, species recovery and conservation of rare and endangered species, and implementing consultation projects on biodiversity documentation, eco-tourism *etc*.

Survey, Exploration and Documentation of Floristic Wealth of Southern Western Ghats

Plant collection trips were conducted to the different forest and non-forest areas of Kerala to collect specimens, as part of the enrichment of on TBGT Herbarium South Indian Flora. A total of 56 plant collection trips were conducted, which led to the collection of 1120 specimens belonging to 263 species. The details of the work done are as follows.

New Taxa Published

1. *Ardisia agasthyamalayana* Nazarudeen, G Rajkumar & Alister (Fig.2).
2. *Ardisia ramaswamii* Nazarudeen, G Rajkumar & Prakashk. (Fig.3).
3. *Pothos boyceanus* G Rajkumar, Shaju, Nazarudeen & Prakashk. (Fig.4).
4. *Asystasia gangetica* var. *krishnae* Tandyekk., Pandur. & N Mohanan
5. *Polycarpaea rangaiahiana* Geethakum., Deepu & Viji
6. *Biophytum agasthyamalayanum* Jisha, E.S.S Kumar, Decruse & Rajendrapr.
7. *Eugenia codyensis* var. *obovata* Rijuraj, Shareef, Rajendrapr. & Shaju
8. *Rungia anamalayana* (Chandrab. & V. Chandras.) Nazarudeen, G. Rajkumar (Fig.1).

New Plant Records

1. *Lepidagathis clavata* Dalzell (Acanthaceae) - new record for Kerala.
2. *Ardisia agasthyamalayana* (Primulaceae) - new record for Tamil Nadu.
3. *Dimeria gracilis* Nees ex Steud.
4. *D. hohenackeri* subsp. *kodaguensis* Kiran Raj, Sivad.& Dileep has been recorded for the first time from the State of Kerala.

Rungia anamalayana (Chandrab. & Chandras.) Nazarudeen & G Rajkumar *comb.* & *stat.nov.* A. & B. - Habit; C. - Flowers enlarged; D. - Spike showing fertile and sterile bracts.

Ardisia agasthyamalayana Nazarudeen, G Rajkumar & Alister *sp. nov.* A. - Habit; B. - Flowering branch; B1. - Flower; C. - Branching pattern; D. - Leaf venation; E. - Auricled leaf base; F. - Seed; G. & H. - Ripe fruits; I. - C.S. of ovary.

Ardisia ramaswamii Nazarudeen, G Rajkumar & Prakashk. *sp. nov.* A. to D. - Habit, E. - Twig with flower buds; F. - Flower buds enlarged; G.- Flowering twig; H.- Flower enlarged; I. & J. - Mature and fully ripe fruits; K. - Half ripe fruits.

Pothos boyceanus G. Rajkumar, Shaju, Nazarudeen & Prakashk. *sp. nov.* A. - Habit; B. - Shoot apex showing long flagellum; C. - Inflorescence; D. - Infructescence showing long spathe.

A *Eugenia codyensis* var. *obovata* Rijuraj, Shareef, Rajendrapr. and Shaju var. nov. B *Lepidagathis clavata* Dalzell - new report for Kerala.

Taxonomic studies on the genus *Cinnamomum* of southern Western Ghats

Cinnamomum Schaeffer is one of the economically important genera belonging to the family Lauraceae, consisting of about 350 species in the world. It is one of the oldest spice in the trade and even mentioned in the ancient epics, commonly known as 'Cinnamons'. Regardless of the species, the bark, leaves and roots produce an essential oil that is used not only to scent and flavour but also for tonic, antiseptic and remedy for cold, nausea, flatulence and high blood pressure. Because of their economic potential, they are over exploited from the wild which led to the fragmentary population of many species in the Western Ghats. In India, the genus consisting of about 45 species and most of them distributed in Eastern Himalayas and the Western Ghats. In spite of its manifold economic importance, the genus has not been taxonomically well studied, and the identity of this taxon is confusing due to overlapping phenotypic characters. Hence, the genus needs a thorough systematic approach for a proper understanding of the number of species occurring in the Western Ghats.

During the period under report, four plant collection trips were conducted to different parts of southern Western Ghats and collected 47 specimens of *Cinnamomum* belongs to 5 species. The important collections are *C. wightii* Meisn., *C. litseifolium* Thw*aites*, *C. verum* J.Presl *etc*. The specimens were processed for the herbarium and descriptions were prepared along with illustrations and deposited in the herbarium. During the period, for collecting further information on the species, visited Madras Herbarium and consulted the specimens deposited there. Details of 6 *Cinnamomum* species were provided for updating in the IUCN Red List.

Taxonomic studies of the family Gentianaceae in southern Western Ghats

Gentianaceae is commonly known as 'Gentian family' with about 100 genera and 1800 species distributed throughout the world and is mainly centred in the tropical and temperate mountains. The members of the family are of great importance as medicine, dye yielding, ornamental *etc*. In India, the family is represented by 16 genera and 165 species of which seven genera and 42 species are occurring in southern Western Ghats. It is very difficult for the collection and preservation of these species due to their grassland and high altitude habitat specificity and herbaceous nature. The study has been taken up to bring out a comprehensive account on the family Gentianaceae in southern Western Ghats. In continuation of the ongoing programme, 4 plant collection trips were conducted to different parts of Kerala and collected 30 specimens of 4 species along with photographs. The specimens were processed for herbarium. The important collections include *Swertia lawii* Burkill, *Exacum petiolare* Griseb., *Swertia beddomei* C.B. Clarke *etc*. Regional herbaria were consulted for collecting further distribution information on the species found in this region.

Taxonomic studies of the Genus *Sonerila* Roxb. in Western Ghats of Kerala

The genus *Sonerila* Roxb. was proposed by Roxburgh in 1814 from the Malayan name Sonerila and belongs to the family Melastomataceae. Wight & Arn. (1834) were the first to describe a species of *Sonerila, S. zeylanica* from Sri Lanka. It is commonly seen during monsoon in spray zone of waterfalls, wet rock crevices, stream banks of mid and high lands mostly as herbs and rarely as woody subshrubs. It is characterized by its trimerous flowers, 3 celled inferior ovary and scorpiod cymes and exhibits variegated leaves and attractive flowers and are thus considered as potential ornamentals which can be suited to cultivate in mid and high lands. The genus has about 175 species mainly distributed in tropical Asia. In India, it is represented by 51 species of which 34 species inhabits in the Western Ghats including 22 endemics and 12 threatened ones.

As part of taxonomic studies of the genus *Sonerila,* plant collection trips were conducted to different areas of Western Ghats during monsoon season and collected specimens. Altogether 30

species and one variety were so far collected and processed for herbarium following standard procedures. All the specimens were critically identified with the help of local floras. Illustration and discriptions of 28 species were completed. The important collections were *S. travancorica* Bedd., *S. scapigera* Hook., *S. wynaadensis* Nayar, *S. elegans* Wight, *S. grandiflora* R. Br. ex Wight & Arn., *S. devicolamensis* Nayar, *S. barnesii* C.E.C. Fisch., *S. pulneyensis* Gamble, *S. pedunculosa* Thwaites, *S. keralensis* Deepthikum. & Pandur. *etc*.

Taxonomic revision of the genus *Ceropegia* L. in Kerala

The genus *Ceropegia* L. comprises of 244 species distributed only in tropical and sub tropical regions of the Old World (Bruyns, 2014). In India, the genus is represented by 61 taxa, of which 44 are endemic to peninsular India (Kambale & Yadav, 2019). The present study is aimed at documenting the species diversity in Kerala with a view to understand their distributional ranges, phytogeography and threat status.

An in-depth study of the genus resulted in generating much more interesting information on systematics, distribution, rarity, endemism *etc*. Thus, 12 species of *Ceropegia* were collected from various localities of Kerala, of which the following species are either rare or critically endangered: *Ceropegia omissa* H. Huber, *Ceropegia ciliata* Wight, *Ceropegia vincifolia* Hook., *Ceropegia maculata* Bedd., *Ceropegia metziana* Miq., *Ceropegia spiralis* Wight.

Climbing flora of Kerala

As part of taxonomic studies of climbing flora of Kerala, different forest types were surveyed and documented 60 species representing 20 genera and 11 families. Interesting species include *Adenia hondala* (Gaertn.) W.J. de Wilde, *Argyreia leschenaultii* Choisy, *Ceropegia spiralis* Wight, *Connarus paniculatus* Roxb., *Celastrus paniculatus* Willd., *Dalbergia malabarica* Prain, *Flagellaria indica* L., *Holostemma annularis* (Roxb.) K. Schum., *Jasminum angustifolium* (L.) Willd., *Kamettia caryophyllata* (Roxb.) Nicolson & Suresh, *Miquelia dentata* Bedd., *Myxopyrum smilacifolium* Blume, *Odontadenia macrantha* (Roem. & Schult.) Markgr., *Olax imbricata* Roxb., *Pyrenacantha volubilis* Wight, *Rubia cordifolia* L., *Rubus micropetalus* Gardner, *Stephania wightii* (Arn. ex Wight) Dunn, *Mukia maderaspatana* (L.) M. Roem., *Trichosanthes anaimalaiensis* Bedd. *etc*. The collected specimens were processed for herbarium as per the standard procedures.

Phytochemical profiling of the aromatic Cyperaceae members of south India

A total of 26 species of Cyperaceae were identified and collected in bulk from various localities of Kerala and given to the Phytochemistry division for Phytochemical Profiling.

Custard Apple Garden

The family Annonaceae represented 130 genera and 2200 species world over. The present study is aimed at documenting the species diversity in the southern Western Ghats with a view to understand their distributional ranges, phytogeography threat status *etc*. Economically Annonaceae is of considerable importance throughout the tropics of the world as a source of edible fruits. Locally called as 'Aathaka', a delicious fruit to enrich the fruit basket. In tropical region, large fleshy fruits of various species of *Annona* viz. *A. muricata* (Soursop), *A. squamosa* (Sweetsop, Custard apple, Sugar apple, Sitaphal) *A. reticulata* (Bullock's Heart, West Indian Custard apple) are juicy and edible. Soursop is cultivated widely for its large fruits which yield a sap used as beverage and in the preparation of jellies and the juice pulp is used for consert. It is also used as a potential plant for green fencing. Flowers of *Cananga odorata* is the source of world famous perfume Ylang- Ylang', while *Desmos chinensis* yield Macassar oil. The repository inhabits about 40 species collected from The Western Ghats and the stock germplasm can be utilized for further studies on cytology, anatomy, pollination biology and breeding programmes.

Retrieving Native Mango Resources of southern peninsular India

Through the programme entitled "Germplasm documentation, evaluation, *ex-situ*

conservation and popularization of local mango varieties of southern peninsular India", JNTBGRI has been successfully establishing a field gene bank and brings out an inventory of the local mango varieties of southern peninsular India. The research team has located, documented, collected and conserved 126 different local mango varieties and the 'plus trees' were marked for future breeding programmes. Produced 100000 saplings of all the varieties collected during the programme and supplied to the general public for planting. Brings out the first-hand information on the dwindling genetic stocks of mango which definitely attracts attention of researchers, plant breeders and government agencies to tap the promising native mango types for future breeding programmes. *Ex-situ* conservation of all such varieties is being carried out in a five hectare plot chosen for the programme in the garden site. The initiative will make the farmers and consumers aware of the potentials of such neglected genetic resource and will definitely kindle an all-round holistic approach for the conservation and sustainable utilization of native mango resources of southern peninsular India which certainly hold promise for improving the economic wellbeing of the people. As mango varieties are out breeding types, exactly similar characters of the mother plant are reproduced using grafting techniques which also helps in bringing plus characters such as heavy bearing and early maturing. JNTBGRI provides a significant boost to the mango conservation process at the local and regional levels and ccontinuously enriching the varietal wealth so as to make JNTBGRI as the largest conservatory of Native Mangos of Peninsular India. Voucher specimens of all the varieties are kept at TBGT (Herbarium of Tropical Botanic Garden & Research Institute, Trivandrum) for reference.

Studies and *ex-situ* conservation of Acanthaceae of southern Western Ghats

Acanthaceae with c.4000 species and 220 genera contributes nearly one per cent of the total angiosperm diversity, among which India alone contributes 475 species and 118 varieties belonging to 47 genera. The family represents nearly 200 species in the study area which belongs to nearly 35 genera. The family also holds numerous medicinal plants *Adhatoda*, *Hygrophila, Hemigraphis etc*. including rare, endangered and threatened species. It has been planned *en-massae* multiplication and reintroduction in the natural habitat attributing greater significance in the conservation and sustainable utilization of the plant wealth of the family. The study focuses on the conservation and sustainable utilization of the family Acanthaceae in the southern Western Ghats which assumes great significance in the conservation and sustainable utilization of the target plants in the region as the family consists of a large number of wild ornamental plants including *Strobilanthes, Asystasia, Barleria, Justicia, Thunbergia etc*. The study also aims in the *ex-situ* conservation of the species including endemic and threatened species in the garden as a measure to ensure their survival at least under captive conditions.

Laterite flora and endemism in North Kerala

Sediment seed banks or soil seed banks are a collection of seeds in the soil or sediment substratum - a natural mechanism offering preservation of endemic ephemerals for the ensuing season and occasionally for years to come. Such a natal system plays a key role in sustaining vegetation dynamics of many ephemeral plant communities. In a global climate change scenario, especially threatening the microhabitats of critical land forms, it has become crucial to understand the key role that the soil seed banks of the temporary pools play in maintaining ecosystem dynamics in order to develop appropriate management plan for the protection of such unique habitats. Laterite form zonal habitat complexes that harbor diverse plant communities. Among these, ephemeral flush vegetation symbolizes a prominent example of highly seasonal plant community, which is characterized by high diversity of specialist and endemic taxa contributing significantly to the regional biodiversity. In such a backdrop, a

comprehensive study was conducted concentrating on different ephemeral pools of laterite dominated ecosystems (special habitats), which has resulted in the identification and documentation of 256 native angiosperm taxa, covering 39 families. Of these, 71 species are endemics, which include 18 exclusively endemic species (to the state of Kerala), manifesting an exceptional concentration of endemic taxa, that are confined to a relatively small area. These ephemeral pools are characterized by the occurrence of several endemic species of Eriocaulaceae (14 spp.), Lythraceae (9 spp.), Lentibulariaceae (4 spp.), Menyanthaceae (4 spp.), Scrophulariaceae (6 spp.), Gentianaceae (3 spp.), Poaceae (33 ssp., 1 sub. spp., 2 var.) *etc*. in the wet as well as the dry phase and is characterized by the occurrence of highly adaptive xerophytic species of dry grasslands. The composition of seed bank provided an indication of species vulnerable to local extinction and the ones which can potentially colonize a site if the hydrology is altered. Thus, the present analysis of seed banks and of the established vegetation in the lateritic belt indicated succession stages of the community, their relationship to standing vegetation and responses to different environmental factors, at the same time as offering a useful tool for restoration and conservation of those special habitats. Further, the seed bank deposits and the emergence of vegetation exhibited notable variations, possibly due to climate change.

Vegetation legacy

Preservation of endemic ephemeral taxa has been accomplished for centuries through sediment seed banking, thus constituting a historical basis while offering a potential natural strategy for continued existence of the vegetation.

Distant disjunction

Distribution of two endemic species of the genus *Lindernia* in geographically distant areas could be attributed to the loss of intermediate link by geological causes, such as continental drift. The distribution of *Lindernia madayiparensis* Ratheesh *et al.*, an exclusive endemic species of the family Scrophulariaceae is restricted to Madayi village in Kannur district of Kerala State, while its sister species *L. acicularis* Eb. Fisch. is reported only from Savanna wetlands of Burundi in Tanzania.

Climate change connections

Climate change plays a powerful role in ecosystem changes all over the world. These changes are not only upsetting vegetation growth and distribution, but are also affecting seed bank deposits and emergence of vegetation. So far, little attention has been given to the responses of endemic-rich plant communities in isolated patches of low-nutrient soils (laterite/ferricretes).

Adaptive traits

Seed reservoirs and adaptive traits manifested by the ephemeral endemics could provide a natural strategy for the continued existence of wetland vegetation in the current scenario of climate change. The following are the adaptive traits evident in the components of ephemeral vegetation in the study area.

1) Predominance of C_4 plants

Majority of the endemic grasses of the low nutrient soils (laterite/serpentine) is formed by C_4 plants (Andropogonoid grasses). While C_4 plants are considered better adapted to climate change, the endemic C_4 grasses manifest clear, predictable responses towards climate change.

2) ***Nanism***

Shortening of habit (nanism) and life span is a characteristic feature of seasonal vegetation, as exemplified by *Eriocaulon madayiparense* Swapna *et al*. and *E. lanceolatum* Miq. ex Steud.

3) ***Convergent evolution***

Development of similar appearance, structures or behavioural pattern in unrelated species/populations as adaptation to the same environmental conditions indicates convergent evolution. Here two species or populations of the grass genus *Danthonidium* C.E. Hubb. of the tribe *Pooideae* and genus *Bhidea* Stapf of the tribe

Andropogoneae, evolve to become more similar to each other; evolution of analogous structures is always an example of convergent evolution.

4) ***Sympatric speciation***

The process through which new species evolve from single ancestral taxa while thriving in the same habitat is referred to as sympatric speciation. Such a sympatry ('together') may be the result of seed banking mechanism. The three exclusive endemic species, *Isachne veldkampii* K.G. Bhatt & Nagendran, *Isachne bhatii* P. Biju *et al*. and *Coelachne madayensis* Pradeep & Pramod of the two genera *Isachne* R.Br. and *Coelachne* R.Br. have evolved sympatrically from the tribe *Isachneae* in the ephemeral pool.

Lead Garden Programme

The programme is a major break through *ex-situ* conservation programme of invaluable plant genetic resource envisaged by MoEF & CC. The programme was launched on 5th June 2019, the World Environment Day along with the participation of students planting saplings. The conservatory is spread over 5 acre plot in the campus and beholds 142 species falling under threat and endemic category. The conservatory acts as an asylum of threat category species, ensuring their existence and survival away from their natural habitat. The huge germplasm collection acts as a base resource for further varied research programmes enabling comparative studies on phenology, pollination *etc*. During the reporting period, 9 species have been newly added viz. *Ardisia nayarii*, *Bentinckia nicobarica, Buchanania barberi, B. lanceolata, Eugenia kalamii, Garcinia pushpangadaniana, Syzygium myhendrae, S. caryophyllatum* and *S. travancoricum*. The establishment of RET species park will be globally recognised for the conservation efforts.

Herbarium Management and Development

During the reporting period 15 field drips were conducted to different areas of southern Western Ghats and collected 1600 specimens representing 380 species. Incorporation of 1701 sheets were made as per procedure. As part of maintenance, fumigation was carried out in time. Renovation and maintenance were carried out focusing on type specimens.

TBGT as on March 2020 holds 39,109 specimens belonging to 3,997species, 1,428 genera and 190 families.

Species collected for the reporting period	- 288
Specimens processed	- 1420
Genus addition to herbarium	- 4
Species additions to herbarium	- 16
Sheets renovated	- 1240

Biodiversity Assessment and Eco-restoration of Rivers of Kerala - A Case Study: Manimala River

The most disastrous flood took place in the state of Kerala during 2018 altering the biotic and abiotic componets of riverine ecosystem and its flood drainage corridor.

The study aims ecological and edaphological assessment of flood and floodplains of Manimala River with special emphasis on bio-wealth and biodiversity.

Jeevanam

A healthy environment is essential for growth and survival of living things including mankind. The conservation and protection of environment in the state of Kerala become a challenge to development due to population growth and consequent pressure on natural resources. This growing concerns on environment calls for a new direction to address the issues in a more scientific and popularized manner. By imbibing this fact and factual, KSCSTE-JNTBGRI implemented a year long Science-Popularization Programme – Jeevanam 2018- in Kalyasseri constituency, Kannur District.

Myristica swamp conservatory at KSCSTE - JNTBGRI

JNTBGRI has launched a programme for the restoration and conservation of Myristica swamps in degraded swampy area. Myristia swamps are

Keynote address by Dr. Murali Thummarakudy, Head of the UN Disaster Management Team on the topic 'Natural Calamities and Mitigation' at Payyannur College, Kannur on Jan. 5, 2019

a vanishing ecosystem that could yield precious information about evolutionary biology and climate change. Dr. Mohammed Aslam, Advisor, Dept. of Biotechnology, inaugurated the conservatory at KSCSTE - JNTBGRI.

Eco-tourism Initiative

Being a socially committed scientific institute, JNTBGRI has been conducting many society-friendly programmes such as guided tours for students and general public, plant related trainings, technology transfer, extension activities *etc*.

Myristica conservatory Inauguration at JNTBGRI by Dr. Aslam, Chairman, DBT

These biological resources with its present institutional build up provide ample scope for ecotourism initiatives. The rich bio heritage with its available knowledge base can be the basis for integrating tourism needs and conservation imperatives. This can usher in a new paradigm in the tourism initiatives of this region.

DIVISION OF ETHNOMEDICINE AND ETHNOPHARMACOLOGY

The Division of Ethnomedicine and Ethnopharmacology was established in the year 1992, with the mandate for conservation, preservation, sustainable utilization and bio-prospecting of the rich traditional knowledge related to plants used for food and medicine of our country through systematic documentation, pre-clinical studies molecular ethnopharmacological research to translate/extend the outcome of the research into action for the benefit of common people.

Areas of Research

- Ethno-medico-botanical survey, Systematic documentation of Traditional Knowledge and Preparation of Database on Ethnomedicine/Traditional Knowledge related to plants used for food and medicine.
- Comparative studies of Ethno-medico-botanical data with Ayurvedic system of medicine for enriching Ayurvedic Pharmacopoeia.
- Preclinical studies which include Pharmacological, Phytochemical, Pharmacognostical and Toxicological evaluation of plant extracts / formulations on experimental animals based on Molecular-Ethnopharmacological approach through activity guided fraction and their molecular expression studies, molecular docking studies and elucidation of mechanism of action.
- Implementation of participatory programme on "Conservation and Sustainable utilization of Medicinal and Aromatic plants in tribal/rural areas. "Herbs for All and Health for All" – Sustainable utilization of locally available medicinal and food plants resources for Primary Health Care.
- Publication of Journal "Journal of Traditional and Folk Practices" (UGC Care listed).
- Publication of books on various awareness programmes related to biodiversity conservation and sustainable utilization of medicinal/aromatic/wild edible plants.
- Strengthening research in evaluation of quality, safety and efficacy of Ayurvedic/ herbal drugs/nutracentical.
- Interinstitutional programmes for the development of potent herbal drugs for combating infectious diseases and lifestyle diseases through collaborative projects funded by DBT, DST, NMPB, WGDP, KSCSTE *etc*.

- Traditional knowledge based development of herbal drugs/formulation/nutraceuticals/ potent fractions/compound/plant based products their and standardization, patenting, technology transfer and commercialization.
- Extension activities/outreach programme related to traditional knowledge associated with biodiversity and its protection, primary health care and empowerment of rural women.

Systematic documentation and Bio prospecting of ethnomedically important medicinal plants on tribal/traditional knowledge through molecular pharmacological approach

Data entry of the collected traditional knowledge in to the software is in progress. Pharmacognostic characterization and quantitative phytochemical analysis of (ethanolic, hydroethanolic and aqueous extracts) of coded plant (RN) were completed. The hydroalcoholic extract showed significant *in vitro* antioxidant potential and *in vitro* anti-inflammatory potential. *In vitro* antioxidant assays (DPPH Radical scavenging activity, nitric oxide radical scavenging activity, super oxide radical scavenging activity, reducing power activity, ABTS radical scavenging activity, determination of Hydrogen Peroxide radical scavenging activity, Deoxy ribose degradation assay, FRAP assay, total antioxidant activity and lipid peroxidation assays of all extracts were completed. The hydroalcoholic extract showed significant *in vitro* antioxidant potential and *in vitro* anti-inflammatory potential.

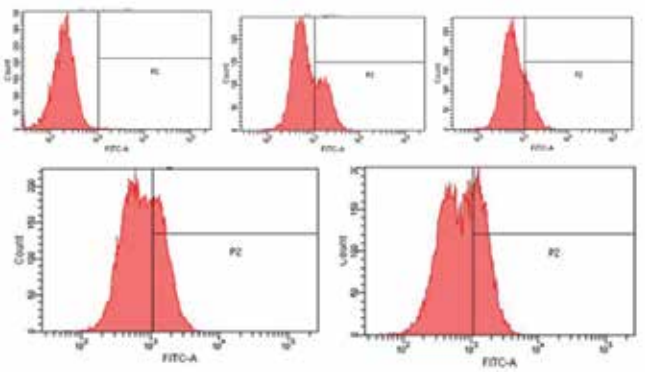
Ethnobotanical studies of coastal areas of Kadappuram and Engandiyur Gramapanchayaths of Thrissur district and tribal areas of Athirappilly, Varantharappilly, Kodassery, Puthur, Nadathara, Pananchery and Mattathur Gramapanchayaths of Thrissur district have been carried out and completed the data analysis work of the ethnobotanical information.

Interviewed 121 knowledge holders and collected 1231 Ethnobotanical information. Overall, information on 426 single drugs, 259 combination drugs, 220 information on plants used for food, 159 information on plants used as tools/artefacts for fishing and 167 miscellaneous information were collected and documented. Survey of rest of the Gramapanchayaths in Thrissur district is in progress.

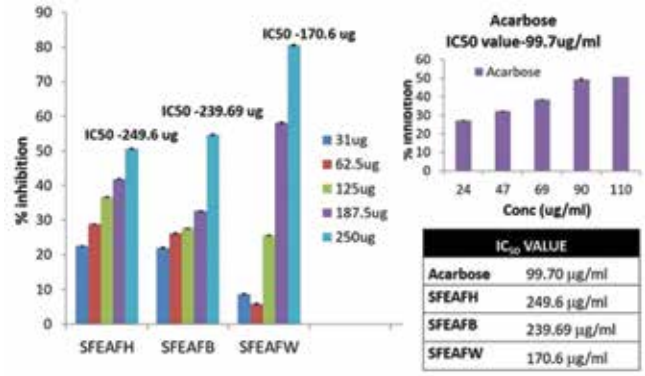
Completed data analysis work of seven Gramapanchayaths in which field trips were undertaken during the period of January to March 2019. Data entry in to the software is in progress. Field trips could not be conducted from April 2019 to March 2020 due to non-availability of funds.

Bioprospecting of two coded anti-diabetic medicinal plants based on ethnomedical leads with special reference to diabetic complications A molecular pharmacological approach.

As part of the DBT programme support project, JNTBGRI in collaboration with CSIR - NIIST based on the preliminary antidiabetic screening of selected ethnomedicinal plants for diabetic complications. Alcoholic extract (SFEA) 100% of *Salacia fruticosa* had demonstrated comparatively significant antidiabetic potential when tested using different targets of diabetes using chemical, enzyme inhibition and cell based methods. It was further fractionated with Hexane, Chloroform, Butanol and Water to yield its respective fractions, out of which the Butanol fraction (SFEAFB) showed significant anti-diabetic activity which is a major lead for the development of phytopharmaceutical compared with the other fractions of SFEA. SFEAFB was subjected to column chromatography with 100% Ethyl Acetate, to obtain five major fractions (SFEAFB2F1, SFEAFB2F2, SFEAFB2F3, SFEAFB2F4, SFEAFB2F5) and needs to be investigated for marker compounds followed by secondary *in vitro* screen and *in vivo* studies.



Glucose uptake-flow cytometry 1-5



Alpha glucosidase inhibitory potential of different fractions using acarbose as positive control

Anti-virals from medicinal plants of Western Ghats selected based on Traditional Knowledge (TK) Ethnomedical information

As part of the DBT project, JNTBGRI in collaboration with RGCB, out of 23 hydroalcoholic extracts(70%) of the plants screened based on traditional knowledge, six plants showed promising activity against CHIKV virus and from the hexane fraction (JNTBGR14H) of one coded plant (SA) based on traditional knowledge identified a single molecule (A1B1) showing significant anti-CHIKV activity. One of the subfractions from chloroform fraction SAEAWFCF4SF4 showed 100% activity in antiviral assays from which a compound SAEAWFCF4SF4C1 is also identified and is subjected to NMR analysis. The present leads can be used to identify drug for chikungunya virus with the anticipation of a potent antiviral candidate (compound/formulation) against Chikungunya. (A provisional patent has been filed.)

Systematic Documentation of Traditional Knowledge Related to Plants used for Food AYUSH & Indigenous Medicine

Ministry of AYUSH, Government of India sanctioned a project entitled 'Systematic Documentation of Traditional Knowledge related to Plants used for Food, AYUSH and Indigenous Medicine'. As part of the implementation of the deliverables in the second part of the project, conducted field level research work in the selected seven Gramapanchayaths of Thrissur and Ernakulam districts of Kerala.

Organized contact and awareness programmes/meetings with the elected local body members including President, Vice-president, Ward members, Traditional Knowledge (TK) holders/ providers including tribal healers, local traditional vaidyas, farmers *etc*., in seven Gramapanchayaths of Thrissur and Ernakulam districts namely Erumapetty, Panjal, Puthenvelikkara, Koovappady, Njarakkal, Vengola and Chottanikkara Grama Panchayaths. Inventorization, data analysis and database preparation of these 7 Gramapanchayths have been completed and data entry of 28 Gramapanchayaths of Phase I of the project is in progress. The total number of informants interviewed during the study was 187 from the two districts, Thrissur and Ernakulam. Among the informants, one person is from the tribal community and provided 17 information. The total number of information documented was 927. Among them, 406 information were about single drugs and 384 information about polyherbal formulations were grouped. Information based on food plants were 137. From the documentation. It has been observed that 210 plant species are used as single drugs, 379 plant species are used in polyherbal formulations and 147 plant species are used for food.

The information can be used as a tool for researchers, foresters, administrators, general public and policy makers for developing leads/ ideas for new projects/programmes based on pre clinical and clinical studies, product development, patent, technology transfer and benefit sharing.

Database is being prepared incorporating all these information. All the collected data is entered into database software developed with PHP as frontend and MySQL as backend platforms. Information on number of healers/knowledge holders interviewed, total information documented on medicinal/food plants, details of plants used for medicine/food, total number of information documented, total number of plant species used as single/combination drugs, total number of food plant species used *etc.*, can be generated from the database software. Passport script data of plants used for single/polyherbal formulation and food can also be generated. The field research work could not be carried out from March 2020 onwards due to Lockdown and continued restrictions.

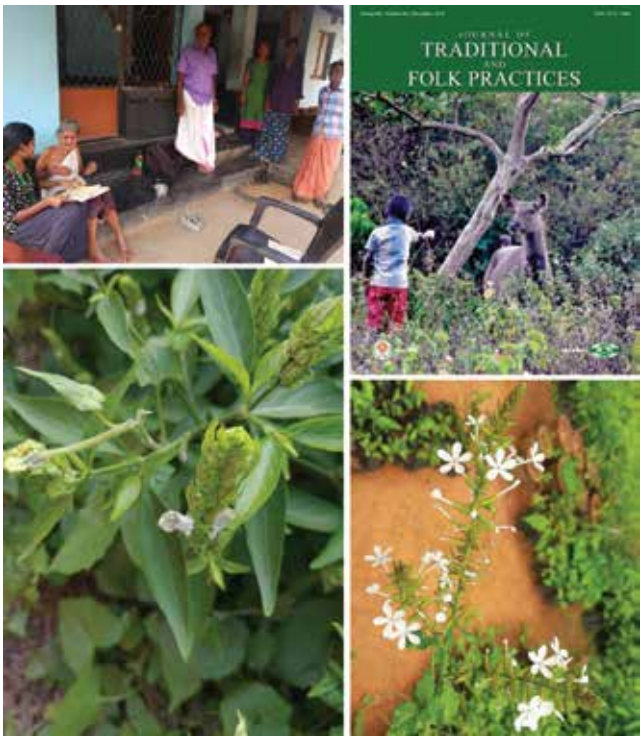
Assessment of medicinal plant resources in seven southern districts of Kerala

The major objectives of the project are resource mapping of medicinal plant resources in seven southern districts of Kerala and preparation of medicinal plants directory of 7 districts. Completed the project and submitted the Technical Report and prepared the Medicinal Plants Directory and check list of Medicinal plants. The intensive field study resulted in the generation of enormous field data on the medicinal plant wealth of seven southern districts with readily usable 7 directories and check lists as a reference tool for researchers, foresters and general public. Prepared and submitted medicinal plants directory of 7 districts in seven volumes.

Publication of Journal of Traditional and Folk Practices (JTFP) (UGC Care listed)

JTFP is a peer reviewed journal covering original research and review articles in the area of Traditional Knowledge (TK), Ethnobotany, Ethnomedicine, Ethnobiology, Ethnozoology, Ethnopharmacology, Pharmacognosy, Ethnoveterinary medicine, Phytochemical studies based on TK, drugs and nutraceuticals development based on TK, protection of TK, Intellectual Property Rights (IPR), Vrikshayurveda *etc*. So far, published six volumes. Sixteen articles were received and reviewed for the forthcoming volume (7) of JTFP.

JTFP is jointly published by Kerala State Council for Science Technology and Environment (KSCSTE) and Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), funded by Ministry of AYUSH, Government of India, under the Central Sector Scheme for upgradation to Centres of Excellence. JTFP is a UGC care listed Journal (https://ugccare.unipune.ac.in) which publishes peer reviewed original research and review articles including case studies on Traditional and Folk Practices.



1. Interview with the traditional knowledge holder, 2. Journal of Traditional and Folk Practices, 3. *Justicia* sp. - A traditional medicine for bronchial problems, 4. *Plumbago zeylanica* L. - An important ethnomedicinal plant

DIVISION OF MICROBIOLOGY

The Microbiology Division of JNTBGRI is mainly engaged in the inventory, documentation and sustainable utilization of microbial wealth of Western Ghats. Studies include systematic studies on Mushrooms, Phylloplane fungi and Lichens. The division also focuses on the characterization and bio-processing of enzymes and bioactive metabolites from actinomycetes, fungi and halophytic bacteria and explore the anti-biofilm potential of different bioactive compounds from ethnobotanical plants.

Three mushroom species new to science were discovered from Western Ghat Forests of Kerala. An interesting edible species, *Agaricus flocculosipes* R.L. Zhao, Desjardin, Guinb. & K.D. Hyde which is not so far reported from India was collected from JNTBGRI campus. Gene sequences (nrITS & LSU) from these species were deposited in Gene Bank.

The novel anti cancer compounds Urdamycin E and Urdamycin V were isolated from the Streptomyces sp. and identified that the compounds employed a novel mechanism of mTOR inhibition which was more efficient than clinically known natural mTOR inhibitor Rapamycin. The study offers future potential for developing novel targeted chemotherapeutics.

Fukugiside isolated from *Garcinia travancorica* exhibited concentration-dependent biofilm inhibition against multiple M serotypes of *Streptococcus pyogenes*.

Survey and Inventory of Foliicolous Fungi and Lichens of Western Ghats and Enrichment of culture collection/Herbarium

Various forest localities of Kerala were surveyed for collection of Foliicolous Fungi and Lichens. Forests of Kollam, Ernakulam, Idukki and Wayanad districts were surveyed and collected 325 foliicolous fungi and 180 lichen samples. The samples collected were systematically analysed and processed and added to the existing fungal and Lerbarium lichen herbarium. The fungal holds presently holds 7080 samples while lichen herbarium with 3755 samples. One new foliicolous fungus viz., *Asterina gordoniae* A. Sabeena, H. Biju, S.S. Dhanusha & S. Shiburaj is described during the period.

Mushroom Herbarium

A well maintained mushroom herbarium is established in JNTBGRI. The specimens after recording macromorphological features were dried in a hot air over at 40-50^{0}C overnight. The dried specimens were removed from the oven and kept in paper packets of suitable size with the accession number. These were stored in cold room at 10-15^{0}C and 30-40% relative humidity to avoid damage by insects, mites, moulds etc.

1. *Agaricus flocculosipes*, 2. *Crepidotus globisporus*, 3. *Hohenbuehelia odorata*

All collections made so far are preserved in perfect condition in the herbarium. The mushroom herbarium presently holds 18,016 individual collections (as on 31-03-2020). Some of the collections also preserved wet in Kew spirit.

EXTENSION AND TRAINING UNIT

Extension and Training unit (CARC) prepared and marketed Five Herbal Products during this period:

Herbal tea

Herbal mix

Herbal hair oil

Herbal mosquito repellent agarbathies

Herbal soap

During 2019 – 2020, this unit has traded up to 1230 nos. of Herbal soap, 1052 nos. of Herbal Mix, 1053 nos. of Agarbathies, 490 nos. of Box soap, 100 nos. of Hair oil and 140 nos. of Herbal tea. In this way this unit itself has pooled Rs.1,06,510/-(Rupees one lakh six thousand five hundred and ten) to the Institute's account.

Participated in the India International Science Festival 2019–A Mega Science, Technology & Industry Expo held at Science City, Kolkata from 04/11/2019 to 08/11/2019. In this expo, we have displayed our five herbal products.

Herbal Products Development, JNTBGRI

LIBRARY AND INFORMATION CENTRE (LIC)

The Library and Information Centre (LIC) of JNTBGRI is adhered to the principle of '*Correct and comprehensive information to users on accurate time in precise format*'. The library team is dedicated to carry out the best efforts to reach this objective. Our endeavor is to provide relevant and latest information to all scientific communities of JNTBGRI as well as our various esteemed visitors from other institutions in their respective area of research. The JNTBGRI library resources consist of Books, Journals, Periodicals, CDs, Reports, Reprints, Theses, Maps, Atlases *etc*. As an integral part of the organization, our primary aim is to support the research objectives of JNTBGRI and its dissemination.

Maintenance and Development

The Library and Information Centre ought to keep up with ongoing and latest developments in multi-disciplinary platforms of various scientific subjects of the organization. In order to fulfill this objective, library used to follow demand-driven acquisition of books and periodicals. During the reporting period JNTBGRI library has been subscribed 40 International Journals (print and online) and 49 Indian Journals. Digital collection includes Scientific Papers, Classic Books in Botany, Digital compact discs, Annual Reports and Index to journal articles database. During the reporting period, 20 books were added to the existing collection. The JNTBGRI Library and Information Centre is also providing Selective dissemination of Information, Current awareness services, Indexing services, Bibliographic services, Conference alert services, Press clippings services, Reprographic services, Internet browsing services, Reference services, Document Delivery services, Literature Search Services *etc*. as part of its routine maintenance. The principle of 'Green Protocol' is following by the Library and Information Centre to the level best to minimize the usage of paper.

Library Statistics

Books	-	60581
Indian Journals	-	49
International Journals (Print & Online)	-	40
Back Volumes	-	3546
Annual Reports	-	920
Reprints	-	1124
Technical Reports	-	130
Thesis	-	134
Digital CDs	-	34

Creation of mailing list

In collaboration with the JNTBGRI Computer System Administrator, a mailing list has been created for all official communications of library.

e- News paper clipping service (e-NCS)

JNTBGRI library has been providing newspaper clipping service to all users, since its inception, aiming to reach out the important news to almost all people of JNTBGRI. As a pilot project, currently news digest related to the field of Science and Technology, Environment and Ecology, Agriculture and Education were disbursed through E-mail service on daily basis. The Library and Information Centre currently started efforts aiming to create a database on these news digests for future purpose also.

e-Current Awareness Service (e-CAS)

All new additions into the library are intimated to the users in weekly basis. Moreover, 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 new information with regard to library data collections in respective platforms of research. JNTBGRI Library has automated online services via campus LAN to enable member's access from their own computers. Five monitors are provided for Internet browsing at main library hall, especially for visitors from outside.

Reference Management Services (RMS)

Reference Management is being one of the most vital; while tedious efforts in scientific research, JNTBGRI library is well supporting to the users for error free referencing in their research publications. This is ensured through the authentication of open-source RMS software and other online tools. JSTOR (Biological Sciences Collection including Global Plants Initiative) and BioOne are remarkable online subscriptions of the JNBGRI Library and Information Centre.

Library and Information Centre, JNTBGRI

Memberships

JNTBGRI Library and Information Centre has IAPT and BGCI memberships

Sharing the Research Output

Library and Information Centre is enthusiastic to deal out the research outputs of the organization. The Library and Information Centre has taken various initiatives to market JNTBGRI publications through online service. The sales of these JNTBGRI publications are currently handled by the Library Division. As part of this, copies of JNTBGRI publications are demonstrated at Library hall as well as providing to JNTBGRI pavilions arranged at various exhibitions sites throughout the state. To ease the procedure of publication, library holds the responsibility of obtaining ISBN number onbehalf of the institution. The library operations are automated by using the proprietary software LIBSOFT. It is an integrated multi-user Library Management System that supports all in-house operations of the Library. It has different modules like Acquisition, Catalogue, Circulation and Serial Control. Circulation control is bar code enabled.

JNTBGRI Publications for sale

1. Bamboos at TBGRI by K C Koshy
2. Flowering Plants of Kerala-A Handbook by TS Nayar *et al*.
3. Introduction to Orchids by Abraham & Valsala
4. Glimpses of Indian Ethnopharmacology by Pushpangadan P *et al*.
5. *Meliolales* of India by Hosagoudar VB
6. Fungi of Kerala by Hosagoudar VB
7. Plant wonders; Evolution and genetics by Sathish Kumar, C
8. Students Handbook on Medicinal and Food Plants by Rajasekharan S *et al*.
9. Flowering plants of the Western Ghats, India Vol.1 & 2 by TS Nayar *et al*.
10. Bees Herbal Garden - A garden in the forest @ JNTBGRI by Mathew PJ *et. al*.
11. Live Plants of JNTBGRI by Mohanan, N and Mathew PJ (eds.)
12. Ferns and *Lycophytes* of Kerala: Taxonomy, Cytology and Evolution by Ninan CA and Mathew PM
13. Scientific Contributions of JNTBGRI (Bibliography) by Mathew Dan *et. al*.

Happy to Help Always

'Cheerful to Help Forever' is the motto of JNTBGRI Library and Information Centre. We are happy to hear grievances, suggestions and feedbacks of our esteemed users. The Library and Information Centre believes in empowering our users which is vital for the growth of our division.

EXHIBITIONS

1. India International Science Festival, Chennai 2019; 2. Medicinal Plant Cultivation Training Programme 2019, 3. Science Congress 2019 Venue: Fathim Matha National College, Kollam

PRODUCTS/ PLANTS FOR SALE

Plants	Rate (₹)
Pandanus furcatus	20
Pandanus fascicularis (Odorifer)	20
Pandanus tectorius (Thornless)	50
Pandanus variegated white stripped	50
Pandanus variegated yellow stripped	50
Pandanus variegated yellow dwarf	25
Banana Nendran (ordinary)	20
Banana Nendran (large)	25
Hibiscus diff. varieties	20
Ixora diff. varieties	20
Lotus marantha (*Calathea loosnerii*)	50
Bougainvillea diff. varieties	50
Aglaonema diff. varieties	150
Tinospora crispa	50
Tradescantia	10
Vitex negundo	20
Withania somnifera	20
Plumbago rosea	20
Mint Thulsi	20
Piper nigrum	20
Asparagus	50

DBT PROGRAMME SUPPORT PROJECTS

In May 2015, DBT sanctioned 6.71 crores for eight research programmes under Programme Support. These research programmes involve the participation of collaborating institutes like Indian Institute of Science, Bangalore; Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram; Indian Institute of Science Education and Research, Thiruvananthapuram; Indian Institute of Science Education and Research, Pune; National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram; Alagappa University, Karaikudi; University of Agricultural Sciences, Bangalore and Industries like Natural Remedies, Bangalore. These eight research programmes were aimed at (i) Search for plant-based antiviral and antidiabetic drugs, (ii) Screening for elite accessions of high value medicinal plants for industrial applications, (iii) Plant-pollinator interaction studies, (iv) Ecology and conservation of fresh water swamp ecosystems of the Western Ghats, (v) Comparative biogeography of plants of the Western Ghats, (vi) Metabolic pathway analysis of L-DOPA synthesis in *Mucuna pruriens* and (vii) Discovery of commercially important microbial enzymes. The first Phase of Programme Support was satisfactorily completed in May 2018. A proposal for an Extension Phase (2 years) was submitted and after a review, DBT sanctioned 353.80 Lakhs in the Extension Phase (2018-2020). The Extension Phase projects are now in progress.

MoU AND COLLABORATIONS

1. A MoU was made with Kerala State Biodiversity Board (KSBB) for undertaking and implementing a Project titled *"Monitoring of Biodiversity Status – Preparation of Red Data Book and assessment of threatened species of Kerala (Flora including aquatic species)"*.
2. Based on the significant outcome of the Antiviral programme of DBT programme support a proposal "Antiviral (Covid-19) activity evaluation of a coded medicinal plant, chosen based on promising leads" was submitted to ICMR as an attempt to address the corona virus pandemic in the world .The proposal was approved by ICMR and a tripartite MOU was generated between ICMR-NIV, KSCSTE – JNTBGRI and Department of Health & Family Welfare, Government of Kerala.
3. MoU with the University of Kerala for Digitizing Herbarium of Department of Botany.
4. MoU with Directorate of Sports and Youth Affairs for landscaping and gardening at G.V. Raja Sports Hub, Thiruvananthapuram.
5. Eco-tourism Initiatives with Kerala Tourism Department.
6. Initiated a collaborative venture with CIMR - AIMS, New Delhi for a project on Arogyapacha. A MOU was executed between KSCSTE- JNTBGRI and CIMR AIMS, New Delhi for the implementation of a project on Multiple Sclerosis treatment with *Trichopus zeylanicus*.

HYBRID REGISTERED

A primary hybrid Acampostylis tropgarden fragrance (*Acampe praemorsa x Rhyncostylis retusa*) registered with RHS, London. The hybrid is intermediate between the parents and exhibited sweet fragrance. It flowers more than twice in a year and overcome seasonal dominance of parents with regard to flowering.

Ph.D AWARDED

1. Aneeshkumar AL, 2019. Ethnopharmacological evaluation of leaves of *Neurocalyx calycinus* (R.Br. ex Benn.) Roxb., an ethnomedicinal plant with special reference to anti-inflammation and wound healing. University of Kerala, Thiruvananthapuram.
2. Anjana RG Nair, 2019. *In vitro* studies on triploid banana *Musa paradisiaca* cv. Poovan (AAB). Manonmaniam Sundarnar University, Thirunelveli.
3. Bijeesh C, 2019. Taxonomic studies of poisonous mushrooms of Kerala. University of Kerala, Thiruvananthapuram.
4. Binoy Kurian, 2019. Development of molecular markers for sex determination and analysis of genetic diversity and phylogeny in *Calamus* L. (Arecaceae). University of Kerala, Thiruvananthapuram.
5. Deepa V, 2019. Bioprospecting of selected medicinal plants for viper anti-venom drug. University of Kerala, Thiruvananthapuram.
6. Deepthi Kumary KP, 2019. Reproductive biology of two red listed medicinal plants of the Western Ghats. Manonmaniam Sundarnar University, Thirunelveli.
7. Neethu Viswanath, 2019. Hepatoprotective and antioxidant properties of *Schumanianthus virgatus*" (Roxb.) Rolf. University of Kerala, Thiruvananthapuram.
8. Nimmi Haridas, 2019. Bio-prospecting of selected medicinal plants for anti-tuberculosis drugs. University of Kerala, Thiruvananthapuram.
9. Nisheeda Basheer A, 2019. *In vitro* mutagenesis in *Plectranthus vettiveroides* (Jacob) N.P. Singh & B.D. Sharma. University of Kerala, Thiruvananthapuram.
10. Shamnad J, 2019. Assessment of intraspecific variability in *Clitoria ternatea* L. (Fabaceae) from Kerala, India. University of Kerala, Thiruvananthapuram.
11. Thomson Davis, 2019. Biosystematic studies on the *Piper* species of Kerala forests with special reference to intraspecific variants of the wild *Piper nigrum* L. University of Kannur.
12. Anju Sudhakaran, 2020. *Ex situ* conservation and Chemical characterization of *Etlingera fenzlii* (Kurz) Skronick. & M. Sabu (Zingiberaceae) - The honey bee repellent endemic plant species of the Andaman Nicobar Islands. University of Kerala, Thiruvananthapuram.
13. Krishnakumar NM, 2020. Immunomodulatory and antioxidant potential of *Morinda umbellata* L., a traditionally important medicinal liana. University of Kerala, Thiruvananthapuram.
14. Manoj Kumar A, 2020. Studies on systematics, diversity and ecology of the genus *Crepidotus* (Basidiomycetes, Agaricales) of Kerala. University of Kerala, Thiruvananthapuram.
15. Shailaja Kumary S, 2020. Floristic studies on the sacred groves of Kollam district, Kerala. Manonmaniam Sundarnar University, Thirunelveli.

HONOURS/ AWARDS/ RECOGNITIONS

1. Sakthipriya M received Newton Bhaba Fellowship (2019) for attachment programme at James Hutton Institute, Scotland during October 2019 – January 2020.
2. Suja SR IASR Excellence Award 2019, International Academy of Science and Research, Kolkata, West Bengal.
3. Suja SR received Distinguished Women in Health and Medical Science Award of 4th Venus International Women Award-VIWA 2019, Venus International Foundation, Chennai, India on Annual Womens Meet on 2nd March 2019.
4. Radhakrishnan K received Dr. B.N. Mehrothra Medal of Society of Ethnobotanists for significant contributions in ethnobotany, medicinal plant conservation and extension services, 6th March 2020, Jiwaji Univerity, Gwalior.
5. Suja SR received Scientist of the Year award 2019, International Foundation for Environment & Ecology, Kolkota, West Bengal.
6. Vinodkumar TG Nair has been elected as the Senate Member, University of Kerala, Thiruvananthapuram.
7. Sreekumar S has been appointed as Member in the AYUSH Department – Human and Animal Ethical Committee (GO (Ms) N0.35/2019/AYUSH, dtd.02-08-2019.
8. Lekshmi N Menon has won Prof. Dr A Hisham Endowment Award in phytochemistry – 2020. Kerala Academy of Sciences, Thiruvananthapuram.
9. Amitha Prasad, Suja SR and R Prakashkumar has obtained the best oral presentation Award in the International Multidisciplinary Research Conference on Biodiversity, Climate Change, Environment and Life Sciences held at SBES College of Science, Aurangabad, Maharashtra, 29th and 30th July 2019.
10. Aswathy V Nair , Suja SR and R Prakashkumar has bagged the best poster Award in the International Multidisciplinary Research Conference on Biodiversity, Climate Change, Environment and Life Sciences held at SBES College of Science, Aurangabad, Maharashtra, 29th and 30th July2019.
11. Aswathy V Nair, Suja S R and R Prakashkumar has received prestigeous Carl Linnaeus Award 2019 for best research paper from Ph.D thesis in 11th NABS National Conference on Climate Changes Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development, Pondicherry University, Pondicherry, 25th to 27th September 2019.

12. Ragesh R Nair, Suja SR Shine VJ and S Rajasekharan bagged the Best Research Paper Award on Effective amelioration of liver fibrosis by *Tetracera akara* (Burm. f.) Merr., an ethnomedicinal plant via. Inibiting NFkB signalling pathway and HSC activation-a novel therapeutic approach, 31st Kerala Science Congress,2019.

13. Reshma VR Nair, Aji Kumaran Nair S, Anil John Johnson and Sabulal Baby won the first Prize for Oral Presentation on Phytochemical and biological activity studies of *Humboldtia unijuga* Bedd., International Conferenceon Advances in Material Science and Chemistry (ICAMSC-2020), Amrita Vishwa Vidyapeetham, 10-12 August 2020, Kollam, Kerala, India.

FINAL TECHNICAL REPORTS

1. 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. Kerala State Planning Board, Western Ghats Development Cell (Principal Investigator Dr.S.R. Suja, 2019).
2. Project on Publication of "Journal of Traditional and Folk Practices" (Principal Investigator Dr. Vinod Kumar T.G. Nair, 2019).
3. Assessment of Medicinal Plant Resources of Kerala - seven southern districts and District wise directory of Medicinal Plants in 7 volumes. State Medicinal Plants Board (Principal Investigators Dr. G. Rajkumar, 2019).

RESEARCH PUBLICATIONS

- Ajikumaran Nair Sadasivan Nair, Reshma Vijayakumari Raveendran Nair, Aroma Prasanna Rajendran Nair, Akhila Sasikumar Nair, Sabu Thyagarajan, Anil John Johnson and Sabulal Baby, 2020. Antidiabetes constituents, cycloartenol and 24-methylenecycloartanol from *Ficus krishnae*. *PloS One* 2020 15: e0235221. https://doi.org/10.1371/journal.pone.0235221
- Ajin Sreekumar VP, Prasannakumari AA, Sumitha V, Pramod B and Scaria S, 2020. Phytoremediation potential of *Lagenandra ovata* L. and *Nelumbo nucifera* Gaertn. associated with Aruvikkara Reservoir, Kerala - South India *Eco. Env. & Cons*. **26(1)**: 206-212.
- Aneeshkumar AL, Suja SR, Vilash V, Ragesh R Nair, Siril EA and Rajasekharan S, 2018. Sub chronic oral toxicity assessment (90 days) of ethanolic fraction of leaves of *Neurocalyx calycinus* (R. Br. ex Benn.) Rob. in Rodents: A lesser known ethno medicinal plant from the Cholanaickan tribal community, India. *Interdisciplinary Toxicology* **11(3)**: 221-235.
- Anju Sudhakaran and Radha RK, 2019. Evaluation of hepatoprotective effect of essential oil of *Etlingera fenzlii* (Kurz) Skronick. & M. Sabu (Zingiberaceae) - the honey bee repellent endemic plant species of Andaman Nicobar Islands. *Indian Journal of Physiology and Pharmacology* **63(4)**: 309-316.
- Anto M, Angala M and Anilkumar C, 2018. Stochastic stress and survivability of *Garcinia imberti* Bourd. (Cluciaceae), an endangered tree of the Western Ghats. *Journal of Traditional and Folk Practices* **6(1)**: 103-108.
- Anto M, Angala M, Jothish PS and Anilkumar C, 2019. Conservation of *Garcinia imberti* Bourd. through seeds. Plant Science Today **6(2)**: 243-251. https://doi.org/10.14719/pst.2019. 6.2.518.
- Anto M, Angala M, Jothish PS, Padmesh P and Anilkumar C, 2020. Population genetic structure of *Garcinia imberti* Bourd., an endangered endemic tree of southern Western Ghats, India. *Plant Science Today* **7(3)**: 424–431. https://doi.org/10.14719/pst.2020.7.3.734.
- Anto M, Jothish PS, M Angala and C Anilkumar, 2018. Fruit predation and adaptive strategies of *Garcinia imberti*, an endangered species of southern Western Ghats. *Current Science* **115(12)**: 2315-2321.
- Anto, M and Anilkumar C, 2018. Impact of fast and slow desiccation on *Garcinia imberti* seed and seedling vigour. *Plant Science Today* **5(3)**: 95-105. https://dx.doi.org/10.14719/pst.2018.5.3.398.

- Anu S and Mathew Dan, 2019. Macroscopic and microscopic foliar features in ten species of *Curcuma* L. (Zingiberaceae) from southern India. *International Journal of Research and Analytical Reviews* **6(1)**: 841-847.
- Anu S and Mathew Dan, 2020. Characterization of starch from selected *Curcuma* species of Kerala through microscopy and CHNS analysis. *Indian Forester* **146(4)**: 347-352.
- Anu S, Mathew Dan, Ramesh Kumar KB and Suja SR, 2020. Wild relative of turmeric, *Curcuma zanthorrhiza* Roxb. - A source of edible starch. *Indian Journal of Traditional Knowledge* **19(3)**: 519-524.
- Anu S, Navas M and Mathew Dan, 2020. Morpho-anatomical characterization of the rhizomes of ten species of *Curcuma* L. (Zingiberaceae) from South India. *Journal of Spices and Aromatic Crops* **29(1)**: 38-47.
- Anuja GI, Shine VJ and Suja SR, 2018. *In vitro* anti-inflammatory and free radical scavenging properties of *Oldenlandia auricularia*. *Toxicological and Environmental Chemistry* **100(5-7)**: 573-582.
- Anuja GI, Shine VJ, Latha PG and Suja SR, 2018. Protective effect of Ethyl Acetate Fraction of *Drynaria quercifolia* against CCl4 induced rat Liver Fibrosis via Nrf2/ ARE and NFκBsignalling pathway. *Journal of Ethnopharmacology* **216(24)**: 79-88.
- Anurag Dhyani, 2020. Plants of the world. *Science Reporter* **57(3)**: 18-22.
- Anurag Dhyani, Baskin CC, Nautiyal BP and Nautiyal MC, 2019. Overcoming root dormancy and identifying the storage behaviour of *Lilium polyphyllum* seeds. *Botany* **97(2)**: 161-166.
- Anurag Dhyani, Nautiyal BP and Nautiyal MC, 2018. Distribution, status and Conservation of *Lilium polyphyllum* (Liliaceae), a Critically Endangered medicinal plant from India. *Plant Biosystems* **152(4)**: 608-611.
- Anurag Dhyani, Semwal KC, Gebrekidan Y, Yonas M, Yadav VK and Chaturvedi P, 2019. Ethnobotanical knowledge and socioeconomic potential of honey wine in the Horn of Africa. *Indian Journal of Traditional Knowledge* **18(2)**: 299-303.
- Anusha S, Riyas CT, Reshma M Das, Soorya S, Namitha LH, Vishnu B, Arun R Pillai, Anilkumar C and Kamarudeenkunju M, 2019. A preliminary pharmacological evaluation of methanolic extract of *Gymnacranthera canarica* (King) Warb seeds: A threatened species of Myristica swamp ecosystem of southern Western Ghats, Kerala. *Journal of Pharmacognosy and Phytochemistry* **8(3)**: 1957-1961.
- Anusha SN and Suja SR, 2019. Anti inflammatory, antioxidant and phytochemical properties of *Clematis gouriyana* Roxb. *ex* DC. Leaves. *International Journal of Research and Analytical Reviews* **6(1)**: 31-37.
- Bijeesh C, Manoj Kumar A, Pradeep CK and Vrinda KB, 2019. A new species of *Hohenbuehelia* (Pleurotaceae) from India. *Phytotaxa* **420(1)**: 56-64.
- Bijeesh C, Manoj Kumar A, Pradeep CK, 2020. A new species of *Resupinatus* (Agaricomycetes) with merulioid hymenophore from India. *Phytotaxa* **464(2)**: 167–174.
- Bijeesh C, Pradeep CK and Vrinda KB, 2020. *Inocybe* poisoning from Kerala - a case study. *J. Mycopathol. Res.* **57(4)**: 255-258.
- Bindu S and Anilkumar C, 2019. Seed desiccation tolerance of south Indian *Rauvolfia* species. *International Journal of Science Environment and Technology* **8(2):** 264-277.
- Chitra CR, Bindu S, Shareef SM, Hima VS and Anilkumar C, 2019. An account of fruit and seed morphology, germination and seedling growth of four species of *Salacia* L. *Journal of Non Timber Forest Products* **26(3)**: 145-150.

- Deepa V, Sreekumar S and CK Biju, 2018. In silico Validation of Anti-Russell's Viper Venom Activity in *Phyllanthus emblica* L. and *Tamarindus indica* L. *International Journal of Pharmaceutical Sciences and Drug Research* (IJPSDR) **10(4)**: 217-226.
- Deepa V, Sreekumar S, Evans DA, Biju CK, Asha Nair S, Kavitha KJ and Ketakee M, 2019. Validation of the Efficacy of Viper Venom Neutralizing Activity in *Curcuma aromatica* through *In Vitro* and *In Silico* Methods. *Journal of Applied Science and Computations* (JASC) **6(4)**: 2463-2476.
- Deepthi Kumary KP Sreekala AK, Chitra CR, Joemon Jacob and Usha VS, 2018. Seed germination and Dormancy breaking in *Embelia ribes* seeds. *Journal of Non-Timber Forest Products* **25(2)**: 77-80.
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- Dhanya J and Sreekala AK, 2018. A characteristic analysis on the reproductive trends favoured by anther and pollen grains of *Xanthophyllum arnottianum* Wight (Polygalaceae). *Advances in Pollen Spore Research* **36**: 19-26.
- Dhruvan Tandyekkal, Pandurangan AG and Mohanan N, 2019. *Asystasia gangetica* var. *krishnae* (Acanthaceae): A new variety from Kerala, India. *Rheedea* **29(2)**: 174-177.
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12. Shefin B, Sreekumar S and Biju CK, 2018. Bioprospecng through *in silico* method and idntification of lead molecules with anti-hepatitis B activity in *Azadirachta indica* Juss. In: Krishnan PN, Jayakumar S, Bijukumar A, Peethambaran CK, Ajithkumar KG, Eswaran EK, Sureshkumar C and Priya PK (Eds). Perspective on Biodiversity of India - Volume III. CISSA, Thiruvananthapuram. pp. 393-396. ISBN: 978-81-937930-0-8.
13. Sreekumar S and Biju CK, 2019. Relevance of Bioinformatics in plant taxonomy. In Pandurangan AG and Krishnan PN (Eds.). Plant Taxonomy and Biodiversity. Centre for Innovation in Science and Social Action, Thiruvananthapuram. pp. 200-203.
14. Suja SR, Aneeshkumar AL, Prakashkumar R, 2020. Bioprospecting of Ethno-Medicinal Plants for Wound Healing. In: Sukumaran ST, Sugathan S and Abdulhameed S (Eds.) Plant Metabolites: Methods, Applications and Prospects. Springer Nature, Singapore. pp. 553-581. https://doi.org/10.1007/978-981-15-5136-9_22.
15. Suja SR, Ragesh RN, Rajasekharan S and Prakashkumar R, 2019. Relevance of ethnopharmacological research related to threatened medicinal plants associated with traditional knowledge. In: Rajasekharan PE & Wani S (Eds). Conservation and Utilization of Threatened Medicinal Plants. Springer, Cham. pp. 463-487. https://doi.org/10.1007/978-3-030-39793-7_16.

IUCN Red List Assessments

1. Anurag Dhyani, Joshi G, and Arunkumar AN, 2020. *Madhuca insignis*. The IUCN Red List of Threatened Species 2020. Et33655A117415121.
2. Anurag Dhyani and Barstow M, 2020. *Vateria indica*. The IUCN Red List of Threatened Species 2020. Et33029A115935674.
3. Barstow M and Anurag Dhyani, 2020. *Ochreinauclea missionis*. The IUCN Red List of Threatened Species 2020. E.t33650A115932864.

STUDENT'S PROGRAMME

1. Amal, 2019. Preliminary studies on *in vitro* auxin induced root culture in *Bacopa monnieri* (L.) Wettst., a medicinal plant of the Western Ghats. Indira Gandhi College of Arts and Science, Kothamangalam, Ernakulam; Mahatma Gandhi University, Kottayam.
2. Amritha R, 2019. Validation of anti-cobra venom activity of *Albizia amara* (Roxb.) B. Bovin through in silico methods. University of Kerala, Thiruvananthapuram.
3. Anjana A J, 2020. Preliminary studies of *in vitro* propagation of *Bacopa monnieri*. National College; University of Kerala, Thiruvananthapuram.
4. Anjana H Nath, 2019. Training in Molecular Biology and Biotechnology. MSc Integrated Course on Biotechnology, Department of Plant Biotechnology, College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapauram.
5. Aswathy U, 2019. *In silico* validation of anti-cobra venom activity in *Alysicarpus monilifer* (L.) DC. University of Kerala, Thiruvananthapuram.
6. Geethalakshmi C, 2019. Genetic Diversity Analysis of *Trichopus zeylanicus* Gaertn. Accessions Using SCoT Markers. M.Sc. Botany, Bharathidasan University, Tiruchirappalli, Tamil Nadu.
7. Gokul CS, 2020. Preliminary studies of *in vitro* propagation of *Rubia cordifolia* L. National College; University of Kerala, Thiruvananthapuram.

8. Gopakumar, 2019. Preliminary studies on *in vitro* auxin induced root culture in *Rauvolfia beddomei,* a medicinal plant of the Western Ghats. Indira Gandhi College of Arts and Science, Kothamangalam, Ernakulam. Mahatma Gandhi University, Kottayam.

9. Gouthaman PP, 2019. De novo transcriptome assembly and downstream analysis using custom Galaxy server. MSc Bioinformatics, Union Christian College, Aluwa, Mahatma Gandhi University, Kottayam.

10. Jagannath RS, 2019. Callus culture of *Gynochthodes umbellata* (L.) Razafim. & B. Bremer for *in vitro* production of anthraquinones. M.Sc. Biotechnology, Department of Bioscience, Union Christian College, Aluva. Mahatma Gandhi University, Kottayam.

11. Lamiya A, 2019. Effect of different explant and plant growth regulators on callus culture of *Gynochthodes umbellata* (L.) Razafim. & B. Bremer for *in vitro* production of anthraquinones. M.Sc. Botany, Iqbal College, Peringamala. University of Kerala, Thiruvananthapuram.

12. Nandu Mohan, 2019. Evaluation of anti-tuberculosis activity in selected vegetable crops: Garlic, Onion and Drumstick. College of Agricultute, Vellayani, Thiruvananthapuram.

13. Niveda Johnson, 2019. *In silico* validation of anti-cobra venom activity in *Acalypha hispida* Burm.f. University of Kerala, Thiruvananthapuram.

14. Reshma R Nair, 2019. Evaluation of anti-cobra venom activity in *Alangium salvlifolium* (L.f.) Wangerin. University of Kerala, Thiruvananthapuram.

15. Sajna Salim, 2019. Effect of carbon source and pH on callus culture of *Gynochthodes umbellata* (L.) Razafim. & B. Bremer for *in vitro* production of anthraquinones. M.Sc. Botany, Iqbal College, Peringamala. University of Kerala, Thiruvananthapuram.

16. Sreedevi, 2019. Preliminary studies on *in vitro* regeneration and auxin induced root culture in *Rubia cordifolia* L., an endangered medicinal plant of the Western Ghats. Mar Thoma College of Science and Technology, Ayur, Kollam. University of Kerala, Thiruvananthapuram.

17. Sruthi B Kumar, 2019. Preliminary studies on *in vitro* regeneration and auxin induced root culture in *Decalepis arayalpathra* (J. Joseph & V. Chandras.) Venter, an endangered medicinal plant of the Western Ghats. Mar Thoma College of Science and Technology, Ayur, Kollam. University of Kerala, Thiruvananthapuram.

18. Vel Kumar, 2019. Genetic Diversity Analysis of *Centella asiatica* (L) Urb. Accessions Using SCoT Markers. M.Sc. Botany, Bharathidasan University, Tiruchirappalli, Tamil Nadu.

19. Vijeesh R. 2019. Genetic diversity analysis of *Cullenia exarillata* from Wayanad, Kerala using ISSR markers. B.Sc. Botany and Biotechnology, Emmanuel College, Vazhichal. University of Kerala, Thiruvananthapuram.

OUTREACH PROGRAMMES

1. Dr Abdul Jabbar M gave an awareness class on Principles and Practices of FGB and plant systematics to 40 UG students of Botany from National college of Arts & Science, Trichy, Tamil Nadu.
2. Dr Gopakumar B conducted an awareness class on 'Importance of Bamboo Cultivation' to farmers and Panchayath members at Kuttiady, Kozhikode on 21.9.2019 and to Beat Forest Officer Trainees (2 batches -100 nos.) at the Forest School, Arippa, on 10.10.2019 along with a demonstration class at the Bambusetum of JNTBGRI on 25.10.2019.
3. Dr Gopakumar B delivered a talk on Bamboos for the students of Women's College, Thiruvananthapuram and students of G.H.S.S. Koduvazhannur along with the Beat Forest Officer Trainees, Kerala Forests and Wildlife Department.
4. Dr Jothish PS conducted a science quiz programmes to five batches of school students from 13th to 19th May 2019 as part of the 'SASTHRA SAMEEKSHA 2019', sponsored by KSCSTE.
5. Dr Mathew Dan attended a Meeting at Peringamala Grama Panchayath as part of 'Grameenam Project' on 4.12.2019.
6. Dr Mathew Dan attended a two day workshop on preparation of Hand Book for '*Pachathuruthu'* for Haritha Kerala Mission, Govt. of Kerala during 10 & 11 April 2019 at Thiruvananthapuram.
7. Dr Mathew Dan served as a resource person in the awareness meeting on 'Grihachaithanyam' programme organized by SMPB at the Conference Hall of Collectorate, Pathanamthitta on 2.7.2019.
8. Dr Saleem M conducted an awareness class on 'Floriculture and landscaping' to the 8th batch of KFDC Field officers at Forest Training Center, Arippa on 6.8.2019.
9. Dr Saleem M offered a demonstration class on orchids to the Forest Trainees from Kerala Forests and Wildlife Department along with two individual orchid growers from Ernakulam.
10. Dr Vinodkumar TG Nair and Dr Navas M jointly conducted classes and practical demonstrations related to value addition of medicinal plants during the training programme organized by Kerala State Biodiversity Board at 5 gramapanchayaths of Wayanad district in connection with implementation of NMPB project.

11. Dr Vinodkumar TG Nair, Dr Navas M and the project staff conducted a 'Contact and Awareness Programme' with the Presidents, elected local body members, secretaries and other officials of 7 Gramapanchayaths of Thrissur district on January and February 2020, as part of the implementation of the AYUSH project entitled 'Systematic Documentation of Traditional Knowledge (TK) related to Plants used for Food, AYUSH and Indigenous Medicine'.

12. Dr Vinodkumar TG Nair, Dr Navas M and MS Sreedevi S Kumar together conducted a Quiz Competition for school students on 'Medicinal Plants' in connection with the Children's Day celebration at JNTBGRI, on 14th November 2019.

13. Mr Subeesh AS, JPF, delivered a 'Bamboo Awareness Class' to the student participants of Sasthra Sameeksha Programme on 13 to 17 May 2019 to BFO trainees from Arippa Forest Training School on 27.1.2020 and NSS UPS Mukhathala, Kollam on 31.1.2020.

INVITED TALKS

1. Dr Jothish PS delivered a talk entitled '*Distinguished Indian Scientists and their Contributions to the World*' to school students during the National Science Day Celebrations held at JNTBGRI, on February 2019.
2. Dr Mathew Dan and Sri M Sreekumaran delivered a talk on 'Micropropagation aspects for propagation and conservation' and Dr Abdul Jabbar explained on 'Field Gene Banking' for PG Ayurveda Students, Govt. Ayurveda College, Thiruvananthapuram, on 30.7.2019.
3. Dr Mathew Dan delivered a talk on 'Characterisation of Medicinal and Aromatic Plants – a Pharmacognostical Approach' for PG Ayurveda Students, Govt. Ayurveda College, Thiruvananthapuram and UG Students from Pankajakasthuri Ayurveda Medical College and P. G. Centre, Kattakada, on 11.06.2019.
4. Dr Mathew Dan delivered a talk on 'Conservation- What, Why' for Students as part of the Mathrubhumi Seed Programme, on 6.12.2019.
5. Dr Mathew Dan delivered a talk on 'Importance of Medicinal plants and its Conservation aspects' for Forest Range Officers, Arippa Forest Office, on 20.12.2019.
6. Dr Mathew Dan served as a resource person in 'Sasthrasameeksha' programme for school students, funded by KSCSTE, and delivered a talk on 'Biodiversity conservation and management' on 14.5.2019.
7. Dr Navas M delivered an invited talk entitled 'Ethnobotany of Kani Tribes Leading to Access and Benefit Sharing' in connection with the Webinar on E.K. Janaki Ammal on 5th November 2020, organised by Centre for Intangible Heritage Studies, Sree Sankaracharya University, Kaladi.
8. Dr Pradeep CK delivered a lecture on the topic 'The Fascinating World of Fungi' in connection with 'Sasthra-Sameeksha-2019', organized by JNTBGRI on 15th May 2019.
9. Dr Pradeep CK served as resource person and delivered a lead lecture on the topic 'Western Ghats of Kerala - A Hotspot for Mushrooms', in the International Conference on 'Algae, Fungi and Plants: Systematics to Applications (AFPSA)', organized by CAS, Department of Botany, University of Calcutta in collaboration with Botanical Survey of India, 24-25th January, 2020.
10. Dr Radha RK delivered an invited lecture for the 3rd International Conference on Biodiversity (7th November 2020) Singapore (Webinar of global expert meetings) in the topic: *Ex situ* Conservation of threatened medicinal plants of the Western Ghats, India.
11. Dr Radhakrishnan K delivered Dr BN Mehrortra medal lecture on his contributions to ethnobotany in the National Seminar on 'Moden Trends in Ethnobotanical

Research' held at Jiwaji University, Gwalior from 5-6 March 2020.

12. Dr Sabu KK conducted an invited talk on 'Promise of RNA Biology: Novel insights from plant systems' during the Refresher Course in Life Sciences at UGC Human Resource Development Centre, University of Kerala on 12.7.2019.
13. Dr Sabu KK delivered an invited talk on 'Functional genomics for bioprospecting of plant genetic resources' during 2nd National Conference on Current Trends in Biological Sciences at St. Xavier's College, Palayamkottai on 7 February 2020.
14. Dr Sabu KK made an invited talk on 'Genetic analysis of plants through RNomics – Fundamentals and Applications' during the 5-day Bioinformatics workshop organized by the School of Life Sciences, Mahatma Gandhi University, Kottayam on 28.11.2019.
15. Dr Santhosh Kumar ES delivered an invited lecture cum hand-on-training on 'Taxonomy of Angiosperms and Medicinal Botany' in connection with the national workshop on Taxonomy of Medicinal Plants at Department of Botany, University of Kerala on 14th February 2020.
16. Dr Santhosh Kumar ES delivered an invited lecture entitled 'Introduction to Dicotyledons' at the National level training programme on Taxonomy and Biodiversity', organized by the Centre for Innovation in Science and Social Action (CISSA), Trivandrum on 8th July 2019.
17. Dr Santhosh Kumar ES delivered an invited lecture on 'Identification and Nomenclature of flowering plants' to the BSc students of S.N. College, Chempazhanthy, Thiruvananthapuram on 11th February 2020.
18. Dr Santhosh Kumar ES delivered an invited lecture on 'Identification and Nomenclature of Flowering Plants' to the M.Sc. students of St. Mary's College, Thrissur on 30th January 2020.
19. Dr Santhosh Kumar ES delivered an invited lecture on 'Untapped plant resources of God's own country' to the B.Sc. students of All Saints College, Thiruvananthapuram, on 5th February 2020.
20. Dr Sreekumar S delivered an invited lecture on the topic 'Herbarium digitization – An overview' in the seminar on 'Herbarium Techniques', organized jointly by KSCSTE-JNTBGRI and Department of Botany, University of Kerala on 30th April 2019.
21. Dr Sreekumar S delivered an invited lecture on the topic 'Relevance of Bioinformatics in plant taxonomy' in the National level Training Programme on Plant Taxonomy and Biodiversity organized by Centre for Innovation in Science and Social Action (CISSA), Thiruvananthapuram during 8th to 12th July 2019.
22. Dr Sreekumar S delivered an invited lecture on world environment day on 6th June, 2019 at Marian College of Architecture and Planning Thiruvananthapuram.
23. Dr Suja SR and Dr Vinodkumar TG Nair have delivered invited talks in the Brainstorming session on 'Setting up of National network on documentation of LHTs and Ethnomedical Practices & formulation of a National strategy for their validation and IPR protection' on 14th August 2019, organized by CCRAS at New Delhi.
24. Dr Vinodkumar TG Nair delivered a talk on 'Importance of Trans-Himalayan Medicinal plants in AYUSH Systems, in the National Seminar on 'Importance of Trans-Himalayan Medicinal plants in AYUSH' at National Research Institute for Sowa Rigpa, Leh-Ladakh, from 17th to 19th October 2019.
25. Dr Vinodkumar TG Nair delivered a talk on the 'Nutritional and Health Benefits of Indian Herbs', in the Annual National Conference on 9th November 2019 held at Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram Kerala.

MEDIA INTERACTION

1. Dr Vinodkumar TG Nair has made a talk through All India Radio (Akasavani Prabhatabheri) on the topic "Hot summer food and drinks" broadcasted on 8.4.2019.
2. Dr Vinodkumar TG Nair has made a talk on "*Junk foodinu pakaram naadan bhakshana sheelam*" in All India Radio on 7.11. 2019.
3. Dr Vinodkumar T G Nair has attended as a discussant on Corona Virus outbreak in Janam TV channel on 19.3.2020.
4. Dr Mathew Dan has done a talk on 'Kuvalam' (*Aegle marmelos*) which was broadcasted through Akashvani, Thiruvananthapuram Station on 11.7.2019.

SEMINAR/SYMPOSIA/ POSTER PRESENTATIONS

1. Ajmi Shahul, Suja SR, Prakashkumar R, 2019. Comparative phytochemical and *In-vitro* antioxidant studies of ethanolic, hydroethanolic and aquoues root extract of *Rhinacanthus nasutus* (L.) Kuntze. International Conference on Impact of Innovations in Science and Technology for Societal Development (IISTSD-2019), held at Kongunadu Arts and Science College, Coimbatore from 19th to 21st September.
2. Ajmi Shahul, Suja SR, Vinodkumar TG Nair, 2019. Ethnobotanical aspects of *Rhinacanthus nasutus* (L.) Kuntze, an ethnomedicinal plant used as traditional medicine and evaluation of its antioxidant potential. 29thIAAT Annual Conference and National Symposium on Modern trends in Biosystematics of Angiosperms. JNTBGRI from 11th to 13th November.
3. Akhil R and Sreekala A K, 2018. Effect of Nectar Robbing on Pollination in *Humboldtia brunonis*- A Paleoendemic ant Plant of the Indian subcontinent in the International Biodiversity Congress (IBC 2018) held at Forest Research Institute, Dehradun on 4-6 October 2018.
4. Akhil R and Sreekala AK, 2019. Rarity and Conservtion status of *Humboldtia brunonis* (Fabaceae) of the Western Ghats. Poster presented in International Seminar on Life Sciences for Sustainable Development: Issues and Challenges, held at Department of Botany, University College, Thiruvananthapuram during October 3-5.
5. Amitha Prasad, Suja SR and Prakashkumar R, 2019. A glance in to the therapeutic potential of plants in sacred grooves based on traditional knowledge/ ethnomedicinal information - An urgent need of its conservation. Proceedings of the 11th NAB National Conference on Climate Changes Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development. Pondicherry University, Pondicherry from 25th to 27th September.
6. Amitha Prasad, Suja SR and Prakashkumar R, 2019. *In vitro* anti-oxidant and *in vivo* anti-inflammatory studies on hydro alcoholic leaf extract of *Sauropus androgynus* (L.) Merr. International Multidisciplinary Research Conference on Biodiversity, Climate Change, Environment and Life Sciences held at SBES College of Science, Aurangabad, Maharashtra on 29th and 30th July (Best Paper award).
7. Angala M, Anto M and Anilkumar C, 2019. Comparative phenology of *Trichopus zeylanicus* Gaertn., sub sp. t*ravancoricus* (Bedd.) Burkill ex K. Narayanan: An

ethnomedicinal plant. 31st Kerala Science Congress, pp. 193.

8. Angala M, Anto M, Navas M and Anilkumar C, 2018. 'Studies on morpho - variants and phenological observations of *Trichopus zeylanicus* Gaertn. subsp. *travancoricus* (Bedd.) Burkill ex KNarayanan - a high value Ethnomedicine from Western Ghats, India' in the abstracts of Indo-Mexican Seminar On Emerging Trends in Bio-Resource Utilization & Enzyme Technology on 13th April at JNTBGRI, p. 48.

9. Anjusha and Radha RK, 2020. Callus culture – an alternative method for the production of anthraquinone from *Gynochthodes umbellata* (L.) Razafim. & B. Bremer, Webinar Series, JNTBGRI.

10. Anoosh Varghese and Sreekala A K, 2019. Approaches on conservation of an endemic tree species *Syzygium occidentale* (Bourd.) Gandhi with special reference to seed biology on National Seminar - Advances and Applications in Plant Science organised by Department of Botany, University of Kerala on 6-8 February 2019.

11. Anto M, Angala M, Jothish PS and Anilkumar C, 2018. 'Survival constraints and Adaptabilities of *Garcinia imberti* Bourd. (Clusiaceae)'. Indo-Mexican Seminar on Emerging Trends in Bio-Resource Utilization & Enzyme Technology on 13th April at JNTBGRI, Thiruvananthapuram, pp-29-30.

12. Anu S and Mathew Dan, 2019. Nutritional significance of starch isolated from the rhizomes of *Curcuma* L. (Zingiberaceae) species from south India. International Conference on 'Advances in Food and Industrial Biotechnology' MACFAST, Thiruvalla, November 24-26.

13. Anu S, 2019. Search for edible starch from selected *Curcuma* species (Zingiberaceae) in south India. Prof. A. Abraham memorial award contest, JNTBGRI, May 24.

14. Anu S, Navas M and Mathew Dan, 2019. Morphological,Anatomical and Histochemical characterization of rhizomes from ten species of *Curcuma* L. (Zingiberaceae) in southern India. 29th IAAT Annual Conference and National Symposium on 'Modern trends in Biosystematics of Angiosperms held at JNTBGRI, from 11th to 13th November.

15. Anusha S, Reshma M Das, Soorya S, Vishnu B, Namitha LH, Arun R Pillai, Anilkumar C and Kamarudeenkunju M, 2019. Physiological and biochemical charecterization of the seeds of *Gymnacranthera canarica* (King) Warb. during different development periods. Proceedings of International Conference PROVECTUS PLANTAE' 19. Theme 6: Plant Physiology Biochemistry and Bioinformatics. International Conference on exploring the scope of plant genetic resource. On 22-24th May at Department of Botany, University of Kerala, Kariavattom, Thiruvanathapuram, pp. 467-472. ISBN No. 978-81-940888-0-6.

16. Aswathy Anand A and Radha RK, 2019. GC/MS analysis of essential oils of *Etlinger afenzlii*. International Conference on Energy and Environment during 12-14 December, at TKM College of Arts and Science, Kollam.

17. Aswathy Anand A and Radha RK, 2019. Repellent activity of essential oils derived from *Etlingera fenzlii*, an endemic honey bee repellent plant of the Andaman Nicobar Islands against *Aedes aegypti*. 29th IAAT Annual Conference and National Symposium on Modern Trends in Biosystematics of Angiosperms during 11-13 November, at JNTBGRI.

18. Aswathy V Nair, Suja SR and Prakashkumar R, 2019. Comparative Phytochemical Screening and Antioxidant Activity of *Phyllocephalum rangacharii* (Gamble) Narayana, an Ethnomedicinal Plant. International Multidisciplinary Research Conference on Biodiversity, Climate Change, Environment

and Life Sciences held at SBES College of Science, Aurangabad, Maharashtra on 29th and 30th July (Best Poster award).

19. Aswathy V Nair, Suja SR and Prakashkumar R, 2019. Evidence based scientific validation of the antioxidant potential of *Phyllocephalum rangacharii* (Gamble) Narayana, an Ethnomedicinal Plant and its quantitative phytochemical evaluation. Proceedings of the 11th NAB National Conference on Climate Changes Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development, Pondicherry University, from 25th to 27th September (Carl Linnaeus award for best paper in Ph. D thesis).
20. Biju H, 2019. Lichens in the Shendurney Wildlife Sanctuary, Kollam, Kerala. *Proc. Intl. Conference on Microbial Interventions for the Welfare of Human beings*, Mannargudi, Tamil Nadu.
21. Dhanusha SS, Sabeena A, Shiburaj S and Biju H, 2019. Molecular identification of foliicolous fungi infecting tropical forest plants - A study on Western Ghats region of Thiruvananthapuram district. *Proc. Intl. Conference on Microbial Interventions for the Welfare of Human beings*, Mannargudi, Tamil Nadu.
22. Dhanya J and Sreekala A K, 2018. Morpho functional traits and pollination mechanisms of the flowers of *Xanthophyllum arnottianum* Wight (Polygalaceae) in the 3rd National conference, FESA held at Periyar University on 7-9 February 2018.
23. Dhanya J and Sreekala AK, 2018. Some underutilized leafy vegetables as potential bioresource for vitamin-A harvesting, in the Indo-Mexican seminar held at JNTBGRI, 13th April 2018.
24. Dhanya J and Sreekala AK, 2018. The Flower Syndromes and Micromorphological Adaptations in *Xanthophyllum arnottianum* to compete against a diverse pollination network in the International Biodiversity Congress (IBC 2018) held at Forest Research Institute, Dehradun, 4-6 October 2018.
25. Divya N Murali, 2020. Some lesser known wild relatives of spices from Agasthyamalai Biosphere Reserve (ABR) and the importance of their conservation. International Conference on Environmental, Agricultural, Chemical and Biological Sciences (ICEACBS 2020), Puducherry, January 24-25.
26. Divya N Murali, Sam P Mathew and Gangaprasad A, 2019. Wild relatives of Malabar tamarind from Agasthyamalai Biosphere Reserve and conservation of selected species through seed germination. 29th IAAT Annual conference, JNTBGRI, Nov. 11-13.
27. Divya S Pillai and Sreekala AK, 2019. Conservation of an endangered tree species *Syzygium myhendrae* (Bedd. ex Brandis) Gamble through studies on reproductive phenology in International Seminar on Life Sciences for Sustainable Development: Issues and Challenges held at Department of Botany, University College, Thiruvananthapuram during October 3-5.
28. Divya S Pillai and Sreekala AK, 2018. Preliminary Assessment on Seed Viability and Germination of an Endemic and Endangered tree species of the Western Ghats: *Syzygium Myhendrae* (Bedd. ex Brandis) Gamble in the International Biodiversity Congress (IBC 2018) held at Forest Research Institute, Dehradun on 4-6 October 2018.
29. Govind MG, 2019. Foliar chemical characters in *Myristica* species of Western Ghats – a chemotaxonomic approach. 'Prof. A. Abraham Memorial Award Contest', JNTBGRI, Thiruvananthapuram. May 24 (First Prize).
30. Govind MG, Radhakrishanan KV, Mathew Dan and Ramesh Kumar KB, 2019.

Chemosystematics of Myristicaceae members in the Western Ghats. National Symposium and 29th IAAT Conference, JNTBGRI, Thiruvananthapuram, Nov. 11-13.

31. Jisha D, William Decruz S, Rajendra Prasad M and Santhosh Kumar ES, 2018. On the identity and nomenclature of todda – vaddi' in Rheede's Hortus Malabaricus'. National seminar, Plant diversity conservation and biopropsecting in Western Ghats at Dept. of Botany, Govt. College Kasargod on 26-27 September 2018.

32. Lakshmi S and William Decruse S, 2019. Comparative study of Symbiotic and asymbiotic seed germination of *Papilionanthe subulata*, an orchid endemic to India and Sri Lanka. National Symposium and 29th IAAT Conference, JNTBGRI, November 11-13.

33. Lakshmi S and William Decruse S, 2019. Isolation and characterization of endophytic fungi from *Vanda thwaitesii* and evaluation of its symbiotic activity in two vandaceous orchids. International Conference on Energy and Environment, 12-14 December, TKM College of Arts and Science, Kollam.

34. Lekshmi S Nath, Suja SR, Pradeep NS and Prakashkumar R, 2019. Phytochemical evaluation and comparative free radical scavenging activity of *Lagenandra ovata* (L.) Thwaites an ethnomedicinal plant with special emphasis on biodiversity conservation. International Conference on Energy and Environment at TKM College of Arts and Science, Kollam from 12th to 14th December.

35. Lekshmi S Nath, Suja SR, Pradeep NS and Prakashkumar R, 2019. Evaluation of pharmacognostical and antioxidant activity of *Lagenandra ovata* (L.) Thwaites an ethnomedicinal plant. International Conference on Impact of Innovations in Science and Technology for Societal Development (IISTSD) held at Kongunadu Arts and Science College, Coimbatore from 19th to 21st September.

36. Mathew PJ, Mathew Dan, Anilkumar C and Muraleedharan Unnithan C, 2019. Conservation of *Coscinium fenestratum* (Maramanjal) - significance of a field observation, and a success story of JNTBGRI. Proceedings of International Conference PROVECTUS PLANTAE' 19. Theme 1: Cytogenetics Plant Systematics and Conservation of Diversity. International Conference on exploring the scope of plant genetic resource on 22-24th May at Department of Botany, University of Kerala, Kariavattom, Thiruvanathapuram, pp. 60-61. ISBN No. 978-81-940888-0-6.

37. Meera TS, Suja SR and Vinodkumar TG Nair, 2019. Role of phyto-engineered nanocomposites as an Anti-inflammatory Biomedical tool in therapeutic applications. International Conference on Energy and Environment at TKM College of Arts and Science, Kollam from 12th to 14th December.

38. Murugesan K and Mathew Dan, 2019. Variability of floral morphology in *Pellionia heyneana* Wedd. (Urticaceae) from the Western Ghats. 29th IAAT Conference held at JNTBGRI, Nov. 11-13.

39. Murugesan K, 2019. Intraspecific variability studies in *Pellionia heyneana* Wedd. (Urticaceae) from southern Western Ghats – special emphasis on foliar characters. Prof. A. Abraham Memorial Award Contest, Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Palode, May 24 (Third Prize).

40. Navas M, Rajkumar G, Radhakrishnan K, Shaju T, Latha PG and Rajasekharan S, 2019. Diversity of Medicinal plants in Thiruvananthapuram District, Kerala: An overview. Proceedings of the 11th NAB National Conference on

Climate Changes Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development, Pondicherry University, from 25th to 27th September 2019. Book of Abstracts. pp.103-104.

41. Nusrin S and Sreekala AK, 2019. Conservation of *Elaeocarpus munronii,* an endemic and threatened tree species of the Western Ghats through studies in reproductive biology. Poster, 29th IAAT Conference held at JNTBGRI, Palode, Thiruvananthapuram, 11-13 November.

42. Ragesh R Nair, Suja SR and Rajasekharan S, 2018. Anti fibrotic effect of *Tetracera akara* (Burm.f.) Merr. via modulation of NF-kB signaling pathway in CCl_4 - induced liver fibrosis. National seminar on interdisciplinary approaches in materials and biological research. Mahatma Gandhi College, Thiruvananthapuram.

43 Ragesh R Nair, Suja SR and Rajasekharan S, 2018. Phytochemical investigation and Anti-hepatotoxic effect of *Tetracera akara* (Burm.f.) Merr. against alcohol induced liver damage in Wistar rats. International Seminar on Phytochemistry organized by JNTBGRI, Palode (Best Paper award).

44. Ragesh R Nair, Suja SR, Shine VJ and Rajasekharan S, 2019. Effective amelioration of Liver fibrosis by *Tetracera akara* (Burm.f.) Merr., an ethnomedicinal plant via inhibiting NF – Kb signalling pathway and HSC activation - a novel therapeutic approach at the 31st Kerala Science Congress. KSCSTE & JNTBGRI at Fathima Matha National College, Kollam, 2nd - 3rd February 2019 (Best Paper award).

45. Rajkumar G, Stephan J and Mohanan N, 2018. Phytogeography, endemism and Conservation of the genus *Thottea* Rottb. in Western Ghats. In: Proceedings of the 28th Annual Conference of IAAT and International Symposium on Conservation of Angiosperm Diversity: Hidden Treasure of Today and Tomorrow. Organized by Dept. of Botany, Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, October 29-31.

46. Rajkumar G, Stephan J, Mohanan N and Sabu K K, 2019. Phytogeography, Endemism and Conservation of the genus *Humboldtia* Vahl in Western Ghats. In: 11th National Conference of National Association of Biological Sciences (NABS) on Climate Change Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development Pondicherry University, Pondicheery. September 25-27.

47. Raseena NR, Suhara Beevy S and Sabu KK, 2019. Regulation of PISTILLATA gene in the petal and anther development in *Coccinia grandis* (L.) Voigt (Cucurbitaceae). Proceedings of International Seminar on Life Sciences for Sustainable Development: Issues and Challenges, held at University College, Thiruvananthapuram, from 3-5 October.

48. Reshma M Das, Kamarudeenkunju M, Anilkumar C, Anusha S, Vishnu B, Soorya S, Arun R Pillai and Namitha LH, 2019. Biochemical profiling during seed development and maturation in *Bentinckia condapanna* Berry ex Roxb., a rare endemic palm species of southern Western Ghats. Proceedings of International Conference PROVECTUS PLANTAE' 19. Theme 6: Plant Physiology Biochemistry and Bioinformatics. International Conference on exploring the scope of plant genetic resource. On 22-24th May at Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram. pp. 524-527. ISBN No. 978-81-940888-0-6.

49. Rijuraj MP, Shaju T, Rajendraprasad M and Prakashkumar R, 2019. Sediment Seed banks: A Natural Mechanism Offering Preservation of Endemic Plants in Transient Vegetation of Lateritic Zones of Northern Kerala. 29th IAAT Conference held at JNTBGRI, November 11-13.

50. Sayoojia KS, Sreekala AK and Shaiju PN, 2019. Gynostemium morphology of *Thottea duchartrei* Sivar., A. Babu and Balach. (Aristolochiaceae) from the Western Ghats in 29th IAAT Conference held at JNTBGRI, Palode, Thiruvananthapuram on 11-13 November.

51. Shailajakumari S, Sreekala AK, Parthipan B and Santhoshkumar ES, 2019. Rediscovery of *Madhuca diplostemon* (C B Clarke) P Royan (Sapotaceae) a critically endangered species of the Western Ghats. 29th IAAT Conference held at JNTBGRI, Palode, Thiruvananthapuram during 11-13 November.

52. Shalini Rajan, 2020. Ethnobiological study on the mangroves of Vypin Island. Webinar series - Recent trends in Plant Science Research at JNTBGRI, on 9th September.

53. Shefin B, Sreekumar S and Biju CK, 2019. *In silico* validation of anti-tuberculosis activity and identification of lead molecules in *Annona squamosa* L. European Respiratory Society International Congress 2019, held at Madrid, Spain from 28 September to 2nd October, 2019. European Respiratory Journal 54: Suppl. 63, A459. http:// erj.ersjournals. com/content/54/suppl_63/PA4593. abstract. Online ISSN: 1399-3003.

54. Shibin Felix P and Radha RK, 2019. *In vitro* regeneration of *Myristica malabarica* Lam., a threatened medicinal tree of the Western Ghats. 29th IAAT Annual Conference and National Symposium on Modern Trends in Biosystematics of Angiosperms, 11-13 November, JNTBGRI.

55. Shibin Felix P and Radha RK, 2019. Morphological analysis and estimation of β-asarone content in *Acorus calamus* from the Western Ghats. International Conference on Energy and Environment, 12-14 December, TKM College of Arts and Science, Kollam.

56. Sreedevi S Kumar, 2020. Insight into the richness and utilization of coastal biodiversity – An Ethnobiological survey and documentation in the Webinar series - Recent trends in plant science research at JNTBGRI, on 9th September.

57. Sreedevi S Kumar, Vinodkumar T G Nair, Navas M and Suja SR, 2019. Ethnobotanical urvey in the coastal areas of Thrissur District, Kerala. 31st Kerala Science Congress, Fathima Mata National College, Kollam, 2nd and 3rd February.

58. Sreedevi S Kumar, Vinodkumar TG Nair, Navas M and Suja SR, 2019. Ethnobiological survey on Prenatal and Postnatal care practiced in the coastal areas of Thrissur District, Kerala. Proceedings of the 11th NAB National Conference on Climate Changes Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development, Pondicherry University, Pondicherry from 25th to 27th September (Book of Abstracts, P. 112).

59. Sreekala AK and Jayalakshmi M, 2018. Reproductive ecology of *Humboldtia decurrens* Bedd. ex Oliver : An endemic legume of the Western Ghats, India. 7th International Conference on Biodiversity on 26th and 27 th July 2018 at Melbourne, Australia. Organised by OMICS International.

60. Sreekala AK, 2018. *Impatiens johnii* E. Barnes and *Impatiens platyadena* C.E.C. Fisch. (Balsaminaceae): The extinction risk as revealed by Reproductive Ecology in the 23rd International Forestry and Environment Symposium during November 23 & 24, 2018 at Sri Lanka, organized by University of Sri Jayewardenepura, Sri Lanka.

61. Sreekala AK, Anoosh Varghese, Hema Somanathan, Anilkumar C, Sabu KK and Shefeek S, 2018. Ecological perspective of *Xylia xylocarpa* seed biology in abstracts of Indo Mexican Seminar on Emerging Trends in Bio-Resource Utilization & Enzyme Technology on 13th April at Jawaharlal

Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram. p. 25.

62. Sruthy CR, 2020. *Kalamezhuthupaattu'*- A Temple ritual of Kerala. Webinar series - Recent trends in plant science research at JNTBGRI on 9th September.

63. Subin, Sreekumar S and Biju CK, 2019. Validation of Anti-hepatitis B activity of *Vigna mungo* (L.) Heeper and identification of potential lead molecules. Poster, International HBV meeting held on 1-5 October at Melbourne, Australia.

64. Suchithra G. Krishnan, 2019. Foliar studies on *Aristolochia* L. species from Western Ghats. Prof. A. Abraham Memorial Award Contest, JNTBGRI, Palode, May 24.

65. Suchithra G Krishnan, Mathew Dan and Santhosh Kumar ES, 2019. Taxonomic ambiguity due to unstable characters within the genus *Thottea* Rottb. (Aristolochiaceae) from the Western Ghats. 29th IAAT Conference held at JNTBGRI on November 11-13. pp 88-89.

66. Suchithra G Krishnan, Santhosh Kumar ES and Mathew Dan, 2019. Taxonomic significance of foliar micro-morphology in the genus *Aristolochia* L. (Aristolochiaceae) from the Western Ghats. National seminar on 'Plant Systematics: Current scenario and future prospects' at Dept. of Botany, Sree Neelakanta Govt. Sanskrit College, Pattambi on 24-25 October.

67. Suresh Kumar KA, Anilkumar C, Ajithkumar KG and Prajith TM, 2019. Comparative study on level of ABA during artificial dehydration in seeds of *Myristica* sp. and orthodox seeds. In: Kavitha R (ed). Proceedings of National Seminar on New Horizons for Biodiversity – Climate Change and Human Security "Conceptualization of Nature". 2019 November 21-22, pp 81- 87.

68. Suresh Kumar P, Sam P Mathew and Gangaprasad A, 2019. Field Gene Bank Conservation of Potential Lesser Known Wild Ornamental Species from the Western Ghats. 29th IAAT Annual conference, JNTBGRI. 11th to 13th Novmber.

69. Vinodkumar TG Nair, Navas M, Sreedevi S Kumar and Suja SR, 2019. Ethnobotanical investigation on environment friendly materials utilized by the coastal inhabitants of Thrissur district, Kerala, India. International Conference on Energy and Environment, TKM College of Arts and Science, Kollam, 12th to 14th December.

70. Vishnu R Varma, Suja SR and Prakashkumar R, 2019. Evaluation of Anti-Oxidant and Anti-Inflammatory Activity of Hydroalcoholic root extract of *Salacia fruticosa* Wall. International Multidisciplinary Research Conference on Biodiversity, Climate Change, Environment and Life Sciences held at SBES College of Science, Aurangabad, Maharashtra on 29th and 30th July.

71. Vishnu R Varma, Suja SR and Prakashkumar R, 2019. A glance in to the contribution of traditional/ethnomedical knowledge in bioprospecting of economically important medicinal plant for disease treatment. 29th IAAT Annual Conference and National Symposium on 'Modern trends in Biosystematics of Angiosperms'. JNTBGRI, Thiruvananthapuram from 11th to 13th November.

WORKSHOP/TRAINING / WEBINARS ORGANISED

1. Organized an exhibition of *Piper* germplasm in connection with the Regional Work Shop at ICAR-CTCRI Sreekariyam, where in the participants and dignitaries from Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), Govt. of India and farmers from Kerala and Karnataka visited the stall.
2. Bioinformatics Centre, JNTBGRI has launched the herbarium digitization programme and the seminar on herbarium techniques, jointly with the Department of Botany, University of Kerala on 30th April, 2019.
3. Conducted a Certificate course on Plant Tissue Culture Techniques and Applications during 1 Januay to 29 February 2020 for 16 graduates from various districts of Kerala.
4. One-day workshop on 'Application of PCR techniques for Systematics and Biogeography of plants' conducted on 14 November 2019.
5. Provided one-day training on Gardening and Floriculture to 60 students and teachers of Vocational Higher Secondary School for Girls, Thiruvallam, Thiruvananthapuram on 26th September 2019.
6. Training programme on 'Quality Planting Material Produce (QPMP)' was conducted from 1.1.2020 to 11.1.2020 by the Seed Bank of JNTBGRI.
7. Saraswathy Thangavelu Extension Centre, Puthenthope has organised two days workshop on 'Advanced Computer – Aided Drug Design and Computational Biology' from 14th and 15th May, 2019. Twenty-five researchers have participated in the workshop.
8. Saraswathy Thangavelu Extension Centre, Puthenthope has organized six months training course in Bioinformatics for M.Sc. degree holders with DBT sponsored monthly fellowship of ₹ 10000.
9. Six months training course in Bioinformatics to four M.Sc. degree holders with DBT sponsored monthly fellowship of ₹ 10000.
10. JNTBGRI has organized the 29th Annual Conference of Indian Association for Angiosperm Taxonomy and National Symposium on 'Modern Trends in Biosystematics of Angiosperms' during 11-13 November, 2019, at JNTBGRI, Palode, Thiruvananthapuram. There were 242 delegates from 14 States, representing various Institutions/organizations. There were deliberations under the themes biosystematics, conservation, ethnobotany, floristics, and modern trends in taxonomy, in seven sessions.

SEMINARS/SYMPOSIA/CONFERENCES/TRAININGS ATTENDED

1. Dr Santhosh Kumar ES has attended a two day workshop on Botanical Nomenclature at Malabar Botanic Garden and Institute of Plant Sciences from 6-7 February 2020.
2. Dr Rajendraprasad M has attended 'KANDAL KAKKAAM NALEKKAYI' (Conserve Mangrove for Future), 2 days National Workshop on Mangrove conservation held on 28th and 29th June 2019 at Krishi Vignjan Kendra (Kerala Agricultural University Regional Centre), Kumarakom.
3. Dr Saleem M has attended the Seminar on 'Herbarium Techniques Digitization' at Department of Botany, University of Kerala, Thiruvananthapuram on 30.4.2019.
4. Dr William Decruse S has attended a 3-day's workshop on Ecological Niche Modelling, organized by KSCSTE-MBGIPS, Kozhikkode, Kerala, 22-24 November 2019.
5. Dr Suja SR attended 4 days Hands-on Training on 'Medical Genomics & Metagenomics' (Next Generation Sequencing & Data Analysis) for National & International aspirants from January 14th to 17th, 2020 at Cochin University of Science & Technology (CUSAT), Cochin, Kerala.
6. Dr Suja SR and Dr Nazarudeen A participated in the International Virology Discussion Meet, 2019 organized by KSCSTE on 9th February, 2009 at the Institute of Advanced Virology (IAV), Thonnakkal, Thiruvananthapuram.
7. JNTBGRI has jointly organized the World Environment Day awareness programme with Marian College of Architect and Planning and planted trees at Kadinamkulam area on 6th June, 2019.
8. Dr Sabu KK gave training to Mr Anoop K from the Department of Biotechnology and Microbiology, Kannur University on 'Isolation and bioinformatics data analysis of miRNAs from plants' at the Biotechnology and Bioinformatics Division, JNTBGRI during 17-24 October 2019.
9. Mr Shibin Felix, Ms Lekshmi Suresh and Ms Aswathy Anand have attended two days National Workshop on Data Analysis Using Excel and SPSS for Application of Biological Science Research on 18th and 19th December 2019 at Kongunadu Arts and Science College, Coimbatore, Tamilnadu.
10. Ms Aswathy Anand and Mr Shibin Felix have attended Hands-on Workshop on Flow Cytometry from 5th- 7th December 2019 at Division of Thrombosis Research,

Development of Applied Biology, Biomedical Technology Wing, Sree Chitra Thirunal Institute for Medical Science and Technology, Thiruvananthapuram, Kerala.

11. Dr Vinodkumar TG Nair, Dr NavasM and Sreedevi S Kumar attended brainstorming session on 'Roadmap for Science and Technology: Achievements, Gaps and the way forward' organized by Sasthrabharathi on 7th April 2019 at Hotel Pankaj, Thiruvananthapuram.
12. Dr Biju H participated as a resource person in a Workshop on 'Identification, Bioprospecting and Conservation of Lichens' Organized by Department of Botany, Bharathiar University Coimbatore, in collaboration with Indian Lichenological Society & CSIR- National Botanical Research Institute, Lucknow during 12th and 13th September 2019.
13. Dr Biju H successfully completed a hands-on training course on Lichen Systematics jointly organised by Indian Lichenological Society and CSIR-NBRI at Sattal, Uttarakhand from 28 September to 5 October 2019.
14. Dr Radhakrishnan K participated in the workshop on medicinal plant taxonomy, organized by Centre for Biodiversity Conservation, Dept. of Botany, University of Kerala, Kariyavattom and released the book 'Medicinal Plant Taxonomy' on 13.2.2020.

SIGNIFICANT ASSIGNMENTS AND CONSULTATIONS

1. Dr Sreekala AK has evaluated the M Phil thesis entitled "An Ecological study of Mangroves at Visakhapatanam" Submitted by Mrs S Kanakamahalakshmi to Andhra University.
2. Dr Sreekala AK has evaluated the PhD thesis entitled "Exploration of Pharmacognostical, Phytochemical and Bioactive Potential of *Crateva magna* (Lour.) DC (Capparaceae)." Submitted By Mrs G Vijaya to MS University, Tirunelveli.
3. Dr Sreekala AK has evaluated the PhD thesis entitled "Pharmacognostic and anti-microbial Investigations of selected plants for the formulation of herbal shampoo" submitted by Jaya Kuruvilla to M.G. University, Kottayam.
4. Dr Sreekala AK has reviewed a project proposal entitled Pollination ecology and Conservation of some true mangrove plant species at Coringa Mangrove Forest, Andhra Pradesh, India for Rufford Small Grant (Ruffords Foundation).
5. Dr Sreekala AK reviewed six papers: one each for the Journal of Threatened Taxa, Indian Forester, Phytologia Balcanica, Ecological Informatics, Transylvanian Review of Systematical and Ecological Research and Taiwania.
6. Dr Biju CK has been appointed as an evaluator of National Children's Science Congress- State Level Programe 2019. Evaluated student projects and oral presentation on 29 - 30 November, 2019 and 2 - 3 December, 2019.
7. Dr Pradeep CK has reviewed a research paper entitled "*Efibula yunnanensis* sp. nov. (Polyporales, Basidiomycota) from China" by Rui-Xin Ma, Zheng-Jun Shi, Chang-Lin Zhao for the journal *Phytotaxa*.
8. Dr Pradeep CK has reviewed a research paper entitled "*Gloeocantharellus andasibensis* sp. nov. (Gomphaceae) from Madagascar" by Anna Berthe Ralaiveloarisoa, Kare Liimatainen, Helene Ralimanana, Vololoniaina Jeannoda, Stuart Cable & Tuula Niskanen for the journal *Phytotaxa*.
9. Dr Pradeep CK has reviewed a research paper entitled "*Pholiota glutinosior*, a new species of *Pholiota* from South China" by HU Huiping, LIU Yuanchao, WU Qingping, Zhang Zhi, Xie Yizhen, Zhuo Lijun, Shi Chuan for the journal *Phytotaxa*.
10. Dr Pradeep C Khas reviewed a research paper entitled "*Pluteus hubregtseorum,* a new species from Australia and New Zealand" by Hana Ševčíková, Jan Borovička, Genevieve Gates for the journal *Phytotaxa*.
11. Dr Pradeep CK has reviewed a research paper entitled "*Pseudosperma citrinostipes* (Inocybaceae, Agaricales), a new species associated with Keteleeria from

southwestern China, by Wen-Jie Yu, Cheng Chang, Li-Wu Qin, Nian-Kai Zeng, Shao-Xian Wang, Yu-Guang Fan for the journal *Phytotaxa*.

12. Dr Pradeep CK has reviewed a research paper entitled "Studies on Diversity of Macrofungi of Sonitpur and Biswanath Charali Districts of Assam, India" for the journal *Defence Life Science Journal*.
13. Dr Pradeep CK has reviewed a research paper entitled "Notes about the genus *Entoloma* s.l. in the Northwest of the Iberian Peninsula (XI): *Entoloma cedeirense,* sp. nov." for the journal *Studies in Fungi*.
14. Dr Pradeep CK has reviewed a research paper entitled "A new species of *Geopetalum* (Agaricales) from Eastern Ghats, India" by Kumar M and Kaviyarasan V for the journal *Kavak*.
15. Dr Pradeep CK has reviewed a research paper entitled "A review on the genus *Entoloma* (Basidiomycota, Entolomataceae) in Yunnan Province, China" byEdiriweera AN, Karunarathna SC, XU J, Hyde KD, Mortimer PE, De Silva NI for the journal *Studies in Fungi*.
16. Dr Pradeep CK has reviewed a research paper entitled "Morphological and Molecular Characterization of two Lignicolous Taxa: *Pleurotus citrinopileatus* and *P. sapidus* from Jammu and Kashmir, India" by Uzma Altaf and Yash Pal Sharma for the journal *J. Mycology & Plant Pathology*.
17. Dr Anilkumar C has been selected as an Advisory Committee member of the Star College Scheme funded by DBT to St. John's College, Anchal.
18. Dr Anilkumar C became an online reviewer of the research papers of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences.
19. Dr Anilkumar C has delivered a felicitation speech on the Green Band Activities 2019 of the Fatima Mata National College, Kollam.
20. Dr Anilkumar C has participated in the online discussion with the Australian Seed Bank Partnership regarding input of the seed science community to develop a programme for the 2020 Seed Science Forum.
21. Dr Anilkumar C has been appointed as the Chairman of the PhD adjudicator committee of the Viva-voce of Ms. Soumya M, Mahatma Gandhi University.
22. Dr Anilkumar C has conducted the PhD Viva Voce of Ms. Neha CP at the Department of Botany, Sir Syed College, Taliparmba. Kannur University.
23. Dr Anilkumar C has been appointed as an examiner in the evaluation of the PhD thesis of Mr Narayanayyar, submitted to Bharathidasan University Thiruchirapalli, Tamil Nadu.
24. Dr Anilkumar C has been appointed as an examiner for the evaluation of the PhD thesis of Ms C Swathi Krishana submitted to Kannur University.
25. Dr Anilkumar C has been nominated as an external examiner of Ms K Anjana Ajith for her MPhil *Viva -Voce* on 25-10-2019, at the Department of Botany, University of Calicut.
26. Dr Sreekala AK has been selected as the Editor of Journal of Palynology.
27. Dr Sreekala A K served as an external examiner for the second doctoral committee meeting (Approval of Course work) of Mrs. Thilakam, full time PhD Research Scholar, Parasakthi College, Courtallam (Guide -Esakki Ammal) affiliated to MS University, Tirunelveli.
28. Dr Sreekala AK served as the Chairman of the PhD viva voce of Mrs. Vijaya at S T Hindu College Nagarcoil (Guide-Dr B Parthipan) Affiliated to M.S. University, Tirunelveli.
29. Dr Sreekala AK served as the Convener of Reception Committee of IAAT Annual conference during November 11-13, 2019.

30. Dr Sreekala AK served as the Convener of Reception Committees of 27th National Children's Science Congress 2019.

31. Dr Sreekala AK served as the external examiner of Viva voce of the M.Sc. Agriculture student Ms. Pooja in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani.

32. Dr Sreekala AK served as the external member of the advisory committee of the MSc Agriculture student Mr Reddappa in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani.

33. Dr Anurag Dhayni became the editorial board member of the Journal of Sustainable Forestry, Taylor and Francis Group.

34. Dr Anurag Dhyani became selected as a member in the Seed Conservation Specialist Group, Species Survival Commission, IUCN.

35. Dr Anurag Dhyani became a Member of the Global Tree Specialist Group, Species Survival Commission, IUCN.

36. Dr Anurag Dhyani - Member North American Lily Society, USA.

37. Dr Vinodkumar TG Nair attended the Executive Committee meeting of the CCIM, Ministry of AYUSH, Govt. of India on 11.02.2020.

38. Dr Vinodkumar TG Nair attended the Executive Committee meeting of the Central University of Kerala on 18.01.2020, 19.02.2020 and 20.02.2020.

39. Dr Vinodkumar TG Nair assessed and evaluated Central Institute of Buddhist Studies (Sowa-Rigpa College), Choglamsar, Leh, Jammu & Kashmir on 22th & 23th July 2019, Central University of Tibetan Studies, Sarnath Rd, Varanasi, Uttar Pradesh on 25th and 26th July 2019 and Chagpori Tibetan Medical Institute, Darjeeling, West Bengal on 29th & 30th July 2019 as per the Directions of the President, CCIM, Ministry of AYUSH, Govt. of India.

40. Dr Vinodkumar TG Nair assessed and evaluated Namgyal Institute of Tibetology, Gangtok, Sikkim, and submitted assessment report to the Central Council of Indian Medicine, Ministry of AYUSH, Govt. of India on 25th & 26th June 2019.

41. Dr Vinodkumar TG Nair attended CCIM committee meeting on 22nd November and 26th December 2019 at New Delhi.

42. Dr Vinodkumar TG Nair attended Senate Meeting of the University of Kerala on 10th December 2019 at University of Kerala, Thiruvananthapuram.

43. Dr Vinodkumar TG Nair attended Special Meeting of the Senate, University of Kerala on 22nd August 2019 and 5th September 2019 at the Senate Chamber, University Buildings, Thiruvananthapuram.

44. Dr Vinodkumar TG Nair attended the 13th Executive Council Meeting of Central University of Kerala held on 4th June 2019 at 'Sopanam' Board Room, Mascot Hotel, Thiruvananthapuram.

45. Dr Vinodkumar TG Nair attended the meeting of Ministry of AYUSH, Government of India, nominated by Central Council of Indian Medicine, regarding Intangible Cultural Heritage (ICH) submitted by the Govt. of India to the UNESCO for inclusion of Sowa-Rigpa under UNESCO's ICH list on 22.10.2019 at 2.30 pm at AYUSH Bhavan, Ministry of AYUSH, New Delhi.

46. Dr Vinodkumar TG Nair attended Meeting of the Committee as a Member, constituted by the Central University of Kerala, Kasaragod on 17th and 18th September 2019.

47. Dr Vinodkumar TG Nair participated in the expert committee meeting- "Legal issues for implementation of ABS in the State and IPR

issues" held on 15 May 2019 at Govt. Guest House.

48. Dr Sreekumar S has appointed as an evaluator of National Children's Science Congress-State Level Programe 2019 on 29 and 30 November, 2019 and oral presentation on 2 and 3 December, 2019.

49. Dr Sreekumar S has appointed as MSc Biotechnology external examiner by the University of Kerala for conducting viva voice examination held on 18/10/2019 at S.N. College, Kollam.

50. Dr Sreekumar S has appointed as the chairman of adjudicators for conducting PhD public viva voice examination of Ms T Mowna Sundari at Madurai Kamaraj University, Madurai conducted on 17 June, 2019.

51. Dr Sreekumar S has nominated as a member in the Expert Panel for Technical Paper Evaluation committee of 32nd Kerala Science Congress (KSC) and reviewed life science and biotechnology papers.

52. Dr Sreekumar S served as a reviewer of the journals Legume Research, Indian Journal of Agricultural Research, International Journal of life Science and Pharma Research, 3 Biotech, Journal of Biological Sciences and Pharmaceutical Research, etc.

53. Dr Sreekumar S has appointed as a reviewer of KSCSTE-Student project scheme- proposals and reviewed 19 proposals during November, 2019.

54. Dr Suja SR has been appointed as an evaluator of oral presentation of National Children's Science Congress- State Level Programe 2019 on 2 - 3 December, 2019.

55. Dr Suja SR has reviewed 9 manuscripits for the Journal of Ethnopharmacology, Biomed Central Research Notes, Indian Journal of Natural Products and Resources (IJNPR) NISCAIR, Process Biochemistry, Evidence-Based Complementary and Alternative Medicine, Advances in Pharmacological Sciences, Medicinal & Aromatic Plant Research and Indian Journal of Experimental Biology.

56. Dr Suja SR has evaluated the first year and second year progress report of Y.S.S project YSSNOCST/433 of Council of Science and Technology, Uttar Pradesh.

57. Dr Suja SR has evaluated 24 proposals for Student Project Scheme of KSCSTE as expert member.

58. Dr Suja SR has edited one research paper for JTFP (Vol.6 (2).

59. Dr Suja SR has evaluated one Final Technical Report (FTR) of Back to Lab (BLP) of KSCSTE - BLP project eva "Immunomodulatory effect of beta glucan on neutrophil functions in Diabetes mellitus", June 2019.

60. Dr Navas M. had attended the Annual General Body Meeting of Indian Association Angiosperm Taxonomy on 12th November 2019 held at JNTBGRI.

61. Dr Navas M has evaluated the progress report of the research project entitled "Digitisation of Morphological Key Characters of Crude Drugs Received in Raw Materials, Herbarium and Museum Delhi (RHMD)", submitted by Dr. (Mrs.) Sunita Garg, Emeritus Scientist, RHMD, CSIR-NICAIR, New Delhi for extension under the CSIR-Emeritus Scientist Scheme.

62. Dr Navas M has evaluated and reviewed a research paper entitled "*Sida sivarajanii* (Malvaceae): a new species from India" by Gajanan Tambde, Milind Sardesai & Arun K. Pandey, Department of Botany, Savitribai Phule Pune University, Pune.

63. Dr Radhakrishnan K has assisted the preparation of Ethnobotany MSc syllabus for the University of Kerala.

MAJOR FACILITIES AND INFRASTRUCTURE

1. Bioinformatics facilities as Web server, database server, workstations and application package Schrodinger maestro glide.
2. Facilities for Plant tissue culture, cryopreservation and cryobanking, RT-PCR
3. Cryobank of Western Ghats' orchid seeds and pollinia
4. GC-MS (CIF)
5. Autoclave
6. Water purification system
7. Laminar air flow
8. CO_2 Incubator
9. Multiplate Reader
10. Nanophotometer
11. PCR
12. Refrigerated centrifuge
13. Electrical incinerator (Animal House)

RETIREMENTS

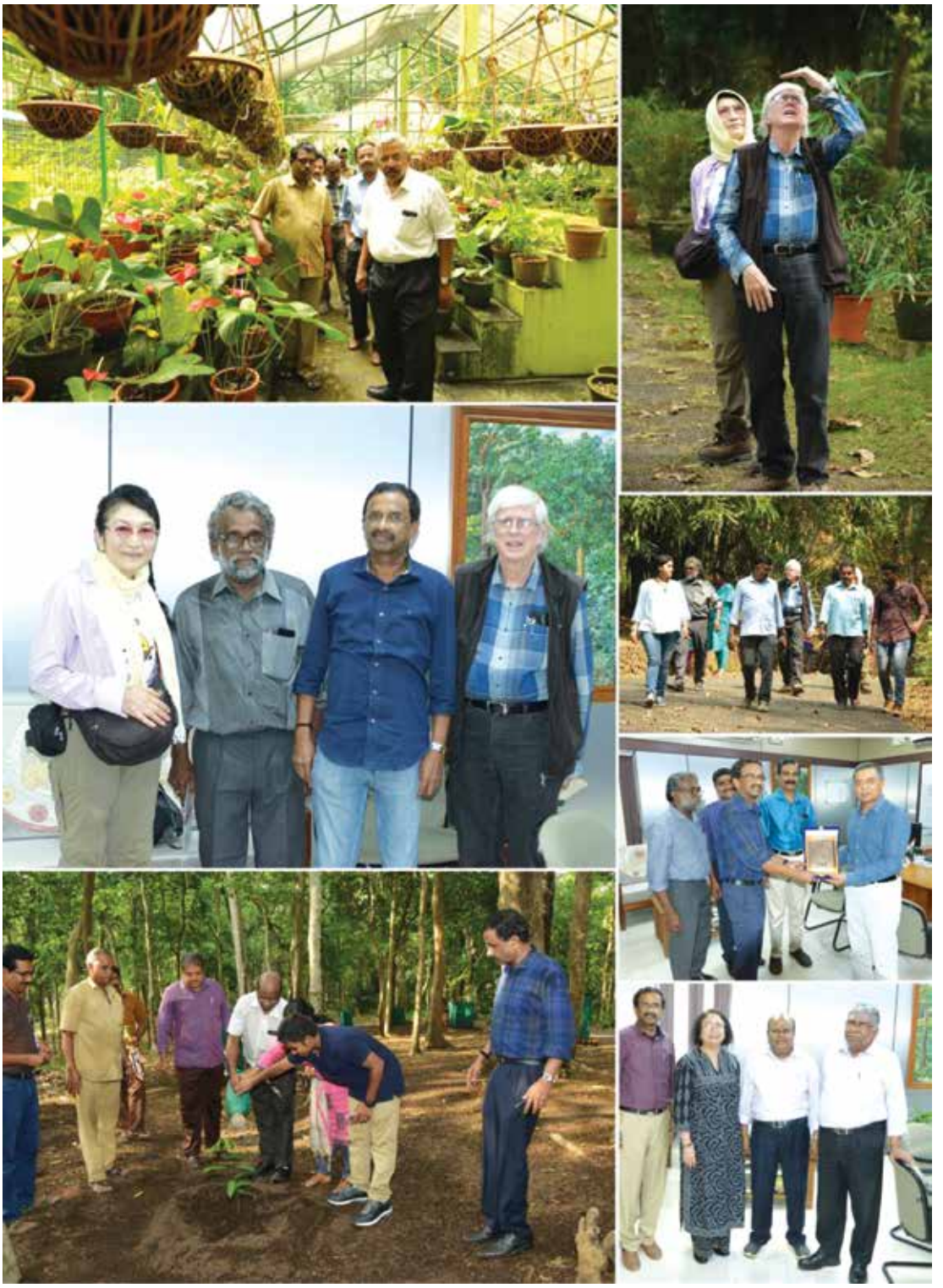
Retried/ Relieved/Departed			
SN	**Name**	**Designation**	**Date**
1	Dr N Mohanan	Senior Principal Scientist	31-05-2019
2	Dr K Satheeshkumar	Senior Principal Scientist	31-05-2019
3	Mrs V Sujatha	Junior Library Assistant	31-05-2019
4	Dr KB Vrinda	Principal Scientist	31-10-2019
5	Dr S Shiburaj	Senior Scientist	Relieved on 13.03.2020
6	Mr P Manikantan Nair	Garden Maestri Gr. II	30-04-2019
7	Mr S Baburaj	Garden Maestri Gr. II	30-06-2019
8	Mr P Jain	Security Guard Gr. IV	Expired on 17.06.2019
9	Mr N Salahudeen	Gardener Gr. IV	30-11-2019
10	Mrs S Jishi	Assistant Gr. I	Relieved on 31.07.2019
11	Mr TS Sunil Kumar	Assistant Gr. II	Promoted & transferred to KSCSTE on 18.02.2020

MAJOR EVENTS

Chief Minister Sri. Pinarayi Vijayan inaugurating the JNTBGRI Extension Centre at Kakkulissery, Kuzhoor.

1. Inauguration of 29th Annual Conference of Indian Association of Angiosperm Taxonomy & National Symposium on 'Modern Trends in Biosystematic of Angiosperms' Inaugural function 11-11-2019; 2. Release of Gardenia, the News letter of JNTBGRI during the Inaugural Function of 29th IAAT-National Conference on 11-11-2019

VISITS




Sasthra Sameeksha- 2


Sasthra Sameeksha-

PLAN FUNDED RESEARCH AND INFRASTRUCTURE PROGRAMMES

SN	Project Name	Division
1	*Ex situ* Conservation and Sustainable Utilization of Selected Plant Genetic Resources in the Southern Western Ghats through the invention of Biotechnology and Bioinformatics	Biotechnology and Bioinformatics
2	Studies on conservation biological aspects of selected flowering plants of Kerala	Conservation Biology
3	Systematic documentation and Bio-prospecting of ethnomedically important medicinal plants on tribal/ traditional knowledge through molecular pharmacological approach	Ethnomedicine and Ethnopharmacology
4	Development and Upkeep of Germplasm Conservatories and Landscapes & Dissemination of Botanical knowledge	Garden Management, Education, Information and Training
5	Survey, Inventory, Bioprospecting and Sustainable Utilization of Microbial and Lichen Diversity of Western Ghats	Microbiology
6	Community Agro Biotech Resource Centre (CARC)	Microbiology
7	Sustainable utilization of medicinal, aromatic and other potential economic plants of the Kerala region of Western Ghats through phytochemical and pharmacological means	Phytochemistry and Phytopharmacology
8	Germplasm Conservation, Conventional and Non-Conventional Multiplication, Maintenance and Sustainable Utilization of Medicinal, Aromatic, Orchid, Anthurium, Bamboo and Crop Related plants from Western Ghats and Andaman /Nicobar Islands	Plant Genetic Resource

9	Survey, Exploration and Documentation of Floristic Wealth of Kerala and Assessment of Ecosystem Services	Plant Systematics and Evolutionary Science
10	Inventory, documentation and phylogenetic studies of mushrooms of Western Ghats and Establishment of a regional reference centre for mushrooms	Plant Systematics and Evolutionary Science
11	Establishment of STEC-JNTBGRI as a nodal Centre for multidisciplinary research, production and supply of quality seeds, large scale cultivation of high value ornamental plants and human resource development	Biotechnology and Bioinformatics
12	Integrated R&D Centre of JNTBGRI – An extension of the Screw pine Tissue culture project at Kuzhur, the Kodungalloor	Biotechnology and Bioinformatics
13	Improvement of Existing Landscape and Field Gene Bank	JNTBGRI
14	Central Instrumentation Facility	JNTBGRI
15	JNTBGRI Infrastructure Programmes	JNTBGRI
16	Cost of implementation of plan projects	JNTBGRI

EXTERNALLY FUNDED PROGRAMMES

Sl No	Project Name	PI Of the Project	Funding Agency	Amount
Ongoing Projects – *Fund received in this financial Year*				
1	Ecology and Conservation of Fresh water Swamp Ecosystems of the Western Ghats - Kerala Region	Dr Rajendraprasad	DBT, Govt. of India	6,49,000
2	Comparative Biogeography of Plants of the Western Ghats	Dr N Mohanan	DBT, Govt. of India	10,94,000
3	Identification of the elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardization of their extracts.	Dr B Sabulal	DBT, Govt. of India	16,64,000
4	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	10,17,000
5	Antivirals from medicinal plants of Western Ghats selected based on Traditional Knowledge/ Ethnomedical information	Dr S R Suja	DBT, Govt. of India	11,14,000
6	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	13,61,000
7	Systematic Documentation of Traditional Knowledge Related to Plants used for Food, AYUSH and Indigenous Medicine	Dr Vinodkumar TG Nair	Ministry of AYUSH, Govt. of India	

8	Identification of potential bioactive chemical marker compounds and biological studies of *Gloriosa superba* and their geographical variations	Dr S R Suja	NMPB , Ministry of Ayush, Government of India	
9	Effect of selected nanoparticles synthesized from plant secondary metabolite on seizures induced by kainic acid in mice	Dr V Gayathri	KSCSTE, Govt. of Kerala	7,97,111
10	Establishment of a Herbal Garden at Raj Bhavan	Dr Mathew Dan	State Medicinal Plants Board, Govt. of Kerala	5,00,000
11	Gradening and Landscaping at Sumanusham Bungalow, the official residence of Chief Secretary	Director	Department of Tourism, Govt. of Kerala	43,175
12	Green Skill Development Programme (GSDP) – Entrusting the Certificate Course on Plant Tissue Culture Techniques and its Applications	Dr KK Sabu	MoEF & CC, Govt. of India	1,35,503
New Projects – *Fund received in this financial Year*				
1	Population Dynamics and agroecology of *Trichopus zeylanicus* Gaertn. ssp. *travancoricus* (Bedd.) Burkill ex Narayanan 'Árogyappacha'	Dr Anilkumar C	Kerala Forest Department, Govt. of Kerala	
2	The production of 50000 seedlings of *Tinospora cordifolia* as a part of Nation-wide campaign on 'Amrita for Life'	Dr Mathew Dan	State Medicinal Plants Board, Govt. of Kerala	
3	Conservation of Vulnerable Sandalwood (*Santalum album* L.) through propagation and reintroduction	Dr Anurag Dhyani	Kerala Forest Department, Govt. of Kerala	
Commitments from Funding Agencies				
1	Ecotourism in JNTBGRI	Director	Department of Tourism, Govt. of Kerala	3.5 Corers
2	Mass Multiplication of commercial important Indian orchids and carnivorous plants with people participation	Director	DBT, Govt. of India	5 Corers

3	Advance centre for molecular taxonomy AICOPTAX	Director	MoEF and CC, Govt. of India	5.2 Corers
4	Lead Garden 2nd Phase	Director	MoEF and CC, Govt. of India	70 Lakhs
5	Conservation of Sacred Grove at Kollam with Community Participation	Director	Kerala State Biodiversity Board, Govt. of Kerala	20 Lakhs
6	Establishment of bio park at Chirayinkeezhu Block Panchayath	Dr Raj Vikraman	Chirayinkeezhu Block panchayath, Govt. of Kerala	11,42,100
7	Landscaping and gardening of GV Raja Sports School	Dr S Sreekumar	Directorate of Kerala sports and youth affairs	50 Lakhs
8	Green Skill Development Programme (GSDP) – Entrusting the Certificate Course on Plant Tissue Culture Techniques and its Applications	Dr KK Sabu	MoEF and CC, Govt. of India	13 Lakhs
9	Development of controlled Release Formulation of Eco-friendly pesticides in stored pest management	Dr V Gayathri	KSCSTE, Govt. of Kerala	10.48 Lakhs
10	Scale Production of *Decalepis arayalpathra,* a critical endangered medicinal plants of Western Gharts by tissue culture for cultivation and sustainable utilization	Dr RK Radha	Kerala Forest Department, Govt. of Kerala	9.5 Lakhs
11	Consultancy Project on the Development of Botanic garden at LAVET, Surat District, Gujarat	Dr Mathew Dan	Gujarat Forest Department, Govt. of Gujarat	50 Lakhs

RESEARCH COUNCIL

SN	Name & Designation	Position
1	**Dr Balakrishnan Pisupathy** Former Chairman, NBA Vice Chancellor, Trans Disciplinary University, Bangalore	Chairman
2	**Prof. Aravind M Lali** Professor & Head Centre of Energy Biosciene Institute of Chemical Technology Nathalal Parekh Marg, Matunga, Mumbai-400019	Member
3	**Dr. Mohammed Aslam** Senior Advisor Department of Biotechnology, Ministry of Science &Technology, 6-8th Floor, Block 2, CGO Complex, Lodhi Road, New Delhi - 110003	Member
4	**Dr Madhmita Biswas** Director, Ministry of Environment, Forest & Climate Change Indira Paryavaran Bhavan, Jorbagh Road, New Delhi - 03	Member
5	**Prof. M Sabu** Department of Botany, University of Calicut Calicut University PO, Malappuram - 673635	Member
6	**Dr N Anil Kumar** Director M S Swaminathan Research Foundation Community Agro Biodiversity Centre Puthoorvayal PO Meppadi, Wayanad 673577	Member
7	**Dr S Pradeep Kumar** Member Secretary Kerala Sate Council for Science Technology and Environment, Government of Kerala, Sasthra Bhavan Pattom PO, Thiruvananthapuram-695004	Permanent Invitee
8	**Director** Jawaharlal Nehru Tropical Botanic Garden & Research Institute, Palode, Thiruvananthapuram - 695562	Member Convener

MANAGEMENT COMMITTEE

SN	Name & Designation	Position
1	Director, JNTBGRI	Chairman
2	Dr S Pradeep Kumar, Member Secretary, KSCSTE	Member
3	Dr Syam Viswanath, Director, KFRI	Member
4	Dr B Sabulal, Principal Scientist, JNTBGRI	Member
5	Mr Madhu, Additional Secretary, Science &Technology Department	Member
6	Mr P Ashok Kumar, Registrar, JNTBGRI	Member Convener

STAFF LIST

Sl. No.	Name	Designation
1	Dr. R. Prakashkumar	Director
Garden Management, Education, Information and Training Division		
2	Dr R Rajvikraman	Principal Scientist& Head
3	Dr A A Prasannakumari	Scientist
4	Mr V Premkumar	Asst. Public Relations Officer
5	Dr Raju Antony	Technical Officer
6	Dr Joemon Jacob	Technical Officer
7	Mr Muhammed Shareef	Technical Officer
8	Dr T Sabu	Technical Officer
9	Dr K J Lathan Kumar	Technical Officer
10	Dr A Hussain	Technical Officer
11	Mr K S Kalesh	Technical Officer
12	Mr B Jayakumar	Labour Superviser
13	Mr C Sudarsanan	Gardener
14	Mr B Harilalkumar	Gardener
15	Mr K Vijayakumar	Gardener
16	Mr K Anilkumar	Gardener
17	Mr J Rajan	Gardener
18	Mr V Satheesan	Gardener
19	Mr M Shajahan	Ticket Issuer
20	Mr R Lalan	Gardener
21	Mr R Suresh Kumar	Gardener
22	Mr P Babu	Gardener
23	Mr D Udaya Kumar	Gardener
24	Mr L Thulaseedharan	Gardener

25	Mr N Pradeep	Gardener
26	Mr AK Azeem	Gardener
Plant Genetic Resources Division		
27	Dr Mathew Dan	Principal Scientist and Head
28	Dr Sam P Mathew	Principal Scientist
29	Mr C Muraleedharan Unnithan	Technical Officer
30	Dr E S Santhosh Kumar	Technical Officer
31	Dr M Abdul Jabbar	Technical Officer
32	Dr M Saleem	Technical Officer
33	Dr B Gopakumar	Technical Officer
34	Dr BJ Radhika	Technical Officer
35	Mr M K Sreekumaran	Technical Officer
36	Dr S Anilkumar	Technical Officer
37	Mr V Venugopalan Nair	Garden Maestri
38	Mr G Manoharan	Gardener
39	Mr S Ajayakumar	Gardener
40	Mr K Ashok Kumar	Gardener
41	Mr B Jayalalkumar	Gardener
42	Mr S R Kamaleshkumar	Gardener
43	Mr P Shaji	Gardener
44	Mr S Thulaseedharan	Gardener
45	Mr K Asokachandran Nair	Gardener
46	Mr G Sudarsana Kurup	Gardener
47	Mr A Ullas	Gardener
48	Mrs Mini Thomas	Gardener
49	Mrs R Sreekumari	Gardener
50	Mr J Jose	Laboratory Assistant
51	Mrs A Manjuladevi	Laboratory Assistant

Biotechnology and Bioinformatics Division		
52	Dr S William Decruse	Principal Scientist and Head
53	Dr S Sreekumar	Principal Scientist
54	Dr K K Sabu	Principal Scientist
55	Dr C K Biju	Principal Scientist
56	Dr R K Radha	Senior Scientist
57	Dr M Raveendran	Scientist
58	Dr S Shailaja Kumary	Technical Officer
59	Dr A S Hemanthakumar	Technical Officer
60	Dr C Sunil Chandran	Estate Supervisor
61	Mrs V S Sindhu	Lab Assistant
62	Mrs S Syamala Kumary	Lab Attendant
63	Mr B Chandran	Gardener
64	Mr M Vijayan	Gardener
65	Mr R Anil Kumar	Gardener
66	Mr M Shajahan	Gardener
67	Mr G S Madhusoodhanan Asary	Office Attendant
Conservation Biology Division		
68	Dr C Anilkumar	Principal Scientist& Head
69	Dr A K Sreekala	Principal Scientist
70	Dr PS Jothish	Principal Scientist
71	Mrs A Rasiya Beegam	Senior Scientist
72	Dr Anurag Dhyani	Scientist
73	Dr CR Chitra	Technical Officer
74	Mr M Sibi	Technical Officer
75	Mr S Suresh	Technical Officer
76	Dr S Bindu	Technical Officer
77	Mr G Madhu	Gardener

Ethnomedicine and Ethnopharmacology Division		
78	Dr S R Suja	Principal Scientist and Head
79	Dr S Binu	Principal Scientist
80	Dr Vinod Kumar TG Nair	Senior Scientist
81	Mr K Radhakrishnan	Senior Scientist
82	Dr M Navas	Technical Officer
83	Mr S Radhakrishna Pillai	Animal House Technician
84	Mr G Anilkumar	Lab Attendant
Phytochemistry and Phytopharmacology Division		
85	Dr B Sabulal	Principal Scientist and Head
86	Dr KB Rameshkumar	Principal Scientist
87	Dr V Gayathri	Senior Scientist
88	Dr S Ajikumaran Nair	Technical Officer
89	Dr J Anil John	Technical Officer
90	Dr S R Rajani Kurup	Technical Officer
91	Mrs B Sumitha	Technical Officer
92	Mr G Santhoshkumar	Animal House Technician
93	Mrs P Sasikala	Lab Attendant
94	Mrs A Leela	Office Attendant
Plant Systematics and Evolutionary Science Division		
95	Dr G Rajkumar	Principal Scientist
96	Dr M Rajendraprasad	Principal Scientist
97	Dr A Nazarudeen	Senior Scientist
98	Dr T Shaju	Senior Scientist
99	Dr Dhruvan Tandyekkal	Scientist
100	Dr VS Usha	Herbarium Asst.
101	Dr M P Geethakumary	Technical Officer
102	Dr K P Deepthi Kumary	Technical Officer
103	Mr G Thulasidas	Technical Officer
104	Mr R Thulaseedharan	Gardener

Microbiology Division		
105	Dr C K Pradeep	Principal Scientist& Head
106	Dr Vipin Mohan Daniel	Scientist
107	Dr H Biju	Technical Officer
108	Dr A Sabeena	Technical Officer
109	Mrs S Sheeja	Office Attendant
110	Mrs Kanakasundaram	Lab Attendant
Library and Information Centre		
111	Mrs V Leena Kumary	Clerical Assistant
112	Mr C R Vinu Krishnan	Clerical Assistant
Administrative Staff		
113	Mrs S Meenakumary	Sect. Officer Gr. I
114	Mr K Vijayan	Sect. Officer Gr. I
115	Mr M Anilkumar	Sect. Officer Gr. I
116	Mrs B S Ajanthakumary	Assistant Grade I
117	Mrs R Subha Sankar	Computer Operator Gr. I
118	Mrs R Sofia	Assistant Grade I
119	Mrs T Ajithakumary	Assistant Grade I
120	Mrs S Sudha	Assistant Grade I
121	Mr P S Vishnu	Assistant Grade I
122	Mrs Seema Viswanath	Assistant Grade II
123	Mrs R Chithra	Assistant Grade II
124	Mrs R Anuradha	Assistant Grade II
125	Mrs P S Prathibha Rani	Assistant Grade II
126	Mrs R S Athira Nair	Assistant Grade II
127	Mrs R Prasannakumary	Stenographer Gr. II
128	Mrs P S Shyladevi	Typist Gr. II
129	Mr K P Eliyas	Store Assistant Gr. II
130	Mr K Mohammed Habeebulla	Typist/ Data Entry Operator Gr. II

(on deputation to KFRI)		
131	Mr B R Dinesh	Record Keeper Gr. I
132	Mr S Safeerkhan	Photocopy Operator Gr. I
133	Mr V Sudheeshkumar	Driver Gr. I
134	Mr G Murukesan Nair	Driver Gr. I
135	Mr S Sanalkumar	Driver Gr. I
136	Mr N Hariprasad	Driver Gr. I
137	Mr Balachandran	Driver Gr. I
138	Mrs KS Bindu	Office Attendant
139	Mrs J Anithakumari	Office Attendant
Engineering Section		
140	Mr S Ajith	Asst. Work Supervisor Gr. I
141	Mr V S Sureshkumar	Technical Assistant Gr. I
142	Mr P Ajithkumar	Supervisor (Electrical)
143	Mrs M R Geetha	Overseer Gr. I
144	Mr G Ajayakumar	PABX Oprator Gr. II
145	Mr P S Hanikumar	Label Writer
146	Mrs K Lalikutty	Sweeper Gr. II
147	Mrs Baby Girija	Sweeper Gr. II
Security Section		
148	Mr K Ramachandran Nair	Security Officer (i/c)
149	Mr A Vijayan	Security Guard Gr. I
150	Mr P Devaraj	Security Guard Gr. I
151	Mr C Jayakumar	Security Guard Gr. I
152	Mr S Vikraman Nair	Security Guard Gr. I
153	Mr G Ashokkumar	Security Guard Gr. I
154	Mr K Suresan	Security Guard Gr. I
155	Mr C Sureshkumaran Asari	Security Guard
156	Mr S Rajan	Security Guard
157	Mr R Prasannakumar	Security Guard
158	Mr R Nagappan	Security Guard
159	Mr G Anilkumar	Security Guard

JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN & RESEARCH INSTITUTE
PALODE, THIRUVANANTHAPURAM
(A Unit of Kerala State Council for Science, Technology and Enviornment of Govt. of Kerala)
BALANCE SHEET AS ON 31ST MARCH 2019

Liablities	Sch No.	As on 31-03-2019	As on 31-03-2018	Assets	Sch No.	As on 31-03-2019	As on 31-03-2018
Capital Reserve	I	6,57,51,754.00	6,10,22,614.00	Fixed Assets	V	6,57,51,754.00	6,10,22,614.00
Capital Reserve- External Projects	I	8,52,83,490.00	8,33,28,680.00	Fixed Assets External Projects	V	8,52,83,490.00	8,33,28,680.00
General Fund	I	4,79,03,075.00	4,79,03,075.00	Current Assets	VI	2,46,66,136.00	2,00,48,247.00
Book Publication Reserve	I	2,09,904.00	2,09,904.00	Current Assets External Projects	VI	4,69,35,742.43	5,14,36,976.00
Corpus Fund	I	1,71,68,666.00	1,46,39,003.00	Loans & Advances	VII	1,27,21,890.00	1,22,89,452.00
Loan Funds	II	4,23,291.00	4,23,291.00	Loans & Advances External Projects	VII	1,64,445.00	34,15,306.00
Orchid Farming Project Reserve		3,00,000.00	3,00,000.00	Suspense Accounts	VIII	6,02,915.00	6,02,915.00
Current Liablities & Provisions	III	2,03,68,130.00	5,10,84,455.00				
Current Liablities & Provisions External Projects	III	2,70,297.00	7,41,884.00				
Unspent Balance GOK	IV	(5,37,55,806.00)	(8,69,92,795.00)				
Unspent Balance External Projects	IV	4,68,29,890.43	5,41,10,398.00				
Control Accounts		25,73,594.00	25,73,594.00				
Suspense Accounts External Projects		23,63,850.00	23,63,850.00				
STEC / CSIR / UGC		4,36,237.00	4,36,237.00				
TOTAL		23,61,26,372.43	23,21,44,190.00	**TOTAL**		23,61,26,372.43	23,21,44,190.00

Significant Accounting Policies and Notes to Accounts XVIII

For Jawaharlal Nehru Tropical Botanic Garden & Research Institute

Dy. Registrar (Finance) Registrar Director

For Varma & Varma
Chartered Accountants
Firm Reg. No.: 004532S

VARMA & VARMA THIRUVANANTHAPURAM CHARTERED ACCOUNTANTS

Rajeev.R
Partner
Membership No. :211277

Place : Thiruvananthapuram
Dated : 31.10.2019

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 at 31st March 2020

(in Rs.)

Liabilities	Sch No.	As at 31.03.2020	As at 31.03.2019	Assets	Sch No.	As at 31.03.2020	As at 31.03.2019
Capital Reserve	I	7,09,94,842	6,57,51,754	Fixed Assets	V	7,09,94,842	6,57,51,754
Capital Reserve- External Projects	I	7,64,41,134	8,52,83,490	Fixed Assets External Projects	V	7,64,41,134	8,52,83,490
General Fund	I	4,79,03,075	4,79,03,075	Current Assets	VI	3,79,59,046	2,46,66,136
Book Publication Reserve	I	2,09,904	2,09,904	Current Assets External Projects	VI	2,79,70,373	4,69,35,742
Corpus Fund	I	1,94,01,939	1,71,68,666	Loans & Advances	VII	1,25,79,419	1,27,21,890
Loan Funds	II	4,23,291	4,23,291	Loans & Advances External Projects	VII	13,47,761	73,612
Orchid Farming Project Reserve		3,00,000	3,00,000	Suspense Accounts	VIII	6,17,353	6,02,915
Current Liabilities & Provisions	III	4,49,07,248	2,02,77,297				
Current Liabilities & Provisions External Projects	III	3,91,174	2,70,297				
Unspent Balance GOK	IV	(8,22,88,237)	(5,37,55,806)				
Unspent Balance External Projects	IV	4,38,51,877	4,68,29,890				
Control Accounts		25,73,594	25,73,594				
Suspense Accounts External Projects		23,63,850	23,63,850				
STEC / CSIR / UGC		4,36,237	4,36,237				
TOTAL		**22,79,09,928**	**23,60,35,539**	**TOTAL**		**22,79,09,928**	**23,60,35,539**

Significant Accounting Policies and Notes to Accounts **IX**

For Varma & Varma
Chartered Accountants
Firm Reg. No.: 004532S

Rajeev.R
Partner
Membership No. :211277

For Jawaharlal Nehru Tropical Botanic Garden & Research Institute

Dy. Registrar (Finance) Registrar Director

Place : Thiruvananthapuram
Dated : 19.12.2020

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, 2019

EXPENDITURE	SCH NO	YEAR ENDED 31.03.2019	YEAR ENDED 31.03.2018	INCOME	SCH NO	YEAR ENDED 31.03.2019	YEAR ENDED 31.03.2018
To Research & Development Expenses	A	5,32,87,157.00	4,20,44,514.00	By Grant From Govt of Kerala	G	21,24,10,276.00	20,18,13,397.00
To Employee Benefits	B	15,92,93,962.00	16,59,95,674.00	By Other Receipts	H	16,44,153.00	64,32,992.00
To Administrative Expenses	C	16,72,417.00	10,67,068.00				
To Other Expenses	D	10,849.00	28,806.00	By Interest from Banks		2,09,956.00	8,89,673.00
To Expenses of External Project	E	3,09,21,500.57	3,00,94,813.00				
To Depreciation - Institute	F	87,35,011.00	86,03,770.00	By External Projects			
To Depreciation - External Projects		1,15,49,135.00	1,16,98,051.00	Grant for External Projects	I	2,91,99,204.57	2,78,50,425.00
				Interest From Banks		16,40,571.00	22,00,205.00
				Other Income		81,725.00	44,183.00
				By Depreciation on Asset Acquired out of Grant Written Back		2,02,84,146.00	2,03,01,821.00
TOTAL		26,54,70,031.57	25,95,32,696.00	**TOTAL**		26,54,70,031.57	25,95,32,696.00

own income

Significant Accounting Policies and Notes to Acco XVIII

For Jawaharlal Nehru Tropical Botanic Garden & Research Institute

For Varma & Varma

Chartered Accountants
Firm Reg. No.: 004532S

Dy. Registrar (Finance) Registrar Director

Rajeev.R
Partner
Membership No. :211277

Place : Thiruvananthapuram
Dated : 31.10.2019

VARMA & VARMA THIRUVANANTHAPURAM CHARTERED ACCOUNTANTS

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, 2020

(in Rs.)

Expenditure	Scg No	Year Ended 31.03.2020	Year Ended 31.03.2019	Income	Sch No	Year Ended 31.03.2020	Year Ended 31.03.2019
To Research & Development Expenses	A	3,71,98,904	5,32,87,157	By Grant From Govt of Kerala	G	18,66,19,311	21,24,10,276
To Employee Benefits	B	14,98,58,663	15,92,93,962	By Other Receipts	H	12,44,279	16,44,153
To Administrative Expenses	C	11,23,990	16,72,417				
To Other Expenses	D	-	10,849	By Interest from Banks		3,17,967	2,09,956
To Expenses of External Project	E	3,26,32,239	3,09,21,501				
To Depreciation - Institute	V	96,53,854	87,35,011	By External Projects			
To Depreciation - External Projects	V	1,13,16,058	1,15,49,135	Grant for External Projects	I	3,06,24,519	2,91,99,205
				Interest From Banks		11,06,416	16,40,571
				Other Income		9,01,304	81,725
				By Depreciation on Asset Acquired out of Grant Written Back		2,09,69,912	2,02,84,146
TOTAL		**24,17,83,708**	**26,54,70,032**	**TOTAL**		**24,17,83,708**	**26,54,70,032**

Significant Accounting Policies and Notes to Accounts **IX**

For Jawaharlal Nehru Tropical Botanic Garden & Research Institute

For Varma & Varma
Chartered Accountants
Firm Reg. No.: 004532S

Dy. Registrar (Finance) Registrar Director

Rajeev.R
Partner
Membership No. :211277

Place : Thiruvananthapuram
Dated : 19.12.2020

Notes